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21st century cash: Central banking, technological innovation and digital currencies*

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Technological progress is allowing for the digitization of many objects of our daily life. Cash may be next in line. The paper analyses the pros and cons of issuing a Central Bank Digital Currency (CBDC), a dematerialized liability of the central bank accessible by anyone in the economy. While recourse to a CBDC as a means of payments may well have benefits, their precise nature is uncertain and they may be too small to justify the introduction of a CBDC. A digital currency could increase financial instability risks, due to its potential effects on the demand for commercial bank deposits; however its impact on the banking system is unlikely to be disruptive. Overall the case for issuing a CBDC remains at best unclear. In addition, a digital currency introduces many open questions, like the role and footprint of central banks in the economy and the extent to which it should preserve anonymity in transactions. Especially the latter implies that the decision to issue a CBDC is hardly a technical one: society as a whole must be involved.

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1. Introduction

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[2], 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. 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*.[3] Instant messaging apps such as QQ and WhatsApp allow their estimated three billion users to have digital conversations across the globe.[4] The process of digitization reflects increasing demand for immediacy by individuals, and is transforming our behaviour, our culture and the structure of the economy.

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.

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

[2] 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.

[3] Source: based on data from Universal Postal Union and Radicati Group.

[4] Source: Radicati Group.

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.[5]

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.[6] 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.[7]

In Italy the proportion of unbanked households is similar (7 per cent, or 1.8 million households).[8] 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.[9]

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,[10] or to around €76 billion. By way of comparison, this figure amounts to almost half of the annual EU budget.

[5] 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.

[6] 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.

[7] 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.

[8] Source: Survey on Household Income and Wealth, Banca d'Italia.

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

[10] 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.

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.

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.[11] 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 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,[12] 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,[13] 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.

[11] This idea was first formulated by Brunnermeier. M, L. Garicano, Ph, Lane., M. Pagano, R. Reis, T. Santos, D. Thesmar, S.Van. Nieuwerburgh, and D. Vayanos, European Safe Bonds (ESBies), The Euronomics Group (2011).

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

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

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 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.[14] 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.

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.[15]

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.[16] Though it may be over simplified, this example emphasizes that we need to 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.[17] 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

[14] 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.

[15] See Bank for International Settlements, "Central bank digital currencies", March 2018.

[16] 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).

[17] 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.

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.[18] 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.[19] At the same time, an interest-earning CBDC would reinforce the transmission of monetary impulses to banks, households and businesses.[20] 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 unconventional measures.[21] 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)[22] or the organization of

[18] On the contrary, a CBDC without interest would be comparable to cash.

[19] 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.

[20] 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.

[21] 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.

[22] See for example Mersch, Y. "Digital Base Money: an assessment from the ECB's perspective", speech at Suomen Pankki, January 2017.

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.[23] 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 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.

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 years[24] and is still very much in use. Cash is by far the dominant means of payment, both in the euro area[25] and elsewhere,[26] and demand for it has been on the rise in most

[23] For instance, a malware installed on the Bangladesh central bank's computer successfully diverted around $80 million from its accounts.

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

[25] 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.

[26] Bech, Morten Linnemann, Umar Faruqui, 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.

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.

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