New and Better Money – Future Digital Currencies

Improvements in information technologies are opening ways for fully digital forms of money. Digital currencies have a potential to be a better medium of exchange and a safer store of value. We compare potential benefits and costs of public and private digital currencies, looking at several alternative properties. Among private-sector solutions stable-coins fully backed by reserves are the best alternative. However, central bank digital currencies can offer all the benefits of private solutions, without some of their risks and/or costs. Account-based digital currencies are most promising for future payment systems. Providing a truly global digital money can possibly change the established dominance of global currencies.

Introduction

The evolution of money is closely tied to technological possibilities. While the function of money stays remarkably constant throughout history – a medium of exchange, a store of value, and a unit of account – changing the form of money has led to more efficient and safer money. Creation of mining and smelting technologies has allowed the mankind to move from commodity money to standardized coins. Invention of the printing press led to fiat paper money. Computers and communication technologies allowed us to move most of our money to an electronic form. Today the progress in cryptography and further advances in electronic communication and data management are opening a way to fully cryptographic forms of money.

The case for better money

Let us look at how the current fiat currencies stand with respect to the basic functions of money and what could be improved with fully digital currencies.

First, let us deal with the minor issue of a **unit of account**. In principle, we could use any measuring system to assign value. So long as the system is logical and easy to use – what applies to all relevant currencies at least since 1971.[1] Most, if not all, currencies are easy to express values in – both large and small values are easily communicated. All major currencies have values such that the most commonly used prices are in single or double digits, maybe except for the Japanese yen. Also, all currencies are divisible to small enough units that there is no practical need to use any finer detail.

Second – but probably the most important attribute – **medium of exchange**. We want our transactions to be fast, comfortable, and secure.

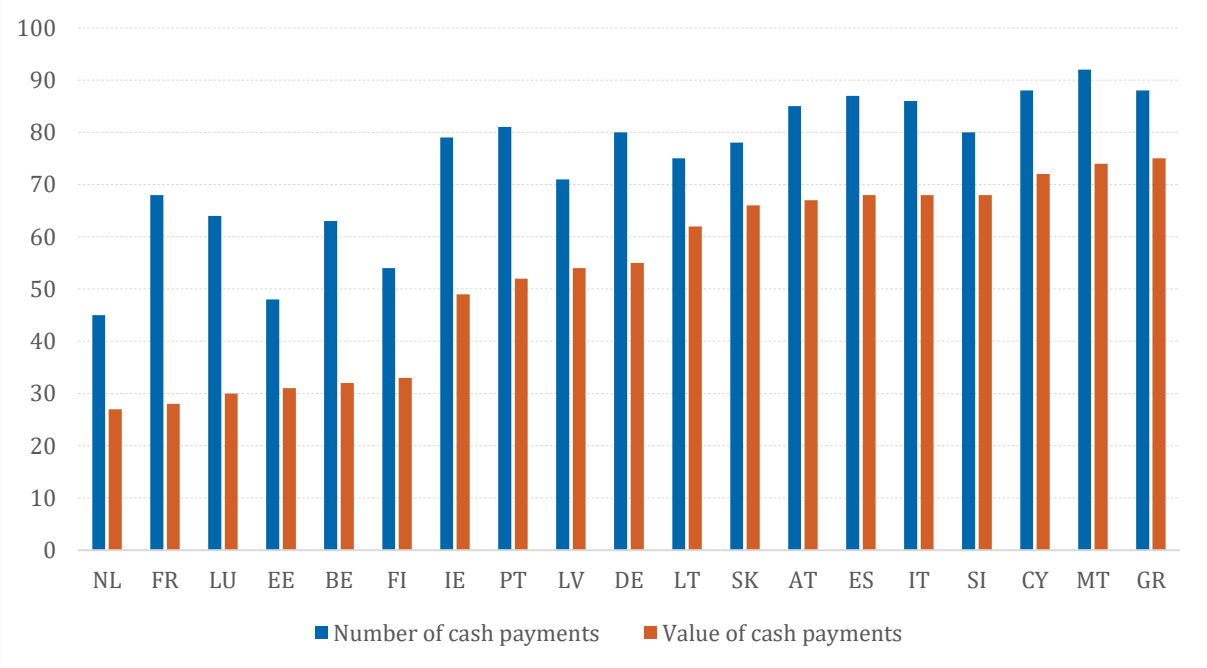
In terms of speed, most retail transactions take between 30 to 60 seconds, with cash and contactless payments being the fastest (NFC or RFID). Cash payments and some debit-card or

[1] The British pound was decimalized on February 15, 1971. The old system of pounds, shillings, and pennies – on top of crowns, florins, or farthings – was maybe romantic and had a long history, but was clearly cumbersome. Note: The Scudo of the Maltese knights is *not* a relevant currency.

mobile payments tend to be final at the time of the transaction.[2] Most other card transactions, including credit cards, and most electronic payments, take at least 24 hours to settle. In the largest economies cash is the most frequent mode of retail payment (see Figure 1), although in some countries its use is rapidly declining.[3] Digital currencies could make the payments slightly faster, but not much compared to NFC contactless payments.

International transactions take usually much longer. Unless major credit cards are used, fast and cheap domestic payment systems are not compatible across countries. Especially international payments among consumers take from several hours to several days, depending on the system used. International digital currencies have a potential to significantly speed up the payments.

Figure 1: Share of cash payments in Euro Area countries (%)



Source: Esselink and Hernandez (2017).

Regarding the costs of transactions, these vary widely. Often the costs are distributed in a non-transparent way between the consumer and the merchant. Costs can be as low as 1-euro-cent in the case of Target Instant Payment in the euro area, but as high as 15 to 25 dollars in the case of wire transfers in the US. Estimates of the costs of cash payments vary across countries and studies, averaging around 3% of the transactions. Card payment costs range from 1.5% to 3%. Digital money has a potential to decrease the transaction costs to about 1 cent per transaction, or even less if the fixed costs of the platform are spread over a large volume of transactions.[4]

International transactions are much more expensive and tend to be most expensive for poor senders or receivers. According to the World Bank the average cost of remittances is 6.8% of the transferred amount, but the costs can easily double for some Sub-Saharan countries. Moreover,

[2] For example, the instant payment system rolled out by the Eurosystem in 2018 can facilitate a transaction settlement in 10 seconds or less. Even more advanced is the Indian Unified Payments Interface, offering real-time payments and other advanced services. Other examples include the New Payment Standard in Australia or private payment systems in China such as WePay and Alipay.

[3] For example, in Sweden cash payments are down to 6% of retail payments.

[4] The most efficient cryptocurrencies are already approaching 1 cent per transaction, although Bitcoin, which is 2/3 of the cryptocurrencies market, cost between USD 0.3 and 6.5 per transaction in the past year.

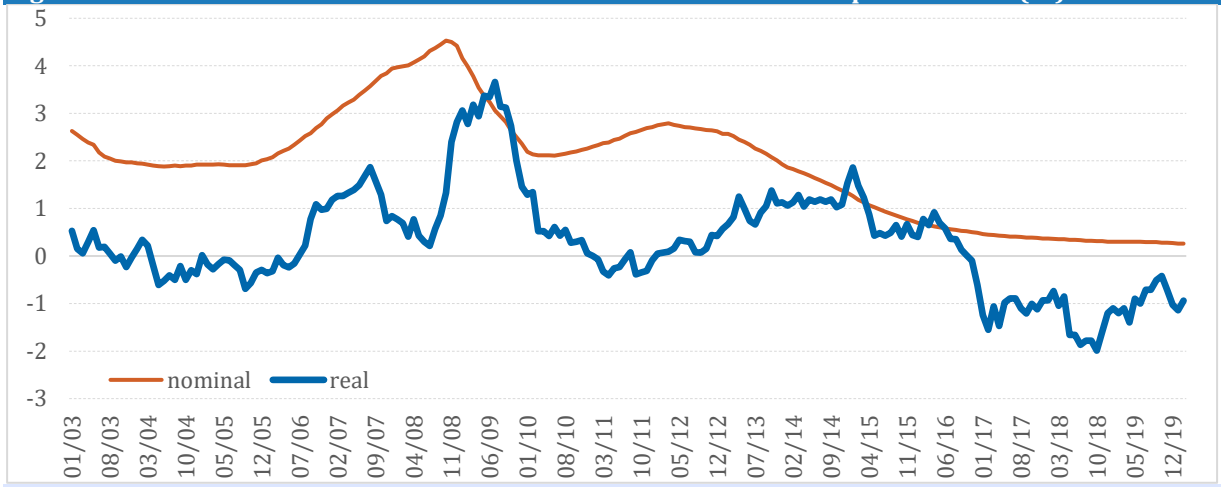
safer and faster forms of transfer, such as banks, tend to be the most expensive.[5] Among the G20 countries only Russia can send remittances below the 3% Sustainable Development Goal – currently at 1.83%. On the receiving end, among large recipients only Mexico was able to squeeze below the threshold, although only if the value of remittance exceeds 500 USD – which costs 2.54%. Digital money, so long as it were universal, could cut the transaction cost to about 1 cent per transaction – as in the case of domestic payments, plus around 1% transaction cost of converting the payment to a domestic currency of the recipient.

Another important aspect is the safety and finality of transactions. From the point of view of the seller/receiver cash transactions are final and settled immediately. Bank transfers may take from seconds to one or two days, depending on the particular retail payment system. Card transactions and various private platforms (such as PayPal, Alipay, or WeChat) may confirm the transaction almost immediately, but expose the recipient to reversal of the payment for several weeks, even months. Digital payments would be final and most likely irreversible, protecting the seller from incomplete transactions.

The final property of money – **store of value** – can, and should, be assessed from both private and social perspective. The value of cash is stable in nominal terms, but cash gradually loses real value due to inflation, and its storage costs are not negligible. Most advanced economies target a 2% inflation rate; thus cash loses about 2% of its value annually. The costs of storing larger volumes of cash were not well researched until the recent global financial crisis, when many central banks turned to negative interest rate policies. The effective lower bound for deposit interest rate can be thought of as an opportunity cost of cash storage – including insurance costs, security, warehousing and handling. Switzerland and Denmark went up to -0.75% interest rates, with Sweden and Japan also having slightly negative rates. Estimates of the lower bound go below -1%.[6] Thus overall cash may cost up to 3% of its real value.

Electronic money is usually much cheaper to store – most consumers with bank accounts can get accounts with no or minimal fees, unless they require additional services. For example, in the Euro area while the average inflation since 2003 was 1.6%, nominal interest rates on household short-term deposits averaged 1.9%, making cash savings a decent store of value (Figure 2).

Figure 2: Nominal and real interest rates on short-term household deposits in EUR (%)



Source: ECB, Eurostat.

[5] See for example https://blogs.worldbank.org/peoplemove/data-release-remittances-low-and-middle-income-countries-track-reach-551-billion-2019.
[6] Kolcunová & Havránek (2018).

From a social point of view the trending loss in value of money due to inflation is "not a bug, but a feature". Central banks intentionally "manipulate" the value of money, or, in other words: use monetary policies to stabilize the economy. The positive trend in the price level is the price paid for the ability to implement monetary policy, since decreasing inflation below zero is dangerous from policy perspective and policy interest rates cannot go too far into negative territory. Thus, from a social point of view an ability of a central bank to vary the value of money is preferable to money that has a constant value all the time.

Digital money as a store of value could be anywhere on the scale between cash and electronic money, or even a bit off the scale, depending on the setup of the digital money. For example, central bank digital currencies that try to resemble cash as close as possible would face the same inflation tax as cash, but without the storage costs. Private digital money, such as Libra proposed by Facebook, would probably not be remunerated and thus face the same value attrition in real terms. On the other hand, central bank digital money designed to resemble central bank reserves would probably pay interest rates. On average, the real value of such money would be more stable; in fact, it could grow in a long run, even more than indicated in Figure 2. In the short run, however, it is possible to envisage negative interest rates – possibly significantly below current estimates of the effective lower bound – making the value of such digital currency more volatile.

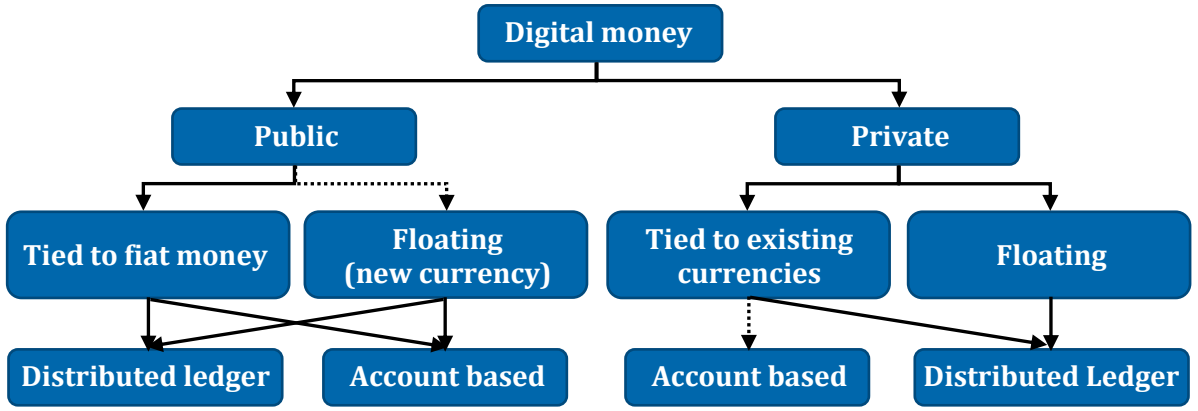
Overall, we see potential benefits of digital money in most of the major characteristics of money. Depending on what is considered as the baseline money now, the future digital money could be anywhere from slightly better to significantly better.

What is digital money?

So far, we have discussed digital money without being strict about what exactly it is. There are several possibilities of digital money (or currency), that differ in their relation to the existing fiat currencies, the issuer, or the underlying technology. The one common theme is that **digital money will be a fully electronic currency available to the final consumer as a base money**. This contrasts with the current electronic money – checking accounts, bank deposits, or other forms of M1, M2, and other M-s. Electronic money is always backed by fiat currency (banknotes and coins), but there is an intermediary between the consumer and the issuing authority. As holders of electronic money we are exposed to a credit risk of the intermediary, however small it may be. With digital money the final consumer will be able to hold M0 directly in a digital/electronic form.

Digital money will be a subset of a broader class of digital assets. Digital assets are (will be) assets in purely electronic form – either as a unique piece of information (a token) or as a record in a digital accounting system. Digital assets can be connected to an underlying real asset, or to some valuable commodities, goods, or services. However, some digital assets may derive their value primarily from trust of its users in the value of the asset – in its ability to be exchanged for something else, which is valuable. This is especially true for digital money – a subset of digital assets designed to be used to facilitate transactions.

Figure 3: Design options for digital money



Source: author.

Public or private

The first crucial distinction is whether the future digital money will be public or private. There is no public digital currency yet, but experience tells us that eventually all forms of money in history became publicly issued. They will most likely be issued by existing central banks, but it is possible to envisage a special public authority issuing (minting) official digital currency. Public digital money would allow monetary policy to function by manipulating the supply of the digital currency or its official interest rate. Moreover, any seigniorage from issuing the currency would remain in the public hands. Finally, national security issues might be important (above the concerns for monetary policy and seigniorage). Private attempts to create digital currencies already exist – there is a wide and growing variety of crypto-coins, starting with Bitcoin. An initially promising plan to create a global stable-coin Libra, led by Facebook, seems to have stalled.[7]

Fixed or Floating

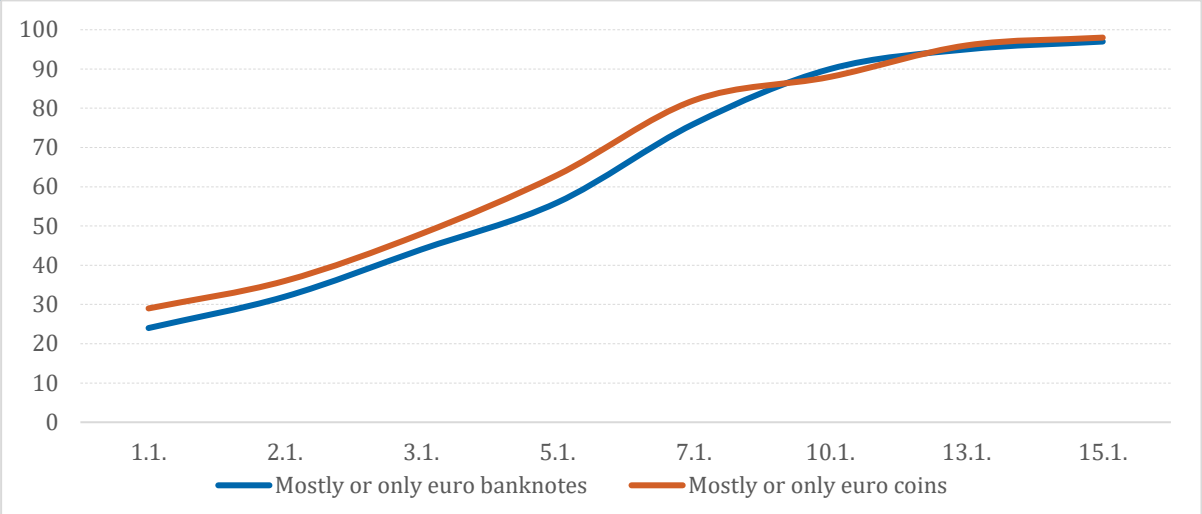
The new digital currency can be just another form of an existing currency – besides the widely used cash and electronic forms. If publicly issued it would be backed by a promise of the central bank to convert the money on demand to a different form.[8] Or – if issued privately – it would essentially be a stable-coin, fully backed by reserves (i.e. a form of digital currency board).

A floating digital money would be a completely new currency. It is unlikely to be issued publicly – there is no good reason for a sovereign to issue two parallel currencies. We know from several episodes with two or more parallel currencies that consumers are very averse to dealing with more than one money on daily basis. For example, during the cash changeover in the Euro area in 2002 and in following years in new entrants, the consumers made serious attempts to get rid of the legacy currencies and only have one type of cash in their wallets (Figure 4).

[7] see for example https://www.ft.com/content/79376464-72b5-41fa-8f14-9f308acaf83b

[8] An equivalent of the current practice of exchanging coins and banknotes for different denominations of fiat money, or the 1-to-1 conversion of electronic money to cash.

Figure 4: Share of euro cash held by consumers during dual circulation period in Slovakia (%)



Source: European Commission, NBS.

Floating private digital assets already exist – in the form of various cryptocurrencies. Their solution to preserve the value of the "coins" is to limit supply by alternative means, since there is no single authority (central bank) to otherwise limit supply. The consequence of this technological choice is that mining of the coins is computationally expensive and all potential seigniorage is wasted on computing power and/or energy.

Distributed ledger or account based

The final design choice is between account based and distributed ledger based digital money. An account-based system requires a trusted central counterparty – an institution tasked with protecting the value of the currency. Traditionally this has been the role of central banks. However, central banks can choose to create also ledger based (cryptographic) digital money, for example to promote the acceptance of the new money in other jurisdictions or offline. Stable-coins could be both ledger-based (as is currently the norm) or account-based. True crypto-coins must be ledger-based by construction, since they assume no trusted counterparty exists.

Costs and benefits of private digital currencies

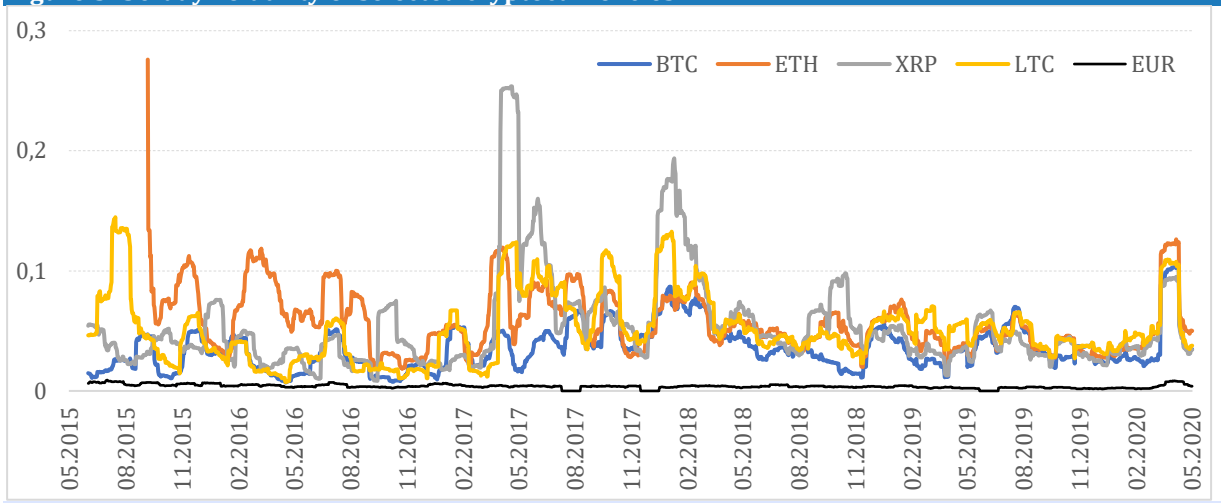
Floating cryptocoins

Traditional cryptocoins fail as money in two dimensions. First, from a social point of view they are extremely wasteful. Increasing money supply is dependent on a "mining" technology – solving complicated computational puzzles. This consumes real resources, electric energy and hardware, that the society could put to a better use. Contrary to crypto-coins, fiat money, or even centrally created cryptocurrencies, can be created with minimal or no costs. Second, all major crypto-coins are extremely volatile (Figures 5 and 6) and thus fail in one of the basic functions of money: they are a miserable store of value.[9] While Bitcoin is an amazing proof of concept of the viability of the distributed ledger technology and blockchains, it failed to attract user base besides technological enthusiasts, speculators, victims of ransomware attacks and the perpetrators of the attacks

[9] Therefore crypto-coins are currently not held for transaction purposes, but either by speculator or to help concealing cybercrime – e.g. most ransomware payments are in bitcoins.

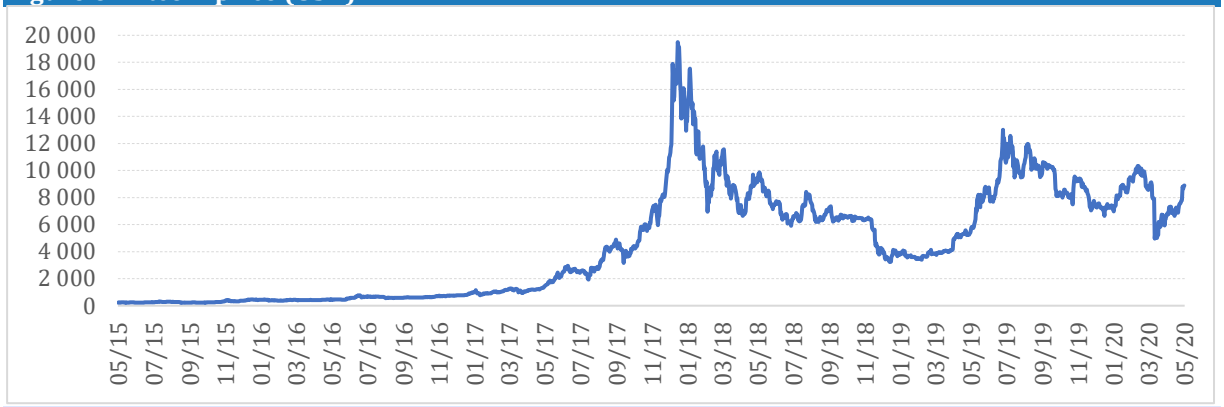
(maybe in reverse order).[10] All the remaining cryptocurrencies seem to only attract speculators and should be considered risky assets, not currencies.

Figure 5: 30-day volatility of selected cryptocurrencies



Source: Yahoo Finance, own calculations.
Note: EUR-USD volatility added to allow scale comparison.

Figure 6: Bitcoin price (USD)



Source: Yahoo Finance.

Benefits of stablecoins

Stable-coins avoid the largest drawback of traditional cryptocurrencies – the extreme volatility in value. Existing stable-coins, especially Tether, are controversial due to the opaque nature of their governance and reserves. That is why a proposal by a consortium led by Facebook to create a new global stable-coin Libra has gathered so much attention. A successful stablecoin could fill in several gaps in the market for payment instruments. Although the Libra project seems to have reduced its ambitions significantly, it successfully moved the mainstream discussion about digital currencies from a theoretical curiosity (such as Bitcoin) to a practical possibility.

First, a widely used stablecoin has a potential to be much better integrated into our digital life, so long as it is backed by a trusted and transparent governance. Moreover, almost half of the adult population (over 2 billion) does not have a bank account and this holds for an even larger share in the subgroups of women and developing countries. On the other hand, a large share of these

[10] An additional insult to the Bitcoin aspirations to be used as a payment instrument is the refusal of the North American Bitcoin Conference to accept fees paid in Bitcoin.

financially excluded people owns a cellphone. A digital coin might provide access to micro-credit for small companies and entrepreneurs.

Second, cross-border transfers could be fast and cheap. It is estimated that the transfers fees from migrants sending money home is about 30 bn USD.[11]

Third, blockchain-based technologies allow completely avoiding back-office tasks related to the transaction settlement.

Forth, because of the open source technology, the functions of a stablecoin can be further extended by an active developer community. For instance, developers can allow users to buy only certain types of goods (this could be used for instance to restrict homeless from using donations to buy alcohol rather than food and other necessities).

Fifth, transfers in stablecoins could be almost immediate and thus resemble hand-to-hand transactions with cash. As a result, people might agree to sell even relatively expensive products, as the seller will see the money on their account instantaneously. However, more importantly, it can be used for micropayments. For instance, it may bring a new way for users to pay for digital content as they read it or watch it, or it can make it convenient to pay for public transport.

Sixth, in many developing countries trust in official currencies is rather poor and a successful global stable-coin can provide a much more 'trusted' mean of payment.

Seventh, payments could now be fun, emojis, messages and photos and customer rating can accompany the payment.

Costs of stablecoins

Seigniorage is usually a source of income for the government. If the volume of cash in circulation drops significantly when consumers switch to a stablecoin, the governments will have to find other alternative revenues, most likely increasing some taxes. Furthermore, although the governments are aware of the seigniorage revenue, they have institutions in place to prioritize price stability over seigniorage revenue (i.e. independent central banks are charged with monetary policy). The same is not true in the case of a private coin issuer, who will be motivated to be more profitable by increasing its seigniorage revenue by either manipulating the composition of the coin or increasing yields on its reserves. In other words, it will face a significant time inconsistency problem, similar to what not independent central banks used to face in the past.

There is a possibility of a **default or a loss of confidence risk**. The value of the coin would be backed up by a portfolio of bonds, or other assets. This makes a stable-coin similar to a mutual fund – but without the regulation and safety checks imposed on most mutual funds. Reserves behind the stablecoin could lose value, or be even criminally misplaced, without the users of the coin knowing. That also allows for the possibility of a loss of confidence risk – similar to the well-known bank-run phenomenon – likely putting strain on the liquidity of the reserve fund and leading to losses if the reserves are liquidated quickly.

A global stable-coin, such as the original Libra project, is likely to be a type of a **currency board tied to a basket of other currencies,** which are more likely to fail compared to one-currency hard pegs. The coin's money creation will be anchored to the fiat currency reserves. Currency boards have been tried at different times and places, and the many lessons we have learned about

[11] See for example https://voxeu.org/article/stubbornly-high-cost-remittances.

them apply to stable-coins. The value of the stablecoin in terms of traditional national currencies will be effectively determined by the coin issuer. If the coin becomes a widely used currency, then allowing its value to drop down just by a fraction of percentage point will mean enormous capital gain for the issuer. This could be easily accomplished by changing the weights of the currencies in the portfolio. Thus, a global coin tied to a basket of currencies will face time inconsistency issues as changing the rules in the future could bring economic gains.

Financial crime concerns come from:

1) Money laundering: Nowadays any suspicious transactions are recorded and reported and thus it is not easy to legalize money gained from crime. If the coin wallet is not linked to the user real life identity it might provide channel to legalize money from crime.
2) Tax evasion: Trading of goods might be anonymous with a crypto currency and outside of a merchant's bookkeeping system.
3) Hacking: As the coin is purely electronic it is vulnerable to hacking.
   Most crypto coins allow users to create multiple accounts with pseudonymous identity. It would operate outside the traditional banking channels and thus it might be much harder for governments to limit payments out of a country or apply sanctions against a foreign power.

Financial stability risks:
A widely-used coin may break down the **monetary policy transmission mechanism** – especially for small countries. If many transactions are based on a currency which is pegged to a basket of foreign currencies this means that many transactions in the economy will be implicitly backed by a foreign currency. This would weaken the transmission of monetary policy. In a way, a country heavily "cryptoized" will face the same policy ineffectiveness as dollarized or euroized countries face nowadays. Furthermore, should a coin become the global dominant i-currency, as was Facebook's initial hopes, then the issuer would be in charge of **global monetary policy**. However, an entity without any taxing authority would not be able to provide some essential monetary policy and financial stability functions, such as the lender of last resort or restructuring systematically important financial institutions (SIFIS)

Privacy: Depending on the particular design of the coin, pseudonymity of the coin may turn out to be easy do de-anonymize and large volumes of private transactions may become transparent either to the coin issuer, or to the keepers of the ledger, or even to a much wider audience.

Adoption and network risks. These are two often mentioned risks which stand against each other. On one hand, many banks decided not to join Libra Association arguing that in their experience it is very difficult to convince merchants to adopt even simple technologies and so it very difficult to persuade merchants to use a coin whose values fluctuates against the local currency, in which they have to pay taxes and rents. On the other hand, should some future stable-coin break through the obstacles and gain sufficiently large acceptance, it could become a natural monopoly for global payments. A global coin with billions of users cannot technically sustain a fully permission-less network. There would have to be a limited network of ledger administrators or overseers. The potential market power of the coin issuer and the administrators could be enormous. Furthermore, due to the nature of a first-mover advantage in a global network, alternative coins would find it extremely hard to compete with the one that gains global dominance.

Moral hazard: should a coin succeed and become a widely used global i-currency, it will be motivated to exploit a moral hazard faced by many other SIFIs. It could engage in excessively risky activities (e.g. investing its pool of reserves in high-yield high-risk assets) while counting on being

bailed out by governments, which would not accept the threat of losing a large global payment system.

Governance issues: Most, if not all, existing cryptocurrencies have very opaque governing structures. The legendary Bitcoin founder Satoshi Nakamoto has managed to remain anonymous. Paradoxically, among the various coin backers Facebook Inc. seems to be the most trustworthy – being one of the largest publicly traded companies it is required to maintain some level of public disclosure. However, from a point of view of money creation, Facebook has proved to be a company with a rather poor governance record. It had violated its user's privacy at several occasions. For instance, Cambridge Analytica, was harvesting Facebook user data by exploiting a loophole in the way the social network stored its information. It is also believed that Russian agents have exploited Facebook's advertising system to target specific demographics with fake or misleading news, in a bid to get their preferred candidates elected in several foreign countries. In late 2018, the UN condemned Facebook for providing a platform to those inciting genocide in Myanmar.

Costs and benefits of public digital currencies

Public digital currencies can come both in the form of account-based or distributed ledger-based money. Both have its specific advantages, thus it is not absolutely clear which form should be chosen by central banks in the future. Maybe both.

Account-based digital currencies

From a technical point of view an account-based system is easier to implement and faster. The whole point of distributed ledger technology is to validate transactions when no trusted central party exists. This is in direct contrast with the monetary systems we have, which are centered around a trusted issuer – a central bank. Modern central banks are well aware of how important their credibility is and have a decades long track record of keeping the value of a currency reasonably stable. It is therefore **natural for central banks to be the trusted central party** in a digital currency system and to administer the accounts.

Currently central banks provide banking and transaction services only to commercial banks and a select handful of other institutions. Only commercial banks now have access to base money (M0) in an electronic form. Ordinary citizens can have claims on the central bank only in the form of banknotes or coins. A digital currency would allow all citizens (and potentially also foreigners) to have accounts with a direct claim on the central bank.

It is not clear how wide services would a central bank want to provide to the general public. Central banks are not used to dealing with retail customers and do not have the expertise to cater to the varied requests of individuals. Thus, they may want to outsource the administration of the individual accounts to other institutions – commercial banks or private payment service providers. The crucial difference would be, that the commercial banks would act as brokers (or agents) of the consumer, administering her holdings of central bank money – but the consumer always retains the ownership of her digital money. It is even possible that the consumer could have several banks or other providers managing the same account, if each of them provides a different level of service.[12]

[12] Maybe similar to the current situation, when one credit card account may be tied to several other payment systems such as Google Pay, Apple Pay, Alipay or PayPal.

Account-based digital currency system **transactions can be lightning fast**. Compared to the currently widely used card payments or interbank payments, basic payment service could be instantaneous. Validating a transaction today involves the seller contacting his bank, which contacts the hub (credit card company or a retail payment system operator), which in turn verifies fund availability or good standing of the buyer's account. Each step involves a short delay, which can add up to several seconds. Bypassing the middlemen and confirming the transaction with the central bank only can complete the payment as fast as we are used in internet communication. This would probably be effective only for small transactions – on a retail level – when no additional checks, such as anti-money laundering or anti-tax evasion, are needed.

At the same time, **market competition for additional services could be allowed**. Banks and payment service providers could build add-ons and provide repeated or algorithmic payments, direct debits, smart payments and micro payments, or integrating IOT payments.

Balances in the digital currency accounts could (and should) be remunerated – either at the main central bank rate, or a new policy rate would be created. The advantage for consumers would be a more stable real value of their currency holdings, compared to cash. From a central bank perspective, this would be **another transmission channel for monetary policy**. Possibly stronger or faster than the existing transmission mechanisms.

Obviously, there are several downsides (or risks) related to a more widespread use of digital currencies.

First, the **commercial bank business model would be constrained**. If all consumers can have basic checking accounts in a central bank, with add-on services from a variety or providers, there is no need to keep a basic checking account in a commercial bank. Banks would therefore find it harder to attract deposits. They would either have to pay interest rates on deposits above the remuneration the consumers can get in the central bank or be more reliant directly on central bank liquidity. The core bank business would move towards lending, both transforming short funds to long lending and in managing lenders' credit risks.

Second, **anonymity of payments would be limited**. Cash payments are the only fully anonymous instrument today. Consumers often value the anonymity and are willing to go to great lengths to protect it.[13] The central bank would in principle have information on all payments made in an economy. While appropriate protection of personal information would duly be taken, it will still make many consumers uncomfortable. The situation can get worse with the eventual success of the digital currency. If it gets so widely adopted that the usage of cash declines, some consumers may find it difficult to pay cash when they want to make a completely anonymous payment – or just the fact of using cash can become suspicious.

Third, access to the digital currency would be limited for foreigners, immigrants, tourists, or people with limited legal capacity. The issuing central bank would have to make steps to allow

[13] The argument that hiding a payment indicates something illegal or immoral is fundamentally flawed. While illegal activities, tax evasion, or grey economy are among the transactions that seek anonymity, there are many completely legal and socially beneficial activities that may also require anonymity. A business may want to protect its information from competitors – and often one of the competitors may be also the government or an institution involved in the payment system. An individual may not completely trust the government, the central bank, or some of their employees – misuses of government authority or a position of power are possible in all countries. Some people may value their privacy just for the privacy sake. And there are some good surprises that people want to keep secret – such as buying gifts for family members or partners.

these groups access to the payment system – regardless of other sovereign policies (such as discouraging illegal migration or the views on the use of their currency abroad). There is a risk that **socially excluded communities** – such as minorities in ghettos, immigrants, very poor people, or some conservative religious communities – **could become even more excluded** from the mainstream society.

Should the digital money become so successful that the use of cash is completely marginalized, it would open **new avenues for monetary policy**. With no cash, there would be no effective lower bound on policy interest rates. Any negative rate could be imposed on digital currencies and bank deposits, making monetary policy much more potent in deflationary times. Obviously, savers would be extremely opposed to significantly negative rates – but in practice a central bank would probably resort to negative rates very rarely, exploiting just the opportunity of such an option to better anchor expectations.

Ledger-based digital currencies

As discussed above, in a public digital currency case a central bank is a natural trusted counterparty. A central bank would give up this advantage only to overcome some major obstacle of an account-based digital currency. The primary candidate seems to be anonymity of payments.

A distributed ledger-based currency could provide a decent degree on pseudonymity, even if not a complete guarantee of anonymity. In a public digital currency setting the central bank would be the only authority creating (mining) new money – and thus also validating all transactions – but the individual users could be anonymous.

Compared to private cryptocurrencies a public one would have two major advantages (a) mining (money creation) could be very cheap, as it will be controlled by the central bank – avoiding waste of resources on energy and computing power, and (b) money creation could be controlled to maintain stability of the digital currency, including one-to-one convertibility to traditional cash.

On the other hand, compared to an account-based system the creation of a public crypto-currency would be exposed to several risks. From a technical point of view, if the cryptocurrency is widely adopted, the **ledger would become enormous**. In a large economy, such as the Euro area or the US, with hundreds of millions of consumers and thousands of transactions per user, the ledger would grow by billions of transactions a day! Such a huge ledger cannot be shared with all the users – only a select number of users would eventually have access. In a way, this might resemble a hub-and-spoke system of the central bank – commercial banks – and retail customers, just now composed of a central bank – ledger keepers – and regular customers. A second technical drawback is, that it **would take some time to validate transactions** – definitely more than the almost instantaneous finalization possible in an account-based system.

A sovereign may be reluctant to allow a system with reasonable anonymity without any restrictions. Most countries now regulate large cash payments, deposits and withdrawals. This would be hard in a cryptocurrency world – if a reasonable anonymity existed, a multitude of cheap and fast small payments could be combined by an adverse actor to execute any desired large transaction. Either the anonymity would be compromised, or very severe restrictions would have to be placed on the transactions. For example, only very small payments could be allowed, and/or there would be a limit on how many transactions can each digital coin make before having to "resurface" to a non-cryptographic word (possibly just one).

A viable compromise could be a combination of both types of public digital currencies. A majority of the transactions could be taking place in an account-based system. A crypto-based system

would be just a supplement, in case a consumer requires anonymity and cash is not available. In this case the size of the distributed ledger would stay reasonable. Cryptographic transactions could also serve as a back-up, for offline[14] transactions or if the main system experiences technical difficulties.

Public vs. private money

Overall it seems that public digital currencies offer a better cost-benefit ratio than private ones. Among the options technically feasible the traditional (floating) cryptocurrencies seem to come out the worst. They fail in essential features of money, mostly store of value, and are wasting scarce resources. Stablecoins seem to come up as feasible, and the interest in the Libra project has shown their potential. However, a publicly created digital currency can provide all the advantages of a private stablecoin, without some of their drawback.[15] The main problem is, that no mayor central bank is close to the issuance of digital money.

Digital money could offer an instant payment infrastructure for various areas of life, wide scope of sectors and different types of transactions. If globally available, an individual could buy various goods or services, irrespective of denomination (EUR, USD, CHF or CZK), using a mobile phone app, scanning the sellers QR code, or touching a friend's phone. Such transaction would be settled instantaneously. Alternatively, individual business card information could be collected for future transactions. Other options would be for example online shopping, settling utility bills, splitting bills for dinner with friends etc.; all this without leaving the app universe.

From the perspective of the previous decade, this may seem as a magic. This is, however, how most of the transactions are settled nowadays in many Asian countries. E-money transactions in China (through WeChat and Alipay) surpass those worldwide of Visa and Mastercard combined. The payment systems they are introducing are so common in China that even beggars use them. Traditional banking business may be reduced to large transactions only, such as mortgages or long-term saving.[16]

If central banks in Europe and Americas do not act, the payment universe will be soon taken over either by digital platforms (such as Alipay and WeChat) or by private stablecoins. What is essential for success is the convenience for consumers and creation of network effects, not the underlying technology. There is just a short window of opportunity for major central banks to start providing their own money fit for the third millennium, before someone else invades their market.

One of the major central banks (i.e. US or Euro Area) could also use digital money to expand the use of its currency abroad. Already more than half or dollar or euro cash is used abroad. Replacing cash with digital currencies would also require giving access to foreign residents to the digital payment infrastructure. Many of the holders of euro or dollar banknotes abroad are resorting to these currencies because their own currency is not a good enough store of value, or because they do not trust their own governments. They may nevertheless have enough confidence in the ECB or the FED. Whether one

[14] Offline transactions would require either some hardware tokenization of the cryptocurrency, or some degree of trust among the transacting parties – that the debtor will honor the transaction once online, or giving up anonymity on the part of the buyer. Regarding hardware tokenization – one is left to wonder why should we use a new physical device, when we already have perfectly working physical cash.
[15] Our view is close to Bordo & Levin (2017).
[16] Based on a survey by The Economist in China and Singapore.

considers the dollar's (and partially also the euro's) international standing as an exorbitant privilege or an exorbitant duty,[17] moving to a digital world would require giving access to the foreigners – or possibly losing the role of the dominant global currency.[18]

Another argument for the creation of central bank digital currencies is a perspective of maintaining level playing field and limiting income inequalities. Richer consumers are moving to electronic payments and the use of cash is already rapidly declining in some countries. If cash transactions become difficult, if merchants stop accepting cash payments, then poor people without access to banking services would find it even harder to go about their daily life. A digital currency could provide a replacement claim on the central bank if cash becomes unattractive.

The international dimension of digital currencies

Digital currencies can potentially move across borders in unlimited amounts and instantaneously. The only effective constraints on international transactions can be built by the issuer, especially if the issuer is a central bank, or another public body, and is backed by the legal system of its country. On the side of the receiving country any restrictions on currency flows would be imperfect and hardly enforceable.[19] In comparison, international cash transactions are limited by the time it takes to physically transport the cash and but the weight and bulk of large cash amounts. Most countries limit or regulate cash transfer across borders over 10 000 euros or dollars. Bank transfers are not limited by technology, but are easily detected by authorities and can be subject to capital account restrictions and anti-money laundering rules.

A creator or an issuer of a digital currency can thus almost freely decide how easy they might want to make international transactions. They might not want to – e.g. a central bank issuing a digital currency might want to keep control of its money supply and limit outgoing international transactions. Creators of private digital currencies seem to be keen on maximizing their customer base and place no limits on the international use of their coins. Similarly, some public issuers may also encourage wider international use of their digital money – to support international trade in their own currency, to increase international seigniorage, to increase the soft power of their country, or even for purely altruistic reasons (e.g. to enable people in third world countries an easy access to stable and trustworthy currency with a well-functioning payment system).

Almost all countries prefer to use their own currencies, even though better foreign currencies are available. There are a handful of microstates using the currencies of neighboring countries and very limited number of small countries that have mismanaged their own currency to such an extent, that they decided to fully switch to foreign currencies – in particular El Salvador switched to US dollar after a devastating earthquake delivered a final blow to its already ailing economy, Ecuador switched to US dollar in 2000 after a financial crisis, sharp drop in its export prices, and a series of natural disasters due to El Nino, or Monte Negro which switched to the euro as a part

[17] A duty to provide insurance and liquidity to the international payment system and to engage in global monetary policy setting, especially during financial crisis.

[18] If the European Commission (2018) is serious about increasing the international role of the euro, promoting a digital euro accessible worldwide would be a very promising avenue. Furthermore, it would be in line with the leading role of the EU in providing development aid to poor countries – giving them access to a solid store of value and an efficient international retail payment system.

[19] Proponents of Bitcoin and other private cryptocurrencies see the ineffectiveness of regulation as one of the major advantages – e.g. enabling people in living in autocratic regimes to make transactions without fearing government restrictions and punishment.

of its effort to become independent from Serbia. Countries and consumers prefer to stick to their own currency, unless a competing currency is significantly better. Therefore, even if a superior digital currency is available from abroad, it is unlikely that any country with a well-functioning economy would switch.

The best one can realistically hope is that a digital currency would enhance the international role of a currency with already serious international status. The US dollar remains the most important international currency, with 61% share in international reserves. It is followed by the euro, with a21% share, Japanese yen at 6%, British pound 5% and Chinese renminbi 2%.[20] Among these five major currencies only the renminbi is close to a digital version. With the international share of renminbi at just 2%, far below the relative weight of the Chinese economy, it is unlikely that the availability of a digital currency will help changing the ordering. The global importance of the renminbi is set to improve, but the main driver will be the strength of the Chinese economy, not the form of the currency.

Regulation of digital currencies

Digital currencies will be subject to regulation sooner or later. Sovereign countries will regulate some currencies to support them (e.g. their own official digital currencies) and some to limit their use. There are several reasons why digital currencies need to be properly regulated:

- Consumer protection – payment systems involving digital currencies will be regulated to provide the consumers with a similar level of security and confidence as existing payment systems, including supervision, disclosure of information, and minimum requirements for providers.
- Anti-money laundering and anti-terrorist financing – should a country feel a digital currency is used to launder money or transfer funds to illegal activities, it will impose restrictions and (try to) limit such transactions.
- Monetary policy – should a digital currency become systematically important, it may either help or hinder transmission of monetary policy. Proper regulation can ensure we move towards the state where digital currency supports the desirable monetary policy transmission.
- Confidence in the digital currency – a country may wish to support the use of its central bank digital currency by declaring it an official legal tender. This would improve the public confidence in the new money and speed up its adoption in the economy.
- Seigniorage and taxes – seigniorage income is a non-negligible part of public sector revenue and its loss would have to be compensated by some other taxes. Moreover, digital transactions may contribute to easier tax evasion. To protect these public sector revenues, regulation of digital currencies may be called for.

As discussed above, it is not clear how effective regulation of digital currencies can be. On one side of the spectrum are central bank digital currencies, which can be easily regulated by bot the governments and respective central banks – considering the governments and central banks are very likely to voluntarily cooperate to reach common goals. Somewhere in the middle are private stablecoins. Corporations sponsoring these stablecoins would be subject to regulation as any other private sector business. However, there would be technological constraints on how far the regulation can go. Free floating cryptocurrencies would be much harder to regulate. There would be no central counterparty nor a specific institution responsible for "running" the currency.

[20] European Central Bank (2020)

Therefore, individual holders of the coins would have to be the subjects of regulation. Given the technological constraints, effectiveness of the regulation is not clear. A regulator would need to gather a large amount of information and be sophisticated enough to be able to trace some transactions. The most likely path is regulating transactions involving a "real" leg – i.e. purchases of goods and services, or transfers between cryptocurrencies and standard money.

Given the difficulty of regulating digital money, that can move almost immediately across borders, there is a strong case for international cooperation in regulating digital currencies. Some minimum standards could be set at the G-20 level,[21] especially to protect against money laundering and countering the financing of terrorism. Such common standards would protect countries against regulatory arbitrage and can also support timely exchange of information among regulators.

Last but not least, digital currencies can help some countries to bypass intrusive regulation of third countries. This is especially true of US regulation, which uses its global power, its access to the worldwide interbank payment system S.W.I.F.T. and its clout over all large international banks to impose US rules to non-residents and non-citizens. Moving transactions to a new digital platform may therefore allow other countries to regain sovereignty over regulation of transactions within a country or with other international parties.[22]

The optimal path to future digital currencies

A future monetary system will encompass digital currencies – either global or local. Cash may be reduced to a niche role, or even completely replaced by an anonymous form of digital money.

In staking the path to the future we should always be remained of the ultimate objective – to provide the best possible money to our societies. This will be best served by central bank digital currencies, which will be open to add-on services from the private sector. The central bank (sovereign) will retain control over the money supply, implement stabilizing monetary policies, and guarantee access to a fast and safe payment system to all members of the society. The private sector players will contribute additional services and competition-driven continuous improvements.

Some central banks are already moving forward rapidly. The People's Bank of China is planning to launch its digital currency DCEP already this year, only being delayed by the Covid-19 epidemic. Bank of Canada and the Monetary Authority of Singapore are cooperating on creating a blockchain-based cross-currency settlement system. Sweriges Riksbank is working on an e-krona project, with cooperation from private sector technological companies.[23]

Regarding central banks that are not at the front of the game – including the largest global monetary areas – before the new digital money are available, the central banks should "protect" their turf from both private competitors and foreign players. Fast, safe, and even "fun" payment systems are feasible even without central bank digital currencies. Resolute steps should be taken to improve payment systems in Europe and Americas to protect the central role of central banks and sovereigns.

[21] See Banerjee (2020) for an overview and discussion of the state of play.
[22] See Kumar and Rosenbach (2020) for an example.
[23] Duong (2020).

The optimal policy response is to update the existing fiat national currencies with equally fast, comfortable and cheap transaction services as digital currencies or private platforms promise. Central banks are in a position to offer transaction services superior to what the private sector itself can produce – alleviating the inherent volatility in the value private crypto-coins, lack of trust in their providers, and overcoming the network risks to become widely accepted.

Central banks or governments/regulators should significantly **speed up transition to fast and easy to use official payment systems**. The technology for instantaneous payments already exists in the Euro area (TIPS[24]) – apart from the fixed costs, the ECB charges only €0.002 per transaction and guarantees settlement in 10 seconds. We should strongly "nudge" our banks to quickly adopt TIPS and to provide their customers with easy to use mobile apps. On top of that, we should, where necessary, relax some of the stringent regulations to allow foreigners access to the infrastructure.[25] There are only two central banks in the world that could provide globally accepted and trusted payment services – the ECB and the Fed. Already 88% of foreign exchange transactions involve the USD and 32% involve the euro. Consumers buying goods and services from abroad or sending remittances home are most likely to use the dollar or the euro. The euro is at some disadvantage in terms of the current market share, but has a stronger hand in terms of technology (TIPS already exists and experience with SEPA shows many countries can use a single payment system) and probably also credibility (the US government is globally much less trusted to not use information from payment systems for its own political benefits).

Eventually some hard decisions will have to be made – on the value of privacy, on the degree to which central bank independence includes ability of the bank to resist requests from authorities to monitor private transactions, on the effects of digitization of payments on income inequalities – and to what extent is an access to a payment system part of basic social rights, and probably many other, or on the exposure to cyber-risks and optimal preventive measures. Nevertheless, we should be looking forward to the future with better money providing better services to the general public.

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[24] Target instant payment settlement: https://www.ecb.europa.eu/paym/target/tips/html/index.en.html
[25] As an analogy, consider the taxi services, which used to be heavily regulated in the past – both to protect the consumers and the incumbents. Technological companies led by Uber forced many countries to cut back on regulation and open the market to new technologies – with no visible loss in consumer protection. Similarly opening payment system infrastructure to foreign consumers may open new markets to euro-area banks without compromising safety of the domestic systems.

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