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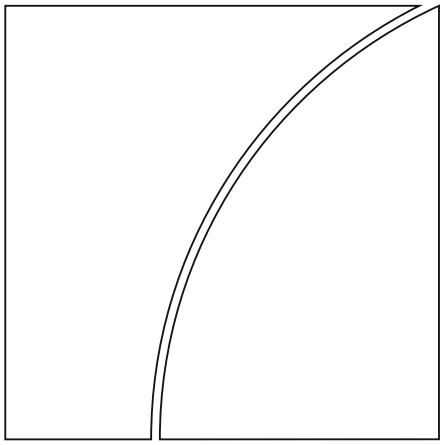

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The digitalization of money

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The Digitalization of Money*

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Abstract

The ongoing digital revolution may lead to a radical departure from the traditional model of monetary exchange. We may see an unbundling of the separate roles of money, creating fiercer competition among specialized currencies. On the other hand, digital currencies associated with large platform ecosystems may lead to a re-bundling of money in which payment services are packaged with an array of data services, encouraging differentiation but discouraging interoperability between platforms. Digital currencies may also cause an upheaval of the international monetary system: countries that are socially or digitally integrated with their neighbors may face digital dollarization, and the prevalence of systemically important platforms could lead to the emergence of digital currency areas that transcend national borders. Central bank digital currency (CBDC) ensures that public money remains a relevant unit of account.

Keywords: Digital Money, Digital Currency Area, Digital Dollarization, Currency Competition

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1 Introduction

Digitalization has revolutionized money and payments systems. Although digital money itself is not new to modern economies, digital currencies now facilitate instantaneous peer-to-peer transfers of value in a way that was previously impossible. New currencies will emerge as the central lynchpins of large, systemically important social and economic platforms that transcend national borders, redefining the ways in which payments and users' data interact. The advent of these new monies could reshape the nature of currency competition, the architecture of the international monetary system, and the role of government-issued public money.

Digital money has already surfaced in a variety of contexts. WeChat's and Alipay's digital wallets have come to dominate the payments system in China. In Africa, mobile providers have launched successful money transfer services, such as Safaricom's M-Pesa. Facebook has led the development of digital currencies for social media networks, announcing plans to issue its own currency, the Libra, which is a type of "stable coin" that will be pegged to a basket of official currencies. Finally, in recent years, thousands of fiat cryptocurrencies maintained on blockchains by anonymous record-keepers have been launched.

This paper discusses the key questions and economic implications of digital currencies. The first important economic insight is that digital currencies feature innovations that will unbundle the functions served by money (store of value, medium of exchange, and unit of account), rendering the competition among currencies much fiercer. Digital currencies may specialize to certain roles and compete exclusively as exchange media or exclusively as stores of value. The second prediction is that digital money issuers will try to "product differentiate" their currency by re-bundling monetary functions with traditionally separate functions, such as data gathering and social networking services. Both convertibility between digital currencies and interoperability of platforms may be required to maximally exploit the benefits of this type of competition. The importance of digital connectedness, which often supersedes the importance of macroeconomic links, will lead to the establishment of "Digital Currency Areas" (DCAs) linking the currency to usership of a particular digital network rather than to a specific country. The international character of these digital currencies will make both emerging and advanced economies vulnerable to "digital dollarization," in which the national currency is supplanted by a digital platform's currency rather than another developed country's currency. Third, digital currency, and its integration with pervasive platforms and services, raises impor-

tant questions regarding the competition between private and public money. In a digital economy, cash may effectively disappear, and payments may center around social and economic platforms rather than banks' credit provision, weakening the traditional transmission channels of monetary policy. Governments may need to offer central bank digital currency (CBDC) in order to retain monetary independence.

2 Monetary Systems and Independent Currencies

In order to understand the significance of digital currencies, we first describe the design of traditional monetary systems. We then define what constitutes an independent currency and discuss how digital currencies fit into the traditional paradigm.

2.1 The architecture of monetary systems

Traditionally, monetary systems have been organized around an anchor. Any payment instrument in the monetary system is ultimately linked to a fixed amount of the anchor. The anchor can take many forms, such as a commodity or a fiat currency.[1] For instance, under the gold standard, the anchor was gold: each unit of currency issued by a government was convertible into a unit of gold. In fact, this anchor held together the entire international monetary system under Bretton-Woods, when the U.S. dollar had a legal convertibility into gold and all other currencies were pegged to the dollar. Currently, the anchor in most monetary systems is a government-issued fiat currency.

Issuers of money may offer full and unconditional convertibility, or they may instead back the money with other assets without offering full convertibility. Under a convertibility arrangement, the issuer of a monetary instrument (which may or may not be an independent currency) makes a legally binding commitment to exchange that instrument at a fixed rate for another payment instrument. Convertibility serves two purposes. First, it serves to maintain the value of the currency. The issuer of a convertible currency effectively ties its hands. It must either fully back its issuance with reserves of another payment instrument or risk forfeiting a claim to its assets if it defaults on its promise to maintain convertibility. Second, convertibility effectively allows one payment instrument to replicate the store of value and unit of account properties of another. A system

[1] In fact, in the early modern world, many cities and countries had systems with parallel gold and silver currencies, meaning those monetary systems had two anchors.

of convertibility among several different types of money creates uniformity among them, typically referred to as the "uniformity of money". The archetypal example of an issuer that makes a legally binding commitment to convertibility is a bank. Bank deposits are convertible to an equal quantity of the corresponding government-issued fiat currency. If the bank defaults on its obligations, the deposits it issues cease to circulate and deposit holders receive a claim on bank's illiquid assets.

Backing, on the other hand, also supports the value of a monetary instrument, but it allows the issuer a much greater degree of freedom. An issuer that backs its money with a collection of assets does not always offer full convertibility to those assets. Even if the issuer targets an exchange rate against another currency, it may abandon its target and does not forfeit claims on its assets when doing so. Rather, the issuer manages the value of its money *at its own discretion* by issuing or buying back money in exchange for those assets. Good examples of backing arrangements are currency pegs and currency bands. Another example is a cryptocurrency "stable coin" that expands and contracts the money supply in order to keep its value fixed relative to that of an official currency, such as the Tether currency (which is "pegged" to the dollar). In each case, the issuer may find it desirable to manage the exchange rate, but it does not face legal consequences for deviating from its initial plan.

A related distinction is that between inside and outside money. Inside money represents a claim on a (private) issuing entity. It is a liability on the issuer's balance sheet and is in zero net supply. If the issuer of inside money fails to meet the terms of that claim, which typically involve convertibility on demand to some other monetary instrument, the holders of inside money receive a residual claim on the issuer's assets. Bank deposits and many forms of e-money, such as Alipay's token, are inside money. Outside money, by contrast, is not a claim on anything. Outside money does not appear as a liability on any private entity's balance sheet and is in positive net supply. Nevertheless, outside money may be backed by another type of money. Government-issued fiat currencies, for example, are outside money regardless of whether they are pegged to some other currency. Similarly, both backed and unbacked cryptocurrencies are outside money.

Finally, money comes in multiple forms. There are two main forms of money: account-based money and token money. The key difference between the two types of money lies in the verification process for payments.[2] In an account-based system, what must be verified

[2] Our characterization of this distinction is taken from Kahn and Wong (2019), who explain it in greater detail.

is the payer's identity. As such, bank deposits are account-based money: a payment from an account is considered valid if the bank is able to confirm that the person making that payment is the account holder. If it is later discovered that the bank incorrectly identified the payer, the bank assumes liability and refunds the account holder. In a token system, what must be verified is instead the authenticity of the item to be exchanged. Cash and coins are types of token money that have existed for centuries. In a cash transaction, the payee will accept payment only if she believes the cash is genuine, meaning the payee effectively assumes liability if the cash is counterfeit. Modern e-money and cryptocurrencies are also token money. For example, to transact currency on Alipay's network, all that is needed is a password linked to a particular digital "wallet." No one is required to verify that the person who presented the password is the wallet's true owner. Similarly, to transact cryptocurrency, the payer must sign transactions with a "private key" linked to a particular set of coins, but the transaction is valid regardless of who presents that key. Importantly, account-based money tends to be inside money linked to the creation of credit, whereas token money is typically unrelated to the provision of credit. Hence, an expansion in the supply of account-based money may have quite different implications from an expansion in the supply of token money.

2.2 What defines an independent currency?

In order to understand what constitutes an independent currency, we first define what it means for a payment instrument to belong to a currency. We say a collection of payment instruments form an independent currency if the following two conditions hold:

(i) The payment instruments are denominated in the same unit of account.

(ii) Each payment instrument within the currency is convertible into any other.

We adopt this definition of an independent currency to ensure that monetary instruments are linked to a currency via their unit of account rather than their properties as exchange media. Hence cash, reserves, and bank deposits denominated in an official currency, for example, are all part of the same currency despite having strikingly different technological features.

If a payment instrument is not part of an existing currency, then it is an independent currency. By this definition, a currency board arrangement like the Hong Kong dollar constitutes a currency independent of the U.S. dollar, as it is denominated in its own

unit of account and the peg maintained by the central bank is not legally binding. Bank deposits denominated in dollars are not an independent currency because the convertibility arrangement is legally enforceable. In other words, one factor that distinguishes independent currencies is the issuer's level of commitment. The issuer of an independent currency denominated in an existing unit of account ultimately retains the option to break any convertibility commitments it has made in the past. Issuers of payment instruments that are not independent currencies forfeit residual claims on their assets if they break their promises.

An example that illustrates how several currencies could merge into one is that of the transition from the European Exchange Rate Mechanism (ERM) to the Euro. During this transition period, countries could have decided to break away from the arrangement without forfeiting the ability to issue money. After the Euro was introduced, though, countries did forfeit their ability to issue money, and the multiple currencies ceased to be independent.

This definition suggests that several ubiquitous forms of digital money are, in fact, independent currencies. For example, the basket underlying Facebook's Libra currency would consist of many official currencies, so Libra would be denominated in its own unit of account and thus be independent. Fiat cryptocurrencies are clearly independent currencies, as they are not convertible into anything and have their own unit of account. This includes all of the most popular cryptocurrencies, such as Bitcoin and Ether. Even some stable coins, which are backed by a bank account owned by the issuing entity, are independent currencies, because they could continue to exist on an exchange even after the issuer unilaterally abandons the currency's backing.

Other types of digital money are not fully independent currencies but nevertheless enable transfers of value that were not previously possible. For instance, many mobile applications now permit peer-to-peer digital transfers, whereas digital transfers under the traditional banking system were typically limited to purchases. These applications, such as Alipay in China or M-Pesa in Kenya, permit existing currencies to circulate in a new way and among new populations, but their issuers are legally bound to maintain convertibility to their countries' currencies (renminbi in the case of Alipay and shilling for M-Pesa).

3 The Changing Nature of Currency Competition

3.1 The roles of money and traditional currency competition

Economists have been interested in competition among currencies at least since the time of Hayek (1976)'s contribution, who suggested that a solution to the mismanagement of government-issued currencies would be competition among a variety of privately issued currencies. Hayek's proposal for competing currencies, however, faced problems when confronted with the difficulty of establishing a system in which multiple assets could have all three defining properties of money.

Traditionally, money has been defined as an asset that acts as a a unit of account, a store of value, and a medium of exchange. Each of these three roles emerged in order to overcome a different economic friction. The unit of account role is perhaps the most important in understanding currency competition and the difficulties with Hayek's proposal. Units of account have developed to mitigate the problem of tracking the relative prices of multiple different goods in an economy. In an economy with n goods, there are $n(n-1)/2$ relative prices that would have to be tracked in the absence of a unit of account. With money that serves as a unit of account, only n prices need to be tracked: the price of each good in units of money. The unit of account permits agents to communicate value in an easily understandable way. It is, in a sense, like a common language.[3] More importantly, however, the specification of the unit of account together with the monetary policy rule impacts risk sharing among agents in the economy (in an incomplete market setting).[4] Agents tend to write contracts in nominal terms because those are the terms in which they conceptualize value, so monetary policy that reacts to shocks reallocates resources among borrowers and lenders. That is, a cyclical monetary policy can effectively transfer risks. In a world where agents face cognitive limits, then, a monetary system with a single unit of account plays an important role in ensuring the efficient operation of markets and sharing of risks.

The need for a store of value arises from the fundamental inability of economic agents to coordinate on and commit to future transfers of value. For example, a farmer must compensate the workers on the farm in some way for their labor. However, the farmer may not be able to credibly commit to give the workers a share of the produce after they

[3] See Issing (1999) for pointing out this analogy.

[4] See Brunnermeier and Sannikov (2016) "I Theory of Money" that clearly spells out this role of the unit of account.

have done their work. The farmer can instead compensate the workers by paying them in money as they work, allowing them to purchase produce at a future date. Importantly, the workers will be incentivized to work only if they believe the money will retain its value in the future, so money must be a store of value. In Hayek's vision, currencies would compete primarily as stores of value. Those with credible issuers that could maintain the currency's value would succeed, whereas others would be driven out of the market.[5]

The medium of exchange role stems from the need to circumvent the double coincidence of wants. This issue is the key friction that impedes efficiency in barter economies. Without money, any two economic agents who meet may trade only if each values a good that the other has. These situations are exceedingly uncommon in specialized economies. For instance, a lawyer who wishes to take a taxi would be able to do so only upon finding a taxi driver who requires legal assistance. Money allows for trade in the absence of a double coincidence of wants. When one agent (the buyer) wants a good or service that another (the seller) produces, the buyer may simply transfer money to the seller in exchange for the good. In fact, the need for a medium of exchange to lubricate transactions in the economy may lead to a bubble value for liquid assets.[6] A liquid asset that never pays a dividend, like money, can therefore have a positive value (i.e. a bubble value), since its value stems from its usefulness in exchange: it can be used to trade with others in a way that illiquid assets cannot.

3.2 Two forms of competition among monies

Technology and digital networks profoundly alter the nature of competition among monies. While they can do much to overcome the traditional barriers to competition, they introduce new dimensions of currency differentiation that may have countervailing effects. Henceforth, we make a distinction between two types of competition among monetary instruments: "full" and "reduced."

1. **Full currency competition:** Under full competition, currencies compete including in their role as unit of account. Competition takes place between monetary instruments denominated in different units of account, with different price systems and inflation rates. Currencies can compete internationally, as official fiat currencies do,

[5] Issuers would need to overcome the time-inconsistency problem articulated by Kydland and Prescott (1977): they would want to initially promise low future growth of the money supply, but later would want to break that promise and over-issue given the currency's high value.

[6] See Brunnermeier and Niepelt (2019) for a full characterization of the bubble value of financial assets.

or domestically, as long as private entities are permitted to issue their own currencies (as in the free banking era). Issuers are disciplined by the presence of reputable, well-established currencies with stable rates of inflation. This is the type of competition emphasized in the literature and by Hayek.

2. **Reduced competition of monetary instruments:** Under reduced competition, monetary instruments denominated in the same unit of account compete in their role as medium of exchange. This type of competition among monetary instruments is already prevalent within countries. Deposits issued by different banks compete with each other and with electronic monetary instruments, such as tokens held in digital wallets. Regulators typically encourage competition among monetary instruments for the sake of efficiency.

3.3 The unbundling of the roles of money

Hayek (1976)'s proposal for a system of competing private currencies faces a fundamental issue: the use of currencies exhibits strong network externalities.[7] The need for a unit of account gives rise to network externalities in the same way that a common language does. It would be difficult to interact speaking only Russian in a society where everyone speaks only English; similarly, it would be difficult to transact using rubles in a society where everyone is accustomed to quoting prices in dollars. Just as learning multiple languages is difficult, adopting multiple currencies and tracking their relative values may be difficult as well, so there are strong incentives to adopt only one currency. Unlike languages, which change only slowly over time, exchange rates of different currencies might also fluctuate widely.

Convertibility can be a force that leads to the unbundling of the store of value and medium of exchange role of money. A classic example is Gresham's law, mostly applied to gold and silver coins. If the exchange rate between the two types of coins is fixed, people start to hoard gold and use silver coins as medium of exchange. Since the velocity of silver coins is higher, its value reflects a greater liquidity component. In a world of digital currencies, imagine two tech companies agreeing to issue digital tokens that are one-to-one convertible. Each company backs its currency with its own balance sheet. The currency issued by the company with the stronger balance sheet will serve as a better

[7] Dowd and Greenaway (1993) explore the implications of network externalities and switching costs for currency competition.

store of value, while the currency of the other tech company will primarily assume the role of a medium of exchange. In other words, Gresham's law also applies in a world with digital currencies in which issuers commit to convertibility.

Switching costs also generate network externalities. In the past, transactions costs made it difficult to frequently switch among different currencies, giving people an incentive to conduct trade within their own currency area. This motive for coordination meant that in the past, currencies could not compete effectively. First, incumbent official currencies were at an enormous advantage. Once a particular group (typically the citizens of a country) had adopted a currency, it would have been difficult for entrant currencies to displace the established one even if those entrants had been far superior along all dimensions. In the rare instances when official currencies were displaced, this occurred only during severe crises of confidence in the established currency. The new dominant currency was always an existing national currency rather than a privately issued one. Second, even during historical periods when many competing currencies did circulate, the resulting competition was disorienting rather than beneficial. Until the middle of the nineteenth century, for example, in most states (including the United States) business was conducted in a variety of bizarrely confusing currencies, and in addition some (like the United States) suffered from banknotes whose traded value varied because of differing estimations of the solvency of the issuing bank.[8]

Economic competition in digital networks, and digital currency competition in particular, differs starkly from traditional currency competition. The Internet provides the infrastructure on which digital networks, both commerical and social, can be built. Amazon and Alibaba create a whole ecosystem on their own with platforms in which various goods are exchanged. Facebook has a social network with links to 3 billion people. Once those networks have been established, information can be diffused across them cheaply and near-instantaneously. That information can then be automatically converted into whatever form is most convenient for the receiver. Modern technology makes frictionless, unintermediated peer-to-peer transactions possible using digital tokens. These characteristics of digital networks weaken the rigidities that impede competition in traditional settings.

Network externalities that hindered competition in the traditional setting can actually enhance competition in a digital setting. An issuer of a new currency can leverage a

[8] See Helleiner (2002) for a detailed historical account of the transition from a regime of multiple currencies within every country to a regime of national currencies.

network's communication and transaction systems to immediately access a large set of potential counterparties across several countries. The network facilitates both diffusion of information about the currency and adoption of the currency, as any adopter would know that other potential adopters are connected to a common payment network. The structure of digital networks hence reduces the informational barriers to entry that existed in the traditional setting.

Switching costs, which severely impair traditional currency competition, are likely to be much lower in a digital environment. The ability to exchange value peer-to-peer within networks eliminates the need for a third party, and thus any fee that party would charge, in an exchange of currencies. Users could set up their mobile devices to execute currency exchanges automatically whenever needed. Mobile applications will also reduce the need for financial expertise in conducting currency transactions. In principle, applications could even automate their devices to conduct cross-currency arbitrage.

In the past, given that trade occurred mostly within geographic regions, it was improbable that a currency would diffuse across regions. Only a few, such as the dollar and the euro, managed to do so. Digital networks are also particularly well-suited to address the issue of diffusing currencies across geographic regions. Whereas geographic constraints limit the spread of physical currencies, digital currencies are free to circulate within networks that cross borders and service tens or even hundreds of millions of participants.

The reduction in switching costs brought about by mobile networks will lead to one of the most salient features of digital currency competition: an unbundling of the roles of money. When switching costs are low, there is no longer a strong incentive to use one currency as both a store of value, medium of exchange, and unit of account. Instead, users of the network can seamlessly switch among currencies and convert units when needed. For instance, if currency A is a good store of value but a poor medium of exchange, and currency B is a good medium of exchange but a poor store of value, users may choose to hold A when they are not conducting transactions, converting some of their holdings into B only milliseconds before they need to execute a transaction. Ignoring exchange rate risk, the fact that B is a poor store of value would make no difference, as users keep their holdings for less than a second. Therefore, unlike in Hayek's vision, B may not necessarily be driven out of the market in favor of the more stable A. Instead, the digital network can foster an environment in which both can thrive, serving distinct purposes.

Similarly, if two agents who have adopted different units of account wish exchange

value on a digital network, digital technology can easily convert the offer made by one agent into the units understood by the other. Just as speech translation software eliminates the need for participants in a conversation to speak the same language, this type of conversion software would eliminate the need for counterparties in a transaction to use the same unit of account. Thus there would be no motive to coordinate on a common unit of account. Overall, then, the unbundling of the roles of money reduces the need for coordination on a single currency. It does so by allowing users to obtain the distinct services provided by money from multiple different assets and by mitigating the importance of coordination on a common asset across users.

The unbundling of money can lead to increased competition among currencies. In Hayek's view, currencies would compete primarily as stores of value, but historically this type of competition has been limited due to switching costs and network externalities. With unbundled money, currencies are free to specialize to a certain role. Currencies that act as stores of value may compete with one another while others that act as exchange media compete separately. Reduced frictions and network externalities make this competition along specialized dimensions much fiercer than Hayek's currency competition.

3.4 The re-bundling of money and payment platforms

The role of *platforms* in the economics of digital currencies is quite different from the unbundling role of digital *networks*. In the economics literature, platforms are typically two-sided markets where buyers and sellers exchange multiple products. The emphasis is often on how network externalities and cross-subsidization between those products impact their pricing.[9] By contrast, we emphasize the role of platforms as aggregators of mutually complementary activities. In other words, we view platforms are "ecosystems" in which consumers, merchants, and service providers interact. Digital payment instruments associated with platforms will effectively combine the functionalities of traditional money with the platform's functionalities and data, leading to a *re-bundling* of money that contrasts with the unbundling role of digital networks.

[9] Rochet and Tirole (2003) study the pricing and welfare implications of competing platforms for various ownership and governance structures.

3.4.1 Platforms and the information factor

The economic logic underlying platforms is that they are able to develop and optimize links between different activities. Platforms are uniquely suited to this role because they are able to exploit the key input to those activities: data. Data recorded and shared on a platform can be used to make recommendations to users, to construct reputation systems, or to efficiently match users to each other, among other possibilities. Large commercial and social platforms, like those operated by Amazon and Alibaba, exhibit several of these features. The use of data generates both economies of scale and economies of scope.

Platform cohesion is promoted by an activity that dominates all others. Payment is a natural candidate for such an activity on many platforms. All other activities on a platform depend on payment, and all data is generated through payment. Hence, payment functionality is crucial for the platform's value and growth. Consumers must adopt a platform's payment protocols to ensure access to all the services it offers. Service providers and application developers depend on a robust payment system to guarantee the continued viability of their products. Social groups benefit from a system to transfer value on the platform that links their members.

Most importantly, payment networks have unparalleled access to data. The benefits of a database are derived not only from its size, but also from its diversity: it is far more valuable to know the habits of a million random individuals than to know the habits of a million individuals from the same city. A large payment-based platform that aggregates a wide array of activities is therefore an ideal tool for gathering data. Given that payment is used in essentially all economic activities, no other, more specialized platform could ever hope to rival a payment platform's ability to aggregate information on economic behavior. Consider a bank evaluating a loan applicant, for example. If the bank has access to a payment platform's data, it could track the applicant's income and payments, including data on the frequency, location, and nature of purchases. Analysis of such rich data would enable the bank to estimate the probability of repayment with great precision, far exceeding the predictive accuracy of the applicant's credit score. Payment data generated by platforms are, in fact, an ideal predictive tool for users' preferences and behavior. It is no surprise that algorithms to price goods, target advertisements, and recommend products have all blossomed on payment-based platforms.

3.4.2 The re-bundling of money

The economics of digital platforms have important implications for currency competition. Digital currencies associated with platforms will be far more differentiated than ordinary currencies are today. They will differ not only in their monetary functions as stores of value, exchange media, and units of account, but also in the functionalities offered by the associated platforms. That is, currencies will no longer simply grant payment services– they also grant access to interactions with other platform users. Hence, a digital currency is inseparable from the characteristics of the platform on which it is exchanged.

A currency's traditional features, such as its ability to store value, may not be of much consequence in determining its success in a world where those features can be unbundled. Rather, a currency's appeal will likely be governed by other platform features, such as the platform's information processing algorithms, its data privacy policies, and the set of counterparties available on the platform. Currency competition will effectively be competition between bundles of information and networking services. We term this hypothesis the *re-bundling* of money.

The re-bundling of money has additional implications for currency competition. With ordinary currencies, most users have uniform preferences regarding their fundamental properties. Users would like currencies that are broadly accepted and can be used to store value safely. Network externalities are the barrier to currency competition. With re-bundled digital currencies, on the other hand, users' preferences may be far more heterogeneous. Some users may want absolute guarantees of privacy, whereas others may prefer a platform that makes greater use of their data in order to provide better recommendations. Network externalities are less restrictive given that digital currencies' underlying monetary functions can be unbundled. This heterogeneity in preferences will therefore incentivize large issuers to differentiate their products, creating segmented markets in which different platforms cater to different types of consumers.

3.5 The structure of a platform-based market

An economy centered around digital platforms will be structured differently than the current system. The organization of the financial system and the allocation of data ownership will both change. The nature of platforms could also change the competitive landscape in the economy. While platforms create previously impossible connections, they may tend towards monopolies or fractured markets, so the question of interoperability between

platforms takes on new importance.

3.5.1 Inversion of the industrial organization of financial activities

The centrality of payments and data on social and commercial platforms may lead to an inversion of the current industrial organization of financial activities. In many modern economies, payment services are offered as an extension of banks' intermediation activities. The motive for the creation of payment instruments is banks' demand for funds. Banks are the point of contact for all users of the payment system. In many countries, banks' dominance of financial activities extends even to the provision of insurance and asset management services. The financial system, and the way in which consumers store and exchange value, is organized around banks and credit. As illustrated in Figure 1, banks can be thought of as the top of the financial hierarchy, while payments are further down, being dependent on banks' central role.

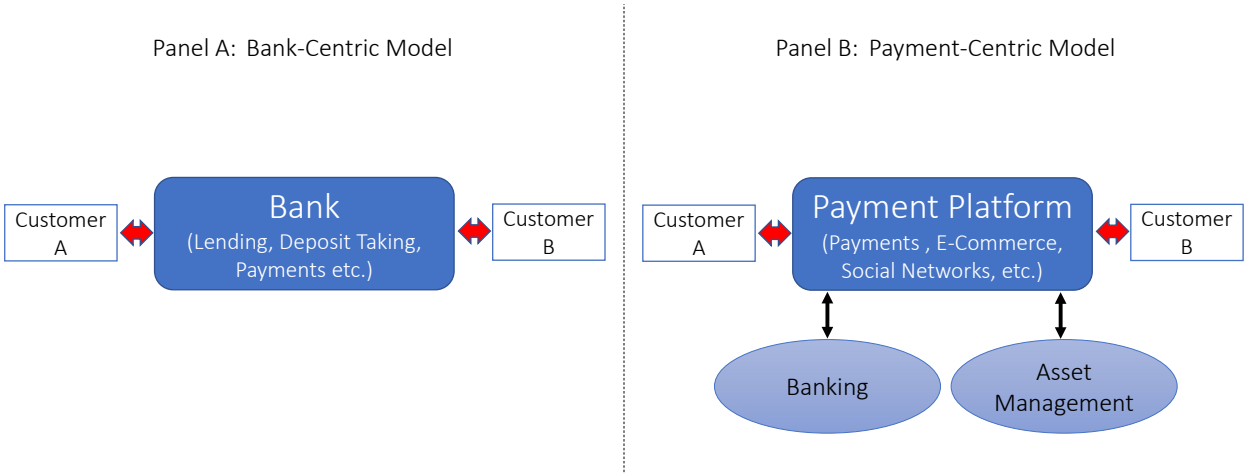
In a platform-based economy, this hierarchy could be overturned. Payments are at the center of any economic platform, and all other activities would organize themselves around the central payment functionality. Consumers' point of contact would be the entity that owns the platform rather than a bank. Financial services such as payment and insurance would be subordinated to payment services. In this new type of financial hierarchy, traditional financial institutions such as banks could be replaced by fintech subsidiaries of payment systems. This type of industrial organization is already flourishing in some countries. In China, for example, Yu'e Bao, which is a subsidiary of Ant Financial (Alibaba's financial branch), has become the world's largest money-market mutual fund. Sesame Credit, another subsidiary, has emerged as a dominant credit scoring system.

3.5.2 Data ownership and regulation

Economies are moving towards a regime where big tech companies are systemically important data intermediaries. Even today, there is concern that these companies have excessive power over users' data, resulting in regulations such as the European Union's GDPR. These concerns will certainly deepen if data intermediation activities percolate through all aspects of the payments system.

Different monetary arrangements have different implications for who controls user data. In the current system, banks and credit card companies have the greatest access to transaction data. Whenever a transaction is made, either the bank or the credit card

Figure 1: The Inversion of the Industrial Organization of Financial Services



company can see exactly when, where, and how the transaction occurred. This data is then used primarily to score users on their creditworthiness, which permits lending institutions to decide the rates at which they will lend to each individual.

The ownership structure of payment data could change drastically in an economy dominated by digital platforms. There are two important possibilities to consider. First, it could be that digital currency issuers emerge as important players in currency markets, but that individual bank accounts continue to interact with digital currencies in an important way. To a large extent, a transformation to this type of economy is currently underway in China. Alipay and WeChatPay issue large amounts of digital currency and operate applications that permit transfers to and from bank accounts. As a result, both the digital currency issuers and banks have access to some transaction data.

A more radical departure from the system is one in which large digital money issuers back their currencies with deposits held at large banks, but consumers hold digital currency exclusively. This type of environment is similar in spirit to the current one, in which consumers hold deposits that are backed by reserves but do not hold reserves directly. Nevertheless, the implications for data ownership are quite different. If consumers hold digital currency exclusively, then the digital currency issuers act as information oligopolists. The banks are unable to monitor transaction data without purchasing it. In fact, digital currency issuers may find it more efficient to set up banks as subsidiaries in order to avoid relinquishing their data. In this case, the primary purpose and value derived from transaction data would not be to provide credit more efficiently, but rather to monitor consumers' tastes and tendencies. The privacy and efficiency considerations

that policymakers would need to weigh would be much different in this type of environment, and perhaps regulations restricting the types of data that could be collected would be necessary.

3.5.3 Interoperability, convertibility, and platform-specific discount incentives

The diversity of services offered by platforms leads them to develop as closed ecosystems. Consumers would like to be able to use a platform's currency in order to purchase a wide range of the goods and services they need in everyday life. A recent article in The Guardian articulates the strategy pursued by these networks as well as the depth of their research into consumer activities:

> The company sees itself more as a "lifestyle platform" on which people conduct most of their life's transactions. From ordering food, to buying movie tickets, to paying utility bills. "The idea is that people are living their lives through this platform," an Ant Financial spokesperson said.[10]

From the platform owner's perspective, it is desirable for consumers to use the platform for all activities. The value of the platform's monopoly on the data that passes through it greatly strengthens this desire. From an economic perspective, however, it may be optimal for consumers to spread their activities across multiple platforms, to the extent that different platforms are specialized in different activities. The platform owner's disinterest in promoting interoperability with other platforms thus conflicts with economic efficiency. That is, platform owners would like to create "exit costs" that make it expensive to switch over to another platform's currency or services.

A lack of interoperability may create excessive barriers to trade across networks. The incentives to impede interoperability should therefore be a primary concern for policymakers, especially given that large platforms have already shown their reluctance to accept interoperability in some cases. For example, in Kenya, the government passed a regulation forcing the large mobile payment providers, such as Safaricom and Orange, to integrate their payment services after the companies initially refused to do so.[11]

The importance of convertibility for digital currencies is similar to the importance of interoperability for platforms. Networks and platforms tend to create fractured markets, but integration is critical for the efficient functioning of a monetary system. In particular,

[10] Kuo (2018).
[11] See Dahir (2017).

payment networks should not create onerous barriers to trade. A strict regime of convertibility to an official currency lowers these barriers. Under a convertibility arrangement, there are minimal frictions to moving value into or out of a digital network. New users can transfer value into a network without having to worry about the stability of the network's currency. When existing users need to trade with agents outside the network, they can easily transfer their holdings out of the network at a known rate. In a sense, the logic of convertibility is quite similar to the logic underlying optimal currency areas, but in this case the dividing lines that need to be considered are the boundaries of digital networks rather than regional borders.

Efficient competition among currencies is likely to be especially important when currencies are bundled with other platform and data services. Convertibility permits currencies to compete on the basis of the bundles of services they deliver rather than on the basis of issuers' reputations. New, disruptive innovators may therefore benefit from a regime in which all platforms must offer currency convertibility.

Given the value of a dominant market position, platforms may also adopt aggressive expansion strategies that are beneficial for users in the short run but not in the long run. A platform may attempt to expand its operations by making deals with other service providers in the economy. For example, a platform may join with large chains to offer discounts whenever its currency is used for a purchase. Indeed, Alipay has done exactly that in China. While these strategies may be effective in growing the network, the associated benefits for users may eventually dissipate, when the platform becomes so systemically important that users can no longer abandon it. These developments are in their infancy and limited in their geographic scope so far. The underlying technology nevertheless supports rapid geographic expansion, and payment networks are already expanding into neighboring countries such as Malaysia and the Philippines.

4 Reshaping the International Monetary System

New currencies redraw the map: they create new links and new boundaries. Digitalization may alter the foundations of the international monetary system. Further, it can lead to the rise of new international monies. Digital currencies have the potential to reshape networks of economic interaction, both transcending the borders of traditional optimal currency areas (OCAs) and creating new barriers to exchange. They also allow us to introduce a synthetic international currency.

4.1 Digital currency areas

In a digital world, economic interactions will occur within the borders of what we term a "digital currency area" (DCA).[12] The areas will form endogenously and may or may not be governed by national boundaries.

We define a digital currency area as a network where payments and transactions are made digitally by using a currency that is specific to that network. By "specific," we mean that it possesses either one or both of the following characteristics:

1. The network uses its own unit of account, distinct from existing official currencies. As an example, Facebook has recently announced the launch of Libra. It is designed to be a digital representation of a basket of existing currencies and therefore will define a new unit of account. Hence, these types of DCAs arise through full currency competition.

2. The network operates a payment instrument, a medium of exchange, that can only be used inside, between its participants. So, even if the network still uses official fiat currencies as unit of account and to back the payment instrument, that instrument cannot serve for transactions and exchanges outside the network. Typically, that is the case for some large issuers of e-money when their systems are not interoperable with others. Today, the main example is China, where both Tencent and Ant Financial have developed such networks with hundreds of millions of users, but with no mutual connection or interoperability. These DCAs are typically examples of reduced currency competition, in which the new currencies are not denominated in their own unit of account.

The amount of economic activity in DCAs will likely dwarf that in many national economies. For example, as of 2019, the Alipay network reached 870 million users, and *quarterly* trade volume reached RMB 47.2 trillion ($7 trillion). Tencent, the second-largest payment provider in China, is not far behind.

Obviously, a DCA is very different from an OCA as defined in the massive literature following Mundell (1961)'s contribution. An OCA is typically characterized by geographic proximity and the ability of participants to dispense of the exchange rate as an adjustment tool. In turn, that implies some commonality of macroeconomic shocks and

[12] Brunnermeier, James and Landau (2019) were the first to introduce this concept.

a sufficient degree of factor mobility.[13] The design of OCAs is focused on the monetary authority's ability to smooth shocks, to the extent that they are symmetric across agents in the OCA, and ability to improve risk sharing, to the extent that markets in the OCA are incomplete.

By contrast, DCAs are held together by digital interconnectedness. The focus is not on the role of the monetary authority; indeed, the currency's issuer may be under a legally binding convertibility arrangement that ties its hands. Rather, DCAs aim to take advantage of the mutually complementary activities and data linkages that arise in a digital network's ecosystem. A payment function allows these connections to be fully exploited. The unique technology underlying network-based digital payment systems allows for stronger ties than those created by traditional digital payments. Network users in DCAs can make direct, peer-to-peer transfers using mobile applications, whereas until recently digital transfers using credit or debit cards were limited to transactions.

When participants share the same form of currency, whether or not it is denominated in its own unit of account, strong monetary links develop. Price transparency is greater inside the network, price discovery is easier, and conversion to other payment instruments is less likely and sometimes technically impossible. These monetary links further create an incentive to accumulate balances in the network?s currency. This holds true regardless of whether the DCA is associated with a multifaceted platform or a more specific digital network, such as a messaging service.

Paradox of digital currency areas. One might think that the potential of DCAs to expand across national borders would lead to the emergence of global digital currencies. However, DCAs may be limited in their scope by regulatory frameworks. The digital networks associated with DCAs may treat data, and users' privacy in particular, in quite different ways. To the extent that jurisdictions such as Europe, the U.S., and China use different regulatory frameworks to approach privacy issues, it may be that certain digital payment networks are viable only within a restricted set of jurisdictions. In fact, it may be impossible to use some digital currencies within certain jurisdictions. This could be the ultimate paradox of digitalization. Digitalization has the ability break barriers and cross borders. But, because of its many inseparable dimensions, it may ultimately lead to an

[13] Historically, there have even been cases in which the shocks within a country were asymmetric enough to merit multiple currencies. In early modern Italy and the Netherlands, wage payments were made in silver, insulating them from shocks to the supply of gold, which was used to denominate larger payments (Goldthwaite (2009)).

increased fragmentation of the international financial system.

4.2 Digital dollarization

Digitalization can provide new paths to internationalize existing currencies and transform international monetary relations. There are, schematically, two ways through which a currency can internationalize: by becoming a global store of value, as a reserve instrument; or by being used for international payments, as a medium of exchange.[14] Historically, the two roles have progressively converged. However, different paths and strategies are conceivable for a currency to gain international status and use in the 21st century. Analyzing the current dominant position of the dollar in the international monetary system, some economists emphasize its function as a reserve asset in its role as store of value, based on the size, depth, and liquidity of US financial markets. Others (e.g. Gopinath et al. (2016)) give more importance to its role in the denomination and settlement of international trade and transactions.

The distinction becomes relevant and important in a digital environment. Becoming a reserve asset is demanding as, in particular, it implies full and unconditional capital account convertibility. However, the theory that international status can be achieved through trade suggests that digital networks may be another device to internationalize a currency. The theory emphasizes a complementarity in invoicing decisions: merchants whose purchases are invoiced in a currency will want to invoice in the same currency in order to ensure they can make those purchases.[15] Digital networks are particularly effective at opening new possibilities for trade and proliferating a medium of exchange beyond national borders. The closed nature of platform ecosystems further incentivizes invoicing in the platform's currency. A country that is home to large digital networks could therefore find new ways for its currency to gain international acceptance by exploiting the integrating effects of a DCA. Digitalization may thus serve as a powerful vehicle to internationalize some currencies as media of exchange.

Symmetrically, other countries may be exposed to more intense currency competition from foreign currencies through cross-border payment networks. Existing cross-border systems are currently pure infrastructures. They use domestic currencies as the medium

[14]The early modern Florentine and Venetian currencies are examples of currencies that gained broad acceptance through trade. Gold, of course, is an example of a commodity money that gained international status in this way.

[15]See Gopinath and Stein (2018) for a formal model of this phenomenon.

of exchange and unit of account. However, that may change. As the example of Libra shows, private networks may be created that would give access to new and specific units of account to people in many countries. Even official currencies may progressively penetrate other countries' economies if supported by a strong digital network. Cross-border effects also may be significant. Within large networks, the same digital instruments of payments may easily be used in several jurisdictions. If so, they may have the effect of promoting the use of a specific unit of account outside of the country where it is legal tender.

Importantly, while small economies (especially those with high or unstable domestic inflation) are susceptible to both traditional and digital dollarization by a stable currency, economies that are economically or socially open to large DCAs will be uniquely vulnerable to digital dollarization. The same is true for smaller countries as they do not provide the same scale of network externalities, large networks can offer. That is, even economies with stable currencies could be digitally dollarized if their citizens find themselves often transacting with users of a digital platform with its own currency. As the importance of digitally delivered services increases and social networks become more intertwined with the ways in which people exchange value, the influence of large digital currencies in smaller economies will grow.

4.3 A Synthetic International Currency

The prospect of digital dollarization creates the possibility that a synthetic digital currency, backed by a variety of official currencies, may internationalize. The rise of a synthetic international currency (such as the Libra) has deep macroeconomic implications, as noted by Carney (2019). In recent decades, growing international linkages have created a scarcity of dollar safe assets and large cross-border spillovers from US monetary policy via the global financial cycle (GFC). Both of these forces have, in turn, contributed to permanently low interest rates.

A synthetic international currency linked to several different units of account could play a role in remedying the shortage of safe assets, as the value of debt denominated in multiple official currencies would fluctuate along with the value of the synthetic currency. However, no individual official currency would be perfectly safe, meaning the issuers of debt denominated in the synthetic currency may take on exchange rate risk if their assets are denominated in the local currency.

If international trade were invoiced in the synthetic currency's unit of account, global

correlations in trade flows would also be reduced. Currently, international trade prices are sticky in dollars, so US shocks and monetary policy have outsized effects in stimulating or hindering international trade. In a world with a synthetic currency, such shocks to the dollar would create smaller deviations from efficiency in trade. A synthetic currency would, of course, create spillovers from shocks to the other underlying currencies, but to the extent that countries face idiosyncratic shocks, diversification could dampen those spillovers.

5 The Competition Between Public and Private Money

In a world of digital currencies, policymakers will face a variety of conceptually challenging issues. Money will no longer be as simple as it was in the past: each digital currency will come bundled with an array of data services and be associated with a collection of economic activities occurring across borders. The traditional system of intermediation may be turned on its head, with payment providers sitting on top of subsidiaries that provide intermediation and other financial services. In this section, we discuss the competition between public and private money and the implications of the introduction of CBDC in an environment with digital currencies.

5.1 Public versus private money

Digital currencies raise new questions regarding the competition between private and public money. Historically, one reason governments have sought to regulate private money has been to curb financial instability. Indeed, the record of unregulated private money in western society is often seen as problematic. Free banking in the United States lasted less than 30 years in the US and in Switzerland.[16] The only case in which some stability was achieved was in Scotland, where free banking prevailed for slightly over a century. Nevertheless, there are some episodes in which unregulated private currencies have succeeded and even outlived the official government currency. One of the most interesting examples is that of the "Swiss" dinar in Iraq, which continued to circulate in the Kurdish part of the country even after the government disavowed it. Even so, that incident provided further evidence on the importance of government backing, as the Swiss

[16] Rolnick and Weber (1985) provides an account of the free banking era in the US (1837-1883) and argues that problems were not due to inherent to banking but by other shocks. Baltensperger and Kugler (2017) describes the free banking era in Switzerland (1848-1881).

dinar began to appreciate when it seemed that the United States would depose Saddam Hussein and officially recognize the old Swiss dinar.[17] In recent years, fiat cryptocurrencies such as Bitcoin have again raised the question of whether unbacked, privately issued money can succeed. Although fiat cryptocurrencies have yet to stabilize as stores of value and are usually inefficient exchange media, they have found uses as vehicle currencies in international transactions (especially for the evasion of capital controls).

Economists often attribute the failure of unbacked private currencies to the lack of a fiscal anchor. An unbacked, privately issued currency faces a dynamic instability problem: it may suddenly lose its transaction value if people believe that in the future, others will not accept it in exchange. This fundamental instability can lead to hyperinflations in which the currency unravels. A government, on the other hand, can guarantee the value of the currency through its ability to tax. As argued in Obstfeld and Rogoff (2017), a government can raise real resources through taxation and offer to purchase (even a small amount of) currency using those resources, putting a hard cap on the price level. If the government declares its currency legal tender, this policy rules out the possibility of an ever-accelerating inflation. Similarly, the government's taxation power can be used to purchase foreign reserves and fend of an attack on a peg. Hence, currencies backed by governments do not have the same instability problem faced by private currencies. The government's willingness to accept its own currency as payment strengthens a publicly issued currency further. The fiscal theory of the price level (FTPL) suggests that the ability to pay taxes in a currency issued by the government puts a lower bound on the currency's value. When the government is expected to run primary surpluses, the private sector must save in government debt because their taxes exceed the income they expect to receive from government spending, so the value of currency outstanding can be no less than the present value of government surpluses.

However, the arguments as to why unbacked private money failed in the past may be less relevant today because public money is often a very poor substitute for modern digital currencies, so digital currencies may be much less susceptible to failure. For instance, cryptocurrencies can be used to conduct large international transactions, or evade capital controls, in a way not possible with ordinary money. Some privately issued money also

[17] King (2004) gives an account of this incident, showing how the Swiss dinar's value fluctuated in tandem with the probability that Hussein would be captured. In the same vein, another interesting example is that of the Somali shilling, which has not been backed by any entity since the government was disbanded in 1991. Counterfeiting is rampant, but the value of notes has converged to the marginal cost of counterfeiting, so there is little incentive to overproduce currency. See Koning (2017) for details on the Somali shilling.

grants access to automated payment agreements ("smart contracts") or prediction markets that are specific to a particular platform. Most importantly, the owner of a platform could effectively impose that its currency is the sole form of tender that can be used on that platform unless the government intervenes.

The prospect of viable independent currencies also raises concerns for monetary policy. Monetary policy is usually considered a public function that private issuers would conduct inefficiently. The fear that an entity with the power to conduct its own monetary policy will act in its own favor is what underlies the "original sin" faced by emerging countries in sovereign debt markets. Large private issuers of digital currency would similarly face the concern that if permitted to freely conduct monetary policy, it would be tailored to benefit the firm rather than the public. Similarly, the provision of emergency liquidity has usually been thought of as an essential function of the central bank. In a banking system centered around a digital network's currency, it would likely be necessary for some entity to be able to provide emergency liquidity directly on the network, and it is not at all clear that the network's owner would provide the optimal emergency funding facility. These concerns present an additional rationale for enforcement of an interoperability and convertibility regime: convertibility would constrain issuers' monetary policy, and interoperability with the national currency would allow the central bank to provide emergency liquidity directly.

5.2 Monetary independence and CBDC

Traditionally, an important question in macroeconomics has been how a government can retain monetary authority when challenged by the prospect of dollarization. This question is likely to become even more relevant with the possibility of digital dollarization. In modern economies, there is essentially no direct monetary interaction between the government and private citizens. Cash represents a tiny fraction of the outstanding money supply, and most consumers hold the majority of their money in the form of bank deposits. The government is able to exert some influence on the public by affecting the rates at which banks can borrow and lend. It may do this through open market operations, which change interbank borrowing rates, or it may directly set the interest rate on reserves and the discount window rate. If the advent of digital platform-based currencies alters the financial hierarchy (as in Figure 1), the role of banks may be diminished, though. Both the disappearance of cash and the reduced role of banks threaten monetary independence. Here, we consider the viewpoint that CBDC may be a natural countermeasure to

some of the effects of digitalization.

5.2.1 CBDC in a cashless society

Today, it is technically feasible for all payments in advanced economies to be made without cash. In a cashless society, the general public does not have access to public money. They instead hold deposits or digital currencies backed by the assets of private issuers. Even if those monetary instruments are convertible into each other, people would not have access to any monetary anchor into which bank deposits or digital currencies could be converted. In effect, private issuers would lose the discipline of public money, and their issuance would instead be shaped by other market forces.[18]

Without a mechanism to transform one payment instrument into another, perfect substitutability among payment instruments would not necessarily be enforced. The relative prices of different banks' deposits, or different networks' currencies, would be free to float, at least in principle.[19] In this type of system, money would be fundamentally different: it could remain liquid, but its safety would depend on its issuer. In effect, the monetary system would behave much more like the broader financial system, where the creditworthiness of each issuer would have to be continually re-assessed in order to value monetary instruments. Payments could become segmented into different categories of instruments according to the reliability of the issuer.[20]

CBDC would again grant the general public direct access to public money. Deposits and other digital currencies would be convertible into CBDC. This would immediately restore substitutability between payment instruments and keep their relative prices fixed. Hence, CBDC could be essential in maintaining the uniformity of money in a digital economy. A system of convertibility into CBDC would therefore eliminate any inefficiencies arising from information asymmetries in an economy with imperfectly substitutable currencies. Furthermore, and perhaps more importantly, the elimination of imperfectly substitutable currencies would lead to a single unit of account, which, as we discuss in detail later, is critical in maintaining the central bank's monetary authority.

The government, of course, can always exert a great degree of control over how pay-

[18] Indeed, if there were a broad loss of confidence in the banking system, people would have nowhere to run. The general availability of public currency disciplines the banking sector as a whole.

[19] See Eichengreen (2019) for an extensive discussion of the history of private money and the introduction of fiat cryptocurrencies and stable coins. Fernández-Villaverde and Sanches (2019) study competition among privately issued currencies in a workhorse macroeconomic model.

[20] See Landau and Genais (2019) for an extensive discussion of this and related issues.

ments are made by forcing households to pay taxes using a certain payment instrument or make that instrument legal tender.[21] Nevertheless, it is worth understanding the tradeoffs the government faces if it does not wish to take draconian measures to ensure the viability of its currency. Extreme measures may also be undesirable if the government wishes to promote innovation in digital payment technology. The introduction of CBDC may restore some power to the monetary authority without requiring the direct regulation of new currencies.

5.2.2 CBDC in a payments-based financial system

A central bank money that serves only as a medium of exchange is potentially vulnerable to technological change. Digitalization may allow to dispense from base money and settle payments differently. Inside large digital networks most transactions can be settled internally, thus bypassing central banks. The larger the network, the smaller its need for an outside settlement asset. Some projects launched by consortiums of banks, such as JP Morgan's JPM Coin or the Finality blockchain, could circumvent traditional settlement with reserves by building a network on which many types of payments, including cross-border payments, could be instantaneously finalized using tokens.

The disappearance of central bank currency as a means of payment does not necessarily imply a loss of monetary authority, though. The unit of account role of money, arguably its most important and basic function, gives the central bank power even when its liabilities are not used as a medium of exchange or a store of value. In modern economies, the unit of account is defined by reference to some fiat interest-bearing liability of the central bank. As long as transactions are made using that unit of account, the central bank will keep its power in all circumstances. It can fix the overnight interest rate on its own liabilities and, by arbitrage, influence the whole set of monetary and financial parameters. This will be the case even if no payment was made using central bank money, and if (almost) no value was stored in the central bank balance sheet.

This logic relies critically on the assumption that financial contracts are written solely in the unit of account defined by the central bank's liabilities. In an economy based on banking, this assumption makes sense: banks settle some payments with central bank money regardless, so it makes sense for them to write contracts in the same unit of account as reserves.

[21] Rogoff (2017) emphasizes governments' historical role in regulating the monetary system to put the official currency at an advantage.

If digital currencies succeed in fully exploiting the value underlying the associated networks, the financial system may instead center around the owners of large digital platforms. Payments will not necessarily be linked to the provision of credit by banks. The most important consequence of a system based on digital platforms may be that agents begin to write contracts in a unit of account specific to a platform rather than the central bank's unit of account. A change in the unit of account convention may become more likely with a large technological change that eliminates the use of cash and shifts economic activity towards platforms with their own units of account. The disappearance of the central bank's liabilities as a unit of account would eliminate the monetary authority's ability to reallocate risks among borrowers and lenders. This would also destroy the link between the interest rate set by the central bank and the arbitrage that allows monetary policy to have real effects on the provision of credit. In that case, the power of monetary policy may be severely impaired, as even the indirect links between monetary policy and consumers will be weakened.

CBDC would open up a direct channel by which monetary policy could be transmitted to the public. It may also permit the central bank's unit of account to remain relevant in a rapidly changing digital economy. As long as the public becomes accustomed to using the central bank's unit of account in some cases, the traditional channel of monetary policy in a cashless economy would remain effective. This effect of CBDC does not require it to compete other forms of payment out of existence– rather, this channels would be operative even if CBDC were a complement to other digital currencies.

Interoperability between CBDC and large digital platforms may also be essential in ensuring the success both of CBDC and those platforms. Publicly issued CBDC may not be sufficiently attractive to the public as a unit of account if it cannot be used on popular platforms. Therefore, interoperability may be critical in maintaining the link between public money and the general public. From the platform's perspective, interoperability may be beneficial as well. Users would likely be more prone to use the platform if they were permitted to use both the network's currency and whatever publicly issued digital currency they hold.

6 Conclusion

The ongoing digital revolution and the rise of large tech firms present the possibility of a radical departure from the traditional model of monetary exchange. The structure and

technology underlying digital networks may lead to an unbundling of the separate roles of money, creating fiercer competition among specialized currencies. The association of digital currencies with large platform ecosystems, on the other hand, may lead to a re-bundling of money in which payment services are packaged with an array of data services, encouraging differentiation but discouraging interoperability between platforms. Convertibility among monetary instruments and interoperability between platforms will be crucial in lowering barriers to trade and promoting competition. Digital currencies may also cause an upheaval of the international monetary system: countries that are socially or digitally integrated with their neighbors may face digital dollarization, and the prevalence of systemically important platforms could lead to the emergence of digital currency areas that transcend national borders. The rise of digital currencies will have implications for the treatment of private money, data ownership regulation, and central bank independence. For monetary policy to influence credit provision and risk sharing, public money must at least be used as a unit of account. In a digital economy where most activity is conducted through networks with their own monetary instruments, a regime in which all money is convertible to CBDC would uphold the unit of account status of public money.

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