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Central Banking in a Digital Age: Stock-Taking and Preliminary Thoughts

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1. Introduction

This note provides a broad overview of how technological changes are likely to affect the practice of central banking. While the advent of decentralized cryptocurrencies such as Bitcoin has dominated the headlines, a broader set of changes wrought by advances in technology are likely to eventually have a more profound and lasting impact on central banks. While it is premature to speak of disruption of traditional concepts of central banking, it is worth considering if the looming changes to money, financial markets, and payments systems will have significant repercussions for the operation of central banks and their ability to deliver on key objectives such as low inflation and financial stability. New forms of money and new channels for moving funds within and between economies could also have implications for international capital flows and exchange rates, which are of particular relevance for emerging market central banks.

The note touches on the relevant considerations (for monetary policy and financial stability) and catalogs the approaches that major central banks are taking towards three inter-related issues: central bank digital currencies (CBDCs), nonofficial cryptocurrencies, and fintech, a term that encompasses new and evolving financial technologies. The objective of this note is not to offer policy prescriptions but to survey the issues that central banks will have to grapple with and describe how some of them are preparing for the looming changes. The potential implications for the international monetary system will also be addressed briefly.

A few key points:

- There are many potential advantages to switching from physical to digital versions of central bank money, in terms of easing some constraints on traditional monetary policy and providing an official electronic payments system. The basic mechanics of monetary policy implementation will not be affected by a switch from physical currency to CBDCs. However, other technological changes that are likely to affect financial markets and institutions could have significant effects on monetary policy implementation and transmission.
- New financial technologies—including those underpinning nonofficial cryptocurrencies—herald broader access to the financial system, quicker and more easily verifiable settlement of transactions and payments, and lower transaction costs. Domestic and cross-border payment systems are on the threshold of major transformation, with significant gains in speed and lowering of transaction costs on the horizon. The efficiency gains in normal times from having decentralized payment and settlement systems needs to be balanced against their potential technological vulnerabilities and the repercussions of loss of confidence during periods of financial stress.

- Multiple payment systems could improve the stability of the overall payments mechanism in the economy and reduce the possibility of counterparty risk associated with the payment hubs themselves. However, multiple systems without official backing could be severely tested in times of crisis of confidence and serve as channels for risk transmission. Decentralized electronic payment systems are also exposed to technological vulnerabilities that could entail significant economic as well as financial damage. CBDCs could function as payment mechanisms that provide stability without necessarily limiting private fintech innovations.
- Financial institutions, especially banks, could face challenges to their business models, as new technologies facilitate the entry of institutions (or decentralized mechanisms) that can undertake financial intermediation and overcome information asymmetries. Banks will find it difficult to continue collecting economic rents on some activities that cross-subsidize other activities. The emergence of new institutions and mechanisms could improve financial intermediation but will pose significant challenges in terms of regulation and financial stability.
- The proliferation of channels for cross-border capital flows will make it increasingly difficult for national authorities to control these flows. Emerging market economies will face particular challenges in managing the volatility of capital flows and exchange rates, and could be subject to greater monetary policy spillovers and contagion effects.

The basic functions of central bank issued money might also be at the threshold of change. Fiat money now serves as a unit of account, medium of exchange, and store of value. With the advent of various forms of digital currencies, the functions of money can in principle be separated. While some nonofficial cryptocurrencies aspire to serve these multiple roles, the technology behind them could be the ultimate game-changer in terms of facilitating commercial and financial transactions by serving as a medium of exchange rather than as a store of value.

2. Basic Concepts

This section provides a brief overview of key concepts and definitions relevant for understanding how technological changes could affect the operation of financial markets and monetary policy.

Definitions

At the outset, it is worth laying out some relevant definitions for the purposes of this note and to clarify certain terms that are sometimes used interchangeably in popular discussions.

- *Fiat currency*: Currency issued by a national central bank, typically in the form of currency banknotes and coins (which will henceforth be referred to as *cash*). Generally issued by a government entity, although can also be issued by private institutions under the authority of the government.¹
- *Legal tender*: Form of payment that a creditor is legally obliged to accept from a debtor in order to extinguish a debt. Fiat currencies are typically legal tender. Not only must they be accepted as settlement for debt between private parties, but the government—which has the authority to levy taxes—can require that such tax obligations only be settled using the legal tender. Fiat currencies are, in principle and at least to a limited extent, backed by this authority of the government.
- *Digital currency*: Broad term that encompasses any form of currency that is not tangible.
- *Central Bank Digital Currencies (CBDC)*: Fiat currencies issued by central banks in place of, or as a complement to, physical currency (banknotes and coins).
 - *E-money*: A simple version of an electronic currency, wherein the central bank in effect manages a centralized payment system linked to electronic “wallets”. The payment system could be managed using blockchain or other versions of distributed ledger technology to verify transactions, with the verification process managed by the central bank rather than through a decentralized mechanism.
 - *Official cryptocurrencies*: Cryptocurrencies issued by a government entity, although not considered the equivalent of fiat currency; could in principle count as legal tender if the government were to decree this. Logically, government cryptocurrencies would be centralized, with verification of transactions provided by the government itself or its appointed agents rather than through a decentralized verification mechanism. Open question if this provides anonymity to transacting parties.
- *Nonofficial Cryptocurrencies*: Digital currencies that are virtual, typically not backed by a government, and do not constitute legal tender. Key characteristic is the ostensible anonymity

1. In Hong Kong, for instance, the Government, through the Hong Kong Monetary Authority has authorized three commercial banks (Bank of China (Hong Kong), HSBC, and Standard Chartered (Hong Kong)) to issue currency banknotes.

of transactions conducted principally using blockchain technology (this aspect is similar to cash, but cryptocurrencies are easier to scale than cash and do not require physical transfers of currency notes).² Cryptocurrencies can either be decentralized (wherein any economic agent with enough computing power can verify transactions, in return for a reward) or centralized (with verification authority limited to those appointed by a central authority).³ Another relevant characteristic is whether the record of transactions is public or private.

- *Fintech*: Broad term that refers to various technological developments that are relevant to financial markets. While there are many developments under this rubric that are not directly related to digital currencies, they could facilitate the use of such currencies since many of the relevant technologies, especially decentralized distributed ledgers, are relevant to both contexts.

These broad definitions need to be complemented by a range of other combinations of these underlying concepts, as well as some practical and legal considerations. The blockchain or Distributed Ledger Technology (DLT) underpinning Bitcoin allows for decentralized public verification of transactions and ensures immutability of those records. This technology clearly has applications beyond Bitcoin. A similar technological setup could be used to set up a CBDC, although the nature of verification of transactions (by miners who get rewarded for this process or by a set of authorized agents) and whether the system allows for true anonymity would have to be decided by the central bank.

This points to an important difference between official and nonofficial digital currencies. A fiat currency in a decentralized distributed ledger would in effect be an IOU, which would have to be backed up by a payment system to transfer the underlying financial asset (the currency). By contrast, for a nonofficial cryptocurrency, the entry on the public ledger is itself the digital asset, which is not backed in any way. The status of official cryptocurrencies is ambiguous—in principle, such a cryptocurrency could be backed by the government; if this backing was credible, this would be similar to other official digital currencies with the potential for anonymity being the distinguishing characteristic relative to electronic money.

Of course, as noted above, a CBDC could also be set up more simply as an electronic token on the government's payment network. Raskin and Yermack (2016) argue that it is now (or will soon be) technologically feasible for a central bank to set up electronic deposit accounts for all of a country's residents, with blockchain technology making it easy for the central bank to manage a multitude of such accounts. Presumably, these accounts would not normally be interest bearing and would be used for payments rather than as a channel for financial intermediation by the central bank.

2. There is an ongoing debate about whether Bitcoin transactions, which use the blockchain technology, are truly anonymous and untraceable. As discussed later in this note, a number of new cryptocurrencies purport to ensure true anonymity such that neither party in a transaction can be traced even though the transactions themselves are publicly verifiable.

3. In practice, the degree of centralization is not a binary choice.

While a CBDC might serve as a complement to a physical currency, there could be legal considerations involved since, in some countries, the definition of legal tender might not cover the issuance of a CBDC. A statutory remedy would then be required to ensure the equivalence of digital and physical versions of the fiat currency. CBDCs could be limited to wholesale transactions between financial institutions or expanded to retail transactions, in the latter case essentially functioning as a central bank-managed retail payment system.

Cryptocurrencies, which lack government or other backing, might appear to stand little chance of competing with fiat currencies. Moreover, with growing indications that cryptocurrencies such as Bitcoin do not truly guarantee anonymity, their roles as currencies rather than as just sophisticated payment systems have come under question. The natural market response has been the proliferation of cryptocurrencies that attempt to address one or more of these concerns. There are now close to 1400 cryptocurrencies that come in various flavors. Some of these are ostensibly backed in one form or another and are intended for a variety of purposes. For instance, the blockchain-based cryptocurrency Tether is in principle backed by and trades at par with the U.S. dollar (or, in its other incarnations, at par with other major currencies). Cryptocurrencies backed by a physical currency do not constitute new money creation and are in effect just a payments system. The value of some cryptocurrencies is backed by commodities or their prices are pegged to the prices of specific commodities.⁴

One of the initial attractions of nonofficial cryptocurrencies, and the reason for official concerns about them, was the anonymity they provided. Bitcoin and Ethereum, two popular cryptocurrencies, are in fact not anonymous since the amounts as well as source and destination addresses associated with each transaction are public information (this could allow the parties to any transaction to be traced). By contrast, Monero and ZCash are considered truly anonymous in the sense that none of this information associated with a particular transaction is publicly available. However, researchers have raised questions about the non-traceability of transactions even in these cases (see Box A). These findings have implications for security risks associated with CBDCs and especially for official cryptocurrencies that might purport to provide anonymity in a digital environment.

The proliferation of cryptocurrencies and their relationship to fiat currencies, whether physical or digital, is likely to ultimately hinge on how effectively each currency delivers on its intended functions. In this sense, by parceling out the various functions, the advent of cryptocurrencies has already changed the nature of money. Fiat money bundles together multiple functions as it serves as a unit of account, medium of exchange, and store of value. Now, with the advent of various forms of digital currencies, these functions can conceptually be separated. Moreover, whatever the future of cryptocurrencies, the DLT and

4. The U.K.'s Royal Mint has issued a cryptocurrency backed by its gold holdings. For other gold- or commodity-backed currencies, the verification mechanism for the backing seems to rely on audits by major auditing firms. Concerns have been raised about whether Tether is in fact fully backed by dollars as claimed by the issuers, who indicate that their reserve holdings are published daily and subject to frequent professional audits.

related technologies underlying their creation could have major impacts in the realms of finance and central banking.

Box A. Anonymity of Transactions Using Nonofficial Cryptocurrencies

Bitcoin and Ethereum verify transactions through a decentralized network of “miners” who attempt to solve difficult cryptographic puzzles in exchange for a reward. Multiple transactions are bundled into a “block,” which is then strung on to the blockchain. For a given transaction, the identities of the two transacting parties are publicly available on the blockchain. For a given block containing several transactions, the identity of the relevant miner is also publicly visible.

Anyone with a computer can access the blockchain for either Bitcoin or Ethereum. Ethereum’s blockchain (which can be viewed at etherscan.io) shows the digital addresses for all transacting parties. Further, clicking on an address yields that user’s Ether balance, number of transactions on Ethereum, and a detailed transaction history. Bitcoin’s blockchain shows much of the same information. Neither blockchain includes any information linking Bitcoin or Ethereum addresses to personal information, however.

Monero differs from the Bitcoin-Ethereum configuration in three ways. First, Monero uses one-time addresses for transactions, such that any single transaction cannot be associated with an individual user. This is called “unlinkability.” Second, Monero uses “ring signatures” to obscure a user’s transaction history, such that funds one party receives from a previous transaction cannot be traced by the sender in that previous transaction. Third, Monero uses “Ring Confidential Transactions,” which operate as an extension of ring signatures, to hide (on the blockchain’s public record) the amount of funds transferred in a transaction.⁵

This description suggests that Monero-based transactions are “truly” anonymous: unlinkable to any fixed identity, untraceable flows of funds, and concealed transaction sizes. However, Miller et al. (2017) report vulnerabilities in the Monero blockchain that would allow transactions to be traced, casting doubt on Monero’s anonymity.

Zcash, another cryptocurrency claiming to be “truly” anonymous, was introduced in October 2016.⁶ Rather than using ring signatures like Monero, Zcash uses “zero-knowledge proofs,” which masks the sender’s and recipient’s information in a transaction.⁷ These appear to be “truly” anonymous but come with associated security risks. A hacker able to crack Zcash’s algorithm would be able to generate unlimited crypto-tokens with only a minor risk of detection.⁸ In contrast, Bitcoin’s publicly-available blockchain means that any fraudulent tokens would be noticed quickly. Thus, there appears to be a tradeoff between anonymity and security. Similar questions have been raised about the true “finality” of settlements using DLT.⁹

5. “A Low-Level Explanation of the Mechanics of Monero vs Bitcoin in Plain English.” www.monero.how/how-does-monero-work-details-in-plain-english
6. “Zcash - Frequently Asked Questions.” z.cash/support/faq.html
7. For an explanation of zero-knowledge proofs, see hackernoon.com/eli5-zero-knowledge-proof-78a276db9eff
8. www.draglet.com/what-is-zcash#security-concerns.
9. See “Distributed Ledger Technology in Payments and Securities Settlement: Potential and Risks.” Deutsche Bundesbank Monthly Report, September 2017.

Money

While the term money has no singular definition, it is popularly associated with currency banknotes and coins. Much of the above discussion about digital currencies is related to a narrow concept of money. Monetary aggregates that are more relevant for evaluating the stance and outcomes of monetary policy are much broader and can be classified into two categories:¹⁰

- Outside money: Fiat (unbacked) money issued by a central bank (or government entity) or backed by an asset that is not in zero net supply in the private sector (e.g., gold).
- Inside money: An asset representing or backed by any form of private credit; circulates as medium of exchange; in net zero supply in private sector.

These two concepts could become blurred as unbacked money that is privately issued (or created by a non-governmental entity) competes with government-issued fiat currency. This raises a number of analytical issues about the different roles played by various forms of money, some of which will be explored later in this note. It should also be noted that inside money, in the form of bank deposits, is arguably already mostly in electronic form.

The share of central bank money in overall monetary aggregates has declined in recent years in most economies. For instance, take Sweden, which has gained some attention as an economy that is fast moving towards becoming cashless. The ratio of currency (banknotes and coins) to the monetary aggregate M3, which includes currency as well as bank deposits of various maturities, fell from 7 percent in the early 2000s to 2 percent by 2016. A report from the Riksbank states that “the proportion of cash payments in the retail sector has fallen from close to 40 percent in 2010 to about 15 percent in 2016.”

The ratio of currency to M2—which typically includes currency as well as savings deposits, time deposits, and money market deposit accounts (although the precise definition varies from country to country)—ranges from close to 20 percent in Russia and Mexico, to about 10 percent in the India, Japan, Kenya, and the U.S., to under 5 percent in China, the U.K, and the Euro zone. In recent years, the ratio of currency to M2 has fallen in a number of advanced and emerging market countries, indicating the declining importance of outside money even within this narrow monetary aggregate. Since 2003, the ratio of currency to M2 has fallen by 5 percentage points in China, 7 percentage points in India, and 3 percentage points in the Euro zone.¹¹

10. See Lagos (2006) for an exposition.

11. The ratio has held relatively steady in Japan, Switzerland, the U.K., and the U.S., all of which are, interestingly, reserve currency economies.

The implications of these crude calculations of the low and declining importance of currency are two-fold. First, the typical notion of money needs to be extended to consider broader concepts of money that are more relevant for economic activity and monetary policy. Second, when considering how technological developments could affect monetary policy, it is essential to examine the potential implications of these developments for financial institutions that play a critical role in creating inside money.

3. Approaches Taken by Different Central Banks and Governments

The rapid rise of cryptocurrencies has elicited a range of responses from central banks and governments, from trying to co-opt the changes to their advantage to resisting certain developments for fear of stoking monetary and financial instability. For many central banks, the responses are driven by concerns about the rapidly declining usage of currency and the implications for both financial and macroeconomic stability if decentralized payment systems displace both cash and traditional payment systems managed by regulated financial institutions. For instance, Sweden’s Riksbank is actively exploring the issuance of an e-krona, a digital complement to cash, with the objective of “promoting a safe and efficient payment system” as the use of cash plummets faster there than in other countries.

A taxonomy of the responses is laid out below, along with an indication of where some key central banks currently stand on these issues. This exercise is partly to take stock of the range of official responses and also to serve as a framework for keeping track of changes in official attitudes. There are three main elements to be considered—CBDCs, regulation of cryptocurrencies, and fintech developments more broadly. The list below is not meant to be comprehensive, nor are the categories mutually exclusive of one another. More details about the approaches being taken on these issues by the major central banks are in the appendixes to this note.

CBDC

A number of central banks are at various stages of looking into the feasibility and desirability of issuing CBDCs. The status of some key central banks is listed below. A more comprehensive listing of the positions of different central banks on this issue is provided in Appendix A.

- *In operation:* Tunisia issued the first CBDC, an e-Dinar designed as a virtual account, as early as 2010. It has now been superseded by a blockchain-based centralized digital currency

(using the Monetas digital platform) that also functions as a payments system. In 2015, Ecuador introduced a centralized payment system backed by a digital currency but, since the system failed to attract a significant number of users or volume of payments, is deactivating the system in April 2018.

- *Preparation for implementation/groundwork in progress:* China has successfully tested a block-chain based digital notes transaction platform and is developing a digital currency known as the Digital Currency for Electronic Payment. A consortium of Japanese banks plans to introduce a digital currency (J Coin) in time for the 2020 Tokyo Olympics. This project has the approval of the Bank of Japan, which has indicated that it is not considering issuing a digital currency by itself. The Bank of Canada has a joint initiative with the national payment system operator to develop a DLT-based settlement asset for wholesale transactions (Project Jasper). The Monetary Authority of Singapore is developing a tokenized version of the Singapore dollar on an Ethereum-based blockchain (Project Ubin). Senegal intends to issue an electronic version of the eCFA that will co-exist with physical CFA. This will be issued by a regional bank and will not rely on blockchain technology.
- *Evaluating pros and cons, with no specific plans to issue digital currency:* None of the major advanced economy central banks have announced specific plans to issue CBDCs. Some officials of the Bank of Japan, Bank of Canada, Bank of England, European Central Bank, and the Federal Reserve have indicated they are evaluating the pros and cons of CBDCs, although none of them appear to be giving this serious consideration.

Cryptocurrencies

The approaches of governments and central banks to permitting and/or regulating nonofficial cryptocurrencies span a wide spectrum, with individual countries often changing their positions back and forth in response to consumer demand and concerns about financial stability implications. The list below provides a brief and selective indication of the positions of some key central banks, with a more detailed listing provided in Appendix B.

- *Active regulation:* Canada and Japan have explicit laws concerning the trading and use of cryptocurrencies. The U.S. considers Bitcoin and other cryptocurrencies as financial assets that are subject to tax laws as well as regulations concerning anti money laundering and combating of financing of terrorism (AML/CFT).
- *Soft/hard bans on cryptocurrencies:* India's central bank, the Reserve Bank of India (RBI), has not provided authorization for any of the institutions it regulates to trade in or conduct business using cryptocurrencies. In April 2018, the RBI prohibited banks, financial

institutions, and other regulated entities from dealing in virtual currencies. Korea’s regulators have taken a dim view of cryptocurrencies, although they have not banned them outright. China banned domestic Bitcoin exchanges when it was trying to restrict speculative capital outflows in 2017, and has subsequently taken steps to block access to all cryptocurrency exchanges. China has also more recently banned domestic initial coin offerings (ICOs) and prohibited individuals and institutions from participating in them.

- *Passive tolerance:* A majority of countries are in this category, not banning cryptocurrencies but discouraging their use by financial institutions and, in many cases, not clarifying the legal status of such currencies even as means of payment.
- *Governments/central banks issuing their own cryptocurrencies:* Venezuela’s government issued the first official cryptocurrency, the petro, in February 2018. In April 2018, Venezuela declared the petro to be legal tender. The petro’s value is in principle backed by Venezuela’s oil reserves and the cryptocurrency’s issuance was intended to bolster public finances and evade financial sanctions imposed against Venezuela by the U.S. and other countries. Russia has indicated that it will issue a CryptoRuble, mainly for the latter reason. Cambodia, Estonia, and the Republic of the Marshall Islands have announced plans to issue official cryptocurrencies.

In short, there is hardly a unified approach to regulation (or tolerance) of cryptocurrencies. However, as indicated by the recent G-20 statement, many countries are concerned about the potential problems posed by cryptocurrencies, especially the avenues they may provide for evasion of taxes and AML/CFT regulations.¹²

Fintech

A number of central banks, recognizing the potential benefits of new technologies, have tried to allow some experimentation under controlled circumstances. Regulatory sandboxes have proliferated as regulators try to take the measure of the new technologies and their potential without engendering systemic risks. The U.K. Financial Conduct Authority Regulatory notes that its sandbox “allows businesses to test innovative products, services, business models and delivery mechanisms in the real market, with real consumers.”¹³ This sandbox is open to a wide range of entities rather than just

12. The March 2018 communiqué of the G-20 finance ministers and central bank governors states that “Crypto-assets do...raise issues with respect to consumer and investor protection, market integrity, tax evasion, money laundering and terrorist financing. Crypto-assets lack the key attributes of sovereign currencies. At some point they could have financial stability implications.” The full communiqué is available at: https://g20.org/sites/default/files/media/communique_-_fmcbg_march_2018.pdf

13. The FCA adds that its sandbox seeks to provide firms with (i) the ability to test products and services in a controlled environment; (ii) reduced time-to-market at potentially lower cost; (iii) support in identifying appropriate consumer protection safeguards to build into new

traditional financial institutions—authorized firms, unauthorized firms that require authorization, and technology businesses. The Monetary Authority of Singapore states that its regulatory sandbox enables financial institutions “...as well as FinTech players to experiment with innovative financial products or services in the production environment but within a well-defined space and duration. It shall also include appropriate safeguards to contain the consequences of failure and maintain the overall safety and soundness of the financial system.” The sandboxes allow regulators to observe the operation of new financial technologies as a precursor to designing suitable regulation as these activities scale up and move out of the sandboxes and into the broader financial system.

The list of countries that already have such financial regulatory sandboxes operating includes a number of advanced and emerging market economies such as Australia, Canada, Denmark, Hong Kong, Malaysia, Thailand, Saudi Arabia, South Africa, Sweden, and the United Kingdom (see Appendix C for a fuller listing and more details).

The European Union recently set out proposals for an EU-wide regulatory sandbox. This followed on the heels of a paper issued by the European Banking Federation, an industry group, recommending the creation of a Europe-wide fintech sandbox that would let companies experiment with new cross-border financial services. The Federal Reserve has not initiated any proposals for such a sandbox or indicated any intention of doing so. Interestingly, in March 2018, Arizona enacted a new law establishing a fintech sandbox, making it the first U.S. state to do so.¹⁴ The program is to be managed by the Attorney General’s office, is due to open for applications in late 2018, and is slated to run through July 2028. Applicants will be able to serve up to 10,000 Arizonian customers, and will have two years for testing.

4. Implications for Financial Institutions, Markets, and Stability

This section briefly reviews the implications of recent technological developments for the structure of financial markets as well as for banks and other financial institutions. These developments have the potential to increase the efficiency and stability of financial markets but could also create new risks and amplify them in certain circumstances. The structures of financial markets and institutions will also be affected, with even the viability of some traditional institutions coming into question.

products and services; and (iv) better access to finance. The sandbox also offers tools such as restricted authorization, individual guidance, informal steers, waivers, and no enforcement action letters.

14. The official press release is available at: <https://www.azag.gov/press-release/arizona-becomes-first-state-us-offer-fintech-regulatory-sandbox>. The press release notes that, while the idea of a regulatory fintech sandbox is “being discussed at the federal level, Congress is moving at a glacial pace.”

Payment Systems

The potential efficiency gains and welfare improvements from DLTs and other technologies underlying both CBDCs and cryptocurrencies could be significant. As the technology matures, it will confer a variety of benefits such as lower transaction costs as well as quicker and more easily verifiable settlement of transactions. It will become easier and cheaper to conduct even micro transactions using electronic payment systems.¹⁵ Such technologies can also help in broadening access to the formal financial system, especially in developing economies. An earlier fintech development, mobile banking, is already revolutionizing the very concept of banking in developing economies and giving much of the population—including rural and poor households—access to the formal financial system.

Many of these efficiency gains are related to improvements in payment systems, which have the potential to transform a variety of financial transactions. Both domestic and cross-border payment systems face disruption, with significant gains in speed and lowering of transaction costs on the horizon. Traditional messaging and payment/settlement systems across institutions (e.g., Fedwire and Clearing House Interbank Payments System (CHIPS) in the U.S., SWIFT for international transactions) could be displaced by cheaper and more efficient alternatives based on either decentralized or centralized monitoring. Payment systems and intermediaries such as Visa and Mastercard, which operate both within and across national borders, could also have their business models disrupted if their innovation does not keep pace.

These changes have obvious positive welfare implications. The proliferation of payment systems could increase financial stability by creating multiple levels of redundancies, so that the technological (or other forms of) failure of one payment system would not be harmful to the system. However, there are important considerations that could worsen instability. As has become abundantly clear in multiple contexts, electronic systems have considerable technological vulnerabilities. These vulnerabilities, in addition to the lack of official backing, could expose these systems to crises of confidence. If this happens at a time when official payment systems have been sidelined as a result of competitive forces, there could be dire financial and macroeconomic consequences. Fragmentation and lack of oversight of payment systems could also lead to pooling of counterparty risk in the payment hubs, further increasing their fragility at times of financial stress.

15. This is already a reality in China where payment systems such as Alipay have made it possible to conduct micro transactions using mobile phones and with minimal transaction costs.

Financial Institutions

As discussed earlier, banks play a crucial role in the creation of money. Hence, changes to the financial system that affect the relative importance, or even the viability of, traditional banks have implications not just for financial markets but also for economic activity and monetary policy.

The traditional roles of banks—intermediating between savers and borrowers by offering deposits and loans—could be upended by more direct intermediation channels. But issues of maturity transformation and information asymmetries, traditionally the main issues that gave banks advantages over other financial institutions, could still affect whether commercial banks will in fact be displaced or simply switch to different roles in the financial system.

Commercial banks' traditional advantages can no longer be taken for granted. For instance, relationship banking and other sources of information give banks an advantage over other financial institutions in dealing with information asymmetries between borrowers and lenders. However, as has already been demonstrated by Alibaba and Alipay in China, the use of big data and tracking of multiple attributes and economic activities of agents (including their purchase and payment histories) could provide even more effective credit scoring that reduces information asymmetries. Similarly, peer to peer lending and other direct intermediation channels between savers and borrowers are being facilitated by new technologies.

These alternative channels of financial intermediation have clearly passed the proof of concept stage, but whether they will be scalable to the extent that they challenge commercial banks remains to be seen. Maturity transformation is an inherently risky activity for a financial institution and there may be a limit to which informal institutions can take on this task. At any rate, banks can no longer count on collecting economic rents on many intermediation activities that they had hitherto conducted inefficiently and charged high fees on, exploiting their oligopolistic power. Competitive pressures from nonbank institutions are likely to lead to a rapid erosion of such rents, which could cause financial pressures for banks that had been using profits on certain activities to cross-subsidize other activities.

The rise of new types of nonbank and informal financial institutions could help increase the efficiency of financial intermediation, including by creating new products for savers and borrowers. But as these institutions intrude on the business areas of traditional banks, they would also take on some of the financial fragilities associated with those activities. Hence, the structures of financial supervisory and regulatory frameworks will need to adapt since the risks might shift to the under-regulated parts of the financial system.

Financial Market Regulation

The nature of regulation will change not just as new financial players emerge but also as the financial operations of existing players and the structures of financial markets are affected by the technological developments discussed in this note.

One of the key changes wrought by technology is that the cost of information acquisition and dispersion is falling. This should in principle engender greater financial stability since asymmetric and incomplete information are impediments to the smooth functioning of financial markets. However, a reduction in the cost of obtaining information, without commensurate improvements in reliable signal extraction mechanisms or the displacement of trusted signal interpreters, could actually lead to information overload. This in turn could lead to information cascades that worsen herding behavior and intensify contagion across financial markets. Bandwagon effects could intensify volatility in financial markets as more investors, including retail investors, can jump on more quickly and cheaply as they try to follow trends.

Informal financial institutions, which are outside the purview of regulators, could become increasingly important to the financial system. If the system does in fact efficiently disperse risk, then the outcome with a larger number of institutions due to the lower cost of entry might be a better one than present system. It has also been argued by some analysts that market discipline is often thwarted by government intervention or, worse, direct government involvement in the market. But will a decentralized system truly be subject to checks and balances in the absence of any oversight/regulation?

Decentralized payment processing and settlement systems could, in addition to increasing efficiency, level the playing field across small and large banks. The advantage of scale that large banks (and other large financial institutions) have would matter less as the costs of financial intermediation fall. However, regulators will need to be vigilant to avoid the risks of capture by large institutions. For instance, a set of large banks could set up a closed and centralized payment system that smaller banks do not have access to, making it harder for smaller banks that have access only to alternative decentralized systems to compete effectively.

Thus, while some aspects of financial regulation might become easier (because of better and quicker monitoring of digital transactions), the nature of financial regulation might have to shift in line with shifts in the structures of financial markets and institutions. For instance, while considerations such as too big to fail have been important in recent banking regulatory reforms, future regulation might also need to ensure that big banks do not use their size to cartelize the financial system by setting up restricted access payment and settlement systems outside the purview of the central bank or other regulatory authority.

Cryptocurrencies themselves pose an additional set of challenges. The range of financial activities that are facilitated by cryptocurrencies and the potential for gaps in regulatory oversight as different

regulators sort through jurisdictional issues is illustrated by the U.S. experience so far. The following summary is based on a recent CFTC document:¹⁶

U.S. law does not provide for direct, comprehensive Federal oversight of underlying Bitcoin or virtual currency spot markets. As a result, U.S. regulation of virtual currencies has evolved into a multifaceted, multi-regulatory approach:

- State banking regulators oversee certain U.S. and foreign virtual currency spot exchanges largely through state money transfer laws.
- The Internal Revenue Service (IRS) treats virtual currencies as property subject to capital gains tax.
- The Treasury’s Financial Crimes Enforcement Network (FinCEN) monitors Bitcoin and other virtual currency transfers for anti-money laundering purposes.
- The Securities and Exchange Commission (SEC) has the authority to oversee initial coin offerings (ICOs) since they typically involve the offer and sale of securities.
- The CFTC has declared virtual currencies to be a “commodity” subject to oversight under its authority under the Commodity Exchange Act (CEA).

The document notes that the CFTC has “taken action against unregistered Bitcoin futures exchanges (BitFinex), enforced the laws prohibiting wash trading and prearranged trades on a derivatives platform, issued proposed guidance on what is a derivative market and what is a spot market in the virtual currency context, issued warnings about valuations and volatility in spot virtual currency markets, and addressed a virtual currency Ponzi scheme.”

The complexity of regulations when secondary markets are involved is illustrated by the case of Bitcoin derivatives. As the price of Bitcoin surged towards \$20,000 near the end of 2017, derivatives exchanges sensed an opportunity to exploit the interest in products for speculating on Bitcoin prices. In December 2017, the Chicago Mercantile Exchange Inc. (CME) and the CBOE Futures Exchange (CFE) self-certified new contracts for bitcoin futures products, and the Cantor Exchange (Cantor) self-certified a new contract for bitcoin binary options.¹⁷

16. “CFTC Backgrounder on Oversight of and Approach to Virtual Currency Futures Markets” CFTC Public Affairs Office, January 2018. https://www.cftc.gov/sites/default/files/idc/groups/public/%40customerprotection/documents/file/backgrounder_virtualcurrency01.pdf

17. See <https://www.cftc.gov/PressRoom/PressReleases/pr7654-17>. The CFE and CME Bitcoin futures began trading in December 2017, the Cantor exchange product has not yet been launched.

The CFTC claims jurisdiction when a virtual currency is used in a derivatives contract (or if there is fraud or manipulation involving a virtual currency traded in interstate commerce). However, the CFTC noted that, so long as the self-certification by the derivatives exchanges adhered to certain guidelines, it had no authority to even hold public hearings or seek public input before the new products were launched. In responding to concerns about the new products adding to the Bitcoin hype (and price volatility), CFTC Chairman Giancarlo acknowledged that “Bitcoin...is a commodity unlike any the Commission has dealt with in the past.” The CFTC added that “In working with the Commission, CME, CFE and Cantor have set an appropriate standard for oversight over these bitcoin contracts given the CFTC’s limited statutory ability to oversee the cash market for bitcoin.”¹⁸

As Bitcoin and other cryptocurrencies, along with the technologies underpinning them, start playing a bigger role in financial markets, issues of regulatory jurisdiction and the potential for regulatory gaps/arbitrage take on greater significance. This discussion raises some important concerns in the context of the fragmented, overlapping, and inconsistent regulatory framework for U.S. financial markets that may have played a role in the global financial crisis and remains largely unchanged to this day.¹⁹

Nonofficial cryptocurrencies may also require greater coordination and harmonization of regulatory efforts across national regulators. While some cryptocurrency exchanges are nominally domiciled in specific countries, the nature of these virtual currencies makes it difficult to subject them to national rules and regulations, especially in terms of investor protection. U.S. Securities and Exchange Commission Chairman Jay Clayton summarized this in a cautionary statement to the public: “Please...recognize that these markets span national borders and that significant trading may occur on systems and platforms outside the United States. Your invested funds may quickly travel overseas without your knowledge. As a result, risks can be amplified, including the risk that market regulators, such as the SEC, may not be able to effectively pursue bad actors or recover funds.”²⁰

18. A CFTC press release stated: “It is important to note that there is no provision in statute or regulation for public input into new product self-certifications. Neither statute nor rule would have prevented CME and CFE from launching their new products before public hearings could have been called. Even if the CFTC could have held public hearings or requested public input, it is unlikely that the outcome would have changed, as the CFTC staff found no basis to determine their filings to be inconsistent with the CEA or CFTC regulations.” See <https://www.cftc.gov/PressRoom/PressReleases/pr7654-17>.

19. For a comprehensive description of the U.S. financial regulatory structure, see GAO (2016).

20. “Statement on Cryptocurrencies and Initial Coin Offerings,” SEC, December 11, 2017. <https://www.sec.gov/news/public-statement/statement-clayton-2017-12-11>

5. Monetary Policy Implications

Central banks are likely to face technical and operational challenges to their core monetary policy mandates or, at a minimum, will need to adapt to the evolving financial technologies.

Monetary Policy Implementation

One obvious question is whether CBDCs will have an effect on monetary policy or other aspects of macroeconomic policies. CBDCs disseminated through electronic wallets would make it easier to implement monetary policy more effectively in two ways. First, the nominal zero lower bound, which became a binding constraint for traditional monetary policy in advanced economies during the worst of the global financial crisis, would no longer apply. The central bank could institute a negative nominal interest rate simply by reducing balances on these electronic wallets at a pre-announced rate. In an economy with physical cash, this should in principle not be possible since consumers (and firms) always have the alternative of holding physical currency banknotes, a zero nominal interest rate instrument. As was evident in the aftermath of the financial crisis, central banks were in fact able to push nominal policy interest rates below zero, in fact significantly below zero and for extended periods in some cases.²¹ Apparently, the effective zero lower bound is actually below zero but it is unlikely that negative nominal interest rates would be sustainable beyond a certain threshold, although that threshold is not as well defined as economists once thought it was.²² In principle, negative nominal interest rates should encourage consumption by making it expensive for households to maintain cash positions.

Monetary policy could also be implemented through “helicopter drops” of money, once seen as just a theoretical possibility of increasing cash holdings in an economy in a non-distortionary fashion by making lumpsum transfers to all households.²³ This would be easy to implement if all citizens in an

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21. Policy interest rates (typically the interest rate the central bank pays to commercial banks on their reserves) have been pushed below zero in the Euro zone and countries such as Denmark, Hungary, Japan, Sweden, and Switzerland (<https://www.stlouisfed.org/publications/regional-economist/fourth-quarter-2017/central-banks-negative-interest-rates>). In Switzerland, this rate has been held at -0.75 percent since January 2015. In Sweden, the main policy rate, the repo rate, has been held at -0.50 percent since February 2016. Although there have been reports of commercial banks trying to charge corporations a fee on their deposits, it does not appear that household deposit rates breached the zero lower bound.
 22. If CBDC were to co-exist with physical currency notes, then there could be interesting equilibria in which digital cash could trade at a discount relative to physical cash in such circumstances.
 23. See Buiter (2014) on the efficacy of helicopter drops of money even in liquidity trap situations. Kocherlakota provides an alternative view: <https://www.bloomberg.com/view/articles/2016-03-24/helicopter-money-won-t-provide-much-extra-lift>. Bernanke points out that the term helicopter money refers more broadly to money-financed fiscal programs (see <https://www.brookings.edu/blog/ben-bernanke/2016/04/11/what-tools-does-the-fed-have-left-part-3-helicopter-money/>) Such programs require coordination between monetary

economy had official electronic wallets and the government could transfer central bank money into (or out of) those wallets. Channels for injecting outside money into an economy quickly and efficiently become important in circumstances of weak economic activity or looming crises, when banks might slow down or even terminate the creation of outside money.²⁴

Thus, a central bank could substantially reduce deflationary risks by resorting to such measures in order to escape the liquidity trap that results when it runs out of room to use traditional monetary policy tools in a physical cash-based economy.

There is an important asymmetry in this context that could become even more consequential if outside money were to have only a small role in the overall money supply. In that case, if banks were expanding outside money rapidly at a time of strong economic activity with rising inflationary risks, the central bank's ability to shrink electronic wallets holding CBDC might not do much to control the overall money supply. Although most advanced economy central banks now use price-based monetary policy measures (policy interest rates) rather than quantity-based monetary policy measures, this might be another reason for central banks to issue CBDCs rather than letting central bank money wither away if households were to use less and less cash.

There is, however, a flip-side to the ease with which a central bank can increase or decrease the supply of outside money. The ability to impose a haircut on CBDC holdings, or to increase them rapidly in case the government were to apply pressure on a central bank to monetize its budget deficit, could itself lead to substitution away from the CBDC. The reduction in nominal balances and the erosion in the real purchasing power of nominal balances through monetary injections would have similar effects—decreasing confidence in the currency as a safe asset that can hold its value, at least in nominal terms.

Monetary Policy Transmission

A number of banks and consortiums of banks are exploring the use of DLT for bilateral settlement of clearing balances without going through a trusted intermediary such as the central bank. DLTs, as discussed earlier, make it easier to track and verify transactions. If all participants in a closed pool can monitor such activities and if there is a permanent indelible transaction record that is tamper-proof, they may be able to use group monitoring as an alternative for a trusted central counterparty.

Will such developments dilute the ability of the central bank to affect interest rates in the economy through its control of very short-term policy interest rates (such as the discount rate and the Fed funds rate

and fiscal authorities, which may not be necessary if all households have electronic accounts that the central bank can directly inject money into.

24. The reasons could include higher risks of default as well as weaker demand for new loans.

in the U.S.)? This gets to the crux of the question about whether central banks can maintain their influence over aggregate demand and inflation even if they are sidelined from some of their traditional roles—issuing (outside) money and providing payment and settlement services for major financial institutions.

If banks and other major financial institutions do create such settlement mechanisms among themselves (both bilaterally and across members in the group), and are also able to more effectively manage their liquidity positions and overnight balances, then settlement and liquidity management through the central bank might play a less important role. Of course, the ability to observe such transactions (or even to observe that such transactions are taking place between certain participants in the system) conveys important information that banks might not want to reveal to their competitors. Thus, competitive forces might limit the use of DLTs as an alternative for a trusted third party such as a central bank to provide settlement services while maintaining the confidentiality of those transactions. In short, significant technological as well as conceptual hurdles will need to be overcome before commercial banks sideline the central bank.

If these challenges are overcome, one possibility is that the central bank eventually becomes a liquidity provider of last resort in times of crises but, otherwise, commercial banks route their settlement and liquidity management operations through direct channels among themselves.

A related issue is whether nonbank and informal financial institutions are less sensitive to policy interest rate changes than traditional commercial banks. If these institutions do not rely on wholesale funding and have other ways of intermediating between savers and borrowers, then the central bank might face significant challenges to the effectiveness of the monetary policy transmission. This might also prove to be only a long-term challenge for advanced economies if and when the relative importance of traditional commercial banks declines, although in developing economies informal financial institutions already play a significant role.²⁵ Despite the proliferation of nonbank financial institutions and more direct intermediation channels, it is far from obvious that these can be scaled up such that they displace (rather than erode the prominence of) commercial banks.

Capital Controls and Exchange Rates

Financial globalization has increased as a result of greater pressures for capital to flow across national borders, in search of either or both yield and safety, and the spread of financial institutions with a global footprint. This has led to rising de facto financial openness of all economies, including emerging market economies such as China and India that maintain de jure capital controls. In the case of China, for

25. There is a small and inconclusive literature on whether, in developing economies, credit conditions in informal financial markets are affected by monetary policy to the same extent as formal financial markets or institutions. See Ghosh and Kumar (2014) and references therein.

instance, its large banks now have a global presence and provide channels for moving money into and out of the country more easily than when the operations of these banks were mostly domestic. In addition, rising trade volumes have created opportunities for evading capital controls through trade misinvoicing.

New channels for transmitting payments across borders more quickly and cheaply are likely to make it more difficult to regulate and control capital flows. This will pose particular challenges for emerging market economies that have shallower and less-developed financial markets, making it harder for them to cope with capital flow and exchange rate volatility. New channels for capital inflows and outflows would also make these economies more susceptible to larger spillovers of monetary policy shifts in advanced economies and to contagion effects resulting from portfolio rebalancing decisions of international investors. Such changes are hardly imminent since cross-border payment systems are still in their infancy. But China's recent experience provides a cautionary tale. When the government was trying to control capital outflows in order to manage pressure on the currency, Bitcoin demand emanating from China surged. It is not possible to establish a clear connection between these developments, but there was enough circumstantial evidence that the government banned Bitcoin trading in order to tamp down on speculative capital outflows through this channel.

Other Considerations

Paper currency is vulnerable to counterfeiting, a challenge that governments have faced since the very introduction of paper currency by the Tang Dynasty in China in the 7th century.²⁶ CBDCs could in principle reduce this risk, although the risk of electronic counterfeiting on an even more massive scale through hacking is a major concern for governments that intend to take this route.

A potential advantage of a CBDC is that it would discourage illicit activity and rein in the shadow economy by reducing the anonymity of transactions now provided by the use of currency banknotes, a point made forcefully by Rogoff (2016), especially in the context of high-denomination banknotes. This would also affect tax revenues, both by bringing more activities out of the shadows and into the tax net and also by enhancing the government's ability to collect tax revenues more efficiently.

An argument in favor of preserving physical cash is that the level of access to the formal financial system is limited in developing economies, particularly in rural areas. Hence, cash is crucial for financial intermediation and as a more secure form of savings (McAndrews, 2017). This argument is being undercut rapidly by technologies such as mobile banking and the falling cost of digital transactions. Moreover, the introduction of CBDCs does not necessarily entail the immediate elimination of physical cash. The two could co-exist during a transition period or even indefinitely.

26. See Prasad (2016).

Would the proliferation of digital currencies affect the seigniorage revenues that accrue to central banks when they issue cash?²⁷ These revenues are the difference between the worth of the cash issued (in terms of goods and services it can procure) and the cost of producing and distributing it. The cost of printing paper currency and its lack of durability reduce direct seigniorage revenues. Hence, a CBDC could, all else unchanged, increase seigniorage revenues. However, the demand for central bank issued currency, either in physical or digital form, could be lower if it is displaced as a medium of exchange. Hence, the net effect on seigniorage revenues depends on how technological developments affect the demand for central bank money. In any event, seigniorage revenues tend to be modest for most central banks although, especially for a central bank such as the Federal Reserve or ECB that issues a major reserve currency, the revenues are hardly trivial.

Ensuring compliance with AML/CFT regulations has been a major challenge for government authorities. The elimination of physical cash could assist in these efforts, although the likely shifting of illicit fund transfers to decentralized payment systems and intermediated through anonymous, decentralized cryptocurrencies could vitiate this progress. This is one reason why central banks might seriously consider issuing CBDCs so they can retain control of or at least oversight over payment systems that could as easily be used for illicit as for licit purposes.

6. Implications for the International Monetary System

The advent of CBDCs and cryptocurrencies could have implications over the long run for certain elements of the international monetary system, but these are not likely to be revolutionary. Some changes could occur even earlier, although their effects on global finance will mostly be limited to the structure of financial markets themselves.

One of the major benefits of improved electronic payment and settlement systems that would go with the proliferation of digital currencies is the increase in speed and security of transactions, along with a reduction in their costs. This would mark a substantial improvement for settlement of trade-related transactions as well as remittances. Even cross-border settlement of other types of financial transactions could benefit from these developments. DLTs offer the potential for reliable tracking of different stages of trade and financial transactions, reducing one of the frictions associated with such transactions. Such changes might simply increase the efficiency and lower the cost of transactions routed through banks and other traditional financial institutions rather than displacing such institutions.

27. Seigniorage is distinct from inflation tax revenues, although the two concepts are often conflated.

International payment messaging systems such as SWIFT are also vulnerable to being replaced by alternatives that have the benefits of security and verifiability, but at a lower cost. SWIFT has the major initial advantage of a standardized communication protocol but it is difficult to imagine that that advantage is sufficient as a business model. Indeed, many countries such as China and Russia are setting up their own payment systems so as to reduce their reliance on foreign payment systems and also as a gateway to the international payment system. In other words, such countries could conceivably link their payment systems, routing bilateral international transactions through their own payment systems rather than relying on SWIFT and the payment systems that use it for messaging.

A longer-term and perhaps less likely outcome is the advent of cryptocurrencies, or at least decentralized payment systems, that function as mediums of exchange in international transactions. This would in effect create new channels for cross-border capital flows that are more difficult for a government to control through either macroprudential regulations or explicit capital controls. Concepts such as global liquidity, which came into vogue in the aftermath of the financial crisis (although they were never defined or measured with much precision), might become relevant due to the decline in frictions that now impede cross-border capital flows.

Financial and Real Spillovers

Both banks and nonbank financial institutions could expand the geographical scope of their operations across national borders using the new technologies. This entails new challenges for supervision and regulation. One complication is the lack of clarity about the domicile of informal financial institutions and the geographical locus of the supervisory authority of national regulators. The second is the potential accentuation of cross-border financial stability risks as more institutions operate across national borders. Some of this could be overcome by the greater transparency of transactions if they are conducted using a public DLT or if the regulator has access to the relevant private ledgers.

More channels for capital flows and reduced frictions could have the unintended consequence of amplification of potential cross-border spillovers of policies. This is a major concern for emerging market economies that experienced capital flow surges and reversals associated with the quantitative easing and subsequent tapering operations of the G-3 central banks. New channels for capital flows could also transmit financial market volatility more rapidly across countries.

Reserve Currencies

The demand for Bitcoin as a store of value rather than as a medium of exchange has stoked discussion about whether such cryptocurrencies could challenge that role of traditional reserve currencies. It is more likely that, as the underlying technologies become more stable, such decentralized nonofficial

cryptocurrencies will start playing a bigger role as mediums of exchange. Even that proposition is a tenuous one given the high levels of price volatility experienced by such currencies recently. Nevertheless, this shift could occur over time as the utilitarian functions of cryptocurrencies and the underlying payment verification and transfer systems take precedence over the speculative interest in them.

The decline in transaction costs and easier settlement of transactions across currency pairs could have a more direct and immediate impact—a decline in the role of vehicle currencies such as the U.S. dollar that are used to intermediate transactions across pairs of other currencies. The dominance of the dollar as a vehicle currency, followed by the euro, is related to the depth and liquidity of most currency pairs with the dollar (and the euro), which reduces the associated transaction costs.²⁸ This dominance is unlikely to persist and could even result in an erosion of the dollar’s role as a unit of account. For instance, the denomination of all oil contracts in dollars could easily give away to denomination and settlement of contracts for oil and other commodities in other currencies, perhaps even emerging market currencies such as the renminbi.²⁹

Notwithstanding any such changes, the role of reserve currencies as stores of value are not likely to be affected.³⁰ Safe financial assets—assets that are perceived as maintaining most of their principal value even in terms of extreme national or global financial stress—have many attributes that cannot be matched by nonofficial cryptocurrencies.³¹ The key technical attributes include liquidity and depth of the relevant financial instruments denominated in these currencies, such as U.S. Treasuries. More importantly, both domestic and foreign investors tend to place their trust in such currencies during times of financial crisis since they are backed by a powerful institutional framework. The elements of such a framework include an institutionalized system of checks and balances, the rule of law, and a trusted central bank. These elements provide a security blanket to investors that the value of those investments will be largely protected and that investors, both domestic and foreign, will be treated fairly.

While reserve currencies might not be challenged as stores of value, digital versions of extant reserve currencies and improved cross-border transaction channels could intensify competition among reserve currencies themselves. In particular, one could conceive of two types of equilibria—one in which a single

28. There is an important element of endogeneity implicit in this statement, of course. The lower cost of trading in the dollar increases the liquidity of instruments that feature the dollar paired with another currency.

29. For reasons unrelated to those discussed in this note, China and Russia are already conducting bilateral trade in oil and other commodities using their own currencies rather than relying on the dollar as an intermediating currency (see Prasad, 2014). This is based on a bilateral trading agreement but such agreements might well become superfluous in the future.

30. See Prasad (2016). For an alternative point of view, see Gopinath and Stein (2017), who argue that in international finance the medium of exchange and store of value functions of a currency are closely related and reinforce one another.

31. A more technical definition of a safe asset is one that has a negative beta relative to the overall market, i.e., its value tends to move inversely with the state of broader financial conditions, say as reflected in equity prices.

reserve currency becomes even more dominant than the U.S. dollar is right now and another in which there is active competition among an even larger set of reserve currencies, with the emergence of new reserve currencies facilitated by new technologies.

A final, more exotic possibility is the creation of new privately-issued synthetic financial assets as technology allows better spreading of risks across countries and across financial markets. An asset that diversifies away industry-specific risk, country-specific risk, and risk in other such disaggregated dimensions could in principle be “safer” in most states of the world than an asset issued by a national government. Still, if global shocks are a major source of risk, or if there is a lack of trust in the issuer of the new financial asset, traditional safe assets such as U.S. Treasuries are likely to retain their dominant role in global finance.

In short, the finance-related technological developments that are on the horizon portend important changes to domestic and international financial markets but a revolution in the international monetary system is not quite on the cards for the foreseeable future.

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Appendix A. Central Bank Digital Currencies

1. CBDC Status: Issued

Country	Digital Fiat Currency	Details	Current Status
Ecuador	Dinero electrónico	Dinero electrónico (“electronic money”) was a mobile payment service in Ecuador where the central bank provided the underlying accounts to the public. Citizens could open an account by downloading an app, registering their national identity number, and answering security questions. People could deposit or withdraw money by going to designated transaction centers. https://www.bis.org/publ/qtrpdf/r_qt1709f.htm	The state system had failed to attract a significant number of users or volume of payments. [Electronic money] account holders had until the end of March 2018 to withdraw their funds. Complete deactivation was scheduled for mid-April. https://seekingalpha.com/article/4159982-worlds-first-central-bank-electronic-money-come-gone-ecuador-2014minus-2018
Tunisia	e-Dinar	The e-Dinar is designed as a virtual account that is debited on one hand by the sum of digital transactions and credited on the other by the value of recharge cards, by transfer from another virtual account or by deduction from a postal account or another e-Dinar account. http://www.certification.tn/en/content/e-dinar-tunisian-post	In October 2015, the Tunisian Post launched blockchain experimentations in partnership with the Tunisian fintech startup to migrate e-Dinars into a blockchain-based system. https://www.uneca.org/sites/default/files/images/blockchain_technology_in_africa_draft_report_19-nov-2017-final_edited.pdf

		<p>e-Dinar is a digital wallet service from the Tunisian Post, launched in 2000 as part of the government’s e-Tijara initiative.</p> <p>https://coinjournal.net/tunisias-postal-services-teams-blockchain-startup-national-payment-platform/</p>	<p>Experimentation with blockchain-based e-Dinar started in October 2015. The project claimed in 2016 that 600,000 customers would soon be transitioned to the new system.</p> <p>https://futurism.com/tunisia-puts-nations-currency-Blockchain/</p> <p>No evidence of a full-scale migration of the e-Dinar to blockchain was found.</p>
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2. CBDC Status: Announced

Country	Digital Fiat Currency	Details	Current Status
Senegal	eCFA	<p>The currency is designed to operate alongside the African Financial Community (CFA) franc. It will be issued by the regional bank Banque Régionale de Marché (BRM) and will be used by countries in the West African Economic and Monetary Union, according to a statement from the BRM.</p> <p>The currency does not use blockchain-based technology. The physical technology behind the currency is digital currency production engine described as “a pyramidal structure with a tiny slot at the top.” Each central bank will have its own engine, locked in a vault and kept offline. It will only be operational when the central bank wants to use it.</p> <p>https://qz.com/872876/fintech-senegal-is-launched-the-ecfa-digital-currency/</p>	<p>In November 2016, Senegal announced that eCFA distribution would begin soon.</p> <p>https://www.ecurrency.net/static/news/201611/press_release_BRM_translated.pdf</p>

3. Official Cryptocurrency Status: Issued

Country	Digital Fiat Currency	Details	Current Status
Venezuela	Petro	<p>Petro will be a sovereign crypto asset backed by oil reserves, issued by the Venezuelan state and open to direct participation of citizens. http://www.elpetro.gob.ve/index-en.html#about</p> <p>In April 2018, the Venezuelan government declared the petro to be a legal tender, with government institutions given 120 days to start accepting it as such. https://www.bloomberg.com/news/articles/2018-04-12/venezuela-says-government-bodies-must-soon-accept-cryptocurrency</p>	<p>The Petro was first offered in presale in February 2018. Following the launch, President Nicolás Maduro said proceeds had reached US\$735 million. The actual sale of the cryptocurrency began a month later, and Maduro claims this has raised US\$5 billion to date. There is no evidence of these proceeds yet.</p> <p>https://oilprice.com/Latest-Energy-News/World-News/Venezuelan-Parliament-Finally-Approves-Oil-Backed-Cryptocurrency.html</p>

4. Official Cryptocurrency Status: Announced, Not Yet Issued

Country	Digital Fiat Currency	Details	Current Status
Russia	CryptoRuble	<p>The CryptoRuble is not associated with a mining process. All transactions will be recorded via blockchain and verified by a centralized government authority. https://arxiv.org/ftp/arxiv/papers/1801/1801.05760.pdf</p>	<p>Launch of CryptoRuble is delayed to mid-2019.</p> <p>https://cointelegraph.com/news/is-cryptoruble-back-launch-set-for-mid-2019-says-russian-blockchain-association</p>

Estonia	Estcoin	<p>Estonia is now moving ahead with plans to launch its own crypto token, the Estcoin. The proposal is not for a coin (like Bitcoin), but rather a digital token which would not fluctuate in value. The Estcoin, ultimately, is part of a larger plan—the e-Residency program—for establishing Estonia as a global “haven” for initial coin offerings.</p> <p>http://incorporate.ee/news/estonia-to-become-a-global-ico-hub/?gclid=EAIaIQobChMI2rrgnoG12gIVjzqBCh0KawWVEAAYASAAEgLf6PD_BwE</p>	<p>In December 2017, Estonia’s e-Residency program announced a proposal to launch the Estcoin via an initial coin offering. The coin has yet not been launched.</p> <p>https://medium.com/e-residency-blog/were-planning-to-launch-estcoin-and-that-s-only-the-start-310aba7f3790</p>
Cambodia	Entapay Token (Enta)	<p>Entapay is a blockchain payment system that provides offline exchange services for other cryptocurrencies. It consists of storage management, trade, exchange, and offline transactions. Enta is the common measure of value in the Entapay financial system. Users can mine Enta coin with the Entapay mining machine. https://www.entapay.io/ https://www.entapay.io/download/Whitepaper_English.pdf?r=1.1</p>	<p>In March 2018, Men Sam An, Cambodia’s Deputy Prime Minister, announced the launch of Entapay.</p> <p>https://www.phnompenhpost.com/business/uncertainty-over-future-cryptocurrencies-cambodia</p> <p>The Entapay Token’s public sale will start in May 2018.</p> <p>https://www.entapay.io</p>
Marshall Islands	Sovereign (SOV)	<p>The Sovereign (SOV) is a cryptocurrency to be issued by the government of the Republic of the Marshall Islands (R.M.I.). It will constitute legal tender. Neema, an Israeli startup, is developing the technology to support SOV and will oversee both the presale and the coin offerings.</p> <p>https://futurism.com/marshall-islands-crypto-official-currency/</p>	<p>In February 2018, the R.M.I. passed a law approving the launch of SOV. The nation plans to distribute SOV later in 2018 via an initial coin offering. SOV supply will be capped at 24 million tokens, with that number chosen in reference to the R.M.I.’s 24 municipalities.</p> <p>https://futurism.com/marshall-islands-crypto-official-currency/</p>

5. CBDC Status: Considering or Experimenting

Country	Digital Fiat Currency	Details
USA	N/A	<p>New York Fed President William Dudley said that the Fed is beginning to explore whether it could adopt its own digital currency. https://www.wsj.com/articles/dudley-says-fed-has-started-thinking-about-official-digital-currency-1511968465</p> <p>San Francisco Federal Reserve President John Williams (and incoming New York Fed President) said in late November 2017 that “Right now the Federal Reserve is not developing its own digital currency.” https://cointelegraph.com/news/us-federal-reserve-has-no-plans-to-introduce-digital-currencies-says-san-francisco-fed-president</p>
China	DCEP	<p>The People’s Bank of China (PBC) established its Digital Currency Research Institute in 2017, and it has been actively developing prototypes related to blockchain-based digital currency. https://www.coindesk.com/chinas-central-bank-opens-new-digital-currency-research-institute/</p> <p>Yao Qian, director of the Digital Currency Research Institute, wrote in a 2017 report that a digital currency could be integrated into the existing banking system, with commercial banks operating digital wallets for the central bank’s currency. https://www.technologyreview.com/s/608088/chinas-central-bank-has-begun-cautiously-testing-a-digital-currency/</p> <p>The PBC is currently developing a digital currency known as the DCEP, or Digital Currency (for) Electronic Payment, according to a 2018 report from the Beijing Youth Daily. https://www.ethnews.com/pboc-governor-digital-currency-could-replace-cash-in-china http://news.ifeng.com/a/20180309/56592674_0.shtml (Chinese)</p>

Japan	MUFG Coin	<p>Mitsubishi UFJ Financial Group Inc. is planning to release its own blockchain-based MUFG Coin. The coin would be pegged to the Japanese yen and may use both QR codes and FeliCa as its platform. It will enable peer-to-peer and point-of-sale payments plus transfers. The coin is under internal testing with no clear timeframe for general release.</p> <p>https://www.bloomberg.com/news/articles/2018-04-04/banks-rush-to-turn-japan-cashless-ahead-of-looming-tech-rivals</p> <p>Meanwhile, the Bank of Japan (BoJ), Japan’s central bank, sees no need to mint a digital currency.</p> <p>https://www.bloomberg.com/news/articles/2018-01-28/japanese-don-t-need-digital-currency-as-they-love-cash-boj-says</p> <p>The BoJ is conducting a joint research initiative (“Project Stella”) with the European Central Bank (ECB) to assess the applicability of DLT solutions in the area of financial market infrastructures.</p>
European Union	N/A	<p>The ECB has published the findings from the second phase of “Project Stella,” which is a joint research initiative run by the BoJ and the ECB. The project serves the sole purpose of assessing whether specific functionalities of existing payment systems could be safely and efficiently run with a DLT application, focusing on hands-on testing only. The areas of cost efficiency, market integration, and oversight are left for future study. https://www.boj.or.jp/en/announcements/release_2017/data/re1170906a1.pdf</p>
France	N/A	<p>The Bank of France developed a DLT version of its Single European Payments Area (SEPA) Creditor Identifier database in 2016.</p> <p>https://www.bis.org/publ/qtrpdf/r_qt1709f.pdf</p>

Canada	CADcoin	Project Jasper – the Bank of Canada’s DLT experiment – is a joint initiative with national payment system operator Payments Canada, leading Canadian banks, and the R3 technology consortium. The project has used CADcoin, a DLT-based settlement asset, to create and test two proof-of-concept wholesale payment systems. http://www.bankofcanada.ca/wp-content/uploads/2017/07/fintech-collaboration-vital-unlock-promise.pdf
UK	N/A	The Bank of England does not currently plan to issue a CBDC. However, the bank is undertaking research to better understand the implications of a central bank issuing a digital currency. https://www.bankofengland.co.uk/research/digital-currencies
Brazil	N/A	The Central Bank of Brazil is now developing proofs-of-concept on four different platforms—Ethereum, JPMorgan’s Quorum, and Hyperledger Fabric alongside Corda. https://www.coindesk.com/immature-no-longer-brazils-central-bank-is-ramping-up-its-blockchain-work/
Australia	N/A	The Reserve Bank of Australia has no immediate plans to issue an electronic form of Australian dollar banknotes. However, the bank is continuing to look at the pros and cons of issuing a digital currency. http://www.rba.gov.au/speeches/2017/pdf/sp-gov-2017-12-13.pdf
South Africa	N/A	According to an official statement dated February 13, 2018, the South African Reserve Bank (SARB) revealed a fintech program that will prioritize a project dubbed “Khokha” to explore a proof-of-concept using the blockchain technology. https://www.coindesk.com/south-africas-central-bank-eyes-jpmorgan-blockchain-tech/
Singapore	N/A	Under Project Ubin, the Monetary Authority of Singapore and the Association of Banks in Singapore announced that they have successfully developed software prototypes of three different models for decentralized interbank payments and settlement with liquidity savings mechanisms. http://www.mas.gov.sg/Singapore-Financial-Centre/Smart-Financial-Centre/Project-Ubin.aspx

Hong Kong	N/A	In March 2017, the Hong Kong Monetary Authority launched a research and a proof-of-concept work on CBDC in collaboration with the three note-issuing banks in Hong Kong, along with the Hong Kong Interbank Clearing Limited and the R3 consortium (which is setting up a DLT called Corda for financial transactions), to explore the potential of DLT. ³² http://www.legco.gov.hk/yr16-17/english/panels/fa/papers/fa20170418cb1-777-3-e.pdf
Sweden	e-krona	The Riksbank is investigating whether it would be possible to issue a digital complement to cash, the e-krona, and whether such a complement could support the Riksbank in the task of promoting a safe and efficient payment system. The decision on issuing a digital fiat currency will be made by 2019. http://www.riksbank.se/en/Financial-stability/Payments/Does-Sweden-need-the-e-krona/Reports/
Philippines	e-Peso	Kimi Cojuangco, a member of the Filipino House of Representatives, has filed a bill creating electronic money, e-Peso, as a medium of exchange. Cojuangco said the e-Peso would be legal tender for debt, taxes, goods and services transacted through the internet. http://congress.gov.ph/press/details.php?pressid=8212
Indonesia	N/A	PayPro Indonesia has partnered with eCurrency Mint Limited to provide eCurrency's digital fiat currency solution in Indonesia. https://www.businesswire.com/news/home/20171018006021/en/Indonesia-Takes-Steps-Digital-Fiat-Currency-Solution Bank Indonesia official Susiatio Dewi said that trials of the digital rupiah would be conducted in 2018 in an effort to improve the efficiency of the payment system. Susiatio added that the calculation of the circulated digital money would also be based on the current currency system, and would take into account the inflation rate. http://www.thejakartapost.com/news/2018/01/29/bank-indonesia-considers-issuing-digital-rupiah.html

32. The three note-issuing banks in Hong Kong are the Hong Kong and Shanghai Banking Corporation Limited, the Standard Chartered Bank (Hong Kong) Limited, and the Bank of China (Hong Kong) Limited.

India	N/A	<p>The Reserve Bank of India (RBI), the country’s central bank, has spoken about its ongoing cryptocurrency research, hinting at its role in a future digital alternative to the rupee. RBI executive director Sudarshan Sen said in September 2017, “Right now, we have a group of people who are looking at fiat cryptocurrencies. Something that is an alternative to the Indian rupee.”</p> <p>https://www.coindesk.com/indian-central-bank-studies-fiat-cryptocurrency-for-digital-rupee/</p>
Lebanon	N/A	<p>In a recent statement, the governor of the Bank of Lebanon, Riad Salameh, stated that the central bank plans to introduce its own digital currency. The digital currency will be issued by the Bank of Lebanon (BDL) in the next few years.</p> <p>https://themerkle.com/lebanon-to-issue-its-own-digital-currency/</p>
Eastern Caribbean	N/A	<p>The Eastern Caribbean Central Bank, in partnership with Bitt Inc., is planning a pilot project to test blockchain technology within the central bank’s member nations. Those member nations include Anguilla, Antigua and Barbuda, the Commonwealth of Dominica, Grenada, Montserrat, St. Kitts and Nevis, Saint Lucia and St. Vincent and the Grenadines.</p> <p>https://www.coindesk.com/eastern-caribbean-central-bank-pilot-bitt-blockchain-tech/</p>
South Korea	N/A	<p>The Bank of Korea (BoK), South Korea’s central bank, has launched a cryptocurrency task force to explore the technology’s effects on the financial system. The BoK is also seeking to explore a central bank-backed digital currency as part of the project.</p> <p>https://www.coindesk.com/koreas-central-bank-forms-task-force-to-study-cryptocurrency-impact/</p>
Israel	N/A	<p>The Bank of Israel is examining issuing digital currency as a means of creating a faster payment system as well as reducing the amount of cash in the economy, a central bank source said in October 2017, though he stressed that no decision had yet been made.</p> <p>The Israeli source said any digital currency introduced by the country’s central bank would be centralized, safe, and abide by money laundering rules – in contrast to Bitcoin and its peers, which are decentralized and whose value has often oscillated considerably.</p>

		https://www.reuters.com/article/us-israel-cenbank-currency/israel-central-bank-mulls-issuing-digital-currency-for-faster-payments-idUSKBN1EIOD5
Netherlands	DNBcoin	In 2015, De Nederlandsche Bank, the central bank of the Netherlands, started experimenting with its own cryptocurrency (DNBcoin). However, the central bank has stated that DNBcoin is restricted to internal testing purposes and that it will not be put into circulation. https://www.dnb.nl/binaries/Speech%20Ron%20Berndsen_tcm46-342846.pdf

Appendix B. Selected Countries' Approaches to Cryptocurrencies

Australia: In August 2014, the Australian Taxation Office issued a notice stating that transacting with Bitcoin is akin to a barter arrangement, with similar tax consequences. Those using digital currency for investment or business purposes may be subject to capital gain tax when they dispose of digital currency and individuals will be charged goods and services tax when they buy digital currency. Moreover, businesses providing an exchange service, buying and selling digital currency, or mining Bitcoin, will pay income tax on the profits. In December 2016, the Attorney-General's Department issued a consultation paper, suggesting that the AML/CTF (sic) (Anti-Money Laundering/Counter Terrorist Financing) Act should be amended to ensure that digital currencies are comprehensively captured by AML/CTF regulation. The Australian Securities & Investments Commission states on its website that the legal status of an ICO depends on the circumstances of the ICO. In some cases, the ICO will only be subject to the general law and the Australian consumer laws regarding the offer of services or products. In other cases, the ICO may be subject to the Corporations Act.

<https://www.ato.gov.au/misc/downloads/pdf/qc42159.pdf>

<https://www.ag.gov.au/Consultations/Documents/AML-CTF/Regulating-digital-currencies-under-Australias-aml-ctf-regime.pdf>

<http://asic.gov.au/regulatory-resources/digital-transformation/initial-coin-offerings/#legal>

Brazil: In October 2017, the Securities and Exchange Commission of Brazil (CVM) issued a statement saying that securities offered through ICOs cannot be legally traded on virtual currency exchanges, since the latter are not authorized by the CVM to provide securities trading platforms in Brazil. According to the CVM, no ICO has been registered or exempted from registration in Brazil. In November 2017, the central bank of Brazil issued a notice stating that it does not regulate or supervise operations with virtual currencies.

http://www.cvm.gov.br/subportal_ingles/menu/international/ico_statement.html

<https://www.bcb.gov.br/ingles/norms/Virtual-currencies-Communique-31379-English.pdf>

Canada: Canada Revenue Agency in 2013 stated that the rules for barter transactions apply to digital currency transactions. Therefore, the value of the goods or services purchased using digital currency must be included in the seller's income for tax purposes. The amount to be included would be the value of the goods or services in Canadian dollars. It also stated that digital currency can be bought and sold like a commodity. Any resulting gains or losses could constitute taxable income or capital gains for the taxpayer. In June 2014, Canada passed Bill C-31. This new law defines virtual currencies, including Bitcoin, as "money service business", which will be subject to the record keeping, verification

procedures, suspicious transaction reporting, and registration requirements under the framework of Canada's Proceeds of Crime (Money Laundering) and Terrorist Financing Act. In August 2017, Canadian Securities Administrators issued a notice stating that if a cryptocurrency exchange is doing business in a jurisdiction of Canada, it must apply to that jurisdiction's securities regulatory authority for recognition or an exemption from recognition. To date, no cryptocurrency exchange has been recognized in any jurisdiction of Canada or exempted from recognition.

http://www.osc.gov.on.ca/documents/en/Securities-Category4/csa_20170824_crypto-currency-offerings.pdf
<https://www.canada.ca/en/revenue-agency/news/newsroom/fact-sheets/fact-sheets-2013/what-you-should-know-about-digital-currency.html>
<http://www.parl.ca/DocumentViewer/en/41-2/bill/C-31/royal-assent/page-29#1>

China: In December 2013, the People's Bank of China (PBC) issued a notice stating that Bitcoin is not a currency issued by the government and that it should not be circulated on the market as currency. This notice also prohibited all financial institutions from using Bitcoin to price commodities or services, buying in or selling out of Bitcoin, and providing services related to Bitcoin. The notice required websites that provide platform for Bitcoin transactions to be archived at the telecommunication administration. In September 2017, the PBC issued a notice banning all cryptocurrency trading, defining Initial Coin Offerings as illegal activities, and banning all ICO activities in China. The notice prohibited all domestic exchanges from providing services related to cryptocurrency trading. This notice also prohibited all financial institutions and non-bank payment institutions from involvement, directly or indirectly, in any kind of ICO activities. In January 2018, the PBC issued a notice that prohibited all banks and their branches from providing any service for cryptocurrency trading and prevented any payment service being used for cryptocurrency trading.

<http://www.pbc.gov.cn/goutongjiaoliu/113456/113469/2804576/index.html>
<http://www.pbc.gov.cn/goutongjiaoliu/113456/113469/3374222/index.html>
<http://www.waizi.org.cn/doc/30165.html>

European Union: The European Central Bank (ECB) states that it is not the ECB's responsibility to ban or regulate Bitcoin or other cryptocurrencies. But, given the lack of consumer protection, it is important to exercise caution. In October 2015, the Court of Justice of the European Union decided that the exchange of traditional currencies for units of Bitcoin and other virtual currencies is exempt from VAT. In May 2016, the European Commission submitted a proposal for a Directive that aims to extend the scope of Directive (EU) 2015/849 so as to include virtual currency exchange platforms and custodian wallet providers. This new Directive also requires Member States to ensure that providers of exchanging services between virtual currencies and fiat currencies and custodian wallet providers are licensed or registered. In February 2017, the European Parliament passed a new Directive that makes virtual currency exchange platforms and custodian wallet providers subject to some of the same reporting obligations as traditional financial services providers.

<https://www.ecb.europa.eu/explainers/tell-me/html/what-is-bitcoin.en.html>
<http://curia.europa.eu/jcms/upload/docs/application/pdf/2015-10/cp150128en.pdf>

<http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+REPORT+A8-2017-0056+0+DOC+XML+V0//EN#title5>

Hong Kong (China): In March 2015, the Financial Services and the Treasury Bureau of Hong Kong issued a press release stating that Hong Kong does not have any targeted regulatory measures for virtual commodities specifically in terms of their safety or soundness, and the trading platforms or operators of such commodities. That said, the existing laws provide for sanctions against unlawful acts, such as money laundering, terrorist financing, fraud, pyramid schemes and cyber-crimes, whether or not these virtual commodities are involved. In September 2017, Hong Kong’s Securities and Futures Commission (SFC) issued a statement saying that, depending on the facts and circumstances of an ICO, digital tokens that are offered or sold may be “securities” as defined in the Securities and Futures Ordinance (SFO), and subject to the securities laws of Hong Kong. In December 2017, the SFC issued a circular stating that an entity is required to have an appropriate license or authorization from the SFC if it provides any business services which relate to Bitcoin futures contracts or cryptocurrency-related investment products and constitute a “regulated activity as defined in the SFO.

<http://www.info.gov.hk/gia/general/201503/25/P201503250463.htm>
<http://www.sfc.hk/web/EN/news-and-announcements/policy-statements-and-announcements/statement-on-initial-coin-offerings.html>
<http://www.sfc.hk/edistributionWeb/gateway/EN/news-and-announcements/news/doc?refNo=18PR13>

India: In December 5, 2017, the Reserve Bank of India (RBI) clarified that no license/authorization was given to any entity/company to operate or deal with Bitcoin or any virtual currencies. The Indian government also established an Inter-Disciplinary Committee to investigate and better understand matters related to cryptocurrencies. In April 2018, the RBI issued a statement saying it had decided, with immediate effect, that entities regulated by the RBI shall neither deal with nor provide services to any individual or business entities dealing with or settling virtual currencies. In effect, this means that banks, financial institutions, and other regulated entities are prohibited from dealing in virtual currencies.

<http://pib.nic.in/newsite/PrintRelease.aspx?relid=160923>
<https://rbi.org.in/scripts/PublicationsView.aspx?Id=18085>
<https://rbi.org.in/Scripts/NotificationUser.aspx?Id=11243&Mode=0>

Japan: In April 2014, the National Tax Agency of Japan issued a notice saying that the profit gained by an individual using Bitcoin would be classified as “miscellaneous income” and subject to income tax. Japan approved its Virtual Currency Act in March 2017 to subject digital currency exchanges to several added regulatory requirements. The new law defines Bitcoin and other virtual currency as a form of payment method, not a legally-recognized currency. Bitcoin will continue to be treated as an asset unless there are future revisions or directives to Japanese tax law. In October 2017, the Financial Services Agency of Japan issued a notice stating that, depending on the mechanism of an ICO, it is subject to regulation such as fund settlement law and financial product trading law.

<http://www.fsa.go.jp/news/28/ginkou/20170324-1.html>
<http://www.nta.go.jp/taxes/shiraberu/taxanswer/shotoku/1524.htm>

https://www.fsa.go.jp/policy/virtual_currency/06.pdf

Russia: In October 2016, the Russian Federal Tax Service issued a letter stating that operations related to the purchase or sale of cryptocurrency should be treated in a manner similar to transactions with foreign currencies. In January 2018, the Bank of Russia published draft laws entitled “On Digital Financial Assets” and “On Alternative Ways to Attract Investment”, which suggest that cryptocurrency exchange operators have to be legally incorporated and meet the requirements of federal laws on stock markets and organized trading. Moreover, exchange of cryptocurrencies and tokens for other cryptocurrencies, rubles, and foreign currencies is allowed only via Russia-based exchanges.

<https://www.cbr.ru/eng/press/event/?id=1629>

<http://base.garant.ru/71584452/>

Singapore: The Inland Revenue Authority of Singapore (IRAS) states that profits derived by businesses which mine and trade virtual currencies in exchange for money are subject to tax. Businesses that buy virtual currencies for long-term investment purposes may enjoy a capital gain from the disposal of these virtual currencies. In March 2014, the Monetary Authority of Singapore (MAS) issued a statement, saying that it would regulate virtual currency intermediaries in Singapore to address potential money laundering and terrorist financing (ML/TF) risks. To address this, MAS would introduce regulations to require virtual currency intermediaries that buy, sell or facilitate the exchange of virtual currencies for real currencies to verify the identities of their customers and report suspicious transactions to the Suspicious Transaction Reporting Office. In February 2018, the MAS issued a notice indicating that there was no strong case to ban cryptocurrency trading in Singapore. However, all suspicious transaction reports, including those involving cryptocurrencies and digital tokens, which are commonly known as initial coin offerings (ICOs), are analyzed by the Suspicious Transaction Reporting Office (STRO). Where there are indications of an offence, STRO will refer the matter to the enforcement agencies, such as IRAS for possible tax crimes and the Commercial Affairs Department (a department of the Singapore Police Force) for possible money laundering.

<http://www.mas.gov.sg/news-and-publications/Parliamentary-Replies/2018/Reply-to-Parliamentary-Question-on-banning-the-trading-of-bitcoin-currency-or-cryptocurrency.aspx>

<https://www.iras.gov.sg/irashome/Businesses/Companies/Working-out-Corporate-Income-Taxes/Specific-topics/Income-Tax-Treatment-of-Virtual-Currencies/>

<http://www.mas.gov.sg/news-and-publications/media-releases/2014/mas-to-regulate-virtual-currency-intermediaries-for-money-laundering-and-terrorist-financing-risks.aspx>

South Africa: In September 2014, the National Treasury of South Africa issued a notice stating that virtual currencies are not defined as securities in terms of the Financial Markets Act, 2012 (Act No. 19 of 2012). The regulatory standards that apply to the trading of securities therefore do not apply to virtual currencies. In December 2014, the South African Reserve Bank issued a position paper on virtual currencies, stating that it does not oversee, supervise or regulate the virtual currency (VC) landscape, systems or intermediaries for effectiveness, soundness, integrity or robustness. Consequently, any and all activities related to the acquisition, trading or use of VCs (particularly Decentralized Convertible Virtual Currencies) are performed at the end-user’s sole and independent risk and the user has no recourse to the

Bank. In April 2018, the South African Revenue Service (SARS) issued a media release stating that it would continue to apply normal income tax rules to cryptocurrencies and expected affected taxpayers to declare cryptocurrency gains or losses as part of their taxable income.

http://www.treasury.gov.za/comm_media/press/2014/2014091801%20-%20User%20Alert%20Virtual%20currencies.pdf

https://www.golegal.co.za/wp-content/uploads/2018/01/Virtual-Currencies-Position-Paper-Final_02of2014.pdf

<http://www.sars.gov.za/Media/MediaReleases/Pages/6-April-2018---SARS-stance-on-the-tax-treatment-of-cryptocurrencies-.aspx>

Sweden: In June 2014, the Swedish Central Bank issued a report saying that, while Bitcoin issuance is unregulated, Swedish companies offering exchange services for Bitcoin are regulated primarily through the Payment Service Act which sets forth the rights and obligations of both the payment intermediary and the payment service users. In April 2014, the Swedish Tax Agency issued a statement, saying that the sale of Bitcoin is subject to capital gains tax under the provisions on Other Assets. In April 2015, the Agency issued another statement saying that mining of Bitcoin and other cryptocurrencies would be subject to income tax.

https://www.riksbank.se/globalassets/media/avdelningar/svenska/afs/2014/rap_ek_kom_nr02_140617_sve.pdf

<https://www.skatteverket.se/privat/skatter/vardepapper/andratillgangar/kryptovalutor>

<https://www4.skatteverket.se/rattsligvagledning/338713.html>

United Kingdom: The U.K. HM Revenue & Customs issued a policy paper in March 2014 stating that income received from Bitcoin mining activities would generally be outside the scope of VAT. However, the general rules on foreign exchange and loan relationships apply to the tax treatment of virtual currencies. In March 2015, HM Treasury issued a report stating the government intended to apply anti-money laundering regulation to digital currency exchanges in the U.K. to support innovation and prevent criminal use. In December 2017, the U.K. Financial Conduct Authority issued a notice warning of the risks of Initial Coin Offerings. The notice indicated that while many ICOs fell outside the regulated space, depending on how they are structured some ICOs may involve regulated investments and firms involved in an ICO may be conducting regulated activities.

<https://www.gov.uk/government/publications/revenue-and-customs-brief-9-2014-bitcoin-and-other-cryptocurrencies/revenue-and-customs-brief-9-2014-bitcoin-and-other-cryptocurrencies>

<https://bravenewcoin.com/assets/Industry-Reports-2015/UK-HM-Treasury-digital-currencies-response-to-call-for-information-final-changes.pdf>

<https://www.fca.org.uk/news/statements/initial-coin-offerings>

United States: The U.S. Commodity Futures Trading Commission (CFTC) classified Bitcoin and other cryptocurrencies as commodities under the Commodity Exchange Act. The CFTC maintains general anti-fraud and manipulation enforcement authority over virtual currency cash markets as a commodity in interstate commerce. In March 2014, the U.S. Internal Revenue Service issued a guidance stating that it

would treat virtual currencies, such as Bitcoin as property for federal tax purposes. As a result, general tax principles that apply to property transactions apply to transactions using virtual currency. In December 2017, the Securities and Exchange Commission (SEC) issued a statement saying that to date no initial coin offerings had been registered with the SEC. The SEC also had not until that date approved for listing and trading any exchange-traded products (such as exchange traded funds or ETFs) holding cryptocurrencies or other assets related to cryptocurrencies. The statement asserts that cryptocurrencies are not securities and that the offer and sale of cryptocurrencies are beyond the SEC's jurisdiction. However, it notes that the structures of initial coin offerings (ICOs) directly implicate the securities registration requirements and other investor protection provisions of federal securities laws.

<https://www.irs.gov/pub/irs-drop/n-14-21.pdf>

https://www.cftc.gov/sites/default/files/idc/groups/public/%40customerprotection/documents/file/oceo_ai_vc0218.pdf

https://www.cftc.gov/sites/default/files/idc/groups/public/%40customerprotection/documents/file/oceo_bitcoinbasics0218.pdf

<https://www.sec.gov/news/public-statement/statement-clayton-2017-12-11>

Appendix C. Countries That Have Implemented Fintech Regulatory Sandboxes

Europe	United Kingdom, Lithuania, Denmark, Netherlands, Switzerland, Sweden, EU
Asia/Asia-Pacific	Singapore, Brunei, Australia, Hong Kong (China), Malaysia, Thailand, Indonesia
Africa	South Africa, Mauritius, Sierra Leone
North America	Arizona (USA), Canada
Middle East	Saudi Arabia, Abu Dhabi (UAE), Bahrain
Caribbean	Eastern Caribbean

The country-by-country summary follows the same order as in the table above. The links are provided at the end of the appendix in the same order as the countries below.

United Kingdom: The Financial Conduct Authority (FCA) launched a regulatory sandbox in June 2016. The sandbox is open to authorized firms, unauthorized firms that require authorization, and technology businesses. The sandbox also offers tools such as restricted authorization, individual guidance, informal steers, waivers and no enforcement action letters. As of February 2018, the sandbox has supported 60 firms to test potential innovations with real customers in the live market under controlled conditions.

Lithuania: The central bank of Lithuania has launched a new regulatory sandbox for startups working with Blockchain. The “LBChain” initiative will see the Bank of Lithuania set up a dedicated platform around the technology, through which companies can develop services (though these services will be subject to some gatekeeping by central bank officials). It is a notable spin on the sandbox model, which sees institutions enabling firms to test financial products in a limited setting and under the auspices of regulators.

Denmark: In February 2018, the Finanstilsynet (Danish Financial Supervisory Authority) opened its first cohort applications for the FT Lab, a regulatory sandbox in which selected companies can test their innovative business models and fintech initiatives in a safe environment. Only a limited number of companies will take part in the first cohort of FT Lab. Based on the experience with the first cohort, the Financial Services Authority will again open up for applications from companies at a later date (e.g., when the companies from the first cohort are leaving the FT Lab).

Netherlands: The Authority for the Financial Market (AFM) and De Nederlandsche Bank (DNB) put a regulatory sandbox into practice in January 2017. The sandbox is available to all financial services companies looking to operate an innovative financial product, service or business model, whether supervised players or newcomers. Such innovations may result from the application of technology (fintech), but this is not a prerequisite for qualifying for the sandbox, the scope of which is broader than just fintech.

Switzerland: In July 2017, the Swiss Federal Council amended the Swiss Federal Banking Ordinance to ease the Swiss regulatory framework for providers of innovative financial technologies. As a result, a regulatory sandbox enters into force on August 1, 2017. It allows businesses in an early stage of development to experiment without being subject to prudential supervision.

Sweden: The Swedish Financial Supervisory Authority (FSA) established Fintech Regulatory Sandbox in Stockholm after receiving an assignment to facilitate fintech innovation from the Swedish National Innovation Council in May 2017.

European Union: In March 2018, the European Commission unveiled an Action Plan on how to harness the opportunities presented by fintech. The Fintech Action Plan set out that the Commission will present a “blueprint” with best practices on regulatory sandboxes, based on guidance from European supervisory authorities.

Singapore: In 2016, the Monetary Authority of Singapore (MAS) set up the Fintech Regulatory Sandbox to encourage more fintech experimentation. Financial institutions or any interested firm can apply to enter a regulatory sandbox to experiment with innovative financial services in the production environment, but within a well-defined space and duration. Depending on the financial service under experimentation (i.e., the applicant involved and the application made) MAS will determine the specific legal and regulatory requirements for each case.

Brunei Darussalam: In February 2017, the Monetary Authority of Brunei Darussalam (AMBD) formally issued the Fintech Regulatory Sandbox Guidelines, which aim to aid in the development of fintech companies in Brunei Darussalam through the creation of regulatory sandboxes.

Australia: Australia’s regulatory sandbox framework is comprised of three broad options for testing a new product or service without a license: (i) relying on existing statutory exemptions or flexibility in the law—such as by acting on behalf of an existing licensee; (ii) relying on Australian Securities & Investments Commission (ASIC) ‘fintech licensing exemption’ for the testing of certain specified products and services; and (iii) for other services, relying on individual relief from the ASIC. ASIC’s current fintech licensing exemption allows eligible businesses to test specified services for up to 12 months with up to 100 retail clients, provided they also meet certain consumer protection conditions and notify ASIC before they commence business operations.

Hong Kong: The Fintech Supervisory Sandbox (FSS), launched by the Hong Kong Monetary Authority (HKMA) in September 2016, allows banks and their partnering technology firms to conduct pilot trials of their fintech initiatives involving a limited number of participating customers without the need to achieve

full compliance with the HKMA's supervisory requirements. This arrangement enables banks and technology firms to gather data and user feedback so that they can make refinements to their new initiatives, thereby expediting the launch of new technology products and reducing development costs.

Malaysia: In October 2016, Bank Negara Malaysia, the country's central bank, issued the Financial Technology Regulatory Sandbox Framework, which set out its key principles and approach in operationalizing the regulatory sandbox. As of 2017, Bank Negara had approved four firms to operate within its regulatory sandbox.

Thailand: The Bank of Thailand issued a consultation paper on Fintech Regulatory Sandbox Guidelines in October 2016. The purpose of the regulatory sandbox is to allow businesses to test their financial products or services in a live but limited environment, without being fully subject to all requirements that are normally applicable.

Indonesia: From 2013 to 2014, Bank Indonesia (BI) conducted a pilot program to experiment with branchless banking services ("Pilot Branchless Banking Program"). The program allowed banks and/or telecommunication companies (with BI oversight) to offer banking and payments system services through agents. In September 2016, Bank Indonesia claimed to launch the Fintech Office and Regulatory Sandbox. Indonesia's Financial Services Authority also has plans to launch regulatory sandbox.

South Africa: South Africa's central bank has launched a program to evaluate the potential of JPMorgan's Quorum, an Ethereum spin-off targeted at businesses, for interbank clearing and settlement. According to an official statement in February 2018, the South African Reserve Bank revealed it has established a fintech program that will prioritize, among other things, a project dubbed Khokha to explore a proof-of-concept using the technology.

Mauritius: The government of Mauritius announced the introduction of the Regulatory Sandbox License (RSL) in the 2016/2017 National Budget. The Board of Investment is responsible for managing the new scheme, and RSL will be delivered to eligible companies willing to invest in innovative projects within an agreed set of terms and conditions for a defined period.

Sierra Leone: The Bank of Sierra Leone will provide access to its newly launched regulatory sandbox to the finalists of the Sierra Leone Fintech Challenge 2017.

Arizona, U.S.A.: In March 2018, Arizona enacted a new law that will see the state establish a fintech sandbox, making it the first U.S. state to do so. The program, which will be managed by the state attorney general's office, is due to open for applications in late 2018 and run until July 2028. Applicants will be able to serve up to 10,000 Arizonian customers, and will have two years for testing.

Canada: In February 2017, the Canadian Securities Administrators (CSA) launched a regulatory sandbox, an initiative that supports businesses seeking to offer innovative products, services, and applications. The CSA regulatory sandbox is open to business models that are truly innovative from a Canadian market perspective. The CSA will assess the merits of each business model on a case-by-case basis and

businesses that register or receive relief could be permitted to test their products and services throughout the Canadian market.

Saudi Arabia: The cryptocurrency platform Ripple has struck a deal with Saudi Arabia's central bank on a pilot program that will see banks in the country trial the company's technology. This pilot program is a sandbox for participating banks from the Kingdom of Saudi Arabia to use xCurrent, a clearing-and-settlement platform, to instantly settle payments sent into and out of the country with greater transparency and lower costs.

Abu Dhabi, UAE: Abu Dhabi Global Market (ADGM) unveiled its Innovation Centre at the Fintech Abu Dhabi Summit in October 2017. The Centre will also be home to participants of the Regulatory Laboratory (RegLab). ADGM's regulatory sandbox allows companies to live-test innovative fintech products in collaboration with the regulator. As of October 2017, the Centre has admitted a second batch of fintech startups to RegLab.

Bahrain: In June 2017, the Central Bank of Bahrain (CBB) announced new regulations to create a regulatory sandbox that will allow startups and fintech firms to test and experiment their banking ideas and solutions. The objective of the creation of the regulatory sandbox is to provide an opportunity for fintech businesses around the world to expand and thrive in the Gulf and strengthen Bahrain's position as a fintech and financial services hub in the Gulf Cooperation Council.

Eastern Caribbean: The Eastern Caribbean Central Bank, in partnership with Bitt, a platform for money transfers, will launch a pilot project to test blockchain technology within the central bank's member nations next year. Those member nations include Anguilla, Antigua and Barbuda, the Commonwealth of Dominica, Grenada, Montserrat, St. Kitts and Nevis, Saint Lucia, and St. Vincent and the Grenadines. The pilot will be restricted to controlled environments and supervised by the bank. The results could be used to develop more effective digital payment and settlement systems, and may also be used to help issue a digital currency for the region.

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