

IMF STAFF DISCUSSION NOTE

Fintech and Financial Services: Initial Considerations

Dong He, Ross Leckow, Vikram Haksar, Tommaso Mancini-Griffoli, Nigel Jenkinson, Mikari Kashima, Tanai Khiaonarong, Céline Rochon, and Hervé Tourpe

DISCLAIMER: Staff Discussion Notes (SDNs) showcase policy-related analysis and research being developed by IMF staff members and are published to elicit comments and to encourage debate. The views expressed in Staff Discussion Notes are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

Monetary and Capital Markets, Legal, and Strategy and Policy Review Departments

Fintech and Financial Services: Initial Considerations

Prepared by an IMF Staff Team¹

Authorized for distribution by
Tobias Adrian, Ross Leckow, and Hugh Bredenkamp

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EXECUTIVE SUMMARY

From artificial intelligence to cryptography, rapid advances in digital technology are transforming the financial services landscape, creating opportunities and challenges for consumers, service providers, and regulators alike. This paper reviews developments in this new wave of technological innovations, often called “fintech,” and assesses their impact on an array of financial services. Given the IMF’s mandate to promote the stability of the international monetary system, it focuses on rapidly changing cross-border payments.

Using an economic framework, the paper discusses how fintech might provide solutions that respond to consumer needs for trust, security, privacy, better services, and change the competitive landscape. The key findings include the following:

- *Boundaries are blurring* among intermediaries, markets, and new service providers.
- *Barriers to entry are changing*, being lowered in some cases but increased in others, especially if the emergence of large closed networks reduces opportunities for competition.
- *Trust remains essential*, even as there is less reliance on traditional financial intermediaries, and more on networks and new types of service providers.
- *Technologies may improve cross-border payments*, including by offering better and cheaper services, and lowering the cost of compliance with anti-money laundering and combating the financing of terrorism (AML/CFT) regulation.

Overall, the financial services sector is poised for change. But it is hard to judge whether this will be more evolutionary or revolutionary. Policymaking will need to be nimble, experimental, and cooperative.

At the same time, regulatory authorities need to balance carefully efficiency and stability tradeoffs in the face of these rapid changes. They need to be assured that risks to stability and integrity—including from cyberattacks, money-laundering and terrorism financing—can be effectively managed without stifling innovation. They need to ensure that trust is maintained in an evolving financial system. In particular:

- *Regulators may need to complement their focus on entities with increasing attention to activities*, as financial services are increasingly provided by a diverse group of firms and market platforms.
- *Governance needs to be strengthened*. Rules and standards will need to be developed to ensure the integrity of data, algorithms, and platforms.
- *Policy options to support open networks could be considered*. In doing so, central banks may need to assess costs and benefits of increasing access to their settlement systems or offering digital national currencies.

- *Legal principles need to be modernized.* Maintaining trust in financial services may also require the development of new legal rules to clarify rights and obligations within the new global financial landscape.

Fintech is an international issue. With the blurring of boundaries among entities, activities, and jurisdictions policymakers need to consider implications for common standards and legal principles, to the extent that they align with national priorities. International cooperation will therefore be essential, and the IMF is well placed to play a significant role.

INTRODUCTION

1. A new wave of technological innovations, often called “fintech,” is accelerating change in the financial sector. Fintech leverages the explosion of big data on individuals and firms, advances in artificial intelligence, computing power, cryptography, and the reach of the internet. The strong complementarities among these technologies are giving rise to an impressive array of new applications touching on services from payments to financing, asset management, insurance, and advice. The possibility now looms that entities driven by fintech may emerge as competitive alternatives to traditional financial intermediaries, markets, and infrastructures.

2. The widespread adoption of new technologies offers advantages but also poses risks. Fintech may spur efficiency gains in the financial sector, offer better and more targeted products and services, and deepen financial inclusion in the developing world. However, it may also pose risks if its application undermines competition, trust, monetary policy transmission, and financial stability.

3. What impact might fintech have on the financial sector, and how should regulation respond? This paper lays out key regulatory issues and provides a framework through which to tackle the question. The framework recognizes that technological change is driven by the profit motives of service providers seeking to fulfill unmet needs of users. It emphasizes the role of market imperfections that loom large in finance services. Regulation too plays an important role, both in encouraging technological change, and adapting to continue to meet regulatory objectives. The hope is that this general discussion will continue to guide future work assessing fintech.

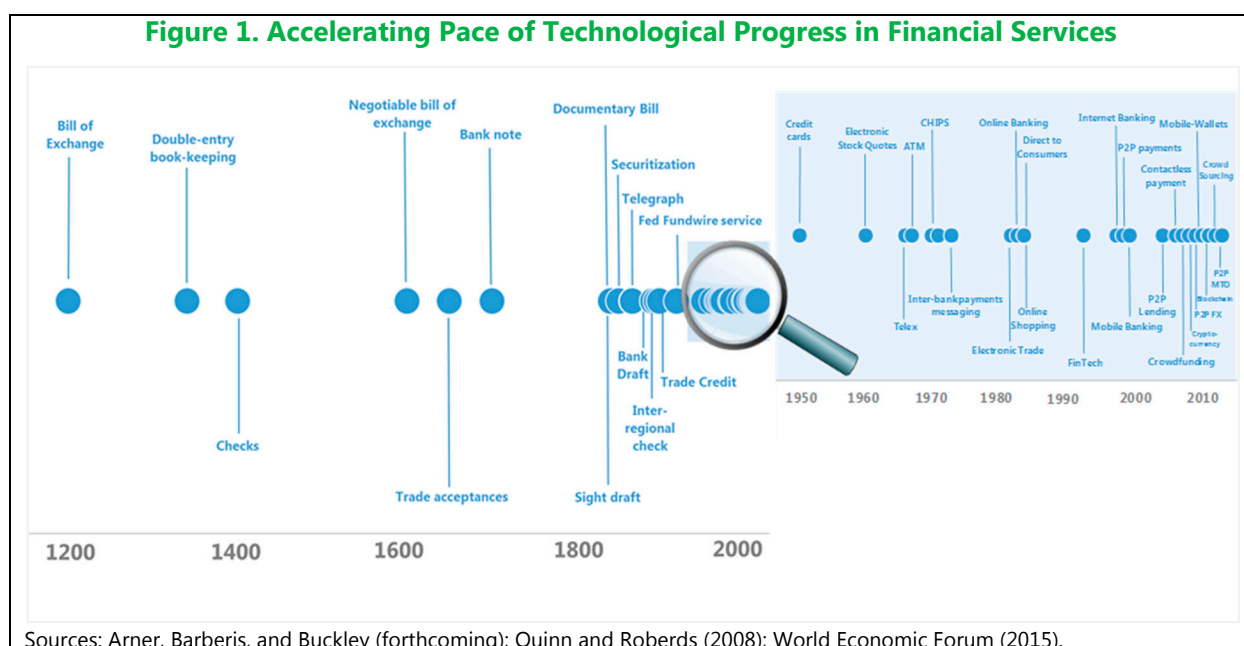
4. The paper focuses on cross-border payments, a topic that lies at the heart of the IMF’s mandate to promote the stability of the international monetary system. The more specific evaluation of cross-border payments will help regulators and central bankers prepare new policy solutions to tomorrow’s challenges. While the paper discusses a broad range of new technologies under development, it places emphasis on distributed ledger technology (DLT) which has the potential to offer important service improvements and cost savings, and may disrupt barriers to entry stemming from economies of scale and network effects characteristic of cross-border payments.

5. The paper is divided into five sections. Section II provides an overview of emerging fintech technologies. Section III sets out a general framework through which to analyze prospects for change in the provision of financial services. Section IV discusses overarching implications for financial regulation arising from fintech innovations. Section V considers how fintech innovation may change the landscape in cross-border payments. The final section offers some conclusions.

EMERGING FINTECH INNOVATIONS

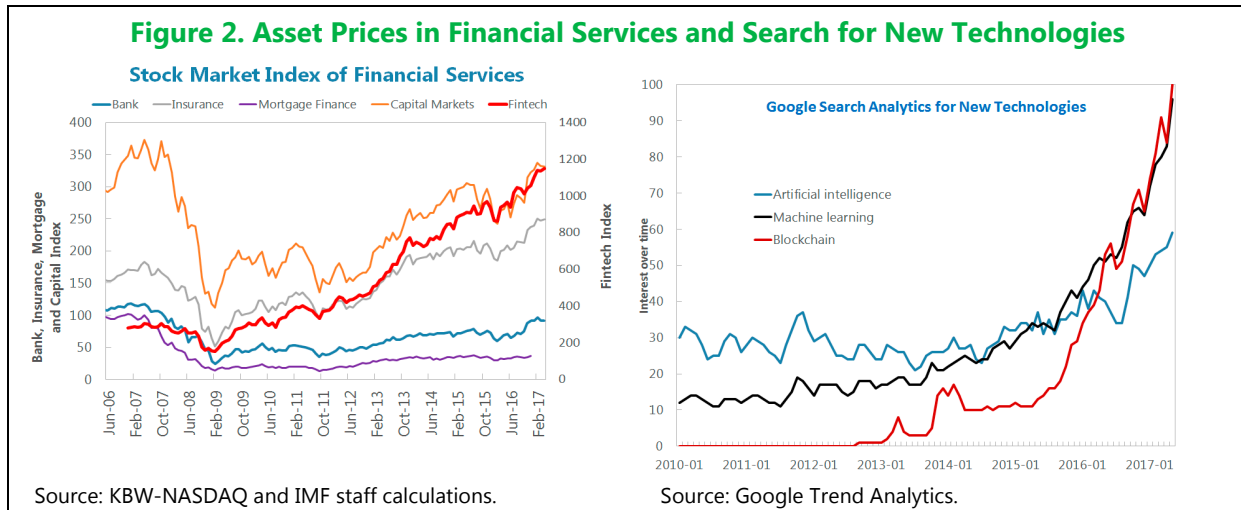
6. For centuries, technological progress has been an important force in the transformation of finance. Innovation in the financial sector has a long history ranging from the development of double-entry book keeping, to the establishment of modern central banks and payments systems, and the more recent introduction of complex asset markets and retail financial products (Figure 1).

7. Change has accelerated in the new millennium. New payment tools have emerged (such as digital wallets), and new service providers have entered the market for financial services (including internet, retail and telecom firms). Recent years have witnessed a rise in automation, specialization, and decentralization, while financial firms have found increasingly efficient and sophisticated ways of leveraging vast quantities of consumer and firm data.



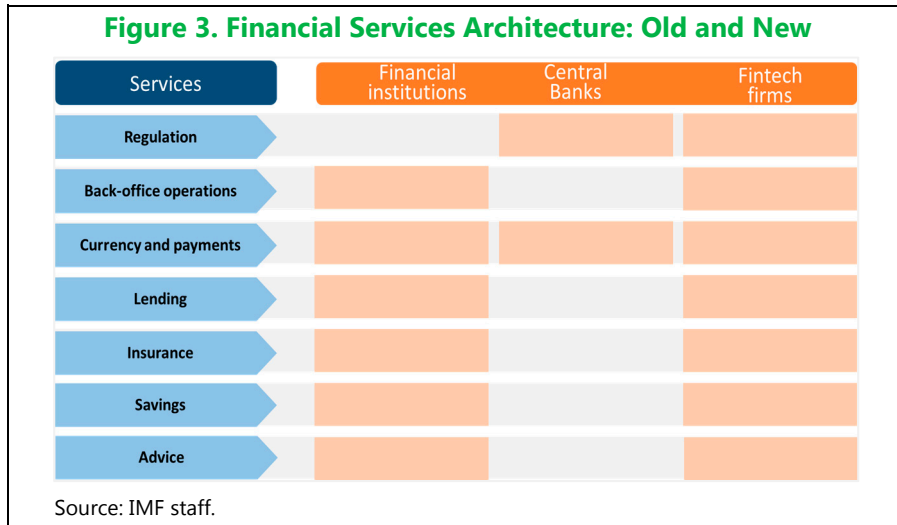
8. Fintech firms have attracted substantial investment in recent years, while public interest has grown significantly. Most firms have remained small—reflecting their knowledge-based business model—but investment in them has risen substantially. Total global investment in fintech companies reportedly increased from US\$9 billion in 2010 to over US\$25 billion in 2016. Venture capital investment has also risen steadily, from US\$0.8 billion in 2010 to US\$13.6 billion in 2016.² Market valuations of public fintech firms have quadrupled since the global financial crisis, outperforming other sectors. Meanwhile, public interest in the sector seems to have grown exponentially (Figure 2).

² KPMG (2017).

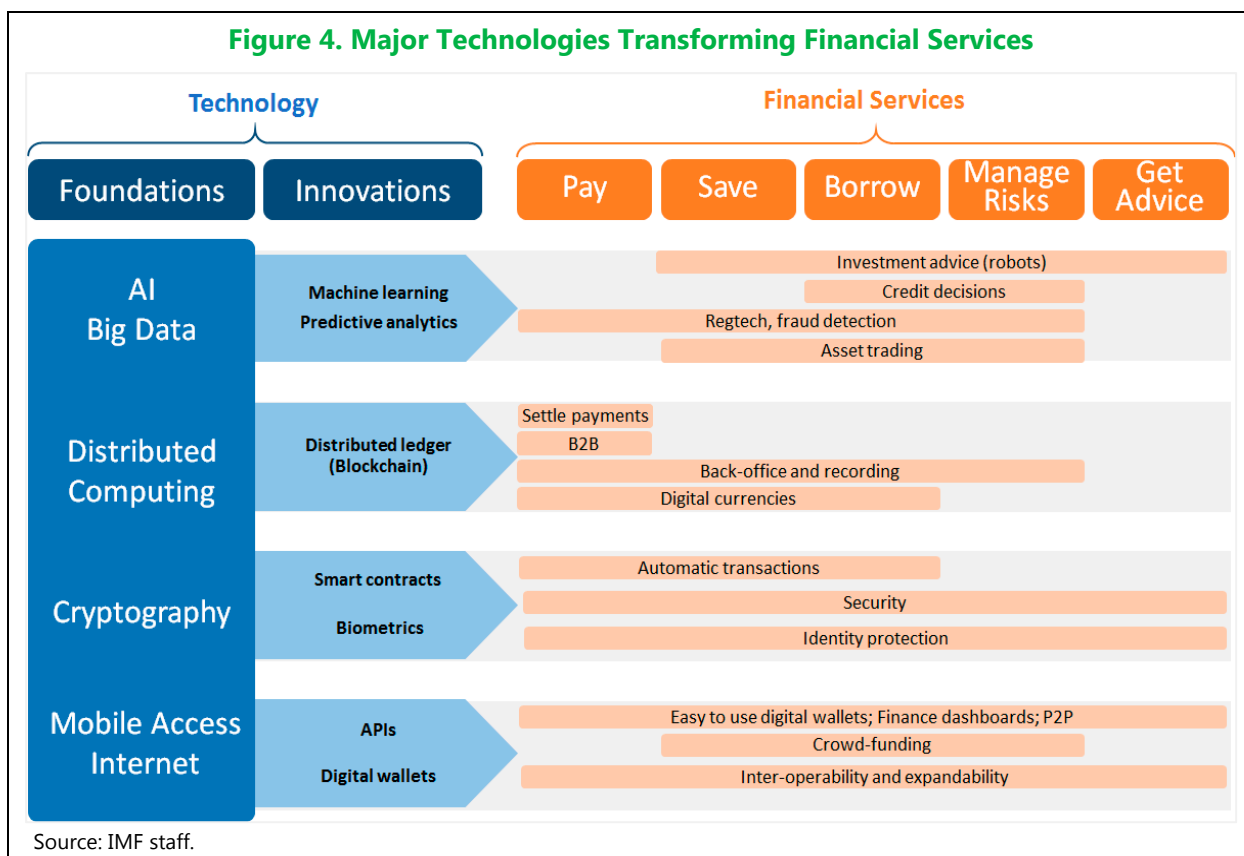


9. Will the impact of current technological progress be evolutionary or revolutionary?

Time will tell, but the potential exists for deep-seated change given the broad reach of fintech. It is conceivable that the full range of services currently offered by banks, central banks, and certain market infrastructures could be at least partly supplanted by new entrants, automated processes, and decentralized networks (Figure 3). The increased competition is forcing incumbents (banks and non-banks) to react by adopting new technologies, improving service offerings, altering business models, and reducing costs.



10. The last decade has witnessed the rapid development of a broad range of technological innovations. As illustrated in Figure 4, these have benefitted from advancements in fundamental technologies, and are giving rise to new applications in all functions of finance, from making payments, to saving, borrowing, managing risks, and getting financial advice.



- Artificial intelligence (AI) and big data** capture the parsing of vast databases containing the characteristics and transactions of billions of economic agents through advanced algorithms to derive patterns used to predict behavior and prices, and in the end mimic human judgement in automated decisions. Related applications can automate credit approvals or advice, facilitate regulatory compliance and fraud detection, and automate the trading of financial assets.
- Distributed computing** has permitted a jump in computing power and stability by linking (or networking) individual computers. Distributed ledgers have recently emerged as a key technology supporting multiple applications (as discussed further below). The potential exists to transform payments and securities settlement as well as back-office functions by substantially cutting costs, allowing direct business-to-business (B2B) transactions bypassing intermediaries, and offering currency substitutes (as discussed in He and others 2016). Applications are also possible outside the financial sector to securely maintain databases including those for land registries, and medical records.
- Developments in cryptography** have facilitated a variety of applications including smart contracts (a set of promises specified in digital form, to be executed following certain procedures and if certain conditions are met—such as selling an asset at a certain price), and have combined with sensing technologies and biometrics to create more robust security systems.

- **Mobile access and the internet** have been transformational, allowing the gains from technological progress to be shared directly with billions of individual consumers whose mobile devices are now portals for accessing a full range of financial services, and can be extended by third parties via Application Programming Interfaces (APIs). This massive decentralization is opening the door to direct person-to-person transactions (P2P), and to the direct funding of firms (crowd-funding). It has profound implications also for financial inclusion by permitting “unbanked” consumers in low income countries to access financial services for the first time.

11. These innovations feed off each other, driving rapid change. Fintech innovations are characteristically overlapping and mutually-reinforcing. For instance, distributed computing relies on big-data as well as AI and cryptography for effective distributed ledgers, used by online applications such as digital wallets to transform cell phones and/or wearable devices into points of sale for payments. These strong complementarities reinforce the potential for disruption of the financial sector. The adoption of new applications could also grow non-linearly, given the network effects (the more people are linked through a network, the more valuable is the network to each member) common to finance, but also to communication technologies.

12. Distributed ledger technology (DLT), in particular, could spur change in the financial sector. The concept of DLT is that ledgers—records of transactions or ownership of assets and liabilities—can be maintained and updated securely (called “validation”) for an entire network of users by users themselves—rather than by a central agency.

13. As DLT can take different forms, its potential as well as challenges will vary accordingly. DLT can be categorized as “permissionless” or “permissioned” depending on who can participate in the consensus-driven validation process. Permissionless DLTs allow anyone to read, transact on, and participate in the validation process. These open schemes (that underlie Bitcoin, for instance) could be very disruptive if successfully implemented. By contrast, in permissioned DLTs, the validation process is controlled by a pre-selected group of participants (“consortium”) or managed by one organization (“fully-private”), and thus serve more as a common communications platform. Some technological hurdles still limit DLT adoption. To date, scalability of DLT networks is not fully demonstrated, especially to process a volume of transactions characteristic of large, liquid markets. In addition, DLT networks are still not perfectly interoperable. Finally, privacy protection, as well as operating costs, speed, and transparency still need to be improved.

THE ORGANIZATION OF FINANCIAL SERVICES—A GENERAL FRAMEWORK

14. An economic framework helps assess the impact fintech might have on the financial sector, and how regulation should respond. The financial sector covers five broad functions. These are to (i) make and receive payments, including across borders; (ii) save to be able to consume or invest later; (iii) borrow to be able to consume or invest now; (iv) manage risks to

income, savings, and transactions; and (v) receive advice on all the above. As discussed, this paper will focus on the cross-border aspect of payments.

15. Whatever the function, technology can impact the attributes—for instance, speed, security, transparency—of new services, as well as the organization of service providers—termed market structure. Both attributes and market structure are closely related, though do not necessarily go hand in hand (a new service does not necessarily imply a new firm and vice versa). And, importantly for this paper’s main question, each can have independent effects on regulation. For instance, virtual currencies might pose challenges for regulatory compliance. Or services provided by decentralized markets (such as peer-to-peer lending) as opposed to intermediaries might require a change of regulation to bolster financial stability. Thus, effects of technology on service attributes and market structure can be discussed, if not analyzed, separately.

16. Technological progress can promote the development and adoption of new services especially when targeted at unmet user needs—what this paper calls “shortcomings” of services (Box 1). The bigger the shortcoming, the greater the incentive for firms to improve services as permitted by technological advances, and the faster users’ adoption of such services. For instance, as will become evident later, cross-border payments are slow, opaque, and expensive relative to user expectations, in part due to technological limits. New technologies therefore promise substantial gains to providers and users of services. Appendix I offers further details.

Box 1. Technology and Service Attributes

Different groups of users have different preferences for specific attributes (or combination of attributes) of services (what the industrial organization literature refers to as “product differentiation,” a concept dating back to Chamberlin 1933; see also Eaton and Lipsey 1989). For instance, some will prefer safe and transparent financial services, while others will seek speed and usability.

However, users may not be satisfied with the combination of attributes and prices they have at their disposal. In those cases, improving the attributes of services would induce a jump in demand (users will either be willing to pay more for the new service, or consume more of it at unchanged prices). If so, existing services are said to have “shortcomings” (Appendix I).

Why do firms not seek to address shortcomings perceived by consumers when that would increase their profits? From the standpoint of firms, shortcomings are opportunities. There are three possible answers: technology, regulation, and market structure. Technology could physically limit the quality of services; speed, for instance, may be limited by bandwidth. Regulation could constrain the attributes of services; inter-state banking laws in the United States, for instance, limited the convenience of one-stop-shop banking services. And market structure can also impact the supply of services; a monopolist, for instance, will tend to provide more expensive and lower quality services. Clearly, the factors are not independent, as technology also impacts market structure, which in turn affects the incentives (potential gains) to advance technology.

17. Technology can also affect the market structure of service providers. Will new technologies merely increase profits and efficiency of established players, or have deeper repercussions? Specifically, will they (i) reduce the need for financial intermediaries (specialized financial firms, banks and non-banks alike, that facilitate transactions between two or more parties);

(ii) push intermediaries to change their internal structures (possibly leading to partnerships and acquisitions); or (iii) induce the entry of new intermediaries while displacing older ones?

18. Technology may affect the factors shaping intermediaries. The industrial organization (IO) literature provides useful guidance (details are provided in Box 2). Technology can alter the market imperfections pervasive across the financial system, which underpin the need for trusted intermediaries. It can reduce asymmetric information (limited knowledge of one's counterparties to a transaction), facilitate the matching of parties to a transaction, and reduce transaction costs. Technology can also affect the incentives for intermediaries to be horizontally or vertically integrated (offer multiple services to end-users, as does a universal bank, or acquire upstream suppliers). Finally, technology can alter barriers to entry for new intermediaries to compete against incumbents.

Box 2. Technology and Market Structure

Intermediaries exist because of market imperfections. Three sources of imperfections are relevant:

- *Information asymmetries.* Intermediaries offer information on transaction counterparties, as well as monitoring, and enforcement services, and share costs of doing so over their many users. This helps minimize problems of moral hazard and adverse selection. Trust in intermediaries is therefore essential.
- *Matching asymmetries.* In financial markets, investment opportunities are often indivisible (need to be funded in their entirety to pay off). Individual savers, instead, may not be able to, nor want to, take on a few large exposures. By pooling their savings into intermediaries, however, each can manage his or her exposure to a given investment project. Similarly, pooling allows savers to make more liquid and shorter-term investments than are available.³
- *Transaction costs.* Transactions can be complex and costly, and require specialized knowledge of operational, technological, and legal issues.

Intermediaries can be horizontally or vertically integrated. Horizontal integration comes from economies of scope—namely the ability to leverage fixed resources or intangible assets, such as information on users' payment patterns, for the provision of multiple services. Vertical integration arises from the strategic advantage of controlling, as opposed to monitoring, upstream activity, or relying on core competencies to compete in upstream segments.⁴

Finally, new intermediaries will need to overcome barriers to entry—what has been termed market contestability.⁵ There are two broad determinants of contestability: constraints external to the firm, such as regulation, and economic barriers to entry. The latter arise from three sources. The first is economies of scale—the extent to which average costs decline with output, and thus give an advantage to incumbents. In the financial sector, fixed costs of producing and distributing services, as well as complying with regulation, are a common source of economies of scale. Second, sunk costs needed for operation—such as marketing expenses to build brand value and trust—can also deter entry. Finally, network externalities are pervasive

³ To the extent that the liquidity needs of individual savers are randomly distributed and independent of one another, intermediaries can keep only small reserves of liquid funds, and the interest rate risk of longer-term investments can be hedged across projects of different maturities. Both are applications of the law of large numbers. See, for instance, Genberg (2008).

⁴ Appendix I provides a richer discussion of the relevant literature.

⁵ See McAfee and others (2004) and Sutton (2007).

especially in payment systems. The more users participate in an exclusive network, the more the network is valuable to each user, and thus the harder it is for new entrants to compete.

Technological innovations can affect any of the above determinants of market structure. For instance, technology can undermine the need for intermediaries by lowering asymmetric information (automated credit scoring), or transaction costs (online payments), or allowing for a more efficient matching of savers and borrowers (peer-to-peer lending platforms, or crowd-sourcing). Technology could also lower barriers to entry by decreasing fixed costs of operation (back-office automation), or lowering network externalities (inter-network operability). Finally, the degree of horizontal and vertical integration will change if technology affects economies of scope (social media platforms could cross sell financial services based on their knowledge of user behavior), or the incentives to control upstream production (by commoditizing certain functions, such as compliance verification).⁶

TECHNOLOGY, REGULATION, AND FINANCIAL STABILITY

19. The question arises: what impact might technology have on the financial sector, and how should regulation respond? Technology and regulation closely interact. As technology alters financial service attributes and market structure, financial regulation must adapt to remain effective. In turn, regulation has an important influence on the development of technology. Neither technology nor regulation is exogenous (Kane 1987 and Kane 1988). This section discusses both directions of causality: first, how should regulation respond to the challenges brought by fintech, and second, how could regulation affect the development of fintech? See also FSB (2017) for a discussion of similar issues.

20. To start with, why regulate the financial sector? Financial regulation seeks to address vulnerabilities and imperfections in financial markets that weaken financial stability, undermine market efficiency, and expose consumers to risks (Joskow and Noll, 1981 and Brunnermeier and others 2009). Financial regulation should: (i) *provide incentives* for institutions to take into account systemic risk; (ii) *protect consumers* where information is hard or costly to obtain; and (iii) *support competition* and prevent oligopolistic behavior. In pursuing these objectives, regulation should be proportional to the contribution of entities and activities to systemic risk. Also, the boundary for regulation should be flexible and enable regulatory arbitrage between the unregulated and regulated perimeter to be monitored and adjusted to ensure that systemic risks are contained and the goals of regulation are sustained.

21. Financial regulation helps support trust in the financial system (Box 3). Finance involves creating added value through transferring assets and claims among entities (e.g., payer and payee) as well as over time (e.g., lending and borrowing). It requires trust among all entities involved, and toward the asset being transferred. A lack of trust in financial intermediaries and processes can hamper the functioning of financial markets. Technological change will not eliminate the need for

⁶ See Mori (2017) for different stylized scenarios of potential future market structure resulting from some of these changes.

trust but may induce market participants to look for it elsewhere, beyond traditional intermediaries like banks. In the future, networks and new types of service providers will need to find ways to gain the trust of users. Effective regulation will have a critical role to play in this process.

Box 3. The Role of Regulation in Supporting Trust in the Financial System

Finance involves creating value by transferring assets and claims among entities (e.g., payer and payee) as well as over time. Doing so requires trust among the entities, and toward the asset being transferred.

Trust is defined as “a meaningful expectation as to the future conduct of a person, an organization or as to the functionality of a system” (de Larosière 2009). Trust thus reduces uncertainty. It also reduces transaction costs by diminishing the need for costly legal and operational safeguards. Finally, trust mitigates risks arising from complexity.

How can trust be established and maintained? Legal certainty is key, as provided by a clear and predictable legal framework, both in the context of public law (namely regulation) and private law (contractual and property law). To some extent, trust also stems from private information (such as a long-term professional relationship), and a public track record (as in well-functioning payments infrastructure).

Finally, regulation plays a central role in establishing trust. The regulation of market participants ensures that their financial position is sound and accurately represented, and meets prudential standards, and that governance and management of risks meet regulatory requirements. Regulation may also signal the resilience of counterparties, markets, and infrastructure.

22. Emerging technologies could raise financial stability risks. The development of financial services outside the boundaries of the supervisory and regulatory framework may lead to the emergence of new risks. Emerging technologies may also significantly accelerate the speed and volume of financial transactions, although it is not clear whether this would promote financial stability through more efficient price discovery, or lead to greater volatility and instability. Greater reliance on automated transactions could potentially increase market volatility due to higher asset price correlations. The wider adoption of certain algorithms and technological solutions may increase vulnerabilities to cyberattack. It may also increase concentration risk on key nodes within the global system as market structures adjust and network interconnections strengthen. Finally, to the extent that services are increasingly offered by specialized firms along the payments chain, as opposed to large, vertically integrated intermediaries, there may be fewer controls for the processing of data, and the management of risks.

23. As market structure changes, regulation may need to complement its focus on entities with increasing attention to activities. Financial regulation has been traditionally based on the regulation of (i) types of entities or intermediaries; and/or (ii) types of activities. Licensing regimes will need to be redesigned to bring new types of service providers within the regulatory perimeter where appropriate. More fundamentally, the “unbundling” and migration of services from intermediaries to networks may require regulators to rely less on entity-based regulation and more on activity-based regulation.

24. Regulation has already begun to evolve. This has particularly been the case in the enforcement of AML/CFT requirements on the use of virtual currencies where the financial

institutions (e.g., banks and money transmitters) that typically conduct customer due diligence (CDD) and know your customer (KYC) procedures are not involved.⁷ The Financial Action Task Force (FATF) has therefore issued specific guidance that calls on countries to impose these CDD obligations and other AML/CFT preventive measures on new types of virtual currency service providers—primarily virtual currency exchanges—by clarifying that they are “financial institutions” under the FATF standard. This focus on exchanges may be effective for now as most users will, at some point, have to buy or sell virtual currency for fiat currency. But it may need to be revisited if virtual currencies become so widely used that conversion may no longer be necessary.⁸

25. Oversight and regulation of algorithms underlying fintech innovations may be needed to build confidence in the systems that rely on them. Regulators will need to ensure that algorithms are designed and operate in a manner that does not expose consumers or the financial system to undue risk. Self-governance, including standards enforced by the network itself, may provide some assurances, especially where the governance framework is transparent and subject to the scrutiny of interested stakeholders. However, there are inherent limitations with self-governance, and oversight and regulation may be necessary.⁹ But effective regulation that would allow the authorities to verify the robustness of the underlying technologies (e.g., the Basel approach for banks’ internal risk models) would require a significant commitment of public resources to build the necessary expertise within the regulatory community.¹⁰ It is not clear whether this would be possible.

26. Emerging technologies that distribute information across networks, like DLT, raise questions about the right balance between privacy and transparency. Users of a financial service need to ensure that the privacy of their information is protected. Privacy is therefore an important element of trust in a service, but transparency is also needed to reduce transaction costs, and to give regulators the information they need to conduct supervision.¹¹ Existing legal frameworks protect data from disclosure as well as ensure access to necessary financial information by imposing obligations on intermediaries holding the data. This approach is difficult to take when the data is held within an open network, lacking a “data controller.” Moreover, ledger immutability that is characteristic of some DLTs may be at odds with a person’s right to rectify or erase personal data.

⁷ Given their pseudo-anonymous nature where the identities of participants in a transaction are not known, cryptocurrencies do give rise to significant money-laundering and terrorist-financing risks.

⁸ Indeed, the European Commission is considering imposing CDD obligations not only on virtual currency exchanges but certain types of wallet service providers as well.

⁹ Regulation can play a role in increasing the accountability and transparency of algorithms. For example, the EU General Data Protection Regulation (GDPR) will require certain information regarding the logic of the algorithm to be provided to the data subject.

¹⁰ Considering these challenges, lessons may be drawn from the regulatory approach taken in the field of algorithmic trading, focusing on adequate internal governance and controls e.g., the European Union Markets in Financial Instruments Directive (MiFID) II; U.S. NASD, and Financial Industry Regulatory Authority, Inc. rules.

¹¹ For example, under the FATF standards countries are required to ensure that secrecy laws do not inhibit AML/CFT implementation, while under the OECD Guidelines Governing the Protection of Privacy, personal data may be used for purposes other than those for which they were initially collected “by the authority of the law.”

27. DLT “designs” have implications for privacy. Permissionless networks are generally “pseudo-anonymous,” as the identity of transacting parties is not revealed, but the details of the transaction are known. In permissioned networks, information on transacting parties, or on the details of transactions, may or may not be revealed to all participants in the network. New technologies are allowing a greater level of control in the design of DLT networks. Encryption technologies, such as zero-knowledge protocol, can allow identity verification and transaction processing without revealing any information. Other technologies could enable “selective disclosures” by users to trusted parties (such as supervisors).

28. New technologies may require jurisdictions to revise rules governing ownership and contractual rights and obligations. DLT records the transfer of ownership of “digital tokens,” which are essentially units in a ledger. They can either have intrinsic value themselves (an “intrinsic token” like Bitcoin), or be digital representations of a physical or digital asset that exists outside the ledger (an “asset-based token” representing an interest in another asset such as securities). The legal status of a digital token, and the legal effect of its transfer are not clear. For example, would the transfer of an asset-backed token (e.g., representing a security) on a ledger transfer legal ownership of the security or would registration outside the ledger (e.g., in a corporate share registry) still be required? Jurisdictions are trying to develop answers to these questions but country practice varies. The resolution of these questions is crucial for the economy to function and will require more thought by policymakers.

29. The use of DLT in payments systems also raises questions about settlement finality. To ensure legal certainty, jurisdictions have enacted legislation that prohibits the reversal of payments that are deemed to have been completed by the payment systems’ rules (CPSS 2005). These rules have worked well in traditional domestic and cross-border payments systems but may not in a distributed network based on technologies that provide only probabilistic finality (rather than settlement finality at a definitive point in time).¹² Even for distributed networks not based on such technologies, existing rules may not be effectively applied. These problems will need to be resolved through legislative change or, as a second best, contractual and general legal principles.

30. In developing regulatory approaches for fintech innovations, some jurisdictions are putting in place “regulatory sandboxes.” Sandboxes allow firms to test new technologies and business models in a controlled environment, and enable regulators to address the potential risks of new technologies without stifling innovation (Appendix IV). A regulatory sandbox provides valuable insights to policymakers in understanding new technologies and their applications but is not a substitute for effective, permanent regulatory frameworks that will eventually need to be put in place.

¹² In such systems, the legal certainty of a payment being final builds progressively as more blocks are added to the chain until the probability that a given transaction will be undone becomes infinitely small. For example, in the case of Bitcoin blockchain, a new block is added approximately every 10 minutes. In contrast, permissioned blockchains would not necessarily face such constraints.

31. Emerging technologies themselves could facilitate regulatory compliance (“Regtech”) and reduce compliance costs. The financial industry is exploring the use of new technologies to: automate manual processes (e.g., artificial intelligence); aggregate, share and store data (e.g., cloud-computing, DLT); enhance security (e.g., cryptography); identify suspicious transactions (e.g., biometrics, big data) and facilitate regulator-bank interactions (e.g., APIs) (Appendix V). Excessive or indiscriminate reliance on Regtech solutions may, however, create new problems and could potentially cause system wide disruptions. For example, if multiple financial institutions rely on a single firm providing such solutions or on a single regulator to aggregate the data, this entity could be subject to a cyberattack or a malfunctioning of the underlying technology. Further analysis and assessment may be needed for these technologies to be used for regulatory compliance.

32. As new technologies operate seamlessly across borders, international cooperation is essential to ensure effective regulation. At present, there is little consistency in regulatory approaches across jurisdictions. This may undermine regulation at the national level and create incentives for regulatory arbitrage. Greater harmonization between national regulatory frameworks would help level the playing field and facilitate the adoption of these technologies on a global scale.

33. Efforts are already underway to strengthen cross-border cooperation and harmonization. Bilaterally, some national regulators have put in place cooperative arrangements to promote innovation and share information about innovative financial services.¹³ At the multilateral level, international standard setters such as the International Organization of Securities Commissions, Basel Committee on Banking Supervision and Committee on Payments and Market Infrastructures as well as the FSB, are monitoring and studying the implications of technological change for financial stability, market integrity, efficiency, and investor protection, while others such as FATF, as noted above, have already issued guidance.¹⁴

IMPLICATIONS OF FINTECH FOR CROSS-BORDER PAYMENTS

34. The area of cross-border payments is especially ripe for change, and could benefit from new technologies. Services exhibit significant shortcomings, as illustrated in the first part of this section. These stem in part from technological limits, and in part from a highly concentrated market structure, itself also a function of technology. What might the future hold, then? The second

¹³ For example, the Australian Securities and Investment Commission has signed agreements with the U.K. Financial Conduct Authority (FCA), the Monetary Authority of Singapore (MAS), the Ontario Securities Commission (OSC) in Canada, and the Kenyan Capital Markets Authority (CMA).

¹⁴ For example, IOSCO Research Report on Financial Technologies (fintech) February 2017; CPMI report on Distributed Ledger Technology in Payment, Clearing and Settlement: An Analytical Framework, CPMI, February 2017; The Financial Stability Board (FSB) is also currently working on the topic.

part of this section looks toward different scenarios of technology adoption—principally based on DLT—and considers the implications for service attributes, market structure, and regulation.

35. The fact that cross-border payments are considered a separate area of payments—and a very large one—may be surprising.¹⁵ This section emphasizes that cross-border payments are inherently different from domestic payments. In a nutshell, the latter are settled in standard ways by the domestic banks and the central bank, while the former require ad-hoc arrangements, often between commercial banks.

36. The future could be different, as suggested by a simple analogy. Before the internet, sending (snail) mail domestically was fundamentally different from sending mail internationally. Pricing was significantly different, the infrastructure was different (air as opposed to land transport—thus the ubiquitous “air mail” stamp), and the handling of cross-border mail required international agreements on payment sharing, and standards on packaging, tracking and handling, as well as addressing other matters. In the age of the internet, instead, there is no distinction between a message going to a domestic or foreign recipient; both take a click. A message is a message; might a payment just be a payment in the future?

A. The Current Landscape of Cross-Border Payments

37. This subsection offers a sketch of the services and market structure characteristic of cross-border payments as they exist today. Appendix II goes into more depth, and provides a description of different types of cross-border payments at the level of transactions.

Demand and Supply

38. Though varied, users of cross-border payments seek similar attributes. Users range from households, to small and medium enterprises (SMEs), and large corporates. They aim to send remittances, make payments while abroad, and pay for foreign goods and services. Transactions can be infrequent and small in value (more typical of households), as well as frequent and large (more typical of corporates).¹⁶ When making cross-border payments, different types of users place special emphasis on low-cost, security, convenience, predictability, and transparency—the assurance that intermediaries will preserve the confidentiality of information.¹⁷

¹⁵ Cross-border payments accounted for 40 percent of global payments revenues, and generated US\$300 billion in global revenues in 2015. Business-to-business payments totaled US\$240 billion in revenue on US\$135 trillion in flows. The average transaction value was of US\$15,000 to US\$20,000, and the typical fee about US\$30 to US\$40 per transaction as per Niederkorn and others (2016).

¹⁶ Financial firms engaged in wholesale foreign exchange transactions are purposefully left out of the analysis given their very different operations (though Appendix II offers some details).

¹⁷ Clearly, attributes sought by users may change over time. New decentralized and global models of production as initiated by Airbnb, for instance, are increasingly pushing large corporates to make small-value cross-border payments, as opposed to lumpy, large-value payments.

39. As payments make their way from sender to recipient, they are handled by multiple firms in four market segments, corresponding to different core functions of the payments chain. These are illustrated in Appendix II. *Capturing* involves interfacing directly with users, as typically done by banks as well as money transfers operators (MTOs), and increasingly—in the remittance space—telecommunications and other digital companies. *Messaging* involves handling payment instructions, often done independently of actual transactions. *Settlement* typically involves two legs: first, the transfer of money from bank to bank within a jurisdiction most often in reserves held at the central bank (“domestic settlement”); and second the transfer of funds across-borders, commonly by correspondent banks that hold accounts with one another (“cross-border settlement”). Finally, *disbursing* entails interfacing again with clients, though on the receiving end.

40. Importantly, these transactions all pertain to “account-based” payment systems; in contrast to “token-based” systems (or “store-of-value” systems). Kahn and Roberds (2009) first introduced this important distinction. Account-based systems involve the transfer of a claim on a payments object recorded in an account maintained with an intermediary. Checks, and credit cards, for instance, are account-based means of payments. As such, they require that the identities of account holders be verified, in a costly process requiring regulation, standards, infrastructure, and intermediaries.

41. Token-based systems simply involve the transfer of a payments object (such as a commodity or fiat currency). As long as the value or authenticity of the payment object (a paper currency note, for instance) can be verified, the transaction can go through independently of trust in, or knowledge of, counterparties,¹⁸ with little infrastructure, and without distinction between messaging, clearing, and settlement. To date, though, token-based systems typically entail high-transaction costs and involve risks related to moving cash (or other payment objects). As discussed later, DLT-based transactions favor token- as opposed to account-based, systems.

Shortcomings of Cross-border Payments

42. Shortcomings of cross-border payment services are substantial. Cross-border transfers are costly, and cumbersome.¹⁹ Moreover, services are opaque; the price paid for cross-border payments is not transparent, nor known at the time of initiating the transaction in most cases. Finally, sending money across borders is slow. Payments can be routed through many banks before they reach their destination causing delays and incurring fees. Settlement times for cross-border payments can take up to five days for the most common currency pairings.

¹⁸ Indeed, when there is little trust in counterparties, cash is the preferred means of payment. This is the case on “Craigslis,” for instance, the popular U.S.-based used goods transactions platform, wherein cash is the *only* accepted means of payment.

¹⁹ Sending a remittance costs an average of 7.5 percent of the amount sent (13 percent by bank wire-transfer), while almost one-third of transactions take two or more days to be processed. See World Bank (2016).

43. These shortcomings arise from technology, regulation, and market structure. The fixed costs of compliance are high. In addition, bilateral relationships require banks to hold idle liquidity and incur FX exposures (Appendix II). Manual and personalized payment operations, including the processing of claims and disputes by the back office further add to these costs. Finally, as highlighted further below, the significant market power of correspondent banks and capturing firms allows them to extract revenue through direct fees, FX spreads, and delays while liquidity is invested (called “float”).²⁰

Market Structure

44. To date, cross-border payments require intermediaries. Individuals have lacked the technology to transfer funds directly, and are subject to information asymmetries. Intermediaries address these challenges. They have the specialized know-how, and can verify the identities of parties to a transaction, and the availability of funds.

45. Existing intermediaries benefit from high barriers to entry; each segment of the payments chain remains highly concentrated. In many cases, barriers stem from high fixed and sunk costs required to interface with users, comply with regulation, build trust in services, and operate large back-offices in the case of correspondent banks. In addition, size matters for these institutions to manage liquidity and counterparty risk. Finally, network externalities are prevalent in messaging, but also in settlement where netting bilateral positions lowers costs, and access to multiple counterparties facilitates transactions. Box 4 offers further details.

46. The degree of vertical and horizontal integration varies across segments. Horizontal integration is systematic only among correspondent banks, due to the cost advantages of offering services across multiple currencies, jurisdictions, and recipients, and of leveraging back-offices and compliance departments to engage in other types of activities including securities clearing and settlement, international credit provision, and trade financing. Some vertical integration exists across segments to the extent that most capturing agents undertake their own compliance verification.

²⁰ Niederkorn and others (2016) estimates that costs of an average cross-border transaction can be broken down into: compliance (13 percent), trapped liquidity (34 percent), foreign exchange risk management (15 percent), and claims, treasury and other operations (38 percent).

Box 4. Market Structure of Cross-Border Payments

In the capturing segment, concentration results from substantial fixed and sunk costs. Fixed costs relate to the establishment of physical branches (for banks) or point of sale contacts, and in some cases the need to handle physical cash. All service providers incur significant sunk costs to comply with regulations, and build trust for their services. At present, MTOs continue to dominate the retail space, even in the area of digital transactions.

In the messaging segment, concentration is the result of network effects. These stem from networks being privately run and not interoperable. SWIFT is the primary messaging network for bank-to-bank payments, and is used by 11,000 institutions in 200 countries, sending more than 25 million messages per day.

In the domestic settlement segment, concentration results from the key role played by central banks. Centralized clearing and settlement requires high sunk costs to establish the necessary infrastructure, and fixed costs for maintenance and monitoring. Network externalities are also very high. The more participants, the easier to settle and net payments. Finally, central banks offer services that others cannot, namely minimal credit risk, payment finality, and liquidity provision.

The cross-border settlement segment is highly concentrated, involving few, large correspondent banks²¹. The first reason is size: only banks with very large balance sheets have the trust necessary to take on credit risk stemming from large value international payments, and the balance sheet space needed to maintain liquidity in foreign accounts. The second reason is fixed costs of large compliance departments, as well as back-office operations needed to process claims and disputes (often manually), and reconcile payment instructions. The third reason relates to network externalities. Client banks are more likely to work with banks that are closely linked to multiple other banks, jurisdictions, and currencies.

B. Possible Evolution of Cross-Border Payments

47. Against this background, how could fintech innovations reshape the cross-border payments landscape? To what extent might new technologies reduce service shortcomings, and alter market structure by favoring market platforms over intermediaries, reshaping business plans and firm boundaries, or encouraging entry? And how should regulation respond? While one can only speculate, to some degree, on potential outcomes, much will depend on the scenario for technology adoption.

48. Three scenarios could be considered, each centered on DLT-based applications. In increasing order of potential disruption, applications might target the areas of: (i) back-end processes; (ii) compliance; and (iii) means of payment. Resulting changes to service attributes and market structure are summarized in Figure 5, and discussed further below, along with implications for regulation.

²¹ The ECB, for instance, in its latest review of correspondent banking, describes the segment's concentration ratio as "typical of an oligopoly" (ECB 2015). The study offers a detailed account of various concentration indices across the sector.

Figure 5. Future of Cross-Border Payments: Three Scenarios

Technological Innovation	Capturing/Disbursing	Messaging	Settlement	Potential New Attributes of Services
Back-end processes (DLT) Compliance (DLT, Big Data, AI, biometrics) Means of payment (DLT) Hub-and-spoke networks Central bank digital currency (CBDC) Increasing level of potential disruption	<ul style="list-style-type: none"> Better payments tracking SWIFT can also implement <ul style="list-style-type: none"> Easier info sharing and lower compliance costs Easier entry in remittance market (lower sunk costs) but sunk costs to build trust remain New compliance-focused entrants become partners <ul style="list-style-type: none"> Wallet into virtual currency (VC), then peer-to-peer transfer New entrants able to connect to VC network Strong competition on all other players Unless limited web access <ul style="list-style-type: none"> Wallet into CBDC, then peer-to-peer transfer New entrants able to connect to CBDC Strong competition on all other players 	<ul style="list-style-type: none"> No independent messaging needed Potential displacement of existing players <ul style="list-style-type: none"> Same as above 	<ul style="list-style-type: none"> Automated info sharing & risk management Partnerships with DLT firms; replacement of legacy systems Easier entry in correspondent banking (lower scale economies/ fixed costs) But size still matters (liquidity and credit risk) Barriers to entry from private/permissioned DLT <ul style="list-style-type: none"> Lower compliance costs Easier entry in correspondent banking But size still matters (liquidity and credit risk) <ul style="list-style-type: none"> No additional cross border clearing and settlement needed Potential displacement of existing correspondent banks <ul style="list-style-type: none"> Same as above Even domestic settlement potentially redundant (though probably still used for large value payments) 	<ul style="list-style-type: none"> More transparent/traceable payments Better invoice reconciliation Cheaper (but correspondent banking may remain oligopolistic) <ul style="list-style-type: none"> Cheaper Greater financial inclusion Lower switching costs Potentially more control over use of personal information Privacy and security issues <ul style="list-style-type: none"> Faster More traceable Easier to use Cheaper (but possible network externality) Greater financial inclusion But wallet, FX, tech risks <ul style="list-style-type: none"> Same as above, But cheaper (no rents from network externality), Lower FX & tech risks than above

Source: IMF staff.

Back-end Processes

49. DLT could be applied to various processes in cross-border payments. Various initiatives are underway. For example, with its global payments innovation initiative, SWIFT is aiming at using DLT to improve the speed, transparency, and end-to-end tracking of cross-border payments, including reconciliation with invoices. Correspondent banks could also participate in a shared permissioned DLT platform to automate the tracking of payments, and to optimize liquidity and risk management. In such a scenario, regulators will need to be satisfied that the underlying technologies would be sufficiently robust so as not to increase operational risk.

50. Gains would be most evident in efficiency, with little impact on market structure. In theory, lower fixed back-office costs would diminish economies of scale, spurring new entry possibly by new types of service providers. However, many of the other barriers to entry to correspondent banking would remain.

51. End-users may still benefit. Payments settled through correspondent banks would become more transparent and traceable. In addition, costs of invoice reconciliation would be reduced,

especially if third-party software providers could tap a DLT-based messaging system through APIs. However, the impact on speed and costs for the end-user is unclear. Correspondent banks may remain oligopolistic and thus unlikely to pass-on cost savings.

Compliance

52. DLT, when combined with other technologies, has the potential to significantly lower the cost of compliance. In particular, know-your-customer (KYC) utilities and digital identity can facilitate information sharing and help reduce the cost of compliance, including with respect to AML/CFT regulation and sanctions-related controls. DLT could be used to create and maintain registries of standardized customer information, along with their digital identities, which could facilitate access to, and sharing of, customer information. In this case, DLT would be complemented by other technologies such as biometrics and artificial intelligence. However, the use of new technologies in the field of compliance may be limited by broader issues, including the extent to which regulation would allow financial institutions to outsource customer due diligence.

53. Market structure would not be left unscathed. New entrants, focused on DLT-based compliance solutions might be expected to collaborate with incumbents in the capturing, disbursing and settlement segments. Entry would be easier, especially in the capturing and disbursing segments. Digital identities could allow end-users to switch more easily between service providers, thereby reducing the economies of scope extracted by intermediaries from proprietary information on customer profiles. Such a development would depend on the willingness of existing service providers to share such information, unless they are required to do so by regulation.²² To the extent cross-border payments continue to be mostly settled through correspondent banks, though, size would remain an important barrier to entry.

54. New compliance technologies could benefit end-users, but privacy and security issues may arise. Services would likely become cheaper, and more inclusive. However, DLT-based applications for compliance could raise concerns over privacy and the security of personal information maintained on the ledger, unless participation in the relevant network is limited to trusted counterparties, or technologies are used to limit the available information on the ledger (e.g., restrictive disclosure). In addition, the security of digital identities will be an important issue to address (e.g., if a digital identity were stolen and misused by a third party). Further, authorities will need to ensure that regulatory compliance is not hampered by new technologies and reliance on third parties.

Means of Payment

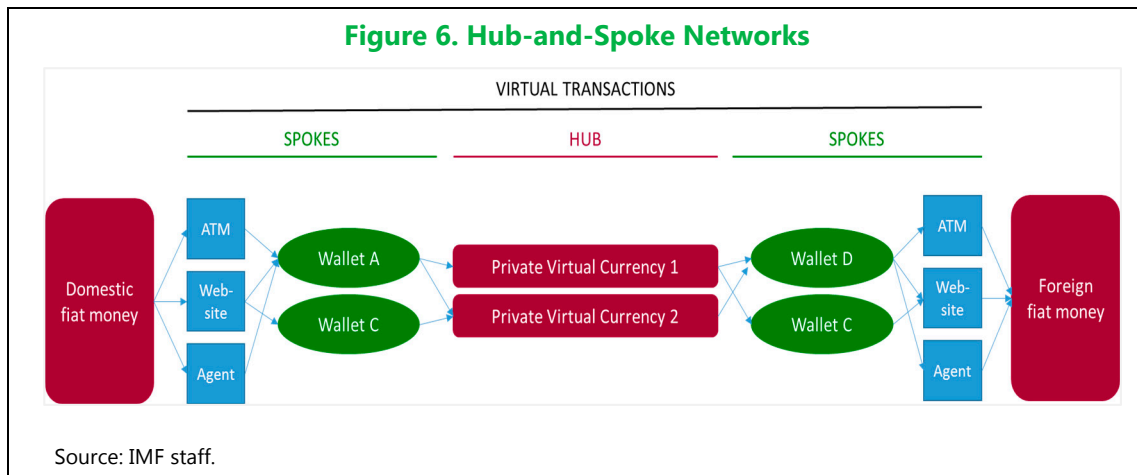
55. DLT can be used to underpin an entirely new means of payment. This is already happening with the emergence of virtual currencies.²³ These means of payment are tokens that are

²² For example, this is the case of the EU's Second Payment Services Directive (PSD2).

²³ Bitcoin is perhaps the most well-known, but many other examples exist, each based on its own specific underlying technology.

exchanged electronically between market participants (individuals or firms), much like cash, over a permissionless (open) or permissioned (fully private or consortium) DLT-based network. The use of these systems effectively shifts payments from accounts-based systems to token-based systems.

56. Two applications of DLT as a means of payment are relevant for cross-border payments; the first involves a privately run hub-and-spoke payments network. As illustrated in Figure 6, users exchange fiat money into a virtual currency (DLT-based tokens) held in digital wallets through ATM machines, point of sales terminals, online interfaces, or other means (the spokes). These tokens are then transferred, possibly across borders, over the virtual currency’s secure network (the hub) to the payee’s digital wallet. Finally, tokens are exchanged into foreign fiat money, as desired, through the same means as above (spokes again).²⁴



57. The implications for market structure are significant; pressure would grow to shorten the traditional payments chain. Messaging and settlement either in central bank money or through correspondent banks would no longer be needed.²⁵ In the capturing and distributing segments, instead, virtual currency exchanges and wallet providers would compete for customers, potentially taking significant business away from other players. Specialized firms such as MTOs could feel the greatest pressure, while banks might continue to attract customers with other services related to saving, borrowing, risk management, and advice. But the need to build trust—and thus the requirement of sunk costs—would remain.

58. From the end user’s perspective, the attributes of payment services offered by hub-and-spoke networks look attractive, despite three important caveats. Cross-border payments

²⁴ Such networks are already being explored by Circle, Ripple, and Visa, for instance, through their “B2B Connect,” in partnership with Chain. Commercial banks are also exploring the issuance of virtual currencies to facilitate transactions between banks, possibly in different jurisdictions.

²⁵ Note, however, that the transfer of fiat currency from a user’s account to the virtual currency exchange’s account, upon purchase of the token, would still be settled through the central bank.

could become significantly faster, more traceable, and easier to use. Payments could also become cheaper, and more secure.

59. First, the potentially erratic valuation of virtual currencies introduces risks and could limit the adoption of hub-and-spoke networks, at least for large value payments. He and others (2016), for instance, argues that in their current form, virtual currencies are not likely to be adequate stores of value given the volatility in their exchange rates to fiat money. This same volatility would undermine hub-and-spoke networks, as two “foreign exchange rate” conversions are needed: when the token is acquired, and when it is sold. Even if the virtual currency is held for very short periods, the transaction involves foreign exchange rate risk. FX risk could potentially be hedged, although costs could then rival those of correspondent bank transfers.

60. Second, a lack of trust in hub-and-spoke networks could erode their value, though regulation could help. Just like trust is needed in the authenticity of a paper bill in traditional token-based payment systems, trust in the hub-and-spoke solution is also essential. First, counterparties need to have legal certainty regarding the transfer of ownership of the virtual currency. Second, counterparties need to have trust in the stability and security of the technology underlying the virtual currency. This also implies trust in the issuance rule (or backing) for the virtual currency.²⁶ Finally, users need to trust the security of the virtual currency exchanges and wallet providers needed to enter and manage hub-and-spoke transactions. Users may be concerned with the security of their data, and the ability of others to access their wallets. Regulators may then need to consider regulatory approaches to virtual currency exchanges and wallet providers that would sufficiently protect consumers, and address AML/CFT concerns.

61. Third, the lack of interoperability among networks could keep prices of hub-and-spoke payments high. If networks are not interoperable, network externalities could be strong, and providers could take advantage of market power to charge high fees. Regulation aimed at addressing anti-competitive concerns could help alleviate this outcome.²⁷

62. A second avenue exists to leverage DLT for a novel means of payment; central banks could offer their own digital currencies. A central bank digital currency (CBDC) would not be a parallel currency, but merely a widely available DLT-based representation of fiat money. The idea is not to introduce a new unit of account, but a new means of payment and store of value. The CBDC would presumably be exchanged at par with the central bank’s other liabilities (cash and reserves),

²⁶ The issuance rule could affect the exchange rate with fiat money; consider, for instance, a rule that issues one token for each unit of fiat money received—as would a currency board. Questions arise as to how the issuer of a virtual currency would transparently and credibly disclose, and commit to, its issuance rule.

²⁷ For example, in the United Kingdom, the Financial Services Act 2013 created the Payment Systems Regulator (PSR) as a new competition-focused regulator for retail payment systems as a subsidiary of the Financial Conduct Authority. The PSR was established based on concerns that the combination of strong network effects and the ownership of many of the key payment systems by overlapping groups of large incumbent banks was undermining competition.

through banks or directly at the central bank, and would not be interest bearing, at least as a starting point.

63. Central banks might introduce CBDCs for various reasons, though the balance of benefits and costs need further study.²⁸ A CBDC might resolve the coordination problem over new virtual currencies, and thus spur technological innovation. Alternatively, it might allow the central bank to retain control of monetary policy effectiveness, in case privately-issued virtual currencies started to gain significant ground (though this is unlikely as suggested in He and others 2016).²⁹ A DLT-based CBDC could also be more secure and resilient than current settlement systems which are exposed to single point of failure risk. Finally, by facilitating small value payments, it could boost the adoption and efficiency of the new, decentralized, service economy. However, CBDCs raise multiple potential costs and risks, such as managing the platform and its integrity, resolving scalability, and dealing with issues of privacy. Appendix III offers further details.

64. A CBDC would have many of the same implications on services and market structure as a hub-and-spoke network, but with features that would alleviate some concerns. By virtue of being government sponsored, trust in the technology and issuance rule should be greater. Stable issuance should also help stabilize the exchange rate.³⁰ Finally, privately-sponsored networks for payment services would become more interoperable, and thus more competitive, as they migrate to using the CBDC.

Other Sources of Change

65. New players in the domestic and cross-border payments space could come from other sectors. Their advantage would not be technological, but would emerge from the application of core competencies and service know-how developed in other sectors. For instance, the earlier discussion of services underscored the advantage of companies that users trust, and that offer services that are easy to use, and tailored to users' behavior and preferences. From this perspective, social media companies, online retailers, and popular tech companies are well positioned to enter, if not further extend into, the payments space.

CONCLUSION

66. This paper sets out a framework for thinking through the economic channels by which technology affects financial services. It emphasizes the evolving needs of users and the special role of market imperfections, and cost structures that arise in financial markets. Fintech firms have

²⁸ Central banks are still far from offering wide access to a digital currency but are actively exploring the possibility of going further. The Bank of England, for instance, announced in June 2016 that it would extend direct RTGS system access to nonbank payment service providers.

²⁹ See Weber (2015) for a historical overview of privately issued currencies in the United States.

³⁰ FX risk with other currencies would remain, however, as foreign payees would seek to transfer the CBDC into their local currency. In countries with less liquid currencies, this could induce a certain degree of "dollarization"—namely the adoption of the payer's more liquid currency as a common unit of account.

the potential to significantly change the landscape by attenuating these imperfections, and transforming existing cost structures. They are providing innovative products and services that respond to users' needs for trust, speed, low cost, security, usability, and transparency.

67. A key uncertainty is whether the changes in financial markets will be gradual and evolutionary, or potentially disruptive. To the extent that the new technologies lower the cost of doing business, they could support more gradual change, indeed one where incumbents may acquire new technologies from new entrants. However, the introduction of new products that bypass existing intermediaries and markets, or network effects that very rapidly change existing market structures, could stimulate a more disruptive evolution.

68. These possibilities confront regulators and central banks with both challenges and opportunities. Fintech could substantially change the stability versus efficiency trade-offs that regulators seek to manage. Regulators will increasingly need to look to the specifics of the technology itself. Managing issues related to trust and privacy are likely to become more challenging. On the other hand, the benefits of the technology for user choice, cost, and access are sizable. Moreover, fintech itself may offer solutions to some of the current regulatory challenges including on know your customer and AML/CFT issues. Central banks are also assessing how fintech may impact their current dominant role in payments systems and the provision of a medium of exchange.

69. Cross-border payments provide a case in point for applying the paper's approach. The analysis of the demand for, and supply of, cross-border payments services, and the study of the market structure of service providers point to various shortcomings, driven by technological limitations, regulation, or market structure. Fintech innovations—in particular DLT—have the potential to offer important service improvements and cost savings, and may disrupt barriers to entry including the scale and network economies that are characteristic of cross-border payments. Some technical advances will undoubtedly be more disruptive than others, and will require the development of a supportive regulatory environment.

70. Fintech raises several issues to consider for international collaboration. Developments in fintech raise important questions that are not only national but also global in scale. To ensure that effective regulatory frameworks are developed to address the challenges posed by fintech, international cooperation will be essential, and the IMF is well placed to play a role in this process.

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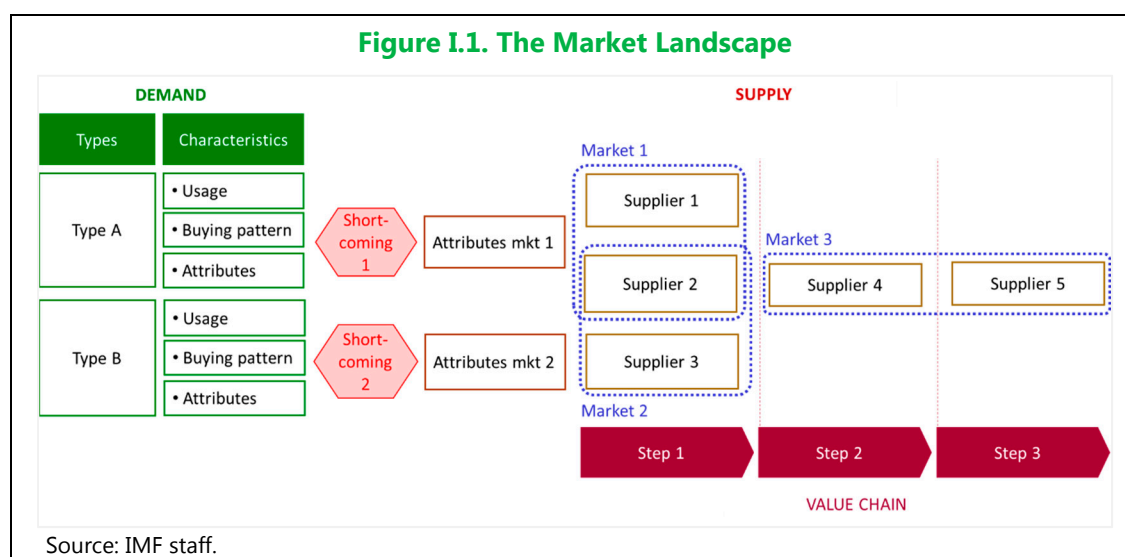
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Appendix I. A Framework of Analysis

1. The paper offers a high-level description of the framework. The goal of this appendix is to provide details of how to apply the framework to gauge the impact of new technologies on service attributes and market structure. The focus in Figure I.1 is on service attributes, specifically on describing demand and supply and identifying shortcomings of services. This appendix follows a step-by-step approach, intended to be sufficiently general to also guide future work.



Demand, Supply, and Service Shortcomings

2. The first step is to restrict and focus the analysis to one basic function of finance. From the standpoint of end-users, these are to: (i) make and receive payments, (ii) borrow, (iii) save, (iv) manage risks, and (v) receive financial advice.

3. For each function, the second step is to categorize end-users into groups, and highlight the attributes of services most valued by each one. Users can also be categorized by common usage goals, and buying patterns (as drawn in Figure I.1).

- *Most valued attributes of services* capture users' preferences or main purchasing criteria, in other words the attributes of services for which users are most willing to pay. In the area of financial services, these may include speed, security, transparency, ease of use, and, importantly, trust. The attributes most valued by users can change over time, as habits and expectations change, and new generations come on board.
- *Usage goals* are a description of the ultimate intent of users. For cross-border payments, for instance, these include sending and receiving remittances, and paying for foreign goods and services.
- *Buying patterns* describe the patterns of purchasing decisions such as the research done by users to compare services, and the frequency and ease of switching between service providers.

4. **Common user groups are households, small and medium businesses, large corporates, and financial firms.** But other typologies are also possible.
5. **The third step is to consider the supply of services.** Eventually, demand and supply will be compared on the basis of service attributes. Supply can be described through three intermediate steps.
6. **Supply can be decomposed into a value chain.** As in a manufacturing assembly chain, the term is intended to capture the sequential functional steps involved in satisfying the usage goals of end-users. Figure I.1 shows a generic value chain composed of “steps 1, 2 and 3.” The value chain referred in the paper, relevant for cross-border payments, is illustrated in Appendix II.
7. **Next, it is useful to list the service providers active in each segment of the value chain, and to group these into markets.** A market is a set of firms which cater to the same user groups. For instance, while commercial banks and mobile wallet solutions exhibit very different business models and offer very different services, they compete for the same user group—households valuing the same service attributes, wanting to make payments abroad, and exhibiting common buying patterns. Note that markets can span various segments of the value chain if a firm’s main user group is composed of itself—this is known as vertical integration, as discussed further below and in the paper. Moreover, the same firm can span various markets if it caters to more than one user group. Both possibilities are drawn in Figure I.1.
8. **The study of supply ends by evaluating the attributes of available services in each market.** The emphasis in the paper is on the markets catering to end-users. Relative to the attributes mentioned earlier, the question is whether actual services are fast, secure, easy to use, transparent, and trustworthy.
9. **Finally, shortcomings of services are derived by asking how satisfied end-users are with the attributes of services they most value.** If different attributes, or combinations of attributes, would entail a jump in demand—because users would be ready to pay significantly more for the new service, or consume significantly more of it at unchanged prices—the existing service is said to exhibit shortcomings. This is as in the spirit of Fung and Halaburda (2016), as well as Berger, Hancock, and Marquardt (1996).

Some Details on Market Structure

10. **The determinants of market structure are laid out in some detail in the text already.** This section merely offers a more detailed discussion of the determinants of vertical integration, or what is also referred to as the boundary of the firm.
11. **Vertical integration results from the strategic decision to act in more than one segment of the value chain (see Lafontaine and Slade, JEL 2007 for a survey, or Whinston 2003, and Gibbons 2005).** According to Coase (1937) and later Williamson (1971, 1975, 1979, and 1985) vertical integration is a response to the potential hold-up problem whereby relationship-

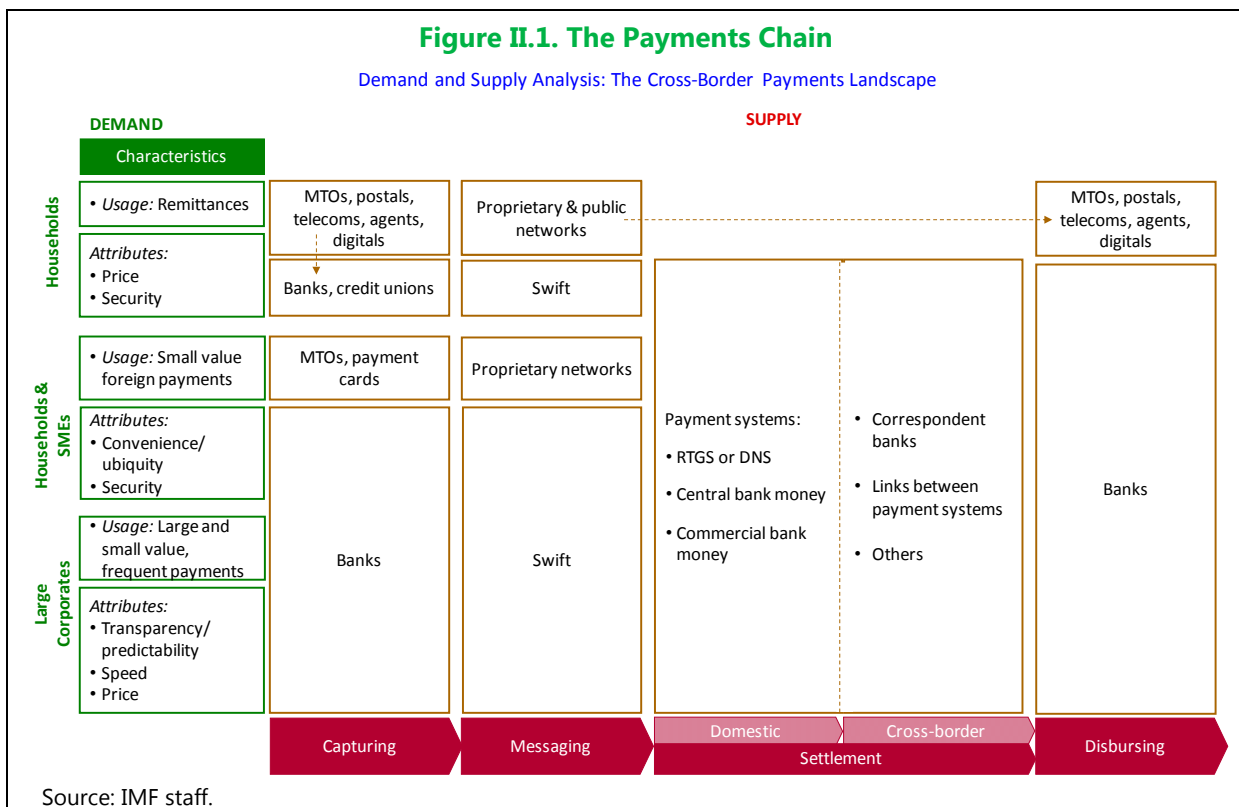
specific investments leads to ex-post haggling about monopoly or monopsony rents. Grossman and Hart (1986) and later Antras (2003), suggested that vertical integration is a means to ensure sufficient investment in relationship-specific innovation. Lafontaine and Slade (2001), following Holmstrom and Roberts (1998), emphasize the moral hazard arguments for vertical integration, to contain agency problems and enhance monitoring. Another explanation is that vertical integration induces cost savings since certain core capabilities are at the heart of multiple segments of the value chain.

Appendix II. Cross-Border Payments and Correspondent Banking

1. This appendix complements the text by providing further details on cross-border payments. It begins by surveying the characteristics of demand for, and supply of, cross-border payments services, following the framework outlined in the paper and Appendix I. It then illustrates the basic functions of correspondent banks using a schematic example, and highlights the main sources of risks and costs. Finally, the appendix discusses variations to the basic correspondent banking model, including other means to send payments abroad.

Demand, Supply, and the Payments Chain

2. The paper identifies three different user groups. As illustrated in Figure II.1, these are (i) households sending regular though infrequent remittances abroad, sometimes to countries with low levels of banking penetration; (ii) households and small and medium enterprises (SMEs) making small value payments abroad, or paying for foreign goods or services; and (iii) large corporates making frequent foreign transfers to pay for foreign workers or inputs to production, for instance. While these groups of users were traditionally distinct, lines are now blurring. For instance, in some segments, large corporates are increasingly moving from lumpy and large-value cross-border payments, to frequent and small-value payments as the organization of supply is increasingly fragmented and decentralized.



3. Each group of users has different attributes it values most in the services it receives.¹

Households engaged in remittances especially value low cost and security. Households and SMEs seek convenience and security above other attributes. And large corporates place a premium on costs, given the large amounts they transfer. They also seek speed, predictability, and the assurance that intermediaries will preserve the confidentiality of information.

4. As payments make their way from sender to recipient, they are handled by multiple firms in four market segments, corresponding to different core functions of the payments chain. These are illustrated in Figure II.1.²

- Households engaging in remittances will first turn to “capturing” firms, which can be banks or credit unions offering wire transfers, or other remittance service providers (RSPs) including specialized money transfer operators (MTOs), as Western Union, post offices, telecommunication companies, as well as digital companies.³
- Payment instructions will be sent via “messaging” services, ultimately to the final “disbursing” agent in the foreign country. Banks and credit unions will typically use SWIFT, the international interbank messaging standard. Other entities will instead favor proprietary networks or turn to public channels such as the internet for messaging. In general, these firms will not actually send cash overseas, but merely instruct their foreign offices or partners to disburse funds, after netting out bilateral transactions. In other words, they do not need to actually settle transactions; messaging is sufficient. However, to replenish liquidity in foreign offices, these firms turn to local banks to send money abroad.
- Whether to service the needs of other RSPs, or undertake wire transfers for their own clients, banks will first transfer funds to domestic correspondent banks. “Domestic settlement” most often involves the transfer of reserves held at the central bank from one bank’s account to another.⁴
- In most cases, “cross-border settlement” is instead ensured by correspondent banks, which transfer funds among accounts they hold with one another, after netting out payment orders

¹ The matching of attributes to user types is based on Niederkorn and others (2016), and Visa, Inc. (2007). See also Jonker and Kosse (2008), Kosse and Vermeulen (2014), and Russell (1986) for a discussion of users’ desired attributes.

² See CPMI (2014), CPSS-World Bank (2007), and Federal Reserve Bank of Kansas City (2007) for similar examples.

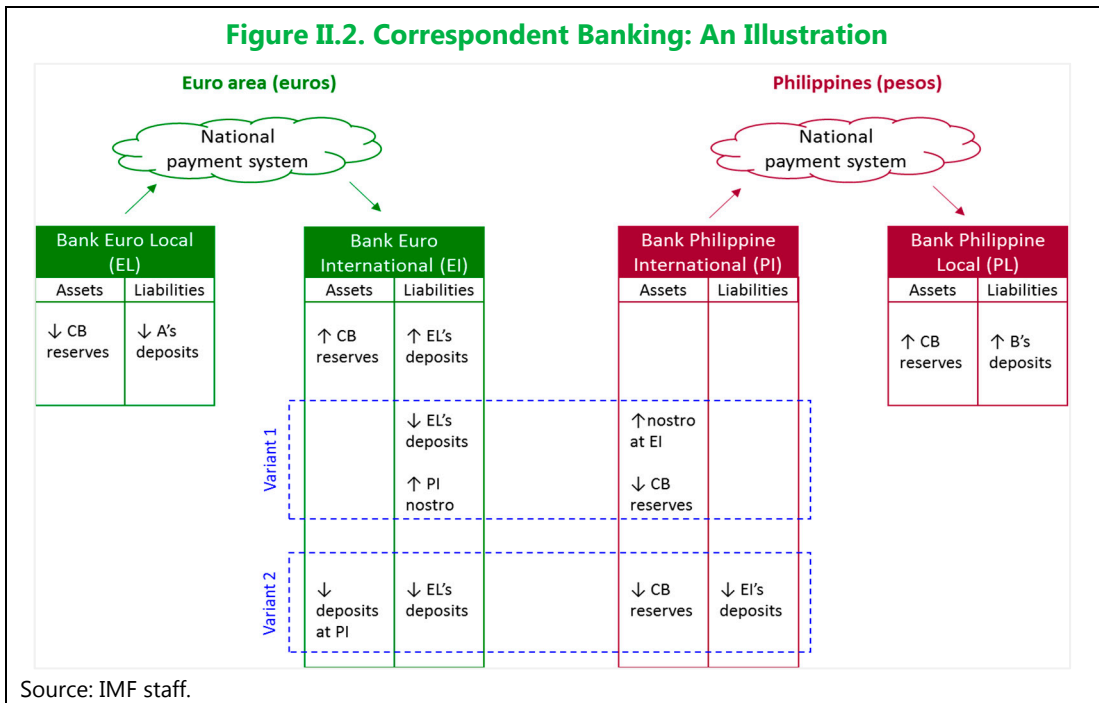
³ Digital companies as Xoom, Worldremit and Transferwise, for instance, do not have a physical presence, but interface with users through online applications. Other remittance channels might include bus/courier companies, collection agencies, Hawala operators, and friends/relatives (IMF 2009, El Qorchi and others 2003).

⁴ Settlement in central bank money can be done immediately, upon receipt of the payment instruction (called Real Time Gross Settlement—RTGS), or at the end of a waiting period allowing payment orders to first be netted (Deferred Net Settlement—DNS). RTGS transactions are final and non-reversible. Settlement is also possible in commercial bank money, by directly debiting or crediting accounts held among banks—though this method is more expensive and risky.

bilaterally. Doing so entails substantial foreign exchange (FX) exposures and risks, credit risk, costs of managing liquidity, as well as manual labor.

- Larger value or more frequent cross-border payments initiated by SMEs and large corporates typically go through banks directly, following much of the same channels as above.⁵

A Closer Look at Correspondent Banking



Basic Functions

5. In this schematic example (Figure II.2) individual or firm A in the euro area instructs its bank, Bank Euro Local, to transfer pesos to individual or firm B in the Philippines.⁶ The instruction takes the form of a message, coded in standard language, sent through the various banks involved in the payment chain.

6. Funds, however, do not travel as easily. Bank Euro Local does not have access to recipient B, nor to B's bank, Bank Philippine Local. So Bank Euro Local must go through a correspondent, Bank Euro International, which has a banking relationship with Bank Philippine International.

⁵ Some MTOs also cater to SMEs. Credit and debit cards also send payments through the banking system, though after netting out bilateral payment orders through their networks.

⁶ Other studies providing additional background and explanations, and covering further variations of cross-border payments include: CPSS and World Bank (2007), Erbenová and others (2016), IMF (2017), CPMI (2016), and Lipis and Adams (2014). CPSS (2008) offers a detailed account of different cross-border settlement systems.

7. The chain begins with Bank Euro Local debiting A's account and transferring an equivalent sum to Bank Euro International (only the elements that change in banks' balance sheets are shown in the figure). To do so, it instructs the euro area's central bank, the ECB, to debit its reserve account and credit Bank Euro International's reserve account. Settlement through the central bank ("domestic settlement") can take place in real time or after netting banks' daily payment instructions to the central bank.

8. To transfer money abroad, however, Bank Euro International cannot rely on a central bank for settlement. This is where correspondent banking relationships come into play. Two variants are possible. In *Variant 1*, Bank Euro International credits Bank Philippine International's account, referred to in the jargon as a "nostro" account (more on related exchange rate transactions below). In turn, Bank Philippine International transfers funds through the Bangko Sentral ng Pilipinas (the Central Bank of the Philippines) to Bank Philippine Local, which then credits B's account. In *Variant 2*, Bank Philippine International debits the account it maintains for Bank Euro International, before transferring funds through the central bank to Bank Philippine Local.

Foreign exchange exposures, liquidity costs, and credit risk of correspondent banks

9. The transfer of funds from Bank Euro Local to Bank Euro International through the ECB is straightforward. There is no credit risk as the central bank cannot go bankrupt, no FX exposure as payment and receipt are in euros, and hardly any liquidity cost, as commercial banks typically keep very low levels of non-interest bearing reserves at the central bank (and in some cases, reserves are remunerated at the policy rate). Note that the longer Bank Euro International keeps Bank Euro Local's deposit on its books, the more interest it can earn from it (called a "float").

10. In contrast, the correspondent banking transaction between Banks Euro International and Philippine International involves greater costs and risks.

- Credit risk can be high, especially in Variant 1. Bank Philippine International essentially extends credit to Bank Euro International, and would only do so if it had significant trust in Bank Euro International. Net credit exposures can balance over time, if correspondent banking flows are approximately equal in both directions. But large gross balances can accumulate quickly and still pose significant credit risk.
- These inter-bank exposures also entail FX risks depending on the currency of the nostro account. If it is in peso, Bank Euro International will need to manage (hedge) FX exposure on its books. If it is in euros, Bank Philippine International will need to do so.
- FX settlement risk can also be significant. Because the transfer of the sold currency typically takes place independently of the transfer of the bought currency, parties are exposed to principal and liquidity risk to the full value of the trade. (BCBS 2013; CPSS 2008 provide further information).

- Variant 2 usually involves lower credit and FX risk, as Bank Euro International’s account with Bank Philippine International can be topped up as needed (funds are deposited through spot FX transactions). However, this variant involves costs of maintaining idle liquidity.
- A separate and additional source of credit risk arises in the chain if Bank Philippine Local disburses funds to individual or firm B before it receives funds from Bank Philippine International.

Variations and Extensions

11. *Single correspondent bank (“on-us” transactions; see CPSS 2008 for a further discussion).* Instead of Bank Euro International operating through Bank Philippine International, it may also be active in the Philippines and offer direct correspondent banking relationship to Bank Philippine Local. The process would resemble Variant 1, though involve internal treasury operations (usually done in the currency of the parent bank). Bank Euro International would credit Bank Philippine Local’s nostro account in pesos, after undertaking an FX transaction, then transfer these to Bank Philippine Local through the central bank’s settlement system. There would be no need to resort to Bank Philippine International.⁷

12. *Netting.* Many correspondent banks will first net FX trades bilaterally, or within a network, before sending outstanding balances through correspondents.

13. *Links between payment systems.* In other limited cases, cross-border payments can also be settled through direct links between payment systems. Some inroads already exist. The first is CLS, which allows for real time settlement in central bank money of wholesale foreign exchange transactions, as discussed earlier. Others are the “shadow” RTGS systems created in Switzerland in euros (EuroSIC), and in Hong Kong in dollars (USD CHATS) and euros (Euro CHATS), for which the settlement bank and liquidity provider is a bank operating in the foreign currency jurisdiction. This gives domestic banks direct access to the foreign payment system. However, implementation is limited to a small scale given the need to offer settlement liquidity in foreign currency. Other regional arrangements exist in Asia, Africa, the Caribbean, and Central America, as discussed in World Bank (2014). The Federal Reserve Banks in the United States have also offered links between one of their settlement systems (the Automatic Clearing House—ACH) and that of selected other countries. However, these services are currently limited to outbound transactions from the United States, and are mostly used to transfer U.S. government payments (more details are offered in CPSS/World Bank, 2007).

14. *Links between payment systems for wholesale FX transactions.* CLS is a multicurrency cash settlement system that helps mitigate settlement risk for foreign exchange transactions. This is

⁷ Banks that have branches or subsidiaries in foreign countries can also transfer money through internal book entry transfers. However, the ECB (ECB, “Improving Cross-Border Retail Payment Services, the Eurosystem’s View,” 1999) estimates this to be the most expensive channel for cross-border payments, mostly due to the low degree of automation in banks’ internal systems and the different standards used in branches or subsidiaries in foreign countries.

done through its payment versus payment settlement service, which has direct links to the real time gross settlement systems of the currencies it settles. CLS currently settles payment instructions related to underlying foreign exchange transactions in 18 currencies. CLS holds accounts with all central banks of the currencies settled. Settlement members each have a multi-currency account. Funding and payout of net positions is conducted using a daily defined schedule. There is final and irrevocable settlement in all CLS currencies.

15. *Payments using credit or debit cards.* Card providers distribute cards to end-users through local banks. They aggregate and net out payment information, but continue to rely on correspondent banks to clear and settle cross-border transactions.

16. *Remittances through multiple players.* Remittance flows are characterized by further links in the chain, but not a different chain altogether. For instance, individual A (from the earlier example) might first deposit money with a “capturing agent,” which then operates through a money transfer operator (MTO) with links to the domestic banking system. Likewise, individual B might receive money from a local “disbursing agent” affiliated with a local MTO, different from that in the euro area. These complications merely add transfers between domestic banks, settled in central bank money, on either end of the chain. The heart of the chain, however, continues to be characterized by a correspondent banking relationship.

17. *Remittances through franchised or integrated networks.* Remittances can also be intermediated by a single MTO, or through other specialized agents operating proprietary communications networks. In many of these cases, remittances will not involve an actual flow of funds. As individual A deposits money in the euro area branch of a given MTO, a message is sent to the Philippine branch to disburse funds to individual B. However, this can only go on while the Philippine branch has peso liquidity. Since remittances tend to involve one-way flows, at some point the euro area branch will have to transfer funds to the Philippine branch. Doing so will involve a correspondent banking relationship as discussed above.

Appendix III. Central Bank Digital Currencies: Why and How?

1. This appendix considers two questions in turn. First, why would a central bank want to issue a digital currency? And second, what form could such a currency take and how would it be distributed? The implications for the setting and transmission of monetary policy, as well as for financial stability, will be left for future discussions.

Why Issue a Central Bank Digital Currency?¹

2. Efficiency considerations provide a first reason. Introducing a CBDC may allow the central bank to perform its role in insuring an effective payments infrastructure, including the issuance of currency and the provision of a lender of last resort function, more efficiently.² However, even if there is scope to narrow the shortcomings of services in the payments space, the central bank would still have to show that introducing a CBDC would provide for greater efficiency gains than regulating the payments industry (including virtual currencies) and/or entering into public-private partnership to remedy existing deficiencies. There are in this respect several examples of impressive progress in fostering the efficiency of payments systems without the issue of a CBDC, in Africa among others; and Denmark has become close to a cashless society with a very efficient payments system without a CBDC.^{3, 4}

3. That said, gradually replacing notes and coins with a central bank electronic currency entails savings on the costs of maintaining and replacing notes and coins for the state. It may also significantly reduce transactions costs for individuals and small enterprises that have little or costly access to banking services in some countries or regions; and it may facilitate financial inclusion. Such arguments underlie the discussion on the possible introduction of a CBDC by a number of central banks.⁵

¹ A good discussion of the rationale for issuing a CBDC can be found in Fung and Halaburda (2015). The paper emphasizes efficiency considerations and carefully list the questions to be answered before the creation of a CBDC can be justified. The paper also relates the purpose of its creation to the characteristics that the CBDC should possess. The discussion of this section of the appendix draws in part on their contribution.

² The demand of the public for electronic means of payments could be satisfied more cheaply, the payments system would thus be more efficient, and it may be more easy to supply electronic-cash than notes and coins when lender of last resort operations require it.

³ For instance, much progress in fostering financial inclusion and access to payments is being made in India, Kenya, and other developing and emerging markets through central bank and government supported and regulated private initiatives.

⁴ See Danmarks National Bank (2017).

⁵ As Skingsley (2016) emphasizes, the goal would not be to eliminate “ordinary” cash but to foster further efficiency gains and inclusion by the issuance of e-Krona, or “electronic cash” by the central bank; and the intent is to proceed cautiously and progressively. Nicolaisen (2017) also emphasizes the importance of respecting social preferences for the form of money. For an early discussion of the introduction of a CBDC in the UK context, see Broadbent (2016); for a Canadian perspective, see Wilkins (2016) in addition to Fung and Halaburda (2015); for an ECB perspective, see Mersch (2017).

4. Further efficiency arguments for CBDCs are based on countering the monopoly power that strong network externalities might confer on one or a few private virtual currencies or operators in the payments system, or on the inability to ensure the full stability and safety of privately coded and maintained currencies. In addition, it has been argued that a CBDC could overcome the coordination failure of inability to agree on a single new technological standard for electronic payments.

5. Monetary policy considerations provide a second reason. The introduction and potential proliferation of private virtual currencies might, in one view, threaten to erode the demand for central bank money and the transmission mechanism of monetary policy. A CBDC may forestall such private virtual currencies or relegate them to a secondary role in the payments system. This threat is not imminent given the current transactions domain and limitations of existing private virtual currencies (see He and others (2016)) and their likely medium-term growth. Stability and safety considerations connected to this proliferation may, however, be relevant in the medium run but could presumably be dealt with by other measures.⁶

6. The challenge for central banks will be to weigh carefully the possible pros and cons of being an overseer, regulator, catalyst, or operator of applications based on new technologies, while acting in ways that do not stifle but encourage innovation and realizing that they will most of the time be behind the private sector in terms of technological know-how.

What Kind of Central Bank Digital Currency?

7. The impact of a CBDC will depend crucially on (i) the CBDC's basic design; (ii) its other characteristics; (iii) how it is distributed; and (iv) the technology used.

8. In terms of basic design, the CBDC would presumably respect the following requirements: it would be issued in the same unit of account as fiat money; it would be a liability of the central bank and would be exchanged at par with its other non-equity liabilities—mainly cash and commercial bank reserves; these other components of base money would continue to be issued, at least initially to ensure a smooth transition; and the CBDC would be exchanged electronically and would have no physical existence (it is an entry in one or several ledgers). By these criteria, commercial bank reserves are a form of CBDC.

9. Other characteristics of CBDCs would, however, differentiate them from commercial bank reserves in one or several ways. Access would not need to be confined to commercial banks; the fees on CBDC transfers may differ from one category of transaction and holder to another; there might be a minimum or maximum size of balances or of transfers; and interest may or may not be paid on the CBDC. Identifying holders of CBDC could be challenging. These diverse design features of a CBDC may be complements or substitutes to each other. For instance, whether interest is paid

⁶ Another monetary policy consideration is that replacing cash, except possibly for costly-to-store small denomination notes, with a CBDC could allow the central bank to lower interest rates well into negative territory when necessary to fulfill its mandate. This argument has been made by, for instance, Buiters (2009) and Rogoff (2014).

on a CBDC or not has important and differing implications for the transmission and effectiveness of monetary policy, as well as for financial stability. A non-interest bearing CBDC would be a better substitute for cash than for bank deposits, an interest-bearing one for bank deposits. The latter may impact the transmission mechanism and financial stability more than the former.

10. The central bank would have to make decisions relative to distribution. The basic questions are how and to whom it would distribute its digital currency. In this respect, whether the CBDC should be issued and transferred in token rather than account-based form constitutes an important consideration. For simplicity, two distribution models can be distinguished.⁷ In the first, the central bank offers to exchange its non-equity liabilities at par against digital currency to commercial banks. The digital currency would then be “retailed” through these banks to other banks and non-banks including individuals, corporations, wallet providers and operators of the payments system. This would avoid the need for the central bank to deal with technical difficulties of end-user usability and platform compatibility. The central bank would, however, want to monitor and regulate the market in which its liabilities are traded, the service providers, and the technology. It should also encourage innovation and competition at least among wallet providers. In this arrangement, the central bank would thus limit its involvement to ensuring the standards and functionality of the digital currency are adequate, and to distributing the currency to banks. The central bank would thus be part operator and part catalyst.

11. The second model of distribution would have the central bank making its digital currency available not only to reserve banks, but also to select other banks and non-banks. Here, as in the first model, the proportion of central bank digital currency in the central bank’s balance sheet would depend on the preferences of banks and non-banks, but transfers of CBDC among (authorized) holders including non-banks would take place directly on the balance sheet of the central bank, whereas in the first model only exchanges among the reserve banks would take place on it. This second model would thus involve the central bank much more closely into operating the system and may raise privacy concerns, especially if transactions are validated by multiple participants (although so-called “zero-knowledge verification” systems are being developed).

12. The last issue concerns the choice of technology used to support the CBDC. One could imagine extending RTGS technology to transfers of the CBDC among its holders. Existing settlement systems are exposed to single point of failure risk. A CBDC could be more secure as the ledger would exist in multiple copies. RTGS, however, has been designed for large value transactions, on uniform terms, among a well-defined set of “permissioned” banks. It could relatively easily be used in the first model of distribution outlined above, where a well-defined set of banks and possibly a few other agreed financial intermediaries are allowed to hold the CBDC and “retail” it thereafter. Whether RTGS could/should be extended to a much larger set of holders and for relatively small amounts is not clear.

⁷ “For simplicity” as there are many other criteria than access to the central bank’s balance sheet along which to define distribution models, notably along rapidly evolving technology lines, and many combinations are possible.

13. The form and broad design of the CBDC eco-system will eventually reflect the answers to such questions and, importantly, the development and maturing of fintech technologies.

These technological and organizational choices raise several questions, such as: can the chosen technology guarantee privacy if not anonymity, can it be made secure, and can speed be maintained? What does it imply as to who bears the costs of operating, maintaining, and developing the digital currency? Should it be the central bank, or could private sector participation be possible, so that the central bank can remain a catalyst as opposed to a full-scale operator?

14. These are among the many questions the introduction of CBDCs raise about the nature and regulation of the financial system, the conduct of monetary policy, and the role of the central and commercial banks in the economy.

Many of these questions are deeply political and complex. This would seem to warrant a gradual approach to introducing CBDCs, if at all, building on experience, and on evolving and maturing financial technologies.

Appendix IV. The Sandbox Approach: Selected Jurisdictions

1. Sandboxes have been developed by regulators and supervisors in a few jurisdictions to provide a controlled and contained environment in which firms can conduct pilot trials of innovative financial services and products in a timely and cost-effective manner before these are launched on a larger-scale. While regulatory and supervisory sandboxes vary from jurisdiction to jurisdiction, they share some common features and differ in others (Figure IV.1).¹

Figure IV.1. The Sandbox Approach in Selected Jurisdictions

General Information		Type of Applicant		Benefits for Businesses			Safeguards			
Country	Regulator	Authorized/ Licensed/ Incumbents	Unauthorized/ Unlicensed/ Startups	Regulations relaxed or waived	Licensing requirements relaxed or waived	Clarifications on regulatory expectations	Limits on customers, value and/or duration	Additional reporting obligations/closer monitoring	Additional consumer protections/risk mitigation	Specified regulations that cannot be waived
Australia	ASIC	✗	✓	✗	✓	✗	✓	✓	✓	✓
Canada	CSA	✓	✓	✓	✗	✓	✗	✗	✓	✗
Hong Kong SAR	HKMA	✓	✗	✓	✗	✗	✓	✓	✓	✗
Malaysia	BNM	✓	✓	✓	✗	✗	✓	✓	✓	✗
Singapore	MAS	✓	✓	✓	✗	✗	✓	✓	✓	✓
Switzerland	FDJ	✓	✓	✗	✓	✗	✓	✗	✓	✓
United Arab Emirates	ADGM	✓	✓	✓	✗	✗	✓	✓	✓	✗
United Kingdom	FCA	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓ Explicitly mentioned in the regulatory authority's disclosure, staff analysis.
✗ Either not required or not mentioned in the regulatory authority's disclosure.

Source: IMF staff.

2. Objectives: While the objectives of the regulator or supervisor in adopting a sandbox approach to fintech ultimately depends on its mandate, in general this approach reflects an attempt to strike a balance between promoting innovation and preserving financial stability and consumer protection. The sandbox approach proposes to achieve this by lowering barriers to testing innovative financial products and services while at the same time ensuring that adequate safeguards are in place to mitigate risks and protect consumers. Some sandboxes also provide greater clarity on regulatory expectations and applicable rules for products or services that do not easily fit within existing regulatory frameworks.

3. Regulations: Depending on the particular sandbox, certain regulatory or licensing requirements can be relaxed, adapted or waved on a case-by-case basis, to allow firms to test innovative services and products without incurring the full cost of compliance with licensing and regulatory requirements, and reducing the time needed to get these services and products to markets. This will often be limited to the regulations and licensing regimes within the purview of the relevant supervisory or regulatory agency responsible for the sandbox, and will at times expressly

¹ The information gathered in the appendix includes readily available information from public sources and does not necessarily reflect all actions taken by any given jurisdiction.

exclude certain regulations that cannot be waived like AML/CFT, fit and proper requirements and tax legislation.

4. Eligibility criteria: To qualify for most sandboxes, the financial product or service to be tested must involve genuine innovation, for instance, by using new or emerging technologies or using existing technologies in an innovative way, and must either have the potential to address a problem or bring benefits to consumers or to the industry. Other criteria include having the necessary resources, a thorough business plan, and a test-ready product or service. The intent to deploy the product or service in the jurisdiction of the sandbox is often included as a requirement.

5. Safeguards: All sandboxes in the sample included some form of safeguards to mitigate the risks and contain the potential consequences of the live tests. Safeguards typically include restrictions on the scope of the live test, including on the number and type of customers, the duration, the total value and, in more prescriptive frameworks, on the specific products and services that can be tested. Some sandboxes also require additional customer protection measures, such as compensation arrangements, dispute resolution and redress mechanisms, and specific disclosure and consent requirements. Other safeguards include risk management controls (e.g., against cyberattacks and system disruptions), and monitoring and reporting requirements.

Appendix V. Examples of Regtech Solutions to Facilitate Regulatory Compliance

1. **Data analytics tools** can be used for continuous risk monitoring and analysis as mean to enhance compliance. These technologies could serve as tools for information management as well as transactions reporting and regulatory reporting. For example, they can be used to identify virtual currency wallets associated with “bad actors” based on common technical information or transaction patterns. By identifying these wallets, public authorities will be able to identify which transactions involve illicit activities. Absent these tools, the analytics of increasing larger datasets would entail significant costs in time and labor with an added risk of human errors and omissions.
2. **Cognitive computing and artificial intelligence technologies** enable data mining algorithms based on machine learning which can organize and analyze large sets of data. Machine learning can create self-improving and more accurate methods for data analysis, modeling and forecasting as needed, for example, for stress testing. Artificial intelligence solutions seek to enable the treatment of regulatory content as data, further permitting to manage it programmatically. These technologies may eventually be applied to track regulatory changes and even interpret new regulations.
3. **Application programming interfaces (APIs)** allows different software programs to connect, enabling their interoperability and communication with each other. APIs could be used for automated exchange and reporting of data, including information exchange with regulators.
4. **Cloud applications** provide relative low cost and flexible solutions for data storage, standardization and sharing by allowing financial institutions pooling some of their compliance functions on a single platform. A central data repository on the cloud could serve different subsidiaries within a single institution or even allow access to multiple organizations across the industry (e.g., KYC repository).
5. **Identity verification technology** (including biometrics) provides effective and secure ways to confirm a purported sender’s identity. Both startups and established AML compliance companies are incorporating facial recognition software. For example, money transfer companies can require a user to upload photos of both the user’s national ID and the user’s face, and the software can confirm that the person in the photo is the same as the person on the ID. Further, the identity could be confirmed with software designed to conduct pattern analysis against a company’s proprietary transaction records—as well as publicly-available digital ledger transaction records.
6. **Blockchain and other distributed ledgers** could be used to give regulators direct, instant access to the information of financial institutions, and could replace regulatory reporting by having regulators participating in the ledger (with appropriately secured permissioned-based systems).