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Do We Need Central Bank Digital Currency?

Economics, Technology and Institutions

Edited by

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*A joint publication with the Bocconi University
and BAFFI CAREFIN*

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Do We Need Central Bank Digital Currency?

Economics, Technology and Institutions

DO WE NEED CENTRAL BANK DIGITAL CURRENCY? ECONOMICS, TECHNOLOGY AND INSTITUTIONS

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CIP

**Do We Need Central Bank Digital Currency?
Economics, Technology and Institutions**

Editors: Ernest Gnan and Donato Masciandaro

Authors: Itai Agur, Mario Bergara, Michael D. Bordo, Walter Engert, Andrew T. Levin, Santiago Fernandez de Lis, Ben S.C. Fung, Ernest Gnan, Dirk Niepelt, Ruth Judson, Donato Masciandaro, Fabio Panetta, Paul Pichler, Jorge Ponce, Martin Summer

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1. DO WE NEED CENTRAL BANK DIGITAL CURRENCIES?

ECONOMICS, TECHNOLOGY AND INSTITUTIONS

**Findings from a conference organized by SUERF –
The European Money and Finance Forum and
BAFFI CAREFIN Centre, Bocconi University –
Milan, 7 June 2018**

Ernest Gnan and Donato Masciandaro

Central bank digital currencies (CBDC) have become a vividly discussed topic over the past few years, and the speed of the debate has gained pace recently. To gain an overview of various perspectives on this topic, SUERF and the BAFFI CAREFIN Centre at Bocconi University convened an expert conference. The conference focused on these questions:

- Is physical or paper cash really vanishing? How far is this process across the world? How big are differences across countries?
- What exactly is a CBDC? What are defining properties of a CBDC? What technical options are there? Depending on the combined features, what different types of CBDC might be conceived, and what properties would they each offer?
- What are the consequences – pros and cons as well as risks – of the various conceptions of CBDC for society at large (e.g. power balance between state and individual, personal privacy), for citizens and businesses, for banks (e.g. business model), for central banks (e.g. role, size of balance sheet) and monetary policy (e.g. effectiveness of monetary policy transmission) as well as for financial stability (e.g. bank runs)?
- What might be the political economy processes governing the drive towards (or against) the introduction of CBDCs? How might voters', politicians', central banks' and banks' interests and preferences influence this process?
- Would an economic system without cash and without a replacement for central bank money, which is available to the general public, be problematic?
- Should central banks therefore, if cash were indeed to be nearly fully replaced by private payment services, actively offer an electronic alternative issued by the central bank, i.e. a CBDC? Or should central banks actively

pursue the transition from paper cash to CBDC? Can central banks decide this themselves? Or is this an issue of such far-reaching consequences, and legal implications, that the democratic instances need to be actively involved?

- What are potential risks in the transition and in a potential future CBDC-based system? How about robustness to cyber-crime, electrical outages and extreme crisis situations?
- What are first experiences from a pilot project in Uruguay and what is the thinking of pioneering central banks in this field, such as Sveriges Riksbank and the Bank of Canada?

A FIRST OVERVIEW

Fabio PANETTA, Deputy Governor of the Bank of Italy, in his opening keynote embedded the topic in the wider digital revolution, the fourth industrial revolution, and the digitization of the financial system, which has been underway for many years (e.g. dematerialization of financial assets, electronic trading platforms, digital and mobile banking etc.). So, why should cash not also become digital? Before developing on this topic further, Panetta emphasized that CBDC has nothing to do with private crypto assets such as bitcoin. The former would be currency like cash and be governed by the same standards on stability as physical cash, while the latter is not currency but just an asset not backed by any clear governance, mandate, laws or other assets. Concerning the pros and cons of CBDC, Panetta first considered them as a *means of payment*. CBDC would add another digital payment alternative. However, given the already large range of electronic payments options available and the resulting existing strong competition, the marginal value of central banks' additional involvement in an area already well served by the private sector would appear small. However, CBDC might improve access to digital payments to non-banked consumers, a non-negligible fraction of the population even in highly developed countries. Whether this potential advantage would indeed materialize depends on the reasons why these groups are non-banked (cost of banking, remoteness, lack of digital literacy) and needs further research. Finally, CBDC might help save on the high costs associated with physical cash handling, which is estimated to cost at least ½% of GDP in EU countries. Regarding CBDCs role as *store of value*, again physical cash involves high storage costs, estimated in the order of 0.5-1% of the value stored, compared to quite negligible storage costs of CBDC. Contrary to bank accounts, CBDC would also be free of credit and liquidity risks. However, this advantage might deprive private banks of a major source of funding, which in the euro area currently makes up 20% of the euro area banking system's funding, with potentially adverse consequences for the cost and supply of bank lending.

CBDC might even trigger a “digital bank run”. In any event, CBDC would likely push banks’ business models towards “narrow banking”.

The most important issue is whether it should be *traceable* or to guarantee, as best as possible, *anonymity*, as cash perfectly does. Weighing the pros and cons of the privacy of payments transactions is a choice that does not belong to central banks alone but also to the political sphere, as it affects the heart of personal freedom and modern liberal democracy. This is also linked to the question whether CBDC would be *token-based* or *account-based*. The former would safeguard privacy better; the latter would imply a huge IT and human resources effort by central banks. Another important issue is whether CBDC should be *interest-bearing*. This choice would affect the central bank’s role, scope of monetary policy action and seigniorage. The monetary transmission mechanism would become more immediate, and, absent physical cash, negative interest rates would become fully feasible. If CBDC were remunerated, it would also become a closer substitute to commercial bank accounts and facilitate digital bank runs. Seigniorage would fall due to the interest paid on CBDC but it would increase through savings on cash handling and increasing demand for central bank liabilities. The overall impact is ambiguous, the distributional impact for society as a whole is non-trivial. An important challenge is also *cyber-security and resilience* to technical failure and *hacking*. Finally, there are a number of *legal issues* to be clarified, such as the legal tender nature of CBDC, whether this would imply that every citizen will need to have the technical means to use it, and whether central banks need authorization by government to issue it.

Weighing the costs against the benefits and considering potential risks, in Panetta’s view, the case for CBDC is as yet unclear. The impact and risks of a CBDC on the financial system, the real economy and on society depend on their specific design characteristics. If remunerated and available to anyone at no cost, CBDC would substantially *boost central bank balance sheets*. If account-based, central banks would directly interact with the private non-financial sector. This would substantially increase *central banks’ role in the economy*. *Society, through its democratic instances, should first decide* on its preferences on fundamental matters such as privacy of payments transactions before the central bank comes in with implementing CBDC. Given its well-established nature, its robustness and general acceptance and usability, cash is here to stay, at least for a while.

IS CASH REALLY OBSOLETE? WOULD A CBDC SATISFY PEOPLE’S NEEDS AS WELL AS CASH?

Ruth JUDSON, Federal Reserve System, offered insights on the *evolution of the demand for banknotes* in the US and in other countries and made speculations

about the effects from CBDC on cash banknote demand. US banknote demand trended down from the 1960s through the mid-1980s and in the years prior to the financial crisis. The upswing between 1985 and the early-2000s as well as since the financial crisis was driven by large denominations (USD 50 and 100), with smaller denominations trending further down. Much of the upswing was likely the result of foreign demand and coincided with crises. By contrast, US domestic banknote demand has been flat or been falling for all denominations, except for the year 2008, when also domestic demand for large denominations was strong. At a global level, *in almost all countries banknote demand rises, with large denominations dominating* in almost all countries. Relative to GDP, cash demand varies widely across countries; there is no correlation with income levels. In most countries, currency holdings are relatively large and on a stable or rising trend. *Sweden* with very low and rapidly further diminishing cash holdings is an extreme *exception* to the broader global pattern. If a CBDC were introduced alongside paper cash, its voluntary use would depend on who is now using currency and why. Foreign users would probably have no access to CBDC. Regarding *use of large denominations* by US citizens, little is known about *motivations*. They might include precautionary savings for fear of financial instability, privacy concerns, which have always existed but may be increasing in recent years, and gray/black market activities. Very little is known about the relative importance of these three factors, but is unlikely that users driven by any of them would find a CBDC attractive. Regarding smaller denominations, demand is trending down in the US but very slowly. Circulation in the US is still very high: USD20 notes in circulation are over USD500 per person, USD10 and smaller notes are USD140 per person. It is unclear whether a CBDC would be more appealing than other already existing payments media replacing cash.

CBDC WOULD CONTINUE THE HISTORY OF MONEY – VARIOUS OPTIONS TO DESIGN CBDC

Morten BECH, Bank for International Settlements, started by the observation that in the evolution of money, after primitive money, coins and notes, electronic money and digital money, we are now on the verge of creating *digital money 2.0*, the form and characteristics of which are as yet unknown, though. While globally the use of card payments (transactions as share of GDP) has consistently increased over the past decade, so has the amount of cash in circulation as a share of GDP in most countries. Notable exceptions to the latter trend were Sweden and some EMEs; in the UK, Canada and Australia cash circulation grew only marginally, while card payments grew strongly. Bitcoin as a peer-to-peer version of electronic cash challenged the established centralized model prevalent until then. *Various forms of money can be usefully categorized using four criteria:* wide

accessibility, whether they are physical or electronic, whether they are issued by the central bank or privately, and whether they allow peer-to-peer transactions. In this four-dimensional structure, central bank reserves, banknotes, fractional reserve money, bitcoin, Uruguay's e-Peso, central bank retail and wholesale crypto-currencies all fill specific niches and needs. Bech then compared *three forms of CBDC – retail tokens, retail accounts, and wholesale-only tokens* – with existing paper cash and reserves and settlement balances using five criteria. Retail CBDC tokens could fulfil all five criteria, i.e. ensure 24/7 availability, ensure anonymity vis-à-vis the central bank, allow peer-to-peer transfers, bear interest and be capped regarding the size of transactions. CBDC retail accounts could also be available 24/7, anonymity and peer-to-peer transfers would not be possible, while they could also bear interest and be capped. Wholesale-only tokens could be designed to satisfy all five criteria. So, CBDC offers vast degrees of freedom in implementing specific features. Most notably, for monetary policy CBDC would enable the application of *negative interest rates* on CBDC and the issuing of *helicopter money*. Regarding financial stability, CBDC might alter the nature of bank runs and *disrupt banks' business models*.

ALTERNATIVE CBDC CONCEPTIONS, FOUR SCENARIOS, AND THEIR QUITE DIFFERENT CONSEQUENCES

Santiago FERNANDEZ DE LIS, BBVA Research, defined CBDC as central bank-issued instruments combining cryptography and digital ledger technology to achieve four goals: improved inter-bank settlement, improved payment system efficiency, improved monetary policy effectiveness through overcoming the zero lower bound on nominal interest rates, and stronger surveillance and better financial system stability. He analyzed various *conceivable forms of CBCD by combining three features*: access, anonymity and yield. Contrary to physical cash, access to CBDC might not need to be universal but could also be restricted. Contrary to physical cash, transactions in CBDC might be identifiable. Contrary to physical cash, CBDC might yield interest.

Combining these three design elements, Fernandez de Lis chose *four scenarios* (more combinations would of course be conceivable) for CBDC to illustrate the *wide range of possible conceptions*.

A. A *non-yield-bearing CBDC with restricted access and full identification* might be conceived for interbank settlement. In the speaker's view, this would improve wholesale money market efficiency, and the reduction of barriers to entry would open participation of third-party providers.

B. A *non-yield bearing CBDC with universal access and anonymity* might replace

physical cash, at lower cost and with higher efficiency. In the speaker's view, this would improve retail payments efficiency. Having an account with the central bank might need to be made obligatory. As a result, bank deposits and credit might fall. Overall, it would be convenient for end-users. Given anonymity, the informal economy might be encouraged.

C. A *yield-bearing CBDC with universal access and anonymity* would appear to help central banks overcome the zero lower bound on interest rates. However, this measure amounts to financial repression: thus, negative interest rates might as a further measure prompt the introduction of capital controls to avoid flight to higher yielding assets. Physical cash would also need to be actively abolished by the authorities to make the negative interest rates work. Due to the far-reaching impact of financial repression and the fiscal nature of negative interest rates on CBDC, the frontiers between monetary and fiscal policy would be blurred, raising questions of central bank legitimacy and ultimately threatening central bank independence. Overall, this scenario would therefore be highly disruptive.

D. A *non-yield bearing CBDC with universal access and full identification* would make the central bank a deposit-taking institution for the general public, increase surveillance and reduce financial system instability. This approach might sharply reduce bank credit unless the central bank redirects funds to the financial systems. This form of CBDC would amount to a total disruption of banking systems as we know them today, implying a potentially painful transition phase. The lack of bank credit might give rise to new credit mechanisms, e.g. through crowd-funding. The very far-reaching nature of this form of CBDC would again raise issues of central bank legitimacy.

The probability of introduction and the extent of disruption of these four scenarios are plausible to be inversely related. In Fernandez de Lis' assessment, the *less disruptive scenarios A and B* are likely to be introduced *within a five year horizon*. Central banks are aware of the more serious disruption of the financial system in scenarios B to D: they would thus move forward only with gradual testing and implementation. *Increasing competition from private cryptocurrencies might push central banks towards adopting CBDCs*. The *example of first-mover central banks* may increase incentives by other central banks to follow.

EMES HAVE DIFFERENT NEEDS

Fernandez de Lis concluded with some thoughts on the *special situation in emerging market economies* (EMEs). Using CBDC for interbank settlements (Scenario A) might have merits in EMEs in the event that existing wholesale

payment systems are not yet well developed and efficient. An anonymous CBDC cash replacement (Scenario B) might be particularly helpful to enhance financial inclusion and efficiency in EMEs, while risking to consolidate tax evasion. If not credible, such a CBDC could also easily fail, as multiple examples of dollarization have shown. Using CBDC to enhance monetary policy with negative interest rates (Scenario C) is less relevant in EMEs given their usually higher inflation rates. Non-anonymous CBDCs as public deposits at the central bank (Scenario D) would reduce informality but might hamper bancarization in EMEs.

HOW TO DESIGN A CBDC, AND WHICH CONSEQUENCES WOULD ARISE?

Andrew T. LEVIN, Dartmouth College, formulated *broad design principles for CBDC* based on the requirements to provide a legal tender with stable value that facilitates transactions, provides a stable unit of account and serves as a store of value. A *stable unit of account is a public good*, like metric units etc., which the state should provide. Because of the enabling the use of negative interest rates, CBDC enables the central bank to pursue *true price stability* in the sense of zero average inflation, thus facilitating decisions of households and firms and increasing economic efficiency. CBDC would be *much more cost-efficient* than physical cash. Central banks should implement CBDC not in the form of digital tokens using distributed ledger technology: while these would provide anonymity, they might facilitate criminal activity and are costly and non-instantaneous. Thus, central banks should provide *CBDC through accounts*, using well-established, cheap and fast technology. Rather than providing accounts directly to the public (which might exacerbate bank runs), central banks could provide such *accounts in public-private partnerships through commercial banks* overseen by the central bank. This would enhance privacy and financial system stability. In the spirit of Friedman's rule for optimal monetary policy, *CBDC should yield the same rate of return as other safe assets*. While in the case of physical cash this implies steady-state deflation, digital cash can be interest-bearing, with essentially the same rate of return as short-term government securities, thereby eliminating the costs of holding cash, seigniorage, and thus any conflict between price stability and efficiency. In Levin's view, while *paper currency* should not be abolished it *will become obsolescent*. Given network externalities inherent in payment systems, retailers have strong incentives to curtail the use of paper cash and coins. This in turn will diminish consumers' incentives to carry cash. This feedback loop has proven to be very rapid in Sweden and will become evident elsewhere.

By establishing *graduated fees for transfers between digital and physical cash*, central banks can eliminate the effective lower bound on interest rates if the fees

are sufficiently substantial for large transactions. This new freedom with regard to interest rate setting would enable to rest on this tool also in severe downturns or crisis and thus to refrain from opaque and discretionary balance sheet tools. Monetary policy would thus become more systematic, transparent and effective. The *central bank's balance sheet* could become quite simple, with assets of short-term government securities matching its digital cash liabilities. Monetary operations would simply adjust the supply of digital cash to meet demand at the pegged interest rate, with corresponding adjustments in holdings of government securities. As the central bank no longer generates seigniorage and will *cover its costs through minimal transaction fees*, central banks would be better shielded from pressures and political interference. In a crisis, the central bank could fulfill its *lender of last resort* role by providing digital cash to financial institutions in need for assistance.

CENTRAL BANKS SHOULD ACT PRO-ACTIVELY NOW

To conclude, Levin warned that the *payments system is evolving very rapidly now*. Instability and price level indeterminacy could arise if all payments were made with private currencies. Systemic risks could be exacerbated by the emergence of quasi-monopolistic payments. With the present system, central banks might be unable to mitigate severe deflationary shocks. Thus, *central banks should engage in an active dialogue* with elected officials, the private sector and the general public on whether and how to proceed with launching CBDC.

IS A CASH-LESS SOCIETY PROBLEMATIC?

Ben FUNG, Bank of Canada, defined CBDC as central bank liabilities, widely available to the general public which can be used to make payments. Thus, besides physical cash and electronic central bank reserves, they would represent a *third possible form of central bank ("outside") money*. There are many possible *motivations* for the introduction of CBDC: responding to a decline in the use of physical cash, the preservation of seigniorage and ensuring an adequate share of central bank money in the monetary system; improving the contestability and efficiency of payments; the elimination of the zero lower bound and the facilitation of quantitative easing; improving financial stability; enhancing financial inclusion; and fighting criminal activities.

Fung then focused on two questions: first, *whether a cashless society is problematic*, and how the central bank should respond. The use of cash for payments transactions has been declining in Canada. The rise in the volume of cash circulation is mostly due to high denominations. Nevertheless, cash plays no

role in large value payments. The abolition of paper cash would hit those in society that do not have access to bank accounts or electronic payments; but instead of taking this as an obstacle, one could work on financial and digital inclusion. There is also the question whether the abolition of paper cash would reduce competition in retail payments systems. The loss of seigniorage for central banks due to the abolition of paper cash would be small given the small fraction of cash in central banks' balance sheets. Fung then offered some considerations on the *financial stability implications* of a (nearly or completely) *paper-cash-less monetary system*. Would the abolition of paper cash reduce the probability of *bank runs* and thus weaken market discipline on banks? In Fung's view not necessarily, since depositors can in any case already now transfer money to other, safer banks or buy government securities, which would remain options for a run also in the absence of paper cash. Furthermore, during episodes of severe financial instability, wholesale runs by large firms were more important than retail runs by small depositors. While periods of financial crises have in the past indeed been associated with a *flight to cash* as a *safe store of value*, they continued to use credit and debit cards. To meet the increased demand for risk-free assets in a systemic banking crisis in a (nearly) cash-less monetary system, the central bank could (a) provide cash from a large emergency stock that it holds for contingencies; (b) rely on government securities as a safe store of value, possibly in smaller denominations in order to widen access to the general public; (c) temporarily open the possibility for savers to open deposits with the central banks (temporary or contingency CBDC).

WHAT WOULD BE THE CONSEQUENCES OF CBDC FOR PAYMENT SYSTEMS AND FINANCIAL STABILITY?

The second question addressed by Fung was whether the central bank should issue a CBDC to promote the *competition and efficiency in payments systems*, and what the consequences for the financial system would be. First, he sketched the attributes that a CBDC in his view should have: it would be legal tender in national currency convertible to banknotes and reserves at par, it could bear an interest of zero, positive or negative value, it would not involve fees, access would be non-exclusive, it would be available 24/7, supply would be entirely demand-driven, distribution would be channeled through financial institutions, there would be counterparty anonymity, but no anonymity to the financial institution and central bank (to avoid tax evasion and criminal activity), payments processing would be close to real time, the timing of irrevocability would depend on the technical solution, and the CBDC payment network structure would be distributed and bilateral, not tiered. Such a CBDC would likely reduce paper cash demand but would increase overall central bank seigniorage, there would likely

shifts from bank deposits to CBDC, in response banks would raise deposit interest rates, bundle services, rely more on wholesale funding or else reduce lending. Monetary policy would be affected since the central bank would be able to directly influence retail interest rates on CBDC.

Fung concluded that much more in-depth studies are needed to shed light on these and many other issues including potentially high set-up and operating costs, as well as cyber and reputational risks.

WHAT INFLUENCES THE DRIVE TOWARDS CBDC: A POLITICAL ECONOMY PERSPECTIVE

Alessandra CILLO and Donato MASCIANDARO, Bocconi University, reported on an ongoing project which investigates whether people would like CBDC. They started from the observation of two seemingly contradictory developments: on the one hand, the use of cash has further increased in the euro area over recent years; on the other hand, new private electronic currencies have gained prominence and increasing acceptance. So, there seems to be the need for the safety of assets issued by a state authority, on the one hand, and the technological progress as represented by e.g. private crypto-currencies. Is CBDC, being electronic public legal tender, the answer to this combined need? How high would actual demand for CBDC be? What would the interest elasticity between CBDC and bank deposits be? The authors presented a theoretical model to identify the drivers of the political consensus in favor of or against a CBDC. Given three different properties of a currency (two standard functions of medium of exchange and store of value and a third, less explored one of store of information, in other words the risks for privacy from using money for exchanges) and different types of money (as paper currency, banking currency and crypto-currency) and assuming that individuals are rational but at the same time can be subject to behavioral biases (loss aversion), three different groups of individuals – CBDC lovers, neutrals and haters – emerge. Given the alternative opportunity costs of the different types of currencies, CBDC issuing is more likely to occur, the stronger the preference for a legal tender and/or the more they are indifferent with respect to anonymity. The probability of a CBDC being introduced also increases if it is remunerated and if its implementation can guarantee at least counterparty anonymity. Finally, the authors presented the key features of a planned experiment. The aim of the experiment will be to find out about individuals' relative preferences attached to the above three properties. This should help to better anticipate public acceptance of various forms of CBDC.

A FIRST CBDC PILOT PROJECT: CONSIDERATIONS, EXPERIENCES AND FIRST RESULTS FROM URUGUAY

Jorge PONCE, Central Bank of Uruguay, shared the Bank of Uruguay's experiences with a just finished real world *pilot test* of a digital version of the Uruguayan Peso, called *e-Peso*. The e-Peso was designed as an electronic platform for Uruguayan Peso with legal tender status. To begin with, the legal framework was verified to allow the issuing of electronic bills as a complement to physical ones. Cyber-, information-, financial and reputational risks were reasonably hedged and mitigated. The pilot was performed to test various technical aspects, such as e-Peso production, the digital vault, digital wallets, the transactions system, infrastructure and business continuity. The central bank conducted it in close cooperation with a telecom provider, and a handful of IT and payment solutions providers. The pilot lasted for 6 months from 17 November 2017 until 18 April 2018. A volume of 20 million e-Pesos (equivalent of around EUR 550,000 as at June 2018) was issued. 10,000 mobile phone users, chosen on a first-come-first-serve basis, were involved. E-Pesos were generated at the central bank, transferred from the e-vault to users' digital wallets, and could from there be used for payment transactions in registered stores and businesses as well as for peer-to-peer transfers among registered users. Digital wallets were limited at an equivalent of EUR 800 (EUR 5,500 for registered businesses). Participants were incentivized to initially convert cash into e-Pesos and then to actively use the system for transactions. At the end of the pilot, e-Pesos were converted back into conventional Pesos, and the e-Pesos were destroyed by the central bank. Currently, the pilot is being evaluated and further steps are being decided. The pilot system provided for instantaneous settlement, relied merely on a working mobile phone line, not requiring an internet connection, the users' wallets and the encrypted e-note manager were designed to render transactions anonymous yet traceable; e-Pesos were secured even if users lost their phones or the password for their digital wallet; unique traceable bills prevented double-spending and falsification.

The overall *experience* with the pilot was *positive*: there were no technical incidents, transactions were mostly peer-to-peer, the number of participating stores and businesses increased over time, and also banks got interested in joining. Overall, Ponce highlighted many *advantages of central bank digital currencies* (lower costs, financial inclusion, prevention of crime and tax evasion, customer protection) and called for central banks to embrace new technologies, which are in any case unavoidable, and be pro-active in promoting further financial innovation in cooperation with the private sector and start-ups.

THE SVERIGES RIKSBANK'S E-KRONA PROJECT: MOTIVATION, STATE OF PLAY, AND FURTHER PLAN

Bjorn SEGENDORF, Sveriges Riksbank, defined a CBDC as a central bank liability, denominated in national currency, available 24/7, more broadly accessible than current central bank deposits. Generally, motivations for issuing a CBDC can be rooted in socio-economic considerations, in financial stability goals, in monetary policy objectives and in the quest for efficiency. In Sweden, retail payments developments are the driver for considering an *e-krona*, as the *use of paper cash is quickly dwindling*. Thus, if cash disappears, the *general public would no longer have access to central bank money*. In the medium term, *Sweden would no longer have a domestic infrastructure for retail payments*, given the dominance of global card schemes, pan-European clearing and the ECB's trend towards multi-currency settlement systems. A retail CBDC would ensure that the Swedish public has access to central bank money. It would provide a payment infrastructure and may increase payment system resilience. The Riksbank's current concept for an e-krona aims to provide a means of payment primarily between households and firms, it would be accessible 24/7 and process payments in real time. Currently, there is no legal basis for remuneration. The issues of (partial) anonymity and off-line functionality are as yet open.

A CBDC is, however, *no free lunch*. The advantages have to be weighed against the consequences. For instance, in the area of financial stability, many argue that it would enable *instant bank runs* by enabling depositors to shift savings from bank deposits into CBDC and lead to a dramatic expansion of the central bank balance sheet during crises. Segendorf challenged this assertion by showing that the consequences of a bank run on the overall size of the central bank balance sheet need not differ with CBDC as compared to the present situation (while the composition effects differ, of course).

The *e-krona project* is currently underway. Phase 1 in 2017 was devoted to drawing up a general proposal for an e-krona and a potential design for an e-krona system. During phase 2 in 2018 the e-krona concept is refined, deeper legal analyses are being conducted and monetary policy issues are being investigated. By end-2018, the decision to move to stage 3 or to conclude the project will be taken. Phase 3 might either lead to the development and implementation of an e-krona system or be used for a continuation of analyses.

CBDC IN THE BROADER CONTEXT OF THE CURRENT DISCUSSION OF CRYPTO-CURRENCIES

Martin SUMMER, Oesterreichische Nationalbank, provided an introduction into various forms of money and payments methods, including cash, bank deposits, SEPA, crypto-currencies, emphasizing their distinctive features. Both *paper and book money* crucially rests on trust, be it in the monetary authority or the stability of banks. Trust in the current monetary system relies on a well-established combination of hierarchy between money created by the central bank and deposit institutions, of centralization and coordination with incentives for the parties involved to maintain the integrity of the system. Deposit money is the digital representation of cash, convertible at a fixed rate of 1:1. Traditional forms of money and payment systems function smoothly and efficiently. *Crypto-currencies* are privately issued value units convertible to actual currencies at flexible exchange rates. Contrary to the terminology of “digital coins” and “digital wallets”, they are conceptually closer to deposit money and accounts. Agents exchanging crypto-currencies are represented as addresses in computer networks, which do not reveal the owner’s identity. Transactions are authorized and verified using cryptographic techniques and the integrity of transactions is verified collectively and in a decentralized manner by “miners”. The latter verify transactions, batch them into blocks and append them to a register of all blocks of verified transactions that ever happened in the network, called the “block-chain”. The popularity of crypto-currencies rest on the fact that a central authority is deliberately excluded, it is open source, and everybody is free to participate. Anonymity adds to its attractiveness. A clever system of technology and economic incentives aims to ensure honest behavior among participants. Given the complex process of creation and encryption, payments in crypto-currencies are slower than e.g. SEPA, they have a much lower transaction capacity, and they are inefficiently resource intensive. For these reasons, the use of the block-chain technology would not make sense for CBDC. Even more, the concepts and technology implemented in *crypto-currencies* (in particular the *block-chain technology*) are *irrelevant* for a discussion of CBDC. If CBDC means direct access for citizens to central bank money through accounts at the central banks, this would imply a major structural change in monetary arrangements. Summer doubted, however, why central should go this way: there is *no convincing case that the still widespread use of cash* can be interpreted as a *market failure that calls for public policy intervention*.

A MACROECONOMIC PERSPECTIVE: INSIDE VERSUS OUTSIDE MONEY, AND THE ROLE OF INCENTIVES

Dirk NIEPELT, University of Bern and CEPR, offered a macroeconomic perspective. Would CBDC by *substituting outside money* (i.e. money coming from outside the private sector, in practice from the central bank) *for inside money* (i.e. money backed by credit from inside the private sector, in practice book money, i.e. deposits at banks which were created through postings in the banks' account books) *change macroeconomic outcomes*? Does inside money add social value? If not, could we abolish inside money along the lines of the Swiss "Vollgeld initiative"? Niepelt first considered arguments *why substitution might not matter*. As regards money as a store of value, the composition of money between inside and outside money does not affect the economy's balance sheet; assets, saving and investment are unaffected. By contrast, there also *arguments why substitution does matter*. Incentives to screen borrowers might weaken, the incentive to lend might actually increase. Central banks' incentives in a politico-economic equilibrium might change. As the monetary system becomes more transparent, support for implicit transfers from the central bank might dwindle. In conclusion, if incentives for central banks and politicians were held constant, "reserves for all" would not change much. However, in reality these *incentives would change*.

THE DISCUSSION IS STILL AT AN EARLY STAGE AND MANY ISSUES ARE STILL OPEN AND CONTROVERSIAL

The conference concluded with an *extended, free, highly explorative discussion* among all conference participants. This discussion highlighted the key controversies around CBDC. It was seriously doubted that a CBDC could ultimately guarantee anonymity, even if this were included in its design. It became obvious that the value attached to privacy of the individual versus state power was maybe THE central distinguishing feature between advocates and adversaries of CBDC. The issue of robustness to cyber-attacks, electric outages and natural catastrophes was highlighted as a weakness, and the solutions offered ranged from ensuring that a CBDC would have to be designed in a way to also operate without the internet, at least for a while, to the recommendation that the central bank should for contingencies always hold a stock of paper cash. Various important legal obstacles were highlighted, including the question whether it would actually be for the central bank or the government itself to issue CBDC.

The highly focused conference topic as well as the ample room for informal discussion particularly in the last session were highly appreciated by conference

participants. This approach ensured that the conference indeed increased all participants' insight and reflection on the topic. SUERF thanks all speakers and participants for their engagement in this open yet constructive dialogue. SUERF particularly appreciates the long-standing and regular co-operation with the BAFFI CAREFIN Centre at Bocconi University and is grateful for generous sponsoring by Intesa Sanpaolo Bank.

2. 21ST CENTURY CASH: CENTRAL BANKING, TECHNOLOGICAL INNOVATION AND DIGITAL CURRENCIES

*Fabio Panetta*¹

2.1. INTRODUCTION²

It is a great pleasure to be here. The topic of this conference speaks to the heart of some of the most challenging questions for central banks today: how is the digital revolution affecting the financial system? What is the impact on consumers, the economy and on central banks themselves? These are complex questions, related to the consequences of the fourth industrial revolution in our society,³ within which central bank digital currencies (CBDC in short) might one day play an important part.

I will not attempt to provide comprehensive answers to all of these questions. Rather, I will focus on some general issues related to the digital transformation of our society, the pros and cons of digital cash (as a means of payment and store of value) and, before concluding, recall some of the open issues regarding CBDCs.

2.2. THE DIGITAL TRANSFORMATION OF SOCIETY

Technological progress is fostering the digital representation of many of our daily activities. For example, the use of physical letters and postcards has been dwarfed by emails and digital photos, with the estimated number of letter-like items sent worldwide *in one year* roughly equal to the number of emails sent *in a single day*.⁴ Instant messaging apps such as QQ and WhatsApp allow their estimated three billion users to have digital conversations across the globe.⁵ The process of digitization reflects increasing demand for immediacy by individuals, and is transforming our behaviour, our culture and the structure of the economy.

¹ Deputy Governor of the Bank of Italy.

² I wish to thank Nicola Branzoli and Marcello Miccoli for their valuable help during the preparation of this speech.

³ See Schwab K. *The Fourth Industrial Revolution*, New York: Crown Publishing Group, (2017) and Gordon R. (2012), 'Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds', NBER, Working Paper 18315, August 2012.

⁴ Source: based on data from Universal Postal Union and Radicati Group.

⁵ Source: Radicati Group.

Digitization has also been prominent in the financial system. For example, the dematerialization of financial assets has been instrumental in the emergence of electronic trading platforms. Online banking, the digital representation of brick-and-mortar bank branches, has gained in popularity since its introduction in the 1990s. The advent of digitization is particularly evident in the payment system. Until not long ago retail payments could only be made with cash or cheques. But these days who uses cheques anymore? Digital innovation in payments has gone even further, with payment tools available directly through an app on a smartphone or even by simply using a smartwatch.

The issuance of CBDCs – a digital version of cash – could accordingly be seen as a natural consequence of the broader process of digitization of the financial system. In a world where securities and contracts are dematerialized and traded electronically, where payments are made with smartphones and investment advice is provided by computers, why should cash be only physical? Is the central bank missing out on the benefits of innovation by not issuing a CBDC?

Crypto-assets (or virtual currencies as they were called before it was realized that they cannot perform the functions of money) are sometimes associated with digital currency. Let me emphasize, though it is redundant for this audience, that CBDCs have nothing to do with crypto-assets such as Bitcoin. In fact – just like banknotes – a CBDC would be a liability of the central bank and would be backed by its assets. It would be supported by the credibility of the central bank and, ultimately, by the rule of law. Crypto-assets, on the other hand, are a liability belonging to nobody: there is no asset that backs them up and no clear governance structure that can guarantee trust. For these reasons, the value of a CBDC would not suffer from the excessive volatility that affects crypto-assets.

2.3. THE PROS AND CONS OF DIGITAL CASH

But let's go back to the main question of today's conference: should central banks issue a digital currency? One way to address this issue is from the perspective of an agent (the central bank) in charge of supplying cash on behalf of the State, with the ultimate goal of maximizing social welfare. In this respect it is important to distinguish between the possible role of the digital currency as a means of payment and as a store of value.⁶

⁶ These are two of the three functions of money. The third one, money as a unit of account, is not relevant here, since a digital currency issued by the central banks would be denominated in the same unit as existing banknotes.

2.3.1. CBDCs as a means of payment

As a means of payment, a CBDC would add to the available digital payment services, thus increasing the degree of competition in this sector. But the set of tools that permit almost frictionless and instantaneous payments is already large: today we can make a digital payment by wire transfer (through online banking), with credit or debit cards, using Paypal or Apple pay (to name just a few); we can do it via computers, smartphones or smartwatches, by simply putting our wrist close to a point of sale. Competition in the supply of payment services is already high, and the efficiency of the system will increase with the introduction in many jurisdictions of instant payments – yet another alternative to cash.⁷ From this vantage point the advantages of a CBDC are at best unclear: its potential benefits in terms of improving the ease of transactions are probably insufficient to justify the involvement of central banks in an activity that is well served by private suppliers.

A CBDC could nonetheless improve access to digital payments for specific groups of consumers. In fact, some consumers do not have a bank account – a precondition for using existing digital payment tools. A CBDC could offer them access to these tools at minimum or zero cost. In the United States, the United Kingdom, France and Spain, to name a few high-income countries where one might easily think that financial inclusion is almost universal, the share of the population without a bank account is between 4 and 7 per cent.⁸

In Italy the proportion of unbanked households is similar (7 per cent, or 1.8 million households).⁹ Survey evidence suggests that account maintenance costs and physical distance from a bank are among the reasons for not having a bank account. However, a closer look at the socio-demographic characteristics of unbanked consumers shows that they have low income but also low education: 90 per cent of the unbanked households are in the bottom half of the income distribution and have little or no formal education. To the extent that consumers have no access to bank accounts – and thus to digital payment tools – for reasons other than cost, the introduction of a CBDC would not improve the situation. Again, at this stage the available evidence is at best insufficient to justify introducing a CBDC, in spite of the importance of the goal of improving financial inclusion.¹⁰

⁷ Instant payments (IPs) allow consumers to transfer funds in almost real time. The Eurosystem entered into IPs with the TIPS project, which will offer settlement facilities in central bank money to IPs schemes starting from November 2018. The extent to which IPs will succeed as substitutes for cash is an open question. The experience of the countries where IPs were first introduced is mixed. For example in the UK, where IPs were introduced ten years ago, the average value of IPs is £800, more than an ordinary cash payment and similar to a traditional credit transfer.

⁸ Demirgüç, A., Klapper, L., Singer, D., Ansar, S., and Hess, J. *The global Findex database 2017: Measuring Financial Inclusion and the FinTech revolution*, World Bank Group, 2018.

⁹ Source: Survey on Household Income and Wealth, Banca d'Italia.

¹⁰ Here I ignore the fact that it is disputable, likely suboptimal and undesirable to assign the goal of improving financial inclusion to central banks.

The introduction of a digital means of payment could be justified by the objective of reducing the cost of cash i.e. outlays for its production, transportation, disposal, etc. Recent estimates suggest that these costs amount to about half of a percentage point of GDP in the European Union every year,¹¹ or to around €76 billion. By way of comparison, this figure amounts to almost half of the annual EU budget. These estimates are a lower bound of the actual costs, since they do not include households' costs, such as the time it takes to obtain banknotes (shoe-leather costs), which are difficult to estimate. However, they are shrouded in uncertainty; moreover, central banks, commercial banks and all those who handle cash are constantly striving to improve efficiency.

Would the cost of providing a CBDC be lower than that of cash? The costs of managing cash are due to its physical nature and in a digital world they would disappear. Non-monetary costs, such as households' shoe-leather costs of finding a cash provider, would also disappear if cash were accessible via the smartphone in our pocket. Hardware and software costs would, instead, increase. However, digital technology already plays a crucial role in the financial sector. It is used to transfer commercial bank money, to buy and sell securities, and to process information. It is continuously tested and updated and protected against risks, first and foremost cyber risk. The technology needed to transfer digital cash would likely have strong complementarities with the existing digital networks and infrastructure. This suggests that the overall costs of providing a means of payment may well decrease with the introduction of a CBDC. The potential efficiency gains promised by new technological solutions such as Distributed Ledger Technology (DLT), though still unclear, could also help lower the cost of managing CBDCs.

2.3.2. CBDCs as a store of value

Another important function of money is as a store of value. The cost of storing cash, a key factor in its use as a store of value, has been estimated at between 0.5 and 1 per cent of the value stored.¹² Since it would be completely dematerialized, a CBDC would have very few or no storage costs and would be a convenient way for households and firms to keep liquid wealth. Mattresses could be freed from their role of vaults!

In addition to being superior to cash as a store of value, a CBDC would be an asset with unique characteristics, free of credit and liquidity risk. It might be

¹¹ Schmiedel, H., Kostova, G., and Ruttenberg, W. 'The social and private costs of retail payment instruments: a European perspective', European Central Bank Occasional Paper 137, 2017.

¹² See, for instance, Witmer, J. and Yang, J. "Estimating Canada's Effective Lower Bound", *Bank of Canada Review*, Spring 2016 or "Banks look for cheap way to store cash piles as rates go negative", *Financial Times*, August 16, 2016.

preferred to other instruments commonly used to store wealth, such as bank deposits. The consequences of this have caused concerns: a switch from bank deposits to a CBDC could lead to a funding shortfall in the banking system, with potential adverse effects on the supply and cost of lending to the real economy. In extreme conditions the availability of a CBDC could even increase the risk of a digital bank run. The potential consequences of having a large portion of wealth structurally transferred from bank deposits into a CBDC could be significant for our financial system. Currently in the euro area overnight deposits of non-financial private entities amount to around €6.5 trillion, 20 per cent of the balance sheet of the banking system.

I am not convinced, however, that the effects would necessarily be disruptive for banks. First, only some categories of deposits might migrate to the central bank (most likely sight deposits, that pay little or no interest). Second, banks can compete by offering services that CBDCs cannot, such as access to credit and payment services. Third, banks could increase their recourse to wholesale funding.

But banks' business model would be affected. The decrease in callable liabilities could ultimately push towards a 'narrow' banking system,¹³ that is an operational framework in which banks have little or no maturity mismatch between assets and liabilities. The debate about the benefits of narrow banking goes back centuries,¹⁴ with no easy answer; economists will likely have to examine the issue anew.

The magnitude of these effects will depend on the demand for CBDCs by the public, which in turn will vary according to the currency's specific, yet still uncertain, characteristics – such as whether it would be remunerated or whether it would be account based or token based.

2.3.3. Balancing the risks and benefits

The risks and benefits of CBDCs are two sides of the same (digital) coin, related to the role of money as a means of payment and a store of value. Recourse to a CBDC as a means of payment may well have benefits, but their precise nature is uncertain and they may still be too small to justify the introduction of a digital currency. Moreover, the issuance of a CBDC may become less positive on balance if we take into account the potential effects on the demand for commercial bank

¹³ See Broadbent, B. "Central banks and digital currencies", speech at the London School of Economics, March 2016.

¹⁴ See Pennacchi, G. (2012), 'Narrow Banking', *Annual Review of Financial Economics*, vol. 4, issue 1, pp. 141-159.

deposits. The risks and benefits would be affected by the characteristics of the CBDC, but in any event the risks would not disappear altogether.

The business case for introducing CBDCs remains at best unclear. However, like all issues related to technological innovation, the costs, benefits and risks of digital currencies are likely to change rapidly in the future. This suggests that central banks should continue to examine the potential effects of digital currencies. Indeed, many of them are currently engaged in research and technical experimentation with a CBDC. The Riksbank, Bank of England, and Bank of Canada, to name a few, are actively analyzing the issue. Some have gone even further, such as the Central Bank of Uruguay, which has launched a pilot project.¹⁵ At Banca d'Italia, we are also studying how a CBDC would impact our financial system and monetary policy, and we are working within the Eurosystem on trials using DLT, which might prove useful for a digital currency. Researchers are also actively reflecting on CBDCs. Today's conference is a notable example.

2.4. SOME OPEN ISSUES

As mentioned above, the risks and benefits of CBDCs, together with their impact on the financial system, the real economy and on society, closely depend on their characteristics.¹⁶

Probably the most important issue is whether the digital currency should be traceable or whether it should be designed to guarantee, to the extent possible, anonymity. Cash has always been an incredible instrument: it allows for third-party anonymity in transactions and leaves no trace. While this implies that it is an effective means of payment for illicit activities such as money laundering, the financing of terrorism or tax evasion, it also ensures privacy for its users.

The possibility of tracing our digital transactions may have important economic and ethical implications. Imagine for a moment that payments data suggested that spending on alcohol and the probability of defaulting on a loan are positively correlated. Based on such evidence, a bank might decide to reject a loan demand by an applicant with high expenditure on alcohol, even though the correlation does not reflect any *ex-ante* causal relationship between these two variables but could be simply due, for example, to an *ex-post* common psychological factor.¹⁷ Though it may be over simplified, this example emphasizes that we need to

¹⁵ The Danmarks Nationalbank is sceptical about whether the benefits of a CBDC can really prevail over its costs. See Gürtler, S., and Rasmussen, S. *Central bank digital currency in Denmark?*, December 2017.

¹⁶ See Bank for International Settlements, "Central bank digital currencies", March 2018.

¹⁷ The introduction of the General Data Protection Regulation might limit the application of profiling but does not make it illegal (see https://ec.europa.eu/info/law/law-topic/data-protection/reform/rights-citizens/my-rights/can-i-be-subject-automated-individual-decision-making-including-profiling_en).

address carefully the privacy issues that may stem from digitization, and in particular from the introduction of a CBDC. Today these risks are still limited, as in most countries retail transactions are concluded mainly with cash, and the record of our electronic payments represents an imprecise screening device.¹⁸ This is changing rapidly, however.

Just who should decide on the degree of anonymity associated with the use of a CBDC? Clearly, this is more than just a technical issue, and as such, the choice does not belong to central banks alone but also to the political sphere. We need to think carefully, right now, about how to make the introduction of a CBDC fully compatible with the rights of individuals and about how to square the increasing availability of information on the private lives of each one of us in relation to our political views, state of health, or sexual orientation, with the protection of our personal freedom and with the rules that govern the functioning of a modern liberal democracy.

Another key issue is whether a CBDC should be remunerated or, as in the case of cash, should pay no interest. This choice would have far-reaching consequences for the core activities of the central bank, from financial stability to monetary policy, but they would also affect other issues, such as the volume and allocation of seigniorage.

For example, interest payments would make a CBDC a closer substitute of bank deposits.¹⁹ This would increase the volatility of deposits and, in extreme conditions, could even facilitate a digital bank run (whose probability is increased by the very existence of a CBDC): in bad times, depositors could switch rapidly and at no cost from their bank account to the CBDC. The central bank could limit such risks – for example by setting a ceiling on the amount of CBDC that each individual investor can hold, or by bringing the remuneration to zero for holdings of CBDCs above a certain threshold – but this would raise a number of technical issues.²⁰ At the same time, an interest-earning CBDC would reinforce the transmission of monetary impulses to banks, households and businesses.²¹ In downturns, by lowering the remuneration of the digital currency the central bank could spur banks to reduce deposit rates; it could push them below zero (assuming that cash would no longer be available), improving its capacity to stimulate the economy in extreme conditions without necessarily resorting to

¹⁸ For example, in the EU cash payments represent 65 per cent of total retail transactions. See Schmiedel, H., Kostova, G. and Ruttenberg, W. “The social and private costs of retail payment instruments: a European perspective”, *European Central Bank Occasional Paper*, no. 137, 2017.

¹⁹ On the contrary, a CBDC without interest would be comparable to cash.

²⁰ For example, a ceiling on individual holdings of CBDC could limit the number or size of payments, as the recipients’ holdings of CBDC would have to be known in order to finalize the payment. See Gürtler, S., and Rasmussen, S. *Central bank digital currency in Denmark?*, December 2017.

²¹ See Bank for International Settlements, “Central bank digital currencies”, March 2018, and Coeuré, B. “The future of central bank money”, speech at the International Center for Monetary and Banking Studies, Geneva, May 2018.

unconventional measures.²² A symmetrical mechanism would be at work in upturns, when an increase in the remuneration of the CBDC (which would represent the floor of market rates) would force banks to take swift action to also increase the remuneration of their deposits.

A shift from interest-free cash to an interest-bearing CBDC would affect seigniorage in multiple ways: in addition to the direct effect on interest payments by the central bank (which would have a negative impact on seigniorage), it would have indirect effects by reducing the costs of supplying cash (positive impact) and by increasing the demand for central bank liabilities (positive impact). The overall effect is ambiguous, but it could be non-negligible and have non-trivial distributional consequences: central bank profits, transferred to the State and used as the State sees fit, could change significantly once currency holders are remunerated. The political economy consequences of this should not be underestimated.

Turning now to the specifics of CBDC implementation, central banks should decide whether CBDCs should be token-based – whereby each token represents a particular denomination of the currency, like banknotes – or, like bank deposits, account-based, whereby holdings are accounting records. Again, this choice would have important consequences for a number of key issues such as anonymity (a token-based CBDC would imply a better protection of privacy)²³ or the organization of the central bank. In particular, managing an account-based system with millions of account balances, each potentially changing every day, would require an incredible effort by the central bank. The implementation of a token-based system, instead, would be easier and could be delegated to a private party. In both cases the security and resilience of the CBDC to cyber-attacks must be assured, in order to preserve trust in the currency. Digital hacking of the currency can reap very large rewards, in all likelihood larger than counterfeiting banknotes – the recent attack on the central bank of Bangladesh comes to mind.²⁴ Undoubtedly hackers everywhere are dreaming about how to violate the digital currency system!

The number of questions related to CBDCs is enormous and the public debate about them is only in its infancy. I cannot address all the issues today. But I do wish to emphasize one last point before concluding my remarks. If central banks decided to make an asset – the CBDC – free of credit and liquidity risk, possibly

²² If central banks pushed interest rates into negative territory in a world with a non-remunerated CBDC, banks would effectively avoid the negative rates by substituting reserves with digital currency. Banks could adopt this same strategy in a world with physical cash, but the high cost of storing it makes this option less attractive, inducing banks to accept moderately negative interest rates.

²³ See for example Mersch, Y. “Digital Base Money: an assessment from the ECB’s perspective”, speech at Suomen Pankki, January 2017.

²⁴ For instance, a malware installed on the Bangladesh central bank’s computer successfully diverted around \$80 million from its accounts.

remunerated, and available to anybody at no cost, their role in the economy would fundamentally change. The size of their balance sheets would likely increase, and with it their footprint in the economy. If the CBDC were account-based, central banks would start to interact directly with the private non-financial sector. Are central banks ready to play this new role and to deal with the attendant complexities? In the short term my answer is no. Beyond the short term, greater investment in new technologies and human capital would be necessary to address the challenges associated with issuing a CBDC.

2.5. CONCLUSIONS

The technological revolution is pushing us towards a digital representation of many objects in our daily lives. Banknotes might be next in line. However, there are still many uncertainties on that front. Some of them are economic in nature, such as the efficiency of the payment system and financial stability. Others are related to individual rights, such as the right to privacy.

Society as a whole would do well to decide on how to tackle the latter before the central bank steps in. Other issues, which I have not had time to touch on today, but are no less important, are of a legal nature. Can a central bank issue a new form of currency without explicit authorization by the government? If the CBDC is legal tender, does this mean that everybody will need to have the technical means to accept it? In many countries new laws may be required before any concrete steps towards a CBDC are taken. For a central bank, issuing a digital currency is like travelling in a new land: the path to take will be chosen at the same time as the map is drawn. The many uncertainties involved will undoubtedly make the journey exciting and full of discoveries, though a substantial amount of prudence and wisdom will still be required. All in all, this is hardly going to be a purely technical decision. Society as a whole, through its political bodies, will need to be involved.

Whether central banks should issue digital currencies – and with what characteristics – remains an open question and I look forward to hearing the views that will be presented today. I remain convinced that physical cash will continue for quite some time to be part of the payment system. It is hard to dispute that money is probably one of the most important and useful social constructs, one that has been with us for around 3,000 years²⁵ and is still very much in use. Cash is by far the dominant means of payment, both in the euro area²⁶ and

²⁵ See, for instance, Robert A. Mundell, 'The birth of coinage', Columbia University, mimeo, 2002.

²⁶ Esselink Henk and Lola Hernández (2017), 'The use of cash by households in the euro area,' ECB Occasional Paper series 201/2017. Available at <http://www.ecb.europa.eu/pub/pdf/scpops/ecb.op201.en.pdf>.

elsewhere,²⁷ and demand for it has been on the rise in most advanced economies in the last decade. Currency in circulation in the euro area amounts to around €1.1 trillion, and has recorded steady growth rates in recent years. Coins and banknotes have proven to be a resilient technology, it may be too early to call for their complete retirement.

While the jury is still out on whether we will have a CBDC, the debate is already bringing benefits. Many central banks, including Banca d'Italia, are experimenting with new technologies such as DLT and Artificial Intelligence, studying how they work and how they can be put to productive use. This research contributes to the advancement of the technological frontier, and helps make the financial system more resilient to technological and cyber risks. These benefits are here to stay, independently of whether one day we will live in a world with digital cash.

²⁷ Bech, Morten Linnemann, Umar Faruqi, Frederik Ougaard and Cristina Picillo (2018), 'Payments are a-changin' but cash still rules'. BIS Quarterly Review, March 2018. Available at https://www.bis.org/publ/qtrpdf/r_qt1803g.pdf.

3. BIG NOTE, SMALL NOTE: CENTRAL BANK DIGITAL CURRENCY AND CASH

*Ruth Judson*¹

The question of whether central bank digital currency is needed or desirable raises many additional questions about its potential design and implementation. In this paper, I assume, in line with most central bank statements on this topic, that any central bank digital currency (1) would not be anonymous; (2) would coexist with physical cash. In this context, this paper focuses on large and small denominations separately, in order to assess the potential interaction of cash and a central bank digital currency. I first review the evolution of demand, by denomination group, for U.S. dollars as well as other currencies. I find that large-denomination notes constitute the large majority of notes in circulation in the United States as well as in other countries, cash-intensive (for example, Japan) and cash-light (for example, Sweden). Although precise information on how banknotes are held and used is notoriously scarce, I then review the possible roles that central bank digital currencies might play as substitutes for small and large banknotes. I conclude that, in the near term, it seems unlikely that a central bank digital currency would hold much appeal to many current users of U.S. banknotes.



The question of whether central bank digital currency (CBDC) is needed or desirable raises many additional questions about potential CBDC design and implementation. In this paper, I assume, in line with most central bank statements on this topic, that any central bank digital currency (1) would not be anonymous; (2) would coexist with physical cash.² In this context, I focus in this paper on what we do and do not know about the potential interaction between a potential CBDC and cash, evaluated for large and small denominations separately.³ I first review the evolution of demand, by denomination group, for U.S. dollars as well as other currencies. I find that large-denomination notes constitute a large and growing share of notes in circulation in the United States as well as in other countries, cash-intensive (for example, Japan) and cash-light (for example,

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² It should be noted here that very few central banks are actively pursuing the idea of a CBDC, with Sweden currently in the forefront. The United States in particular is not actively pursuing a CBDC. In a mid-May 2018 speech, Federal Reserve Governor Lael Brainard said, "There is no compelling demonstrated need for a Fed-issued digital currency." (<https://www.federalreserve.gov/newsevents/speech/brainard20180515a.htm>)

³ There are, of course, many other potential interactions to consider, such as the potential impacts of CBDCs on bank deposits and existing electronic payments systems.

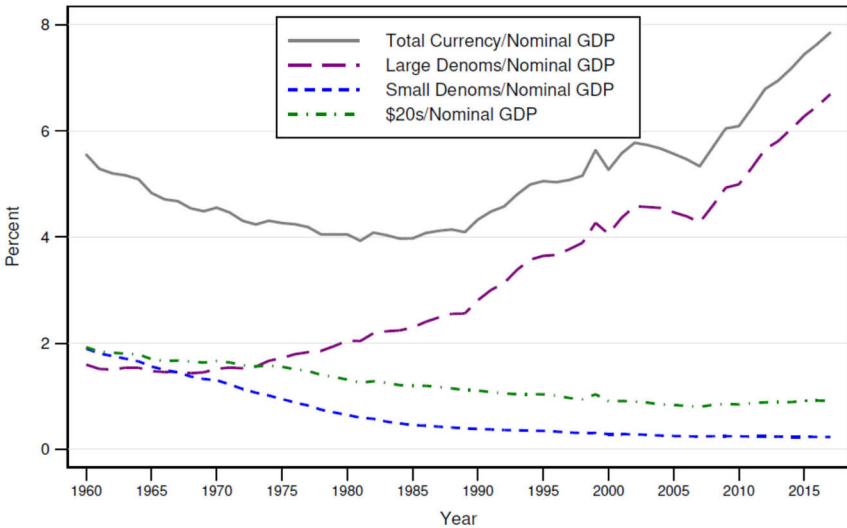
Sweden). In contrast, demand for smaller-denomination notes is in general stable or declining. Although precise information on how banknotes are held and used is notoriously scarce, I then review the possible roles that central bank digital currencies might play as substitutes for small and large banknotes. I conclude that, for now, it seems unlikely that a central bank digital currency would hold much appeal to many current users of banknotes.

3.1. THE EVOLUTION OF DEMAND FOR U.S. CURRENCY

3.1.1. Data: Levels

Figure 1 displays the evolution of demand for U.S. currency relative to nominal GDP, overall and for three denomination groups, since 1960. Two features of the data stand out. First, demand has not shown a uniform trend: the overall ratio was declining steadily from 1960 until the mid-1980s, and was also on a downward trajectory from about 2000 until late 2008. Second, the increase in demand is entirely driven by large denominations – \$50s and \$100s – with demand for \$20s (green) and smaller denominations (blue) generally declining over time.

Figure 1: U.S. Currency to Nominal GDP Ratios, 1960-2017



These differences in the demand patterns for large and small denominations reflect many forces, but a prominent force faced by the United States is foreign demand for its banknotes. As noted in some of my earlier work (Judson (2012);

Banegas et al. (2015); Judson (2017)), increases in demand for the larger denominations generally coincide with crisis conditions in countries that use dollars heavily as a second currency and are attributable to demand from those countries, where U.S. \$100 notes are a popular vehicle for savings and transactions when other assets are inferior in stability and liquidity. In particular, demand increased in the 1990s as Argentina and the countries of the former Soviet Union faced political and economic instability. As these countries stabilized over the early 2000s (and as the cash euro was introduced), demand for large U.S. denominations trended down.

As seen more clearly in Figure 2, this downward trend ended abruptly in late September 2008 and was dominated by \$100s. Prior to September, the 2008 data (red lines) were in line with the 2000-2007 path, but since that date, overall demand and demand for \$100s has followed earlier patterns more like the 1990s.⁴ It is notable that this sharp increase was seen primarily in \$100s: demand for \$20s and for smaller denominations did not immediately change in 2008. The significance and dominance of foreign demand is a complicating factor faced by few other currencies when considering prospects for cryptocurrency demand and design, to which I will return later.

Still, foreign demand does not account for all demand for large-denomination U.S. currency: the estimates in Judson (2016) indicate that about 70% of \$100s could be held abroad, with the rest held at home. These holdings are significant: as of the end of 2017, of the \$1.571 trillion in U.S. currency in circulation, \$1.252 trillion (80 percent) was in \$100s and another \$86 billion was in \$50s.⁵ Assuming that 70 percent of \$100s are abroad would imply that 30 percent--\$375 billion--are held by U.S. residents, an average of over \$1,000 per person. This figure is considerably below that found in surveys of consumer payments, such as Greene et al. (2014).

Figure 3, similar to Figure 1, displays currency to GDP ratios by denomination group, but with the large denominations divided into estimated foreign (gray) and domestic (blue) components, and only since 1987.⁶ Based on these estimates, U.S. domestic currency demand has generally fallen over time, but remain substantial: for 2017, these figures indicate that domestic per capita holdings currency were around \$1,250 for \$100s and \$50s combined, \$550 for \$20s, and \$140 for smaller denominations.

⁴ Indeed, a variant of this chart that shows weekly data for total currency in circulation shows that the 2008 upturn occurred in the last two weeks of September 2008.

⁵ These figures are published quarterly in the Treasury Bulletin: <https://www.fiscal.treasury.gov/fsreports/rpt/treasBulletin/current.htm>.

⁶ As noted in my other work, there are many ways to estimate the share or volume of U.S. currency held abroad, and no single method is definitive. This chart takes as the foreign component the “Adjusted shipments” estimate of Judson (2012) and assumes that all of the estimated foreign holdings are in the form of \$50s and \$100s. The estimated domestic component is then calculated as (total \$50s and \$100s in circulation) – (adjusted shipments).

Figure 2: Annual Cumulative Increases in U.S. Currency in Circulation

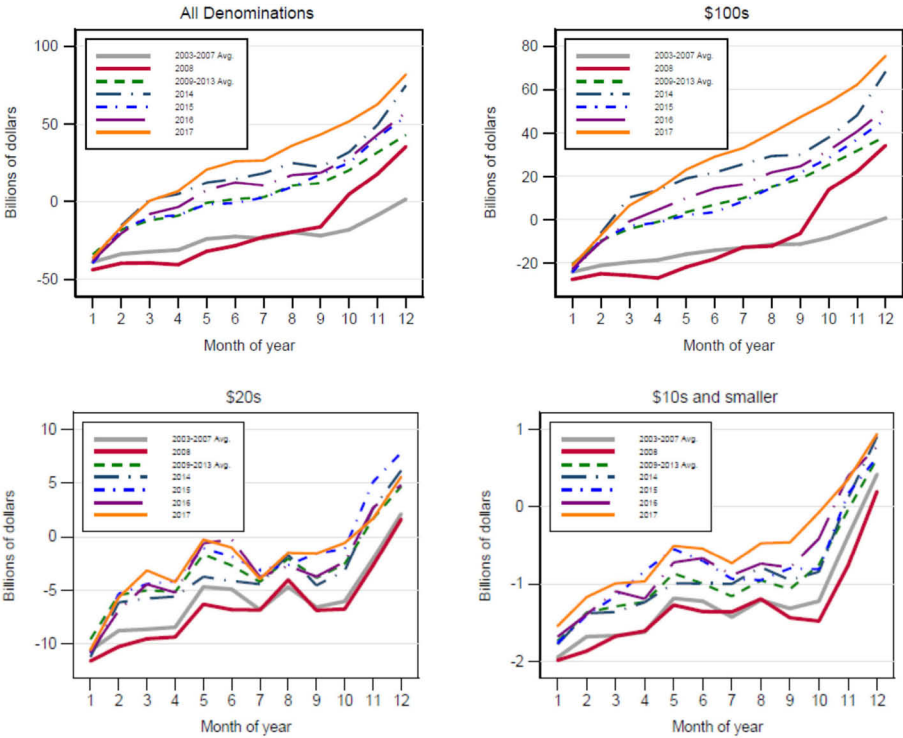
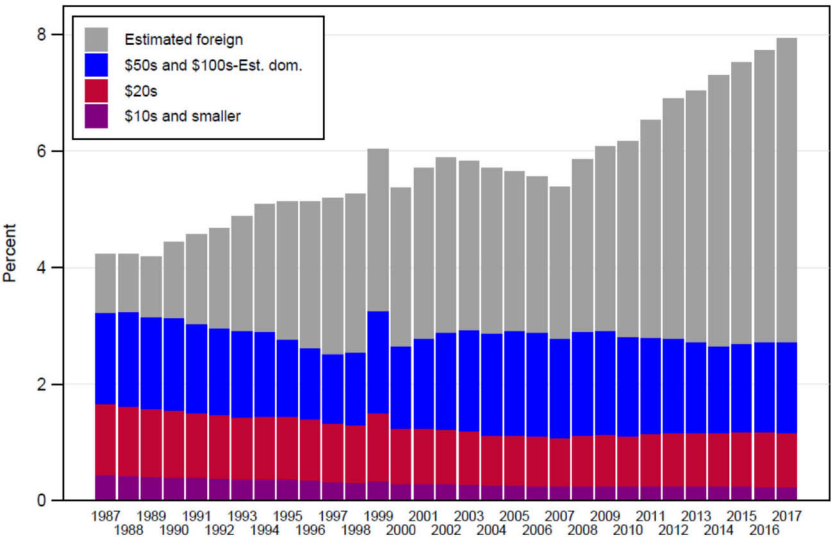


Figure 3: Currency in Circulation / GDP by Denomination, 1987-2017

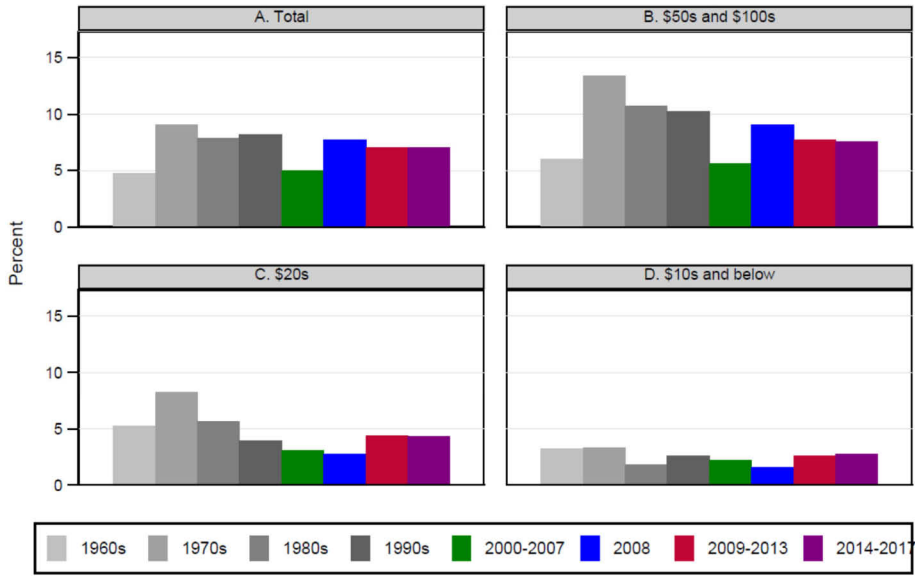


Source: U.S. Treasury and Department of Commerce

3.1.2. Demand for U.S. Currency: Growth rates

Reviewing the evolution of U.S. currency demand in level terms is helpful for illuminating patterns related to shifts for large denominations, but trends in smaller denominations are less obvious in these terms, and so Figure 4 displays average annual growth rates by denomination group since the 1960s. The gray bars show averages for decades and the colored bars show more recent years. The slowdown in 2000-2007 (green) is pronounced overall and for \$100s. For smaller denominations, a slowdown over 2000-2007 is also evident, but growth fell further in 2008 (blue).

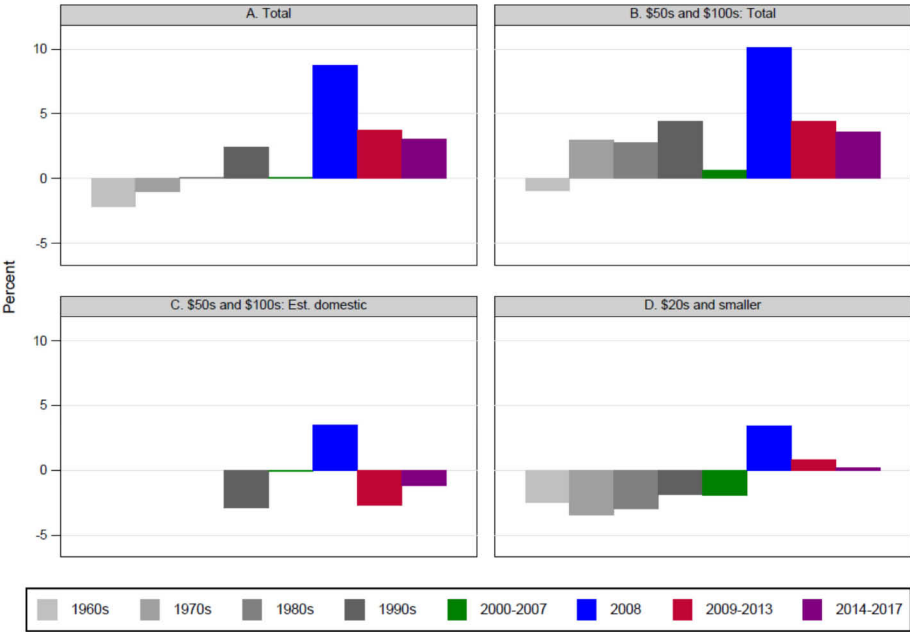
Figure 4: Average Annual Growth Rates for Currency in Circulation by Denomination



One interpretation of these movements is that the crisis of 2008 stimulated demand for \$100s as a store of value for foreign and possibly also domestic users, but that demand for smaller denominations fell along with consumption. In the years since 2008, demand for large denominations – dominated by foreign demand – has remained strong while demand for smaller denominations has risen some but remains near or below nominal GDP growth, consistent with the trends in Figure 1.

Figure 4B shows the same data as Figure 4, but scaled by GDP growth and including a panel for the estimated domestic component of large denominations. As usual, 2008 is an outlier, with exceptionally strong currency growth.

Figure 4B: Average Annual Growth in Currency in Circulation / GDP by Denomination



Source: U.S. Treasury and Department of Commerce and author's estimates

Notably, this view of the data shows strong growth in domestic demand for all denominations in 2008. This view of the data also shows that the decline in domestic demand has been slowing and, for small denominations, growth relative to GDP has been slightly positive in the past several years, a reversal of earlier trends.

3.1.3. Regressions

Of course, demand for currency – like demand for money overall – is thought to be a function not only of income, but also of the opportunity cost of holding cash, typically proxied by a short-term Treasury rate.

Table 1: Currency demand regressions by denomination group

OLS Currency model by denomination group, 1988-2017. Dependent variable is log difference CIC, SA.

	Curr comp	All	100	Big	20	Sml20	Sml
Trend	-0.830* (-3.4)	-0.990* (-2.6)	-2.129* (-5.9)	-1.840* (-5.2)	-0.055 (-0.1)	-0.018 (-0.0)	-0.006 (-0.0)
D.T-bill rate	0.184 (1.5)	0.274 (1.5)	0.253 (1.5)	0.255 (1.5)	0.298 (0.9)	0.260 (0.9)	0.132 (0.7)
Nominal GDP, log difference	-0.128 (-1.4)	-0.296* (-2.1)	-0.272* (-2.1)	-0.284* (-2.2)	-0.345 (-1.4)	-0.278 (-1.3)	-0.050 (-0.4)
Adjusted net shipments	66.398* (10.8)	61.511* (6.5)	86.943* (9.7)	77.128* (8.7)	19.687 (1.2)	17.976 (1.2)	12.130 (1.3)
Constant	5.332* (4.0)	6.383* (3.1)	12.348* (6.4)	10.844* (5.6)	1.378 (0.4)	1.062 (0.3)	0.575 (0.3)
Observations	120	120	120	120	120	120	120
R ²	0.58	0.37	0.58	0.53	0.05	0.04	0.02
Adjusted R ²	0.56	0.35	0.57	0.51	0.01	0.01	-0.01

t statistics in parentheses

+ $p < 0.10$, * $p < 0.05$

Table 1 presents some very simple regressions that examine currency demand by denomination group.⁷ In these regressions, I regress seasonally-adjusted currency demand on a trend, the change in the 3-month T-bill rate, the growth rate of GDP, a proxy for foreign demand (adjusted net shipments), and a constant.⁸ The results for total currency and for large denominations indicate no relationship with interest rates, a negative trend overall, a negative correlation with nominal GDP growth, a strong positive correlation with foreign demand, and a sizable R². The negative trend term is the most interesting: it indicates that, after accounting for foreign demand as best we can, there is a downward trend in currency demand overall and for large denominations. For smaller denominations, this specification has no explanatory power, suggesting that other factors – perhaps including use of noncash payments – drive demand for smaller denominations.

3.1.4. Summary: U.S. Currency Demand

In sum, the recent data suggest several trends and factors to keep in mind when evaluating the interaction of cash and central bank digital currencies. First, at least for the United States, foreign demand for large banknotes is a substantial

⁷ There is, of course, a vast literature on the estimation of money demand, typically focused on broader aggregates such as M2.

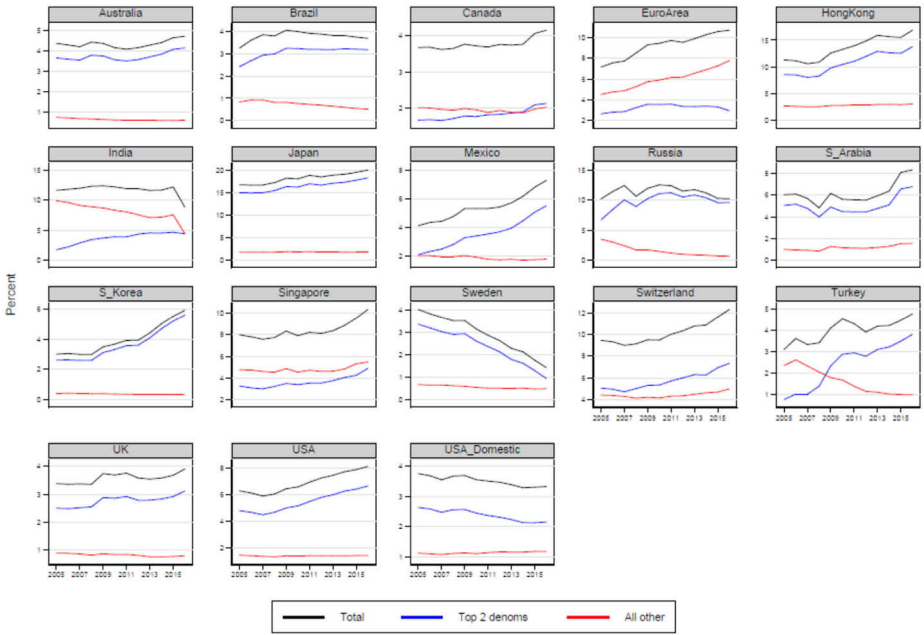
⁸ The seasonal adjustment first-stage regression also includes dummies for the quarters in late 1999 and early 2000, a period when currency in circulation spiked and then dropped back as banks stockpiled vault cash and then returned these stockpiles to the Federal Reserve. The aggregate typically used in money demand analysis, the currency component of the money stock, excludes banks' vault cash and does not show these swings. However, data on the currency component is not available by denomination. Adjusted net shipments are total net banknote shipments from the Federal Reserve Bank of New York adjusted as in Judson (2012) for shipments to selected countries that likely receive significant quantities of banknotes through nonbank channels such as tourism and remittances.

element that must be considered carefully. Second, U.S. domestic demand for large denominations is also large and poorly explained, but the estimates shown here indicate a general downward trend. Third, demand for smaller denominations has been trending down relative to nominal GDP but does not appear to be correlated with standard macro variables.

3.2. PATTERNS OF CURRENCY DEMAND IN OTHER COUNTRIES

While the strong external demand for U.S. dollars is a feature shared by few other currencies (most notably the euro), other features of U.S. currency demand are shared by other countries.⁹ Figure 5 displays the ratio of currency in circulation to GDP for 18 countries and for estimated US domestic holdings only, the black lines. The blue and red lines show the same ratio for the largest two denominations and for all remaining denominations respectively.

Figure 5: CIC / GDP Total and by Denomination Group



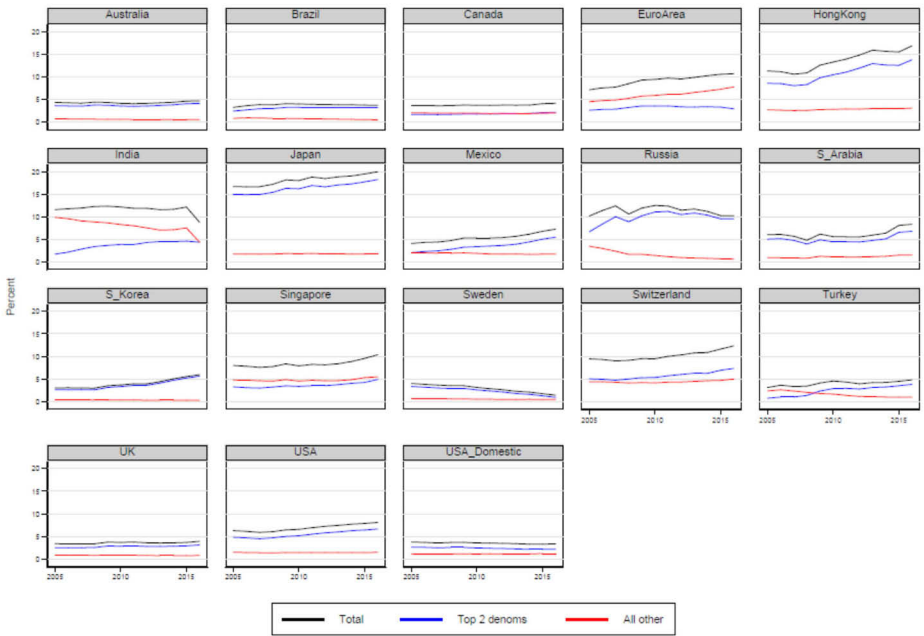
Source: BIS

⁹ See European Central Bank (2017).

3.2.1. Currency in circulation levels

These data raise more questions than answers, but a few patterns emerge. First, most countries have seen their currency in circulation as a ratio of GDP increase over the past 12 years even as noncash payment systems and options have become increasingly available: the only exceptions are Russia, India, and Sweden.¹⁰ In addition, the largest denominations seem to be dominant and to be driving growth in most countries shown.

Figure 6: CIC / GDP Total and by Denomination Group (Unified Scale)

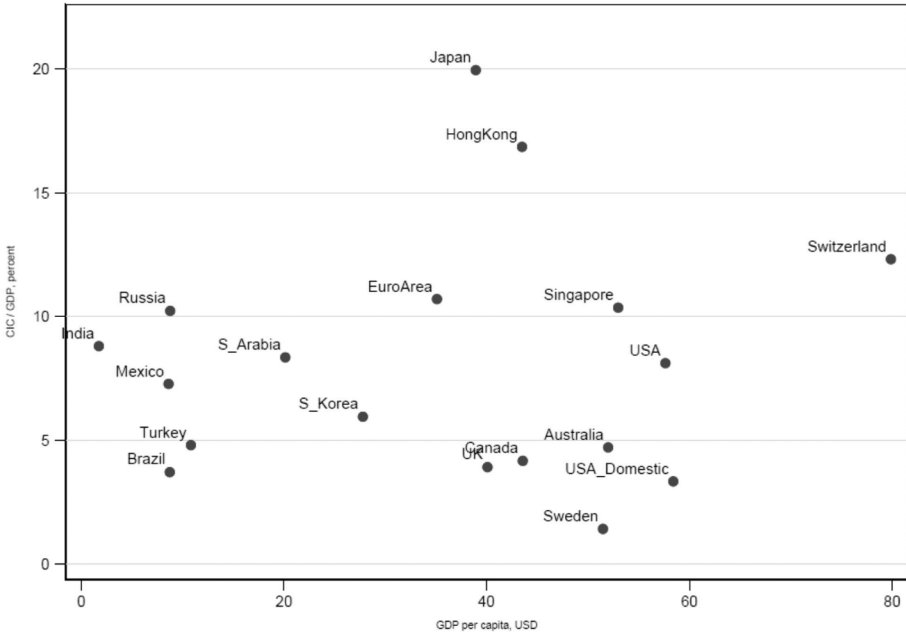


Source: BIS

Figure 6 shows the same data, but with the same scale for every country, to illustrate a third point: currency holdings relative to GDP vary enormously across countries, from a low of 2% for Sweden to a high of 20% for Japan; as shown in Figure 7, these positions do not appear to be correlated with income. As has been noted above for the case of the United States, evidence and robust information about why and how cash is used – especially the larger denominations – is scarce.

¹⁰ India's sharp decline in 2016 was due to a currency reform late in the year and partial data for 2017 suggest that the 2016 decline has already been reversed.

Figure 7: Currency in circulation as a share of GDP and per-capita GDP, 2016



Source: BIS and author estimates

3.3. CASH AND CENTRAL BANK DIGITAL CURRENCIES

These admittedly basic observations should shape the questions that one could ask about how cash and central bank digital currencies (CBDC) might interact. For the purpose of discussion, currency use can be usefully broken down into three groups: external use, mainly of large denominations; domestic use of large denominations; and domestic use of small denominations.¹¹

Of course, the form of the interaction between cash and any CBDC would also be strongly influenced by the exact characteristics of the CBDC. As outlined in the BIS (2018) overview of central bank digital currencies, main design features are availability, anonymity, transfer mechanism (intermediated or peer-to-peer), presence or absence of interest payments, and transaction size limits. For this discussion, I assume – as noted above – that a CBDC would not be anonymous. For the sake of discussion below, the alternative to cash would be a non-anonymous CBDC that otherwise retains the qualities of cash: availability would be unlimited, transfers would be peer-to-peer, no interest rate would be associated with the CBDC, and transaction size would be unlimited.

¹¹ I assume here that external use of small denominations is generally minimal.

3.3.1. External use

For central banks whose currencies are in wide international use, any consideration of CBDC must address the likelihood that external users would be interested in the corresponding CBDC.¹² As noted above, international demand for U.S. banknotes is strongly correlated with economic and political uncertainty in middle-income countries with a history of dollar use. In such circumstances, dollars function as a safe asset and are used accordingly. There is also evidence that U.S. (and other) large denomination banknotes are used to facilitate illicit transactions. It is fair to say that there is little evidence or consensus on what the relative weights of these two factors in external banknote demand are. Either way, in the context of CBDC, it seems unlikely that these users would consider CBDC a good substitute for banknotes.

3.3.2. Domestic use of large denominations

Domestic use of large-denomination banknotes is nearly as poorly understood as external use. Consumer surveys point to minimal holdings of such notes, and yet holdings are substantial. There are at least three possible explanations for this result. First, consumers without access to bank accounts likely hold and use large denominations and are also likely to be underrepresented in surveys. Second, some consumers prefer to hold and use cash due to privacy concerns or concern about banks. Third, some consumers hold and use cash in gray or black market transactions.¹³ The relative contributions of these factors is unknown, but is critical for considering the likely success or usefulness of a CBDC. In the first case – lack of access – a CBDC could be well-received and welfare-enhancing. In the second case – privacy concerns – CBDC would likely be unwelcome. In the third case – gray or black market transactions – CBDC likewise would be unwelcome to users, but making these transactions more costly might be considered welfare-enhancing overall.

3.3.3. Small denominations

Small denominations are generally a minor part of cash in circulation by value but a major part when measured by handling and production costs not only by the central bank, but throughout the economy.¹⁴ Demand for these notes relative

¹² In addition, a significant CBDC design question would be whether foreign residents would be eligible to hold CBDC.

¹³ Here I use “black market” to refer to transactions which are in themselves illicit – such as illegal narcotics sales or human trafficking. I use “gray market” to refer to cash transactions that are themselves licit, but are unreported and thereby untaxed.

¹⁴ For example, the *number* of \$1s in circulation is about the same as the number of \$100s in circulation. See Judson (2012) for a breakdown of U.S. and Canadian notes in circulation by dollar value and by piece.

to GDP is stable or declining, as one might expect as noncash payment options improve. Users of these notes might well find a CBDC appealing.

3.4. CONCLUDING NOTES

Motivations for considering CBDC range widely but fall into four categories. The first two, mentioned by Rogoff (2016), are that a CBDC that largely supplants currency could remove the zero lower bound on policy interest rate targets and could potentially reduce tax evasion and black market trading. Other motivations include reducing the costs associated with cash handling and increasing financial market inclusion for unbanked consumers.

Regardless of the motive for a CBDC, every potential design must address the interaction that the CBDC would have with cash in order to assess the likelihood of its success in meeting the defined objectives as well as potential side effects. Looking at recent cash demand across several countries and with breakdowns by denomination, I contend that we can make two conclusions. First, for large denominations, far too little is known to be able to assess the potential appeal, costs, and benefits of a CBDC. Second, for small denominations, a CBDC could very well be an appealing and natural evolution.

REFERENCES

- Banegas, Ayelen, Ruth Judson, Charles Sims, and Viktors Stebunovs (2015), “International Dollar Flows,” Board of Governors of the Federal Reserve System International Finance Discussion Paper 1144.
- Bank for International Settlements (2017). *Statistics on payment, clearing and settlement systems in the CPSS countries: Figures for 2016*. <http://www.bis.org/cpmi/publ/d172.pdf>.
- Bank for International Settlements (2018). *Central bank digital currencies*. <https://www.bis.org/cpmi/publ/d174.pdf>.
- European Central Bank (2017). *The International Role of the Euro*. <https://www.ecb.europa.eu/pub/pdf/other/ecb.euro-international-role-201707.pdf>
- Feige, Edgar L. (1996), “Overseas Holdings of U.S. Currency and the Underground Economy,” in Susan Pozo, ed., *Exploring the Underground Economy: Studies of Illegal and Unreported Activity*, Kalamazoo, Mich.: W.E. Upjohn Institute for Employment Research, pp. 5-62.
- Feige, Edgar (2012), “New estimates of U.S. currency abroad, the domestic money supply and the unreported economy,” *Crime, Law and Social Change*, vol. 57:3 (April 2012).

- Greene, Claire, Scott Schuh, and Joanna Stavins (2014), "The 2014 Survey of Consumer Payment Choice," *Federal Reserve Bank of Boston Discussion Paper* 14-1.
- Hellerstein, Rebecca, and William Ryan (2011), "Cash Dollars Abroad," *Federal Reserve Bank of New York Reports*, no. 400. February 2011.
- Judson, Ruth A. (2012), "Crisis and Calm: Demand for U.S. Banknotes From the Fall of the Berlin Wall to 2011," Board of Governors of the Federal Reserve System International Finance Discussion Paper 2012-1058.
- Judson, Ruth A. (2017), "The future of cash in crisis and calm: Demand for U.S. banknotes," War on Cash: Is there a Future for Cash? Deutsche Bundesbank conference volume.
- Rogoff, Kenneth (2016). *The Curse of Cash*. Princeton University Press.
- U.S. Treasury (2006). *The Use and Counterfeiting of U.S. Currency Abroad, Part III*. Washington DC: U.S. Department of the Treasury.

4. CENTRAL BANK DIGITAL CURRENCIES: FEATURES, OPTIONS, PROS AND CONS

Santiago Fernández de Lis¹

4.1. INTRODUCTION

The development of cryptocurrencies in recent years has triggered a debate on whether central banks may attempt to issue cash in digital format. An emerging literature on Central Bank Digital Currencies (CBDCs) tries to analyze the viability of this form of digital issuance, the forms it may adopt and the pros and cons of different modalities. This article, largely based on Gouveia et. al (2017), compares four stylized variants of CBDCs, and assesses their relative merits.

The motivation behind this analysis is based on the observation that the first papers on the topic² directly focused on what looked like the most disruptive variants, combined with the intuition that there were other modalities that may provide a better combination of pros and cons.

It is important to introduce a caveat upfront: cryptocurrencies have been accompanied by Distributed Ledger Technologies (DLTs), the best known of which is blockchain, that allows for a decentralized mechanism for proving the legitimate possession of the currencies and transfer this property. By analogy, the literature on CBDCs generally assumes that they will rely in a modality of DLT. But scalability remains a challenge for DLTs, and the comparison with traditional central bank-based payment systems (Real Time Gross Settlement Systems – RTGS) concludes that the latter are generally more efficient than blockchain-based payment systems, introducing certain doubts on the premises of CBDCs: why would central banks move away from a more to a less efficient system? The implicit assumption in this paper is that DLTs are in their infancy and in the near future we will see dramatic improvements in their efficiency, solving the scalability problem, including in energy consumption.

¹ BBVA Research.

² See for instance Barrdear and Kumhof (2016).

4.2. CBDCs FEATURES AND VARIANTS

Cash is a very special type of asset that combines four features: (i) it is exchanged peer to peer (without knowledge of the issuer), (ii) it is universal (anybody can hold it); (iii) it is anonymous and (iv) it does not yield any interest. CBDC is an alternative to cash that is also peer to peer (P2P), but it opens the possibility of introducing changes in the other three features:

- They can be universal or restricted to a particular set of users. Likewise, DLTs can be open or closed (for instance, limited to banks or financial institutions).
- They can be anonymous (like cash) or identified (like current accounts). The first corresponds to the idea of token-based CBDCs, and the second to account-based CBDCs.
- They can pay interest or not. The delinking of cash from paper-money opens the possibility of including interest-bearing as a feature, either in the account based or in the token based variant.

These options can be combined in several ways to generate different modalities of CBDCs. The choice depends crucially on the objectives pursued with the introduction of CBDCs. There are basically four possible objectives: (i) to improve the working of wholesale payment systems; (ii) to replace cash with a more efficient alternative; (iii) to enhance the instruments available for monetary policy, especially when confronted with the zero lower bound and (iv) to reduce the frequency and cost of banking crises. How do these objectives match with the different options that CBDCs open as compared to cash?

- (i) If the objective is *to improve the functioning of wholesale payment systems*, and assuming that DLT technology would in the future be more efficient than RTGS³, you may introduce CBDCs that are only accessible to banks and other financial institutions that participate in the wholesale payment system. The resulting CBDC would be *restricted, identified and non-interest bearing*: restricted because the general public will not have access to it; identified because participants will be known by the rest; and non-interest bearing because payment systems rely on fixed nominal amount accounts, although they are normally accompanied by yield-bearing (positive or negative) accounts in the central bank to and from which these institutions move funds in the context of their liquidity policy. The central bank, which in traditional RTGS is at the center of the system, would be in this scheme

³ As mentioned before, this is a very strong assumption. At the same time, however, closed DLTs (like the ones needed in option (i)) do not face the scalability problem of open DLTs (like those under options (ii) to (iv)). Although DLTs are less efficient now than RTGS, the distance between both is not huge. This implies that a little improvement in DLTs can offer a suitable alternative to RTGS.

just another player, although it may retain control over certain features of the system, like for instance admission and membership.

- (ii) If the aim is to *replace cash* with a more efficient means of payment you would introduce a CBDC that is *universal, anonymous and non-interest bearing*: universal like cash, which can be used by anyone who holds it; anonymous because this is an essential feature of cash⁴; and non-interest-bearing to emulate cash. Why would the authorities wish to replace cash with a digital variant? Among other reasons, cash logistics are costly (to issue, circulate and retire cash requires an expensive infrastructure), it deteriorates over time, it is dirty and transmits diseases, and it generates crime (theft) and falsifications. A digital variant would be more efficient, cleaner and safer.
- (iii) If the authorities want to *enhance the instruments of monetary policy*, in particular in the proximity of the zero-lower bound, they would introduce a CBDC that is *universal, anonymous and yield-bearing*. It should be universal because you want to reach the public (and ultimately replace the banknotes in the hands of the population); yield-bearing because you want to exploit the opportunity digital money provides of carrying interest rates, either positive or negative; and anonymous also for similarity with cash, although it could be identified too (but for reasons of clarity of the different models this option is reserved to the next variant). As mentioned above, interest rates may be positive or negative. Historically the former is much more frequent than the latter, but the objective of this proposal being overcoming the problems of the zero-lower bound, the proponents are rather thinking on negative interest rates situations.
- (iv) If the aim of introducing CBDCs is to *reduce (or even eliminate) the likelihood and destabilizing impact of banking crisis*, then the modality would be *universal, identified and non-interest bearing*. Universal because the idea is to open accounts for the population in the central bank; identified like in the case of bank deposits; non-interest bearing because, like in the previous variant, we want to differentiate option (iv) from option (iii), although the possibility of combining both features (identified and interest bearing) is always an option. The logic behind this proposal is that banking crises are the result of fractional reserves, which implies that sight deposits with fixed nominal value are behind longer-term credit whose value is uncertain. If the central bank provides deposits to the population the provision of payments would be delinked from the provision of credit and, following this logic, most banking crises would be avoided.

⁴ According to some studies, the demand for cash is in a significant part driven by anonymity and related to fraud, criminal activities or tax evasion. Rogoff (2016) mentions that in some countries this type of demand reaches as much as 40%.

4.3. PROS AND CONS OF THE DIFFERENT VARIANTS

These variants have very different implications, and their viability would also be quite different. Option (i) is less ambitious and would “only” imply a change in the functioning of wholesale payment systems, whereas options (ii), (iii) and (iv) are potentially very disruptive, and probably increasingly so. Replacing cash with a digital variant would change many of our habits, but in option (ii) only cash changes, not the economy or the financial system. In option (iii) the possibilities of monetary policy would be significantly enhanced, and the central bank would have at its disposal a very powerful instrument. In option (iv) the financial system would be completely transformed from what we know.

Assessing the pros and cons of these variants is not easy. In general, the most radical modalities are potentially more rewarding, but also riskier. And the uncertainty of this assessment also increases with the ambition of the proposals.

In *option (i)* one may expect an increase in the efficiency of the wholesale payment systems. Current RTGS infrastructure provided by central banks is secure and reliable, but expensive from the point of view of collateral consumption. An alternative based on DLT has the potential to reduce the collateral needs. Also the role of the central bank as guarantor of the transactions would be decentralized, with potential efficiency gains. And it would probably be opened to more participants beyond banks, which would increase competition and reduce costs. Admittedly, the latter is a trend that is in any case ongoing in existing payment systems, and that will take place anyway as new regulations like the PSD2 in Europe are adopted elsewhere.

One area where there is a huge potential for efficiency gains is in cross-border payment systems.⁵ Cryptocurrencies offer an opportunity for dramatic cost reductions, which may translate into faster and less expensive transactions, for instance in remittances. But it is unclear whether CBDCs may compete with cryptocurrencies in this, being based on national payment systems. Central banks may, however, have incentives to develop interconnected payments systems for cross-border transactions if threatened by the competition of cryptocurrencies.

Option (ii) opens the possibility of replacing cash with a far more efficient alternative. As mentioned before, cash is costly to produce and replace, requires a heavy infrastructure, and is also easily lost or stolen. CBDCs open the possibility of central banks offering a far more efficient alternative to facilitate P2P payments. The incentives for central banks to develop this new type of cash can be enhanced if the competition of cryptocurrencies is seen as a threat for seigniorage. This is not the case now, due to the huge volatility of cryptocurrencies, but

⁵ See IMF (2017).

this may change, especially with the development of new, more stable cryptocurrencies (the so called “stablecoins” – see below).

The main drawback of this option lies in the anonymity. One thing is to issue banknotes that by their very nature are anonymous and a very different one is that central banks issue a digital means of payment that is deliberately chosen to be anonymous and therefore a channel of illegal payments and criminal activities. It is very difficult that the same central banks that require commercial banks to implement costly mechanisms to prevent money laundering and the financing of terrorism (the AML/CFT regulation) are issuing at the same time the means to carry such activities. One may argue that this is already the case with cash. But anonymity is intrinsic to cash, whereas in the case of CBDCs it would be a deliberate decision. This is the reason why most central banks consider that, in case they issue CBDCs, they would do it under the account modality (option (iv) in our taxonomy) rather than under the token modality (option (ii)). This implies that the demand for cash driven by anonymity would move to other currencies, including cryptocurrencies. The loss of income (seigniorage) for central banks (and ultimately treasuries) would be significant. If central banks decide to opt for the account based modality it would have far reaching implications, analyzed under option (iv) below.

Option (iii) would open new possibilities for monetary policy. The recent crisis, to which central banks reacted with aggressive monetary easing, opened new questions related to the zero-lower bound of interest rates. As rates approached this limit, but the economy continued to require stimulus, central banks embarked in new Quantitative Easing (QE) strategies, including entering into negative interest rates territory in some of their operations with banks. But the existence of cash, with fixed nominal value, sets a limit to the scope of negative interest rates. If they go too far into negative territory, arbitrage will lead to cash hoarding. In practice this means that central banks cannot go beyond a few basis points, perhaps as far as minus one percentage point, but no farther. This constraint is a limitation to the expansionary monetary policies that can be implemented in a recession.

Hence the proposal to introduce CBDCs to extend the negative interest rate territory (Rogoff (2016)). The firing power of monetary policy would be greatly reinforced. But this proposal has profound implications. To start with, physical cash would need to be eliminated (or limited to very small denominations), to avoid arbitrage. Furthermore, this option would probably require the introduction of capital controls, because with negative interest rates on domestic cash, the population would probably tend to resort to foreign currency (dollarization). Capital controls may limit deposits denominated in other currencies, but cash in dollars or other foreign currency would be much more difficult to control. We

would enter into a world of “financial repression”, in the terminology of Carmen Reinhart (2012).

The key question is whether an independent central bank in charge of maintaining price stability would have the legitimacy to impose such policies. Central banks are vulnerable to democratic legitimacy criticisms; more so the more functions they accumulate. Accountability is easier when you have just one objective (price stability), but much more difficult with several objectives whose weighting is arbitrary. Having at their disposal a tool that may imply the impoverishment of the whole population (at least in nominal terms) and that is in the frontier between monetary and fiscal policy is probably incompatible with central bank independence.

Finally, *option (iv)* opens the possibility for the general public to open an account at the central bank. This is the most disruptive and ambitious option. Proponents of this modality in general want to address the question of recurrent financial crisis and banks vulnerability. In their view, crises are a consequence of the fractional reserves of banks as well as their role as providers of deposits with a fixed nominal value in their liability side and as providers of credit with a variable an uncertain value on the asset side. According to this view, technology offers now the possibility to delink the generation of deposits from the provision of credit, radically transforming the role of banks and central banks. There are several variants of this family of proposals: in some of them banks are transformed into credit institutions that raise their resources in the market. In others, banks issue deposits but only invest in a safe asset like public debt (narrow banking). In yet others, banks compete with central banks in the generation of deposits.⁶ In most of them existing safety nets like Deposit Insurance and the role of the central bank as Lender of Last Resort (and even important aspects of present prudential regulation of banks) would probably be redundant and can therefore be eliminated or significantly reduced.

The goal of this family of proposals is a very relevant and ambitious one: to reduce and eventually eliminate banking crises. This would require profound changes in financial intermediation. In the most elaborated proposal (Barrdear and Kumhof (2016)) central banks issue deposits that do not necessarily crowd out banks' deposits. The latter would always have the possibility of paying interest⁷ and providing transactional services (like transfers and direct debits)⁸ which would make them more attractive to compensate the higher security of central bank deposits.

⁶ See Kotlikoff (2010) and King (2016).

⁷ In option (iv) the account in the central bank may or may not pay interest. I opt for the latter to differentiate from variant (iii). But a combination of options (iii) and (iv) is possible, in which the pros and cons of both options would be exacerbated.

⁸ It is unlikely that central bank accounts would offer these transactional services.

One drawback of this proposal is that it could facilitate bank runs in the case of rumors – founded or not – on the financial health of a bank or banking system. In such a situation depositors will move to the central bank with the speed of a click. This is the reason why this proposal is sometimes accompanied with the idea of limiting the convertibility between both types of deposits (see Kumhoff and Noon (2018)). But this implies another weakness, related to the establishment of capital controls and the related enforceability problems.

Furthermore, the drop in the money multiplier would probably imply, at least initially, a credit squeeze. Gradually new institutions will probably arise that will provide credit to households and companies, but probably at a higher cost. And in any case a transition problem seems difficult to avoid. Although the rewards of this option in terms of eventual elimination of banking crisis are huge, the risks are very significant too.

For this reason, it is important to consider in more detail the implications of this family of proposals. What would the central bank do with the proceedings of the deposits in this family of proposals? It can basically do four things:

- Lend to the government or buy public debt. This would open the way for monetary financing to the public sector, which is normally prohibited in the statute of modern independent central banks. And would lead to so called “fiscal dominance”, in which monetary policy is subordinated to fiscal policy objectives.
- Lend to the private sector. It would require developing an expertise in central banks far beyond their present capabilities, and more importantly, would imply a degree of interventionism difficult to reconcile with a market economy.
- Acquire foreign exchange reserves (gold or positions in other currencies): it would hugely aggravate the inherent currency mismatch of any central bank balance sheet (a result of their liabilities being denominated in domestic currencies but part of their assets being in foreign currency) and expose it to the risk of losses as a result of foreign exchange volatility.
- Lend to banks or financial institutions. This would put the central bank in between the generation of deposits and the provision of credit. Depending on how this is done, the current implicit guarantee of banks deposits (which was one of the roots of the crisis and one of the problems that the recent regulatory reform is trying to fix) may become explicit, thus exacerbating moral hazard.

The main drawback of variant (iv), like in the case of variant (iii) – and even more in the combination of both, where the central bank offers interest bearing deposits to the general public – is that the resulting central bank is too powerful.

As a result of the crisis, central banks are currently doing already too many things: monetary policy, financial stability, payments systems, banking supervision, consumer protection... and with the QE after the crisis they already intermediate an important part of interbank transactions. If they were also in charge of providing deposits – and perhaps credit, or financing the public deficit, or holding a significant part of the nation's foreign assets – it would be incompatible with their independence. The political economy aspects of the most disruptive variants of CBDCs should be analyzed extremely carefully before moving in that direction.

4.4. FIAT MONEY, DISCRETIONARY POLICIES, CRYPTOCURRENCIES AND STABLECOINS

Fiat currency relies on the confidence on the central bank. Since the collapse of the gold standard in the 1930s and the move to floating rates in the 1970s central bank issued currency lacks any external anchor. Independent central banks in charge of price stability have been established in most countries to ensure that the money issuance does not take advantage of the lack of an anchor to inflate the economy according to the convenience of the government or the electoral cycle.

The debate on rules vs discretion of monetary policy has long ago been settled in favor of discretion. The instability of money demand led to the abandonment of monetary aggregates as objectives of monetary policy. Anchors defined in terms of nominal exchange rates were abandoned too in most countries as a result of the difficulties to deal with speculative attacks in a world of free capital movements. In a majority of countries monetary policy objectives are defined in terms of inflation targets. In practice this implies a high degree of discretion for central banks, since the link between interest rates and inflation is not a direct one. And the more objectives the central bank has the higher the room for policies that may depart – at least temporarily – from price stability, to reach other objectives like financial stability.

All this implies a challenge for independent central banks, whose role has been questioned in the political debate on grounds of their limited accountability. One may even argue that the recurrent financial crises have been to a certain extent a result of the asymmetric discretionary reaction of monetary policy to asset prices bubbles. For instance, the Fed reacted with aggressive easing when asset prices drop (in 1987, 1990, 1998 and most notably 2008), but did not increase rates so aggressively when asset prices escalated in the booming phase immediately before each of these episodes. This asymmetry arguably led to moral hazard and fueled the development of bubbles in the markets, whose players were confident that the authorities will “mop up after” (the so-called “Greenspan's put”).

What has all this to do with cryptocurrencies? In a world of pure fiat money, the attractiveness of cryptocurrencies lies partly on their delinking from discretionary decisions of the authorities. The issuance of Bitcoin is based on an algorithm according to a preset rule. The external anchor provided by cryptocurrencies has some similarities with gold, and for this reason the emergence of cryptocurrencies reignited the longing for the gold standard. The main drawback of Bitcoin and the like for being an anchor lies in their extreme volatility.

To address this problem, recent initiatives have been developed to create “stablecoins”, a type of cryptoasset whose value is linked to an external anchor, be it a fiat currency or a commodity, collateralized or not, or an algorithm that manages the price controlling the quantity of the cryptocurrency in circulation. Most of them are still in an experimental phase, but if they succeed they may turn out to be more serious competitors to central bank money than present cryptocurrencies.

It is interesting to observe that, on the one hand, markets are developing currencies that may challenge the role of central banks and lead to some type of external anchor to the international monetary system and, on the other, the authorities are analyzing (so far from a purely academic viewpoint) the issuance of account-based CBDCs that would strengthen the role of central banks and confer them much more power than the considerable one they currently have. It seems that the debate is open to extreme forms of means of payment: one private and rules-based and the other public and discretionary. We may witness in the future an interesting competition between both, first in the academic field and perhaps later in practice.

4.5. SOME CONCLUDING REMARKS

- The emergence of cryptocurrencies is opening the way to Central Bank Digital Currencies. The competition of the former may be an incentive for central banks to issue a similar digital currency, but so far the size of the cryptocurrencies stock is far from being a threat for cash.
- Cryptocurrencies are not a threat for cash so far mainly because of their volatility, that prevents them to be used as money to the extent that they do not fulfill its role as means of payment and store of value. They also face a scalability problem. But the development of stablecoins may imply a bigger challenge for cash in the future.
- The different options of CBDCs analyzed here present a correlation in terms of risks and potential benefits: from the more modest proposals (limited to the wholesale payments systems), where risk and reward are both relatively small, to the most ambitious ones (accounts in the central bank for the

whole population), where the ambitious aspiration of ending banking crises is confronted with a serious disruption of financial intermediation as we know it and the political economy problems of an excessive concentration of power in the central bank.

- The main dilemma for central banks lies in anonymity: to issue tokens (like present cryptocurrencies) or account-based CBDCs. For most central banks it is unacceptable to issue an opaque instrument that may be used for crime-related transactions. The only option is therefore account-based CBDCs, which implies a radical transformation of financial intermediation, with serious risks attached. This is why most central banks that studied this topic apparently have decided not to go ahead.
- The central banks that are more seriously considering issuing CBDCs are those that face a reduction in the use of cash and its potential elimination due to the use of alternative means of payment like credit cards.
- The topic is in any case still under analysis and discussion. If one central bank decides to go ahead there may be pressure on others to follow.

REFERENCES

- Barrdear, J. and Kumhof, M. (2016). "The macroeconomics of central bank issued digital currencies." Staff Working Paper No. 605, Bank of England.
- Gouveia, Fernández de Lis, Neut, dos Santos and Sebastian (2017): *Central Bank Digital Currencies: assessing implementation possibilities and impacts*, BBVA Research, Document Number 17/04
- King, M (2016): *The end of alchemy*, Ed. Little, Brown
- Kotlikoff, L. J (2010): *Jimmy Stewart is dead*, Ed. John Wiley and Sons
- Kumhof, M. and C. Noone (2018) *Central bank digital currencies – design principles and balance sheet implications*, Bank of England Staff Working Paper No. 725
- IMF (2017): *Fintech and Financial Services: Initial Considerations*, IMF Staff Discussion Note, SDN 17/05
- Reinhart, C. (2012). *The return of financial repression*. CEPR Discussion Paper No. DP8947
- Rogoff (2016): *The curse of cash*, Ed. Princeton University Press

5. MOTIVATIONS AND IMPLICATIONS OF A CENTRAL BANK DIGITAL CURRENCY¹

Walter Engert² and Ben S. C. Fung²

The emergence of digital currencies such as Bitcoin and the underlying blockchain technology have attracted significant attention. These developments have raised the possibility of considerable impacts on the financial system and perhaps the wider economy. This paper addresses the question of whether a central bank should issue a digital currency that could be used by the general public. It begins by discussing possible motivations for a central bank to issue a digital currency. The paper then sets out a central bank digital currency (CBDC) with a specific bundle of attributes. The implications of such a digital currency are explored, focusing on central bank seigniorage, monetary policy, the banking system and financial stability, and payments. Overall, we find that ensuring adequate central bank money for the general public to support contestability in retail payments and providing for a safe store of value could be credible motivations to issue CBDC. However, before issuing CBDC, a central bank needs to study carefully the broader effects of such a step, which depend importantly on the specific attributes of the CBDC. Further, authorities should also consider whether there are other ways to achieve desired goals and assess which strategy would be most effective.



5.1. INTRODUCTION

The emergence of digital currencies such as Bitcoin and the underlying blockchain technology have attracted significant interest. These developments have raised the possibility of considerable impacts on the financial system and perhaps the wider economy. As a result, over the past few years, public authorities and central banks around the world have been monitoring developments in digital currencies and studying their implications. And a question that has been raised frequently is whether central banks themselves should issue digital currency that could be used by the general public. This paper discusses key motivations for a central bank to issue digital currency and explores the implications of such a step.

¹ This paper is a write-up of a presentation given at the SUERF/Baffi Carefin Center Conference 2018 and is based on Engert and Fung (2017) and Engert, Fung and Hendry (2018). The views expressed in the paper are those of the authors. No responsibility of them should be attributed to the Bank of Canada.

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A central bank typically issues two types of liabilities: physical bank notes and electronic central bank deposits, also known as reserves or settlement balances. A central bank digital currency (CBDC), at the most basic level, is simply monetary value stored electronically that represents a liability of the central bank, is available to the general public, and can be used to make payments. Conceptually, this could be considered as an extension of reserves to the general public, which are currently accessible only to certain financial institutions. Alternatively, a central bank could issue a digital currency in a decentralized manner, similar to how physical cash is distributed, but this could also make use of a blockchain technology.

The focus in this paper is on the economics of CBDC – in particular, on the motivations for issuing CBDC, the design of a CBDC, and its economic implications. The specific motivation for issuing a CBDC could influence the attributes of the CBDC and the technology underpinning its use. We assume that the technological means to issue and use CBDC would be effective, and would be acceptable to the central bank. Thus, our analysis is not technology-specific. Also, this paper does not discuss all of the potential costs to the central bank from issuing a CBDC, such as reputational risks.

The rest of the paper is organized as follows. The next section discusses a number of key motivations that have been advanced for a central bank to issue a digital currency to the general public. Section 5.3 sets out specific design attributes of a CBDC, and discusses the implications of CBDC. Conclusions are in Section 5.4.

5.2. MOTIVATIONS FOR CENTRAL BANK DIGITAL CURRENCY

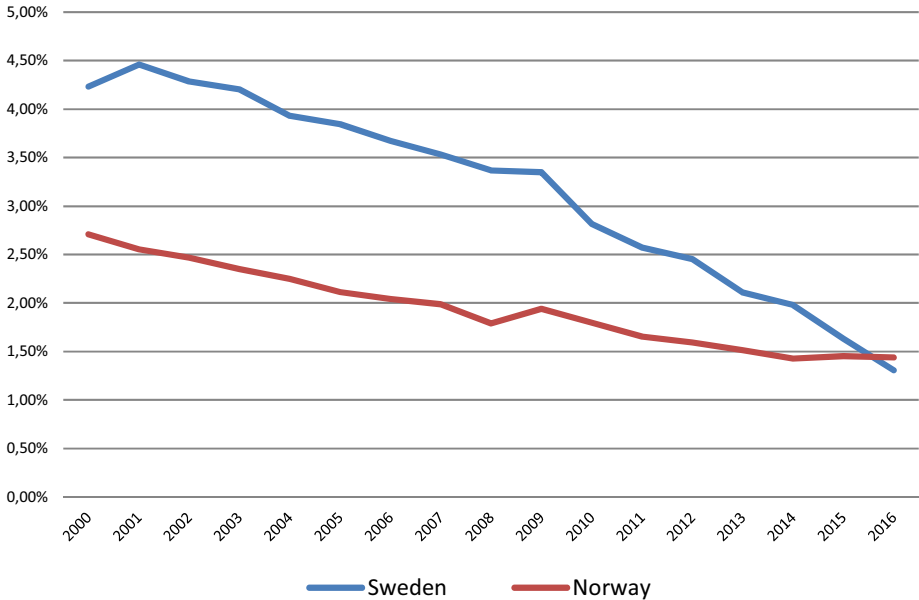
A CBDC available to the general public might be (and has been) motivated in various ways; this section assesses six key reasons for a central bank to consider issuing a digital currency.³

5.2.1. Ensure adequate central bank money for the public

The use of bank notes in Canada for payments has declined consistently over the past 25 years, and similar trends are evident in other countries. This has led some observers to project a “cashless society” in the future. This is especially the case in Sweden and Norway, where bank notes have been declining for a number of years (Figure 1). Skingsley (2016) argues that in Sweden, “there is currently a

³ For a more comprehensive assessment of possible motivations for CBDC, see Engert and Fung (2017).

Figure 1: Notes in circulation over GDP in Sweden and Norway

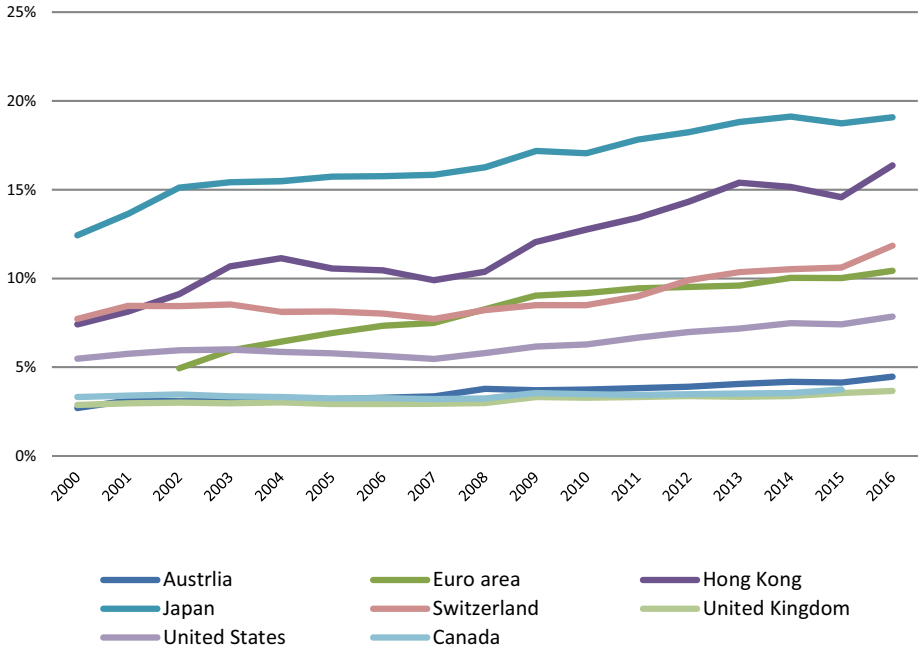


Source: Norges Bank and Sveriges Riksbank

need among the general public and companies to have access to central bank money and this need will still be there in the future.” As more bank branches are becoming cashless, the Swedish public is finding it increasingly difficult to access central bank money. Therefore, the Riksbank “will need to take an active stance on whether or not to issue a digital currency...” However, in most economies, including Canada, notwithstanding the declining use of bank notes for payments, the value of bank notes outstanding – in absolute terms and relative to gross domestic product (GDP) – is not declining, as shown in Figure 2. (See also Bech et al., 2018.)

Looking ahead, the use of cash for payments is likely to continue to decline in Canada and elsewhere as households and firms rely increasingly on electronic payment methods. Further, cash held as savings is likely to decline in the coming years as interest rates are expected to gradually increase. If the demand for bank notes were to decline persistently, a natural question is whether the disappearance of cash would be problematic. Engert, Fung and Hendry (2018) consider potential problems that could arise in a cashless society and discuss how a central bank, and public authorities more generally, could respond. There seem to be two principle concerns that might arise in a cashless society.

Figure 2: Notes in circulation over GDP in selected countries



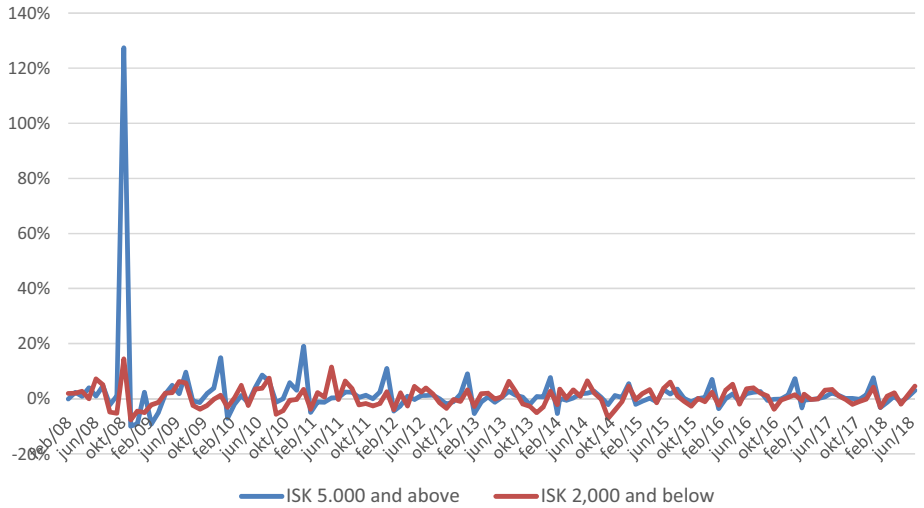
Source: The Bank for International Settlements

First, in an environment where retail payments services are provided by a small number of networks, given large economies of scale and network effects in this industry, contestability in retail payments could already be a concern in some jurisdictions. Concentration in payment services also points to the importance of the operational reliability of these networks. The disappearance of cash would leave retail payments entirely to private-sector providers, which could further reduce contestability in retail payments, and exacerbate the economic disruptions of operational outages.

Second, in the event of widespread bank failures or systemic financial collapse, cash would have increased utility as a means of providing for a trusted transactions medium or store of wealth, as the use of bank deposits to make payments would be compromised. In this regard, the financial crisis that began in 2008 appears to have had an incremental impact on the demand for central bank notes in the major affected countries. Bech et al (2018) show that cash-to-GDP has increased in advanced economies following the financial crisis, and the authors find a structural break in cash demand in 2007-08 for advanced economies (but not for emerging market economies). Further, they find that this change is likely driven by store-of-value motives rather than payment needs.

The case of Iceland is especially striking and informative in this context. In 2008-2010, Iceland experienced what could reasonably be considered to be a financial system collapse, when all of the major banks and savings banks in Iceland failed (Kristinsson 2012). In this extreme crisis environment, the government implemented several measures to enable the normal functioning of the domestic payment system, including the payment card system. Nevertheless, the demand for bank notes initially increased significantly in late September and early October of 2008 with cash in circulation almost doubling (Figure 3), until heavy government intervention managed to arrest this process.⁴ This increase in bank note demand was concentrated in the largest denomination notes (ISK5,000), suggesting that this was driven more by store-of-value motivations, and less by transactions demand. In sum, an increased demand for a risk-free asset, like cash, seems likely in a systemic banking collapse.

Figure 3: Monthly change in bank note demand by denomination in Iceland (2008-2018)



Source: The Central Bank of Iceland

To address these concerns of a “cashless society”, a central bank and other authorities could consider several options. To support retail payments contestability and robustness, a central bank could continue to make cash available, or authorities could regulate private digital networks if contestability and operational reliability were found to be deficient. Similarly, to provide for a safe asset in a crisis, again, cash could continue to be made available by the central bank, or households and firms could rely on government securities as a safe store of

⁴ For more on the Icelandic financial crisis, see Gudmundson (2016), and Benediktsdottir, Eggertsson and Þorarinsson (2017).

value. As well, in all of these cases, a central bank could also reasonably consider issuing CBDC. Such a step, however, would also have a range of implications, as discussed below, that should also be taken into account.

5.2.2. Reduce the lower bound on interest rates, and support unconventional monetary policy

A common perspective following the financial crisis of 2008-09 is that the major economies were in a liquidity trap, where a chronic shortfall of demand required very low real interest rates to move aggregate demand toward potential output. And, in practice, several countries have set modestly negative policy interest rates; for example, the European Central Bank (ECB) set its key policy rate, the rate on its deposit facility, at -0.1 per cent in June 2014, and lowered it further to -0.4 per cent by March 2016.

It has been suggested, however, that the lower bound on interest rates has prevented the real interest rate from falling to the equilibrium negative level required to remedy the persistent shortfall in aggregate demand.

5.2.2.1. Is CBDC needed to reduce the effective lower bound?

Reducing the effective lower bound (ELB) requires increasing the costs of holding bank notes to reduce the usefulness of cash as a way to avoid negative interest rates.⁵ This means eliminating bank notes or at least large-denomination notes so as to increase the frictions related to holding and storing cash. Similarly, a central bank could increase cash-related frictions by suspending or limiting par convertibility of bank notes; that is, discounting (or taxing) the value of bank notes in exchange for other central bank liabilities.

But eliminating larger-denomination notes to reduce the ELB does not require a corresponding introduction of CBDC; the former does not logically require the latter. Reducing the ELB by eliminating the \$100 note, for example, and introducing CBDC are independent decisions.

As a practical matter, imposing a complete elimination of bank notes – while cash is still in demand by the general public – is unlikely to be (politically) feasible; indeed, this seems a non-starter. In Canada, for example, given the income and geographical distributions of cash use, such a step would probably be regressive and have pronounced regional effects. Further, if Canadian bank notes were eliminated (or discounted) to reduce the ELB, a plausible response by Canadian

⁵ For a discussion of cash and the effective lower bound, see, for example, McAndrews 2015 and Witmer and Yang 2016).

consumers and firms would be to switch to United States bank notes for at least part of their economic activity.

On the other hand, if households and firms themselves choose to abandon cash, and society becomes cashless, a central bank could more easily move interest rates to a sufficiently negative level as desired, and a CBDC could help achieve that.

5.2.2.2. CBDC and unconventional monetary policy: “helicopter money”

Given the ELB on interest rates, some central banks have engaged in quantitative easing in recent years, where the central bank has purchased financial assets, typically government bonds, directly from market participants. CBDC could support quantitative easing by facilitating a direct transfer of central bank funds to individuals and firms – so-called “helicopter money” – and so encourage aggregate demand (e.g., Dyson and Hodgson 2016). However, a transfer of central bank funds to individuals and firms could be done without CBDC, although such methods might have larger administrative costs.⁶ More generally, such operations are extremely rare (and, as a practical matter, of limited importance).

In sum, reducing the ELB and supporting quantitative easing do not provide a compelling motivation to issue CBDC.

5.2.3. Reduce aggregate risk and improve financial stability

The financial systems in Canada and other countries feature highly levered banks conducting liquidity and maturity transformation and operating at the core of the payment system. Banks issue claims (liabilities) that are used as both a store of value and means of payment. This is “inside money” – money claims backed by private credit (Lagos 2006). It is well known that under some conditions this set-up can be unstable, and in severe cases the stock of inside money can contract, with adverse negative externalities for the economy. This prospect, in turn, helps to motivate bank regulation, deposit insurance and other policy interventions.

To the extent that individuals and firms were to rely on CBDC as a means of payment and a store of value, overall risk and financial stability could benefit because CBDC (“outside money”) is essentially risk-free.⁷ However, a shift from

⁶ For example, in 2000, the province of Ontario (Canada) distributed part of the government’s fiscal surplus to the public through cheques mailed through the postal service, and, in Hong Kong, authorities have made a similar distribution directly through bank deposits.

⁷ See also Barrdear and Kumhof (2016), Dyson and Hodgson (2016), Raskin and Yermack (2016) and Stevens (2017) for discussions related to financial stability.

bank deposits to CBDC could also have an impact on bank funding and credit provision, which could affect financial stability and efficiency as well. The overall impact of CBDC would depend on the behaviour of economic agents over time, which probably depends also on the specific attributes of the CBDC. Accordingly, these aspects are considered further in the next section of this paper.

5.2.4. Increase contestability in payments

Most central banks have an interest in the efficiency of the payments system, which could be affected by CBDC in the following ways:

- CBDC could provide an alternative to bank notes, cheques, debit and credit cards, P2P or online transfers, etc. So, CBDC could provide for more contestability in retail payments.
- CBDC could also be used for large-value payments among banks and firms, and so could provide for more contestability in large-value payments as well.
- CBDC could also facilitate access to the central bank's balance sheet for a wider range of financial institutions or even non-banks, thus making it easier for these firms to enter the payments industry, promoting contestability.

In principle, this motivation – increasing contestability and efficiency in payments – seems plausible or well-founded, but whether it is a sufficient motivation to issue CBDC depends on a more detailed assessment, which is provided below in the context of a specific CBDC design.

5.2.5. Promote financial inclusion

Some have suggested that CBDC might improve financial inclusion (see, for example, Dyson and Hodgson 2016). Financial inclusion is, however, not a material problem in most advanced economies. For example, in Canada, over 98 per cent of Canadians report having a debit card, and so have a bank account (Fung, Huynh and Stuber 2015). Financial inclusion could be an important concern in some emerging economies. In those jurisdictions, CBDC could provide an accessible general purpose electronic payment method. But there are additional ways to achieve this: M-PESA in Kenya and other countries are examples of payment mechanisms that increase inclusion without reliance on CBDC. In any event, financial inclusion does not provide a compelling motivation for CBDC in most advanced economies, including Canada.

5.2.6. Inhibit criminal activity

It is occasionally observed that some portion of cash transactions, especially with larger-denomination notes, could be related to criminal activity. Therefore, eliminating cash – at least larger-denomination notes – might inhibit criminal activity (Rogoff 2016). However, eliminating larger-value bank notes to inhibit criminal activity does not logically lead to, or require, a corresponding introduction of CBDC. And CBDC itself could also be well-suited for criminal activity if it were anonymous, as is cash. Thus, inhibiting criminal activity does not provide a compelling motivation for CBDC.

5.2.7. Summary

Some of the motivations for CBDC considered here are not compelling, including reducing the ELB on interest rates, and inhibiting criminal activity. Promoting financial inclusion could be an important consideration in some countries, perhaps especially emerging economies, but does not provide a motivation in most advanced countries such as Canada.

While cash is unlikely to disappear in most countries in the near term based on current trends, the role of central bank money in general, and CBDC in particular, if a cashless society were to emerge, is a topic of ongoing research. In a cashless society, CBDC could play a role in supporting contestability in retail payments, and in providing for a safe store of value in a systemic financial crisis, although there are also alternative policy tools as well; see Engert, Fung and Hendry (2018).

More generally, improving financial stability and increasing contestability in retail payments could provide a sound motivation to issue CBDC. A more complete assessment of these specific motivations, however, depends on the specific nature of the CBDC, which is considered in the following section.

5.3. DESIGN AND IMPACTS OF CENTRAL BANK DIGITAL CURRENCY

Regardless of the motivations to issue CBDC, the effects on central bank seigniorage, monetary policy, the financial system and the wider economy could be significant and need to be well understood. However, the nature and extent of such consequences probably depend on the specific features of the CBDC (Fung and Halaburda 2016). Further, different CBDC designs – that is, different bundles of attributes – would generate different trade-offs along several dimensions. So,

in this section, we consider a particular set of CBDC attributes (see Table 1) which could meet the objectives of improving financial stability, supporting contestability in retail payments and providing for a safe store of value in a systemic financial crisis, and study the implications of such a CBDC.⁸

Table 1: Attributes of central bank money – reserves, bank notes and CBDC

Attribute	Reserves	Bank notes	CBDC
Denomination	CAD ^a	CAD	CAD
Legal tender	No	Yes	Yes
Convertibility: Exchange between reserves, bank notes and CBDC	Par	Par	Par
Interest-bearing	Yes	No	Yes
Central bank fees	None	None	None
Access	Only financial institutions (FIs) that are direct clearers in large-value payment system can access reserves	Non-exclusive; anyone can use bank notes. No particular technology required	Non-exclusive; but access to related technology is required
Availability	Subject to operating hours of the large-value payment system	24/7	24/7
Confidentiality of use	All participating FIs are known to the central bank	Anonymous	Users known to the central bank or its agents; could be anonymous to counterparties.
Supply by central bank	Discretionary decision by central bank, depending on its objectives	Perfectly elastic; demand-determined	Perfectly elastic; demand-determined
Distribution channel used by central bank	Participating FIs have accounts at the central bank, which are used for distribution of reserves	Through regulated FIs that have accounts at the central bank. FIs ensure anti-money-laundering (AML) and know-your-customer (KYC) compliance	Through regulated FIs that have accounts at the central bank. FIs ensure AML and KYC compliance
Finality/irrevocability	Final and irrevocable once the risk control tests are satisfied	Immediate, at time of transaction	Timing of irrevocability depends on the technological solution
Payment network structure	Centralized, settles on the book of the central bank	Distributed, bilateral; not tiered	Depends on the technological solution

a. Denominated in the sovereign currency; for Canada, the Canadian dollar (CAD).

⁸ For a more detailed discussion of these features, and different CBDCs, see Engert and Fung (2017).

5.3.1. CBDC and central bank seigniorage

Seigniorage from bank notes and the benchmark CBDC is equal to the face value of the instruments multiplied by the prevailing interest rate, less production and other costs. Thus, central bank seigniorage depends crucially on the demand for bank notes and CBDC.

It is reasonable to expect that CBDC would be adopted as a retail payment method, given the properties in Table 1, especially if CBDC were bearing positive interest. CBDC might also be held as a store of value, again, particularly, if it bears positive interest. Paying interest on CBDC, however, raises a range of practical and operational questions, such as when and how interest would be credited to the corresponding CBDC. Paying interest also raises complications with regard to preserving the anonymity of the beneficial owner of CBDC. For income tax purposes, the central bank (at least in Canada) would be required to provide information about the identity of the recipient of interest income to tax authorities, and to withhold tax on interest income credited to non-resident holders of CBDC. As a result, anonymity – one of the main attractions of bank notes – would not be fully possible with CBDC. The identity of the CBDC owner and the parties involved in an CBDC transaction, however, could still be anonymous to other parties, aside from the central bank or its agents.

Paying positive interest on CBDC would also directly reduce seigniorage in proportion to the level of interest rates and would increase the demand for CBDC, especially relative to bank notes and bank deposits. Also, the erosion of anonymity would tend to reduce demand for CBDC (but it would help address concerns about the use of CBDC for criminal activity). Whether a sustained shift from commercial bank deposits and other conventional claims to CBDC would occur – and so benefit seigniorage – depends largely on how financial institutions respond to the existence of CBDC, which is considered in section 5.3.3.

5.3.2. CBDC and monetary policy

As the central bank would remain the ultimate (monopoly) supplier of reserves, bank notes and CBDC, the central bank could set related terms and conditions, and therefore control monetary policy.

In principle, one would expect that the interest rate paid by the central bank on reserves would be the same as the interest rate paid on CBDC, as each reflects the setting of monetary policy. These liabilities are also close substitutes in some contexts. As such, a spread between the interest rates on reserves and CBDC

would provide arbitrage opportunities for clearing banks, which would tend to attenuate any difference between the interest rates on these central bank liabilities.⁹

As a result of these considerations, it appears that consistency between the interest rate on central bank reserves and the interest rate on CBDC should be expected. Thus, the overnight rate (which would be equivalent to the rate on CBDC) would determine short-term bank and market interest rates in the first instance, and together with expectations, affect longer-term rates across the yield curve.¹⁰

Paying positive interest on CBDC would create a yield differential between CBDC and bank notes, which would increase the demand for CBDC relative to bank notes. However, if the policy rate were negative – to encourage aggregate demand in a liquidity trap (as discussed above) – CBDC holders would tend to convert their CBDC into bank notes, other things equal, which would limit the central bank's efforts to sustain negative rates below the effective lower bound. As a result, to achieve its objectives in this particular case, the central bank would need to discourage conversion of CBDC into cash by suspending par convertibility of bank notes, or by restricting the supply of bank notes. Alternatively, the introduction of CBDC could be accompanied by the (partial) elimination of bank notes.

A possible monetary policy benefit of CBDC is the ability to directly influence interest rates affecting consumers and investors by adjusting the interest paid on CBDC. Historically, however, central banks have been able to exert significant and predictable (indirect) influence on consumer rates by changing the policy rate. The link between the policy rate, consumer and market rates has been reliable and the transmission lag short.¹¹ So CBDC is not needed to provide a stable, predictable influence on consumer and market interest rates in normal conditions (a positive interest-rate environment).

However, such close links between the policy rate and consumer and market interest rates might not hold in a negative interest rate environment, largely because commercial banks could be unwilling to pass on negative rates to all their customers. For example, in Sweden and Switzerland, while the policy interest rate

⁹ For discussion of the arbitrage process that would tend to equalize the interest rates on CBDC and reserves, see Engert and Fung (2017).

¹⁰ This could imply a one-time jump in consumer deposit rates. Historically, consumer deposit rates in Canada typically have been lower than the policy rate. As discussed below, commercial banks would have to offer deposit rates that were competitive with the rate on CBDC, other things being equal.

¹¹ Clinton and Howard (1994) study the stability of the relationships between the monetary policy instrument and consumer and market interest rates in Canada, and conclude that the links of the interest-rate channel of transmission – from policy instruments through short-term rates to short-term bond rates and administered rates – is essentially stable.

has been negative for some time, commercial bank deposit rates have remained at or above zero.

However, when a central bank reduces the interest rate on CBDC, especially as part of an effort to generate negative interest rates, the central bank could be seen as (more) directly impairing the welfare of those who rely on interest income from a safe investment, including those members of society who might be less financially sophisticated and have few financial alternatives. This could generate reputational risk and might invite political interference.¹²

5.3.3. CBDC, the banking system and financial stability

In general, financial claims such as bank deposits are held for a number of reasons: safe-keeping of wealth, to earn income and to make payments. Interest-bearing CBDC would allow agents to simultaneously meet all three objectives. Therefore, it seems likely that such a CBDC would provide meaningful competition for financial intermediaries offering conventional financial services such as bank deposits. However, without anonymity, the principal attraction of CBDC compared with bank deposits is its risk-free nature. And with the introduction of CBDC, there would be a range of endogenous, competitive responses from financial institutions.

- To maintain their funding, banks would offer an incremental spread above the (policy) rate on CBDC to reflect the marginal credit risk, other things being equal. In Canada, this incremental spread would likely be small.¹³
- Bank deposits are also associated with a range of services (e.g., mortgage finance, consumer and business loans, wealth management, financial advice, underwriting, etc.) that would not be offered with CBDC. And banks (and other service providers) are likely to bundle such services to compete more effectively with CBDC.
- To offset increased funding and other costs, banks would probably undertake cost-reduction exercises and raise lending rates and fees. The incidence of the latter changes would fall most on those customers on both sides of bank balance sheets with the fewest competitive options – that is, those with the lowest price elasticity of demand. For example, banks would raise interest costs more for certain borrowers, such as smaller businesses, and on credit cards, and compress net returns to less sophisticated depositors less likely to switch financial service providers.

¹² See also Stevens (2017) and Raskin and Yermack (2016) for more on this aspect.

¹³ Aside from considerations related to probability of default and loss given default, deposit insurance is typically available for Canadian-dollar deposits with a term of five years or less, up to \$100,000.

- Banks might also go up the asset risk curve to earn higher (nominal) returns to compensate for the need to compete with CBDC.
- Increased funding costs and lower profitability could also lead to a contraction in the amount of bank intermediation and lending.
- At the same time, a more credible run threat – into CBDC – under financial stress might imply more *ex ante* market discipline, constraining incremental risk-taking by banks to some extent or motivating more capital to buffer shocks. This, in turn, could result in lower returns to banking, and some contraction of intermediation.

Overall, it seems that a plausible equilibrium is that banks would be able to compete effectively with CBDC through the channels noted above, so that agents would generally rely on bank deposits in normal times to earn higher spreads and to benefit from associated financial services, but under stress, agents could (more) easily shift to (risk-free) CBDC, possibly leading to (large) disturbances to the financial system and the wider economy. In sum, compared with the status quo, CBDC could generate a redistribution of returns away from financial intermediation, perhaps a (modest) contraction of intermediation, and increased volatility.

5.3.4. CBDC and contestability in payments

CBDC would provide for some increased contestability with other electronic payment methods, possibly in terms of reduced costs, and, in particular, in terms of enhanced privacy. However, Fung and Halaburda (2016) also conclude that foregone transactions, for example online purchases, due to such frictions are not material, so that the benefit from the benchmark CBDC in this respect would likely be small. CBDC would provide for more contestability in retail payments, especially if it bears positive interest. As discussed above, banks (and other service providers) would be expected to respond by increasing interest on payments balances or bundling services to maintain market share. This, in turn, would provide incremental benefits to retail payment users. On the other hand, CBDC would not be anonymous (as noted above), which would impair its appeal for some retail transactions.

For large-value payments, real-time gross settlements (RTGS) offers three significant benefits over CBDC: liquidity-savings (quasi-netting) mechanisms; access to central bank overdrafts; and a high degree of security. It seems doubtful that a CBDC would overcome these structural features in the context of large-value payments. Again, banks would be expected to respond to CBDC in order to maintain market share in this context as well. Overall, it seems unlikely that CBDC would lead to material benefits in large-value payments relative to an RTGS system.

5.4. CONCLUSIONS

Consideration of CBDC is a new challenge, which is complex and subject to significant uncertainty. A CBDC could have important consequences, which would depend on its specific attributes, and could include both benefits and costs. Accordingly, assessing CBDC requires careful analysis of motivations and potential implications, including an assessment of the risks that might arise from CBDC.

Some of the motivations for CBDC considered in this paper are not compelling, including reducing the ELB on interest rates and inhibiting criminal activity. Promoting financial inclusion could be an important consideration in some countries, perhaps especially in emerging economies, but does not provide a motivation in more advanced countries such as Canada.

Ensuring adequate central bank money for the general public to support contestability in retail payments and to provide for a safe store of value in a systemic financial crisis might be credible motivations to issue CBDC. However, before issuing CBDC, a central bank needs to study carefully the broader effects of such a step, which depend importantly on the specific attributes of the CBDC. For example, CBDC that pays positive interest would motivate endogenous responses by financial intermediaries to compete with CBDC to retain market share and funding. A plausible outcome is that banks would be able to compete effectively with CBDC so that households and firms would generally rely on bank deposits and related products in normal times. In stress periods, however, they could (more) easily shift to CBDC. As a result, compared with the status quo, CBDC could lead to some redistribution of returns away from financial intermediaries, perhaps a (modest) contraction of intermediation, and increased volatility (other things being equal).

Finally, to the extent that promoting contestability in retail payments and providing for a safe store of value were the primary motivations to issue CBDC, authorities should also consider whether there are other ways to achieve these goals, and assess which strategy would be most effective.

REFERENCES

- Barrdear, J. and M. Kumhof. 2016. "The Macroeconomics of Central Bank Issued Digital Currencies." Bank of England Staff Working Paper No. 605.
- Bech, Morten, Umar Faruqi, Frederik Ougaard, and Cristina Picillo. 2018. "Payments are a-changin' but cash still rules." BIS Quarterly Review, March 2018.

- Benediktsdottir, Sigríður., Gauti B. Eggertsson, Eggert Þorarinsson. 2017. "The rise, the fall and the resurrection of Iceland." BPEA. Fall 2017.
- Clinton, K. and D. Howard. 1994. "From Monetary Policy Instruments to Administered Interest Rates: The Transmission Mechanism in Canada." Bank of Canada Technical Report No. 69.
- Dyson, B. and G. Hodgson. 2016. "Why Central Banks Should Start Issuing Electronic Money." Available at <http://www.positivemoney.org>.
- Engert, W. and B. Fung. 2017. "Central Bank Digital Currencies: Motivations and Implications." Bank of Canada Staff Discussion Paper No. 2017-16.
- Engert, W., B. Fung, and S. Hendry. 2018. "Is a Cashless Society Problematic?" Bank of Canada Staff Discussion Paper, No 2018-2.
- Fung, B. and H. Halaburda. 2016. "Central Bank Digital Currencies: A Framework for Assessing Why and How." Bank of Canada Staff Discussion Paper No. 2016-22.
- Fung, B., K. P. Huynh and G. Stuber. 2015. "The Use of Cash in Canada." *Bank of Canada Review* (Spring): 45-56.
- Guðmundsson, Mår. 2016. "Iceland's recovery: Facts, myths, and the lessons learned." Governor of the Central Bank of Iceland, speech at an OMFIF lecture, 28 January 2016, London.
- Kristinsson, Yngvi Óðrn. 2012. "Icelandic banks: Rebuilding a financial system." Icelandic Financial Services Association.
- Lagos, R. 2006. "Inside and Outside Money." Federal Reserve Bank of Minneapolis Research Department Staff Report 374.
- McAndrews, J. 2015. "Negative Nominal Central Bank Policy Rates – Where Is the Lower Bound?" Remarks at the University of Wisconsin, Madison, 8 May 2015.
- Raskin, M. and D. Yermack. 2016. "Digital Currencies, Decentralized Ledgers, and the Future of Central Banking." NBER Working Paper 22238.
- Rogoff, K. 2016. *The Curse of Cash*. Princeton University Press.
- Skingsley, C. 2016. "Should the Riksbank Issue E-Krona?" Remarks to FinTech Stockholm 2016, 16 November.
- Stevens, A. 2017. "Digital Currencies: Threats and Opportunities for Monetary Policy." National Bank of Belgium *Economic Review* (June): 79-92.
- Witmer, J. and J. Yang. 2016. "Estimating Canada's Effective Lower Bound." *Bank of Canada Review* (Spring): 3-14.

6. THE DEMAND FOR A CENTRAL BANK DIGITAL CURRENCY: A POLITICAL ECONOMY APPROACH

Donato Masciandaro

6.1. INTRODUCTION

What will the future of money be? Large companies of the digital economy – such as Apple, Amazon, Google, Facebook and Twitter – are exploring, with increasing speed and depth, the offer of products and services traditionally provided by the banking sector. In parallel, cryptocurrencies are spreading, generally produced outside the banking perimeter. So, the payment system will undergo an increasing change – and this is good – that however must not put at risk the basic public benefits provided by the integrity and stability of that system. There must be a complete and immediate regulatory response to the new challenges arising from the intertwining of technology and money. The most effective answer could be provided by a healthy competition between the public and the private sectors.

Today the only public currency available is cash. Central banks should instead offer digital currency (CBDC). Like cash, digital money would also be an official means of payment, i.e. the only one to be legally accepted in all economic transactions.

Given the resilience of traditional paper currencies on the one hand and the emerging interest in new private electronic currencies on the other, a question naturally arises: Is it useful to have a public digital currency? Bordo and Levin (2017) suggest that a CBDC could transform all aspects of the monetary exchanges, as a CBDC could serve as a costless medium of exchange, a store of value and a stable unit of account, all of which would benefit households and firms (Moghadam 2018, Berentsen and Schar 2018).

It has been claimed that the introduction of a CBDC could have significant consequences for the implementation of both monetary and banking policies (Barrdear and Kumhof 2016, Raskin and Yermack 2016, Niepelt 2017 and 2018, Kahn et al. 2018), also for a law point of view (Ricks et al. 2018). Therefore, the issue needs to be addressed in a complete and systematic way, taking the fact that CBDCs can be designed in different ways into account. For example, the level of privacy, the possibility of interest-bearing mechanisms (Lober 2017), and the possibility of issuing cryptocurrencies (Berentsen and Schar 2018) need to be considered.

The issuance of a CBDC is an option that both central bankers and academics are carefully considering (Fung and Halaburda 2016, Skingsley 2016, Danezis and Meiklejohn 2016, Bordo and Levin 2017, Bech and Garratt 2017, Hileman and Rauchs 2017, Lowe 2017, Segendorf 2017, Coeurè 2018). Nevertheless, this topic requires consideration of both the economic and the political economy perspectives (Tucker 2017), as well as the role of technological innovation (Velde 2017).

The aim of this chapter is to present a theoretical primer that can be used to analyse the CBDC demand (Borgonovo et al. 2017, Masciandaro 2018). The CBDC – being at the same time a public and virtual medium of exchange – should be completely different on the one side from the existing forms of virtual monies, which are issued from private regulated firms (banks) and private unregulated entities (blockchain network), and on the other side from the paper currency. In other words the existence of a CBDC should change the possibility of each agent to allocate her/his funds – thereafter her – given her preferences.

Therefore the key question arises: how the existence of a CBDC should change the allocation among different media of payments? In order to address such a question, we analyse a simple framework, where individuals choose their portfolio allocation when a new medium of exchange – i.e. the CBDC – is introduced, starting with rational citizens and then taking into account the possibility behavioural biases – i.e. loss aversion.

6.2. THE DEMAND FOR CBDC

Our attention is focused on the individual demand for CBDC. Owing to innovation, the demand for money is likely to change. Let us assume that the State decides to issue a CBDC that shares with the traditional (paper) currency two features: a) it is a legal tender, i.e. the State guarantees its role as medium of exchange (safe asset, i.e. zero illiquidity risk in normal times) and b) no return it is paid, while the main difference is that c) it is distributed via centralized electronic networks, and then it have not the anonymity property, which characterized the paper currency, which is distributed via decentralized physical exchanges.

The CBDC issuing could be implemented by giving the public access to accounts at the central bank, which is already technically feasible (Bech and Garratts 2017), but without any lending opportunity. In other words the CBDC is a public debt-card; the public nature – legal tender – differentiate it from the electronic banking money, which is issued by private entities. Our CDRC is a central bank digital currencies, i.e. electronic central bank money exchanged in a centralized manner (Jobst and Stix 2017).

Our analysis differs from a previous work (Hendrickson et al. 2015) that considers the economics of the policymaker perspective in allowing or not the coexistence between legal tender currencies versus cryptocurrencies, where the preferences of the traders are exogenous, as well as the drivers that give rise to such preferences. Here we try to explore such drivers in explaining the probability of success of a CBDC policy from both an economic and political economics point of view.

For each individual in the population the CBDC share π in her portfolio can be different from zero. Therefore, the CBDC demand will represent a share of the overall portfolio, being an individual component of it.

The specialness of the CBDC depends on being both an electronic and a public currency. For a portfolio diversification point of view, an increasing share of CBDC triggers expected benefits respect to both the paper currency (less transaction costs) and the private coins (less liquidity costs), but also expected costs comparing it with on the side with the paper currency (more transparency costs) and the crypto currencies (more transparency costs and more opportunity costs) and the private currencies (more opportunity costs).

The individual heterogeneous preferences are summarized in a parameter t , that represent the individual type and captures her/his – thereafter her – degree of *aversion* toward the introduction of the CBDC (*CBDC aversion*), which is common knowledge.

The heterogeneity among individuals may arise from any driver that can affect personal preferences, for example from their ideology and culture to the nature and origin – legal or not – of their income and wealth. The degree of aversion summarizes three possible individual and specific features: 1) public issuing aversion ; 2) opportunity loss aversion; 3) transparency aversion.

Having a CBDC share π in her portfolio can influence the utility function of each individual, which can be different across individuals. Using the utility function used in Favaretto and Masciandaro (2016), let $V(t_i, \pi)$ be the description of the preferences of the individual i :

$$V(t_i, \pi) = B(t_i, \pi) - C(t_i, \pi) \quad (1)$$

Where $B(t_i, \pi)$ and $C(t_i, \pi)$ are respectively the individual benefits and costs. We assume that for each individual the abovementioned comparative benefits in having CBDC are increasing and concave in the CBDC share:

$$\frac{\delta B(t_i, \pi)}{\delta \pi} > 0 \quad \frac{\delta^2 B(t_i, \pi)}{\delta \pi^2} < 0 \quad (2)$$

We assume that the benefits of having an electronic safe asset – i.e. less transaction costs respect to the paper currency and less liquidity costs respect to the private coins – is increasing but at a decreasing rate with its share.

At the same time we assume that the individual comparative costs in in having CBDC – more opportunity costs respect to the private coins and more transparency costs respect to the decentralized payment systems, i.e. paper currency and crypto currency – are increasing and concave in the CBDC share:

$$\frac{\delta C(t_i, \pi)}{\delta \pi} > 0 \quad \frac{\delta^2 C(t_i, \pi)}{\delta \pi^2} \geq 0 \quad (3)$$

Finally recalling that the individuals are heterogeneous with respect to their degree of CBDC aversion, they can be indexed such that more adverse individuals bear higher marginal costs and/or enjoy lower marginal benefits from having the CBDC in their portfolios:

$$\frac{\delta B_\pi(t_i, \pi)}{\delta t_i} \leq 0; \quad \frac{\delta C_\pi(t_i, \pi)}{\delta t_i} \geq 0 \quad (4)$$

Given the assumption from (1) to (4), the equilibrium is interior, i.e. the CBDC share is non negative:

$$\frac{\delta B(t_i, 0)}{\delta \pi} > \frac{\delta C(t_i, 0)}{\delta \pi} \quad (5)$$

For each individual the utility is increasing in the CBDC share and the optimal CBDC share π^* is such that marginal benefits match marginal costs:

$$\frac{\delta B_\pi(t_i, \pi)}{\delta \pi} = \frac{\delta C_\pi(t_i, \pi)}{\delta \pi} \quad (6)$$

And that:

$$\frac{\delta \pi^*}{\delta t_i} < 0 \quad (7)$$

In words, the optimal degree of CBDC will be depend on the personal degree of CBDC aversion $\pi^*(t_i)$, i.e. the more the individuals dislike the public nature of the issuer and/or to have opportunity costs and on the contrary like the anonymity gains, the less will be the CBDC share in their portfolios.

It is worth noting that:

Any shock that modify the drivers that influence both the benefits and costs in having CBDC will change the optimal share, given the individual aversion; for example, given its legal tender status, any policy that increases the efficiency and

the security of the public digital currency (Bordo and Levin 2007) will increase the optimal CBDC share.

Similarly an increase in the CBDC share will occur if a return can be paid on it. In fact, as with other kinds of electronic money, it could be technically possible to pay interest on a central bank digital currency, as it is possible today to pay interest on the reserves of the commercial banks (Bech and Garratt, 2017, Bordo and Levin 2017, Segendorf 2017).

The same is true if the CBDC implementation would reduce the transparency costs, for example allowing CBDC exchanges where the payer unknown to payee but the central bank have all information, having counterparty anonymity without third-party anonymity (Segendorf 2017).

Given the individual sensibility respect to the transparency costs, if the existence of CBDC would be a device to isolate the demand for privacy due to illegal reasons, the CBDC issue can be an effective strategy against money laundering and all the correlated illegal activities (Bordo and Levin 2017).

6.3. CBDC DEMAND AND LOSS AVERSION

Now we assume that with loss aversion, and for every portfolio choice, losses loom larger than gains, and both are evaluated with respect to a given *status quo*. Let $z > 0$ be the parameter which captures loss aversion and let π^{SQ} be the *status quo* CBDC share. Given condition (5), the status quo CBDC share is non negative so we can analyze in general how a given portfolio allocation can change if a shock occurs ; on top, if we assume that the CBDC can be arbitrarily small we can also mimic the specific real world situation of the CBDC introduction.

With loss aversion an increasing CBDC share – $\pi > \pi^{SQ}$ – entails more benefits than costs, but higher expected costs yield psychological losses which amount to:

$$z(C(t_i, \pi) - C(t_i, \pi^{SQ})) \quad (8)$$

Vice versa reducing the CBDC share – $\pi < \pi^{SQ}$ – overall entails less benefits than costs, with psychological losses in terms of benefits – i.e. due to less public guarantees and/or less efficiency – which amount to:

$$z(B(t_i, \pi^{SQ}) - B(t_i, \pi)) \quad (9)$$

Therefore the individual goal function with loss aversion $V(t_i, \pi/\pi^{SQ})$ is given by the basic utility $V(t_i, \pi)$ minus the psychological losses due to the departures from the *status quo* allocation:

$$V(t_i, \pi/\pi^{SQ}) = V(t_i, \pi) - z(C(t_i, \pi) - C(t_i, \pi^{SQ})) \text{ if } \pi > \pi^{SQ}$$

$$V(t_i, \pi/\pi^{SQ}) = V(t_i, \pi) - z(B(t_i, \pi^{SQ}) - B(t_i, \pi)) \text{ if } \pi > \pi^{SQ}$$

The optimal conditions are as follows:

$$B_\pi(t_i, \pi) = (1 + z)C_\pi(t_i, \pi) \text{ if } \pi > \pi^{SQ} \quad (10)$$

$$(1 + z)B_\pi(t_i, \pi) = C_\pi(t_i, \pi) \text{ if } \pi < \pi^{SQ} \quad (11)$$

Therefore for each individual it will be true that, given her level of aversion t_i , she will set her preferred CBDC share π_i according to the following rule:

$$\begin{aligned} B_\pi(t_i, \pi) &= (1 + z)C_\pi(t_i, \pi) \text{ if } t_i < t^S \\ (1 + z)B_\pi(t_i, \pi) &= C_\pi(t_i, \pi) \text{ if } t_i > t^T \\ \pi &= \pi^S \text{ if } t^T < t_i < t^S \end{aligned} \quad (12)$$

It is worth noting that t^T and t^S with $t^T < t^S$ represents respectively a lower bound and a higher bound in the distribution of aversion that depend on the status quo portfolio allocation.

Therefore every population can be divided in three different groups: Lovers – if $t_i < t^T$ – Haters – if $t_i > t^S$ and Neutral – if $t^T < t_i < t^S$.

Each individual will express well defined CBDC share preferences. With respect to the basic situation we are now assuming that i) each individual will evaluate any situation in terms of changes from the CBDC share status quo; ii) any negative effect of a change with respect to the status quo are thought to loom larger than a positive effect of equivalent magnitude.

The two assumptions are a simple application of the loss aversion principle, highlighting the fact that if there is a loss/gain asymmetry for individuals, inertia is more likely to occur, as we will see below.

Given the preferences, for each individual the optimal CBDC share will depend on her aversion t_i , having three possibilities: lover, neutral and hater. More precisely three different equilibria can arise:

$$\begin{aligned} \pi &= \pi^{SQ} \text{ if } t^T < t_i < t^S \\ \pi &< \pi^{SQ} \text{ if } t_i < t^T \\ \pi &> \pi^{SQ} \text{ if } t_i > t^S \end{aligned} \quad (13)$$

The existence of loss aversion influences the portfolio decisions at least via a *Moderation (Status Quo) Effect*:

The CBDC share outcome will be the status quo share π^{SQ} if the individual is neutral. Further, given that the distance between t^T and t^S is increasing in $z > 0$, the more the loss aversion is increasing the more likely the individual is neutral: a status quo bias – i.e. portfolio inertia – will emerge.

In other words more loss aversion among individuals reduces the distance between their CBDC share positions. As the individuals become more loss averse, neutral people increase in number and portfolio inertia is likely to increase. In other words being π^* the equilibrium CBDC share, we have that increasing loss aversion triggers portfolio inertia, i.e.:

$$\pi^* = \pi^{SQ} \text{ if } z > 0 \quad (14)$$

In words: the more that are individuals that disproportionately dislike the expected losses the less there will be change in the CBDC share.

6.4. VOTING ON CBDC

Now we assume that our individuals is a population of citizens that have to choose if and how to introduce the CBDC; the overall procedures can be summarized through a unidimensional policy $p \in R^+$. On top we assume that for each individual her optimal policy p can be proxied using her optimal CBDC share. Therefore haters vote for lower CBDC policies, i.e. against them; the opposite is true for lovers preferences.

The policy outcome will depend on the voting rules. First of all, which should be the optimal policy if a social planner is in charge? The benevolent dictator would maximize the overall sum of individuals' preferences:

$$\int [B(t, p) - C(t, p)] dFt \quad (15)$$

Where the first best CBDC policy will be define in order to equalize the average marginal benefits $B_p(p)$ and the average marginal costs $\bar{C}_p(p)$, i.e. solving the equation:

$$\bar{B}_p(p) = \bar{C}_p(p) \quad (16)$$

The social planner goal is to maximize the effectiveness of the CBDC issuing taking into account its relative properties as medium of exchange, store of value

and of information. But the social planner solution is not necessarily the equilibrium solution if a voting regime is in action.

If for the sake of simplicity, we assume that the voting regime is governed via a majority rule, the selected CBDC policy will depend on the preferences of the median voter, i.e. it will be equal to p_m . Therefore the introduction of the CBDC will be more like if the median voter is a lover; the opposite is true if in the given individual preferences distribution the median voter is an hater. The distribution of the preferences among the citizens becomes crucial to define will the actual CBDC policy.

At the same time, given such as distribution, the likelihood of a CBDC establishment will increase whatever event will increase its expected gains and/or will decrease its expected costs.

Finally, if we introduce the loss aversion, we can assume that in the status quo situation the CBDC doesn't exist, i.e. in our model such an assumption implies $p_{ST} = \pi_{ST} = \varepsilon$, where ε is infinitely small. Now we assume that the reference point for the citizens is the status quo situation, our assumption seems to be sufficiently robust, given that usually the debate on the pros and cons of introducing a CBDC is usually assessed against the existing payment system situation; it is a backward looking reference point.

Given the abovementioned three group of citizens – lovers, neutrals and haters in – if the median voter is the intermediate group, the policy outcome is the status quo, i.e. the CBDC is less like to be introduced.

6.5. CONCLUSION

Exploring the link between individual liquidity preferences and CBCD issuing can help in shedding light on the micro foundations of the monetary phenomena. In our theoretical framework the individuals face portfolio decision problems with value trade-offs. The media of payments are heterogeneous, i.e. each of them is characterized by different properties. For example, in a given country and in normal times, a banknote is likely to have zero illiquidity risk, zero expected return and zero privacy risk. Also the preferences are heterogeneous, and we show how the likelihood of having a CBCD issuing depends on these preferences.

We identify the social planner solution; but such as solution is not necessarily the equilibrium if a the individual preferences are heterogeneous and matter via a political process. Having three different group of individuals – CBDC lovers, neutrals and haters – that can be rational but at the same time can be subject to behavioral biases – as loss aversion – we show that the introduction of the CBDC

will be more like if the median voter is a lover; the opposite is true if in the given individual preferences distribution the median voter is an hater. The distribution of the preferences among the citizens becomes crucial to define time to time and country by country the actual CBDC policy.

At the same time, given such as distribution, the likelihood of a CBDC establishment will increase whatever event will increase its expected gains and/or will decrease its expected costs. In general the theoretical assumptions about individual preferences could be tested using laboratory experiments. At the best of our knowledge the money demand features has been analyzed so far in a laboratory experiment only in two cases, and exclusively for pedagogic reasons (Ewing 2004, Chen 2018).

REFERENCES

- Barrdear J., Kumholf M., 2016, *The Macroeconomics of Central Bank Issued Digital Currencies*, Bank of England, Staff Working Paper Series, n. 605.
- Bech M. and Garratt R., 2017, *Central Bank Cryptocurrencies*, BIS Quarterly Review, September.
- Berentsen A. and Schar F., 2018, The Case for Central Bank Electronic Money and the Non-Case for Central Bank Cryptocurrencies, *Federal Reserve Bank of St. Louis Review*, Early Edition.
- Borgonovo E., Caselli S., Cillo A., Masciandaro D. and Rabitti G. (2017), *Beyond Bitcoin and Cash: Do We Like a Central Bank Digital Currency? A Financial and Political Economics Approach*, Bocconi Baffi Carefin Centre, Working Paper Series, n.65.
- Bordo M.D. and Levin A. T., 2017, *Central Bank Digital Currency and the Future of Monetary Policy*, NBER Working Paper Series, n. 23711.
- Chen X., 2018, A Simple Classroom Experiment on Money Demand, *Journal of the Scholarship of Teaching and Learning*, 18(1), January, 115-135.
- Coeurè B., 2018, *Bitcoin's Ascent is Forcing Central Banks to Rethink a Future Without Cash*, The Financial Times, March 13th, p.20.
- Danezis G. and Meiklejohn S., 2016, *Centrally Banked Cryptocurrencies*, University College of London, mimeo.
- Fung B.S.C and Halaburda H., 2016, *Central Bank Digital Currencies: A Framework for Assessing Why and How*, Bank of Canada, Staff Discussion Paper, n.22.
- Ewing, B., Kruse J. B and Thompson M.A., 2004, Money Demand and Risk: A Classroom Experiment, *Journal of Economic Education*, 35(3), 243-250.

- Favaretto F. and Masciandaro D., 2016, Doves, Hawks and Pigeons: Behavioural Monetary Policy and Interest Rate Inertia, *Journal of Financial Stability*, 27, 50-58.
- Hendrickson J.R., Hogan T.L. and Luther W.J., 2015, *The Political Economy of Bitcoin*, mimeo.
- Hileman G. and Rauchs M., 2017, *Global Blockchain Benchmarking Study*, Cambridge Centre for Alternative Finance, University of Cambridge.
- Jobst C. and Stix H., 2017, *Is Cash Back? Assessing the Recent Increase in Cash Demand?*, SUERF Policy Note, n.19, October.
- Kahn C.M., Rivadeneyra F., Tsz-Nga W., 2018, *Should the Central Bank Issue E-Money?*, Economic Research, Federal Reserve Bank of St. Louis, mimeo.
- Lober, K., 2017, Central Bank Digital Currencies – Models and Implications for Payment Infrastructures, mimeo.
- Lowe, P., 2017, *An eAUD?*, Address to the 2017 Australian Payment Summit, mimeo.
- Masciandaro D., 2018, Central Bank Digital Cash and Cryptocurrencies: Insights from a Baumol-Friedman Demand for Money, *Australian Economic Review*, 51(4), 1-11.
- Moghdam, R., 2018, *A Central Bank Digital Cash System Will Benefit Consumers*, The Financial Times, March 19th, p.9.
- Niepelt, D., 2017, *Central Bank Digital Currencies: A Macroeconomic Perspective*, Zurich, mimeo.
- Niepelt, D., 2018, *Reserves for All? Central Bank Digital Currencies, Deposits, and their (Non) – Equivalence*, CESifo Working Paper Series, n.7176.
- Raskin M., Yermack D., 2016, *Digital Currencies, Decentralized Ledgers, and the Future of Central Banking*, NBER Working Paper Series, n. 22238.
- Ricks M., Crawford J. and Menand L., 2018, *A Public Option for Bank Account (or Central Banking for All)*, Vanderbilt Law Research Paper Series, n.33.
- Segendorf B., 2017, *Swedish E-Krona: Motivations, Drivers and Obstacles*, Zurich, mimeo.
- Skingsley C., 2016, *Should the Riksbank Issue E-Krona?*, Fintech Stockholm, Berns, mimeo.

7. CENTRAL BANK DIGITAL CURRENCY: THE URUGUAYAN E-PESO CASE

Mario Bergara¹ and Jorge Ponce²

A digital currency issued by the Banco Central del Uruguay (BCU), called e-Peso, circulates in Uruguay between November 2017 and April 2018. The digital issuance of this legal tender currency was done in the controlled framework of a pilot plan. The objectives of this experience were to test technological aspects of the e-Peso system and to learn about central banks digital currencies (CBDC).

In this article we describe reasons behind the experiment, key features of the e-Peso system, lessons learned and further questions.



7.1. WHY A CBDC?

Financial innovation is driving the world in a direction where the incorporation of digital technologies is rapid, highly demanded by customers and surely without return. Some developments challenge the ability of central banks to efficiently fulfil their mandates towards price and financial stability, as well as to provide secure and efficient payment systems.

Consider, for instance, the case of Sweden. During the last decade, the Swedish banking system develop a very efficient payment system. The success has been of such magnitude that most people are using it through their computers and mobile phones. The use of physical cash, on the other hand, has falling dramatically during the last years. Today, more and more retail stores are not accepting cash as a mean of payment. And forecasts predict that people will completely stop using physical cash by 2025. In scenarios like this, how would a central bank fulfill its mandate of providing an efficient and stable payment system? It will lack one of the key instruments to do so: cash. And, how to provide financial stability in the case a banking crisis occurs?

While digitalization challenges central bank, it may also be part of the solution. For example, the Central Bank of Sweden is studying the possibility of issuing a central bank digital currency, called e-Krona, in order to build an instrument that is accepted by the public and allows the central bank to fulfill its mandates.

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² Banco Central del Uruguay.

Digital technologies may imply more opportunities. For instance, they may help to reduce transaction costs and to improve efficiency; they may help to improve safety in financial transactions; and, they may serve for financial inclusion objectives. The contribution of central banks to financial digitalization would be more important in jurisdictions where the private sector does not take the leadership on technological innovation. In such a case, a proactive attitude of central banks towards financial development of markets and infrastructures would be necessary.

In the case of Uruguay, for instance, there is room for reducing transaction costs in payments. The main costs for using physical cash are related to the production of notes and coins, transportation and security incurred by banks and retailers, and the costs incurred by consumers in terms of fees paid and other opportunity costs, e.g. interest, time expended withdrawing cash from ATMs and the risk of holding cash. Recent estimates show that the cost of using cash in Uruguay is approximately 0.58% of GDP.³ This estimate is in line with previous studies for other economies. Interestingly, 98% of this cost is borne by the private sector: banks 13.7%, retailers 67.3% and households 17%. Overall, if paper money and checks were fully replaced by other (digital) means of payment, it would imply a transaction cost reduction of the equivalent of up to 0.60% of GDP. Of course, digital means of payment will also entail costs that need to be considered.

Even if a CBDC, e.g. the e-Peso, replaces only partially physical cash, the efficiency gain may still be important. Moreover, the CBDC may facilitate a prolific field for startups developing new products and services, e.g. digital wallets with enhanced customers' experience, and for incumbent financial institutions to offer better products and services. In addition to that, empirical evidence suggest that crime rates are positively correlated with the demand for paper cash and negatively correlated with the penetration of electronic means of payment.

Central banks should be part of the new digital paradigm. They should be prepared to fulfill their mandates in this digital era and ready to exploit new technologies in their favor. Central banks need to be proactive in order not to arrive too late to this digital revolution, to be able to fulfill their mandates, and to contribute to a healthy development of financial systems. The pilot plan of e-Peso in Uruguay is a step in this direction.

³ Alvez, M, R. Lluberas and J. Ponce (2018). "The cost of using cash and checks in Uruguay." Working paper of the Banco Central del Uruguay.

7.2. THE E-PESO PILOT

e-Peso is Uruguayan Peso in digital. It is legal tender currency issued by the Central Bank, alike physical Uruguayan Pesos, but it is based on an electronic/digital platform. The BCU issue, put in circulation and test in the real world this CBDC for six months between November 2017 and April 2018. Since these are unknown lands, it was important to conduct a controlled experiment, or pilot, to learn about CBDC without assuming excessive risks.

7.2.1. Proposal and assessment

The preparation of the pilot starts several years before the first e-Peso was put in circulation. In 2014, BCU was approached by The Roberto Giori Company, a firm specialized in money security, with a preliminary proposal to create legal tender digital money which is secure and reliable. Then, legal, information security and technological aspect were evaluated to be sure that relevant risks were under strict control. Risks include financial and legal ones. Also reputation risk was a matter of particular concern.

On the legal side, it turns out that the current legal framework was sufficient for issuing electronic bills as a complement of paper ones. More precisely, article 7 A. of the Central Bank Charter⁴ says that “the Bank will: A. Have under its exclusive responsibility the issuing of currency notes, minting coins, and withdrawal of currency notes and coins in all of the Republic.” Since the law does not determine (neither forbid) a specific form for currency notes, it allows that physical and digital notes may be issued as long as both of them maintain similar security standards. In addition to that, the Central Banks does not need to require further authorization to issuing currency notes.

Several measures were undertaken to reasonably mitigate cyber risk and to make sure that the system provides adequate standards regarding information security. Other risks, e.g. financial and reputation risks, were reasonably hedged through detailed contracting with the participants. Contracts include penalties and guarantee deposits as collateral for risks materialization. On the technology side, all the system’s component (i.e. e-Peso production, digital vault, digital wallets, transactional system, infrastructures, etc.) were successfully tested. Additionally, business continuity plans were designed and successfully tested.

⁴ See https://www.bcu.gub.uy/Ingles/Documents/Ing_Carta_Organica.pdf.

7.2.2. Participants

In addition to Banco Central del Uruguay, who issues the digital e-Peso bills, and The Roberto Giori Company, who provides the core system for it (Global Solution for Money Technologies), there were four more participants to the pilot (see Figure 1).

Figure 1: Participants



Antel, the state-owned telecom company that is also the biggest in the country, provides the telecommunication network. IBM provides data storage services, management and control of circulation. It also provides support to customers through a call center. INSwitch Solutions, a Uruguayan firm specialized in mobile financial services, provides the interface for the management of users, transfers and transactions. Finally RedPagos, a payments service with branches all around the country, provides cash-in and cash-out services. In addition to these participants, final users include individual customers and retail business.

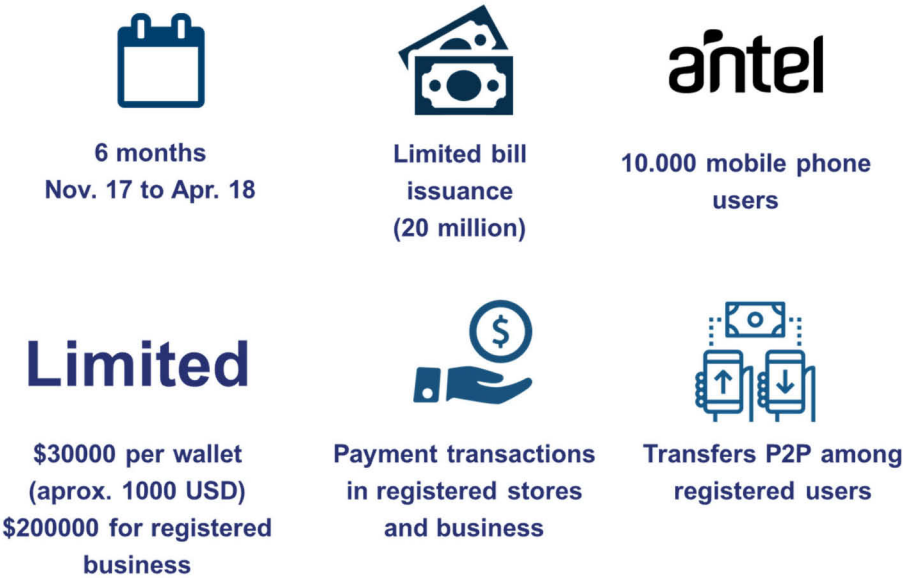
7.2.3. Costs distribution

Importantly, the costs incurred during the pilot were covered by the participants. There was no fee paid by the Banco Central del Uruguay to participants. There were no pricing for services among them neither. Final users and registered retail business access the system free of charge. Finally, the cost of the pilot for BCU was restricted to the salaries of the staff involved in it.

7.2.4. Limits to keep the pilot under control

A series of limits were incorporated in the pilot in order to generate a controlled environment for risk management (see Figure 2).

Figure 2: Limits in the pilot plan



To start with, e-Peso circulates by a limited period of time. Circulation starts on November the 3th 2017 and stops six months after, i.e. by the end of April 2018. The issuance of e-Peso bills was limited to 20 million Uruguayan Pesos. The number of users was limited to 10000 mobile phone users of Antel. More precisely, the first 10000 users that install the e-Peso application and register to the pilot could make transactions. The maximum balance in e-Pesos wallets was set to 30000 Uruguayan Pesos (equivalently to 1000 US Dollars) for final individual users and to 200000 Uruguayan Pesos for retail business registered in the pilot. Finally, the system allows two kind of digital transactions: peer-to-peer transfers among final users and peer-to-business payment between final users and registered retail business.

7.2.5. Timing

After initial evaluation and assessment, the pilot starts with the Banco Central del Uruguay issuing 20 million Uruguayan Pesos in digital format, i.e. e-Pesos. This amount was transfer to the virtual vault that secures them. In order to start the

cash-in, i.e. changing paper bills for digital e-Pesos, 7 million of e-Pesos were transferred to RedPagos.

The second stage starts on November the 3th 2017 and last six month. During this period, mobile phone users of Antel download and install the e-Peso application in their devices, i.e. a digital wallet provided by InSwitch. Final users need to make a short register and their digital wallets keep linked to their mobile phone number. Retail business interested in accepting e-Pesos as a mean of payment registered at the Central Bank and also installs the application. Once registered, final users cash e-Pesos in through RedPagos and start making transactions.

The third stage starts the 1st of May 2018. The possibility of making transactions with e-Pesos stops that day and users could only cash e-Pesos out through RedPagos. Those users that did not cash-out by July 2018 were credited on their Antel mobile phone accounts the balance existing in their wallets. This money could be used to pay the telecom company bills.

Once e-Pesos were completely cashed-out, then they return to the virtual vault at the BCU for destruction. Today, the stock of e-Pesos is nil and the pilot is being evaluated from different perspectives that include technology and their impact on the economy, the payment system, the financial systems, and monetary policy.

7.2.6. Incentives

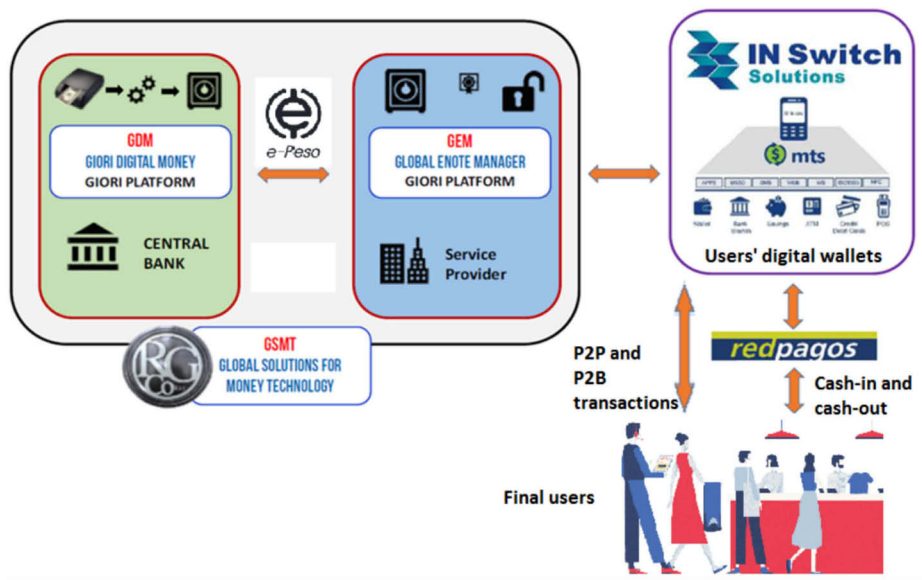
Because it was a pilot lasting only six months, there was an incentive scheme in order to promote the use of e-Pesos. All the costs where covered by The Roberto Giori Company. More precisely, 500 e-Pesos were credited in the digital wallets of the first 1000 final users cashing-in. There were 5 monthly lotteries among the most active individual users and retail business. For the former group, there were 100 monthly prizes of 2000 Uruguayan Pesos each that were randomly assigned among those making 10 or more transactions in the previous month. For the latter group, there were 25 monthly prizes of 2000 Uruguayan Pesos each that were randomly assigned among those making 3 or more invoice collection with e-Pesos in the previous month.

7.2.7. Description of the system

Figure 3 describes the main components of the system. Global Solutions for Money Technology (GSMT) is proprietary software provided by The Roberto Giori Company. GSMT is the core of the e-Peso system. It has two components. First, Giori Digital Money (GDM) is in charge of issuing e-Pesos. This component provides the security and cryptography behind the e-Pesos. Given that the Banco Central del Uruguay has the exclusive right of issuing legal tender money in

Uruguay, this component needs to be managed by the Bank. Second, Global E-note Manager (GEM) serves as virtual vault and digital wallet. This component provides the storage, security, verification and certification of all transactions. During the pilot, the GEM component was managed by IBM, although it could also be managed by the Central Bank.

Figure 3: Description of the e-Peso system



Digital wallets in the GEM component are encrypted, anonymous and linked one-to-one with users' digital wallets. In the pilot, users' digital wallets were exclusively provided by InSwitch Solutions through its Monetary Transaction System. These wallets are linked to the mobile phone number of the user. In addition to this, final users need to register in the e-Peso digital wallet.

This design provides two features to the system. First, e-Peso transactions are made anonymously at the GEM component of the system. This is a shared feature with paper money. Second and differently from paper money transactions, e-Peso ones can be traced back. Indeed, the GEM component stores transactional data per (anonymous) digital wallet. Moreover, the transactional data stored in the GEM component could be decrypted in order to reveal the identity of the user making transactions through a particular wallet. This feature may be useful if, for instance, a competent authority (e.g. a judge of law, a tax authority or an anti-money laundry authority) is prosecuting someone and requires access to transactional information. In such a case, the data can be decrypted and provided to the competent authority.

Finally, cash-in and cash-out of e-Pesos was done through the branches of RedPagos.

Final users make transactions through their InSwitch digital wallets. Transactions are verified and certified in the GEM component of the core GSMT system. During the pilot, transactions can be of two types. First, peer-to-peer transfers among final users were the most common type of transaction accounting for approximately 80% of the total. The second type of transactions is peer-to-business ones. This type of transactions implies the payment for services or products at the retail storers that were part of the pilot.

7.2.8. Key features of the e-Peso system

Apart from anonymity and traceability of transactions, other features of the e-Peso system are as follows. First, the system provides instantaneous settlement.

Second, it uses a dual schema of communications to provide a secondary authentication method. This enhances security in transactions. The primary authentication method involves internet traffic and the second a telecommunication protocol named Unstructured Supplementary Service Data (USSD) that is in use only on the mobile networks (it's similar to SMS messages). USSD messages are used to confirm that a mobile phone is involved in a transaction. It assures that there is a phone with a valid SIM card, and the phone company validates that it exists and is operational.

Third and related to the previous point, in the e-Peso system users can make transactions without an internet connection or even a smartphone. The system could work with any GSM phone using the USSD protocol to make transactions.

Fourth, e-Pesos are secured at the GEM component of the core system even if users lose their mobile phones or password of their digital wallets. This also enhances security with respect to paper money.

Fifth, each e-Peso bill will have a unique serial number (cryptography) and specific denomination (this feature was not provided during the pilot). This feature is aimed to improve security because it helps preventing double spending and falsification. Nevertheless, it could increase the technical requirements of the system because it may need to make change at the GEM vault if the e-Peso denomination in a particular wallet is not appropriate to make the transaction. For instance, a single transfer transaction may need to be followed by one or two automatic exchange transactions in order to complete the settlement and end with the correct balance in the involved wallets. The impact of this potential drawback could, however, be minimize by issuing only e-Pesos of a sufficiently small denomination as to avoid exchange transactions. This is being evaluated.

7.3. PRELIMINARY EVALUATION AND FURTHER QUESTIONS

The e-Peso pilot was successful and delivers several positive results. The technology works without incidents. The experience is being used to evaluate many aspects of these novel technologies and central bank business models. It was also useful to visualize tentative answers to relevant questions about the impact of a CBDC on specific sectors. Should the e-Peso be put in production, this knowledge will inform policymakers and help to determine an optimal design for this CBDC.

For instance, a matter of concern refers to the impact of e-Peso on banks and other financial institutions. During the e-Peso pilot banks were not part of the experiment. Nevertheless, once it started several banks approached the project managers asking to be allowed onboard. Banks seem to visualize profitable business opportunities and potential for cost reduction linked to e-Peso. Should the e-Peso be put in production, then it is likely that the banking system reaches a new equilibrium. Of course, the characteristics of this equilibrium will depend on the settings of e-Peso and, in particular, in the possibility of combining it with bank accounts.

e-Peso may contribute to a level playing field for sound competition and innovation in the financial market. It may reduce entry barriers for startups developing new products and services, e.g. digital wallets with enhanced customers' experience, and could provide incentives to incumbent financial institutions to offer better products and services.

Another question refers to the impact on the efficiency of monetary policy. On the one hand, with e-Peso monetary policy analysis will dispose of granular information in real time, which is not available with physical cash. This should improve the efficiency of day-to-day monetary operations. On the other hand, e-Peso could introduce extra volatility to the velocity of circulation of cash and the money multiplier, making day-to-day operations harder. Once again, the setting of e-Peso, e.g. limits to the balance in final users' digital wallets, would have an impact on these variables.

The transactional information generated by e-Peso may be very useful for economic analysis, even if it preserves the anonymity of users. Moreover, transactional information is traceable and could be release at the requirement of some competent authority (court of law, tax authority, etc.). These features may help on the prevention of tax evasion, money laundry and terrorism financing.

Last but not least, efficiency and security in the payment system may be dramatically improved by the introduction of a CBDC. Moreover, e-Peso would contribute to the objectives of financial inclusion.

8. DIGITAL MONEY, CRYPTOCURRENCIES AND CENTRAL BANKS

Paul Pichler¹ and Martin Summer²

We discuss whether central banks should provide to its citizens an official digital means of payment similar to banknotes and coins. We place the discussion within the context of current monetary arrangements as well as the technological innovations brought about by cryptocurrencies such as Bitcoin. We argue that privately issued cryptocurrencies are inefficient and unlikely to satisfy the demands on modern payment systems, and that the case for introducing a central bank digital currency in advanced economies currently is not very strong.



8.1. INTRODUCTION

The emergence of cryptocurrencies such as Bitcoin as well as remarkable developments in the digitalization of finance, banking and payment systems have recently spurred an international debate about the stance that central banks should take with respect to these technological innovations. Should they embrace the new developments? Should they become an active player in the process of digitalization of money and finance? Or should they rather wait and see?

In order to discuss these questions it is important to first reach a conclusion about the following: Should central banks provide to its citizens an official digital means of payments similar to banknotes and coins? We address this question in three steps. First, we briefly overview the current monetary arrangements and point out that modern money is already to a large extent digital. Second, we discuss whether new systems like Bitcoin or other forms of cryptocurrencies are an efficient new form of digital money and we discuss which role the core innovation in Bitcoin, the public blockchain, might play in this respect. Third, we go into the issues with respect to potential new forms of central bank digital money.

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² OeNB.

8.2. DIGITAL MONEY

In our current monetary system, money has two faces. At the base of the system are currency (banknotes and coins) and commercial bank reserves (deposits commercial banks hold with the central bank). Banknotes and coins are the face of money most of us are familiar with from early life onwards, although the preferences for using currency for payments vary greatly across countries (see Jobst and Stix 2017). The second face of money we are well familiar with is the deposit money we hold in our bank accounts. Even though this form of money has no physical representation, we can use it to make payments by asking our bank to debit our own account, while at the same time crediting someone else's bank account.

In macroeconomics, currency and reserves together with the deposits that households and (non-bank) firms hold with commercial banks are referred to as the money supply (M1). Central bank created money – with physical representation, as in the case of bank notes and coins, or without physical representation, as in the case of reserve accounts of commercial banks at the central bank – forms the base of our current monetary system. Privately created deposit money of the commercial banking system is built upon the base as a second layer. This is also reflected by the fact that the ultimate content of bank deposits as well as most other financial liabilities of banks is central bank currency (see Hellwig 2018). Deposits, for example, are a claim on the bank to deliver banknotes and coins on demand. As a commercial bank cannot produce currency itself, deposit money held in an account is a true liability of this bank.³ Even though today we hold the major part of our money as deposit money, the terminology of currency as the base of the system is therefore still an accurate description.

As deposit money lacks any physical representation, transfers of deposit money merely reflect changes in a system or ledgers maintained by the banking system. While in the past these bank ledgers were taking the form of large collections of books, today they are usually electronic databases stored on servers. Moreover, the vast majority of payments we make using deposit money are initiated via payment cards, online-banking websites or smartphone applications. Banks and payment card providers use state-of-the-art secure data transmission technologies and sophisticated cryptographic techniques to ensure the legitimacy of all transactions. Modern deposit money thus truly is digital money.

The Payment Statistics of the ECB nicely illustrate the increasingly important role of digital payments in the European Union. In 2016, the number of cash-less

³ By contrast, the issuance of fiat currency today does not create a true liability of a central bank, as it merely obliges the central bank to exchange banknotes and coins for new banknotes and coins, which in turn it can produce at virtually zero cost (see Hellwig 2018).

payments in the EU has increased by 8.5% to a total of 122 billion transactions, corresponding to more than 3.800 transactions per second. Of these 122 billion transactions, 59 billion were done using payment cards, implying an increase by more than 12% as compared to 2015. The total value exchanged using card payments amounts to roughly three trillion Euro in 2016, approximately 50 Euro per payment. While both the number of payment cards in circulation and the number of card payments has been steadily increasing over the last years, the number of ATMs provided by banks in the EU has slowly but steadily declined. This reflects the increased usage of digital money rather than physical currency for everyday transactions.

This trend is likely to further accelerate in the future. To make digital payments more convenient, the Eurosystem has recently developed the Target instant payment settlement (TIPS) service. From November 2018 onwards, TIPS will offer payment service providers final and irrevocable settlement in central bank money in real time and around the clock, 365 days a year. This will provide the basis for new and better payment services offered to end-users, such as instantaneous person-to-person mobile payments. The significant increase in the convenience and speed of euro payments will likely contribute to a further rise of digital payments in the European Union.

While modern deposit money is mostly digital, as of today there still exists no digital form of official (central bank issued) currency. When we seek to transfer money online, for example to pay for our online shopping, we have no choice but to use the services offered by private financial intermediaries such as commercial banks and payment card providers. In addition, digital payments cannot be made truly anonymously, as the identities of senders and receivers of deposit money need to be known by the banks acting as financial intermediaries. This lack of anonymity, together with a loss of trust in the banking system in the midst of the global financial crisis, has recently spurred a private initiative to establish a decentralized electronic cash system: Bitcoin.

8.3. CRYPTOCURRENCIES

While private initiatives to create digital money on the technological basis of cryptography have already been explored as early as in the late 1980s, Bitcoin was the first cryptocurrency to become widely known among the general public. Bitcoin was introduced in late 2008 first to a small community of cryptographers and IT specialists, by publication of a white paper explaining its key working principles (Nakamoto, 2008). The scientific paper was accompanied by the open source client software Bitcoin core, which allows users to exchange Bitcoin tokens and engage in activities to create new tokens. At the time of this writing

(July 2018), more than 17 million Bitcoins have been created and the market capitalization of Bitcoin amounts to approximately 100 billion EUR.

Moreover, during the recent years, hundreds of other crypto-coins (so-called Altcoins) have been developed, some of which have turned out successful in raising investor funds and maintaining high market prices. The total market capitalization of all crypto-coins together today amounts to roughly 240 billion EUR. The five largest players on the crypto-coin market (Bitcoin, Ethereum, XRP, Bitcoin Cash and EOS) account for three quarters of this amount.

The Bitcoin system is a combination of different technological components, which allow for the creation of units of value that are privately issued, digitally represented and operated in a decentralized way (see Berentsen and Schär, 2017). It combines cryptographic techniques to ensure the legitimacy of transactions and to avoid double spending. It uses economic incentives and strategic reasoning to implement a public register of all Bitcoin transactions, the Bitcoin blockchain, which every user of the system can access. The public character of the blockchain requires a sophisticated consensus protocol, implemented in the function of so-called Bitcoin mining, to ensure that everybody can agree on the current state of the register. The need for the consensus protocol arises from the deliberate exclusion of a central authority in the issuance and operation of money. This deliberate exclusion comes at a price. The operation and maintenance of a public blockchain is expensive (see Budish 2018). We will not give a detailed description of the Bitcoin system here but refer the interested reader to the literature for more details (see, Böhme et.al. 2015, Narayanan 2016, Berentsen and Schär, 2017, Pichler, Schierlinger-Brandmayer and Summer, 2018).

Do privately issued cryptocurrencies such as Bitcoin or Ethereum constitute the new and modern face of money today? To discuss this question in an economic context we need to look at the three fundamental economic functions of money: being a widely accepted medium of exchange, a store of value, and a unit of account. Do private cryptocurrencies fulfill these three functions?

Looking at the current situation, the obvious answer to this question is no. First, while cryptocurrencies do technically allow users to exchange value over the internet, they are certainly far from being widely accepted today by the general public as a means of payment. It is still almost impossible to use Bitcoins, let alone other crypto-coins, for daily purchases of goods and services, except maybe at some small online shops and retailers which arguably accept these currencies mostly for marketing reasons. Second, due to their extremely volatile prices, cryptocurrencies do not function well at all as a store of value. In fact, their inherent volatility makes cryptocurrencies attractive as a means of financial speculation rather than a means of payment. Indeed, empirical evidence suggests that most owners of cryptocurrencies today hoard their coins hoping for further

price increases in the future rather than using them to make purchases. Finally, hardly anywhere one can see prices of goods and services being denominated in units of cryptocurrencies, i.e. these currencies are not being used as a unit of account. To conclude, privately issued cryptocurrencies clearly do not perform the three economic functions of money today, and hence do not qualify as money in the economic sense of the term.

There are also good reasons to believe that private cryptocurrencies based on public blockchain technologies will never be able to perform all three functions of money well. One reason is their limited scalability. Fully decentralized cryptocurrencies such as Bitcoin are necessarily slow in processing transactions and have limited capacity. This is because, to reach consensus, the current version of the ledger must be exchanged ideally among all users globally before any new transactions are processed. Instantaneous online payments, which are soon possible in Europe with the full introduction of TIPS, will hence never be possible with fully decentralized cryptocurrencies like Bitcoin. This will limit their attractiveness as a means of payment also in the future. From the perspective of the payment system, cryptocurrencies such as Bitcoin are thus highly inefficient compared to the systems in place at the moment: they are slow, limited in scale and, if the externalities imposed by the high energy consumption of the consensus protocol are taken into account, very expensive. The core idea of the public blockchain, the deliberate exclusion of a central authority in the creation and operation of money, makes it obviously also an unsuitable technology for central bank issued digital currencies.⁴

8.4. CENTRAL BANK ISSUED DIGITAL MONEY

The public hype for cryptocurrencies and the blockchain technology has also spurred a growing international debate about central banks issuing digital currency (CBDC). The key question addressed in this debate is whether the state should provide to its citizens an official digital means of payment similar to banknotes and coins, so that online payments do not necessarily have to go through private financial intermediaries.

A recent discussion paper by the Bank of Canada, Engert and Fung (2017), provides an in-depth overview over possible motivations for a central bank to issue digital currency and explores the possible implications of such a step, assuming that the central bank issues digital currency in addition to coins and

⁴ This does, however, not mean that cryptocurrencies based on public blockchains cannot have a meaningful economic role in the future. Pichler et al. 2018 argue that the future economic role of cryptocurrencies is strongly linked to the future economic potential of fully decentralized public blockchain applications. In this context cryptocurrencies find their most natural role.

banknotes (and central bank reserves) rather than as a replacement of those. According to the authors, there are six possible reasons why a central bank might want to make CBDC available to the general public: (i) to ensure adequate central bank money for the public and preserve central bank seignorage revenue; (ii) to reduce the lower bound on interest rates and support unconventional monetary policy; (iii) to reduce aggregate risk and improve financial stability; (iv) to increase contestability in payments; (v) to promote financial inclusion; and (vi) to inhibit criminal activity.

With a view on advanced economies and in particular Canada, Engert and Fung (2017) consider only one of these six possible reasons to be plausible and well-founded: increasing contestability in payments. Providing a digital alternative to banknotes, cheques, debit cards and credit cards, they argue, may likely increase competition and improve the efficiency of the existing payment systems. The remaining five possible reasons are not viewed as compelling. The supply of adequate central bank money for the public and central bank seignorage revenue are both not at risk in most advanced economies, since the value of banknotes outstanding is not declining. Supporting unconventional monetary policy and promoting financial inclusion can be achieved by means other than CBDC in a potentially better way. Finally, according to the authors, the effects of CBDC on financial stability and criminal activity are ambiguous *a priori*, and likely depend on the specific attributes of CBDC.

The international debate is mostly focused on two different possible implementations of CBDC, reflecting the two popular faces of money we have discussed in the beginning of this article. The first implementation closely mimics physical currency. Proponents of this implementation envision CBDC to become a legal tender, be denominated in the local currency and convertible at par to bank notes and deposits with unrestricted access around the clock for all citizens, be anonymous and be non-interest-bearing. The second implementation more closely mimics banks deposits. Notably, the central bank is then assumed to pay interest on its digital currency, or even earn interest when it sets negative interest rates.

Regarding the desirability of introducing currency-like CBDC, Engert and Fung (2017) conclude that there will likely be no significant implications for central bank seignorage revenue, monetary policy or the banking system. There may be some efficiency gains in retail payments, but on the other hand currency-like CBDC would also facilitate criminal activity due to the anonymity features it would provide, which in turn would bring about social costs. Regarding the desirability of introducing deposit-like CBDC, Engert and Fung (2017) arrive at a very similar conclusion. Monetary policy will hardly be affected also by interest-bearing CBDC, as the interest rates paid on reserves and CBDC will likely be

similar due to arbitrage opportunities. However, they caution that interest-bearing CBDC might lead to a modest contraction of intermediation and increased financial volatility; that households and firms can more easily shift from bank deposits to CBDC in times of stress may present a challenge to financial stability.

Overall, the analysis by Engert and Fung (2017) suggests that the case for introducing CBDC in most advanced economies is not very strong. This assessment is currently shared by most central banks including the BIS, the FED, and the Bank of Australia, among others. A notable exception, however, is the Swedish Riksbank. Unlike in most advanced economies, currency in circulation in Sweden has steadily declined over the past decade. As Sweden is moving towards a cashless society, the Riksbank has launched a project aimed at examining whether the krona should not only be issued in physical form but also in an electronic form, referred to as the e-krona. The e-krona would not replace cash but rather act as a complement to cash, with the main benefit being that “by functioning independently from the infrastructure used by the commercial bank system, the e-krona system could also make the payment system more robust in the event of disruptions to, for instance, the system for card payments” (Riksbank, 2017). While it is not yet clear on what technology the digital currency would be based, for example whether it would be based on a blockchain technology, the main working principles of a potential e-krona have already been agreed upon. For example, the e-krona would be primarily intended for smaller payments between consumers, companies and authorities, and it would constitute a direct claim on the Riksbank that does not accrue any interest. The Riksbank’s investigation into the topic is expected to be finalized by the end of 2019, with one potential outcome still being that the Riksbank could decide not to issue an e-krona at all.

8.5. CONCLUSIONS

Most of the money we use on a day-to-day basis is held in accounts at commercial banks. This money is digital money and uses advanced and modern technology to make payments. Online transfers of money, however, today have to rely on the services offered by private financial intermediaries such as commercial banks and payment card providers. Moreover, unlike when using physical currency, digital payments cannot be done truly anonymously, as the identities of senders and receivers of deposit money need to be known by the banks acting as financial intermediaries. This lack of anonymity, together with the need trust in the banking system, has spurred a recent discussion about whether the issuance of digital currency by central banks similar to banknotes and coins would provide an improvement over current monetary arrangements. At the moment, the cons

of such a step seem to outweigh the pros, i.e. the case for issuing central bank issued digital money at the moment does not seem to be particularly strong.

REFERENCES

- Berentsen, Alexander, Schär Fabian, 2017, “Bitcoin, Blockchain und Kryptoassets”, Universität Basel.
- Böhme, Rainer, Christin Nicolas, Edlman, Benjamin, Moore Tyler, 2015, “Bitcoin: Economics, Technology, and Governance”, *Journal of Economic Perspectives*, 29, 2, pp 213-38.
- Budish, Eric, 2018, “The economic limits of the blockchain”, url: <http://faculty.chicagobooth.edu/eric.budish/research/Economic-Limits-Blockchain.pdf>
- Engert, Walter, Fung, Ben, 2017, “Central Bank Digital Currency: Motivations and Implications”, Bank of Canada Staff Discussion Paper.
- Jobst, Clemens, Stix, Helmut, 2017. “Doomed to Disappear? The Surprising Return of Cash Across Time and Across Countries,” CEPR Discussion Papers 12327, C.E.P.R. Discussion Papers.
- Hellwig, Martin, 2018. “Bargeld, Giralgeld, Vollgeld: Zur Diskussion um das Geldwesen nach der Finanzkrise”, *Zeitschrift für das gesamte Kreditwesen*, vol. 8, pp. 37-41.
- Narayanan, Arvind, Bonneau, Joseph, Felten, Edward, Miller, Andrew, Goldfeder, Steven, 2016, *Bitcoin and Cryptocurrency Technologies*, Princeton University Press.
- Pichler, Paul, Schierlinger-Brandmayer Alexander, Summer Martin, 2018, “Digital Money”, *Monetary Policy and the Economy*, 3.
- Riksbank, 2017. “The Riksbank’s e-krona project”. url: <http://www.riksbank.se/en-gb/financial-stability/Payments/e-krona/the-e-krona-projects-first-interim-report/>

9. CENTRAL BANK DIGITAL CURRENCY: WHAT DIFFERENCE DOES IT MAKE?¹

*Dirk Niepelt*²

I offer a macroeconomic perspective on the “Reserves for All” (RFA) proposal to let the general public use electronic central bank money. I argue that a marginal substitution of outside for inside money does not affect macroeconomic outcomes if conditions on bank and government (central bank) incentives are met; and that these conditions likely are violated. I relate my analysis to common arguments in the discussion about RFA and point to inconsistencies and open questions.



9.1. INTRODUCTION

Far into the twentieth century central banks commonly offered accounts not only to a select group of financial institutions but also to non-banks. This liberal approach has given way to a monetary arrangement where the general public typically uses only one form of central bank issued money, namely cash. Access to electronic central bank money – “reserves” – generally is restricted to financial institutions whom the central bank interacts with to implement monetary policy. When households or non-financial firms pay electronically they use privately issued money (e.g., bank deposits), not central bank money.

The advantages and disadvantages of this monetary arrangement are the subject of an intensifying debate which takes place against the background of fundamental changes in the financial system (including technological innovations, the entrance of new players [“fintech” and “bigtech”], new payment systems) as well as questions about the future of cash and interest in private digital tokens like Bitcoin. At the same time, the debate testifies to a loss of trust in traditional banks after the recent financial crisis and an increasingly critical attitude towards their role in money and credit creation. While this attitude has only recently gained prominence in the political arena – most notably in the Swiss constitutional referendum on “Vollgeld” (sovereign money) – it is much older and precedes the recent changes in technology and market structure.

¹ This text is an abbreviated version of CEPR Discussion Paper 13065 (see www.niepelt.ch/research/reserves-for-all-central-bank-digital-currency-deposits-and-their-non-equivalence-cepr-2018/). For more detailed discussions, references, and the bibliography, please refer to the discussion paper.

² Study Center Gerzensee; University of Bern; CEPR; CESifo; www.niepelt.ch.

In this note, I offer a macroeconomic perspective on the implications of letting the general public access central bank money in electronic form – “Reserves for All” (RFA). I do not emphasize technological aspects. Instead, I focus on the key macroeconomic question of interest, namely the difference between bank issued “inside” and central bank issued “outside” money, e.g., RFA.

After distinguishing the RFA proposal from related, but conceptually different proposals to introduce narrow banks or restrict the use of cash, I lay out an equivalence result according to which a substitution of outside for inside money is neutral: When a fiscal-monetary policy implements an “initial” equilibrium with inside money then an alternative fiscal-monetary policy with more outside money and with transfers implements a “new” equilibrium with the same allocation and prices and less inside money. This suggests negligible macroeconomic effects of RFA.

But as I also discuss, the neutrality proposition relies on conditions relating to bank and government (central bank) incentives which are likely violated. Against this background I assess the plausibility of various suggested implications of RFA, including effects on financial stability, national saving and investment, and the conduct of monetary policy. I conclude that some suggested implications are at odds with my analysis and that the policy discussion so far has been missing important elements.

9.2. RESERVES FOR ALL

I adopt a broad perspective. Rather than restricting attention to central bank monies based on cryptocurrencies or other specific technologies I consider arbitrary forms of centrally managed, electronic central bank money. The key aspect I am interested in is universal access that is, the possibility for the general public to use electronic central bank money. The system I consider, then, is a system where reserves serve as unit of account, store of value, and means of payment not only for institutions in the financial sector, as they do today, but also for households and firms outside of that sector.

With this focus on universal access in mind I do not take a stance on technical aspects such as whether payments would be made using a traditional payment system or a distributed ledger; and whether RFA would be held in a central bank account; an off-balance-sheet account managed by a service provider on the basis of a public-private partnership; or on a prepaid card. From a macroeconomic perspective these considerations are of second or third order even if they are of first-order importance for many operational, legal, and technical questions.

The proposal to make central bank issued digital money accessible to the general public in order to provide a partial substitute for cash on the one hand and bank deposits on the other dates back a long time. Most notably, Tobin (1985, 1987) promotes the idea. Recent discussions include Groff (2013), Koning (2014), and Niepelt (2015). Many additional contributions discuss RFA against the background of proposals to relax the effective lower bound on interest rates, see the discussion below.

9.3. RELATED DEBATES

Proposals to introduce RFA often are combined with suggestions to introduce narrow banking or restrict cash use. These three proposals are logically distinct.

9.3.1. Narrow Banking Proposals

Many economists, central bankers, and practitioners voice concerns that the ability of commercial banks to “transform maturity” and create money causes fragility and instability.

The “Chicago plan” from the 1930s proposes to end fractional reserve banking and thus, to separate credit from money creation. Similarly, the Swiss “Vollgeld” initiative proposes a complete ban on private money creation.

Kay (2009) argues that financial regulation and supervision in the run-up to the recent financial crisis has failed and that complex regulatory frameworks should make way for simple structural rules and a “firewall between retail deposits and other liabilities of banks.” Kotlikoff and Goodman (2009) and Kotlikoff (2010) go further and propose a system of “Limited Purpose Banking,” in which financial intermediaries are reduced to managers of equity financed mutual funds invested in financial assets. Melaschenko and Reynolds (2013) propose a resolution mechanism that shares features of equity financing.

King (2016) proposes that all short-term bank liabilities should be covered by liquid assets and a central bank credit line that depends on the quantity and quality of assets lodged at the central bank to serve as collateral when needed.

McMillan (2014) emphasizes that many proposals to implement narrow banking restrictions pose the problem that they require regulators to distinguish between financial and non-financial companies, which could be difficult in practice; as a consequence, banks might circumvent the restrictions. As a solution to this problem, McMillan (2014) proposes a rule according to which the market value of *any* company’s real assets always must exceed the value of its liabilities that is, financial assets always are financed by equity.

These proposed arrangements differ from RFA because RFA does not directly constrain the business model of banks or their ability to create inside money. RFA simply provides the public with an electronic means of payment that serves as an alternative to deposits and other forms of private money.

9.3.2. Proposals to Abolish Cash

Proposals to abolish cash or eliminate large denomination typically derive from two motivations. First, to increase the cost of criminal, black market, or money laundering activities as well as tax evasion (see for example Rogoff, 2016). And second, to enlarge the set of monetary policy options.

How convincing the first motivation is, is a matter of debate. The extent to which cash use fosters crime and illegal activities is unclear, as is the trade-off between the benefit of crime reduction and the cost that cash restrictions create for legitimate activities. (Abolishing cash could also negatively impact financial literacy.) Moreover, restricting cash use would (further) undermine privacy – and privacy has both private and social value (Kahn, McAndrews and Roberds, 2005). In any case, abolishing cash would be difficult because in a free society, any government-led reform of the monetary system is constrained by the requirement that government money must remain attractive for its users.

The second motivation has deficiencies as well. Its starting point is the observation that banks issuing deposits cannot lower the deposit rate significantly below zero without risking large scale cash withdrawals and thus, the stability of the institution. The effective lower bound on the deposit rate implies, in turn, an effective lower bound on the central bank's policy rate unless the central bank is willing to accept a compression of the interest rate spread earned by financial institutions, with negative consequences for bank profitability and potentially, financial stability.³ An abolishment or taxation of cash, or restrictions on its use would limit the outside options for depositors and this would open the way for more aggressive monetary policy interventions.

But a more aggressive monetary policy stance is possible, in principle, even without legal restrictions on cash use. Goodfriend (2000) proposes a carry tax on monetary liabilities – effectively a negative interest rate on cash – to relax the lower bound on deposit rates. Buiter (2009) identifies the bearer security nature of currency (i.e., the fact that the owner of cash remains anonymous) as the fundamental cause of the lower bound on nominal interest rates. He proposes two alternative strategies in addition to taxing currency (which poses incentive

³ The compression is moderated when the central bank only charges negative interest on balances that exceed exemption thresholds, as is current practice in Switzerland.

problems), to relax the bound. First, to abolish currency. And second, to float the exchange rate between cash and reserves. In the process, the medium of exchange and unit of account functions of money would be unbundled. Monetary policy would be conducted as usual by setting interest rates on reserves but positive (negative) interest rates on reserves would be associated with an appreciation (depreciation) of cash.

In conclusion, the RFA proposal is fundamentally unrelated to the question of whether cash should be abolished or its use discouraged. Even if RFA were motivated by the aim to empower monetary policy this could be achieved without abolishing cash or restricting its use.

9.4. EQUIVALENCE

To organize the discussion of possible consequences of RFA, I propose a neutrality result according to which inside money is irrelevant from a macroeconomic point of view. An implication of the result is that the introduction of RFA and its substitution for inside money does not have macroeconomic consequences. After laying out the logic of the argument in this section I subsequently turn to a discussion of key assumptions underlying its validity. Thereafter, I confront the findings with arguments commonly made in discussions about RFA.

The neutrality result is in the spirit of Modigliani and Miller (1958), Barro (1974), Wallace (1981), or Chamley and Polemarchakis (1984). Its purpose is to provide a benchmark, not the most realistic description, in order to identify key conditions for neutrality and thus, potential sources of *non*-neutrality. The macroeconomic perspective I adopt leads me to emphasize the economy's aggregate balance sheet (or consolidated intertemporal budget constraint). This contrasts with partial equilibrium intuitions inspired by models in the tradition of Diamond and Dybvig (1983) which underlie many arguments in the debate.

The basic intuition for the result is as follows: Inside money serves various functions in the non-bank sector. RFA, possibly accompanied by fiscal interventions, can also serve these functions. Inside and outside money thus can be substituted against each other, subject to appropriate fiscal interventions, without macroeconomic consequences.

Money serves as a unit of account; a means of payment to mitigate the double coincidence of wants problem; and thus, also as a store of value. Since central bank money – cash or reserves at the central bank – serve as the unit of account a substitution of outside for inside money does not affect the first of the mentioned functions. I therefore focus on the role of money as a store of value or means of payment. Moreover, I restrict attention to inside money – bank deposits

– that are not “backed” by outside money in the banks’ balance sheets (that is, I focus on the deposits that drive the money multiplier above one). The share of inside money that is “backed” by outside money could be taken off the banks’ balance sheets and thus, replaced by outside money without macroeconomic consequences.

9.4.1. Store of Value

Money serves as a store of value because it is a financial claim. But this claim does not affect aggregate wealth. An economy’s wealth comprises the assets in the consolidated balance sheet, representing the economy’s productive capacity, endowments, and net external assets. The liability side of the consolidated balance sheet determines how this wealth is apportioned and distributed among the various sectors and agents in the economy, but it does not affect its size (*cf.* also Modigliani and Miller, 1958). Whether the central bank issues outside money or the banking sector inside money thus is irrelevant for aggregate wealth.

The composition of the stock of money might, however, be relevant from a distributional point of view, for example because inside and outside money have different payment characteristics, or because their tax treatments differ. These distributive implications of a substitution of outside for inside money can be sterilized by appropriate state contingent transfers.

A counterargument to this reasoning emphasizes “crowding out,” namely the fact that for given private sector saving, additional public sector debt issuance (including outside money issuance) reduces the share of private saving that funds physical investment. When inside money (which is an asset and a liability of the private sector) does not increase private sector wealth but outside money (which is an asset of the private sector but a liability of the public sector) does, as the counterargument asserts, then inside money creation is associated with a smaller wealth effect in the private sector than outside money creation and as a consequence, with less aggregate consumption and crowding out.

This counterargument neglects the fact that the economy’s consolidated balance sheet includes the public sector that is, the public sector’s net worth is a component of national wealth. Since the private sector “owns” the public sector as taxpayers ultimately are responsible for covering public sector deficits, public debt (including outside money) does not increase private sector net worth (Barro, 1974), and this implies that inside and outside money do not have differential aggregate wealth effects. Of course, with heterogeneous groups in society (e.g., different cohorts), crowding out does occur to the extent that debt issuance and the associated change in the timing of taxation redistributes the tax burden across groups with different marginal propensities to save (Diamond, 1965; Niepelt,

2004). But this redistribution can be offset by appropriate transfers between the affected groups.

9.4.2. Means of Payment

To assess whether outside money can substitute for inside money as a means of payment consider the extreme case of a complete replacement that is, a requirement that all payments must be conducted using central bank money. Holding velocity constant, this would require that the share of deposits currently used for payments (rather than held for precautionary reasons) was replaced by central bank money, for example by having banks sell a corresponding amount of assets to the central bank in exchange for reserves.

In effect, banks would replace loans or other financial assets on their balance sheet with reserves and as a consequence, the share of deposits currently used for payments would be fully “backed” by these reserves – a situation akin to having non-banks use reserves as means of payment. Equivalently, households would substitute RFA for deposits and the central bank would provide loans to the banks that are secured by bank assets. In either case, the quantity of central bank money would increase relative to the situation before the financial crisis when banks held few reserves in excess of what was needed to settle *net* payments between them. And the degree of “maturity transformation” in the banking sector would be reduced.

The more limited extent of “maturity transformation” would have distributive implications because banks would earn a lower spread on their assets net of liabilities. To offset these implications the central bank would refund to the banks the seignorage profits that banks generate in the current setting but would lose under the new balance sheet structure. Banks’ profit streams thus would remain unchanged. As would be the process of credit extension. Banks would continue to screen and select projects that receive financing before selling the loans on to the central bank or financing them with central bank funding. At no time would the central bank be in the business of directly extending credit to the “real” economy.

The modified balance sheet structure of banks and the compensating transfers from the central bank would render explicit what is implicit in the current monetary system: The implicit lender-of-last-resort (LOLR) guarantee provided by the central bank; and the value of that guarantee.⁴

⁴ Again, there are parallels to public debt whose dominant component in many countries is implicit.

One might argue that the central bank's implicit LOLR guarantee is much smaller than suggested above, because LOLR assistance is granted only occasionally, and in amounts that are much smaller than the share of deposits used for payments. But this is not clear. The current monetary system relies on the strong perception in the non-bank sector that inside money constitutes a secure claim on central bank money. The deposit insurance system and more importantly, actual LOLR assistance in crisis times; bank supervision; and various other types of assurances by government foster this perception of a fixed exchange rate between inside money in the regulated banking sector and outside money.

If the perception indeed was wrong, and the assurances misleading, then the implicit guarantee would indeed be smaller than suggested. A neutral substitution of outside for inside money then would require, not an unconditional sale of assets to the central bank (or secured borrowing from the central bank) but rather a contingent "liquidity line."

9.4.3. Equivalence Proposition

I have argued that both from an aggregate balance sheet point of view and as far as money's means-of-payment function for the non-bank sector is concerned, starting from an equilibrium, a substitution of outside for inside money accompanied by appropriate transfers leaves macroeconomic outcomes unaffected.⁵ I have not argued, however, that this substitution is consistent with optimality on the part of the parties that issue money, namely the central bank and commercial banks (see below). The neutrality proposition suggested by the preceding discussion thus is a conditional one. Related, I have also not argued that arbitrary compositions of money can be implemented as equilibrium outcomes. (See the discussion paper for a formal statement of the proposition.)

Note that an immediate implication of the proposition is that the introduction of RFA is neutral as long as reserves perform the same payment functions for non-banks as deposits do. Note also that the result can be extended to cover stochastic environments.

9.5. NON-EQUIVALENCE

The result proposed above suggests that key conditions related to incentives have to be satisfied for equivalence to prevail and thus, for a partial substitution of outside for inside money to have no macroeconomic consequences.

⁵ The prices of commodities, financial claims, and "liquidity" in the two equilibria are the same as well.

9.5.1. Bank Incentives

A general argument against the irrelevance of a firm's liability structure relates to the fact that this structure affects the incentives of owners or managers. Similarly, changes in the balance sheet structure of banks might undermine, or strengthen incentives and this might affect the equilibrium allocation.

Most importantly, the incentives for banks to exert sufficient screening and monitoring efforts might suffer. A substitution of reserves for loans on the asset side of banks' balance sheets might give rise to an "originate-to-distribute" business model in which banks extend credit to non-banks before selling the loan to the central bank. This might reduce incentives to carefully screen projects and could have important negative medium- and long-term effects on the economy's development. It could also affect the wealth distribution between the public and private sector (central bank vs. commercial banks).

How strong these effects would be, and whether they would indeed result in weaker incentives is unclear as this would depend on the regulatory framework. After all, depositors do not currently play any meaningful monitoring role but rely on the efforts of the central bank, the banking supervisor, the deposit insurance agency, the consumer protection agency, etc. The latter actors would continue to be active in their present roles and in particular, the central bank would have even stronger incentives than today to supervise banks' lending practices as it would acquire (or accept as collateral) more bank loans than in the present system.

In conclusion, there is a case to be made for changed incentives as a consequence of modified bank balance sheet structures, but the exact form and implications are far from clear and certainly strongly dependent on the regulatory environment.

9.5.2. Government Incentives

The neutrality proposition envisions an exogenous new fiscal-monetary policy. It thus abstracts from politico-economic frictions and assumes commitment. Both assumptions are unrealistic.

Consider first the political support for transfers. I have argued above that a neutral change of fiscal-monetary policy would render the implicit LOLR guarantees provided by the central bank as well as their values under the current monetary arrangement explicit. But it is unlikely that the beneficiaries of these guarantees, once made explicit, would continue to be able to muster the same political support. In other words, the equivalent fiscal-monetary policy most likely would not be an equilibrium policy. In politico-economic equilibrium, the

now explicit support by the central bank could rise or fall and as a consequence, payment related services could become cheaper or more expensive.

Which of these two outcomes would be more likely depends, among other factors, on the degree of competition in the banking system. When competition is high bank customers rather than shareholders benefit from the implicit central bank subsidy in the current system, and increased transparency coupled with the political influence of, e.g., small and medium sized enterprises might strengthen the political support for central bank support. When competition is low, in contrast, such that the shareholders of banks are the major beneficiaries of central bank support in the current system, then it seems more likely that increased transparency would weaken the political support for banks and their customers and as a consequence, payment related services would become more expensive. This would be associated with lower distortions, however.

The political support would also change for other reasons. Policy choices under commitment typically are not time consistent because the incentives of a government change over time as macroeconomic outcomes that are endogenous *ex-ante* turn into *bygones ex post* (Kydland and Prescott, 1977). The initial, equilibrium fiscal-monetary policy in the current policy regime with inside money *is* time consistent, by assumption, and reflects the *ex-post* incentive compatibility constraints faced by political decision makers. In a different policy regime with less inside and more outside money, these incentive compatibility constraints would change if the state variables that determine the choice set of political decision makers evolved in different ways.

It seems likely that this would be the case. At the source of the *ex-post* incentive constraints in the current regime is the fact that private money creation puts the central bank at a second mover disadvantage, effectively forcing it to serve as LOLR during liquidity crises to safeguard the payment system, or even as provider of bailout funds in solvency crises.⁶ According to the neutrality result, the equivalent fiscal-monetary policy would be associated with transfers, including from the central bank to banks (or their customers), and according to the discussion above, these transfers would likely become politically unsustainable once made explicit. As a consequence, bank equity and other state variables would evolve differently and the *ex-post* optimal government choices in the new regime with less inside and more outside money would differ from the equivalent fiscal-monetary policy.

⁶ While the incentive constraints in the current arrangement tend to increase liquidity and financial support for banks this need not result in excess profits in the financial sector. Depending on the degree of competition, bank customers may be the main beneficiaries. Nevertheless, such support distorts prices, with negative welfare implications.

A different source of potential non-neutrality concerns the central bank's asset management. Under the assumptions underlying the neutrality result the central bank purchases additional assets from the banking sector but it does not directly intervene in the process of credit allocation. Whether this would be incentive compatible *ex post* is questionable. It is well conceivable that an extension of the central bank balance sheet would lead fiscal policy makers to impose additional constraints on the central bank, for instance to require the bank's investment policy to meet certain "ethical," "social," "ecological," or other standards. In short, credit extension could become more politicized and this might change aggregate investment.

In conclusion, the political support for the equivalent fiscal-monetary policy would likely differ from the support enjoyed by policy in the current regime and as a consequence, the equivalent policy would not be time consistent. While it is impossible to gauge the properties of the new equilibrium policy outside of a formal model it appears likely that increased transparency would give rise to reduced transfers and less distortions.⁷ At the same time, the risk of political interference with the credit allocation process would likely increase.

9.6. OTHER IMPLICATIONS

I review common arguments in the debate on RFA against the background of the previous discussion.

9.6.1. Financial Stability

Many commentators argue that the risk of bank runs – sudden withdrawals of deposits – could increase when bank customers have the option to convert deposits into RFA rather than just into cash. This argument is difficult to make sense of within the analytical framework used so far. After all, the neutrality result starts from the presumption that deposits in the current system are implicitly guaranteed by the central bank, so there is no reason to run in the first place (Diamond and Dybvig, 1983) and even if depositors do run, the macroeconomic consequences are minor as the central bank steps in and implicit guarantees simply are made explicit. The same mechanism would continue to operate in the

⁷ One might argue that distortions are minimized when inside money creation is completely outlawed. But putting a complete stop to inside money creation would likely not be enforceable. Banks and their clients would search for and find, ways to circumvent the legal prohibition and as a result, the central bank might completely lose control over the money supply. The equilibrium policy would become irrelevant. A fundamental problem at the source of non-enforceability is the difficulty to define money and what it means to make a payment.

new regime, on a smaller scale (because some inside money would have been made explicit as a consequence of substituting RFA for deposits).

The discussion abstracted, however, from physical differences between electronic money and cash; and it therefore cannot speak to the fear of differential risk of “running for RFA” as opposed to cash. If such differential run risk exists, is it higher with RFA? One group of commentators suggests that this is the case. The basic idea is that with RFA it becomes easier to shift funds across accounts, and this increases the elasticity of deposit demand. Others are more skeptical. Koning (2018), for instance, retorts that during a confidence crisis bank customers would no longer have to queue to withdraw cash; LOLR support would be provided much more quickly; and large cash holders would continue to shift funds into treasury bills, not into electronic central bank money. As a consequence, the risk of bank runs would decrease rather than increase.

Riksbank (2017) similarly expects the introduction of an e-krona to have limited effects on financial stability as the Riksbank would continue to engage in the usual LOLR policies. It does see the risk, however, that the substitution of outside for inside money could reduce bank profits and thereby affect banks’ stability. This argument assumes that the hidden transfers present in the current system would no longer be present in a system where the central bank’s guarantees are made explicit. As I argued above, this is indeed likely.

9.6.2. Credit

Many commentators also suggest that the substitution of outside for inside money could reduce the volume of credit, with important macroeconomic consequences for investment and growth. According to this argument the fact that many banks rely on deposits to finance their assets suggests that less deposit funding would reduce the flow of credit extended by these banks.

However, this argument disregards both liability substitution and securitization: Deposits may be replaced by other forms of bank debt, and loans might be sold to investors. Under the assumptions underlying the neutrality result banks continue to originate loans even when they have no, or less deposit funding but they sell the loans to the central bank in exchange for reserves or use them as collateral for central bank financing.

As discussed above, the incentive effects of the modified bank balance sheets could lead banks to change their screening and monitoring efforts. But if these efforts indeed weakened and lenders adopted an originate-to-distribute business model then this would likely work in the direction of banks easing credit standards and originating *more* rather than fewer loans. On the other hand, also as mentioned before, political interference with the central bank’s asset

management and thus, the central bank's refinancing of bank loans could distort the credit allocation mechanism.

Another argument suggests that additional outside money creation, and the associated lengthening of the central bank balance sheet, would reduce the amount of assets that the private sector may use as collateral. The validity of this argument depends on whether banks in the current system do not need to provide collateral in exchange for the implicit central bank guarantees and thus, also, on whether they gamble on receiving LOLR resort even without sufficient collateral.

9.6.3. Monetary Policy

According to the neutrality result, an equivalent fiscal-monetary policy *can* in principle be implemented. In line with this argument, Riksbank (2017) expects limited effects on monetary policy (of the basic e-krona version) and Dyson and Meaning (2018) argue that “with careful design choices, a CBDC need not be disruptive to the conduct of monetary policy.”

At the same time, however, as argued earlier, it is questionable whether this equivalent policy would actually be chosen in politico-economic equilibrium. Moreover, a substitution of outside for inside money could change the economic choice set of monetary policy makers, in particular if it were accompanied by restrictions on cash use (a structural change which, as I have argued, is not inherently connected to the RFA issue). As argued by Bordo and Levin (2017), RFA could then “free” the economy from the lower bound and thereby allow monetary policy to focus on price rather than inflation stability (price level targeting) and to implement the Friedman (1969) rule.

9.6.4. Structural Changes

More generally, the introduction of RFA could give rise to many structural changes whose implications far exceed the scope of the equivalence result. For example, RFA could increase competition in the banking sector. On the other hand, RFA could also lead to reduced variety in payment solutions when the greater role played by outside money leads the government to demand more standardization.

RFA might also affect the resiliency of the payment system. In the current regime consolidation and system integration (due to economies of scale) enhance the system's technological fragility. The introduction of a parallel payment system accompanying RFA could counteract that trend and offer significant gains from diversification. It goes without saying that the abolition of cash would be counterproductive from a resilience point of view.

Still other arguments relate to financial inclusion or government oversight over the payment system.

Last but not least, the introduction of RFA would end what appears to be a slightly absurd situation in countries that prohibit citizens from using cash – the only legal tender accessible to the general public – for larger transactions, thereby essentially forcing them to use privately issued money instead. Opening the central bank’s balance sheet to the public would constitute a more liberal approach than restricting access to financial institutions.

9.7. CONCLUSION

The proposal to issue digital central bank money for use by the general public enjoys surprisingly strong support among finance practitioners but equally often faces skepticism, in particular by central bank representatives. A typical line of argument put forward by the skeptics emphasizes that the traditional approach has served the public and the financial system well, and that RFA could have disruptive effects. This argument is not convincing: The “traditional approach” has evolved over the years and will continue to evolve; and in the absence of a clear counterfactual, it is difficult to assess whether it really has worked “well.”

From a macroeconomic point of view, RFA need not have disruptive effects and if it does have such effects, they might well occur in other areas or have different signs than what is typically suggested. For example, RFA could *increase* the incentive to extend credit but might undermine the political support for implicit financial assistance to banks. This suggests that the discussion about digital central bank money could benefit from well-articulated, coherent, formal models that clarify equivalence relations as well as sources of non-equivalence. This paper is a step in that direction. In work in progress (Brunnermeier and Niepelt, 2018) we formalize some of the arguments.

10. CENTRAL BANK DIGITAL CURRENCIES: AN OVERVIEW OF PROS AND CONS

Itai Agur^{1 2}

Various central banks are actively considering forms of digital currency. This note centers on the form that comes closest a digital equivalent of cash, and summarizes the main pros and cons involved in introducing it. Key sets of considerations are: 1) the extent of anonymity of the digital currency, and the associated trade-off between limiting illicit activity and containing the growth of private cryptocurrencies; 2) monetary control and the downward extension of the Effective Lower Bound; 3) financial disintermediation risks.



10.1. TYPES OF DIGITAL CENTRAL BANK MONEY: RECENT DEVELOPMENTS

Digital money comes in different forms that meet diverse needs. Bech and Garratt's (2017) taxonomy of money summarizes the main categories of money in a Venn diagram. This diagram considers whether money is electronic, issued by the central bank, universally accessible, and usable in peer-to-peer transactions. There is a rich array of types within the "electronic" category. These include regular bank deposits and the reserve accounts that banks hold at the central bank. What distinguishes peer-to-peer types of digital money, is that these allow for direct transfer and settlement without a bank-based clearance system. Peer-to-peer digital money can be privately issued, like Bitcoin, but could also be issued as a central bank liability. The latter would constitute a Central Bank Digital Currency (CBDC).

Various central banks are studying the possibility of introducing a universally accessible "retail" CBDC that would be a digital equivalent of cash (Prasad, 2018; Yao, 2018). For instance, the Swedish Riksbank has published a report on retail CBDCs, and is expected to decide in 2019 on the possible introduction of an eKrona (Sveriges Riksbank, 2017). Uruguay has run a successful pilot on a retail CBDC (Bergara and Ponce, 2018). Other central banks, such as the Bank of Canada and the Monetary Authority of Singapore, have run pilots for

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“wholesale” CBDCs, geared at transactions among financial institutions (Bech and Garratt, 2017).

This note centers on retail CBDCs, summarizing their main pros and cons. Retail CBDCs are arguably the most macro-critical type of CBDC. Wholesale CBDCs would constitute a different settlement system among banks, but should not materially affect the broader economy (BIS, 2018). However, only retail CBDCs contain the potential to significantly affect financial stability or the conduct of monetary policy, because they effectively introduce a genuinely new form of money into the economy, one that matches some characteristics of cash and private cryptocurrencies, while potentially also offering new characteristics, discussed below. Table 1 summarizes the main pros and cons of introducing retail CBDCs that are found in the literature. The next section discusses these pros and cons in more detail.

10.2. PROS AND CONS OF RETAIL CBDCs

The disadvantages associated with the growth of private sector cryptocurrencies could be one push factor towards the development of retail CBDCs. Since the advent of Bitcoin in 2009, investment in private sector cryptocurrencies has grown rapidly. Their use as a means of payment remains modest, but even at present volumes they come with significant social costs (He et al., 2016; Pichler and Summer, 2018). First, the extreme volatility of their prices challenges their usefulness as a stable means of payment, and creates some concern about the impact of contagion, especially if investment originates from small retail investors or when leverage is involved. Second, private cryptocurrencies are subject to high operational risk, as highlighted by the collapse of the Mt. Gox Bitcoin exchange in 2014 or the recent hacking of a South Korean cryptocurrency exchange. Third, the computationally-intense processes creating cryptocurrencies impose a large environmental burden: Bitcoin mining alone is estimated to use as much power as the country of Singapore, at present (Carstens, 2018). Fourth, cryptocurrency ownership and use is effectively anonymous, as accounts can be made under fake names, raising AML/CFT concerns. Fifth, cryptocurrencies face a problem of scalability, because each transaction is recorded on the ledger that all users in the system are sent, implying a network that grows exponentially in the number of transactions (Roubini and Byrne, 2018). Sixth, if in the future private cryptocurrencies were to become a significant part of the payment system, their effect could be similar to dollarization of an economy, involving a loss of a central bank’s monetary control, emergency liquidity provision and seigniorage. While several countries have begun restricting or banning private cryptocurrencies, most countries retain a neutral or open regime towards them. Hence, one incentive that

central banks may have to develop a retail CBDC is to limit demand for private cryptocurrencies.

Retail CBDCs may counter private cryptocurrencies, although to do so, CBDCs may need to inherit the challenges associated with offering a degree of anonymity. An essential feature of physical cash is its anonymity. A preference for anonymity does not necessarily stem from a desire to conduct illicit activities (Bech and Garratt, 2017). Yet, one major externality of anonymity is that it can promote illicit activities (Rogoff, 2016). A stable, trusted, and fully anonymous CBDC could be ideally suited for illicit transactions. Instead, if CBDC transactions are made fully public, the CBDC may fail to contain the demand for private cryptocurrencies, and may raise concerns about excessive state monitoring (Raskin and Yermack, 2016). However, anonymity is a spectrum, not a discrete choice. Under an intermediate option, users do register with their national IDs to create CBDC accounts, but those accounts are kept anonymous unless transactions are larger than a certain threshold, or judicial authorities have reason to suspect an account is associated with illicit activities.

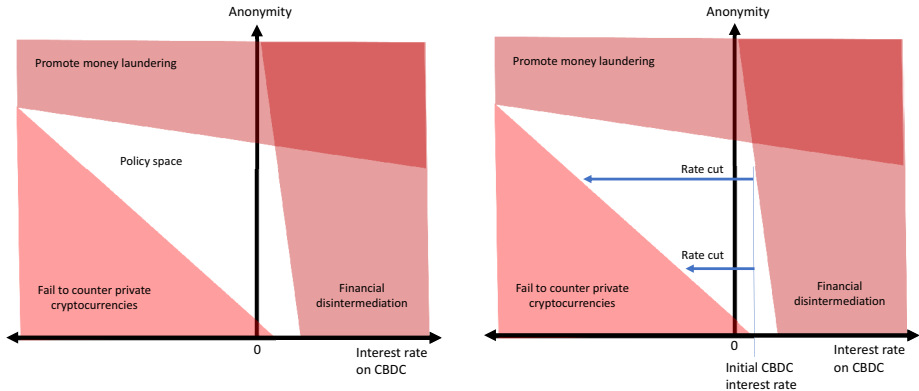
CBDCs are not merely a “Bitcoin-repellent”, however, and can be a natural next step in the development of money. Although some societies, like Sweden and Denmark, have become nearly cashless, in most countries there remains an intrinsic demand for cash (Judson, 2018). CBDCs are a natural extension of cash to the digital realm (Bech and Garratt, 2017). CBDCs can be less costly than cash, which has a high printing and maintenance cost (Ponce, 2018). CBDCs may also offer efficiency gains in certain realms, like international transactions, where settlement through correspondent banking relationships can be slow.³

If retail CBDCs are interest bearing, they can also improve monetary control. Cash is constrained to a zero nominal return. This feature is the foundation of the effective lower bound (ELB) on monetary policy, because if bank deposit rates become too negative, depositors can always switch to cash. In the aftermath of the Global Financial Crisis, the ELB has played a crucial role, arguably providing the impetus for the use of unconventional monetary policies. Moreover, the decline in neutral rates among advanced economies, raises the specter of recurring ELB problems in future recessions. Retail CBDCs can be designed to offer adjustable interest rates, which can go into negative territory, possibly creating the potential to overcome the ELB (Haldane, 2015; Goodfriend, 2016). Agarwal and Kimball (2015) have argued that a time-varying cash conversion fee can allow CBDCs to eliminate the ELB, even with continued presence of cash. Bordo and Levin (2017) make a similar argument, and contend that interest-bearing

³ The list of potential motivations for considering retail CBDCs also includes maintaining seigniorage, promoting financial inclusion, and increasing contestability in payments (Engert and Fung, 2018).

CBDCs can improve monetary policy effectiveness in normal times too, by strengthening the currency’s unit of account function.

Figure 1: Conducting monetary policy with CBDCs: constraints on the policy space



A lower bound constraint can also emerge from competition from private cryptocurrencies or political pressure. To the extent that countering private cryptocurrencies is an aim of retail CBDCs, the central bank may still face a type of ELB, even if the free convertibility of cash were curtailed. The demand for private cryptocurrencies depends on the alternatives that are available to such currencies (Hendry and Zhu, 2017). A CBDC that is fully anonymous and has a zero nominal return is almost certainly more attractive than a private cryptocurrency (outside of speculative motivations to purchase private cryptocurrencies). Instead, negative rates and/or reduced anonymity of the CBDC can raise the demand for private cryptocurrencies. This is represented by the lower left shaded area in Figure 1. This figure qualitatively relates the policy space of a monetary authority to the constraints that it may consider relevant. Offer too much anonymity and the CBDC may accidentally promote illicit activities. But a combination of low anonymity and low or negative interest rates could fail to counter private cryptocurrencies. If this consideration is important enough, the ELB becomes dependent on the CBDC’s extent of anonymity, as seen in the right pane of Figure 1.⁴ In addition, consumers may be inherently averse to a negative return on digital cash, being used to guaranteed nominal returns on physical currency. If so, politicians may face pressure to appoint central bank governors who are sensitive to such concerns, and would not easily cut CBDC rates into deeply negative territory.

⁴ The extent to which consumers value anonymity is an active research question (Athey, Catalini and Tucker, 2017; Borghonovo et al., 2018; Masciandaro, 2018).

Interest rates on retail CBDCs will also have to be carefully geared to avoid financial disintermediation effects. If cash earned a positive interest rate, bank deposits could be at serious risk of depletion. A similar concern applies to interest-bearing CBDCs. Banks could try and compete by raising deposit rates and, to the extent they possess market power, lending rates too, but only to a point, as profitability concerns would begin to surface. This implies an effective upper bound on CBDC interest rates, represented by the shaded area on the right end of Figure 1. This upper bound would be dynamic, moreover, and depend on bank profitability. During the introduction phase, when demand for CBDCs relative to bank deposits may not yet be well understood, the central bank would need to pay extra attention to disintermediation effects. For example, in a country that has become almost cashless, the introduction of a CBDC could entail a “recashification shock”. In addition to financial stability concerns, this may induce volatility in the money multiplier and monetary aggregates.

Irrespective of interest rates, the introduction of retail CBDCs may imply a permanently higher risk of bank runs. The sheer ease of digital conversion from bank accounts to a retail CBDC could have implications for financial stability. Any concern about a bank’s health could prompt depositors to convert their money into CBDCs (Broadbent, 2016; BIS, 2018). To some extent, however, bank runs can already happen at the click of a button, if depositors have accounts with other banks to transfer to. Nevertheless, CBDCs may suit concerned depositors particularly well, because CBDCs are created outside of the banking system and are backed up by sovereign credibility.

When CBDCs experience inflows, due to permanent or temporary disintermediation effects, the central bank faces a difficult decision on the allocation of those flows. The central bank could attempt to prevent some of the disintermediation effects by recycling funds back to the banking system. But, in doing so, the central bank would explicitly take on credit risk, and would need to determine the allocation of funds among financial institutions. Central bankers would likely be averse to such a role, let alone the direct intermediation of credit to the private sector. However, passively investing CBDC inflows in government securities might not be the neutral choice that it seems either. Such a policy would effectively reallocate credit provision away from the private sector (which would face the full brunt of financial disintermediation effects) and towards the public sector.

10.3. OPEN QUESTIONS

When considering the introduction of a retail CBDC, policy makers will need a granular view on many of the considerations outlined above. Open questions for further research include:

- *Financial disintermediation risk:* How will the introduction of a retail CBDC impact upon existing bank deposits (both their level and their resilience to shocks)? If bank deposits are affected, what would be the impact on bank credit provision, and would this depend on the structure of the financial sector (i.e., large banks may tap alternative funding sources more easily than small banks)? To what extent does the impact on bank deposits and credit provision depend on the design features of the CBDC, including anonymity and interest rates? What differences between countries' financial sectors are central in determining whether they are "ready" for a retail CBDC? Is there a sequence of preparatory steps towards such "readiness"? Are there effective ways in which the introduction of a CBDC can "test the water", initially limiting the impact on the financial sector, such as by introducing the CBDC at sufficiently negative interest rates?
- *Monetary effects:* How would the existing transmission channels of monetary policy be impacted by the introduction of CBDCs? To what extent does this depend upon a co-existence of CBDCs and physical cash? Can the ELB indeed be broken while cash is retained, as Agarwal and Kimball (2015) suggest? More generally, is there truly a potential to "end" the ELB with CBDCs, or merely to extend the ELB downwards, and if so, how far? Does CBDCs' impact on monetary transmission channels and on the downward extension of the ELB depend upon their design features? Is there a trade-off between the optimal CBDC design for monetary purposes and for financial stability purposes, or do both sets of considerations point in similar directions? How much of a concern is the potential for volatile monetary aggregates during the introduction of a retail CBDC? How would central banks invest their new CBDC liabilities, and would the answer depend on the state of the economy and the health of the banking sector?
- *Operational risk:* What are the operational challenges involved in the introduction of a CBDC? To what extent are central banks technologically ready to ensure the cybersecurity of a retail CBDC? Is there a risk that operational CBDC issues could cloud the communication and thereby the effectiveness of monetary policy? Can we draw tentative inferences about some of the operational issues associated with the introduction of a retail CBDC from the pilot cases, such as Uruguay?
- *Anonymity and AML/CFT considerations:* In what ways could an "intermediate" degree of CBDC anonymity be offered (i.e., anonymity up to a transaction value threshold, or until judicial authorities have reason to suspect illicit activity, etc.)? Are there significant operational issues associated with tailoring the anonymity of retail CBDCs? What other steps should authorities take to ensure that retail CBDCs are an asset and not a liability to AML/

CFT policy? Would AML/CFT concerns significantly limit the use of CBDCs for cross-border transactions, or would central banks be able to work out bilateral agreements to monitor appropriate usage?

- *Further research on private cryptocurrencies:* In the absence of retail CBDCs, are private cryptocurrencies likely to thrive and become a larger part of the payment system? If so, would that make the negative externalities associated with their use macro-critical?

Table 1: Summary of key pros and cons of introducing CBDCs

PRO	References include:
Eliminate the Effective Lower Bound (ELB) on monetary policy. Central banks can charge negative rates on CBDCs, potentially eliminating the substitution out of bank accounts that creates the ELB. It may be possible to sustain such negative rates without phasing out cash, through conversion fees.	Haldane (2015), Agarwal and Kimball (2015), Barrdear and Kumhof (2016), Rogoff (2016), Goodfriend (2016), Bordo and Levin (2017)
Improve monetary control. Beyond the ELB argument: also in normal times, interest-bearing CBDCs give CBs a new precision tool, which can strengthen monetary transmission; in addition, this could help operationalize price-level targeting.	Barrdear and Kumhof (2016), Bordo and Levin (2017), Davoodalhosseini (2018), Meaning et al. (2018)
Counter cryptocurrencies. Private cryptocurrencies have large disadvantages: volatile pricing; scalability problems; operational risk; transaction costs; environmental impact; and dollarization risks (loss of seigniorage & LOLR function). If CBDCs offer similar use, but with less volatility and risks, they could supplant private cryptocurrencies.	Fung and Halaburda (2016), Barrdear and Kumhof (2016), Raskin and Yermack (2016), He et al. (2017)
Fulfilling a societal need. Digital currency is the natural next step in the development of money. Token-based money has intrinsic value, as does free access to a liability of the central bank: these characteristics are currently constrained to physical cash only. Related: lower cost from maintaining cash.	Raskin and Yermack (2016), Bech and Garratt (2017), He et al. (2017), Bergara and Ponce (2018)

Table 1: Summary of key pros and cons of introducing CBDCs (continued)

References include:	
CON	
Financial disintermediation and the central bank balance sheet. Banks may lose part of their retail funding base, if interest rates on CBDCs are not carefully calibrated. Moreover, CBDCs permanently raise the risk of runs, because they make it easier to convert cash out of the domestic banking system and into an asset that is backed by sovereign credibility. Furthermore, to the extent that disintermediation occurs, the central bank is faced with an unpalatable choice on the allocation of CBDC resources, which would either tilt credit provision towards the public sector or be reinjected into the financial sector. The latter implies explicit credit risk for the central bank and a choice of how to allocate funding among banks.	Broadbent (2016), Raskin and Yermack (2016), Cerqueira Gouveia et al. (2017), Bjerg (2017), BIS (2018), Fernandez de Lis (2018), Kumhof and Noone (2018), Panetta (2018), Keister and Sanches (2018)
Illicit activities. Token-based intermediation is currently anonymous and favored for illicit activities. CBDCs, if anonymous, could make it easier to conduct illicit transactions in digital and global form. But if not anonymous, this raises concern about a “super-state”, capable of full monitoring of all individual transactions (which also means CBDC could boost the demand for private cryptocurrencies, rather than supplant it).	Fung and Halaburda (2016), Bech and Garratt (2017), Raskin and Yermack (2016), BIS (2018)
Operational risk. Among private cryptocurrencies operational risk has been high. Are central banks ready for the operational challenges of CBDC? Any CBDC cybersecurity breach would come with large negative externalities on other central bank activities, due to reputational effects.	Mersch (2017), He et al. (2017), BIS (2018), Panetta (2018)

REFERENCES

- Agarwal, Ruchir, and Miles Kimball (2015) “Breaking Through the Zero Lower Bound” IMF Working Paper 15/224.
- Athey, Susan, Christian Catalini and Catherine Tucker (2017) “The Digital Privacy Paradox: Small Money, Small Costs, Small Talk” NBER Working Paper No. 23488.
- Bank for International Settlements (2018) “Central Bank Digital Currencies” Basel Committee on Payments and Market Infrastructures publication, March 2018.
- Barrdear, John, and Michael Kumhof (2016) “The Macroeconomics of Central Bank Issued Digital Currencies” Bank of England Staff Working Paper 605.
- Bech, Morten, and Rodney Garratt (2017) “Central Bank Cryptocurrencies” BIS Quarterly Review, September 2017.
- Bergara, Mario and Jorge Ponce (2018) “Central Bank Digital Currencies: the Uruguayan e-Peso Case” in Donato Masciandaro and Ernest Gnan (eds.) *Do We Need Central Bank Digital Currencies? Economics, Technology and Institutions*, SUERF/BAFFI CAREFIN Conference Volume.
- Bjerg, Ole (2017) “Designing New Money – The Policy Trilemma of Central Bank Digital Currency” CBS Working Paper.
- Bordo, Michael, and Andrew Levin (2017) “Central Bank Digital Currency and the Future of Monetary Policy” NBER Working Paper 23711.
- Borgonovo, Emanuele, Stefano Caselli, Alessandra Cillo and Donato Masciandaro (2018) “Between Cash, Deposit And Bitcoin: Would We Like A Central Bank Digital Currency? Money Demand And Experimental Economics” BAFFI CAREFIN Working Papers 1875.
- Broadbent, Ben (2016) “Central Banks and Digital Currencies”, speech at the London School of Economics, March 2, 2016.
- Carstens, Augustín (2018) “Money in the Digital Age: What Role for Central Banks?” speech in Frankfurt, February 6, 2018.
- Cerqueira Gouveia, Olga, Enestor Dos Santos, Santiago Fernández de Lis, Alejandro Neut and Javier Sebastián (2017) “Central Bank Digital Currencies: Assessing Implementation Possibilities and Impacts” BBVA Working Paper 17/04.
- Davoodalhosseini, S. Mohammad R. (2018) “Central Bank Digital Currency and Monetary Policy” Bank of Canada Staff Working Paper 2018-36.
- Engert, Walter, and Ben S.C. Fung (2018) “Motivations and Implications of a Central Bank Digital Currency” in Donato Masciandaro and Ernest Gnan (eds.) *Do We Need Central Bank Digital Currencies? Economics, Technology and Institutions*, SUERF/BAFFI CAREFIN Conference Volume.
- Fernandez de Lis, Santiago (2018) “Central Bank Digital Currencies: Features, Options, Pros and Cons...” in Donato Masciandaro and Ernest Gnan (eds.)

- Do We Need Central Bank Digital Currencies? Economics, Technology and Institutions*, SUERF/BAFFI CAREFIN Conference volume
- Fung, Ben S.C., and Hanna Halaburda (2016) “Central Bank Digital Currencies: A Framework for Assessing Why and How” Bank of Canada Staff Discussion Paper 2016-22.
- Goodfriend, Marvin (2016) “The Case for Unencumbering Interest Rate Policy at the Zero Lower Bound” paper presented at the August 2016, Jackson Hole Conference.
- He, Dong, Karl Habermeier, Ross Leckow, Vikram Haksar, Yasmin Almeida, Mikari Kashima, Nadim Kyriakos-Saad, Hiroko Oura, Tahsin Saadi Sedik, Natalia Stetsenko, and Concepcion Verdugo-Yepes (2016) “Virtual Currencies and Beyond: Initial Considerations” IMF Staff Discussion Note 16/03.
- He, Dong, Ross Leckow, Vikram Haksar, Tommaso Mancini-Griffoli, Nigel Jenkinson, Mikari Kashima, Tanai Khiaonarong, Céline Rochon, and Hervé Tourpe (2017) “Fintech and Financial Services: Initial Considerations” IMF Staff Discussion Note 17/05.
- Haldane, Andrew (2015) “How Low Can You Go?” speech, 18 September 2015.
- Hendry, Scott, and Yu Zhu (2017) “A Framework for Analyzing Monetary Policy in an Economy with E-money” Bank of Canada, mimeo.
- Judson, Ruth (2018) “Big Note, Small Note: Central Bank Digital Currency and Cash” in Donato Masciandaro and Ernest Gnan (eds.) *Do We Need Central Bank Digital Currencies? Economics, Technology and Institutions*, SUERF/BAFFI CAREFIN Conference Volume.
- Keister, Todd, and Daniel Sanches (2018) “Managing Aggregate Liquidity: The Case of a Central Bank Digital Currency” mimeo.
- Kumhof, Michael, and Clare Noone (2018) “Central Bank Digital Currencies – Design Principles and Balance Sheet Implications” Bank of England Staff Working Paper No. 725.
- Masciandaro, Donato (2018) “The Demand for a Central Bank Digital Currency: Liquidity, Return and Anonymity” in Donato Masciandaro and Ernest Gnan (eds.) *Do We Need Central Bank Digital Currencies? Economics, Technology and Institutions*, SUERF/BAFFI CAREFIN Conference Volume.
- Meaning, Jack, Ben Dyson, James Barker and Emily Clayton (2018) “Broadening Narrow Money: Monetary Policy with a Central Bank Digital Currency” Bank of England Staff Working Paper No. 724.
- Mersch, Yves (2017) “Digital Base Money: An Assessment from the ECB’s Perspective” Speech at Finlands Bank, January 16, 2017.
- Panetta, Fabio (2018) “21st Century Cash: Central Banking, Technological Innovation and Digital Currencies” in Donato Masciandaro and Ernest Gnan (eds.) *Do We Need Central Bank Digital Currencies? Economics, Technology and Institutions*, SUERF/BAFFI CAREFIN Conference Volume.

- Pichler, Paul and Martin Summer (2018) “Digital Money, Cryptocurrencies and Central Banks” in Donato Masciandaro and Ernest Gnan (eds.) *Do We Need Central Bank Digital Currencies? Economics, Technology and Institutions*, SUERF/BAFFI CAREFIN Conference Volume.
- Prasad, Eswar (2018) “Central Banking in a Digital Age: Stock-Taking and Preliminary Thoughts” Hutchins Center on Fiscal & Monetary Policy at Brookings.
- Raskin, Max, and David Yermack (2016) “Digital Currencies, Decentralized Ledgers and the Future of Central Banking” NBER Working Paper 22238.
- Rogoff, Kenneth (2016) *The Curse of Cash*, Princeton University Press.
- Roubini, Nouriel, and Preston Byrne (2018) “The Blockchain Pipe Dream” March 5, 2018, Project Syndicate posting.
- Sveriges Riksbank (2017) “The Riksbank’s E-Krona Project” first interim report on the e-krona project.
- Yao, Qian (2018) “A Systematic Framework to Understand Central Bank Digital Currency” *Science China Information Sciences* 61.

11. CENTRAL BANK DIGITAL CASH: PRINCIPLES & PRACTICAL STEPS¹

Michael D. Bordo and Andrew T. Levin

11.1. INTRODUCTION

A fundamental purpose of the monetary system is to provide a stable unit of account that facilitates the economic and financial decisions of households and businesses. Thus, as of a few decades ago, monetary economists were primarily concerned about how to prevent a recurrence of the “Great Inflation”, i.e., the design of systematic and transparent monetary policy frameworks that would ensure low and stable rates of inflation.

More recently, however, a number of advanced economies have experienced protracted periods of relatively weak aggregate demand, with inflation falling persistently short of its stated objective and conventional monetary policy constrained by the effective lower bound (ELB) on nominal interest rates that arises from the zero interest rate on paper cash. Consequently, a number of major central banks – including the Bank of Japan, the European Central Bank, and the Federal Reserve – have deployed unconventional policies such as quantitative easing that have proven to be complex, opaque, discretionary, and ineffectual.

Thus, a crucial task in advanced economies is to strengthen the monetary system to ensure that the central bank can provide sufficient monetary stimulus to preserve price stability and foster economic recovery even in the face of severe adverse shocks. One potential option would be to raise the inflation target by several percentage points, essentially allowing inflation to return to the levels last experienced a half-century ago. By raising the normal level of nominal interest rates, the central bank would have more room to cut rates sharply without being constrained by the ELB.² However, such an approach would complicate the decisions and plans of ordinary families and businesses, and the inflation target would most likely become a political football rather than a credible anchor.

Therefore, our analysis indicates that the central bank should take active steps to establish digital cash as the fulcrum of the monetary system.³ Digital cash – often

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² See Blanchard et al. (2010), Ball (2014), and Ball et al. (2016).

referred to as central bank digital currency – can serve as a practically costless medium of exchange and as a secure store of value that yields essentially the same rate of return as other risk-free assets. Individuals and businesses would remain free to use paper cash if desired, but its obsolescence would be accelerated by the convenience, security, and ubiquity of digital cash. Arbitrage between paper cash and digital would be mitigated by a graduated system of transfer fees, thereby eliminating the ELB. Thus, the central bank would be able to follow a systematic and transparent strategy in adjusting the interest rate on digital cash, without the need to rely on unconventional policy tools, and would be able to foster true price stability.

The remainder of this paper is organized as follows. Section 2 documents the muted effectiveness of unconventional monetary policy tools. Section 3 sets forth basic principles for the design of digital cash, and Section 4 discusses the characteristics of the monetary policy framework. Section 5 considers some near-term practical steps that central banks can take in the process of establishing digital cash. Section 6 reflects on financial stability issues. Section 7 concludes.

11.2. ASSESSING UNCONVENTIONAL MONETARY POLICIES

Paper cash pays zero interest and hence limits the extent to which a central bank can provide conventional monetary accommodation by reducing nominal interest rates in the face of weak aggregate demand and persistently low inflation. In the wake of the global financial crisis, a number of major central banks became constrained by this effective lower bound (ELB) and deployed two basic forms of unconventional monetary policy: quantitative easing (QE) in the form of large-scale asset purchases, and forward guidance about the likely trajectory of short-term nominal interest rates. Each of these policy tools is intended to provide monetary stimulus, thereby fostering the pace of economic recovery and bringing inflation back upwards to its stated objective; thus, these tools are intrinsically different from the emergency liquidity measures that a central bank may implement in serving as a lender of last resort during a financial crisis.

In deploying these unconventional policies, central bankers and other analysts were quite optimistic that implementing QE and forward guidance could substantially mitigate the severity of the ELB. However, those projections relied heavily on extrapolations from statistical patterns over preceding decades and on event studies of policy actions taken in the midst of the financial crisis. Consequently,

³ A number of central banks are actively exploring the potential introduction of digital cash. Most notably, the Sveriges Riksbank has been engaged in public consultations about introducing digital cash (“e-krona”) in Sweden; see <https://www.riksbank.se/en-gb/payments--cash/e-krona/>.

such assessments were necessarily subject to a high degree of uncertainty.⁴ With the passing of time, however, it has become increasingly evident that QE and forward guidance are subject to intrinsic limitations and hence have relatively muted benefits in providing monetary stimulus.⁵

In the United States, for example, the Federal Open Market Committee (FOMC) began providing specific forward guidance in its August 2011 statement, which indicated that the target federal funds rate was likely to remain unchanged “*at least until mid-2013*.” That announcement was associated with a decline of about 10 basis points in the 2-year U.S. Treasury yield – roughly similar to a small surprise in conventional monetary policy during the pre-crisis period.⁶ By contrast, subsequent revisions in the FOMC’s forward guidance in January 2012 (“*at least through mid-2014*”) and in September 2012 (“*at least through mid-2015*”) were associated with very small reductions in the 2-year Treasury yield of about 4 basis points and 1 basis point, respectively. Finally, in December 2012 the FOMC reframed its forward guidance in terms of specific quantitative thresholds for unemployment and inflation. According to the Federal Reserve Bank of New York’s survey of primary dealers, that reframing came as a surprise to financial market participants but had negligible effects on their expectations regarding the likely timing of liftoff from the ELB.

The Federal Reserve initiated its first round of large-scale asset purchases (QE1) during the most intense phase of the financial crisis. In particular, at the tail end of 2008 and the first half of 2009, the Fed purchased \$1.35 trillion of agency debt and mortgage-backed securities, predominantly issued by Fannie Mae and Freddie Mac, with the specific aim of “*providing support to the mortgage and housing markets*” by reducing risk spreads on those securities.⁷ QE1 also included \$300 billion in purchases of Treasury securities. In 2010-11, the FOMC initiated purchases of an additional \$600 billion in Treasuries (QE2) and a program to expand the average maturity of its Treasury holdings (often referred to as “Operation Twist”). Nonetheless, the recovery remained sluggish and inflation remained well below target.

The FOMC’s third major round of asset purchases, commonly known as QE3, was launched in autumn 2012 and concluded about two years later. The Federal Reserve concluded all of its emergency lending programs during 2009-10, and measures of U.S. financial stress remained at low levels thereafter. Thus, the QE3

⁴ For example, Hamilton and Wu (2012) noted: “*As should be clear from the description of the exercise, we are talking about a quite dramatically counterfactual event. If one considers the analogous forecasting equations, [this] would represent a 36 σ event, obviously something so far removed from anything that was observed during the historical sample as to raise doubts about interpreting the parameter estimates as telling policymakers what would happen if they literally implemented a change of this size.*”

⁵ See Borio (2018), Greenlaw et al. (2018), and Hamilton (2018).

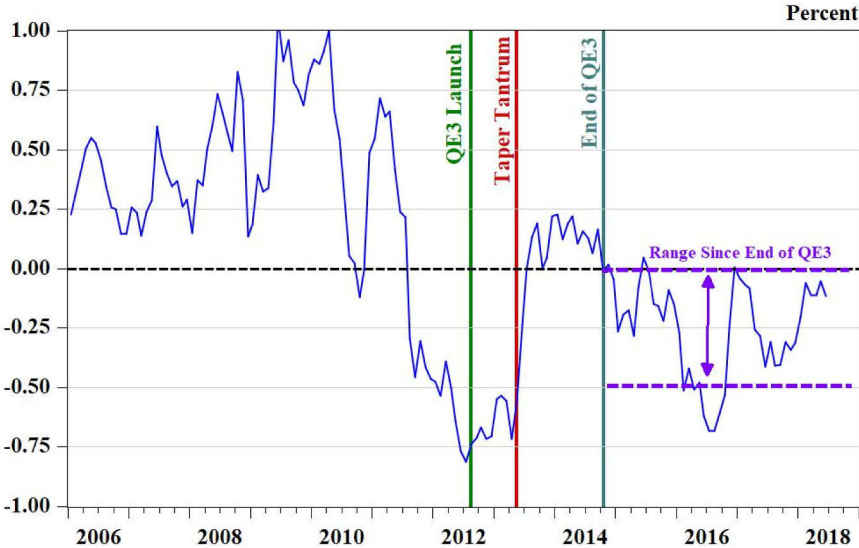
⁶ See Williams (2013).

⁷ <https://www.federalreserve.gov/newsevents/pressreleases/monetary20081216b.htm>.

program was clearly aimed at providing additional monetary stimulus. Indeed, the FOMC specifically stated that QE3 was intended to push down longer-term bond yields, thereby fostering a more rapid economic recovery and pushing inflation upwards to the FOMC’s 2 percent goal.

In explaining the rationale for launching QE3, Federal Reserve officials extensively cited the analysis of Chung et al. (2012), who conducted simulations of the FRB/US model to assess the benefits of QE.⁸ That study indicated that a \$600 billion asset purchase program would reduce the term premium by 20 basis points, expand nonfarm payrolls by about 700,000 new jobs, raise real GDP by nearly 1 percent, and push up core inflation by about 0.3 percent. Given that the FRB/US model is essentially linear, the predicted macroeconomic effects of QE3 (which comprised \$1.9 trillion in purchases) would be roughly three times larger, i.e., reducing the term premium by 60-70 basis points, expanding nonfarm payrolls by 2 million jobs, raising real GDP by about 3 percent, and raising core inflation by nearly a percentage point.⁹ Indeed, internal staff memos that were sent to the FOMC in 2012 (and which have been subsequently released to the public after a five-year time lag) used this methodology to quantify the likely benefits of the QE3 program.¹⁰

Figure 1: The Term Premium on U.S. 10-Year Treasury Securities



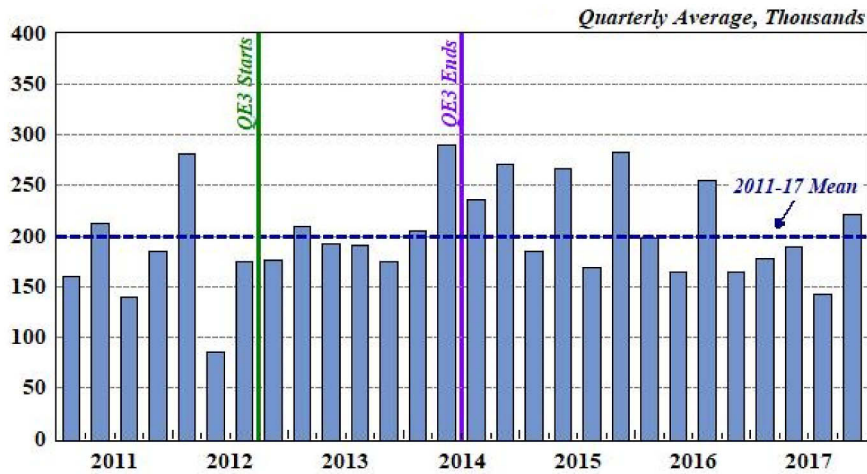
Source: Federal Reserve Board, authors’ calculations.

⁸ See Bernanke (2012, 2014) and Yellen (2012, 2015).
⁹ The FRBNY’s parallel analysis by Chen et al. (2012) obtained much smaller effects of QE, roughly one-eighth those of Chung et al. (2012); however, those results were not cited by Bernanke (2012) or Yellen (2012).
¹⁰ See the staff memos by Laforde et al. (2012) and Cambron et al. (2012), which were sent to the FOMC on August 28, 2012 and November 30, 2012, respectively.

Nonetheless, as shown in Figure 1, the term premium on 10-year U.S. Treasury securities was broadly stable during the second half of 2012 and the first quarter of 2013, even as the FOMC initiated QE3.¹¹ The surveys of primary dealers conducted by the Federal Reserve Bank of New York indicate that the launch of QE3 was largely unanticipated prior to September 2012 and that over subsequent months financial market participants made large upward revisions to their assessments of its likely duration and cumulative size.

Any near-term effects from launching QE3 were subsequently swamped by the so-called “taper tantrum” in spring 2013. At that time, Fed officials suggested that the tantrum was a transitory phenomenon and that bond yields would quickly subside. However, the New York Fed’s June 2013 survey indicated that most primary dealers attributed the tantrum to market confusion about the FOMC’s policy strategy. And the term premium remained elevated over the subsequent year, even as investors made further upward revisions about the likely size of the Fed’s balance sheet, and did not fall significantly until after the end of QE3 in late 2014.

Figure 2: Monthly Growth of U.S. Nonfarm Payrolls



Source: Bureau of Labor Statistics, authors’ calculations.

As shown in Figure 2, the launching of QE3 and the initiation of explicit forward guidance appear to have had only muted effects on the U.S. labor market. Growth in nonfarm payrolls during 2013-14 was practically identical to its average pace from 2011 to 2016, with no evident acceleration due to QE3 nor any apparent

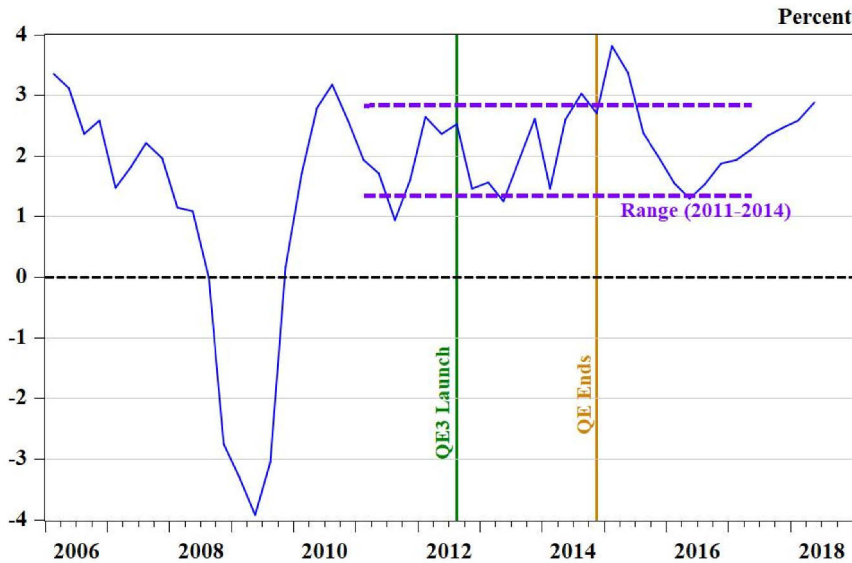
¹¹ Figures 1-6 are taken from a forthcoming study by Levin and Loungani (2019). Information on financial market perceptions of the likely size of the QE3 program.

deceleration following the conclusion of QE3. employment, output, and inflation.

Likewise, QE3 had no visible impact on the broader U.S. economy, as evident in Figures 3 and 4. Real GDP growth remained in a narrow range of about 1½ to 2¾ percent from 2011 thru 2016; the only exception was a temporary pickup in the first half of 2015, well after the conclusion of the QE3 program. Likewise, core PCE inflation – the Fed’s preferred measure of underlying inflation--averaged just over 1.5 percent during 2013-14, little different from its average pace over preceding and subsequent years.

Evidently, the transmission mechanism of QE is fundamentally different from that of conventional monetary policy. A long empirical literature has documented that an unanticipated shift in the target federal funds rate has a significant impact on output and employment within a few months and a peak effect within a few quarters.¹² By contrast, the launch of QE3 in autumn 2012 (which was almost entirely unanticipated prior to late August) had no visible impact on nonfarm payrolls or real GDP growth in 2013-2014.

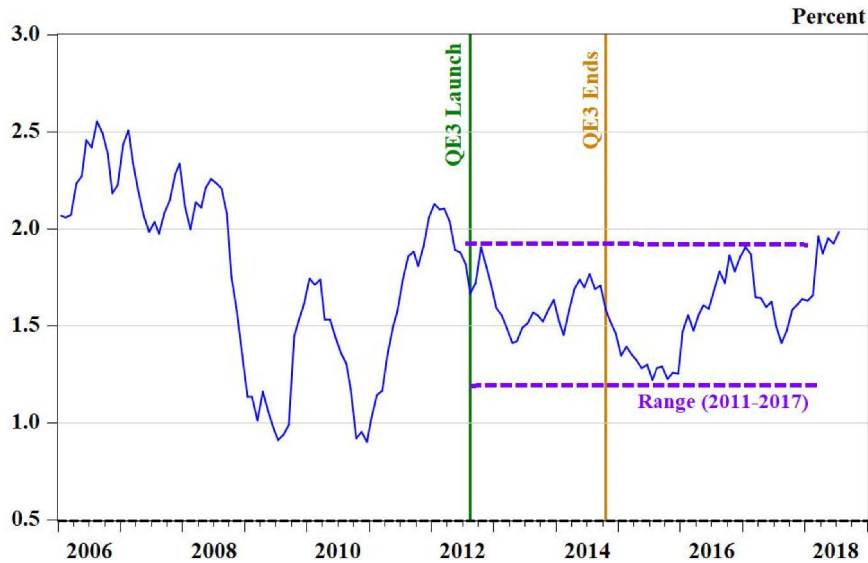
Figure 3: U.S. Real GDP Growth



Source: Bureau of Economic Analysis, authors’ calculations.

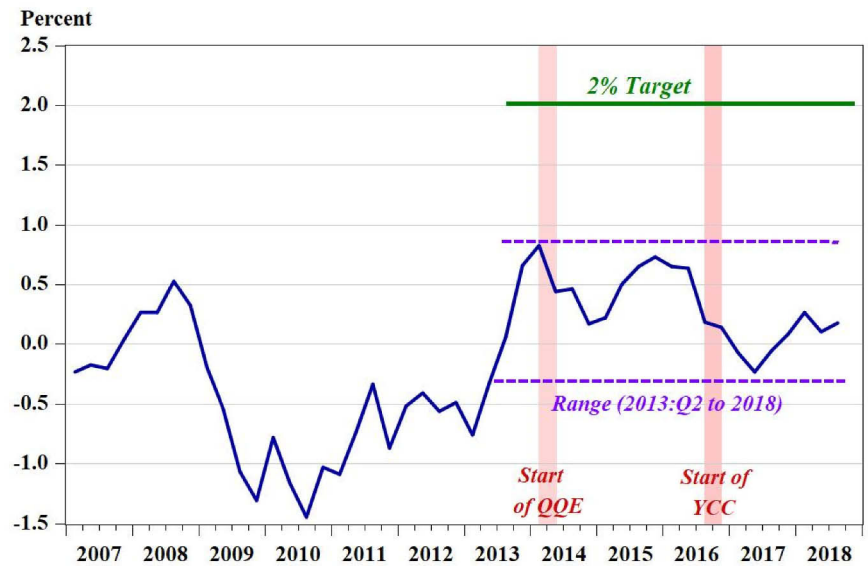
¹² See the seminal contributions of Sims (1980), Christiano, Eichenbaum, and Evans (1999), and Romer and Romer (2000).

Figure 4: U.S. Core PCE Inflation



Source: Bureau of Economic Analysis, authors' calculations.

Figure 5: Japanese Core-Core CPI Inflation (*excluding food, energy, and VAT effects*)

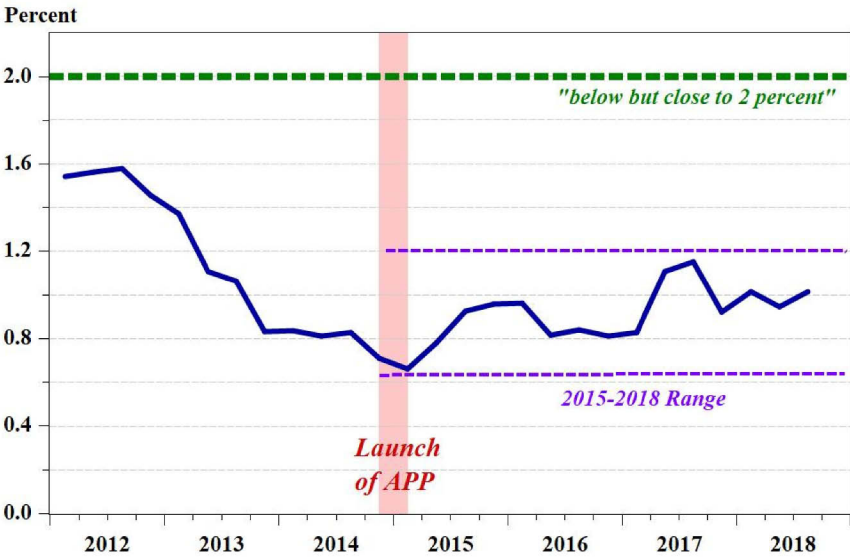


Source: Japan Statistics Bureau, authors' calculations.

Further evidence on the muted effectiveness of unconventional monetary stimulus can be obtained by considering the recent experiences of other major economies where conventional policy has been constrained by the ELB. For example, the Bank of Japan (BOJ) launched its quantitative and qualitative easing (QQE) program in April 2013 and augmented that program in September 2016 by initiating yield curve control (YCC).¹³ Under QQE the BOJ's securities holdings have expanded by about ¥400 trillion, equivalent to roughly 80 percent of Japanese GDP. As shown in Figure 5, however, Japanese core-core inflation (excluding food and energy prices and the direct effects of the 2014 VAT hike) has remained far below the BOJ's 2 percent inflation target. Indeed, over the past year this indicator and other BOJ measures of underlying inflation in Japan have been mired close to zero.

The European Central Bank (ECB) announced its asset purchase program (APP) in late 2014 and initiated large-scale securities purchases – including government securities, corporate bonds, covered bonds, and asset-backed securities – in March 2015. Since that time, the ECB's asset purchases have totalled about 2.5 trillion euros, equivalent to about 15 percent of eurozone GDP. The ECB has specifically stated that this program was intended to “*address the risks of too prolonged a period of low inflation.*”¹⁴

Figure 6: Eurozone Core Inflation (excluding food, energy, alcohol, and tobacco)



Source: European Central Bank, authors' calculations.

¹³ <https://www.boj.or.jp/en/mopo/outline/qqe.html/>

¹⁴ <https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html>.

As shown in Figure 6, eurozone core inflation (i.e., the 12-month change in the harmonized index of consumer prices excluding food, energy, alcohol, and tobacco) has crept upwards to around 1.1 percent in 2018 (an increment of 0.3 percent from its level about five years ago) but remains far below the ECB's objective of keeping inflation "*below but close to 2 percent over the medium run.*"

11.3. FUNDAMENTAL DESIGN PRINCIPLES

With an appropriate design, digital cash can fulfill the three basic functions of money, serving as a practically costless medium of exchange, a secure store of value, and a stable unit of account.¹⁵

11.3.1. Medium of Exchange

Digital cash should serve as legal tender, usable for all public and private payment transactions. In the case of fiduciary currency, increasing returns and network externalities provide a strong rationale for currency to be issued by a public authority, as emphasized by classical economists. The same essential reasoning holds for digital cash.

One potential means of issuing digital cash would be in the form of electronic tokens, analogous to paper cash and stored-value debit cards. Under a token-based approach, however, verification might well be time-consuming and inefficient (as with other uses of distributed ledger technology). Moreover, there would be no intrinsic limit on the size and scope of fraud, and hence hackers could potentially undermine the entire payments system.

Another potential approach would be for individuals and firms to have digital cash accounts at the central bank itself. Such an approach is reminiscent of an earlier era when some private individuals held accounts at the Bank of England. Nonetheless, it seems undesirable for the central bank to start competing directly with commercial banks in attracting deposits, especially in cases where the central bank also regulates and supervises those banks. Such an approach would also raise a host of concerns about privacy and bureaucratic inefficiencies and could pose risks to financial stability, e.g., depositors shifting their funds from commercial banks to the central bank at the onset of a financial crisis.¹⁶

¹⁵ See Bordo and Levin (2017) for a comprehensive discussion of design principles for digital cash.

¹⁶ See Keister and Sanchez (2018).

Thus, our analysis indicates that digital cash should be provided through designated accounts held at supervised depository institutions, which would hold part or all of those funds in segregated reserve accounts at the central bank. This approach would foster competition among digital cash providers and protect the privacy of individual transactions while facilitating appropriate law enforcement. In effect, the provision of digital cash would be similar to that of many other public goods such as water, electricity, and transportation.

Under this approach, payment transaction can be transmitted instantaneously and securely at practically zero cost, simply debiting the payer's digital cash account and crediting the payee's digital cash account. The scope and scale of fraudulent transactions can be mitigated by straightforward and convenient methods such as two-step identity verification.

Of course, individuals and firms should remain free to hold funds at private financial institutions and to make payment transactions using private forms of payment or paper cash. However, once digital cash becomes convenient and ubiquitous, the demand for paper currency will rapidly diminish, especially if deposits and withdrawals of paper cash are subject to a graduated fee system (as discussed further below).

11.3.2. Store of Value

Digital cash can enhance its role as a secure store of value. Following Friedman (1960) who argued that to have an efficient monetary system that government issued money should bear the same rate of return as other risk-free assets. Indeed currently central banks pay interest on the reserves of commercial banks and the Fed has begun paying interest to a much wider array of counterparties. In this framework the digital cash interest rate will be the central banks key monetary policy tool. With the obsolescence of cash, this rate can be cut below zero in response to a severe shock adverse shock (Goodfriend, 2016). The presence of paper money poses a constraint on the central bank's ability to cut its policy rate below zero. This constraint could be removed by establishing a graduated schedule of fees on transfers between cash and digital cash.

11.3.3. Unit of Account

Providing a stable unit of account facilitates the economic and financial decisions of individuals and firms. A digital cash system would do this by adjusting the digital cash interest rate. Indeed, because the digital cash interest rate can be adjusted downward as needed, there will no longer be a compelling rationale for the CB to target a positive average rate of inflation. Therefore, the monetary

policy framework could ensure true price stability, i.e. the real value of digital cash would remain stable over time as measured in terms of a general index of consumer prices.

This design for digital cash embeds the most appealing features of the classical gold standard while avoiding its pitfalls. Indeed, the general price level was not stable during that era (Bordo 1984). It also resonates with Alfred Marshall's tabular standard, Irving Fisher's compensated dollar and Knut Wicksell's plan to use interest rate adjustments to foster price stability.

11.4. THE MONETARY POLICY FRAMEWORK

Digital cash can facilitate the systematic and transparent conduct of monetary policy, thereby facilitating the effectiveness of the monetary transmission mechanism and enhancing the central bank's accountability to elected officials and the public.

11.4.1. Transparency

To facilitate transparency and public accountability, the interest rate on digital cash would serve as the primary tool of monetary policy. In particular, policy-makers would be able to push market interest rates below zero in response to a severe adverse shock, and hence the central bank would be able to provide an appropriate degree of monetary accommodation without resorting to QE.

Thus, the central bank's balance sheet would become very transparent. In particular, the central bank could hold short-term government securities in the same quantity as its liabilities of digital cash. Since QE would no longer be necessary, the size of the central bank's balance sheet would simply reflect the demand for digital cash, and the maturity composition of government debt held by the public would be determined by the fiscal authorities and not the central bank.

The central bank's operating procedures would be correspondingly transparent: It would engage in purchases and sales of government securities to adjust the supply of digital cash in line with movements in demand for digital cash. The spread between the digital cash interest rate and interest rates on short-term government securities would be negligible due to practically costless arbitrage between these risk-free assets. With the obsolescence of paper currency, the central bank would no longer generate substantial seigniorage and would simply cover its expenses via miniscule fees on payment transactions.

11.4.2. Systematic Policy

The central bank's strategy for adjusting the digital cash interest rate can be expressed using a simple benchmark as follows:

$$i_t = \tilde{\pi}_t + r_t^* + \alpha(\tilde{p}_t - p^*) + \beta(p_t - p^*) + \delta(y_t - y_t^*)$$

This formulation is essentially a variant of the Taylor Rule that is oriented towards stabilizing the price level rather than the inflation rate. In particular, the central bank uses the digital cash interest rate (i_t) to keep the actual price level (p_t) stable at its target level (p^*). The digital cash interest rate also reacts to deviations in a core measure of the price level (\tilde{p}_t) and to deviations of real GDP from its potential ($y_t - y_t^*$).

As in the Taylor rule, this specification can be viewed as a benchmark for adjusting the real interest rate in response to fluctuations in economic activity and prices. In particular, the *ex post* real interest rate is given by the nominal interest rate (i_t) adjusted for core inflation ($\tilde{\pi}_t$). When the price level is on target and output is at potential, then the real interest rate is set at its equilibrium value (r_t^*).

11.5. PRACTICAL STEPS

In light of these design principles, it's natural to ask whether digital cash is truly feasible, and if so, over what timeframe? Rather than decades or centuries, our analysis indicates that major central banks could take the essential steps within the next several years, although further refinements would surely take place in subsequent years. In particular, central banks should: (i) establish a real-time clearing and settlement system that facilitates efficient payments for consumers and businesses, and (ii) facilitate the establishment of safe and liquid bank accounts that accrue essentially the same rate of return as other risk-free assets.

11.5.1. Real-Time Clearing & Settlement

As noted above, a key feature of digital cash is to serve as an *efficient medium of exchange*. Thus, a real-time clearing and settlement system is crucial for facilitating secure payments and eliminating counterparty risks by finalizing such transactions within minutes rather than hours or days.

For example, a task force commissioned by the Federal Reserve concluded last year that “*broad access to settlement services will help level the playing field and enhance competition among providers of faster payments services.*” That task

force called on the Fed to “*begin efforts immediately*” on a real-time payment system that could be implemented “*by 2020.*”¹⁷

While a two-year timeframe might seem overly ambitious, recent experience in the Eurozone demonstrates that such a timeframe is indeed practical. Following about nine months of consultations with financial institutions and other stakeholders, the European Central Bank (ECB) reached a decision in June 2017 to establish a new system called Target Instant Payments Settlement (TIPS). The logistical details were worked out within about 15 months, and the new system became active in November 2018.¹⁸

Moreover, the ECB’s new system embodies the principle that digital cash payments can be secure, rapid, and practically costless. TIPS offers final and irrevocable settlements of instant payments in euros and operates on a cost-recovery and not-for-profit basis. In particular, entry and account maintenance are free of charges, and each payment transaction is subject to a miniscule fee of 0.2 eurocents (€0.002) or less.

Following a roughly similar approach, the Federal Reserve Board can move forward expeditiously in carrying out the recommendations of its task force and expediting the establishment of a secure and efficient real-time payment system. Indeed, the Federal Reserve has recently issued a public notice calling for input and comments on the possibility of developing a real-time interbank settlement service along with tools for performing real-time transfers.¹⁹

11.5.2. Interest-Bearing Digital Cash

Another key design principle is that digital cash should serve as a *secure store of value* that bears the same rate of return as other risk-free assets, thereby eliminating the opportunity cost of holding money. In effect, consumers and businesses should be able to receive essentially the same interest on checkable deposits and other current accounts that commercial banks receive on reserves held at the central bank, that is, the interest rate on reserves (IOR) less a very small margin to cover operating costs.

While interest-bearing digital cash might seem like a dramatic new development, in fact the Federal Reserve has already implemented measures that are essentially similar. A wide range of financial institutions (e.g., money market funds) can earn

¹⁷ The Faster Payments Task Force was created in 2015 as a broad and inclusive group of stakeholders with representatives from financial institutions, payment providers, businesses, consumer groups, public agencies, and other experts. Its conclusions are posted at: <https://fedpaymentsimprovement.org/wp-content/uploads/faster-payments-task-force-final-report-part-two.pdf>.

¹⁸ <https://www.ecb.europa.eu/paym/target/tips/html/index.en.html>.

¹⁹ <https://www.federalreserve.gov/newsevents/pressreleases/other20181003a.htm>.

interest on overnight reverse repurchase transactions with the Federal Reserve Bank of New York.²⁰ Moreover, the twelve Federal Reserve Banks have authority to maintain segregated deposit accounts for systemically important financial market utilities (FMUs) so that the customers of those FMUs may rest assured that their funds are secure, liquid, and interest-bearing.²¹

In a competitive banking system, it would be reasonable to expect that the interest rate on liquid deposits would roughly match or exceed the IOR. After all, commercial banks are only required to hold a small fraction of their liquid deposits as reserves at the central bank (which accrue the IOR), and they can earn a higher return by lending out the rest of those funds or through prudent investments in marketable securities. In fact, however, most liquid deposits earn little or no interest, and even short-term savings accounts accrue interest at a rate far below that of IOR.

Thus, one simple way to foster a more competitive banking system would be to encourage the establishment of narrow banks. The business model of a narrow bank is remarkably simple and transparent, because such a bank holds 100% of its deposits as reserves at the central bank. Thus, such deposits can accrue interest at essentially the same rate as IOR (less a small margin to cover the bank's operating costs).

Narrow banks could significantly enhance the competitiveness of the banking system without displacing most conventional banks. After all, huge banks obtain the bulk of their funding from wholesale markets and earn profits from managing complex portfolios, while community banks specialize in "relationship banking" with small businesses and local residents.

It should be feasible for a narrow bank to operate under the same legal arrangements as any other commercial bank. Moreover, it seems reasonable that a narrow bank would have no need for deposit insurance or access to the central bank's lending facility, since its deposits would be inherently safe and liquid.

In light of these considerations, the Federal Reserve and other major central banks should welcome the establishment of narrow banks. To the extent that some public officials have substantive concerns about such an approach, the central bank should initiate a transparent and inclusive process similar to the approach for establishing a real-time payments system, engaging in consultations with financial institutions, community groups, and other stakeholders. If such

²⁰ Information about the design of the Federal Reserve's reverse repo facility and the expanded range of counterparties is available at https://www.newyorkfed.org/markets/rrp_faq.html.

²¹ For example, segregated reserve accounts at the Federal Reserve Bank of Chicago have been created to hold the funds of customers of the Chicago Mercantile Exchange (<http://www.cmegroup.com/notices/clearing/2017/03/Chadv17-107.html>) and the initial margin accounts of customers of ICE Clear Credit (https://www.theice.com/publicdocs/clear_credit/circulars/Circular_2017_015_FINAL.pdf).

consultations conclude that narrow banks would indeed be beneficial to the general public, then the central bank should move expeditiously to facilitate their creation and thereby facilitate the goal of ensuring that the medium of exchange also serves as a secure store of value.

11.5.3. Mitigating the ELB

Given the evident shortcomings of unconventional monetary policies, it is crucial to ensure that the central bank has the ability to foster economic recovery and preserve price stability, even in the face of severe adverse shocks. Indeed, while a decade has passed since the onset of the financial crisis, there is no room for complacency; the global economy remains turbulent, and no one can accurately predict how many more years will pass before the next major downturn. Thus, a key priority is to take steps to mitigate or eliminate the effective lower bound (ELB) on nominal interest rates.

As noted above, one potential option for mitigating the ELB would be to raise the inflation target to around 4 or 5 percent or perhaps even higher.²² However, raising the inflation target to mitigate the ELB seems to illustrate the adage of “throwing out the baby with the bath water.” After all, central banks have a legal mandate of fostering stable prices, and such a mandate seems inconsistent with persistently higher levels of inflation. Such a marked departure from price stability would complicate the decisions and plans of ordinary families and businesses, perhaps leading to widespread adoption of inflation indexation clauses that would in turn undermine the central bank’s ability to keep inflation stable. Moreover, concerns about excessive and volatile inflation would become the subject of election debates, and the inflation target would become a political football rather than a credible anchor.

A far superior plan is to promote the use of digital cash and accelerate the obsolescence of paper cash. It would be completely inappropriate to abolish paper currency; individuals and businesses should remain free to use it for legitimate purposes (though not for criminal activity or money laundering).²³ But paper cash is inefficient and costly at every stage of retail use: supplying automated teller machines, maintaining cash registers at retail stores, using armored cars for transport, and ensuring that no cash is lost or stolen at any point in this process. By comparison, digital cash can be used instantly at practically no cost at all. Thus, as digital cash comes into widespread use, it seems reasonable to expect that paper cash will become practically extinct, just like typewriters and audio cassette tapes.

²² See Blanchard et al. (2010), Ball (2014), and Ball et al. (2016).

²³ See Rogoff (2016).

In addition, central banks should establish a graduated system of fees for transfers between paper cash and digital cash. Small transfers – say, up to \$100 per week for an individual or \$10,000 for a small business – would be completely exempt from such fees. Moderately larger transfers would be subject to a nominal fee (e.g., 2-3%), roughly similar to the size of withdrawal fees at many ATMs and cash service fees incurred by many small businesses. And the largest transfers (say, over \$5,000) would be subject to an even larger fee (e.g., 5-10%). These arrangements would effectively curtail incentives for arbitrage between paper cash and digital cash, thereby eliminating the ELB, while ordinary consumers and small businesses would remain free to use paper cash if so desired.

11.6. FINANCIAL STABILITY

During a financial crisis, the central bank can expand the stock of digital cash as needed to provide emergency liquidity to supervised financial institutions. Alternatively, the central bank could extend such emergency safeguards to another public agency such as a bank regulator or the deposit insurance fund. Appropriate legal safeguards will be necessary to ensure that the lender of last resort actions do not undermine the central bank's ability to carry out its commitment to price stability.

In the event of a financial crisis, the central bank would be able to reduce the digital cash interest rate below zero, thereby preventing runs from other financial assets into digital cash. In effect, a widening of risk spreads would be reflected by a corresponding drop in the risk-free interest rate, rather than a surge in private lending rates (which would remain close to normal levels). Moreover, this policy strategy generates a steep yield curve that facilitates the expansion of bank credit and fosters prudent risk-taking – precisely the opposite of QE and “lower for longer” forward guidance that encourage search-for-yield behavior. Thus, digital cash would foster a more rapid V-shaped recovery instead of the sluggish U-shaped recoveries that many advanced economies have experienced in recent years.

11.7. CONCLUSIONS

Although memories of the financial crisis are gradually receding, the global economy remains turbulent and unpredictable. The “new normal” level of nominal interest rates is likely to be markedly lower than in prior decades, and hence the ELB will almost surely be a perennial constraint on conventional monetary policy in coming years. And a clear lesson from recent experience is that unconventional monetary policy tools are complex, opaque and ineffectual.

Therefore, central banks should move forward expeditiously with the provision of digital cash as a means of mitigating the ELB. This approach will ensure that monetary policy will be systematic, transparent and effective during normal times and in responding to severe adverse shocks. Digital cash should be provided to the public through accounts at supervised financial institutions, which hold part or all of those funds in segregated reserve accounts at the central bank. In the near term, central banks can take practical steps in this direction by implementing a real-time payment system and by encouraging the establishment of narrow banks. Over time, as digital cash becomes ubiquitous, the central bank should foster the obsolescence of paper cash and establish a graduated system of fees that would limit arbitrage between digital cash and paper cash. These steps will strengthen the monetary system by providing a form of money that serves as a practically costless medium of exchange, a secure store of value, and a stable unit of account.

REFERENCES

- Agarwal, Ruchir and Miles Kimball (2015). "Breaking Through the Zero Lower Bound." International Monetary Fund Working Paper 15-224.
- Andalfatto, David (2015). "Fedcoin: On the Desirability of a Government Cryptocurrency." Available at: <http://andalfatto.blogspot.com/2015/02/fedcoin-on-desirability-of-government.html>.
- Ball, Laurence (2014). "The Case for a Long-Run Inflation Target of Four Percent." IMF Working Paper 14/92.
- Ball, Laurence, Joseph Gagnon, Patrick Honohan, and Signe Krolstrup (2016). "What Else Can Central Banks Do?" *Geneva Reports on the World Economy* 18, September.
- Barrdear John and Michael Kumhof (2016) "The Macroeconomics of Central Bank Issued Digital Currencies" Bank of England Staff Working Paper No. 605, July
- Blanchard, Olivier, Giovanni Dell'Ariccia and Paolo Mauro (2010). "Rethinking Macroeconomic Policy." *Journal of Money, Credit, and Banking* 42:199-215.
- Bordo, Michael (1984). "The Gold Standard: The Traditional Approach." In: Michael Bordo and Anna Schwartz, eds, *A Retrospective on the Classical Gold Standard, 1821-1931*. Chicago, IL: University of Chicago Press, 23-120.
- Bordo, Michael and Anna Schwartz (1987). "Clark Warburton: Pioneer Monetarist." In: Anna Schwartz, ed., *Money in Historical Perspective*. Chicago, IL: University of Chicago Press, 234-254.
- Bordo, Michael and Hugh Rockoff (1996). "The Gold Standard as a Good House-keeping Seal of Approval." *Journal of Economic History*, 56:389-428.

- Bordo, Michael and Barry Eichengreen (2013). "Bretton Woods and the Great Inflation." In: Michael Bordo and Athanasios Orphanides, eds., *The Great Inflation: The Rebirth of Modern Central Banking*. Chicago, IL: University of Chicago Press.
- Bordo, Michael and Pierre Siklos (2018). "Central Banks: Evolution and Innovation in Historical Perspective." In: Rodney Edvinsson, Tor Jacobson, and Daniel Waldenström, eds., *Sveriges Riksbank and the History of Central Banking*. New York, NY: Cambridge University Press.
- Bordo, Michael D and Andrew T Levin (2018). "Central Bank Digital Currency and the Future of Monetary Policy" in Michael D Bordo, John H Cochrane and Amit Seru (eds) *The Structural Foundations of Monetary Policy*. Stanford Ca: Hoover Institution Press
- Borio, Claudio and Anna Zabai (2016). "Unconventional Monetary Policies: A Reappraisal." Bank for International Settlements Working Paper 570.
- Broadbent, Ben (2016). "Central Banks and Digital Currencies." Available at: <http://www.bankofengland.co.uk/publications/?Documents/speeches/2016/speech?886.pdf>.
- Buchanan, James (1962). "Predictability: The Criterion of Monetary Constitutions." In: Leland Yaeger, *In Search of a Monetary Constitution*. Harvard University Press, 155-183.
- Buiter, Willem (2009). "Negative Nominal Interest Rates: Three Ways to Overcome the Zero Lower Bound." NBER Working Paper No. 15118.
- Cambron, Alyssa, Michelle Ezer, Andrew Figura, Joshua Frost, Jeff Huther, Jane Ihrig, John Kandrac, Don Kim, Beth Klee, Deborah Leonard, Dave Reifschneider, Julie Remache, John Roberts, Min Wei, and Nathaniel Wuerffel (2012). "Options for Continuation of Open-Ended Asset Purchases in 2013." Available at: <https://www.federalreserve.gov/monetarypolicy/?fomc-memos.htm>.
- Clarida, Richard, Gordi Gali, and Mark Gertler (1999). "The Science of Monetary Policy: A New Keynesian Perspective." *Journal of Economic Literature*, 37:1661-1707.
- Dorn, James and Anna Schwartz (1987). *The Search for Stable Money: Essays on Monetary Reform*. Chicago: University of Chicago Press.
- Dorn, James (2017). *Monetary Alternatives: Rethinking Government Fiat Money*. Washington, DC: Cato Press.
- Dyson, Ben and Graham Hodgson (2017). "Digital Cash: Why Central Banks Should Start Issuing Electronic Money." Available at: http://positive-money.org/wp-content/uploads/?2016/01/?Digital_Cash_WebPrintReady_20160113.pdf.
- Fan Yifei (2016). "On Digital Currencies, Central Banks Should Lead." Available at: <https://www.bloomberg.com/view/articles/2016-09-01/on-digital-currencies-central-banks-should-lead>.

- Friedman (1960). *A Program for Monetary Stability*. New York. Fordham Press.
- Fung, Ben and Hanna Halaburda (2016). “Central Bank Digital Currencies: A Framework for Assessing Why and How.” Available at: <http://www.bankofcanada.ca/2016/11/staff-discussion-paper-2016-22/>.
- Goodfriend, Marvin (2000). “Overcoming the Zero Bound on Interest Rate Policy.” *Journal of Money, Credit, and Banking*, 32:1007-1035.
- Goodfriend, Marvin (2016). “The Case for Unencumbering Interest Rate Policy at the Zero Lower Bound.” *Economic Review*, Federal Reserve Bank of Kansas City.
- Goodhart, Charles (1988). *The Evolution of Central Banks*. Cambridge: MIT Press
- Greenwood, Jeremy, Samuel Hanson, Joshua Rudolph, and Lawrence Summers (2014). “Government Debt Management at the Zero Lower Bound.” Available at: https://www.brookings.edu/wp-content/uploads/2016/06/30_government_debt_management_zlb.pdf.
- Keister, Todd and Daniel Sanchez (2018). “Should Central Banks Issue Digital Currency?” Manuscript, Rutgers University.
- Laforte, Jean-Philippe, David López-Salido, Steve Meyer, Edward Nelson, and John Roberts (2012). “Flow-Based Balance Sheet Policies: Communication Issues and Macroeconomic Effects.” Available at: <https://www.federalreserve.gov/monetarypolicy/fomc-memos.htm>.
- Levin, Andrew, Volker Wieland, and John Williams (2003). “Performance of Forecast-Based Monetary Policy Rules under Model Uncertainty.” *American Economic Review*, 93:622-645.
- Levin, Andrew (2014). “The Design and Communication of Systematic Monetary Policy Strategies.” *Journal of Economic Dynamics and Control*, 49:52-69.
- Nicolaisen, Jon (2017). “What Should the Future Form of Our Money Be?” Available at: <http://www.norges-bank.no/en/published/speeches/2017/2017-04-25-dnva/>.
- Levin, Andrew and Prakash Loungani (2018). “Reassessing the Benefits and Costs of Quantitative Easing.” Manuscript, Dartmouth College.
- Pfister, Christian and Natacha Valla (2017). “New Normal or New Orthodoxy: Elements of a New Central Banking Framework.” Manuscript, Banque de France.
- Rogoff, Kenneth (2016). *The Curse of Cash*. Princeton, NJ: Princeton University Press.
- Scorer, Simon (2017). “Central Bank Digital Currency: DLT or not DLT? That is the Question.” Available at: <https://bankunderground.co.uk/2017/06/05/central-bank-digital-currency-dlt-or-not-dlt-that-is-the-question/>.

- Skingsley, Cecilia (2016). "Should the Riksbank Issue e-Krona?" Available at: <http://www.riksbank.se/en/Press-and-published/Speeches/2016/Skingsley-Should-the-Riksbank-issue-e-krona/>.
- Smith, Vera (1936) *The Rationale of Central Banking and the Free Banking Alternative*. London: King and Son.
- Taylor, John (1993). "Discretion versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy*, 39:195-214.
- Woodford, Michael (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy* (Princeton: Princeton University Press).

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