Principles for a global central bank digital currency and a single global payment system

Mr. Mihai Voicu and Mrs. Irina Mihai support the coordinated development of responsible FinTech technologies, products and services across the world

October 2020

"Ongoing political, economic, social, environmental and **technological developments are challenging many of our underlying assumptions**." [1]

"**The Fourth Industrial Revolution is fundamentally transforming societies, economies, and ways of doing business**. Last but not least, as people seek to reassert identities that have been blurred by globalization, decision-making is increasingly influenced by emotions." [2]

Klaus Schwab

Founder and Executive Chairman
World Economic Forum

"Digital innovation is radically reshaping the provision of payment services. Yet technology by itself is not sufficient to put in place a fast, efficient and cost-effective payment system. The Covid-19 pandemic has accelerated trends that were already under way and highlighted how financial services need to be more inclusive and accessible. In this context, the central bank can play the pivotal role as the operator of the underlying infrastructure, catalyst for innovation and overseer of the system. **Central bank digital currencies (CBDCs) may be an important step in the evolution of the relationship of the central bank with society. All of these developments make central bank public goods more important than ever, and central banks need to be at the cutting edge of technology to serve society**." [3]

Hyun Song Shin

Economic Adviser and Head of Research
Bank for International Settlements

"The Riksbank proposes that a committee with broad-ranging expertise shall be tasked with performing a review of the concept of legal tender and of the role of central bank money in a digitalised economy. The committee should also review the role and responsibility

[1] World Economic Forum (2015)
[2] World Economic Forum (2017)
[3] Bank for International Settlement (2020a)

of both the state and the private sector on the payment market. The digitalisation of payment may lead to cash not being generally accepted in the future. [..] **The general public no longer having access to any form of central bank money can make it more difficult for the Riksbank to promote a safe and efficient payment system in Sweden, not just in times of crisis and war but also in peacetime. The Riksbank has previously expressed concern over this development and has therefore analysed the scope for introducing a Central Bank Digital Currency (CBDC), an "e-krona", to which the general public has access."** [4]

"We think that the concept of legal tender should be technically neutral so that it fulfils a function even in a digital future"[5]

Stefan Ingves

Governor

Sveriges Riksbank

[4] Sveriges Riksbank (2019)
[5] Sveriges Riksbank (2019)

The authors invite the readers, especially central bankers, to set their minds from passive-routine behaviour to pro-active profound responsible innovator behaviour. Why? ... well, because on one hand money affects all of us and such behaviour should define human civilisation as an explorer one and on the other hand, we should continuously improve well-being and not live by ancient laws and rules. So, don't stop reading even if you don't understand or don't agree the model (adding low or no value to your expectations and needs). Keep reading and keep thinking deeply and ethically from all payment stakeholders perspectives if you are right or wrong on the payment model benefits (depending on your position central banker (payment service provider to financial institutions), regulator, supervisor, overseer, banker, FinTech company, payment service user, technology developer, finance professor/lecturer, student, journalist etc.), while imagine such a payment model existing and working for everybody enhancing market discipline, efficiency and fairness to all stakeholders, please. Or, even more, challenge and improve the payment model.

This letter is a result of major thinking outside the box (major shift of thinking frame) and proposes a single retail central bank digital currency (CBDC) to be used around the globe as a legal tender, issued based on an arrangement[6] among all central banks/governments.

Each natural and legal person should have direct instant affordable access to a CBDC account and/or token based CBDC with a central bank, depending on the agreed CBDC design by all central banks/governments.

A single efficient and resilient global 24/7 running payment system should allow natural and legal persons to initiate CBDC (domestic and cross-border) payment orders, directly and/or through a third party, to any other CBDC account and/or token based CBDC.

The global payment system should be equipped with an instant CBDC settlement facility in central bank money and it should replace all current payment/settlement arrangements.

Civilized societies are run by (written or not) laws (social contracts) and individuals have to obey the rule(s), in order to rule-out anarchy and hazard element(s). For the moment, our civilization

[6] periodically reviewed based at least on opinion of international well-known experts in economics, payment, settlement, technology, cyber-security, sociology etc.

is driven by accumulated wealth (income/profit) as a mean to improve well-being and survival of the individuals/communities.

Most probably in the future, the civilization will be driven by (well-balanced) various aims, such as but not limited to (1) survival in case of extreme planet (climate, demographic, diseases, magnetic etc.) changes[7], (2) improve general well-being, (3) enhance general knowledge and (4) explore the space and others stars, planets and solar systems, or even other galaxies.

What is money? Of course, there are a lot of definitions of this concept, but the most relevant is money is a social convention (Carney, 2018)[8]. Please observe the images and engraves on different paper, polymer and metal (legal) money and the forms (neckless, ear-ring, string etc.) and sizes of shell money.

So, relating to the times before money existed, money is an innovation - an invention used in order to improve the quality of life. It allows (1) to store value (to transfer purchasing power from today to some future time), (2) to used it as medium of exchange (to make payments for goods and services) and (3) to measure the value of a particular good, service or product (unit of account). These are the answers to a question: why do we need money?

If (private) entities are allowed/can agree on the type of asset (central bank money and/or commercial money) to be transferred in order to settle a private (payment) obligation, the public (payment) obligations[9] are to be fulfilled according to the applicable jurisdiction/law. In the most cases[10], the settlement asset is central bank money issued by the central bank/government of that jurisdiction. Therefore, natural and legal persons have to acquire central bank money in order to

[7] USA is already coordinating efforts to prepare for space weather events that could "significantly degrade critical infrastructure" White House (2016).

[8] Both legal money and commercial money are expressing social and culture issues. Legal money is money issued by central bank or a government, regardless the form (physical – paper/polymer/metal or digital - account/token based) and shape (rectangular sheet, coin or ring, shell). Commercial money is (1) money created by commercial banks, postal institutions and other financial institutions such as electronic money institutions (generally accepted approach), and (2) assets issued by third parties, including decentralised autonomous organisations (less accepted approach), used to settle private and public (payment) obligations. For the purpose of this letter, shell money is not included, even shell money is commercial money.

[9] social duties/obligations: pay the (local, regional and central) taxes, contributions and state fines and penalties, if case, to (local, regional and central) authority/authorities. Petro is a crypto-currency issued by Venezuelan government.

[10] there are some exemptions where local money (Bristol pound, Brixton pound, Eko currency, Exeter pound, Lewes pound, Liverpool pound, Stroud pound, Totnes pound) and private (crypto-)assets are accepted to settle public obligations (Canton of Zug 2017, Canton of Ticino 2018).

settle their public (payment) obligations. We value central bank money[11] by two characteristics: the need to settle public (payment) obligations and, since natural and non-financial legal persons do not have access to central bank accounts, to preserve value of commercial money in distress times for the financial institution that holds the commercial money.

Anytime and anywhere access to the commercial and/or central bank money increases individual economic mobility and well-being. However, each of these settlement assets delivered to the users by different technologies comes with specific relevant limits and risks.

[11] Currently, the only type of central bank money accessible to public is cash.

Outline

1. Motivation for a single retail central bank digital currency

Modern economies tend to rely on flexible, efficient, on-demand and fast production and delivery systems heavily, regardless of the area where the system is operating (production, storage, transport/distribution etc.).

So, why don't we apply the same principles to production, storage, transport/distribution of money? A quick response is: (central bank) money is a public good, a product of a unique independent entity (central bank or government agency/entity performing central bank duties) that ensures three major functions: unit of account, medium of exchange and store of value. While modern central banks are accountable for fulfilling their mandate in the field of payment and settlement systems, they are not required to be efficient or to adapt to new business environment or technologies. In general, central banks have a mandate defined by law on price stability and some of them, also on financial stability, payment system oversight and economic development.

Financial institutions (mainly commercial banks, postal institutions, electronic money institutions) are not issuing money, but are creating it through lending and thus by increasing the speed of circulation of both central bank money and commercial bank money! When a financial user is making cash deposits with a financial institution, the user is changing a claim (on money issued by central bank) with another claim (on money created by financial institution - commercial money or commercial bank money). When a financial user is making cash withdrawals from the financial institution, the user is changing back the claim on the money created by financial institution (commercial money or commercial bank money), with the claim on money issuing central bank. If the financial institution uses the money deposited by clients to grant credits, then the institution will create money in the economy.

Moreover, financial institutions profitability is tightly linked with their ability to circulate commercial (bank) money in the economy. More credits they grant more commercial (bank) money they will generate, under condition that the risk from credit is adequately mitigated. Central bank money is key to this type of monetary system.

Central bank money also ensures the monetary sovereignty of the state. The rapid developments of technological innovations in this field by the private sector is threating the leading role of central bank money and the monetary sovereignty itself, forcing central banks to adapt to the new technologies and money holder behaviour, even, to enter the new field of digital currency/means of payments (Mersch, 2020).

Mankind is ruled by law and governance bodies (governs and central banks, other financial regulators etc.), but regardless of their abilities, performance, innovative way of fulfilling their mandates, governance bodies competence is limited to a specific territory of their jurisdiction, and central banks are no exception. Standards setting bodies are working to harmonise legal and operational frameworks over different jurisdictions.

Currently, financial regulators are setting up and updating legal frameworks (mainly applicable to regulated/supervised financial institutions, only) without a real involvement of financial end-users. Arguably or not, financial end-users are allowed to express their opinion on the draft law/regulation, during (short) public consultation period. Public hearings are not always applicable/available, unfortunately. Some jurisdictions are involving consumer protections agencies and (seldom) consumer associations, without any information on the representation mandate of consumer associations. Furthermore, Group of Thirty (G30, 2020) is supporting such unbalanced approach on how financial authorities (central banks and finance ministries) should proceed with regard to CBDC and payment innovations, disregarding the real needs of end-users.

Financial institutions are developing and updating financial services and products without a real involvement of financial end-users. Card payment schemes developing and updating financial services and products without a real involvement of financial end-users. Operators of payment systems are developing and updating payment systems and arrangements without a real involvement of financial end-users. Operators of financial markets are developing and running financial markets without a real involvement of financial end-users. All these industry actors aim to make profit and to comply with the relevant legal framework, most of them without considering any purpose of enhancing social well-being (for example, climate).

Nowadays, laws, rules and practices are demanding that (money) payments should be performed via financial institutions (mainly commercial banks), with some exemptions for cash limits, due

to AML/CFT rules. In order to execute payment orders, these financial institutions have to rely on each other in the same jurisdiction or even in different jurisdictions, using payment systems and arrangements run by private entities or central banks with different rules and different execution times, while financial end-users are not aware or involved.

Since each aspect of life could/should be improved (change/innovation) in order to achieve better life experiences, regardless of the innovation pace, why not to use just a single currency on this planet.

There is no real sustainable motivation not to use a single retail CBCD, other than (political) will. Nevertheless, at planetary level, we are subjects to the same physics laws, we use the same electron-based technology (electricity/electronics), we use more or less the same transportation and communication principles, rules and standards, we have more or less the same habits and share the same planet.

Using money (paying or transferring money) is just a matter of transferring money from the payer to the payee(s) by delivering either cash (central bank money) or electronic money (commercial (bank) money).

Historical arguments of sovereignty related to the right of money issuance could be removed by current "new order", current global education level and behaviour of millennials. Furthermore, in Eurozone current legal arrangements allow, on one hand, the currency issued by other Euro Member States to be legal tender in any other Euro Member States and, on the other hand, currency issued by European Central Bank to be legal tender in any other Euro Member States. Even some European micro-states, which are not part of the European Union, are allowed to issue euro currency[12]. Vatican has been issued euro, since 2002[13].

More than 20 years ago, in 1999, Mervyn King, the Governor of the Bank of England, emphasized central bank irrelevance and eliminating the monopoly position of central bank

[12] Andora 2014, Monaco 2001, San Marino 2006
[13] Vatican issued fifth series of euro, since 2002

(King, 1999)[14]. Furthermore, central bank irrelevance could be a result of the use of advanced technology that allow the emergence of one private payment system or more could completely eliminate the need for the central bank(s) to act as a settlement bank/agent (Bindseil et al., 2006)[15], as Facebook is possibly posing with Libra and Calibra/NOVI products since June 2019.

Some central banks and governments have launched discussion papers on Central Bank Digital Currency, are running exploratory projects on launching Central Bank Digital Currency, individually, in bilateral/multilateral central bank arrangements or with non-financial institutions or even issued Central Bank Digital Currency[16].

Arguably, the first plane[17] flew 36 meters in 12 seconds in 1903 and nowadays, after more than 100 years of innovation in aviation, using the same physics laws a plane flew 15,900 km non-stop flight mode for 19 hours from New York to Sydney in October 2019. However, the authors agree this statement: **this single retail CBCD proposed by this letter may not be the best/ideal solution (one implementation fits all purposes), but based on future developments and innovations, it could lead to optimum solution, until it would be replaced.**

2. Main design characteristics of single retail CBDC

(Principle 1) CBDC design should include all the necessary features to ensure financial stability, monetary policy efficiency and payment systems safety, (cyber-) security and efficiency. After

[14] "There would be no unique role for base money, and hence the central bank monopoly of base money issue would have no value. Central banks would lose their ability to implement monetary policy. The successors to Bill Gates would have put the successors to Alan Greenspan out of business."
[15] "The emergence of private payment systems completely eliminates the necessity of payment execution via the central bank, thereby entirely eliminating the monopoly position of the central bank.", page 216.
[16] Central banks motivation differs significantly: (1) (long term) constant notable decrease of central bank money (cash) usage (Sweden, Riksbank/e-krona project, Canada, Norway) as a result of competition between private money and central bank money, (2) enhance control over payments, (3) enhance the thrust in domestic currency (decrease of foreign currency usage), (4) inefficiency of retail and wholesale payments and (5) speeding up social benefits payments (USA FED/digital dollar). Ecuadorian central bank issued e-money during 2014-2018 period, Venezuela is using (crypto-)Petro to pay for governmental services (2019), while China is testing CBDC (digital Yuan) transfers and wallets.
[17] History records show that Orville Wright flew first plane 36 meters in 12 seconds in December 1903.

consulting various stakeholders, CBDC design should take into account experts' opinions[18] also on social policy, environment, technology, legal, including data privacy issues and governance. In addition, its design should incorporate the end-users views and requirements in order for the CBDC to fulfil its role as a public good. "This setup would be good for users, bad for criminals, and better for the state, relative to cash. Of course, challenges remain." (Lagarde, 2018).

2.1. Issuance and design

(Principle 2) The CBDC is issued directly to public (ultimate holders) by central banks against cash and commercial (bank) money, based on an arrangement among all relevant authorities. The convertibility of the CBDC is one key factor that contribute to currency singleness (BIS, 2020b).
(Principle 3) The CBDC should be backed by a trusted authority (the central bank) and should not have limits on the maximum amount that can be held with the central bank[19]. Such a CBDC can prevent the wide adoption of private means of payments (for example, stablecoins) that might generate higher risks for financial stability and have the potential to impair the transmission mechanism of the monetary policy rendering the central bank's first mandate almost impossible (Zhang, 2020).

(Principle 4) The CBDC should be technologically neutral in the sense that it should be accessible, scalable and easy to use[20] irrespective of the technology employed for storing or making payments. Depending on the design, CBDC could be central bank account based or token based[21], but the used technology/technologies should be user-friendly taking into consideration different languages and writings.

(Principle 5). The existing technology inclines now more to the account-based model, as the token-based form fails the test of scalability and finality of payments (Carsten, 2019). In the case of a token form, with small chances CBDC could be supported by a distributed ledger

[18] Providing that these opinions are impartial and independent.
[19] CBDC design could allow a setting-up a maximum amount limit of CBDC that can be held with the central bank, but in this case, authors consider a parallel central bank and or commercial bank money would exist, and some synergies of a unique/single CBDC would be lost.
[20] The design should take into account also different human disabilities (especially, vision impairment).
[21] a representation of a digital asset. It typically does not have intrinsic value but it is linked to an underlying asset, which could be anything of value. World Bank Fintech Note 1 (2017)

technology (held by the government or other relevant authority) that could also have a system that would protect the anonymity of the counterparts, unless it reaches a red zone (illicit transaction, unauthorized counterpart) when AML/CFT legislation applies. In the case of the account-based form, CBDC transactions information could be held by the central bank(s).

(Principle 6) We see **CBDC having a constant nominal value** (like cash, **since CBDC is replacing cash**) and **bearing interest**, but central banks should consider if CBDC will bear interest or not, and even the value of CBDC. Bordo and Levin (2017) show that a **CBDC can serve as a costless medium of exchange, secure store of value, and stable unit of account**, but to achieve these criteria a CBDC should be account based and interest-bearing. The interest rate paid on CBDC holdings with the central bank would act as monetary policy interest rate. This should increase the efficiency of the monetary policy transmission mechanism (the central bank is directly affecting the households and firms' decisions) and facilitate the systematic and transparent conduct of monetary policy (Bordo and Levin, 2017). Moreover, this CBDC interest rate would not be constrained by any effective lower bound (Bordo and Levin, 2017).

CBDC design could provide some of the best features of the actual form of money (cash and account based), especially security (like deposits) and anonymity (like cash) – Lagarde (2018) and Agur et al. (2019).

(Principle 7) Such anonymity should be towards third parties, only, unless ordered by a court Agur et al. (2019) and could be also achieved based on data segmentation[22]. For **AML/CFT purposes**, the design of CBDC could envisage that of each CBDC (unit) is a block of any different, but equal, 100 subdivision units and each subdivision unit is marked with a unique identification number/code/tag/label. At any time, instant payment system logs should provide to relevant authorities for investigation instant/quick circulation account/token path data of each

[22] By data segmentation solution, relevant data are divided and stored in different locations. For reading and changing data, pointers/references are used. For example, John Bell has a payment account AABBCCDDEEFF (IBAN code) with a balance of 12345 EUR. A possible basic data segmentation solution is to store *John* data in file A together with a complex (cryptographic) reference 1 to *Bell* data stored in file B and a complex reference 2 to payment account AABBCCDDEEFF. *Payment account IBAN* code data is stored in file C together with a complex reference 3 to *account denomination* data (EUR) and reference 4 to the account balance data (12345). When settling CBDC transfer only IBAN code data is used and no data on first name and sure name of the CBDC holder is used and/or disclosed. Access of CBDC holder name will be allowed based on a court decision or investigation decision, only.

and every CBDC subdivision unit from issuing date and so CBDC will ensure to holders' anonymity/privacy by design.

(Principle 8) The instant 24/7 running payment system used for (both national and cross border) CBDC transfers and payments should be state of art one with settlement in central bank accounting. (Principle 9) The instant CBDC payment system design should be based on general accepted principles and good practices like the *Principles for financial market infrastructures* issued by Bank for International Settlements in collaboration with IOSCO in 2012 (BIS, 2012). (Principle 10) This instant payment system should ensure high interoperability with relevant securities settlement systems.

(Principle 11) Central banks as payment catalysts and financial innovators should aim to and use effective green technologies (less heat and carbon footprint) and should allow innovative firms to develop new services on their technology. Furthermore, on one hand, FinTech and BigTech could provide innovative products and services, including Applications As a Service, to CBDC holders (natural and legal bodies, financial institutions and government) in a secure and competitive environment and, on the other hand, central banks should allow to CBDC holders to choose among innovative services and (FinTech and BigTech) service providers. Rating services could be available to CBDC holders, also.

2.2. Accessibility and circulation/distribution

"I believe we should consider the possibility to issue digital currency. There may be a role for the state to supply money to the digital economy." Christine Lagarde (Lagarde, 2018).

(Principle 12) The central banks[23] should issue CBDC directly to public[24] and central banks will be the main actor in distribution of CBDC. The access to CBDC account/token based should be granted by the central bank of the jurisdiction applicable to the CBDC holder.

[23] including relevant authorities that perform central bank functions

[24] each and every natural and legal person. We consider that two possible constraints could be set-up: (1) age limit more than 10-year-old (a 10-year-old child is educated enough to understand the concept of money) and (2) civil rights could be suspended/removed (relevant civil rights could be suspended/removed by court)

(Principle 13) Central banks, governments, natural and legal persons and financial institutions will use the single CBDC payment system operated by central banks.

(Principle 14) This CBDC should ensure financial inclusion regardless education, financial status, location and language, by allowing CBDC holders to initiate instant CBDC transfers/payments, even in remote areas with no or limited access to electronic communications and/or to payment/financial service providers acting as intermediaries. The development of remote access technology and infrastructure[25] might allow an easier access also to payment services or even to financial services and, thus, to significantly increase the level of financial inclusion. However, these advances in financial inclusion should come with adequate regulation and oversight as this might also increases the risks for financial stability, especially if the offered financial services and/or products are too complex for the people they are offered or are some kind of products with a debt-like component that the buyer cannot afford it based on its current financial situation and/or level of education. This type of risk is already seen for current Fintech developments (Claessens et al., 2018). By enhancing financial inclusions, the monetary policy could also improve (Zhang, 2020).

(Principle 15) Both on-line and off-line peer to peer CBDC transfers should be allowed. However, for off-line CBDC transfers effective limits should be defined in order to avoid double spending of CBDC and accumulation of large CBDC stocks outside the control of monetary policy. The double spending could occur if individuals use the CBDC holdings stored on offline devices for different purchases without recording the spending on these devices. Storing CBDC holdings on offline devices is equivalent with holdings of cash, currently. This behaviour could be amplified during crises and limits the ability of monetary policy to control the inflation.

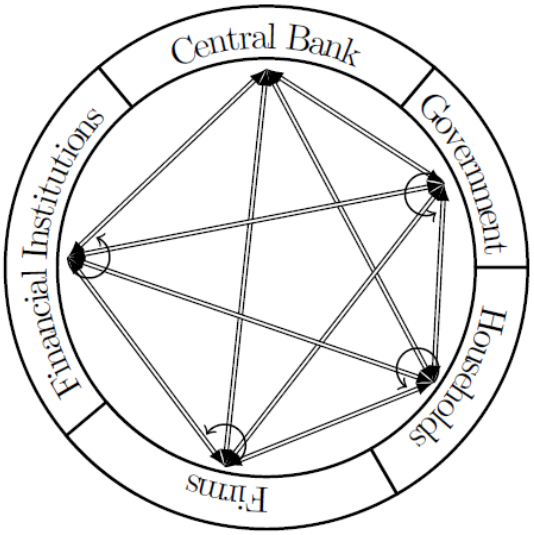
(Principle 16) Central banks, governments, natural and legal persons (firms) should be allowed to make CBDC transfers/payments and use CBDC as collateral in transactions, like cash-collateral currently.

A possible monetary system based on CBDC could be the one described in Figure 1. This is a one-layer monetary system where the Central Bank holds accounts with all the agents from the economy. Both the Central Bank and financial institutions can collect deposits that bear interest

[25] off-line or stand-alone communication technologies or even new WIFI network technologies (WIFI balloons)

rates. Government can issue bonds but can be also financed directly by financial institutions and firms and households. The Central Bank can only purchase Government securities from financial institutions and other firms (secondary market).

Figure 1 CBDC flows in a one-tier monetary system for one country



Notes: a detailed diagram on CBDC flows is presented in the Annex.

This CBDC monetary system model allows households to place deposits directly with the Central Bank, while maintaining their ability to place deposits with financial institutions and invest in financial institutions or other firms (including charity organisations). In addition, households can participate in various firms' projects that the financial institutions are intermediating and, even, lend directly to the Government. This monetary system based on CBDC allows CBDC payments/transfers also between entities within the same category (Government, Financial Institutions, Firms and Households). Under this design, financial institutions might not retain the higher role in financial intermediation, as they do now. Smart contracts could be also used in order to enhance efficiency of all type of CBDC payments (taxes, social benefits, rents, interest etc.).

This type of system warrants a higher efficiency of money transfers in the economy given the more technological advanced payment system that allow for faster transactions and at lower costs. In addition, this type of system will have fewer intermediaries, more investment opportunities (as households can directly buy government securities, stocks and bonds and other financial assets), higher access to finance and, more importantly, provides a higher quality asset for all agents in the economy than the current system – deposits at the Central bank. This efficiency comes at the cost of creating a new regulatory and supervisory framework that should ensure that the agents with lower knowledge of financial risks do not expose themselves excessively to such risks.

2.3. Legal tender

(Principle 17) In order to reach CBDC full potential, laws and regulations need to be adapted but, this will depend on the terms of central banks agreement achieved.

2.4. Instant settlement

Current evolution of digital economy and instant delivery of some digital content are strong stimulates to foster central banks to ensure the payment system will achieve 24/7 instant settlement of (both national and cross-border) CBDC transfers and payments, regardless the nature and location of payer and payee. (Principle 18) CBDC payment system should overperform current real-time gross settlement systems and instant payment systems. A maximum 10-second settlement deadline (from initiation) should be aimed for domestic CBDC transfers and payments with or without confirmation, while cross-border CBDC transfers and payments should be settled in maximum 30 seconds, pending on central banks' agreement.

With regard to interoperability with relevant securities settlement systems, the payment system should be harmonised to each DVP model used by these securities settlement systems.

(Principle 19) Smart contracts should be allowed to coexist with instant settlement model, and all types of CBDC holders should have access to use and set such contracts, but tax and tax refund smart contracts should be regulated, also.

2.5. Efficiency and security

(Principle 20) Efficiency by design could be achieved based on the central banks' agreement, but, nevertheless efficiency should be improved on regular basis, including CBDC holders' inputs/complaints.

Efficiency has multiple dimensions. The core criteria of assessing the efficiency should be at least (1) accessibility of CBDC and availability and performance of CBDC instant payment

system, (2) affordability of CBDC and CBDC transfer, (3) scalability of the payment system and reachability of other CBDC holders, (4) flexibility to innovate on and associated the CBDC, including by Fintech firms, possibly through sandboxes and (5) adequate management of security issues and incidents.

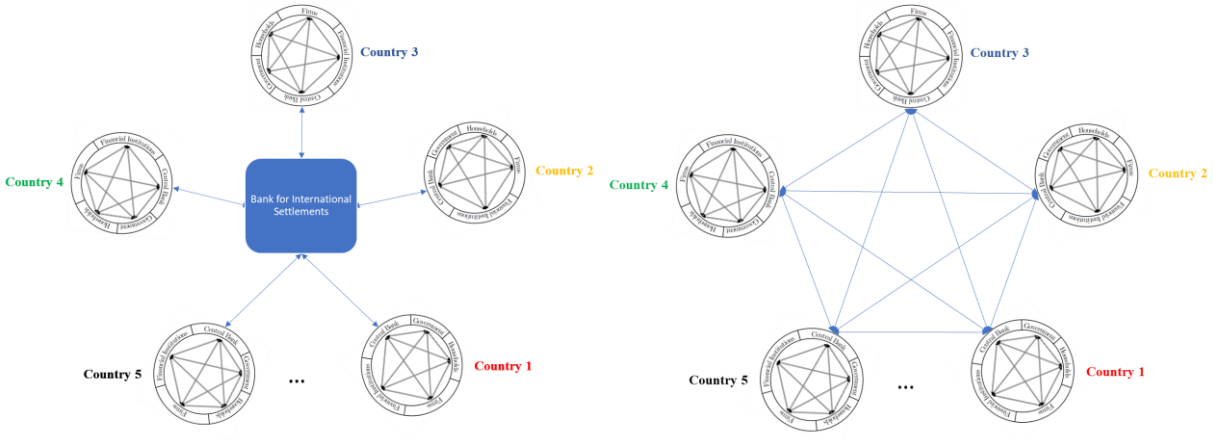
Nevertheless, the technology to be used should ensure high scalability of both online and offline transfers at no, low or affordable cost(s). Daily key performance indicators of the payment system should be publicly available online, free of charge, in diverse formats, languages and writings.

(Principle 21) CBDC security should be developed based on technology used and terms of central banks' agreement.

2.6. Governance and legal issues

(Principle 22) Central banks agreement on governance of a CBDC payment system and system rules (BIS, 2012) should ensure an adequate governance of the CBDC payment system and legal certainty, smooth operation of the CBDC payment system, regardless the settlement of (domestic and/or cross-border) CBDC transfer will be centralised, decentralised or hybrid.

Figure 2 Centralised and decentralised CBDC settlement models



panel (a) panel (b)

In case of centralised settlement model, Bank for International Settlements could act as external technical operator for clearing/settlement of CBDC transfers (Figure 2, panel a). In decentralised model, central banks could act as settlement agents, also (Figure 2, panel b). In case of hybrid settlement model, Bank for International Settlements and groups of central banks are involved in clearing/settlement of CBDC transfers/payments.

(Principle 24) Since private money, other than the current commercial money, could be further developed, the single CBDC should be equipped with a global legal tender facility, enhanced by technology developments.

Taking into consideration the current knowledge base and technology level, this single global instant payment system and a single CBDC design could generate the optimal benefits and efficiency. However, these should be improved on a continuous basis, taking into consideration experience and CBDC holders' requirements.

3. Main implications for different agents in the economy

3.1. Implications for central bank(s)

A first result of holding CBDC with the central bank is that the balance sheet of the central bank will expand exponentially due to the transfer of cash and real sector deposits from commercial banks (commercial bank money) to the central bank (as CBDC). This will create challenges for the central bank in managing the asset side of its balance sheet.

The central banks will face a higher stronger role and responsibility. On one hand, high market discipline will affect also the central bank as CBDC holders will have direct access to central banks (one tier monetary system) and on second hand central banks competition in one single CBDC.

The central banks could reduce the risk of banks' financial intermediations by adjusting its interest rate in order to direct the flow of CBDC to financial institutions (Agur et al., 2019). However, under this system design, the financial institutions compete for finance with other

firms and with the Government as they can directly access finance from households and other firms.

The central banks huge operational and technical challenges due to the need manage millions of CBDC accounts/tokens and perform authentication of the payer for each payment initiated by the payer or payee and each entity that accesses to payment account, including AML issues. In case of malfunctions and frauds, central banks have to report the deficiencies and incidents, publicly, and to take immediate measures to protect all CBDC holders' rights.

Since, the technology is not there, yet, central banks will be the explorers and innovators (especially in green) technology (platform/infrastructure) to serve the CBDC purposes and have to acquire a deep knowledge to ensure safety and efficiency of both national and cross-border CBDC transfers and payments, while retaining oversight function of the CBDC payment system (collaborative oversight).

On one hand, the central banks will have to develop new tools for KYC and AML, and fraud prevention to ensure the safety and efficiency of the CBDC payment system. On the other hand, central banks will have to adapt the monetary and financial stability policies to the new monetary system and, even, to redesign its macroeconomic model given the fundamental changes in the economy, including digitalisation of the economy and of the fiscal policy (for example, taxation might be conducted based on smart contracts). For all of these, central banks should engage with other public institutions and agencies, academia, technology developers, technology standardization bodies, sociology experts, environmental experts and general public (ultimate CBDC user) in order to define and adequately implement user requirements.

Moreover, if the CBDC will encounter difficulties in settling CBDC transfers/payments, there is the risk to stimulate a concurrent parallel monetary system on settlement private assets, including stable-coins.

Central bank seigniorage will be influenced by huge operational and cyber security resilience costs.

3.2. Implications for the Governments

All financial inclusion and financial education policies should be reviewed and adjusted.

CBDC could also foster innovation in fiscal policy like instant taxation of CBDC income when gaining revenues (sales, rent, interest etc.) and/or taxation based on smart contracts with a potential improve of fiscal revenues (collection).

A single CBDC would imply an allocation of financial resources to different governments based on the investors required risk premia (or country ratings).

3.3. Implications for financial institutions

A single retail CBDC one tier monetary system will not just disturb current financial stability and financial institutions business model (especially commercial banks), but will disrupt both current financial intermediation model and eliminate commercial banks' monopoly (main deposits collectors and credit providers). Since the banks will no longer have the same ability to cover the losses from non-performing loans with the income from other loans granted, the financial intermediation model could increase the banks' thoroughness of credit quality assessment. Furthermore, it could empower all CBDC holders since CBDC will enforce market discipline (CBDC holders will decide whether or not they will invest in projects managed by commercial banks, given the investment project expected risk and return). This will have possible implication on the banks' funding costs. The interest rate the banks will pay on the funds received from CBDC holders will depend on the level of the interest rate paid by central bank and Government on CBDC funds.

A single retail CBDC if adopted will reduce the too big to fail problem (Niepelt, 2020), while current bank resolution system could become obsolete and maybe the resolution mechanisms and safety nets could be adjusted to the new financial intermediary model. Even more, the regulatory perimeter could be redefined.

3.4.Implications for public

An optimal CBDC technological environment[26] and holding CBDC with central bank could enhance high market discipline if the public has an adequate financial education and it is well informed on the (quality/risk) investment by investment manager (mainly financial institutions). More transparent investment and more investment opportunities in one platform could allow households and firms to better manage their incomes, investments and taxes.

Households and firms could decide to invest taking into consideration the levels of CBDC interest paid by central banks, governments, and financial institutions around the globe.

All current costs posed by handling cash and currency exchange rates will vanish.

4. Conclusions

The CBDC question is no longer "Should central banks consider issuing it?", but rather when and how. The digitalization of money has the potential to significantly empower CBDC holders (central banking for all[27]), expand investment opportunities and change the way the central banks conduct the monetary policy and, for those that have also this mandate, the financial stability policy. The new technology offers us the opportunity of changing the monetary system in a way that will dramatically increase its efficiency and market discipline. These new solutions come, however, with associated costs. The new monetary system might pose different risks, such as structural disintermediation and systemic run offs. In addition, the introduction of CBDC in one country might have material international spillovers, but the magnitude of the shocks depends on the design of the CBDC.

The new emerging literature on CBDC is considering different architecture models for the monetary system under CBDC, but there is still a long way to go in order to get a good understanding of what should be the optimal set up for a CBDC monetary system. The analysed models vary from no change at all (there is only an exchange between the hard currency with the

[26] high effective, innovative, including smart contracts usage, competitive and secure platform
[27] In our concept, central banking for all include not only deposit services as described by Fernández-Villaverde et al. (2020), but also payment services to CBDC holders.

CBDC) to more complex ones, like two-tier remuneration system (Bindseil, 2020) or the ones that allow general public to hold deposits with the central bank (Fernández-Villaverde et al., 2020).

Central banks should regularly improve their internal innovation organizational culture and should systematically evaluate if their current staffing, training programs and tools are adequate in order to understand thoroughly and to develop and assess the new technologies and payment innovation(s).

Given the nature of the central bank money as a public good, central banks should systematically analyze the prospects and the opportunities of digitalization/virtualization[28] of money in order to ensure that it achieve its functions and the goals and needs of end users. Furthermore, central banks should assess whether or not their legal frameworks allow them to issue CBDC and the limits of these legal frameworks. This process could involve also changing the monetary system in a way that it matches the fundamental changes in technology[29] and in the economy, as well as the evolution of digital economy. These adjustments will probably shift the goals and needs of the end users. Therefore, central banks should regularly trail the changing needs of the CBDC end-users, including payment preferences/behaviours.

In order to do this, central bank could establish multidisciplinary[30] CBDC teams dedicated to (1) explore different CBDC models and the (evolution of) central bank role in never-ending change of payment landscape and (2) coordinate with relevant government agencies and other central banks[31]. More importantly, central banks should act together as a leader and a catalyst in financial technology innovation.

Apart of these, central banks should periodically evaluate their products (CBDC and services) relevance according to generational changes in (payment) behaviour and preferences and engage more in financial education programs, especially in those on new technologies and innovations, and in developing the taxonomy for the new financial services.

[28] projecting real cash into digital item/token/asset
[29] For example, monetary policy could be assisted by artificial intelligence and supercomputers.
[30] at least financial stability, monetary and payments
[31] taking into consideration all households, firms and financial institutions requirements and trends and experts' opinions on social policy, environment, technology, legal, including data privacy issues and governance, in order to remove local, regional and global payments inefficiencies

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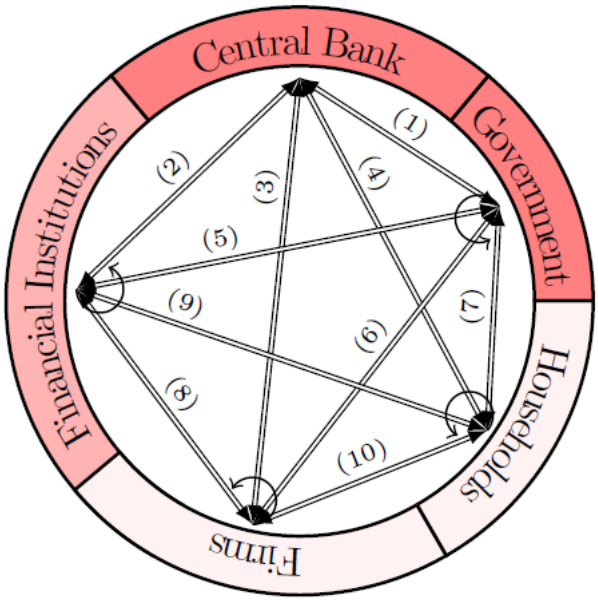
Annex – CBDC flows in a one-tier monetary system

A detailed diagram of CBDC flows in the economy according to a one-tier monetary system is presented in Figure 3 and Table 1.

Figure 3 – CBDC flows under a one-tier monetary system



Note: the double straight arrows represent the CBDC flows between different sectors (detailed in Table 1), while the small round arrows indicate the CBDC flows within sectors.

Table 1 – The description of CBDC flows according to the numbers specified in Figure 3

Link	Details
(1)	a. *Central Bank to Government* - payments of taxes and transfers according to the law (profit transfers) - interest payments on Government CBDC holdings at the Central Bank b. *Government to Central Bank* - deposits at the Central Bank - payments associated to Central Bank holdings of Government securities purchased from the secondary market - payments related to other central bank services
(2)	a. *Central Bank to Financial Institutions* - money market operations and their associated costs - purchases of government securities from the secondary market - interest rates payments on reserves constituted at the Central Bank (including minimum reserve requirements)

	b. *Financial Institutions to Central Bank* - money market and their associated costs - reserves constituted at the Central Bank (including minimum reserve requirements) - CBDC deposits at the Central Bank used as collateral in money market and foreign exchange market operations
(3)	a. *Central Bank to Firms* - interest payments on firms' CBDC holdings at the Central Bank - purchases of government securities from the secondary market - payments of purchased goods and services b. *Firms to Central Bank* - deposits at the Central Bank
(4)	a. *Central Bank to Households* - interest payments on households' CBDC holdings at the Central Bank b. *Households to Central Bank* - deposits at the Central Bank
(5)	a. *Financial Institutions to Government* - payments of taxes - purchases of government securities from the primary market - direct loans to Government for specific large public projects - payments of interest on Government's deposits at financial institutions b. *Government to Financial Institutions* - deposits at financial institutions - payments associated to financial institutions' loans and holdings of Government securities purchased in the primary market
(6)	a. *Firms to Government* - payments of taxes - direct purchases of Government securities - direct loans to Government for specific large public projects b. *Government to Firms* - grants and other transfers - payments of purchased goods and services - payments associated to firms' holdings of Government securities and loans purchased in the secondary market
(7)	a. *Government to Households* - government transfers (pensions, social benefits transfers, etc.) - salaries and other benefits to employees from the public sector - payment of interest rates on households' holdings of Government securities and/or in

	Government for specific (large) public projects b. *Households to Government* - payments of taxes - direct purchases of Government securities - invest in Government specific (large) public projects
(8)	a. *Financial Institutions to Firms* - loans granted to firms or other types of financial assets or projects - payments of interest on deposits or investments in firms or government projects intermediated by the financial institution - payments of purchased goods and services b. *Firms to Financial Institutions* - reimbursements of loans and payments of associated costs - deposits or investments in firms or government projects intermediated by the financial institution - purchases of government securities and other financial assets - CBDC deposits at financial institutions used as collateral for loans
(9)	a. *Financial Institutions to Households* - loans granted to households - payments of interest on deposits or investments in firms or government projects intermediated by the financial institution - salaries and other benefits to employees - payments of dividends b. *Households to Financial Institutions* - reimburse loans and pay interest on loans - deposits or investments in firms or government projects intermediated by the financial institution - purchases of government securities and other financial assets - CBDC deposits at financial institutions used as collateral for loans
(10)	a. *Firms to Households* - salaries and other benefits to employees - payments of dividends - repayments of loans and interest rates on direct loans or debt instruments b. *Households to Firms* - payments of purchased goods and services - direct investments and loans to firms - purchasing of stocks and bonds from capital markets