



# The Palgrave Handbook of FinTech and Blockchain

*Edited by*  
Maurizio Pompella · Roman Matousek

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ISBN 978-3-030-66432-9      ISBN 978-3-030-66433-6 (eBook)  
<https://doi.org/10.1007/978-3-030-66433-6>

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Cover illustration: Zoonar GmbH/Alamy Stock Photo

This Palgrave Macmillan imprint is published by the registered company Springer Nature Switzerland AG

The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

*To our sons Giuseppe and Jan*

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Part I

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## Introduction and Context





# Introduction

*Maurizio Pompella and Roman Matousek*

We decided to propose to the publisher this handbook on Fintech and Blockchain about a couple of years ago. The reason we had moved in this direction was the rapid development of new technologies applied to finance and financial intermediation, combined with the Blockchain spread in almost every field of economy and society. While thousands of Fintech start-ups were emerging all over the world, Distributed Ledger Technology was gaining in popularity and effectiveness, and Internet of Things was becoming part of our daily life. All this, and especially the idea that a synchronous, consensually shared database could replace many of the institutions traditionally in charge of the settlement and management of processes unchanged for decades, or maybe since “time began,” was something intriguing that couldn’t fail to be addressed, from our perspective. This is what we tried to do with an extensive, comprehensive, volume.

We therefore started to look for adhesions among our academic colleagues, and more experienced professionals from these fields, having a very broad, planetary horizon. The result is a volume in which more than 30 outstanding scholars and professionals from all over the world have contributed. Our

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greatest gratitude goes to them, for the energies they have dedicated to this work, especially in the adverse contingency we are now suffering from.

An affectionate thought goes out to two colleagues who unfortunately could not keep the original commitment. Namely, our great friend Professor Christopher Culp, who passed away prematurely last summer, and a young colleague who had to fight for over three months against the virus that is currently continuing to plague the planet, before she could be “on top of things” again. COVID-19 has profoundly influenced the process followed during this handbook production, actually, and imposed a series of unexpected changes. We were forced to delay any of our responses to the publisher, in fact, and to postpone delivering as a consequence. But it also offered the opportunity for a few updates, that could allow us to take into account what is going on because of the medical, and social emergency. This is the spirit of the final chapter in fact.

The handbook starts with a chapter that provides an introduction to Fintech from the historical perspective. Paul Griffiths in his contribution provides an overview of the genesis of Financial Technology and its impact on the business environment. Griffiths tries to search answers for the most relevant questions that are important for a deeper understanding of the penetration of Fintech into the business environment and the role of the Global Financial Crisis (GFC) on the development of Fintech. The author searches to answer the following fundamental questions: Why did Fintech emerge as an industrial sector, independent of banking? How is the Fintech industry organized, in terms of the services it offers and the technologies it applies to deliver those services? What is the relationship between banks and Fintechs, and how has this relationship evolved over time? The author argues, among other important issues that the GFC in 2007–2008 and immediate regulatory changes negatively affected the banking industry that lost sight of the technological breakthroughs and social changes. As a result, the industry left windows wide open for nimble companies based on ground-breaking technologies to emerge and “eat its lunch”. It is further argued that the troubles of traditional and/or incumbent banks were compounded by the advent of the knowledge economy. Banks faced difficulties to keep up as selecting a new technology that will drive its processes is no minor decision for a bank and in times when so many technologies are emerging, it is hard to predict which will be the winning ones. Griffiths points out that this was aggravated by developing the business-cases for change based on criteria of the industrial economy. It seems that technology selection is not a level field. He further argues that banks as incumbents have far more to lose than Fintechs and therefore the question is whether extant strategy-technology alignment models apply to banks in times of so much disruption.

In Chapter 3, Zhuo Zhang provides an insight view on financial engineering and Information and Communication Technology (ICT). The chapter is divided into five mutually linked sections. The chapter starts with an informative

overview of the discipline, including the conceptualization of both financial engineering and computational finance. The next sections then provide a synopsis of the evolution of financial engineering from the early 1700s to the present day. The adopted analytical approach logically shows how financial engineering and ICT developed over the last three centuries with the particular emphasis on the last forty-fifty years. The following section overviews the algorithm concepts and software implementation and their significance in financial engineering. Special attention then is devoted in Sect. 3.4 to ICT that include some deeper thoughts about the rise of modern computers and the digital revolution. The chapter then concludes by exploring the importance of ICT in finance.

Rupesh Regmi and Denesh Rai in Chapter 4: FinTech and Blockchain: Contemporary Issues New Paradigm and Disruption, address several important issues. They argue that the expansion of Fintech has shown promising growth, which was not possible in the field of information communication and technology (ICT) without a thousand corrections. Furthermore, the peculiar feature of blockchain technology that disregards the middleman vastly changes the financial sector landscape. The agent-free process, customized human identification, smart digital contract, global open transaction, etc. are some of the lucrative benefits of blockchain technology that makes Fintech appealing. The path to regulation of a FinTech will be faster and less costly than large financial organizations established. As such, it will empower FinTechs to provide compliance data mapping solutions that help the customer simplify data inventory production and processing registers cheaply and efficiently. The authors also devote their discussion to blockchain. They state that blockchain concept and technology previously used for the generation of bitcoin and the transaction has expanded its area of application due to its properties such as security, privacy, traceability, original data provenance, and time-stamping. The authors also discuss the numerous benefits of blockchain, that is to secure every type of transactions, whether human-to-human or machine-to-machine. They argue that blockchain is still in its early phase, altering its features as per global demand. For data security, blockchain requires another internet component to make it trustworthy. The chapter concludes by pointing out that a further expansion of Fintech and Blockchain is to be undermined by the security and regulatory measures. His framework will address the dangers previously inaccessible. Specialized work to form regulatory measures will help foresee Fintech's dependence on blockchain technology.

The following Chapter 5 prepared by Roman Matousek and Dong Xiang focuses on the challenges and opportunities of Fintech companies. The authors show how the digitalization is galloping to every business area and in particular in financial sector. It is further argued that the implementation of technological changes is driven by customer's demand that is influenced significantly by millennium generation. The changes of the banking sector and its products are distributed across all bank's activities: retail banking including progressively expanding mobile banking, wholesale banking, and of course insurance

companies and their use of blockchain. The authors give the main attention to the key areas that give a better understanding of the complexity of the penetration of Fintech into the banking sector. The chapter starts with a discussion about “Creative Destruction of Traditional Banking”, where the key aspects of the evolution and implementation of Fintech are discussed. The discussion is underpinned by a broader theoretical framework. The discussion then follows by highlighting the link between bank competition and the introduction of new technologies. A substantial part of the analysis is then devoted to the role and future of new technologies and new types of banks. The analytical overview is then wrapped by the exploration of the regulatory challenges with a special focus on regulatory sandboxes.

In Chapter 6, David C. Broadstock, Louis T. W. Cheng, and Jack S. C. Poon of The Hong Kong Polytechnic University analyze Fintech Unicorns. This very original contribution shows how Fintech has emerged as a disruptor for financial services. Technology maturity in key factors including cloud computing, big data, artificial intelligence, blockchain and smartphones have culminated in meteoric successes among fintech start-ups, and the emergence of fintech unicorns—privately held start-ups with a valuation exceeding USD\$1 billion. The successes among fintech unicorns have sent shockwaves throughout the financial services sector. The authors discuss the implications of this to the current and future roles of key market players including regulators, incumbent finance, technology, and dedicated fintech firms, as well as new entrants. The discussion is underpinned by an analysis of initial public offerings of unicorns in China, as a performance indicator for tech start-ups, allowing for richer discussion on the components of a successful fintech business model. It is argued that Fintech unicorns epitomize the disruptive potential of fintech as a whole toward the financial services sector and are generating huge uncertainty and risk to traditional financial services providers. customers. The authors point out that an exciting prospect is that fintech unlocks lower cost advanced financial services solutions. The potential value of this is not to be understated, since advanced banking, investment opportunities, life-long wealth planning, and other financial services have often been confined to preferred banking customers with large enough savings to justify the expense to a bank for providing bespoke financial advice. Through automation, AI and fintech can vastly reduce the costs of providing a version of such services, making them accessible to a considerably larger fraction of the population. The subsequent improvements in financial literacy and economic welfare which may ensue are an exciting prospect. The authors further bring up to the reader’s attention also concerns that financial specialists have e.g., financial analysts, concerning the potential role of fintech to provide automated/programmable analyst solutions, and these are legitimate. There will need to be a re-positioning of staff over time, with some roles becoming more machine-based, yet there will always be a human interface component to financial services provision. In summary, fintech will undoubtedly change the face of financial services, and the balance of personnel required in different

service areas, but it cannot replace the functions of incumbent financial services providers.

Tanguy Jacopin in Chapter 7 provides a case study that explores Fintech, Big Tech, and Banks in India and Africa. Jacopin shows that the disruption within the financial ecosystems of India & Africa was made possible by pressure on the competitive landscape that did mobilize many financial resources in IT for Indian incumbents and in M&A for African. It is further argued that as such, these banks were not able to attend properly the challenge of inclusive growth. At the same period, African mobile operators such as M-PESA paved the way toward mobile payments in Kenya whereas the Indian regional entrepreneurial ecosystem in Bangalore was taking off apart from BPO. With the subprime crisis and the advent of big data and digitization, big techs and financial start-ups took the opportunity to disrupt the local financial ecosystems as incumbents were already weakened. Jacopin further explains that despite low average incomes, poor financial inclusiveness, and a negative legacy, both Indian and African financial ecosystems are the most dynamic at the global scale providing some relevant insights for the benchmark for their counterparts. The author finds that even though the organization of the geographic space is different, comparing Fintech in India and Africa, it provides a framework where the disruption takes place in a different context. It is shown that if banks in India have managed until recently to preserve better the microsphere of activity. This was due to large IT investments that enabled the capillarity to reach 80% by 2020. It is also shown that the existence of entrepreneurial ecosystems around Bangalore, Delhi, Mumbai, Chennai, and Hyderabad paved the way for deals in venture capitals that should be relevant in the upcoming years. In the case of Africa, national incumbents were right to consider M&A when French & English banks left Africa for Asia as it has enabled them to become regional players. Nevertheless, as this phenomenon coincided with the digitization and the mobile payment revolution provoked by M-PESA, all telcos managed to enter mobile payments with the support of local fintech. As it was a source of new income for governments, the barriers to entry that used to protect incumbents disappeared. Jacopin then concludes that in both regions, the competitive landscape has evolved in a much favorable aspect for consumers and the customer experience should be a major stake in this open banking scenario where the influence of Big Tech may increase drastically in the upcoming years.

In Chapter 8: Fintech and the Real Economy—Lessons from the Middle East, North Africa, Afghanistan, and Pakistan (MENAP) Region, Inutu Lukonga of the International Monetary Fund tries to identify the policy mix that can enable MENAP SMEs to leverage digital technologies to boost growth and promote inclusive growth. The analysis addresses three principal questions relating to the digitalization of SMEs in MENAP: Can digital technologies usher in a new era of resilience, growth, and quality employment generation among SMEs? How digitalized are SMEs and what constraints do they face in digitalizing their businesses? What policy mix can enable SMEs

to leverage digital technologies to boost their growth and achieve inclusive growth, and what role should the government play? The author applies benchmarking techniques and gap analysis to evaluate the performance of MENAP SMEs and identify needed policies. The review covers 21 of the 24 countries that make up the MENAP region. The analysis is based on both primary and secondary data sources from central bank reports, presentations by senior government officials, World Bank enterprise surveys, and other studies, as well as information obtained through seminars at the IMF, World Bank, and the MENA region. The chapter's analysis is divided into several key sections. The first part provides an overview of the landscape for SMEs in MENAP, focusing on their structure, performance, and constraints to growth and employment contribution. Lukonga also explores the benefits of SMEs adopting digital technologies, reviews digitalization trends of MENAP SMEs and the broader economy, and identifies the factors that hamper digital transformation among SMEs. The final part then summarizes the findings and discusses policy strategies to enable SMEs to leverage digital technologies to boost their growth and employment creation, thereby facilitate inclusive growth. In the conclusion, the author states that more systematic and regular compilation of SME data is needed to facilitate policy formulation that is evidence based. This requires information on the number of firms—characteristics of the SMEs by size, gender, age, and education, their sectoral distribution, their contribution to output and employment, new entries and exits, gender participation, and bank credit to SMEs and SMEs share of NPLs.

Lin William Cong of Cornell University, Beibei Li of Carnegie Mellon University, and Qingquan Tony Zhang of University of Illinois Urbana Champaign's Gies School of Business in their Chapter 9: Alternative Data in FinTech and Business Intelligence introduce recent research in economics and business-related fields utilizing data from unconventional sources or of unstructured nature. The chapter highlights unifying themes of such big data and the methodologies for analyzing them at scale, this chapter elaborates the applications of (i) textual analysis in corporate finance, investment, and macroeconomic forecasts, (ii) image processing in financial markets and governance, (iii) digital footprints from social media and mobile devices, and (iv) emerging data from the Internet of Things. The authors also discuss promising directions of using alternative or unstructured data for both academics and practitioners. The chapter provides an insight into the major types of alternative data, as well as the methods and examples of analyzing or utilizing them, in academic research or practice. The chapter starts with textual data and analytics, which have been used in finance and accounting since the dawn of the century. The authors then introduce the various approaches, the data sources, and recent developments and examines mine images, another form of unstructured data that is available in abundance before touching on audio and video data. The substantial part of the analysis is then focused on the Internet of Things (IoT), which has become prominent in tech innovations and represents a dominant source of alternative data. The authors summarize

the key takeaways of the discussion in this overview of research in economics and business-related fields utilizing alternative data. They also provide a review of the merits and scope of the different categories of alternative data and the methodologies that have been considered. In particular, they highlight textual analysis in corporate finance, image processing in financial markets and governance, digital footprints from social media and mobile devices, and IoT-based data retrieval and applications. The authors also state that the general trend and utility of using alternative data are here to stay and are likely to significantly impact the world of FinTech and business intelligence.

Chapter 10: Bitcoin and other blockchain technologies—mechanisms, governance, and applications prepared by Shoutong Thomas Zhang. Zhang explains that Bitcoin was created to achieve primarily an organizational rather than technical goal. That goal was decentralization. That is, Bitcoin intended to have no single person or organization be in control of the system. One of the original motivations for this was to avoid possible legal consequences to any identifiable entity for running an unauthorized currency system. He further argues that Bitcoin achieved decentralization by using a shared and regularly updated file called a blockchain to coordinate the activities of its decentralized users. The maintenance of this blockchain file requires a careful set of governance procedures, which are the core innovative aspects of Bitcoin. There are three interrelated components to Bitcoin's governance. The first is a set of procedures on how to update the blockchain without a central administrator. This is known as the consensus protocol. The second is a system of incentives for users to contribute computing resources to maintain the blockchain, a process called mining. This mining activity is incentivized by a system of fees and rewards. The third is a process to amend the official Bitcoin software if and when needed. This is done in a way similar to majority voting. Bitcoin's governance mechanisms have proved at least functional, if not effective, in operating the decentralized Bitcoin system. Indeed, Bitcoin has already now arguably withstood the test of time. The discussion is further directed to blockchain applications. The author argues that blockchain applications have emerged since Bitcoin. However, not all of these applications are aligned to the characteristics of blockchains. I conclude with a discussion and critique of five major categories of current applications and their suitability to blockchains. Two appropriate applications of blockchains appear to be decentralized payment systems and the sharing of digital resources, such as storage space or internet bandwidth. The more ambitious blockchain application of smart contracts is also in theory feasible, but practically still undeveloped. In contrast, blockchain applications for data security seem to be less well aligned to the nature of blockchains. Finally, applications of blockchains that are not decentralized but for use only by closed groups (so-called private blockchains) are generally not beneficial except in very specific circumstances, because there are more direct ways to coordinate the activities of a closed group than through blockchains.

Chapter 11 prepared by Andria van der Merwe provides an excellent overview about blockchain and structured products. The discussion starts with a description of the current status of the development. It is shown that many innovative structured products have been introduced that offer digital variations of more traditional structured products such as asset-backed loans and asset-backed securities. Van der Merwe in her analysis points out that the digital structured products differ in their jurisdiction and the number of regulatory requirements, the type of trading venue (over-the-counter or exchange), and the risks. The author stresses the importance of the blockchain as a fundamental building block of these innovations, these products are necessarily exposed to the inherent risks in the blockchain technology such as possible attack from hackers or a potential lack of market liquidity for the underlying cryptocurreoncludes that digital structured products are still in their infancy. Despite that fact, there is a growing interest in these products in particular from investors searching for higher-yielding assets in a low-interest-rate environment. It is shown that structured digital products such as Arca U.S. Treasury Closed-End Fund or the Genesis Capital cryptocurrency-backed lending are grounded in traditional financial principles enhanced with the efficiency of the blockchain. Van der Merwe further shows that other digital structured products are rather novel applications of innovative blockchain technology that include the Ethereum smart contract in the cryptocurrency-backed Dai stablecoin.

The research focus of Chapter 12 that is titled: Categories and Functions of Crypto-Tokens prepared by Lin William Cong and Yizhou Xiao, is given on the discussion about emerging research on digital tokens and cryptocurrencies. They (i) provide a comprehensive categorization of crypto-tokens as observed in practice or being designed, (ii) discuss major issues concerning the economics of using tokens including platform finance, user adoption, stable coins, crowdsourcing, and agency issues, with legal and regulatory implications, and finally, (iii) suggest future directions of digital currency applications and tokenomics research.

Chapter 13: Emerging prudential approaches to enhance banks' cyber resilience is written by Juan Carlos Crisanto and Jermy Prenio of Bank of International Settlement argue that cyber incidents can pose a significant threat to the stability not only of the financial system but also of the global economy. Crisanto and Prenio show that within the financial sector, banks typically have the most public-facing products and services and could be used as entry points for attacks targeting other parts of the financial system. It is further argued that strengthening cyber resilience is, therefore, a key area of attention for banking regulators and supervisors. Regulatory expectations on cybersecurity, which can either be embedded into risk management regulations or established as separate cyber resilience regulations, focus on identification, protection, detection, response, and recovery capabilities of banks. In terms of supervision, most supervisors are assessing cybersecurity as part of their ongoing risk-based supervisory activities, while others are complementing these with



thematic or specialized supervisory reviews. Regulatory expectations generally inform supervisory reviews but in certain cases, such as in testing cyber resilience, supervisors use specific frameworks or tools. The authors point out that it is necessary to explore further collaboration with the industry in strengthening banks' cybersecurity and to pursue greater cross-border cooperation. The detailed analysis also shows that in some jurisdictions, regulators are working closely with the industry in creating or promoting platforms for intelligence-sharing, developing a pool of cybersecurity professionals, and establishing guidelines on penetration testing. Crisanto and Prenio indicate that this could be a model that other jurisdictions could use, especially those with limited regulatory and supervisory resources, smaller banks, or a scarcity of cyber- and information security professionals. Moreover, given the scarcity of cybersecurity resources and the cross-border nature of cyber risk, the need for supervisory cooperation cannot be overemphasized. In this regard, the BIS's Cyber Resilience Coordination Centre (CRCC) is expected to play a key role in facilitating cross-border cooperation. The CRCC seeks to provide a structured and careful approach to knowledge-sharing and collaboration between central banks in the area of cyber resilience. A core CRCC service is to provide a secure collaboration platform for information-sharing on multilateral cyber threats.

Chapter 14 is prepared by Zenu Sharma and Yun Zhu. The authors overview research on blockchain development, funding of blockchains through ICOs (initial coin offering) and discusses also the implications for risks and regulation of blockchains. This Chapter provides an insight into various risks posed by new technologies. Sharma and Zhu explore ICO with the particular emphasis on the platform developments phase, the recent developments in the blockchain technology/industry. The chapter starts with a brief discussion on the background of the platform development of blockchain system, with a unique focus on the difference between permissionless and permissioned blockchains, and evaluate the consensus mechanism of the permissioned system, which has more pronounced prospect in high-level applications. As for the permissionless blockchains, the authors cover the most trending topic in various types of digital tokens, including Bitcoin and other popular cryptocurrencies, as well as the debate in choosing between ICO vs. Airdrop in developing a new token. This discussion is then followed by the examination of the dark side of the technology. Sharma and Zhu explore various risks and challenges that arise from the blockchain ecosystem, including the traditional systemic risk of the financial system. Consequently, with the challenges and opportunities associated with Blockchain technologies, they further review a few policy responses adopted by various governments in regulating DLT/Blockchain, in issues related to consumer protection, competition and the enforceability of contracts, and cross-border coordination.

Chapter 15: Blockchain and Cyber Risk: Identifying Areas of Cyber Risk and a Risk-based Approach for Executives by Charla Griffy-Brown, Mark W.

S. Chun, Howard A. Miller, and Demetrios Lazarikos. The authors start their analysis by showing that the blockchain architecture could help to improve cyber defense, as the platform can prevent fraudulent activities through consensus mechanisms. It is further argued that the technology can help to detect data tampering based on its underlying characteristics of immutability, transparency, auditability, data encryption & operational resilience (including no single point of failure). The authors point out that there is little evidence in the existing body of research literature on the topic of blockchain, the associated risks, and the extent to which these risks can be evaluated and incorporated into corporate decision-making. Thus, they impose the following research questions: What are the risks associated with blockchain? How can these risks be evaluated and integrated into corporate decision-making? The conducted To answer these questions, the arguments are based on previous research and by developing a risk-based approach for securing our current complex enterprise architecture and agile data center environments. The research methodology involved a survey and interviews with 60 executives from 80 companies from Sept 2018–2019. The authors developed cyber-physical framework for executives to use. This specific chapter offers insight by methodically identifying and characterizing the main risks in blockchain and providing a practical framework and tools for making better security decisions involving this technology. Finally, the authors propose a model for addressing security with the growth of blockchain and other emerging technologies. They suggest that it is essential to focus on the project life-cycle, the deployment process, and constantly asking questions to identify risk as part of the project management organization.

Chapter 16: Fintech and Financial Intermediation written by Panagiota Papadimitri, Menelaos Tasiou, Minas-Polyvios Tsagkarakis, and Fotios Pasiouras, provides a discussion of how the three main product sectors of FinTech are so far seen interacting or potentially disrupting in the near future—key segments of financial intermediaries, as well as an overview of FinTech regulation and financial stability aspects. The authors show that FinTech innovation has truly captured the interest of various agents in the economy over the past decade. The accelerating hype can be observed in several forms, starting from simple interest in the general population, to product adoption rates, and investment indicators. The three product sectors seem to relate directly to banking services, which, combined with the exponentially accelerated hype over the past five years, yield the question of whether this wave of innovation brings any sort of disruption in financial intermediaries' business models. It is argued that the early views and estimations are somewhat mixed on this front, and they may be dependent on the specific product sector and/or for a specific market segment. The analysis indicates that FinTechs have so far enjoyed a booming period, which can be attributed to a declining post-crisis consumer trust in intermediaries, and the lack of strict regulating frameworks like those surrounding traditional banks. Yet, with the spotlight on this industry and the gradual entry of Big Techs in the arena, this

may well change in the near future. The authors try to assess the impact of the evolution of fintech products and services on the banking industry. They identify five scenarios to describe the potential impact of fintech on banks. They also impose an important question whether the FinTech is a true “revolution,” or if it simply remains a mere “evolution.” They show that fintech overall is actually just natural market evolution and the assumptions about disruption—or indeed, creative destruction—are, with apologies to Schumpeter, probably out of proportion. Indeed, some early signs and executives’ thoughts seem to lean toward intermediaries adapting, evolving and even co-operating with innovating FinTech players, rather than directly competing against. After all, let us not forget that, when a pie increases in a market, it may as well be the case that everyone’s share is enlarged, even if unequally. Thus they conclude that banks generally open to innovation and challenge may as well simply “have their cake and eat it too.”

Chapter 17: Financial Disintermediation: The Case of Peer to Peer Lending written by Petr Teplý, Yael Roshwalb, and Michal Polena, focuses on innovations in technology used by finance and banking companies specifically designed to replace established industry middlemen, otherwise known as “financial disintermediation.” The chapter is organized as follows: Sect. 17.2 provides a review of the use of blockchain in financial services. In Sect. 17.3, we discuss P2P lending in a broader context regarding credit risk management. We analyze essential risk management methods recently applied by P2P platforms and also present a case study on the use of blockchain in the P2P lending market. Within this context, we review the key advantages, such as cost reduction, time management, competitive interest rates, flexibility, and better credit risk management on P2P lending blockchain-based platforms against their disadvantages, including the infancy of blockchain, regulatory uncertainty, the inherent risks of P2P platforms and the riskiness for an investor. In addition, we provide a brief review of classifier methods that rely on collecting datasets for decision trees which allow for analysis dependent on the quality of the data itself. However, aggregating collections of decision tree results, such as with random forest analysis, could provide the ability to analyze numerous portfolios of P2P lenders over time, a perspective that could lead to less biased and more robust predictive insights. Finally, Sect. 17.4 concludes the chapter and states the final remarks. In this chapter, the authors present a review of innovations such as blockchain, smart contracts, artificial intelligence, and machine learning approaches. The authors discuss both the recent and the potential uses of blockchain from accounting, legal, and financial perspectives and briefly reviewed smart contracts, a high-level summary of classifiers and risk scoring methodologies. The authors identified five business areas dependent on P2P blockchain technology that have been identified as promising in financial services: payments and remittances, credit and lending, trading and settlement, compliance, and record management. A further contribution to extensive research in this particular area, the authors overview the performance measurement techniques based on classifiers to forecast loan defaults and refine

credit scoring. It is shown that three main areas, in which “blockchain as a service” can be superior are the following: blockchain-based creditworthiness assessments, blockchain and real-time accounting, and historical data-keeping. It is important to note that while the integrity of blockchain code may withstand hacking attempts, the transaction data itself must be accurate and devoid of fraud for the value of blockchain to be recognized. At the end of this chapter, the authors then estimate that the funding of P2P platforms will increase from a recent USD 100 billion to USD 150 billion by 2025 (of which we forecast a 10% market share of P2P blockchain-based platforms or USD 15 billion in absolute terms). These numbers suggest that investment in P2P blockchain-based platforms will rise in the coming years and disrupt more traditional lending establishments relying on “analog” credit scoring methodologies. In terms of potential disintermediation, the authors estimate that a catalyst to the exponential growth of the P2P platforms in the future would be if the private credit market, comprised of high-net-worth individuals offering direct loans (e.g., loans in excess of USD 50 million+ ) in exchange for high yields, were to adopt P2P platforms as their foremost vehicle for extending credit, managing their portfolios and collecting on defaults. Finally, it is concluded that future research will undoubtedly analyze the upcoming trends in loan defaults or investments to provide real insight on P2P platforms during unprecedented market conditions.

Chapter 18: Fintech and Blockchain based Innovation: Technology driven Business Models and Disruption by Maurizio Pompella and Lorenzo Costantino, is about the continuously evolving business models adopted in the Fintech sector, and more specifically is focused on the question of whether Fintech and in general disruptive technologies related to digital banking will lead to the end of traditional banking, and will make banks and financial intermediaries obsolete. By successive approximations, the authors identify the limitations of the arguments for disruption. Starting from the journalistic way of describing disruption of banks as a “uberisation of banking sector,” two paradigmatic examples of sharing economy from mobility and lodging sectors, respectively, are taken into account, such as Uber and Airbnb, to extrapolate analogies and differences. The main conclusion of this exercise is that, in the same way, Uber and Airbnb could not replace taxi and hotels, triggering and accelerating efficiencies, competitive pressure, and opportunities for new entrants instead, fintech and new business models will not disrupt or cancel financial intermediaries, and specifically banks. Rather than “disruption” leading to the disappearance of banks, they will bring a new way of banking and financial intermediation provided by the new entrants actually: a new way of “doing banking” with traditional banks innovating and tailoring servicing and products. The authors suggest that the advent of new technologies will not necessarily disrupt the banking and financial intermediation, therefore. Rather they will trigger innovation and evolutions that may lead to a “new breed of banks and financial intermediaries” that will adjust to those evolutions and embed such innovations. Banking and finance have been evolving over the past

decades with the advent of new technologies and products. As such, banks appear to be well positioned to absorb—and adjust to—any disruptive impact of DLTs and blockchain by developing new business models and capitalizing on their dominant position by embedding those technologies and services.

Then, Pompella and Costantino raise concerns on potential threats deriving from specific financial innovations, such as Tokenomics, for instance, somehow referred to—with an explicitly provocative intention—like a trick to produce “Nothing-Backed Securities.” And this is the opportunity, for them, to emphasize the lack of regulatory framework.

Chapter 18 is complemented by Chapter 22, where the consequences of the pandemic are specifically dealt with, and a few directions for regulators are proposed, in order to let them properly react.

The following Chapter 19: Digital Currencies and Payment Systems. Chinese way into internationalisation of the renminbi prepared by Ewa Dziwok, explore how new payment options and new forms of money allow China a gradual but systematic internationalization of the renminbi and strengthening its role as an international medium of exchange outside a traditional banking system. Dziwok states that in the digital world rules are not the same—no borders and benefits connected with digital technology make transactions faster, cheaper, and easier to do. It simplifies global recognition of different currencies that could either replace or coexist with a local currency. The emergence of a world digital currency is possible and real. The author shows that China’s ambitions to enforce the role of yuan are not new—the path into full internationalization was taken for decades and started in 1979 from its first step “open door policy.” It is further argued that the Global Financial Crisis paradoxically speeded up that process thanks to the fact that China was not affected as much as the rest of the world. The author also imposes a timely question of whether it is enough to make Chinese renminbi (RMB) a desirable reserve instrument, store of value, and medium of exchange. Dziwok argues that there is a need to fulfill several conditions that are crucial to be assessed as an international currency. Dziwok highlights channels of how to spread yuan abroad through several initiatives that have been existing with success for several years.

Finally, it is discussed how the recent regulatory changes in China speeded up preparations to launch its digital currency and Alipay and to switch to clearing company UnionPay (state-owned). Dziwok then concludes that all these activities, together with a new digital currency, could cause that China will not dominate the existing financial system but bypass it.

Chapter 20: Cryptocurrencies and other Digital Asset Investments written by Andria van der Merwe deals with a very interesting topic. The chapter starts with the description of four, interrelated components of the crypto-economy typically consists of: (i) the distributed ledger or blockchain; (ii) the digital assets such as bitcoin; (iii) the active participants or “miners;” and (iv) the passive participants or users. A particular blockchain is comprised of blocks or groups of cryptocurrency transactions. A particular transaction represents the

purchase or sale of cryptocurrency between two participants. The number of transactions per block varies—e.g., the original Bitcoin protocol allowed up to 2,000 transactions per block. Only settled transactions are included in a block appended to the blockchain so that the speed with which new blocks are created effectively determine the time it would take to settle a particular transaction.

The author argues that the real innovation behind cryptocurrency is the blockchain, which enables user-to-user trading among decentralized participants and settlement and recordkeeping of such transactions without a trusted, centralized authority. Transactions are settled by a collection of anonymous, active participants referred to as miners. The price of cryptocurrency is closely linked to the number of participants assigning value to it by engaging in trading. It is further argued that the cryptocurrency is not fiat money, but it could be used as a medium of exchange in the crypto-economy. It is shown that in the broader economy, cryptocurrency functions as a digital, intangible asset with little resemblance to most traditional asset classes. From an economic perspective, cryptocurrency shares the limited supply characteristic of non-renewable commodities—in the case of cryptocurrency the limited supply is an artificial scarcity embedded in the protocol design. Der Merwe shows that cryptocurrency may add diversity to an investment portfolio because of its low correlation with more traditional assets. It concludes that a potential investor should however recognize the qualitative and quantitative risks typically associated with an investment in cryptocurrency such as the high price volatility and unique market structure.

Chapter 21: How does digital transformation improve customer experience?, prepared by Spencer Li, explains how disruptive innovation drive digital transformation rapidly. Li shows that recent researches indicate that good end-to-end customer journeys generate business results better than touchpoints. Customer journey mapping is the center of all consumer-focused organizations and can transform business by multi-layer studying on the existing process and soliciting constructive insights and suggestions from stakeholders. Li points out that the executives always learn lessons from customer journey map exercise. The author advocates the view that Gartner CX Customer Experience Pyramid proves customer experience driving loyalty, and therefore it is recommended to focus on fine-tuning digital services to improve customer care, customer experience, and customer-centricity to achieve better customer satisfaction. It is also suggested that top executives could apply know-how to improve customer satisfaction through digital transformation. It is further shown that recent trends confirm that most promising disruptive technologies have been developed rapidly and come to maturity. These disruptive technologies contribute to the following development: 5G, Blockchain and Crypto-currencies, emerging BaaS, AI, and Machine Learning, Cloud, Big Data and Faster WiFi (according to Accenture, Gartner, McKinsey, etc.); These disruptive technologies will be applied for FinTech, smart cities, IoT, analytics and cloud computing; These disruptive technologies kick-off the

digital transformation era; corporates want to compete with competitors for the survival. ING transformation project “Think Forward” is a good example of changing traditional finance business into an “ING as platform” business. Li concludes that the transformation is not an easy task. Without top management commitment, intensive investment, the right direction, and a good pilot project, transformation does deliver the expected outcome.

Chapter 22: From Disruption to post-Pandemic Scenario, again by Pompella and Costantino, is the ideal complement of Chapter 18. Now the authors bring into the discussion the COVID-19 pandemic stroke, revolutionizing social and economic paradigms, and heavily affecting Fintech, Blockchain, and banking sector as well. “Pandemization of economy” like they call contingent and permanent changes imposed to the economy as a whole, and to financial institutions/intermediaries, is described as a pervasive and irreversible process comparable to Dot-Com Bubble and Great Financial Crisis. Their point is that COVID-19 is deflating the bubble of blockchain and fintech before it bursts: in other words, the pandemic is accelerating the process and anticipating some of the adverse effects of a bubble, enacting a process of natural selection that is due not to an internal process but to an external factor, disruptive again. The COVID-19 can hence be considered a “reset” in the industry as it is revealing the extremely positive potential of fintech and blockchain solutions while exposing the vulnerabilities of the hype-related compliancy of some blockchain and fintech ventures.

Having said this, and assuming just for a while that the devastating health and social consequences of COVID-19 may be ignored, the virus is also presented like an unprecedented opportunity for governments, regulators, and policy makers. In a sense that governments have a chance to advance the implementation of public blockchain and fintech initiatives, whereas policy makers and regulatory agencies could reassert their leading role in the space of blockchain and fintech by proactively acting rather than merely reacting.



# Fintech and Its Historical Perspective

*Paul David Richard Griffiths*

## 2.1 INTRODUCTION

The last three decades of the twentieth century witnessed the adoption of information and communications technology (ICT) by business corporations at an increasing rate and banks were leaders and trendsetters in this process. However, this leadership role of banking in the development of corporate ICT was lost in the second half of the first decade of this millennium. This chapter intends to shed light on the process that led to this. In-so-doing, it addresses the questions: *Why did Fintech emerge as an industrial sector, independent of banking? How is the Fintech industry organised, in terms of the services it offers and the technologies it applies to deliver those services? What is the relationship between banks and Fintechs, and how has this relationship evolved over time?*

This chapter is organised in the following way. Section 2.2 will give an overview of the evolution of ICT in the last three decades of the twentieth century. From the specific perspective of banks, it will show that the financial sector in general, and banking in particular, was a driver of the ICT evolution during that period, until the mid-2000s. Section 2.3 will describe a curious phenomenon that occurred in the 1990s in which companies invested heavily on ICT but those investments had very little perceived effect on performance—it will be shown that this is owed to the transition from the industrial economy to the knowledge economy. Based on current literature, Sect. 2.4 identifies three root-causes for banks to have lost control over the ICT agenda

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in the financial sector. Section 2.5 presents the results of a survey of banking and Fintech players that corroborates those root-causes. In having lost control of the evolution of ICT, banks opened the window for a new industrial sector to emerge, the Fintech sector, and Sect. 2.6 will give a framework to understand how the Fintech sector is structured based on a classification of the players according to the functional services they offer and the types of technology they apply. Section 2.7 describes how the traditional banking system has reacted to the emerging of Fintech, and in the final two sections there will be a discussion and conclusions.

## 2.2 TWENTIETH CENTURY: ICT EMERGING AND EVOLUTION

As anticipated in the Introduction, the last three decades of the twentieth century witnessed the adoption of information and communications technology (ICT) by business corporations at an increasing rate. During the 1970s and 1980s it was large systems developed and running on mainframe computers, with bespoke applications of narrow functional scope and weak integration with other functional applications. ICT was essentially about number-crunching large volumes of flat files, initially fed in by perforated cards and later in the period by magnetic tapes and discs. It was a domain restricted to the largest corporations, prominent amongst them the big banks, government institutions and universities. Systems were all corporate and managed by large IT departments with battalions of in-house programmers, analysts and systems engineers complemented by professional staff belonging to the large systems companies (that later called themselves ‘integrators’) such as IBM, Honeywell-Bull, ICL, Unysis. The technology platforms on which these corporate applications were developed were proprietary, with no convertibility from one vendor’s platform to another vendor’s: Client lock-in was the name of the game.

Democratisation of ICT and its access to the smaller corporations and companies came in the mid- to late-1980s and early 1990s with the advent of the mini-computer, the table-top personal computer, local area networks, handheld devices and, very importantly, the relational database. Democratisation turned into revolution with the access to, and popularisation of, the Internet.

The until then reigning mainframe computer and its centralised architecture ceded part of its domain to the distributed client–server architecture. The mainframe did not completely go away as those organisations who had them tended to keep the mainframe as database server due to its low cost per transaction for large volumes of transactions.

In parallel with client–server a significant change in the 1990s was the advent of the enterprise resource planning (ERP) systems with a new key player that with time became the dominant player in the corporate applications world, breaking the until then hegemony of the Anglo-Saxon companies:

SAP from Waldorf, Germany. Being the four founders of SAP ex-IBM engineers, the first versions of their ERP ran on mainframes, but they really took off with their first client-server version that they called R/3 and released in 1993. There were competing providers such as Oracle (with its Financials), JDEdwards and PeopleSoft. This wave responded to a significant change in philosophy and the name of the game now had two dimensions: (a) it was all about packaged solutions, that is solutions that did not need code developed from scratch for each corporation, but that would be standard with the possibility of configuring parameters for limited adaptation to each company; and (b) integration was dominant over best-of-breed solutions, that is that now it was more important to have integration across functional applications than to have the best individual and isolated application.

Integrated packaged solutions brought with them another significant change: the concept of ‘leading practices’ in business processes. While the bespoke systems of the mainframe era were modelled in line with the processes of each company, in the ERP era the company would adapt its processes to the leading practices in-built in the solution. The implications of this are that the implementation of an ERP system would lead to significant changes in processes that, in turn, radically changed people’s jobs. Thus, change management became an important component of implementation projects, with a focus on stakeholder management and training of people in entire processes, not just their specific task in a large process as was the case before.

Another change that came with the ERP wave is how projects were organised. The configuration of a systems project team was no longer a team of highly technical analysts and programmers, but people who were versed in business processes. The bulk of the work was not in coding but in parameter configuration and change management activities. So, the project teams were integrated mainly by non-technical systems people. ERP projects were not referred to as systems or technology projects anymore, but as business transformation projects enabled by technology.

Ripples of ERP in 1991–1993 became waves in 1994–1998 and turned into tsunamis approaching 2,000 and the generalised policy of implementing ‘vanilla’ ERPs to sort the Y2K problem (this term was coined by Gartner Group and refers to the fact that the early mainframe systems had only two-digits for the year in dates, so it was suspected that they would all fail with the advent of the new millennium). With the advent and establishment of ERPs, came the reduction in the size of the IT departments in corporations. In effect, what adopting and implementing ERP meant was that the development of new functionalities to adapt to changes in the legal and tax environment, or to the need for new functionalities, was outsourced to the ERP vendors.

Of course, ERP was not the panacea that appears at first sight. Significant amount of coding to ensure integration with legacy systems or vertical industry-specific applications were still necessary. Although ‘big bang’ projects were highly promoted, common sense and risk management led to many projects being piloted and phased in, which meant that temporary interfaces

had to be developed. And although the ERP vendors did produce their solutions with specific flavours for different industries, this was still not enough and corporations demanded having some of their vertical functionality developed outside of the ERP. For example, SAP achieved a highly competent footprint in the consumer-packaged goods (CPG) and in the utilities industries, but never managed to produce convincing solutions for the core-banking functionalities despite having invested heavily in its solution for that sector. In other words, coding and development effort for integration did not entirely go away.

After the ERP binge triggered by Y2K came the hangover in the form of a relative slowdown in the ERP market, but that did not stop the corporate-systems business as a whole. At around the time that ERP slowed down e-commerce and client relationship management (CRM) solutions emerged with force. E-commerce was the hottest product but it was severely impacted by 9/11 and the implosion of dot.com, recovering afterwards but growing at a more moderate pace.

With the slow down of the ERP market and of the global economy after 9/11, came a consolidation within the corporate ICT solutions industry. SAP expanded its functionality into CRM, e-commerce and business intelligence through internal developments but later broke this tradition by entering the acquisitions path. Oracle, on the other hand, acquired PeopleSoft, Siebel (the leading CRM provider), JDEdwards and many others, with significant pains in converting all these independent applications into a coherent, seamless offering to its clients. Oracle also moved into the hardware space by acquiring SUN Microsystems and SAP moved into Oracle's traditional realm, the database layer, through acquisition, too. Oracle articulated the concept of 'stack', from hardware to enterprise application, through operating systems, databases, integration layers and others. Oracle publicised itself as being able to offer the whole stack or just some of the layers.

The strong narrative of ERP vendors in terms of the importance of integration started weakening with the advent of intelligent middleware communications platforms that made unnecessary the dreaded point to point, or one to one, interface development. The nightmarish spaghetti-style interfaces that haunted CIOs and kept them awake at night, could now be substituted by simpler to understand middleware layers into which applications could easily be plugged in. Another highly significant concept that was materialising and coming of age at the turn of the century was the API (application programming interface—term that was coined decades before by Cotton and Greatorex 1968), a set of subroutine definitions, communications protocols and tools for building software. Years later APIs would come to play an important role in the Fintech world, particularly as a result of Open-Banking regulation.

The prior paragraphs give an overview of how corporate ICT in general developed from the 1970s to the early 2000s. The effect on business transformation of the adoption of ICT was highly significant, but nowhere more than in banking. Banking is an information-intensive industry, by which it is

meant that differentiation comes exclusively from their intellectual capital and information or, in other words, their people, processes, relationships and technology (Clayton and Waldron 2003; Griffiths 2003, 2005; McKeen and Smith 1996; OECD 2003, pp. 65–66).<sup>1</sup>

Driven by this dependence on information, banks played very much of a leading role in adoption and development of ICT, and the trajectory they followed differed from the mainstream CPG, retail, industrial products, utilities corporations. Banks were clearly ahead of the pack in the early phase of that period, that of the bespoke systems running on mainframe computers. They were so heavily vested in those technologies and had such high numbers of transactions compared to the other industries, that they could not make the business case based purely on tangible benefits for moving to client–server. This, together with the fact that banking processes and applications had become highly sophisticated and business-critical at an extreme, disincen- tivised the ERP vendors to develop vertical solutions for banking in the early days of ERP. Eventually SAP did propose a banking-solution, but its adoption was disappointingly slow and hardly ever with an end-to-end footprint but limited to fragmented pieces of the business. Essentially, the largest banks are trapped, to this day, in their legacy systems.

Indeed, banks have adopted standard packaged solutions in many parts of their business, particularly the highly technical middle office, but the back-office remains on the legacy systems. That is not to say that there have not been any client–server solutions for banks, but the more successful ones have been developed by specialised companies and not the leading ERP vendors. For example, Citi co-developed a client–server core banking system with a company called i-Flex of India, to implement in its smaller operations around the world (it later divested from i-Flex and a few years later i-Flex was absorbed by Oracle). So, essentially, banks did not participate in the ERP part of the prior narrative.

Notwithstanding their attachment to the legacy mainframe systems, banks did make some memorable breakthroughs, of which the ATM is a notable example. The generalisation of ATMs in the 1980s enabled banks to give 24 × 7 service and significantly lower their banking transaction costs. This led to the self-service kiosk technology that is still in the process of being adopted by other corporations in most other industries, and government.

The ATM was followed by the waves of phone banking, home banking and internet banking. They all had in common pushing their Clients out of the branch office and lowering further the costs of banking transactions and brought with them the need for omni-channel, that is the need to show the same face to the client independently of what channel the client chose to interact with her bank. So, the big banks that had departed from mainstream in the ERP age, took leadership again in the CRM phase. With this came the transformation of the banking branch office, that until the 1990s was a mini-bank in its own right with all functionalities in the branch. From the turn of the century banks took all the back-office and middle office functionalities

(e.g., bookkeeping and accounting, credit scoring, loan origination) from the branch to the head-office, and most of the transactional activity out of the branch to remote channels. The branch office became far smaller and focused on value added client services.

This narrative brings us to the mid-2000s when a tipping point with several fronts was reached in the ICT world as will be developed in later sections. As has briefly been outlined in this section, ICT in business and government went from a rarity in the 1970s to complete infiltration and dissemination in the early 2000s. What this story is telling us is that during this period of study the world, or at least what we generally refer to as the Western world, almost unperceptively migrated from an industrial economy of predominantly tangible assets, to a knowledge one where intangible ones overwhelmingly predominate over the tangible. This is a new era where the application of ICT radically changed, and where banks lost their grip on its development.

The importance that ICT took on in the business world in general, but especially so in such an information-intensive sector as is banking, makes the research questions stated in Sect. 2.1 of the utmost relevance both to the practitioner and the academic worlds. The process through which this happened is described in Sect. 2.4.

### 2.3 PRODUCTIVITY PARADOX: THE ICT INVESTMENT AND ITS IMPACT ON PERFORMANCE CONUNDRUM

ICT investment in the last decades of the twentieth century and early years of this millennium were haunted by the productivity paradox as depicted by Robert Solow, the Nobel laureate in Economics, as that ICT is seen all over the place except in the productivity metrics. Corporations were investing billions on ICT, but it was hard to justify such investments in terms of their impact on performance under the purely tangible benefits criterion of the industrial economy.

There already was an extensive body of knowledge on the link between ICT investments and corporate performance; there were many journals (e.g., Electronic Journal on Information Systems Evaluation, EJISE) and popular academic conferences (e.g., European Conference on Information Technology Evaluation, ECITE) that focused exclusively on the issue of ICT evaluation. The extant literature showed how complex an issue this was and how there were a wide variety of opinions which were not easily integrated on the subject. The lack of convergence of thinking amongst the academic community was probably owed to the many perspectives from which this issue can be approached, and that there were no dominant theories on which researchers could underpin their work. Griffiths (2005) provided some conceptual order along four perspectives through which the problems with ICT evaluation can be analysed, as depicted in Table 2.1.

The first of these perspectives, which can be called the *inadequacy of measurement tools*, addresses the relationship between ICT investments and

**Table 2.1** Explanations for the productivity paradox (Griffiths 2005)

<i>Perspective</i>	<i>Most relevant issues</i>	<i>Key papers</i>
Inadequacy of Measurement Tools	Productivity paradox of IT can be explained by: a. Output measurement limitations in a service economy b. The benefits from ICT can take several years to show results	Brynjolfsson (1993), Haynes and Thompson (2000), Bannister and Remenyi (1999), and OECD (2003)
Portfolio Effect	ICT portfolio of infrastructure, transactional, informational and strategic systems Each has its own value proposition driven by a different risk and returns profile Need to move away from traditional accounting based tools for supporting business case quantification	Weill and Broadbent (1998), Ross and Beath (2002), Prahalad and Krishnan (2002), Davis (2002), and Benaroch and Kauffman (1999)
Change Facilitator	Stakeholder management needs to be handled with care Notorious lack of accumulation of knowledge on ICT usage Complementary investments in changing the organisation, in training, in infrastructure	Heraclous and Barrett (2001), Trice and Treacy (1986), McConnell (1997), Keen (1991), and OECD (2003)
Competitive Advantage	ICT capability (more than investment) has a positive effect on the bottom line Must understand the underlying mechanisms through which rational information technology investments and strong ICT capability lead to superior performance Quantity of ICT usage and availability of ICT competencies are not enough A clear mission is a pre-requisite for any ICT based transformation ICT investments to pursue a cost leadership strategy achieve only a temporary advantage Sustained advantage comes from the <i>ICT</i> platform, not from specific ICT applications	Bharadwaj et al. (1999), Bharadwaj (2000), Santhanam and Hartono (2003), McKeen and Smith (1996), Trice and Treacy (1986), Crowston and Treacy (1986), Scott Morton (1991), Hitt and Brynjolfsson (1996), OECD (2003), McConnell (1997), and Keen (1991)

Source Griffiths (2005)

productivity. Although the link between information technology investments and firm performance still needed to be researched, there was evidence to support that the productivity paradox of information technology could be explained by the output measurement limitations in a service economy, and by the limitations in change management in ICT projects. In other words, that the then current accounting practices were inadequate to measure productivity in the information economy (Brynjolfsson 1993; Haynes and Thompson 2000; Bannister and Remenyi 1999; OECD 2003), and that the benefits from ICT could take several years to show results on the bottom line due to limitations in learning how to do business in the post-ICT investment environment (Brynjolfsson 1993; Peppard 2001; Haynes and Thompson 2000; OECD 2003).

The second perspective, which can be referred to as the *portfolio effect* tackles the fact that different ICT Investments achieve fundamentally different business objectives. These are usually described under four headings as infrastructure, transactional, informational and strategic. These management objectives lead to an ICT infrastructure and transactional, informational, and strategic systems which, together, form the organisation's ICT investment portfolio (Weill and Broadbent 1998). Each of the four value creation categories has its own value proposition driven by a different risk and returns profile, and therefore should have its own investment decision criteria (Weill and Broadbent 1998; Ross and Beath 2002). The application portfolio of the firm should balance efficiency for mature processes with flexibility for innovation in evolving processes. A cost leadership strategy is only applicable in the more stable process domains where the firm can invest for standardisation and efficiency. A strategic positioning approach requires investment in flexible applications to support evolving processes in the search for innovation (Prahalad and Krishnan 2002).

But moving to these more sophisticated ICT investment criteria surfaced the limitations of the traditional accounting-based tools for supporting business case quantification. Information technology decision-makers needed to adopt and adapt tools from other disciplines (such as NPVR and OPM) that give more flexibility for estimating risk and could give value to investment deferral options. However, much research needed to be done before these tools were available for practitioners (Davis 2002; Benaroch and Kauffman 1999).

The third perspective, which is the *change facilitator* factor, refers to ICT investments and Change Management. ICT implementations can result in radical changes on how work is performed, and therefore stakeholder management needs to be handled with care. Leaders need to go beyond what multiple stakeholders say about the intended information systems implementations and attempt to understand their deeper values and beliefs (communicative action vs. deep structures) as a means of anticipating and reducing resistance to changing the way people work and their use of the new ICT tools (Heracleous and Barrett 2001). Although ICT Usage is key to enabling ICT investment

returns, there was (and maybe still is) a notorious lack of accumulation of knowledge in this area. This shortcoming is attributed to the absence of standardised measures which, in turn, derives from the absence of accepted underlying theories (Trice and Treacy 1986). Finally, there was research to unequivocally suggest that in order to realise value from ICT investments, these need to be accompanied by complementary investments in changing the organisation, in training and in infrastructure (McConnell 1997; Keen 1991; OECD 2003).

The fourth perspective, referred to here as the *competitive advantage*, is ICT investments to create a distinct competitive edge. Although there was some evidence that information technology investments had a positive effect on long-term firm performance (Bharadwaj et al. 1999), it appeared that it was ICT capability (more than investment) that had a positive effect on the bottom line. Thus, firms should not merely invest in information technology, but also focus on developing their ICT capabilities (Bharadwaj 2000; Santhanam and Hartono 2003). What was not well understood were the underlying mechanisms through which rational information technology investments and strong ICT capability lead to superior performance. The main reason for this is that most research efforts had measured the direct relationship between some independent variable related to information technology and a variable representing performance, without paying attention to intervening variables. An alternative conceptualisation was to have a two-stage model that examined the effects of ICT on intermediate process variables, which in turn were associated with higher level performance variables (McKeen and Smith 1996; Trice and Treacy 1986; Crowston and Treacy 1986).

But even a two-stage model may not be enough. It had been seen that Trice and Treacy (1986) and McKeen and Smith (1996), used a two-stage model with ICT Usage as the intervening construct, and discussed different ways of measuring the *amount* of usage. The question that was not being asked or measured is whether ICT was being used for the right thing. In the same way, much of the research centred on the *resource based view* of the firm (e.g., Bharadwaj 2000; Santhanam and Hartono 2003) looked for associations between ICT Capability and business performance, as if performance depended only on the availability of ICT Capabilities and not on *how* they were used. It is almost as if the relevance of strategy and technology alignment was being ignored, despite of findings that indicated that a clear mission was a pre-requisite for any major organisational transformation, but particularly so if it is a technology-enabled one (Scott Morton 1991).

Additional findings in terms of ICT investments and competitive advantage were that (a) firms that use ICT investments to pursue a cost leadership strategy, achieve only a temporary competitive advantage and forfeit the benefits of their information technology investments to their Clients (Hitt and Brynjolfsson 1996; OECD 2003); and (b) sustained competitive advantage comes from the *ICT platform* rather than from specific ICT applications: an ‘enabling’ view of technology infrastructure that combines global reach



and range of services is far harder to duplicate than individual information technology initiatives (McConnell 1997; Keen 1991) and therefore provide a longer window of competitive advantage.

In order to overcome these limitations Griffiths (2005) defined a model for banks, that was later extended to corporations in general (Griffiths 2011) that classifies ICT investments into *Infrastructure*, *Long Term Value*, *Platform for Change*, and *Platform for Innovation*, and defines which kind of ICT investments will create the most value in terms of the value discipline of the organisation. Each of these categories of ICT investments has different contributions to value and in different forms of value; while some contribute tangible benefits, most contribute intangible ones. What this story is telling us is that during this period of study the world, or at least what we generally refer to as the Western world, migrated from an industrial economy of predominantly tangible assets, to a knowledge one where intangible ones overwhelmingly predominate over the tangible. This is a new era where the application of ICT radically changed, and where banks lost their grip on its development. This process is described in the next section.

## 2.4 ADVENT OF TWENTY-FIRST C AND THE INFLECTION DECADE: WHY DID BANKS LOSE CONTROL?

### 2.4.1 Overview

A thorough review of the literature on the emerging of the Fintech sector was carried out—the emphasis was put on academic papers from 2012 onwards, as it is thought that before then would be too close to the events for clarity and that it has been found by Zavolokina et al. (2016, p. 9, Fig. 1) that article publication numbers started growing that year. Based on that search this section identifies three root-causes that, although unrelated to each other, happened to coincide in time and lead banks to have lost control over the ICT agenda in the financial sector. The narrative in Sect. 2.2 brings us to the mid-2000s and it announces that around that time several major events happened in the banking, the ICT world and society in general that led to the emerging of a new industrial sector that we nowadays call Fintech as a contraction of financial technology. The *Basel Committee on Banking Supervision* (BCBS) defines Fintech quite broadly as:

Technologically enabled financial innovation that could result in new business models, applications, processes or products with an associated material effect on financial markets and institutions and the provision of financial services. (Claessens et al. 2018; Palazzeschi 2018)

So, for BCBS Fintech is a form of innovation, but an overly broad one at that, as it includes business models, applications, processes or products. Dorfleitner et al. (2017) while admitting that there is no universally

accepted definition of Fintech, take a more cautious approach and refrain from proposing a definition based on that while accepting that most companies in the Fintech sector share certain features, there are always enough exceptions to render them inadequate for producing a general definition. They opt to give a summary description of the different service domains of Fintechs, that they group in four: (a) Financing, (b) Asset Management, (c) Payments (in which they include cryptocurrencies) and (d) Other Fintechs. The latter includes a hotchpotch of things such as insurance; search engines and comparison sites; technology, IT and infrastructure; plus ‘Other Fintech’. Both approaches have limitation: BCBS stay at a conceptual level, and Dorfleitner et al. (2017) are far too broad and encompassing, which unsurprisingly gives place to so many exceptions.

This chapter will overcome those problems and propose and adopt a definition. It will overcome the BCBS limitation by defining Fintech as a company/organisation, and it will narrow the service offering domain. It will limit the services to banking services, that is services where the core competence is managing credit risk, market risk or banking operational risk. So, by Fintech in this chapter is understood *not the technology itself, but a digital technology-enabled entrepreneurial initiative that offers services to clients that would traditionally be considered within the domain of banks; or that are an innovative service in the natural business domain of banks; or that help banks develop their back-office processes.*

So, returning to the research question *Why did Fintech emerge as an industrial sector, independent of banking?* and to focus the mind it will be addressed by responding to three subquestions:

- What caused banks to lose leadership in the development of corporate ICT systems?
- What enabled the Fintech sector to emerge with such vitality in a business dominated by behemoths?
- What encouraged entrepreneurs to move into the service domain traditionally served by banks?

Arner et al. (2017) divide the co-evolution of finance and technology into three stages, namely:

- (a) The *analogous age* prior to the late twentieth century;
- (b) The *digitalisation era* that goes from the late twentieth century until 2008; and
- (c) The *diverging era* with the advent of new financial providers based on advanced technologies.

As is mostly the case, there is not a single cause for the advent of the tipping point that moved the evolution of finance and technology into the *diverging*

*era*. This research identifies three unrelated causes that happened in the 2007–2008 point in time; it is quite probable that none of these causes alone would have caused such a disruption, but their coincidence in time enabled them to feed into each other and cause havoc for the banking industry. The first is the global financial crisis known as the Great Recession that is generally accepted as having been caused by the banking system and its greed in the mortgage segment. The second is several nearly simultaneous major breakthroughs in the technology sector that led to a drastic drop in entry barriers to the banking services sector. And finally, significant social changes with the coming of age of the millennial generation and their growing role in the business world and in relationship to banking. The rest of this section will flesh out these three causes.

### 2.4.2 The Effect of the Great Recession

The 2007–2008 recession put banks in the USA, UK and several countries on the Continent at the brink of collapse leading to systemic failure which, in turn, led banking authorities in those markets to bail them out with public funds. Subsequent investigation into the events detected that banks accelerated their growth by taking on excessive risk that they partially transferred to other organisations through financial engineering devises concocted by their investment banking arms. In conjunction with this, the population became extremely critical of banks and there was general distrust in these institutions. These three factors led national authorities to react, and in many cases over-react, with the result of far more stringent banking regulations that caused great regulatory challenges to the banks (European Central Bank 2016; Haddad and Hornuf 2019; Kotarba 2016). These more stringent regulations worked in two directions (see Fig. 2.1).

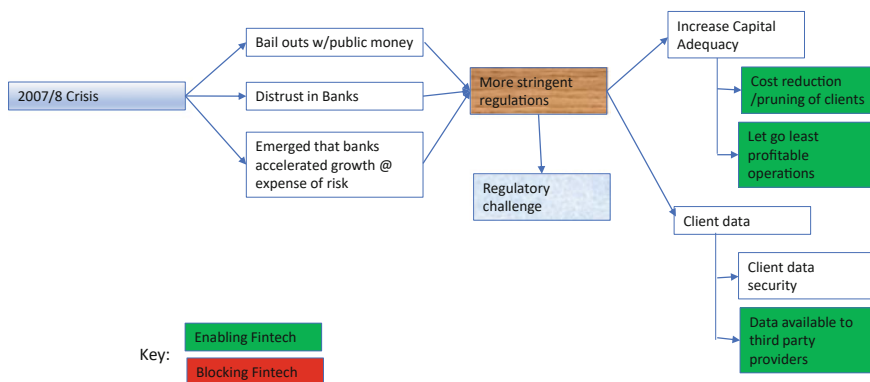


Fig. 2.1 The effect of the 2007–2008 crisis (Source Author)

The first was in the sense of demanding banks to significantly increase their regulatory capital so that never again would they need to be rescued with public money. Because as a result of the crisis capital was costly to acquire by banks, they reacted by reducing the denominator of the Capital Adequacy Ratio, that is by reducing their exposure to risk. They did this by pruning those clients of higher risk profile, and by letting go the less profitable operations (e.g., certain products and geographic markets). The resulting reduction in scale in turn led them to embark on cost reduction initiatives (European Central Bank 2016; Kotarba 2016).

The other way in which more stringent regulations worked was related to client data. On the one hand the authorities put emphasis on client data security, and on the other hand bank regulators demanded that client data be made available to third party providers in order to break the oligopoly of incumbent banks and increase competition in banking service (European Commission 2014, 2015; Tammass-Hasting 2017).

### 2.4.3 *The Effect of Major Technological Breakthroughs*

At the time the banks focused all their senses inside to cope with the regulatory changes that came because of the crisis, three key technology phenomena were happening. The first is incremental and refers to the continuing of Moore's law that translated into lower prices and thus giving more and more people access to devices (Lundstrom 2003; Waldrop 2016).

The second was the swift coming of age of Cloud computing with a change in mind-frame in the business community in the sense that moving from on-premise applications to cloud ones did not bring extra risks in terms of data security, and that adopting an on-demand model for technology appropriation had significant operational and balance sheet advantages (Ambrust et al. 2010; Rimal et al. 2009).

The third phenomenon was surely disruptive and is the advent of the first i-Phone and from there all the forms of smartphones that came after it. Moreover, the smartphone had the effect of enabling the development of social networks and, thus, the side effect of the advent of the data tsunami usually understated as Big Data (Barkhuus and Polichar 2011; Lee and Shin 2018; Smolan and Erwit 2012).

These three phenomena had effect on what was to be the emerging Fintech sector, and on incumbent banks. The effects on these two groups initially developed quite independently of each other, but as will be seen opportunities for cross-fertilisation emerged in later stages (EY 2018, p. 28; Gai et al. 2018; Lee and Shin 2018).

Looking at the Fintech sector first, it is found that the conjunction of the three technological phenomena had both the effect of lowering entry barriers for small new players to offer components of financial services, and giving many more people access to devices and thus become potential clients for these new entrants to the financial services market offering. As opposed to

entrepreneurial technology-based start-ups in other sectors, in general these new players in the Fintech sector did not have cash to burn at outrageous rates, so they developed two characteristics. On the one hand they are limited in the scope of their service, and on the other they take incremental opportunities in relatively mature markets that offer them quick cash-flow. These two characteristics translate into them focusing on niche but profitable parts of the incumbent banks' business, causing strong reaction from the banks who denounce them as avoiding regulations to take the icing of their cake (Lacasse et al. 2016).

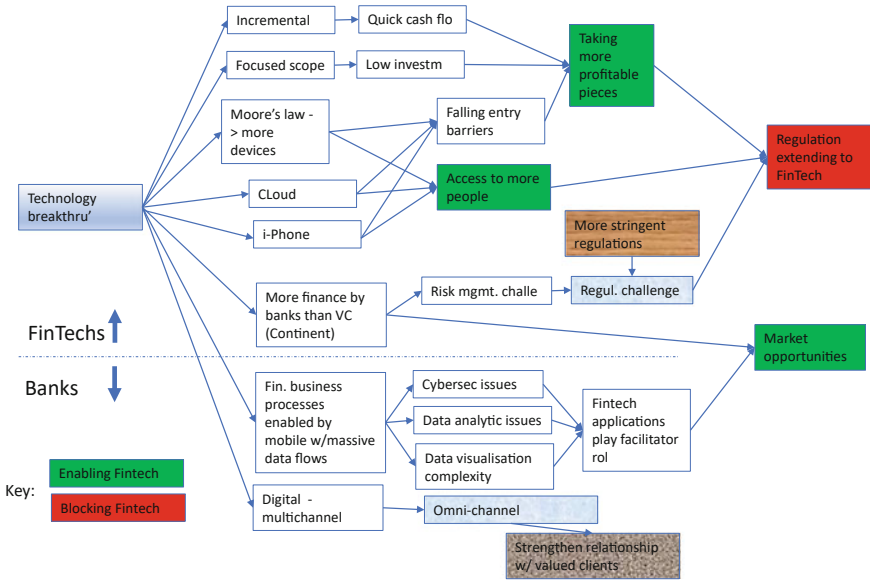
The conjunction of taking the more profitable pieces of the banks' business and being able to serve many more people who were then possessing digital devices, converted into great opportunities for the emerging Fintechs. But their increasing visibility and the protests of the incumbent bankers led banking regulators to observe this new sector and extend at least part of the regulations to them.

From the perspective of incumbent banks, these three technological phenomena and their derivations (i.e., social networks and Big Data) had a significant impact on their own operations. Bank clients were demanding new channels such as mobile and generating massive data flows that offered significant potential if properly exploited. However, they also posed unsurmountable challenges in terms of cybersecurity, of data analytics issues and of data visualisation complexities to incumbent banks that were constrained by their legacy systems as described in Sect. 2.2 above. This led the banks to start seeing Fintechs as potential enablers for their own processes in this new era of financial services (EY 2018; Gai et al. 2018).

Particularly on the Continent where Fintechs were being funded more by banks than venture capital (Lee and Shin 2018), risk management challenges emerged quickly and were addressed by regulators which erected barriers for Fintechs to operate as independent client-facing service providers, but opened opportunities in the banks that were funding them. So, in general, the antagonistic atmosphere between incumbent banks and Fintechs that prevailed in the early post-2008 years gave way to a more collaborative spirit between both sectors. This effect of the technological breakthroughs is depicted graphically in Fig. 2.2.

#### 2.4.4 *The Effect of Social Changes*

At the time of the financial crisis and the advent of the technological phenomena described in Sects. 2.4.2 and 2.4.3 the business world was going through major social transformations in terms of power as depicted by Naim (2013), of the changes in mindset that came with Generation Y taking a growing role in the workforce and of the advent of social entrepreneurs and entrepreneurship.



**Fig. 2.2** The effect of major technological breakthroughs on Fintech and banks (*Source* Author)

The Generation Y are avid adopters of mobile banking as long as it is easy to use and it poses no excessive risks in terms of data security. Both these conditions were hard to meet for incumbent bankers due to their legacy platforms, but straight forward for the Fintechs. On the other hand, due to the capital constraints mentioned in Sect. 2.4.3 above banks put effort into developing CRM processes and solutions that enabled them to strengthen their relationship with their ‘valued’ (i.e., the older more affluent) customers, and let go their less profitable and higher risk ones, as the Generation Y were seen to be. This opened a segment of great potential to the Fintechs (Boonsiritomachai and Pitchayadejanant 2017; Lee and Shin 2018).

In parallel with the above and especially in the Anglo-Saxon world, there emerged a new breed of what was to be called social entrepreneurs whose projects did not pursue a predominantly financial objective and thus were unfit to be assessed in terms of the banks’ traditional credit scoring criteria. This new breed of entrepreneurs resort to alternative finance sources such as crowdfunding so became another market opportunity for Fintechs (Kotarba 2016).

On the Continent it was found that while people do not trust banks much more than in the Anglo-Saxon world, they have less incentive to leave their banks and trust Fintechs even less than banks. So that becomes a barrier for Fintechs on the Continent.

The effects of social changes are depicted and summarised in Fig. 2.3.

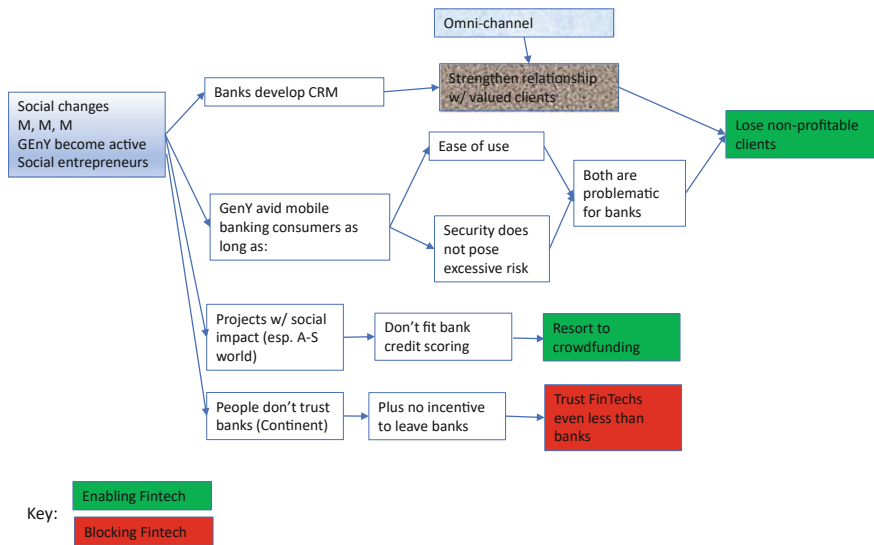


Fig. 2.3 Effects of social changes on banks and Fintechs (Source Author)

As a result of these three external forces (i.e., the Great Recession and subsequent regulatory changes, the technology breakthroughs and the social changes) acting nearly simultaneously, banks lost control of the evolution of ICT and left the door wide open for technology entrepreneurs to set up independently and eat away at the icing of their cake. The next section gives an overview of the industrial organisation of this new sector.

## 2.5 THE BANKING AND FINTECH SECTORS GIVE THEIR VIEWS ON THE PHENOMENON

### 2.5.1 Overview

It was decided to carry out a survey to sound out the validity of the three root-causes for the emerging of the Fintech sector, as described in Sect. 2.4. A measuring instrument was developed and data collected from four different samples. The results confirm that the banking, Fintech and research communities agree with the enablers and barriers to development of Fintech

### 2.5.2 Methodology

The measuring instrument is divided into three parts. Part A collects nominal data on the informants' background, in particular their connection to the banking and Fintech sectors, and their geographic location. Part B is the body of the questionnaire and consists of 17 statements that derive from the green and red constructs in Figs. 2.1, 2.2 and 2.3. These statements are designed

according to a 9-point Likert scale. Part C gives space for an overall opinion on the relative importance of social and technological changes that does not emerge directly from the literature so was not included in Part B; and gives space for unstructured responses. Table 2.2 describes the variables as depicted in the questionnaire, which is available from the author upon demand.

Data collection was done from four samples of people connected to the banking and Fintech sectors through practice or academia. Three of these

**Table 2.2** Description of variables

<i>Variable No.</i>	<i>Description</i>
1	Changes in pro-stability banking regulation has created opportunities for FinTechs
2	Changes in banking regulation in relation to data (e.g., Open Banking) created opportunities for FinTechs
3	Because Banks were forced to focus on their most profitable clients and operations, they underserved a great number of other clients who turned to FinTechs
4	Because of changes in capital requirement, banks let go their most risky clients to the benefit of FinTechs
5	FinTechs have developed by prioritising the most profitable banking niches
6	FinTechs have prioritised banking areas requiring low investment
7	The advent of mobile technology has given FinTechs access to more people
8	The advent of cloud-computing has been decisive in making FinTech viable for entrepreneurs
9	FinTechs are increasingly being funded more by banks than by venture capitalists
10	The challenges of Big Data have led banks to rely on FinTechs for solutions
11	Cybersecurity issues have led banks to rely on FinTechs for solutions
12	Through their demand for services, banks have assisted the development of FinTechs
13	Banks' focus on their more profitable clients has opened opportunities for FinTechs with the underserved bank customers
14	The advent of new regulations will become a roadblock for the future development of the FinTech industry
15	Since the 2008 financial crisis, customers have lost trust in their banks but they do not trust FinTechs either so they have no incentive to switch
16	Serving Generation Y is problematic for banks
17	The rise of projects with social impact objectives that do not fit in the banks' credit evaluation schemes has opened opportunities for FinTechs to offer crowdfunding alternatives
C1 (18 in graphs)	Social changes have been even more important than technological breakthroughs in the development of FinTech

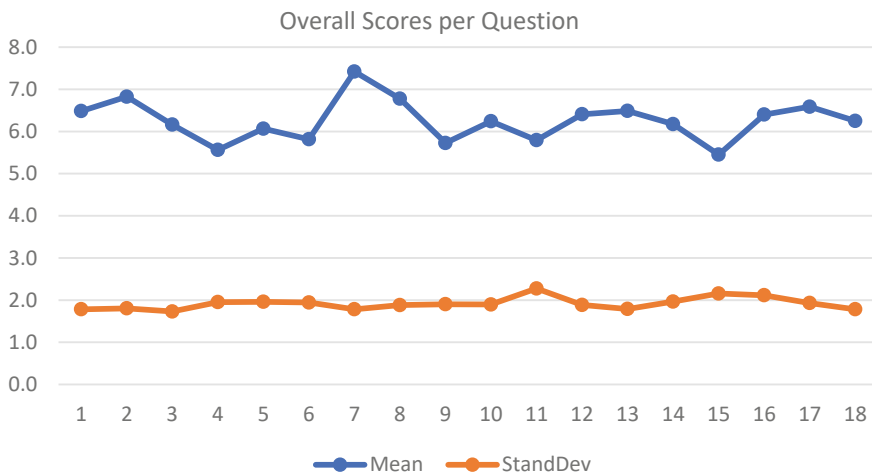
Source Author



**Table 2.3** Responses to survey

<i>Sample</i>	<i>Date</i>	<i>Responses</i>
Oxford Workshop	March 2018	26
Kristiansand Workshop	September 2018	11
Online Campaign	October–November 2018	78
Hanoi Workshop	June 2019	6
Total		121

*Source* Author



**Fig. 2.4** Mean and standard deviation per variable

samples were participants in Fintech workshops held in Oxford, UK; in Kristiansand, Norway; and in Hanoi, Vietnam; the remainder was an online campaign. The number of valid responses is 121 as detailed in Table 2.3.

The analysis of the data is done through the application of descriptive statistics techniques.

### 2.5.3 Results

The outcome of the analysis of the data is that the responses strongly support the enablers and barriers for the emerging of the Fintech sector. Figure 2.4 describes the mean values of the 17 variables of the body of the questionnaire plus question 1 of Part C of the questionnaire, described in the graph as number 18. As can be seen the mean is well above the mid-point 5 of the Likert scale, and the standard deviation is consistently low, indicating that observations are packed tight around the mean.

This is corroborated by the probability of an observation exceeding the mid-point of the Likert scale (i.e., 5). As can be seen in Fig. 2.5, the probability of an observation exceeding 5 is over 60% for all variables except question 15 where it is 58%.

Considering that the data was collected from four distinct samples, it is interesting to see if there are different patterns between the samples. As shown in Fig. 2.6, this is not the case. Responses are consistent across samples.

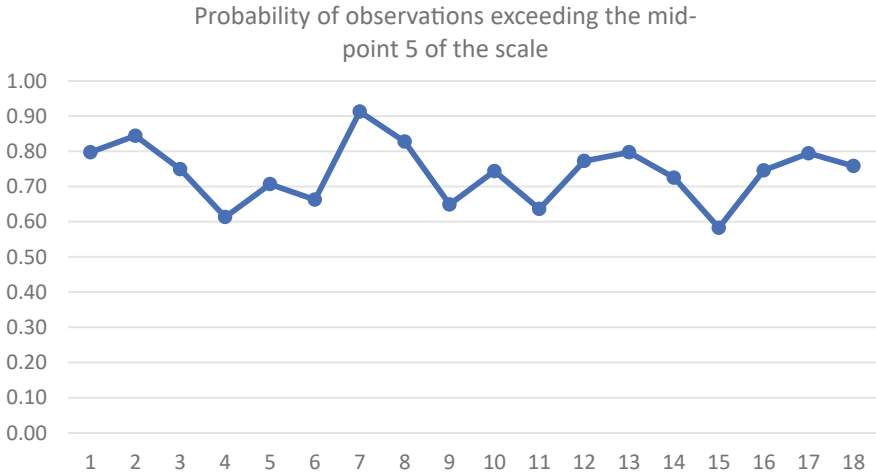


Fig. 2.5 Probability of exceeding 5 for each variable (*Source* Author)

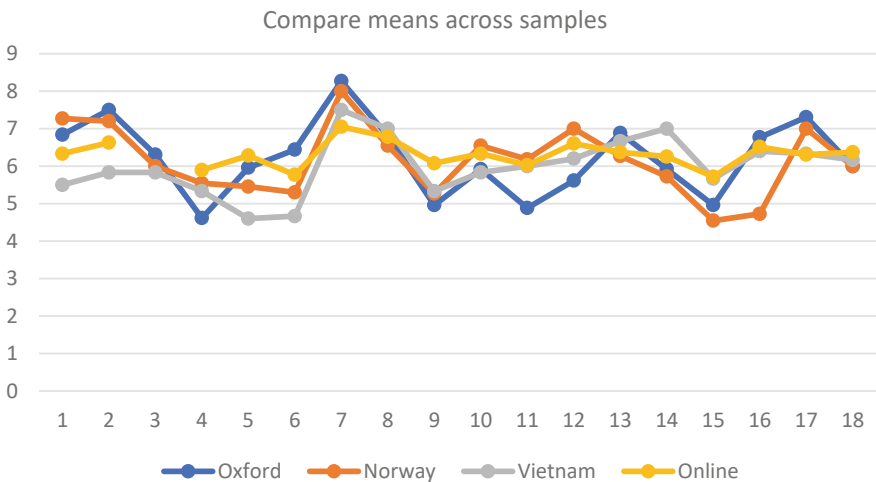
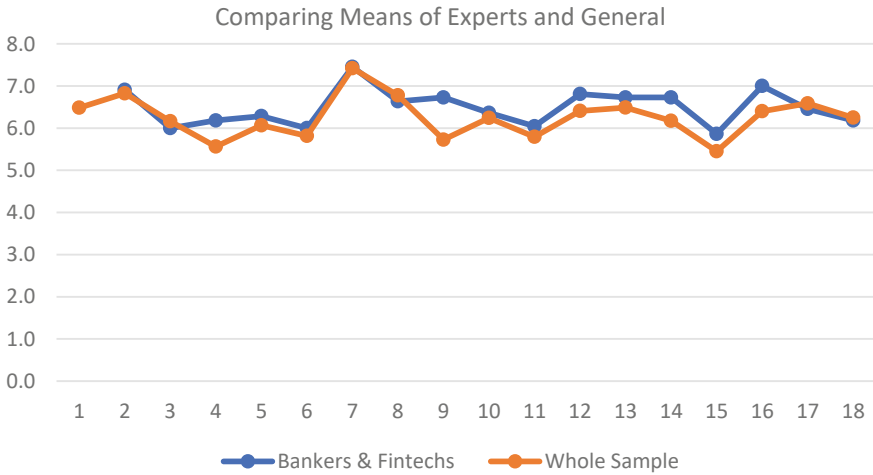


Fig. 2.6 Responses from each sample (*Source* Author)



**Fig. 2.7** Practitioners are even more supportive (*Source* Author)

From observing the nominal data it would be interesting to detect if the opinion of the banking and Fintech practitioners, that is those respondents with more hands-on knowledge of the Fintech sector, differs from that of the academics. The outcome of this analysis, as shown in Fig. 2.7, is that the practitioners are even more supportive of the enablers and barriers to development of Fintech than the complete sample.

#### *2.5.4 Highlights of the Empirical Work*

The analysis of the results will be done in the discussion in Sect. 2.8, however, a fact that needs to be pointed out here, because it complements the literature reviewed in Sect. 2.4, is that variable CI is an interesting one in that it does not emerge directly from the constructs in Figs. 2.1, 2.2 and 2.3 but cuts across the technological and cultural factors leading to the advent of Fintech. As suspected, the responses on this variable give strong support to the insight that cultural factors were more influential than technological ones in the enabling of Fintech.

The next section will present a framework to help understand the industrial organisation of the Fintech sector.

## 2.6 A NEW INDUSTRIAL SECTOR: A FRAMEWORK TO UNDERSTAND FINTECH

As mentioned in Sect. 2.4.3 the Fintech sector is quite different from other technology-driven entrepreneurial or start-up sectors in the sense that it did not access massive funding and therefore its companies had to be focused in terms of service scope, and it did not produce great new markets but rather

served extant markets that were until then poorly or underserved by banks. While, due to the latter, initially the relationship between traditional banks and Fintechs was notoriously antagonistic, with the passage of time banks realised that their constraints from legacy systems would obstruct them entering the digital era, so started to see Fintechs as possible collaborators to help overcome those barriers. This is particularly so in the data-oriented, security and privacy, and compliance spaces (Duan and Da 2012; Gai et al. 2018; Roumani et al. 2016).

Growth of the Fintech sector in terms of investment is literally exponential, going from \$1.8 billion in 2010 to \$19 billion in 2015 according to some sources (Citi 2016 cited by Leong et al. 2017) or from \$1.5 billion in 2010 to \$22 billion in 2015 according to others (Shuttlewood et al. 2016) and there are indications of steep growth in 2016 (Lee and Shin 2018). Within this context, seven banking-service areas emerge as the domains where Fintechs carry out their offering. These are: Alternative Finance, Transactions, Investment Markets, Banking Backoffice, Financial Inclusion, Cryptocurrencies and Business Partner Integration.

*Alternative Finance* refers to services that supersede the traditional lending function of banks. They include personal finance, consumer finance, small and medium enterprise lending and prominent in this category is *Crowdfunding* in its four formats: Reward-based, donation-based, equity-based and loan-based. Examples of reward-based crowdfunding companies include Kickstarter, Indiegogo, CrowdFunder and RocketHub; of donation-based are GoFundMe, GiveForward, and FirstGiving; of equity-based crowdfunding companies are AngelList, Early Shares and Crowdcube; finally, of loan-based crowdfunding companies are Funding Circle and Cumplo (Lee and Shin 2018; Shneor and Munim 2019 citing Ziegler et al. 2018).

*Transactions* refers to one of the most active areas of Fintech as are payments and remittances. These two areas were traditionally controlled by banks but are now giving way—in the case of payments by offering layers of service overlaying those of traditional banks and biting away at parts of the fees that banks charge in this space. In the case of remittances, it is about offering channels that circumvent bank services and fees altogether (Lee and Shin 2018).

*Investment Markets* include services such as equity financing, retail investment, institutional investment, fund management and crowdfunding as an opportunity for investing (Lee and Shin 2018; Shneor and Munim 2019).

*Banking Backoffice* is about Fintechs supplying banks agile services such as banking infrastructure, financial security services, identity verification, compliance, business tools, financial research and energy efficiency in regards to achieving Green Finance. Prominent amongst these are RegTech, a flavour of Fintech aimed at helping banks comply with the demands of regulators and assist banking supervisors in keeping track of the banks under their watch (Gai et al. 2018; Puschmann 2017; Tamas-Hastings 2017).

*Financial Inclusion* means reaching out to the unbanked and offering financial services at an extremely low cost and fill a gap that banks have never tackled, with well thought through and low-cost service offerings; micro-finance is prominent amongst this category (Lacasse et al. 2016).

*Cryptocurrencies* emerged as an initiative to circumvent banks altogether in the payments space but have not materialised as such; up to now they have served more as investment than payment instruments, and with doubtful outcomes at that. However, the distributed ledger technology that underly them could be of application in many other areas such as trading and ‘smart contracts’ (Chen 2018; Hawlitschek et al. 2018).

*Business Partner Integration* is about Fintech offering services that bridge across the traditional offerings of banks and of other sectors with large business-to-consumer operations, such as telecommunications, retailers and airlines (Kumar et al. 2006; Rosingh et al. 2001; Schmitt and Gautam 2016).

To deliver these services Fintechs will apply one or multiple emerging technologies such as the DANCE acronym (Data, Algorithm, Networks, Cloud, Exponential) proposed by McAfee and Brynjolfsson (2017) and others including Mobile, Distributed Ledgers, Bioinformatics and behavioural biometrics, Robots, All-in-one smartcards, and others.

It is helpful to understand the industry to present this in the form of a double entry table and map the Fintech companies onto the cells of this matrix (see Fig. 2.8). Just as an example of how this works, Fig. 2.9 reproduces the contents of one cell in this framework: The cell corresponding to Alternative Finance as a service domain, and data analytics and the exploiting of Big Data as a predominant enabling technology for those services.

With this framework the question ‘*How is the Fintech industry organised, in terms of the services it offers and the technologies it applies to deliver those services?*’ is addressed. The following section will give insights into the relationship between banks and Fintechs, and how the relationship has evolved over time.

## 2.7 REACTION OF THE BANKING SECTOR TO THE FINTECH TSUNAMI

This section addresses the question *What is the relationship between banks and Fintechs, and how has this relationship evolved over time?* Banks departed from a highly antagonistic view of Fintechs to start finding potential in them as start-up venture opportunities and, more importantly, as resources for internal projects to make their operation more responsive, secure, compliant and efficient (EY 2018; Lee and Shin 2018). Typically, they look at Fintechs to help them reduce operational costs, provide more personalised services through data, and respond to customer behaviour changes. As a result of this, Fintechs have extended their role from retail customer-facing to the back-office or middle office of banks. Although it is mentioned above that alternative lending is the most funded domain, this can be contested based on the massive

	<b>Alternative Finance:</b> Personal Finance; Consumer Banking; SME Lending; Crowdfunding	<b>Transactions:</b> Payments; Remittances	<b>Investment Markets:</b> Equity financing; Retail investment Institut. Investment; Crowdfunding	<b>Backoffice:</b> Banking Infrastructure; Fin. Security; Business tools; Financial research; Regtech	<b>Financial Inclusion:</b> Reaching out: Fees & Profitability; Micro-finance	<b>Cryptocurrencies:</b> Payment or investment instrument? ICO.	<b>Business Partner Integrator:</b> Telcos, Retail, Airlines
Data: Exploiting 'Big Data'							
Algorithms: AI and Cognitive Computing							
Networks: 5G, faster data accumulation							
Cloud: Lower entry barriers; local vs central computation							
Exponential improvement in digital h/w; Moore's law effect							
Mobile							
Robotics							
Bioinformatics & behavioural biometrics							
Distributed Ledgers							
All-in-One smartcards							
VR, interactive & AR							
???????							

**Fig. 2.8** The Fintech I/O Framework (*Source* Author)

resources that are increasingly going into security and privacy initiatives (Gai et al. 2018, citing Gartner, says that the cybersecurity market reached \$ 75 billion in 2015 and is projected to reach \$170 billion by 2020; a significant share of this will go to financial services).

Finally, it has been said that in the UK, following the 2007/2008 financial crisis and the tarnished image with which established banks came out of it, the regulators proactively promoted Fintechs in the hope that challenger banks would emerge from them. And in effect this did happen as several challenger banks have emerged (e.g., Monzo, Revolut, Metro) but their real impact on the market concentration has been marginal with the five big banks still firmly in control. What is even more disappointing is that some of these challenger banks have had to have their business models closely scrutinised by the banking supervisors under suspicion of adopting aggressive lending

practices and even manipulating balance sheets to avoid increased demand for fresh regulatory capital (FT 2019). It is hoped that the implementation of Open Banking supported by regulations such as PSDII will enable Fintechs and the most agile and forward-looking mainstream banks to offer more API-enabled services and thus change the oligopolist structure of the banking business. Traditional banks will not go away but they will most likely become a component of a more fragmented industry in the form of a network of hyper specialists (Malone et al. 2011). It can be conceived that the banking sector may fragment into an industrial organisation similar to insurance, where banks may play a key role in credit risk management and credit origination, but in relation to up stream organisations to share risks and downstream partners for securitisation and distribution of their products.

This description of the evolving relationship between Banks and Fintechs is summarised in Fig. 2.10. It depicts that from 2008 to 2009 to approximately 2013, banks and Fintechs took diverging paths, but in the last six or seven years they have come to terms: Separate entities but working close together. Going back to Fig. 2.8, this can be expressed by saying that the service domain *Backoffice* is getting highly populated.

## 2.8 DISCUSSION

In Sect. 2.2 we travelled through the history of the development of corporate ICT where we observed the leading role that banking took in the process up to the beginning of this century. However, development is not linear and there

Company's name	Country	Activity	Notes	Web site
		Alternative finance : Personal finance / customer banking / Crowdfunding		
Lydia	France	Lydia allows its users to pay in store with their contactless mobile phone by generating a virtual card that can be used in Apple Pay, Google Pay and Samsung Pay. It is possible to pay on the Internet by generating "internet cards" (a virtual card system to generate Mastercard payment numbers) from the application. Finally, Lydia offers a Mastercard payment card with no foreign exchange fees. Casino alliance to provide micro credit	Security and rapidity by using only Cloud / Mobile	<a href="https://lydia-app.com/fr/">https://lydia-app.com/fr/</a>
Retail Capital - Karl Westvig	South Africa	Analyse datas on transaction for PME to include cashflows to the calculate of risk on a loan (like that they will find fund more easily) ; assiste both business owners and suppliers to grow their business by providing them with flexible asset finance solutions to suit their cash flow needs ; Through linking payments to turnover and matching the cash flow cycles of the business, we partner with business owners to provide working capital while ensuring	Accessible, flexible and convenient alternative to traditional business loans	<a href="https://www.retailcapital.co.za/">https://www.retailcapital.co.za/</a>
Vanmo	USA	Money transfer between customers, payments	Social commerce platform	<a href="https://vanmo.com/">https://vanmo.com/</a>
Monzo	UK	Only online financial services, card payments, crowdfunding, loans	Combine technology with traditional banking to appeal to customers, offering features like immediate tracking of card payments through its mobile app	<a href="https://monzo.com/">https://monzo.com/</a>
Klarna	Sweden	Online financial services such as payment solutions for online storefronts, direct payments, post purchase payments and more.	Business for customer / Business for professional	<a href="https://www.klarna.com/">https://www.klarna.com/</a>
Transferwise	UK	Online money transfer service	Currency trading	<a href="https://transferwise.com/fr/">https://transferwise.com/fr/</a>
Lyfpay	France	Innovative mobile payment application, multi-service and secure, serving the customer relationship.	Focus on millennials by using only phone between friends	<a href="https://www.lyf.eu/fr/">https://www.lyf.eu/fr/</a>
Adyen	Netherlands	The technology platform acts as a payment gateway, payment service provider and offers risk management and local acquiring.	Global payment company that allows businesses to accept e-commerce, mobile, and point-of-sale payments.	<a href="https://www.adyen.com/fr_FR/">https://www.adyen.com/fr_FR/</a>
Monese	UK	Current accounts and money transfer services as an alternative to traditional banks.	Check out the smart tech that lets you open a bank account with just a selfie and a passport pic	<a href="https://monese.com">https://monese.com</a>
Qonto	France	Professional current account, payment cards and features that make banking and accounting easier for companies.	Create the preferred neobank for companies	<a href="https://qonto.eu/fr/">https://qonto.eu/fr/</a>
Dartagnans	France	Crowdfunding website specialize in real estate capital	Allows people to buy some 50€ shares to invest in real estate heritage.	<a href="https://dartagnans.fr/">https://dartagnans.fr/</a>

Fig. 2.9 Sample from the repository of Fintechs: alternative finance vs data analytics cell (*Source* Author)

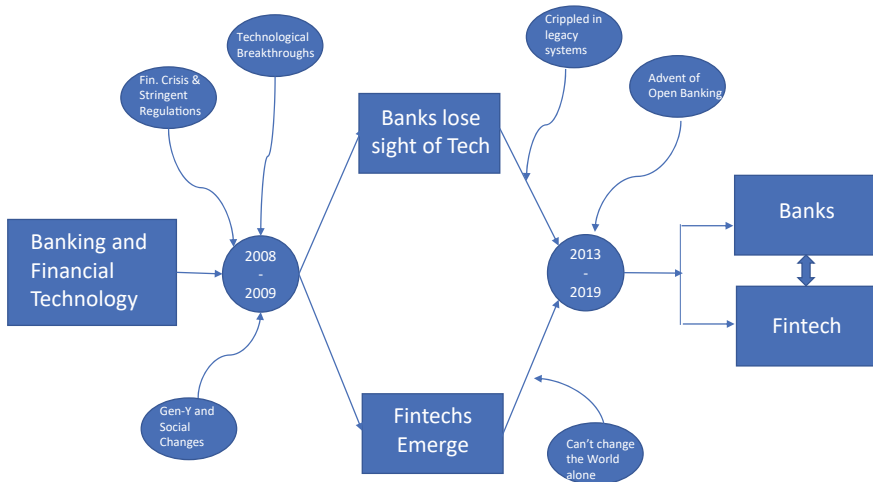
Company's name	Country	Activity	Notes	Web site
Funding Circle	UK	Loan-based crowdfunding	Unsecured loans of up to £500,000; secured loans of up to £1m.	<a href="https://www.fundingcircle.com/uk/about-us/">https://www.fundingcircle.com/uk/about-us/</a>
Cumpro	Chile	Loan-based crowdfunding	Different forms of lending. Factoring is important	<a href="https://secure.cumpro.cl/">https://secure.cumpro.cl/</a>
Lendingkart	India	Small-business lending	Co-lending with banks; non-deposit taking	<a href="https://www.lendingkart.com/">https://www.lendingkart.com/</a>
KredX	India	SME lending	India's leading invoice discounting (factoring) platform	<a href="https://www.kredx.com/">https://www.kredx.com/</a>
Upstart	USA	Bring together high potential borrowers and lenders. - estimate borrower credit score based on background	Upstart is the first artificial intelligence lending platform designed to improve access to affordable credit while reducing the risk and costs of lending for its bank partners	<a href="https://www.upstart.com/">https://www.upstart.com/</a>
Touch Bank	Russia	Online retail banking	Online credit, loans, card and account management without paper work, saving management time.	<a href="https://www.touchbank.com/">https://www.touchbank.com/</a>
Dartagnans	France	Crowdfunding website specialize in real estate capital	Allows people to buy some SOE shares to invest in real estate heritage.	<a href="https://www.dartagnans.fr">https://www.dartagnans.fr</a>
Retail Capital	South Africa	Accessible, flexible and convenient alternative to traditional business loans - typical clients are restaurants; they collect from the card processor a percentage of revenue	Through linking payments to turnover and matching the cash flow cycles of the business, they partner with business owners to provide working capital while ensuring affordability.	<a href="https://www.retailcapital.co.za/">https://www.retailcapital.co.za/</a>
Wefinance	USA	Borrower-driven crowdfunding	The borrower defines the principal, interest rate and maturity period.	<a href="https://www.wefinance.co/">https://www.wefinance.co/</a>
SoFi	USA	P2P Lending for students	Promotes itself as helping young people take control of their finances	<a href="https://www.sofi.com/">https://www.sofi.com/</a>
Rocket Mortgage	USA	Loans and mortgages	Focus on Millennials	<a href="https://www.rocketmortgage.com/">https://www.rocketmortgage.com/</a>
C2fo	UK	Short term loans to business	Much is through invoice discounting to vendors with backing from the large company buyer - the promise is to improve cash flow on demand for the borrower or earn no-risk returns for lender	<a href="https://c2fo.com/">https://c2fo.com/</a>
Zopa	UK	P2P Lending/Crowdfunding	Borrow £1k-£25k Over 1 To 5 Years. Awarded "Best Personal Loans Provider" 2018. Types: Car Loans, Personal Loans, Debt Consolidation Loans, Holiday Loans	<a href="https://www.zopa.com/">https://www.zopa.com/</a> <a href="https://www.zopa-financeuk.com/">https://www.zopa-financeuk.com/</a>
Simple Finance	UK	Short term and payday loans		
Kickstarter	USA	Reward-based Crowdfunding	Crowdfunding platform focused on creativity and merchandising. The company's stated mission is to "help bring creative projects to life"	<a href="https://www.kickstarter.com/">https://www.kickstarter.com/</a>
Indiegogo	USA	Reward-based Crowdfunding	Crowdfund innovations in tech and design before they go mainstream and support entrepreneurs that are working to bring their dreams to life.	<a href="https://www.indiegogo.com/">https://www.indiegogo.com/</a>
Crowdfunder	UK	Reward-based Crowdfunding	The Company invests in energy projects. Crowdfunder also helps communities, support wellbeing, rewards, and super charge business loans.	<a href="https://www.crowdfunder.co.uk/">https://www.crowdfunder.co.uk/</a>
RocketHub	Founded USA, acquired by Crowdfunder	Reward-based Crowdfunding	Its users—including musicians, entrepreneurs, scientists, game developers, philanthropists, filmmakers, photographers, theatre producers/directors, writers, and fashion designers—post fundraising campaigns to it to raise funds and awareness for projects and endeavors	<a href="https://www.crowdfunder.com/rockethub">https://www.crowdfunder.com/rockethub</a>
GoFundMe	USA	Donation-based Crowdfunding	Platform that allows people to raise money for events ranging from life events such as celebrations and graduations to challenging circumstances like accidents and illnesses.	<a href="https://www.gofundme.com/">https://www.gofundme.com/</a>
GiveForward	USA	Donation-based Crowdfunding - "The Chicago Tribune called it the "future of medical fundraising in the Internet Age."	Online fundraising tool designed to help people raise money for the causes and organizations that they care about. Has become popular among the growing number of people who fundraise to	<a href="https://www.giveforward.com/">https://www.giveforward.com/</a>
FirstGiving	USA	Donation-based Crowdfunding	Online fundraising solutions to individuals and nonprofit organizations. Its platform provides tools to manage events, grassroots campaigns, direct donations, and donor communications.	<a href="https://www.firstgiving.com/">https://www.firstgiving.com/</a>
AngelList	USA	Equity-based Crowdfunding - website for startups, angel investors, and job-seekers looking to work at startups.	Mission is to demystify the investment process and to help startups with their challenges in fundraising and talent. It started as an online introduction board for tech startups that needed seed funding.	<a href="https://angel.co/">https://angel.co/</a>
Early Shares	USA	Equity-based Crowdfunding - Launched in April 2012 as a platform for rewards-based crowdfunding campaigns. After the SEC implemented rules for general solicitation in September 2013, EarlyShares began hosting equity investment offerings for accredited investors	Online platform for real estate fundraising and investing.	<a href="https://www.earlyshares.com">https://www.earlyshares.com</a>
Crowcube	UK	Equity-based Crowdfunding	Website shows successful companies coming back for later rounds of funding, and strong support for women-led entrepreneurial initiatives.	<a href="https://www.crowcube.com/">https://www.crowcube.com/</a>

Fig. 2.9 (continued)

are many external factors that have their effect on a stream of progress. There are major tectonic changes that are not perceptible on the surface of the earth until they are revealed indirectly through localised effects. The tectonic change that was taking place in the corporate world and thus was part of the scenery for the development of corporate ICT was the transformation of the Western economy from an industrial to a knowledge-based one, as was revealed by the Productivity paradox. In this new order ICT did not produce value only through transaction cost reduction, but through giving organisations flexibility for change and enabling innovation. The productivity paradox phenomenon also revealed that we moved into the era of predominantly intangible assets (as opposed to tangible ones) which made the traditional accounting and performance measuring systems obsolete.

The literature revealed that the advent of the Fintech sector independent from banking was enabled by three simultaneous though independent factors: The 2007–2008 Great Recession and changes in banking regulations





**Fig. 2.10** Evolution of the relationship between Banks and Fintechs (*Source* Griffiths [2020])

in response to that crisis; the advent of new technologies such as smart-phones and the consolidation of others such as Cloud computing in a context where Moore’s Law continued to hold making devices ever more accessible to consumers and lowering entry barriers for Fintech entrepreneurs; and, finally, the cultural changes that came with the access of Generation Y to the consumer market and the ranks of the labour force. The empirical work in the form of a survey of banking and Fintech practitioners and researchers corroborates those findings. Moreover, the empirical work adds to the literature that the cultural change was more influential on the advent of Fintech as an independent sector than the actual technologies that enable it.

Unsurprisingly, the variable that had the highest support by the informants is No. 7 that refers to the advent of the mobile phone which gave access to online banking services to more people. There is also strong support for variable 2 that refers to changes in regulation in relation to data (e.g., Open Banking) which opened opportunities for Fintechs. The lowest support was given to variable 15 which refers to trust issues; due to that trust issues are strongly related to societal culture, it was investigated if there were differences in responses for this variable dependent on the nationality of the informant, but there was not support for this in the responses.

Taking a more macro view of the emerging of Fintech, bankers were highly unlucky. Just as they were looking inside their organisations to understand, adapt to, adopt and restructure their organisations and client-bases to implement the over-the-top regulations that over-reacting regulators imposed on them, they missed out on the technological breakthroughs that were taking off, and on the dramatic cultural changes that coincidentally happened at the same time. To make things even worse, these three changes happened at

the time when the tectonic transition from the industrial economy to the knowledge-based one, was starting to reveal its effects. In fact, this tectonic change grossly magnified the impact of the three mentioned factors. In all honesty, bankers cannot be too harshly held accountable for their lack of perception and of judgement on what was happening around them—it was just one of those singular times in history when step-change is massive and irrepressible.

In times when such magnitude of change happens, we need binoculars, telescopes and all sorts of ocular devices to help us understand, come to terms with, and become operational upon the new landscape. The Fintech I/O framework proposed in Sect. 2.6 and Fig. 2.8 fills precisely that need. It helps us map each organisation working in the Fintech space onto a service domain and predominant enabling technologies. This is highly useful to understand who its competitors are and with whom it can collaborate on the technological front. This should be particularly useful to banks that can use it to identify those Fintechs they can approach to make their operation more agile through partnering relationships. Banks need this to overcome the in-built rigidities that result from their obsolete legacy systems. An interesting reflection that comes from the prior sections is that it was not having perceived that they were moving into the knowledge economy that led banks to base their business-cases for changing core-banking platforms on industrial economy criteria of exclusively tangible benefits and therefore stay locked-into their old systems.

Finally, the relationship between banks and Fintechs has not remained static over time. Initially, Fintechs cherry-picked the banking services to take away from banks, causing banks to react in a defensive way that led to a highly antagonistic relationship with Fintechs. As time elapsed, Fintechs realised that they do not have the resources to change the financial services world on their own, and banks came around to recognise that Fintechs could help them overcome the crippling effect of their legacy systems. The framework discussed in the prior paragraph is an instrument for the two parts to identify their potential areas of collaboration. Shifting from competition to collaboration is an intrinsic characteristic of the advent of the knowledge economy: Perhaps this is an indication that banks are moving into century XXI.

## 2.9 CONCLUSIONS

In summary this research has found that, distracted by the 2007–2008 crisis and its immediate regulatory changes, the banking industry lost sight of the technological breakthroughs and social changes that were happening around it. As a result, after decades of having been a driver and leader for technological change, the industry left windows wide open for nimble companies based on ground-breaking technologies to emerge and ‘eat its lunch’.

The troubles of traditional or incumbent banks were compounded by the advent of the knowledge economy. Banks have found it very hard to keep up

as selecting a new technology that will drive its processes is no minor decision for a bank and in times when so many technologies are emerging, it is hard to predict which will be the winning ones. This was aggravated by developing the business-cases for change based on criteria of the industrial economy. Technology selection is not a level field: clearly banks as incumbents have far more to lose than Fintechs so the question we need to ask ourselves is this: Do extant strategy-technology alignment models apply to banks in times of so much disruption? This is a promising question for future research.

Notwithstanding the rigidities of the incumbents, it is extraordinary that in such a closely regulated industry as banking, the Fintechs could have found gaps in regulations to eat away at some of the most profitable icing on the banking industry's cake. It is also extraordinary that in such a short period of time Fintechs could open into so many different business domains, enabled by the emerging of such an unprecedented number of different game-changing technologies.

The Fintechs managed this feat with little capital in comparison with the deep pockets of the institutions they were outpacing. They achieved this precisely by focusing on niches where the market was already there and waiting for a solution. So, in a way, it was more a pull by social changes than a push by the Fintechs (this is quite different from other areas of technology-based entrepreneurship where the pioneers created a market). However, Fintechs should not become complacent as regulation is creeping in. Approximately one third of the Fintech business in the Euro-zone is not regulated, but looking forward, Fintechs should count on that banking regulations will move further into their space.

Banks and Fintechs are learning to work together. This learning process could be studied in future research by analysing how Fintech companies have migrated over time from serving consumers directly along six of the seven business domains in the framework of Fig. 2.8, towards the domain titled *Backoffice: Infrastructure, financial security, business tools, financial research, and Regtech*.

It is an interesting turn of events, that the industrial sector that emerged as a result of the banks' lack of vision and bandwidth is what is enabling banks to move into the knowledge economy and the XXIst century.

## NOTE

1. OECD (2003, pp. 65–66), finds that financial intermediation organisations '*are intensive users of information and thus have the greatest scope to benefit from ICT*'.

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## Fintech & Blockchain: International Overview





# Financial Engineering and ICT in the Past

*Rupesh Regmi and Zhuo Zhang*

## 3.1 INTRODUCTION AND CONCEPTUALIZATION

This chapter focuses on the creation, production, subsequent advancement with evolving requirements, and adaptation to the state-of-the-art technologies emerging side by side in the ever-changing world, of financial engineering and information and communication technology (ICT). Financial engineering can influence the day-to-day trends of buying and selling by estimating the associated risks, expected revenues, and the corresponding income after using available computing techniques, thereby allowing the use of investment opportunities and/or purchasing prize shares, stocks or other commodities, etc. These computational techniques may be based on well-defined developed statistical or non-statistical procedures. In financial terms, computing is called computational finance, which is also commonly defined as a cross-disciplinary field based on the mathematics of finance, and numerical methods. With the growth of computer technology and innovation, the programming practices were changed in a way that, by using computer simulations it could save lots of time and do a faster amount of work. With the advent of newer technology, algorithms were developed and designed in order to use machines to create guidelines for decision-making. Such algorithms (one of the many well-defined computational criteria) were quite helpful in generating significant results in

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Switzerland AG 2021

M. Pompella and R. Matousek (eds.), *The Palgrave Handbook of FinTech and Blockchain*, [https://doi.org/10.1007/978-3-030-66433-6\\_3](https://doi.org/10.1007/978-3-030-66433-6_3)

different trade scenarios after being integrated into newly developed computer programs, stochastic models, or numerical models. ICT's primary purpose was to link the various companies and bridge the gap between buyers and sellers. The financial computation was improved by the rise of modern computers with higher speeds and increased workload capacities.

### 3.1.1 *Financial Engineering*

Financial engineering is a revolutionary science that depends on mathematics technology for making an investment, hedging, and trading decisions, as well as promoting risk management of such decisions. While this area deals with the creation of new and value-added financial products, it is also considered to be an omnipresent financial discipline that encompasses the design of innovative financial instruments, acquisition deals and mergers, derivative strategies, and restructuring cooperation, among others (Osuoha 2013). In view of this, various scholars have defined financial engineering differently. Zopounidis and Doumpou (2013) define financial engineering as the advancement and creative use of innovative finance technologies. Financial technologies underpinning this concept include financial processes, financial products, financial strategies, and philosophy of finance. Financial engineering on a macroeconomic level helps to improve the allocation of scarce resources. In comparison, financial engineering produces income for creditors at the microeconomic level by finding better ways to tackle consumer demand (Beder and Marshall 2012).<sup>1,2</sup>

Past studies also conceptualized financial engineering in a diverse array of interconnected ways. For example Marshall and Bansal (1992) and Galitz (1995) think of it as the use of financial instruments and techniques to restructure an existing financial profile to have a more attractive financial product. According to (O'Brien 2001), financial engineering is the application of computer technology, mathematics, scientific method, and financial economics for the optimal use of sourcing and financial asset protection. Borrowing from various definitions and conceptualizations of financial engineering (Eales 2000) suggests that the term can be interpreted as a way of fine-tuning financial processes to suit tax, regulatory, or consumer adjustments. Zopounidis and Doumpou (2013) sum it up as the creation from the outset of financial products to provide consumers with distinct financial layoffs at a given time.<sup>3,4</sup>

### 3.1.2 *Computation and Computational Finance*

The standard definition of computation, at least as echoed in most major scholarly works, emerges from early studies in computer science. In these studies, computation is defined as the execution sequence of the Turing machines and their equivalent (Denning and Wegner 2010).<sup>5</sup> Modernist definitions call computation any kind of calculation which includes both statistical and non-statistical procedures and often follows a well-defined model,

such as the algorithm (Feynman 2018).<sup>6</sup> Computation analysis is vital in the computer science field. In financial matters, computation is classified as computational finance. Computational finance is generally a branch of applied computer science that addresses varied financial issues. Like financial engineering, different financial scholars have also conceptualized this concept differently in the study of data and algorithms used in finance and in the mathematics of computer programs that realize financial systems or models (Levy 2003).<sup>7</sup> Computational finance is related to financial engineering [and often used interchangeably] as it is also commonly defined as a cross-disciplinary area focusing on mathematics finance, computer simulations, and computational methods for making investing, hedging, and investment decisions. In fact, with the use of various computational techniques, quantitative finance experts can reliably determine the financial danger that specific financial instruments may pose (Arratia 2014). Computational finance is also related to other disciplines, such as quantitative finance (Alexandridis and Zapranis 2014; Bock et al. 2013).<sup>8,9</sup>

What is often mistaken is that all of these areas are subfields of financial engineering, and what differentiates computational engineering from other fields is that it is an area of computer science that deals with data and algorithms that emerge in financial simulation or modeling (Chen 2012).<sup>10</sup> On the other hand, the use of mathematical models and extensive data collections for evaluating financial markets and stocks is quantitative finance [also recognized as empirical finance and financial mathematics] (Härdle et al. 2017).<sup>11</sup> Risk management, as it extends to portfolio management, is an example of its application; it is also used in the pricing of derivative securities, such as options. The fields to which computational finance is applicable are roughly categorized either on the sales side or on the acquisition side (LeBaron 2006). Sell-side encompasses the trading operations of investment banks that create and market a wide range of financial products, such as futures, options and interest rate swaps, floors, and caps. In some instances, investment banks would only balance purchase orders. In most situations, they would sell what they produced and purchase-related products to pay off the sales. Conversely, the buy-side is to invest money by buying bonds, stocks, or other complicated products marketed on the sell-side. Some of the modeling and simulation applications used in computational finance include deterministic models, stochastic models, and numerical valuation techniques, among others, as outlined below and described by (Oosterlee and Grzelak 2019).<sup>12</sup>

## 3.2 EVOLUTION OF FINANCIAL ENGINEERING AND COMPUTATION

### 3.2.1 *Evolution of Financial Engineering*

For centuries, certain financial functions and markets have been around. There's evidence, for example, that the Romans may have developed the

checking system as early as 350 BC (Hopkins 1980).<sup>13</sup> In the 1750s, the first financial institutions had already learned how to take deposits, make investments, make loans, and provide protection. From the early 1700s to the 1970s, over two centuries, the growth of finance was constant and was carried out at a reasonable rate (Beder and Marshall 2012). However, the deregulation of interest rates, commodity prices, and currencies have created the need to manage risks. As such, between 1970 and 1997, financial experts were forced to find means of distinguishing the past and the future of financial institutions. The period was marked by four forces working in tandem to accelerate the adapt: technology, risk intermediation, deregulation, and globalization (Beder and Marshall 2012). Despite the need to manage risks, finance companies have begun to change their way of doing business rapidly since the early 1970s. Banks, government entities, dealers, brokers, central banks, funds, and insurance companies were confronted with new challenges and risks (Beder and Marshall 2012). As noted by (Udoka and Roland 2012), currencies and interest rates have been deregulated, leading to significant new volatility. Specialists started to seek technological help to solve these new risks and challenges.<sup>14</sup> As noted by (Beder and Marshall 2012), financial experts began to explore mathematical tools to address the problems, including risk measures, technical measures, and derivatives.<sup>15</sup>

By the 1980s, technology provided a critical field for addressing specific financial issues and established a risk identification and management platform. It is around this time that the world experienced advances in telecom, the first personal computers, and advances in financial hardware and software (Beder and Marshall 2012). As pointed out by (Ajupov et al. 2014), the word “financial engineering” first emerged in literature in the late 1980s, following heavy reliance on computer technology to conduct various financial functions. By that time, financial technology was expanding the demand for derivatives and the emergence of multiple types of innovative financial products. According to (Ajupov et al. 2014), US markets affected significant conversion of the derivatives market of the time, explaining the emergence and establishment of the concept of financial technology and the substantial number of scholarly work on the concept in the country.<sup>16</sup> Correspondingly, (Beder and Marshall 2012) note that globalization was the second force that characterized the late 1980s and early 1990s, where technology-enabled email, as well as satellite communications, were used. As a result, the flow of information in financial institutions was cheap and basically instantaneous, whereas cross-border transfers were done in seconds to a few days.

The rise of banks’ mainframe computers, as well as advanced data and record-keeping systems, also defined the 1980s in financial engineering. The related outcome, as noted by (Helleiner 1995), was that capital market activities began to move beyond borders, and traders began to anticipate one market event in response to another. By the 1990s, the Internet and e-commerce had exemplified most business models, and the end of the millennium resulted in the creation of online stock brokerage sites targeting retail investors<sup>17</sup> while

replacing phone-based retail stock brokering models (Looney et al. 2004; Tiessen et al. 2001).<sup>18,19</sup> The massive growth in financial engineering started in 1998 (Miller 1998). The era between 1998 and 2006 mostly ended the notion of “mono-line” in financial institutions and banks, insurers, and fund managers started integrating companies across the world. This period was characterized by low-interest rates, low-risk premiums, and tremendous profitability and huge growth in firm sizes (Lustig and Verdelhan 2007).<sup>20</sup> As stated by (Drezner 2008), BRICs and sovereign wealth seeking emerged as major players on the global capital markets, propelled by technology and globalization. Since 2007 onward, the field of financial technology, most notably Fintech, has been epitomized by innovative technology pivoting key areas such as e-banking solutions, core banking applications, advisory services, information processing, payment and transaction, monitoring and analysis, data storage and management, IT management and support services, among others (Chishti and Barberis 2016).<sup>21</sup>

### 3.2.2 *Origin of Computation and Rise of Modern Computers*

Edsger Dijkstra made the first case of distinguishing between algorithms and computation in 1970 (Denning and Wegner 2010) and defined algorithms as a static description when computations were defined as a dynamic state-sequence evoked by an algorithm from equipment. Almost 2000 years after the discovery of psychology, physics, and mathematics, after clearing the measurement description, the field of computer science, with which computation and computational principles became centered, appeared. Since then, computing has evolved to biological and interactive modes from Turing machines to object-oriented programming over the Internet. Computer scientists such as Gödel have accepted Turing machines as the foundation of computation models (Eberbach et al. 2004). Computing was seen as pure mathematics, having been used only to work on mathematical problems. But it was found in the 1960s that Turing machines could be used to solve all types of computable problems outside mathematics (Eberbach et al. 2004). As described previously, these revolutionary developments lead to the evolution of modern computing and computation.<sup>22</sup>

## 3.3 ALGORITHMS

In computer science and mathematics, an algorithm is a finite sequence of distinct and computer-implementable instructions, normally used in performing computation or class of problems. Lyuu (2001) defines this as precise procedures that can be turned into computer programs. Algorithms such as Euclids used in specifying the greatest common divisor can be said to be computable, while those that do not admit algorithms are uncomfortable.<sup>23</sup> Historically, alEuclids have played a critical role in computational finance, and the evolution in financial technology has transformed financial

activities from human-driven to algorithm-driven (Chinthalapati and Tsang 2019). Algorithms have not only been employed in traditional financial dealings such as portfolio optimization, risk analysis, trading, and forecasting; they have also been applied in novel areas such as data sampling.<sup>24</sup>

### 3.3.1 *Analysis of Algorithms*

Donald Knuth coined the concept of algorithm analysis as a computer science term for calculating the complexity function of arbitrary large inputs into the computation. In other terms, algorithm research has generally been used to evaluate the difficulty of algorithms, including the amount of storage, time, and other resources needed to run them (Knuth 1985). For statistical accounting, algorithm research has often been done to identify worst-case, best-case, average-case, and amortized case scenarios.

In order to solve a financial problem by computation, it is vital to consider time and space complexity since a particular program may run on a machine where memory space is insufficient or vice versa (Knuth 1985). These evaluations have traditionally been used to provide insight into the reasonable directions for the quest for efficient computational finance algorithms.<sup>25</sup>

### 3.3.2 *Software Implementation*

Throughout programming, software implementation is the process of transforming algorithms into computer programs for a specific computer program (Lyu 2001). Programming, design, coding, module testing, and debugging are all vital components of software implementation. There have been numerous implementation activities for a specification or standard. For example, software development tools include programming language implementations such as SQL, Java, Python, and C++ [programming languages are used in computer programming to implement algorithms]. On the other side, web browsers include implementations of the requirements of the WWW Consortium (Tanenbaum and Woodhull 2008). In technological finance, thus, the implementation of software involves the implementation of an algorithm or functional specification, such as software components, programs, or any other computer system, by computer programming and delivery.<sup>26</sup>

## 3.4 INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT)

Information and Communication Technology (Technologies) or ICT (ICT) is the technology and components that allow computing. Although there is no generally accepted concept of ICT in literature, it is taken to mean all tools, systems, applications, and networking components that combine to allow people and institutions, such as businesses and governments, to communicate

in the digital world (Webb and Cox 2004). As an expanded concept of information technology, ICT emphasizes the role of unified communications and the assimilation in telecommunications (wireless signals and telephone lines) machines and appropriate software, their computing and audiovisual devices to allow all users to access, distribute, display, and manipulate information.<sup>27</sup> Since the 1970s, information technology has evolved with the emergence of four generations of computers.

### 3.4.1 *Rise of Modern Computers*

In order to understand the processes and effects of globalizing technologies and their functions, such as computers and computing, it is vital to take into account the historical development of this technology and the process of disseminating it in general (Duque et al. 2007). It is widely acknowledged that the evolution of ICT has its basis in the rise of modern computers.<sup>28</sup> The term computing has its roots in the 1920s (Copeland 2006; Parolini 2013). Computer machines in that period referred to any machine that did the human-computer work, that is, any machine that was able to solve mathematical problems with effective methods like a human being.<sup>29</sup> However, in the late 1940s and 1950s, the advent of Electronic Numerical Integrator and Computer (ENIAC) replaced computing machines with simply “computers” but initially with digital or electronic prefixes (Goldstine and Goldstine 1996). In 1951, states Tatnall (2012), the first device to use transistors instead of vacuum tubes, was officially introduced; this computer was referred to as the Universal Automatic Computer (UNIVAC 1).<sup>30</sup>

After two years, IBM (International Business Machine), with its 600 and 700 series, made its mark in the development of computer technologies. By this period, more than 100 programming languages had been developed, and computers had operating and memory systems (Copeland 2006). Storage devices had already been developed, such as disks and DVDs. As noted earlier, the Turing machines built-in 1936 formed the basis and principles underlying the development of modern computers. In 1963 the third generation of computers (the modern computer) began with the invention of integrated circuits. The computing machines became smaller and lighter with this invention but also more efficient, durable, and with a strong memory. At the same time, computers could run numerous and diverse programs (Copeland 2006).<sup>31</sup> The early 1980s saw the introduction of the Microsoft Disk Operating System (MS-Dos), and IBM’s development of personal and office computers (Swayne 2003). By the mid-1980s, Apple created its icon-powered GUI for the Macintosh computers (Friedman 1997). Microsoft Corporation created the Microsoft Operating System in the 90s, spearheaded by Bill Gates and Paul Allen. As stated by Hammarlund et al. (2014), the fourth generation came with optimized VLSI circuits and gave rise to 16-bit, 32-bit, 64-bit, and embedded computers, which are still being built into

various creations to date.<sup>32</sup> Currently, the most efficient machine (supercomputer) is named Summit, developed by IBM for the Oak Ridge National Laboratory in Tennessee at the United States Department of Energy. The massive computer can reach an unbeatable 1486 petaflops thanks to its 2.41 million cores and can run 200 quadrillions of calculations per second (Liesch 2020).<sup>33</sup>

### 3.4.2 *Digital Revolution*

Digital revolution signifies the change from mechanical and analog electronic technology to digital electronics, beginning in the late 1950s to the late 1970s instigated by the introduction as well as the proliferation of digital machines and record-keeping that is witnessed today. The digital revolution, as stated by Clarke (2012), was the most significant event in information technology and dissemination since Gutenberg's printing press and marked a huge contribution to human interaction. This revolution began in 1947 with the translator's invention, a data transfer machine that fueled digital technology (Hutchins 1997).<sup>34</sup> The early 1950s saw the debut of the first physician pager in New York City, immediately followed by selling the first machine for simple arithmetic and data handling. By late 1960, the ARPANET network had already formed an early Internet successor (Grubestic et al. 2003). In the early 1970s, the first email was sent reading along QWERTYUIOP (McKenzie 1980). Around the same time, the first computer console was developed and saw the game precursor "Pong" launch.<sup>35,36</sup>

The first computer, equivalent to a modern-day laptop, was produced in 1981, according to Grego (2009), with a panel slightly larger than a matchbox. ABBA was the first artist to capture and store songs on a compact disk (CD) in 1982 (Larkin 2011).<sup>37</sup> The first mobile phone was later created in 1984, costing around \$4000, with a 10-hour charge that only provided 30 minutes of use (Park 2005).<sup>38</sup> The first fully functional digital camera was developed in the late 1980s, noted Kawahara (1988), which provided up to 10 images to be processed. In 1989, Tim Berners Lee invented the World Wide Web while working at CERN, and 0.05% of the world's population used the Internet by 1990 (Gillies 2000). Following the invention of WWW, CERN created the first web browser and released it for public use.<sup>39</sup> In 1994, the first "smartphone" that supported faxing, emailing, and calls was released (Andrew 2018).<sup>40</sup> With the launch of the first smartphone, the creation of the first modern social media site followed in 1997, bearing the name *Six Degrees* (Watt 2004). This invention was quickly followed by the creation of Bluetooth technology to allow the sharing of digital content from one smartphone to the next.<sup>41</sup>

To improve internet connectivity, Broadband was invented in the United Kingdom in 2000, and Skype was launched to connect people around the world by 2003 (Zennström and Friis 2003).<sup>42</sup> Immediately after Skype was born, Mark Zuckerberg and his schoolmates set up Facebook, instigating the



new age of social media. This followed the introduction of YouTube (2005), Facebook (2006), iPhones (2007), 3D printing (2008), and iPads (2010). After the launch of a distributed ledger-based network by Satoshi Nakamoto on January 3, 2009, Bitcoin became a widely accepted digital currency in 2011. Google started testing driverless vehicles in 2012, and Oculus Rift and virtual reality headsets became available to consumers by 2016. Today, virtually everything is digitized, from healthcare to education, and it looks set to continue at an unprecedented pace.

### 3.5 ICT IN FINANCE

ICT focuses primarily on information exchange, and its development as a science corresponds with developments in IT and computing technology (Hitt and Brynjolfsson 1997). As noted previously, the difficulty of conducting business in the 1960s has caused countless uncertainties and risks in the corporate world. The development of IT devices such as computers in the 1970s provided easy and reasonably priced access to financial institutions for information (Ernst and Kim 2002). As machines were inexpensive and publicly available, financial firms became able to manage and process the data efficiently. At the same time, IT efficiency and pace enabled the creation of financial services that included the issuance of credit cards and electronic screening. According to Teo (2002), after the invention of the Internet, business transactions had moved online, and by 1998 more than \$50 billion worth of transactions had been made online.<sup>43,44</sup>

By the twenty-first century, Bughin et al. (2010) reported that routine electronic banking had increased considerably, demanding more computers, networks, and security programs. This has intensified the advocacy of global finance, enabling financial transactions to run on a worldwide scale. Financial markets became the first organized, global markets that operated through a network of computers (Knorr Cetina and Bruegger 2002). Crucially, the Internet allowed the uninterrupted access to credit ratings and scores to all businesses, insurance firms, and lenders.<sup>45</sup> With the emergence of social media, new messaging, and interactive platforms were developed, and people became more linked and educated than ever before. Socially driven information technology has allowed financial institutions and companies to reach out to customers of diverse demographics in pursuit of competitive advantage. Today, as stated by Kirmani et al. (2015), new, most effective, up-to-date, common, and flexible ICT technologies underscored by computer-based modulus operandi have overridden nearly all modern industrial processes, through their efficiency, performance, and reliability.<sup>46</sup>

### 3.6 CONCLUSION

Financial institutions have been around for centuries. Over time, these structures have experienced radical technological reshaping, step by step, of a cycle

that could be divided into different periods. In the first century, from the 1700s to the 1970s, financial infrastructure development was at a comfortable level, yet the globalization of interest rates, commodity prices, and currencies produced a need to manage risks in the early 1970s.

The time from 1970 to 1997 was the second phase that pushed financial experts to find ways to separate the past and future of financial institutions. In this time, four coercing forces, including technology, risk intermediation, deregulation, and globalization, were the bringers of change in the state-of-the-art financial engineering in cooperation with ICT. In brief, economies around boundaries were getting closer and engaging with each other in a way that caused the response of one business to the results of another. As a result of globalization, financial institutions' costs decreased, leading to an exemplary creation of online brokerage deals replacing telephone-driven deals.

The years 1998 and 2006 enabled financial institutions and banks, insurers, and asset managers to merge businesses across the globe. Since 2007, Fintech, the world's most popular financial technology, has been embedded with innovative technologies that address key areas such as banking solutions, core banking solutions, advisory services, information management, payments, and settlement. Financial engineering computation methods evolved due to side-by-side development of the available information communication technology that facilitated the public interest.

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# Fintech and Blockchain: Contemporary Issues, New Paradigms, and Disruption

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## 4.1 INTRODUCTION

The development of financial technology (FinTech or Fintech) can be traced back to the early 2000s through various phases in the financial services industry. Financial technology, popularly known as “FinTech,” signifies the use of computer programs or other technology to support the financial sector. Fintech and its associated technology are not a groundbreaking concept used nowadays. Fintech questions the traditional financial approaches used to provide financial services because of its primacy in innovation and technology. At present, the future of financial technologies mostly relates to blockchain research and its broader implications.

Blockchain technology allows a standard protocol to verify transactions and to upgrade data across various highly secured computer network locations concurrently. Blockchain’s essence resides in the distributive ledger technology (DLT), in contrast to the centralized ledger paradigm. Blockchain is emerging

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in both academia and industry as a concept of the next era of alternative solutions to underlying problems.

Fintech and blockchain are the two different entities evolving as pseudonyms. Blockchain often associated with Bitcoin, Ethereum, Litecoin, Ripple, etc., has recently been vocal as FinTech's spine, suggesting that Blockchain technology has gone beyond cryptocurrencies. Finance industries are benefiting tremendously through blockchain-based Fintech. Large banks like HSBC, Deutsch Bank, etc., use this technology to enhance the level of security and reliability of their services. According to PWC's financial services and fintech study, by 2020, 77% of fintech companies were expected to involve blockchain technology as part of their system.

Undoubtedly, the groundbreaking distributive ledger system has tested the day-to-day functioning of a financial transaction, and several implementations, flexibility, scalability, etc., explorations followed up ever since. Late in 2015, Peters et al. discussed the state of regulatory readiness for dealing with transactions in these currencies in different regions of the world. Apart from the use of blockchain technology in Fintech, researchers have thoroughly discussed its use in finance, supply chain management, notary, voting, etc. There is a wealth of evidence in developing countries in Africa and Asia that is facilitated by this technology. Even in the West, land registries have started to use blockchain to register and own plots. Such technology provides accountability, cost-benefit, pace, and many other factors related to the distributed ledger. Various types of organizations are now looking for ways to implement blockchain into their systems, varying from cloud computing to accounting.

However, a comprehensive study led by Fernandez-Vazquez et al. (2019) shows that the focus on issues such as security, scalability, legal and regulatory, privacy or latency, with proposed solutions, is inadequate. The vast majority of research focuses on finance and banking, avoiding other industries that could play a crucial role in the further expansion of blockchain. The recognized issues and the proposed resolutions may still be far from sufficient. An in-depth focus on tackling the challenges of the proposed solutions is still far from being effective.

## 4.2 CONTEMPORARY ISSUES: OPTIMISM VS. PESSIMISM

Still, one might wonder, what's in there when the proliferation of blockchain and financial technology is increasing broadly? To what extent is the risk left unaddressed? What legislative steps to ensure its trustworthiness will float? These might be the few problems leading to a concept or vice versa by the activities of real academia/researchers. The innovation of blockchain technologies has surprised the industry, it has several implications, which could simplify Fintech, but can we go beyond that?

Financial organizations are on the brink of exploiting the technological aspects to gain market share in contemporary finance. Financial institutions and businesses are increasingly becoming informed of the ramifications of

blockchain technology and have set aside a considerable amount of research and development funds. Apart from the advantages associated with cryptocurrency, there is also a noticeable suggestion of misrepresenting the existing technology.

To address the shared contrast within research communities regarding blockchain development and its phase-in Fintech, we will discuss the following topics briefly.

#### 4.2.1 *Financial Inclusion/Risks*

Leaving aside a competitive banking system, millions of people around the world do not have adequate financial services. Economic infrastructure advancement is often seen as an incentive to support the socially marginalized. The opportunity for expanding financial services to the wider international population is firmly pursued by financial technology. The blockchain is set to have a dramatic impact on financial activities and to change the way financial institutions operate.<sup>1</sup> Fintech is filling a gap in countries of the first world to some extent, but the developing countries are still far from reaching it.

Contrary to this, blockchain technology intends to help the financial transaction at a lower cost, less time to complete the transaction, and allows full governance accountability of the process. Most researchers argue that we should regard Blockchain as conventional technology in the still early stages. Several well-favored developments may have ignored the finance regulatory process, but there is always more know-how to carry it into the next step. Several governments, banks, and companies have entered blockchain projects intending to reduce payment costs and increase transparency and independence.

#### 4.2.2 *Scalability*

According to 2016 data, daily transactions at the bitcoin network are limited to 350,000 full-capacity transactions, whereas on an average business day, the German payment system processes 75 million. A transaction rate per second, Visa handles 24,000 and other blockchain networks like Ripple leads with 1500, Litecoin is low at 56, followed by Ethereum at 15–20, and Bitcoin only processes 7. This could be one of the few reasons blockchain is at an early stage of high-performance enterprise development. At present, the path of financial institutions developed by Fintech is limited by the scalability of blockchain to be implemented and inferred.

Since FinTech is susceptible to cyber-related crime, its growth between innovation and regulation presents an uncertain challenge. Blockchain technology needs to scale up transactions per second and set a benchmark for more global inclusion, with differences in financial and legal protocols across nations.

### 4.2.3 *Lack of Consensus*

Fintech firms are in the process of creating a platform that uses blockchain technology to add value or reduce the latency of the existing model. A lot of investment has been made in research and development in this sector. According to the Accenture report, Fintech's investment increased globally by 201% in 2014.

A survey by Capgemini in 2016 revealed that 60% of financial services executives have a basic understanding and less than 10% possess a very good understanding of the Blockchain technology. Fintech companies provide detailed grassroots research to understand the technical and legal nuances. Lack of consensus could be more costly to send the novel system a green signal early.

## 4.3 NEW PARADIGMS AND DISRUPTIVE INNOVATIONS

### 4.3.1 *Payments*

#### 4.3.1.1 *Non-traditional Payment Schemes*

Over the past several decades, financial institutions have developed payment systems that are increasingly obsolescent as a consequence of Fintech innovations such as decentralized channels, distributed ledgers, and cryptocurrencies (Cai 2018; Chuen and Deng 2017).<sup>2</sup> Today, Fintech companies are more attuned to the high expectations of a new, tech-savvy generation purchasing goods from around the world using smartphones. Frictionless networks such as distributed ledgers created by the digital revolution have removed barriers to cross-border payments, data transfers, and remittances by being safe, inexpensive, and near-instant (Babich and Hilary 2018).<sup>3</sup> Such revolutionary, game-changing, and secure payment systems have allowed greater economic activity and facilitated growth, while also resolving issues of privacy and confidentiality resulting from traditional systems (Nanayakkara et al. 2019; Niforos 2017). Modern consumers can, therefore, trade and pass inventory with needless red tape in a secure and side-step manner. In the contemporary business world, the key principle is that new processes and innovative solutions in the payment industry have enabled banks and consumers to transact anywhere, anytime.<sup>4,5</sup>

Mobile money is a disruptive innovation that sprouted soon after the turn of the century and was widely experimented in both developed and developing countries (Myerson 2019).<sup>6</sup> Half of the world's population does not have a bank account, and mobile money has sought to include this "forgotten" demographic in the financial services industry. According to (Pelletier et al. 2019), the initial incentive to bring digital money to a larger population did not come from the financial sector or existing local banks, but rather from the entry of international telecommunications companies.<sup>7</sup> Telecommunications companies' core capabilities differ considerably from those of banks, as well as the opportunities to exploit new mobile money innovations.

According to Baden-Fuller and Haefliger (2013), the variations in rewards and core capabilities are evident when examining value creation and value capture. Explicitly, value creation reflects how telecommunications companies and local banks engage with customers while capturing value and how value is monetized. Telecommunications companies have been able to induce mobile money because their revenue comes from a transaction fee, while banks are float-based, and their earnings come from deposits.<sup>8</sup>

In the realms of mobile money, digital currencies came to increase digital payment's far-reaching capabilities and skills. As Mendoza-Tello et al. (2019)<sup>9</sup> pointed out, cryptocurrencies in the Fintech world are disruptive technologies because they define a new paradigm: the decentralization of confidence in secure electronics without the need for a central authority to control the system. The era of digital currency is a stimulating concern in contemporary society because it has reformulated both the stage of evolution and money transfer. This industry 4.0 and the Fintech era are changing the financial sector's composition, and many other sectors are the fast following (Nanayakkara et al. 2019).<sup>10</sup> One of Fintech's most prominent applications is a decentralized blockchain-based contract or what is referred to as a distributed ledger network (Crosby et al. 2016; Efanov and Roschin 2018).<sup>11,12</sup> At the very least, Fanning and Centers (2016) noted, blockchain technology to change how many financial firms, conduct their operations, affecting sectors such as product validation, mobile payment, auditing, contracts, and gambling. According to Chen and Bellavitis (2020),<sup>13</sup> this has become a reality with blockchain transforming various aspects of everyday life beyond banks and other financial institutions. Beyond underpinning cryptocurrencies such as Bitcoin Litecoin, Ethereum, Dogecoin, and others, blockchain technology is now widely used in other applications that are transforming the society. Some of these applications include asset management (trade and settlement) (Chiu and Koepl 2019), blockchain healthcare (managing healthcare supplies, testing results, regulation compliance) (Zhang et al. 2018),<sup>14</sup> insurance (processing claims) (Nair 2019), payments (cross-border payments) (Deng 2020),<sup>15</sup> and smart property (Blockchain Internet of Things [IoT]) (Zhang and Wen 2017), among others.

#### 4.3.1.2 *Cashless World*

A Fourth Industrial Revolution is currently being built on the Third and has been taking place since the last century. As noted by Morgan (2019), almost every industry worldwide is disrupted by that. The world is increasingly being cashless, linked, and smartphone-reliant in finance (Heller 2016; Ingves 2018),<sup>16,17</sup> and traditional banks are scrambling to adjust to this period of financial history. Mobile payments continue to hit new heights in its second decade. Numerous industry players have continued to scale, including PayPal, Google Pay, Apple Pay, Alipay, WeChat Pay, MTN, American Express, and others. These are disruptive technologies that require the adaptation of a broad and established ecosystem.

Recent IT technology developments, numerous Fintech technologies have enabled automated billing and simplified payments to improve the customer experience. Therefore, this offers the above-mentioned digital-savvy customers incentives and effortlessness, that rapidly favor cashless transactions from their comfort.

### 4.3.2 *Deposits and Lending*

#### 4.3.2.1 *P2P Lending and Alternative Adjudication*

New-age Fintech (“challengers”) technologies are disrupting conventional banking systems and destroying obsolete deposit and lending practices built up by incumbents in the past century (Gupta and Xia 2018).<sup>18</sup> The banking sector, as well as the larger finance industry, is experiencing a wide range of digital banking innovation challenges not only across the payment and currency continuum, but also financing, money transfers, and investment management, among others. As Raskin and Yermack (2018) have found out, credit card purchases are replaced increasingly by mobile and digital alternatives such as cryptocurrency and mobile money (Apple Pay, Google Pay).<sup>19</sup> Digital wallets such as PayPal also replace traditional bank deposits and the need for typical regular ATMs (Shashikala 2019).<sup>20</sup> Digital banks such as N26 and Manzo are selling enticing mobile-first current account offerings to substitute incumbents. Peer-to-peer (P2P) lending platforms (such as the Lending Club) are now more attractive and appropriate than traditional lending systems (Tang 2019), while real-time payment platforms and systems eliminate the need to use checks.<sup>21</sup>

Following several years of exponential growth, P2P loans are now an important provider of consumer credit. Although Fintech credit only accounts for a small fraction of total credit globally, it is shown to proliferate and could become more dominant, especially in developed markets. In fact, in the United States, Fintech firms provided 36% of unsecured personal loans in 2017, showing Fintech’s rapid growth and disruptive credit capability (Claessens et al. 2018).<sup>22</sup> Innovations in consumer risk assessment allow automated lenders to assess risks based on the customers’ digital footprint. Big data, machine learning, and social data technologies are increasingly being used under this umbrella as enablers to change the consumer lending industry around the world. With such facilitators and the use of innovative and lean adjudication approaches, Budiharto et al. (2019) state that Fintechs are surfacing unique lending items in spaces such as unbanked micro-loans, millennials, subprime customers, purchasing electronic devices in e-commerce stores, auto loans, travel loans, health emergencies, and education loans, among others. This diversification has made it possible to lend P2P to consumer segments that have had no choice to date.<sup>23</sup>



#### 4.3.2.2 *Third-Party APIs and Virtual Technologies*

FinTechs are changing consumer preferences by using third-party APIs and virtual technologies to maintain both the security and reliability of financial services (Ancrì 2016). Most Fintech applications depend on third party data for processing market offers, analyzing user credit score, detecting fraud, evaluating a property, and even linking consumer information to their profile. The use of third-party APIs in lending is part of the business logic; borrowers can effortlessly and promptly obtain critical information, which, in effect, will allow better and faster services to consumers (Ancrì 2016).<sup>24</sup> Virtual technologies, such as virtual lending, make it easy for Fintech firms to access credit scoring systems to make instant mobile loans available to customers. This whole process makes the “last mile” of seamlessly and instantly extending the funds to borrowers (Dube 2019; Emekter et al. 2015). While this lending model improves the end-user experience in many ways, it also offers various advantages for lenders, including risk minimization and customer administration.

### 4.3.3 *Market Provision*

#### 4.3.3.1 *Smart and Faster Machines*

Throughout today’s technology era, smarter and quicker machines are used widely in the finance sector, primarily in big data, artificial intelligence, and machine learning. As stated by Gokul (2018), FinTechs can reach even wider and more direct information about their clients through news breaks, social media, websites, and the Web. In fact, by processing the data by an algorithm to find link correlations, these companies can uncover market trends and change their industry requirements to provide better services. Big data-driven machines are also able to quickly detect problems in processes and check possible alternatives and, based on such analyzes, can make decisions automatically (Bauguess 2018).<sup>25</sup> Similarly, AI can help financial institutions incorporate real-time self-correction and optimization of their processes. These smarter and faster computers have enabled Fintech firms, such as P2P lenders, to analyze customer credit scores by validating information from the Internet to evaluate borrowers’ credit and modify their decisions. This standardization and integration provide distinction in Fintech’s core business. Accordingly, Varian (2018) argues that groundbreaking technologies such as AI and machine learning offer five key advantages, including cost reduction, differentiation, accuracy, speed, and standardization. The use of AI, machine learning, and big data has caught the imagination of many, including how such machines could replace humans in the workplace. Essentially, these machines help to customize business processes and decisions that result in better results tailored to the needs and expectations of the digital-savvy generation of consumers.<sup>26</sup>

#### 4.3.3.2 *Connecting Buyers and Sellers*

As previously stated in this segment, technology has changed virtually every part of today's economy and society, with inventions enabling normal, safe, and efficient data exchange. As such, marketplaces for data have become crucial in connecting buyers and sellers in the respective systems. While different data marketplaces have different properties based on their particular application, Oh et al. (2019) suggest that their model provides a range of advantages, including transparency, standardization, shared opportunities, and crowdsourcing.<sup>27</sup> Big data plays a fundamental role in matching consumers and sellers in these areas, according to Liu et al. (2020). For example, it's used in the real estate industry where customer search is optimized, which offers recommendations to potential sellers and buyers on real estate websites. The use of big data in a situation like this matches consumer with their desired homes.<sup>28</sup>

### 4.3.4 *Investment Management*

#### 4.3.4.1 *Next Generation of Process Externalization (Robo-Advisors)*

Wealth management is becoming more competitive, where labor-intensive and expensive resources are turning into commodities. Like other disruptions discussed before, the core of this evolution is technology. Robo-advisors have become a reality in investment management today, as reported by Sironi (2016).<sup>29</sup> These are online tools that analyze an individual's investment and financial positions automatically and report tailored recommendations informed. According to Uhl and Rohner (2018), some Robo-advisors may invest in ongoing investments with consumer input (such as stock selection), while others may invest in passive investment portfolios (such as exchange-traded funds) and will not allow clients to change investment strategy.<sup>30</sup> Technologies like Robo-advisors for investing and wealth management with limited to moderate human intervention, facilitating precise and rigorous objective preparation, comprehensive education, fund management, account operation, protection, and low fees. Such technologies can now, after a decade of development in this field, manage much more sophisticated tasks such as retirement planning, investment collection, and tax-loss harvesting (Alsabah et al. 2020).

#### 4.3.4.2 *Empowered Investors*

Via technology such as Robo-advisors and others created by the power of cloud computing, investors can now consider the total cost of ownership correctly, take a holistic view of their assets, buy-in from key stakeholders, create and develop KPIs, and distinguish fact from misconceptions before making investments. In Fintech, besides Robo-advisors, there are other technological innovations, such as social trading, that have emerged in recent years to allow various investors to share market insights, tactics, and opinions (Röder and Walter 2019). Likewise, as stated by Mehta et al. (2019), retail algorithmic

trading, another Fintech breakthrough, helps investors to easily create, check, and perform trading algorithms, even those with novice and insufficient technical know-how. Based on the assessment of Kliman and Arinze (2019), the success of investment/wealth management will rely on being cost-effective, customized, secure, transparent, and accessible.

### 4.3.5 Insurance

#### 4.3.5.1 Connected World

Also shown to substantially disrupt the insurance industry are the same disruptive changes that impact the economic and financial worlds, as well as the society. In the age of connectivity, technologies such as sensors, advanced analytics, the Internet of Things (IoT), and communication protocols limiting a broad range of traditional insurance offerings (Pain and Anchen 2017). As such, insurance companies that do not adapt their policies in a tech-driven world are lack competitive advantage. Technologies such as advanced sensors require injury avoidance, increasing operational issues for insurers. The car world is rapidly changing, where cars can even communicate with each other to prevent accidents. Today, modern cars have operating systems, Internet connection, run-user applications enabled, all of which have consequences for insurance companies (Catlin and Lorenz 2017). Connectivity and advanced technologies transform households, too. Sensors can prevent risks such as fire and theft, while other devices monitor and modify metrics in the interior. Healthcare is also evolving in the sense that people may manage their daily activities through wearable devices (computers) that keep them linked to their providers of healthcare. Physicians may discover patterns in the health of patients, enabling them to make medical recommendations more rapidly. Data-based medical intervention can map, calculate, and identify a wide variety of medical conditions today. Similarly, reports Catlin and Lorenz (2017), this poses operational issues for health insurance companies.<sup>31</sup>

#### 4.3.5.2 Disaggregating Forces

Digital technology is proving to decimate significance in the insurance sector. While this may sound counterintuitive considering the possibilities that brought technological advancement to some industries and companies, such innovations that deplete an industry's corporate earnings and overall value (Catlin and Lorenz 2017). For starters, the push observed toward the introduction of autonomous and self-driving vehicles will have direct consequences for car insurers and the insurance industry as a whole. One can say the same about home sensors and medical wearables. The existing insurance companies are assumed to have prospects in this digital revolution, but such benefits will spread unevenly (Catlin and Lorenz 2017; Pain and Anchen 2017). Those who move swiftly and decisively to find opportunities would prosper with

the aid of technology. There are already insurance companies now implementing remote monitoring insurance models that match the needs of an already changing digital world.

#### 4.4 CONCLUSION

2008 global financial crisis could open the door to diverse innovation alternatives in the world economy. Fintech has shown promising growth, which was not possible in the field of information communication and technology (ICT) without a thousand corrections. The peculiar feature of blockchain technology that disregards the middleman will vastly change the financial sector landscape. The agent-free process, customized human identification, smart digital contract, global open transaction, etc., are some of the lucrative benefits of blockchain technology that makes Fintech appealing. The path to regulation of a FinTech will be faster and less costly than large financial organizations established. As such, it will empower FinTechs to provide compliance data mapping solutions that help the customer simplify data inventory production and processing registers cheaply and efficiently.

Blockchain concept and technology previously used for the generation of bitcoin and the transaction has expanded its area of application due to its properties such as security, privacy, traceability, original data provenance, and time-stamping.

Among the numerous benefits of blockchain, it secures every type of transactions, whether human-to-human or machine-to-machine. Establishing a worldwide internet network is very tempting to guarantee data redundancy and, thus, longevity. Blockchain is still in its early phase, altering its features as per global demand. For data security, blockchain requires another internet component to make it trustworthy. Together with Fintech, the expansion of this framework will address the dangers previously inaccessible. Further specialized work to form regulatory measures will help foresee Fintech's dependence on blockchain technology.

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# The Challenges and Competitiveness of Fintech Companies in Europe, UK and USA: An Overview

*Roman Matousek and Dong Xiang*

## 5.1 INTRODUCTION

The digitalisation of the economy progress rapidly. The technological advancements penetrate into everyone day-to-day business activities. The digitalisation is galloping to every business area. In particular we observe milestone changes in financial sector. The implementation of technological changes is undoubtedly driven by customers demand that is influenced significantly by millennium generation that is not only on the side of customers but also developers of new progressive digital innovation. Banking sector is an excellent example to demonstrate these changes. The changes of the banking sector and its products are distributed across all bank's activities: retail banking including progressively expanding mobile banking, wholesale banking and of course insurance companies and their use of blockchain (Carney 2017; Buckley & Malady 2015).

There is a broadly defined consensus of how banks should proceed in their business by taking the advantage of new technologies: Firstly, they could adopt an open innovation approach when *know-how* along with financial capital are used to develop and deliver new technologies that support new products developments. Other possible form is through collaboration across different industries. Such collaboration allows to create new and different

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skills that reflect the complexity of the development and implementation of the financial technologies and products and to determine original ways to generate added values. Finally, there are a number of the so-called accelerators that include broadly defined financial services providers. Those providers use venture capital for supporting start-ups that concentrate on financial technologies and related business activities. It is recognised that the successful start-ups need to be linked with already established financial Fintech companies and financial institutions that allow them to test the developed technologies and products.

In retail banking that deals with customers that include: households, individuals and family businesses, we have been observing the more than gradual changes from the traditional product like savings accounts, cards and consumer loans. Bank's retail consumers are abolishing the traditional delivery channels more and moving to mobile banking. These changes are not only because of convenience for customers but they save the operations cost for banks in long-run. The banks themselves also started with the marketing campaign that aim to educate bank's customers. The new technology used by banks improve bank efficiency and productivity. New platforms as the Banking-as-a-Service (BaaS) allows bank's customers to back up company files and entire data repositories (Dhar and Stein 2016).

The key changes in retail banking are the mobile banking services that are used by the majority of bank's customers. Mobile banking gradually ousts online banking and expands five times faster than online banking. Mobile banking also uses the artificial intelligence that is adopted by services that provide an intelligent money management feature that helps customers to manage their spending and savings (IMF 2017). The barriers of a further expansion of mobile banking services is, however, undermined by security issues. Thus, an integral part of providing services is development and adoption of such security packages that are tailored to the specific customer's needs. These rapid changes push some banks out of this business since they have not made sufficient capital investment to provide these services. Despite this growing popularity, some banks still fall short on the demand for mobile tasks, like bill pay and reward redemption, causing them to push users to online banking. However, online banking loses its appeal to millennials and Gen-Zers, who continue to give their preference choice to the mobile market.

## 5.2 FINTECH: CREATIVE DESTRUCTION OF TRADITIONAL BANKING

From the managerial perspective, it is important to understand how the traditional banking business model will be reshaped as a result of Fintech. These changes are frequently addressed as the outcome of the 'creative destruction' process. The process of creative destruction has been observed across other industries since the late 1990s. Fintech and financial innovation change the

traditional business models in general by offering the new forms of production, supply chain management, marketing strategies among other. In terms of the impact on financial services, there is anecdotal evidence that Fintech has been ‘creatively disrupting’ the individual providers of financial services and financial markets. Financial technologies along with accelerated financial innovation define a new way of how financial services are accessed and delivered. They do not only affect the supply side of the provided services but they also reshape the experience of the individual users of financial services. It is important to acknowledge that the unprecedented innovation boom provided by financial technologies leads to the reduction of asymmetric information and reduces transaction cost.

### 5.2.1 *Bank Competition and Technologies*

The market share of traditional banks not only in retail banking but to some extent in wholesale and investment banking has been rapidly disrupted by the presence of Fintech companies. The business concept of Fintech focuses on the individual financial services that are the outcome of the unbundling process when a single financial services and products are separated for the bank activities. The business of Fintech companies is in general based on these features. Fintech companies have superior expertise in a narrow scale of financial services/products. The product specialisation allows Fintech companies to deliver the product in extremely low costs that the traditional banks cannot meet. Fintech companies also provide mobile applications that support the managerial aspects of business financial management. Fintech core competitive advantages lie in their superior ability and flexibility to provide highly innovative products/services by using advanced technological solutions. The traditional banks neither have the intellectual capacity nor the sufficient flexibility of a quick adjustment of meeting customers preferences.

The accelerator of Fintech progression is the adoption of Artificial Intelligence (AI). AI is essential for bank expansion and the development of new products. PricewaterhouseCooper study shows that the majority of financial services identify the investment in artificial intelligence (AI) as key for the next market sustainability and to deal with the strong competitive pressure. Apart from the importance of AI to react to business needs the investment should be reflected in the cost savings that are expected to be \$447 billion by 2023. The use of AI by banks is essential for bank customers for chatbots and robots. AI is not only used by newly established banks but the traditional banks rely on AI. *Bank of America* and *JPMorgan Chase*, for example, are users of AI to streamline bank customer services. AI is also use for mobile banking customers to have an access to the bank services for 24/7. An important contribution of AI is banking services is the security of the provided services and to prevent fraudulent activities. AI has the capability to be used by banks in risk management and portfolio management. AI technology is based on big data analytics that is key in managerial task.

Voice interfaces are key technological advances for chatbot solutions. It is an outcome of sophisticated artificial intelligence that allow again to reduce the labour-intensive operations and can gradually reduce the number of branches and their employees there. Chatbots is not only an additional way of communication with customers but is to replace the standard communication channels as email, phone and text messages. The penetration of chatbots is fast and the banks now uses for almost 80% of the total communication interaction with banks clients. Chatbots are becoming a popular tool by customers since they have a personal touch. Chatbots have successfully been adopted by Bank of America, Capital One and Wells Fargo for several years. The use of possible use of chatbots is expanding to different bank activities that include financial advising. Chatbots have a very positive impact on the customer 77.

We could also see the implementation of blockchain technology that is key for all the safety issues that are linked to record bank transactions. The use of blockchain has already been changing the business model of how banks operate. The *Harvard Business Review* predicts that blockchain will disrupt banks the way the internet disrupted media. The main advantage for banks to adopt blockchain technology is its transparency, security and not high-cost implementation. The contribution of using blockchain technology is that it supports banking services in all the different ways that include payment facilities, trading with securities, loan contracts.

It is important that all the decision processes on which artificial intelligence, including blockchain technology works is the use of big data. The banking sector is one of the largest investors in big data and business analytics solutions. Indeed, the financial services through the different channels that include credit card transactions, ATM withdrawals, personal characteristics of their customers allow the bank to tailor their service. The use of advanced technologies allows them to support banks' decision processes.

The use of big data and its availability set up the competitive advantages for new digital banks that try to set up their operational (Dermine 2016). A large scale of transactions that include real-time information that allows to detect, for example, to map a customer's spending habits, to optimise marketing strategies for sales management by segmentation of customers based on their spending. An important part of big data analytics is the use for detecting fraud and to reduce operations costs. Big data analyses are a very powerful tool that helps to predict market trends. Big data analyses also help banks to improve their operation efficiency and importantly to reduce operational risk within banks.

The future trends in financial industry are further influenced by the use of Robotic Process Automation (RPA). RPA saves banks their operational cost and reduces operational risk that is inherent in banking operations. Banks recognise that the use of RPA technology is extremely convenient for large-scale bank operations. RPA reduces labour cost and supports bank competitive advantages. In terms of labour cost reduction it is suitable for routine labour-demanding operations that can be fully automated. RPA is also an effective

tool for improving customer satisfaction for such tasks like customer service chatbots. Customer questions about accounts and payments are responded by chatbots that free up human customer agents to deal with the high-priority concerns. RPA is also used by banks for routine compliance activities that are required by the regulators. The RPA might significantly change how the banks make their managerial decisions about the portfolio structure including underwriting of loans (mortgages).

A further technology that may affect, at the end, bank competitiveness is the use of cloud computing. Cloud computing is a technology that is used for a large number of operations that include storing data, databases, networking, software, analytics and moreover the internet. When an individual or a business wants to use the cloud, they will pay a cloud provider based on usage with pay-as-you-go pricing. The advantage of using cloud computing is that it makes 24/7 customer service available regardless of the customer's location.

The use of advanced technologies go hand in hand with cybersecurity. In banking, cybersecurity is a key determinant for further expansion of new advanced technologies. The qualitative aspects of cybersecurity belong to the important elements of non-price competition among traditional and digital banks. Banks collect an extensive volume of sensitive data and deal with the money that can attract the criminal and fraudulent activities within and outside the bank in question. Cyberattacks are and will become a permanent problem for banks and their customers. There is an enormous volume of end-user activities that are very vulnerable to cyberattacks. These include mobile applications, web portals and still prevailing plastic cards. Since safety cannot be fully guaranteed but can be improved by banks, this aspect will be key for further bank competition and attraction for new bank customers. In other words, the investment in cybersecurity has to become crucial for further business activities and the expansion of these activities. The protection against cybersecurity attacks is costly but it has to be seen as the fundamental element of successful business.

### 5.2.2 *Competing Areas*

In order to achieve the sustainable expansion of Fintech companies and overall competitiveness it is essential that there is a sufficient capital flow, labour quality—talent, business demand for services. An integral part of the successful development of financial products is the need for adequate regulation. In the following text we briefly overview these requirements (Matousek 2018).

Fintech has attracted large attention from investors who are willing to invest in different forms of capital. One of the prevailing forms of investment has been through venture capital. However, one may observe that there is a decline of the invested capital in 2018 particularly venture capital. PitchBook Platform reports that 196 deals have been completed for a total of €1.14 billion in 2018. That is only two-thirds of the total transactions reported in 2017. One reason that could explain that drop is the saturation of the market.

**Table 5.1** FinTech adoption rates

<i>Money transfer and payments</i>	<i>Financial planning</i>	<i>Savings and investments</i>	<i>Borrowing</i>	<i>Insurance</i>
China (83%)	China (22%)	China (58%)	China (46%)	India (47%)
India (72%)	Brazil (21%)	India (39%)	India (20%)	UK (43%)
Brazil (60%)	India (20%)	Brazil (29%)	Brazil (15%)	China (38%)
Australia (59%)	US (15%)	US (27%)	US (13%)	South Africa (32%)
UK (57%)	Hong Kong (13%)	Hong Kong (25%)	Germany (12%)	Germany (31%)

Source E&Y Fintech

It is obviously more difficult for start-ups to penetrate into the industry with fundamentally new ideas. They need to improve their network with other established companies but that proves to be more and more difficult. Therefore, one of the viable solutions is to establish links and with those banks that lack the flexibility of coming up with new innovative solutions.

Knowledge economy requires sustainable inflow of innovators, entrepreneurs and consequently highly flexible and innovative companies. This is particularly true for Fintech companies. But it is broadly acknowledged that the supply of talents in this particular field is rather limited. If we take the case of the UK, the sector employed around 80 000 people by the end of 2019. It is important to note that 42% of Fintech workers are from overseas. The lack of talents in this particular area that is Fintech could prove to be a barrier for further expansion.

In order to expand Fintech industry there is a need for a sufficient level of business demand. Europe is still far behind Asian countries. The adoption rates in the developed economies is surprisingly low (Table 5.1).

### 5.3 COMPETITIVE STRATEGIES

How should banks and traditional financial institutions proceed in this very highly competitive environment? One would suggest that one way of how to maximise the effect of highly flexible start-ups is that the traditional financial institutions including banks should try the full integration of these companies and established small-sized Fintech companies. Such a horizontal integration across the different providers should help to accelerate the development and practical implementation of new technologies and products with the focus on customer satisfactions. In terms of providing new services, banks can choose different business models. If they decide to compete with newly established small companies that are flexible and highly innovative with supply of financial products, then banks jeopardise their position. In fact, they will not be able

to keep pace with those highly innovative and specialised firms. The optimal strategy is therefore to ‘use’ and acknowledge these companies and to initiate close collaboration, partnership or even direct inclusion into bank business. Banks have to be aware that they face otherwise a problem of unbundling business activities. The activities that can be easily unbundled and taken over by small and progressive firms can be listed as follows:

#### Retail banking

- Lending and Financing
- Payments and Transfers,
- Wealth and Asset Management,
- Markets and Exchanges,
- Insurance,
- Blockchain Transactions.

Fintech company’s business models are fundamentally different from the standard banks. This means that the competitive environment differs in this particular segment of the financial industry. The first element that shapes competitiveness is the limited regulatory framework that changes across EU countries, UK and USA. In particular the limited or in some cases not even existent regulatory framework gives an incentive to financial institutions to move from the heavily financially regulated market to Fintech sector to provide financial services. Such a situation undermines and causes to some extent unfair competition in the financial sector. The question remains if this migration of bank services is sustainable for a long time period. This situation can cause severe distortion of the supply of the financial products when more profitable activities can permanently move out of the standard banks to unregulated financial providers through Fintech companies. Such a situation could destabilise the financial services in the case of the systemic failure of Fintech companies.

#### *5.3.1 Competitive Pressures in Retail Banking*

One may argue that retail banking is well footed and the services cannot be affected. The main argument is that the retail banks have *know-how* of how to collect primary deposits that are essential for traditional banking activities. However, the online business and new investment opportunities have gradually eroded this function of retail banks as a ‘generator’ of primary deposits. A further argument is that the regulators will promptly narrow the regulatory gap between the standard retail banks and Fintech companies. This would end up the migration of financial services between retail banks and Fintech companies if the same rules are imposed on both (IMF 2017). The progress of imposing the regulatory measures and the cross-country co-ordination is obvious. But the best solution is that retail and only retail banks accelerate



their digitalisation across all the range of their business activities that include retail, wholesale and investment banking including insurance companies. The unbundling process should not be seen as a means to segmentation of the services but improving the quality of services and an easier reach of bank customers.

It is understandable that this cross competition between banks and Fintech companies varies based on the readiness and intellectual capacity of the individual banks in the catch up as for the digitalisation of their services. The advantages of large banks are that they are in a better financial position to acquire small and progressive Fintech companies and integrate their services into their own business strategy. This kind of business strategy corresponds to the strategies we have observed in other digital businesses particularly the digital giants like Google, Facebook, Microsoft among others. The large banks in Europe, UK and USA can successfully adopt this strategy since Fintech companies have more to rely on new customers thus those who have no strong 'relationship' with their retail bank. However, we may expect that some Fintech companies will compete in terms of the high quality tailored services for special clients who differ from the standardised bank clients. This seems to be the appropriate strategy for Fintech companies as for their business expansion.

The situation can be, however, different on the supply side of financial services. The key is to predict how the digitalisation and the use of soft information improve the allocation of assets. There is a large scale of opportunities for Fintech companies to deviate from the standard 'customer relationship' activities that are seen as a way of reducing asymmetric information problem between lender and borrower. The use of soft information might lead to the improvement of more efficient asset allocation of Fintech companies than to focus on the small business including small and medium-sized companies. If the digitalisation leads to this improvement then this might threaten the position of small banks like cooperative banks, thrift banks and small saving and loan institutions. Crowdfunding (P2P) lending can become an attractive substitution to very slow and administratively demanding process. P2P platforms are appealing to small starts up, retail consumers and to some extent small businesses. The penetration of Fintech companies leads also to open banking and it gradually ends the era of the customer life-time loyalty to one bank which was practised for decades.

The competitiveness of financial services providers through the digitalisation of financial services leads to the exponential adoption of new technologies by the millennium customers that have different characteristics with the extremely high flexibility of picking up new form of digital services but at the same time they are very quick to drop the services if they do not meet their expectation. The profile of financial service customers but this is not the specific attitude only for financial services has remarkably changed over the last decade with the introduction of digital applications. As we have mentioned,

this has also changed customer services as a reaction to fragile loyalty. The integration of financial services providers within the digital company as Apple is evident. The digital multinational enterprises collect an unprecedented volume of data based on customers' behaviour through the new payment application like ApplePay. This is completely different volume of information that was not available in past. These new payment companies offer much more flexible and convenient 'loyalty' scheme than the customers obtain from the traditional credit cards. The delay of banks to promptly react to Fintech and digital companies in general is has been mostly caused by the business rigidity of large financial institutions. Anecdotal evidence shows that bank businesses have gradually been affected by inadequate reaction and catch up with this small Fintech providers which business models are inherently based on digital disruptions as catalyst for the innovation of their business activities. The traditional old-fashioned banks not only lack the intellectual capacity in this segment of operations but their rigid hierarchical structure does not permit the quick and flexible to market changes to offer their customers. The open banking that has been introduced further undermines the customer's loyalty across the traditional banks themselves. The current environment that allows to smoothly switch between financial service providers caught the traditional completely unprepared and those banks under the capital constraints to invest to the digitalisation. The digitalisation of service providers not only in banking but across all the retail activities is extremely transparent and the asymmetric information problem in this respect has been almost eliminated.

The traditional retailing banks across the EU countries, UK and USA show a certain degree of frustration with the unprecedented pace of changes that require and additional investment to cope with the digital giants who seamlessly adopt to the new challenges and business activities (Boot 2016). They are forced to compete with the digital giants as Google, Facebook, Apple domestically and internationally. The traditional brand's value of these banks melts down since their human capital is not in line with the latest changes. The innovation process and the nature of business is remarkable. The old-fashioned professions in the banking industry that is historically linked with the perceived experience and business trust eroded. In other words, the institution is much less attractive to merge or collaborate with those digital giants but also already established Fintech companies. There is also incompatibility in terms of managerial styles between the traditional banks and Fintech. Thus, the suggestions of different forms of partnership across these firms are questionable. Despite the fact that digitalisation of banking services took place more than a decade ago banks see digitalisation as a threat and disruption. For example, the largest high street banks in the UK adopted the Open Banking arrangement. Open banking is the system that allows real-time operations through the flow of data that is arranged not only between participating banks but also non-banks that are out of the system.

It is evident that banks have to change their practices or will be ousted from certain segments of their business. The key factor that wins customers

is outstanding customer service that implements the differentiated customer experience approach that boosts customer loyalty. The difficulty is that banks are not flexible enough to adjust to the new digital business environment that is significantly different from the traditional bank customer service. The customer services for the clients will differ based on the use of the financial services. The relationship could be jeopardised by slipping into transactional relationship. This is particularly sensitive areas when the prime client service relationship is reduced to the transactional relationship. The problem is that the banks need to educate their high net worth clients at the age of bank digitalisation. This service is to be hardly replaced by Fintech and digital companies that are focused more on the mass clients or the clients that are not used to the special service management.

This is a challenging issue of how the conventional banks can compete with Fintech. The underlying problem is that new highly worth customers are not requiring so much relationship as the banks used to be accustomed to their pre-digitalisation era (Carbó-Valverde 2017). Despite the fact that traditional banks have soft information about their customer spending and financial behaviour it seems that they are not using this information as they should in order to ease the competitive pressures from Fintech and digital companies. The loyalty schemes that aim to keep their customers have to offer more than just point schemes. KPMG in their research study identifies that 61% of customers value if their bank regularly reviews their loyalty scheme and innovates their reward loyal programmes in taking into account the degree of customers' relationship with a bank. That means banks have to more proactive and meet the client's expectations. This can be problematic for banks to adjust to this pressure that require continuous monitoring and following the trends in the specific services. For example, loyalty programmes are highly demanded in the UK. The analysis by YouGov, indicated that six in ten adults in the UK would like to see that bank branches offer a loyalty programme. Indeed, three-quarters of current customers are subscribed to at least one loyalty programme.

Banks in the UK are aware of the importance of loyalty schemes. This is supported by the fact that majority of high street banks that include Lloyds, Barclays, NatWest, Citibank, among other, have a range of loyalty programme that range from the point-based rewards to cashback rewards for product holdings. The barrier of extensive introduction reward (loyalty) programmes is a broadly prevailing view by banks that these schemes have higher costs than potential income. This view is outdated since it does not fully reflect the fact that customers can now switch banks so easily than relying on the old-fashioned view that the administrative obstacles discourage clients to move to other banks are not valid anymore. The only solution for banks is to quickly adapt to new challenges that are introduced by Fintech. It is important to note that digitalisation is not the end of a means but the way to further innovative disruption to achieve an even higher positive customer experience.

Thus, loyalty is not a solution for further business expansion to maintain and above all the attract new customers. It is quite evident that non-price competition is to be key in the age of bank services digitalisation. The customer centre focused activities will be a key competitive factor among the traditional banks, Fintech and digital companies.

The Fintech companies have made substantial progress in terms of using the soft information about their customers and undermine the dominant position of traditional banks that have a large volume of historical data about the customer's financial behaviour. Multiple relationship banking seems to be inevitable. The problem of cherry-picking will not be made by firms but their customers but the opposite situation that bank customers pick up the best available products offered by the traditional banks, Fintech and other non-financial institutions that provide financial services. This will lead to the erosion of bank income through fees.

Traditional banks that have not yet adopted the advanced digitalisation of their services at the level that is offered by Fintech could be hurt in longer term. The idea of acquiring Fintech is not the way of how to proceed now. The banks that have done it have already gained competitive advantages and Fintech that were resilient to merge or to be acquired by banks had for that a reason and the market gets more competitive. The only solution for them is to catch up through expensive technological innovation and adoption of the latest technologies. This strategy is a viable alternative for large institutions but it is questionable if this strategy can be adopted by cooperative and similar type of banks.

Fintech companies in Europe are very flexible in terms of financial innovation—technology and product development. The ecosystem within which Fintech companies in Europe operate is well established and at a similar operational level as their competitors outside EU countries. There are a number of very dynamic start-ups and Fintech 'unicorns' across the European countries. There is a number of already highly respected start-ups and Fintech firms. These Fintech firms include Klarna, iZettle, Adyen, Funding Circle, TransferWise and POWA Technologies. Those mentioned are all European companies that have worldwide international recognition. The UK is a leader in terms of the market share of Fintech companies in Europe. The second country with the highly established Fintech firms and start-ups is Germany. In Germany, there have been very ambitious companies in the area of financial innovation and technology. Germany has been successfully attracting a large proportion of the capital that is allocated across the European Fintech companies. Even some largest banks are involved too. Commerzbank has, for example, set up the so-called Main Incubator and CommerzVentures through which the capital is invested into start-ups. Deutsche Bank is also closely involved with Fintech centres in London, Berlin and Silicon Valley. That should accelerate its development activities in the use of digital technology. One of the most successful German Fintech companies is T-Number 26. The company expanded to six new countries to make its services available to users in France, Greece, Ireland,

**Table 5.2** Leading international FinTech centre (developed economies)

<i>Centre</i>	<i>Market size (Revenue GBP in bn)</i>	<i>Investment (GBP in mil)</i>	<i>Employment</i>
Britain	6.6	524	61,000
California	4.7	3.6	74,000
New York	5.6	1.4	57,000
Singapore	0.6	44	7,000
Germany	1.8	388	13,000
Australia	0.7	198	10,000
Hong Kong	0.6	46	8,000

*Source* E&Y Fintech

Italy, Slovakia and Spain. The company offers banking services without borders in Europe. The company provides more than 80,000 customers with accounts for cash withdrawals, deposits and overdraft services up to 2,000 euros via a slick smartphone application.

Table 5.2 then provides information about market size, investment and employment in the leading international Fintech Centres. In terms of revenue the UK is a leader across those centres. As for invested capital California and New York are the most attractive destinations for investors.

### 5.3.2 *New Technologies and New Type of Banks*

The progress of how the banking sector changes is remarkable. The digitalisation process offers completely new business models on which new banks are based. In particular, a large number of changes happen in retail banking. The digitalisation of financial services brings also higher competitive pressures that are strengthened by a new type of bank that is fully digital—*neobank*. *Neobank* is a term that is used for new age banking services. *Neobank's* business model is based on the full digitalisation of services that allows those banks to be accessible for their customers continuously compared to traditional banks. The spectrum of services that are offered by *neobanks* is determined by the scale of products and services that are allowed to be provided by the regulators. The unique selling point is that *neobanks* are fully virtual banks that run their operations online and/or through applications. It has been reported that, for example, *neobank* Chime that operates in San Francisco has built up very quickly the base of almost two million customers. The number of new customers per month is much higher than, for example, Wells Fargo or Citi. This clearly illustrates the increasing popularity and marketing success of *neobanks*. A future expansion of *neobanks* paves up the way to even higher popularity of *neobanks* by potential retail customers. *Neobanks* have become a real threat for the traditional banks and undermine their exclusive position in

retail banking. As we have discussed, the traditional banks are under enormous pressure to compete with these new digital banks (Gomber et al. 2017).

Table 5.3 summarises the main differences between a traditional bank and *neobanks*. The differences are in several respects. The main difference is that *neobanks* do not have necessary full banking and licence and all their activities are conducted exclusively online.

The core business idea of *neobanks* is based on the unbundled products of financial services. Neobanking allows to save substantial fixed costs that are typical for traditional banks. In addition, the provided specific bundle of digital financial services is also much more customer-friendly than the products that are offered by the traditional banks. The business model of *neobanks* is supported by a number of already established digital banking providers as Monzo, Revolut and N26 in Europe. These Fintech companies substantially disrupt the traditional forms of how banking services have been provided so far. The business concept is also very well received by investors and venture capitalists. They invested USD 586.7 million of the total funding of USD 3.49 billion received by Fintech companies globally in March 2018, see for more details, <https://theFintechtimes.com/2020-will-be-the-year-of-neo-banks/>. A further positive feature of *neobanks* is that their business strategy relies on the continuous disruptive innovation process that enhances customers' experience and satisfaction.

**Table 5.3** Traditional banks vs Neobanks

	<i>Traditional bank</i>	<i>Neobank</i>
Service platform	Physical banking institution	Primarily digital, apps
Time established	Decades ago	Within last five years
Customer relationship	Long-term, tries to keep customers	Virtual, flexible, no long contracts
Support	In person, telephone, online	Telephone, online, in-app
Fees	Complicated, ongoing costs	Transparent, few costs
Banking licence	Full	None, partial or full
Bank branches	Yes	No
Approval processes	Lengthy, manual	Quick, automatic

*Source* <https://www.mobiletransaction.org/what-is-a-neo-bank/> (accessed 10 May 2020)

## 5.4 COMPETITIVENESS AND REGULATION

There is a general consensus that the market for Fintech has to be appropriately regulated despite its complexity (Philippon 2016; Buchak et al. 2017). The optimal way of how to regulate the products is by the creation of regulatory sandboxes. Empirical evidence indicates that sandboxes encourage innovation in financial products. The word sandbox has acquired new meanings. In the computer science world, a sandbox is a closed testing environment designed for experimenting safely with web or software projects. The concept is also being used in the digital economy field, to refer to regulatory sandboxes. Sandboxes are actually testing grounds that are relevant in the Fintech world. The purpose of the sandbox is to adapt compliance with strict financial regulations. Sandboxes should allow the smooth growth and pace of the most innovative companies. They should prevent any disruptions but also they do not affect consumer protection. The regulatory sandbox allows businesses to test innovative products, services, business models and delivery mechanisms in the real market, with real consumers. The sandbox is open to authorised firms, unauthorised firms that require authorisation and technology businesses. The sandbox seeks to provide firms with:

- the ability to test products and services in a controlled environment
- reduced time-to-market at potentially lower cost
- support in identifying appropriate consumer protection safeguards to build into new products and services
- better access to finance.

BIS—The Fintech companies, as we have mentioned, do not comply with the regulatory framework that is applied for the traditional banks. Despite the fact that they offer to some extent similar digital services as those banks. In addition, newly developed products and services provided by both the traditional banks and Fintech companies as a result of the digitalisation. These new products and services are bearer of potential risk for banks and their clients. It is well documented in the literature that the nature of bank business is not a risk-free activity (Bebczuk 2003). The risk is not constant and of the same attitude but the risk factor is volatile and it differs across the bank activities and over time. In particular the introduction of new services and products can undermine the stability of financial institutions and/or the final users of these untested services and products that are the results of financial innovation and the digitalisation of services.

The rapid expansion of new financial products and services as a result of digitalisation, offer new opportunities for customers but at the same time but they require a new and flexible regime to be adopted by bank supervisors and regulators. New products and services change to some extent the adopted business models and can undermine the financial stability of the financial institution that is involved in the digitalisation of their services. Banks do not have

any kind of experience and data that would clearly indicate the impact of these activities. There is a necessity of introducing and impose such prudential rules that will mitigate negative externalities of these activities.

The challenge is thus to set up a regulatory framework that guarantee a certain degree of balancing their new activities and services with potential risk that could undermine not only the soundness of financial institutions but the system as a whole. A gradual openness and introduction of new services and products through the digitalisation activities is essential to guarantee the bank financial soundness and stability (Financial Stability Board 2017). Of course, other aspects that are linked with financial regulation as consumer protection, the full compliance with the imposed regulatory norms need to be followed.

The risk factors are still largely opaque and unexplored that can be mixed across newly provided and developed products and services. As BIS (2019) describes, we may list the different types of risk in several categories. We assume that strategic risk is an acute form of risk that can undermine the stability of the institution. Our previous discussion about the business strategy imposed by Fintech companies, including the traditional banks, through unbundling of bank services could cause the escalation of the problems in terms of operations management that is to be reflected in the overall business strategy. The unbundling process of the financial services could change market share of the specific bank activities that could lead to the losses of their income. This is of course an outcome of sound competitive forces across the financial institutions. It is a result that some institutions are better equipped to deliver certain products and services in more efficient and productive manner. That has a positive effect on customer experience. The question is how the authority could react to these changes. The protection of the incumbent traditional banks does not seem to be a proper solution to this threat. But the problem arises when a bank that experiences the reduction of their income starts being involved in riskier activities that might compensate the losses caused by the openness of the market to new entrants.

The rise of Fintech leads to more IT interdependencies between market players (banks, Fintech and others) and market infrastructures, which could cause an IT risk event to escalate into a systemic crisis, particularly where services are concentrated in one or a few dominant players. The entrance of Fintech firms to the banking industry increases the complexity of the system and introduces new players which may have limited expertise and experience in managing IT risks. A further type of risk that is linked with the overall introduction of new business activities is operational risk. The introduction of automation of routine operations should in fact reduce operational risk. Nevertheless, it is argued that innovative products and services cause that many day-to-day bank activities can become more complex that could lead to higher probability of operational errors and thuds it could increase operational risk. There is also a problem that Fintech companies use services and products that are offered by third parties to support the bank operations without proper market tests. It is frequently discussed that the impact of new technologies and



the necessity of outsourcing for new types of business activities and operations could erode the security protection that is not set up for the newly adopted business activities. This includes the threat of data security, cybercrime and overall customer protection. Since the digitalisation of services is based on the data there is an increased risk that bank and Fintech companies fail to meet compliance requirements. Compliance risk caused by breaching data privacy could be seen as a consequence of the fact that banks and Fintech may lack the capacity to deal with the enormous data volume. Unbundling of financial services bears a further potential risk that is—outsourcing risk. If unbundling of financial services is adopted by a bank or Fintech company as a business strategy then banks rely also on the services and product from third parties through supply chain that can become too complex to handle by banks. It means it can be a complex network of third party companies. The question is how the banks will be able to control, trace and manage such a complex network that can continuously change based on the intensity of innovative processes. This problem can be further reinforced if some services are to be provided on the global scale from only one or a few big companies. This could lead to the unprecedented concentration of operational risk (BIS 2019). The digitalisation of services and the introduction of new products is by definition linked to Cyber-risk. This is in fact the fundamental problem that undermines the expansion of digitalisation of financial services but not only financial services. The increasing presence of cyber-risk is embedded in the nature of this type of business that includes interconnectivity across the financial institutions, the importance of API for daily operations, cloud computing among others. Cyber-risk is to become a permanent threat for all banks regardless of their degree of involvement in digital banking. The new business model that is adopted by banks as a reaction to the digitalisation of their business activities could also affect bank liquidity management. One may expect higher volatility of the primary deposits that are held with banks. This is given by the easiness of bank customer to move their savings very easily across the domestic and international financial institutions. Thus, the prediction about the fund flows is to be more complex and it can cause liquidity risk.

#### *5.4.1 Regulatory Sandboxes and the Impact on Competition*

The sandbox idea first came from Britain's former chief scientific adviser Sir Mark Walport, who suggested the financial services industry would benefit from having something equivalent to the clinical trials of the health and pharmaceutical sectors. The Financial Conduct Authority (FCA)—specifically its project innovate arm—jumped on the idea, setting up the first sandbox for Fintech companies in 2016. The sandbox has accepted 89 companies since its inception in 2016 and is just finished taking applications for its fifth cohort.

The view of Financial Conduct Authority (FCA) is that the sandbox should improve an understanding of new financial products and services that are the

outcome of the digitalisation processes. In particular they should assess potential risks that are linked with the uncertainty of these development initiatives before the services and products are widely introduced by the bank's Fintech companies. They should also help to protect consumers. The concept is also set up in such a way that should contribute to competition in Britain's financial services market.

There is also an opposite view that sandboxes do not deliver what one expects from them. The limited exposure of the new products and services to a large variety of costumers prevent the regulators to fully understand the potential risk for the system as a whole. It is also problematic to approve these products that underwent the sandbox regime. There is anecdotal evidence that disrupts technology change over time and an example of cryptocurrencies show that financial innovation can end up in a different way than the sandbox 'treatment' indicated. A further argument is that the adoption of sandboxes is not common across the financial jurisdictions. For example, the approval of services and products through sandboxes could be rather detrimental if they are tested by the financial regulatory authorities that do not command the required expertise or lack the capacity to conduct the proper testing. A sandbox should quickly identify any unintended effects of a product's design and fix those issues before the product is rolled out to the general public. It requires some tolerance for trial and error. A sandbox would promote the objectives of secure the fairness, inclusion and transparency that are parts of core principles of banking regulations.

So far around thirty countries have adopted the concept of sandboxes. In the USA the intention of adopting sandboxes was proposed in 2016. However, there is no evidence of the adoption of sandbox regulation across the U.S. Legislation was proposed in the USA in 2016 that would have created a federal sandbox. There are only three states (Arizona, Wyoming and Utah) that adopted the regulatory framework of sandboxes at the state level.

Regulatory sandboxes offer a framework through which firms can test innovative financial products, services or business models in a 'live' context, monitored by competent authorities. Testing occurs during a testing period, pursuant to a testing plan and within specific parameters (e.g., limitations on the number of customers). Similar to innovation hubs, sandboxes are typically open to:

- established financial market players;
- firms considering to enter the financial market or having done so recently; and
- other (e.g., technology) firms—but only if they partner with regulated entities.

To participate, firms have to meet further conditions defined by competent authorities and/or national law. These usually include the proposition having a minimum level of novelty and a certain nexus to regulated activities.

According to a January 2019 report on regulatory sandboxes and innovation hubs by the European Supervisory Authorities (ESAs), 24 European Economic Area states had hubs. Sandboxes were less common, with only five EU member states—Denmark, Lithuania, the Netherlands, Poland and the UK—having such a system. Since then, further innovation facilitators have been set up, including a hub in Bulgaria and a sandbox in Hungary. In Norway, preparations are ongoing to make a sandbox operational this year. In Spain, legislation on a sandbox is underway.

Some authorities are less keen on regulatory sandboxes. For example, in a forthright statement, the New York Department for Financial Services said that: ‘Toddlers play in sandboxes. Adults play by the rules’. (For more on this, see Claire Harrop’s blog.)

In its digitalisation strategy, *Bundesanstalt für Finanzdienstleistungsaufsicht* (BaFin), Germany’s financial regulator, said that it would not use a sandbox approach, arguing that the principle ‘same business, same risk, same regulation’ demands that Fintech firms be supervised just like any other regulated financial institution. According to BaFin, only the intensity of supervision can differ depending on the risk, in application of the proportionality principle.

Interestingly, the concept of a sandbox as promoted by the ESAs seems not necessarily to entail anything to the contrary, depending on its concrete implementation. In their report, the ESAs make it clear that firms participating in sandboxes are required to comply with applicable laws and regulations, and that no ‘light touch’ approach applies. This includes that, to the extent firms carry out a regulated activity in the sandbox, they are required to hold an appropriate licence (i.e. if they do not have it already, they have to obtain it before testing starts).

The ESAs take the view that competent authorities may exercise discretionary powers and apply levers of proportionality embedded into law. This might concern licensing processes—for example, authorities might issue a temporary licence for the duration of the testing or impose further limitations reflecting the restricted scope of the activities to be conducted in the sandbox. It might also be relevant for ongoing supervision—such as in terms of expectations regarding internal governance processes.

However, according to the report, whenever discretion or proportionality is applied, this should occur in line with ‘normal’ practice as per firms not participating in the sandbox. Thus, it seems that even adults in a sandbox have to play by the rules that apply to those outside the sandbox. But if this is so, why have a sandbox at all?

The key advantage of a sandbox seems to be that it is a space, limited by the testing parameters, where firms and authorities can (quickly) find out whether a proposition works and, if so, whether it meets the necessary regulatory requirements. By testing an application before a full market launch, firms

still have time to change their proposition before committing to a broader roll-out. Hence, for firms, the sandbox is, in the end mainly, about saving costs and time, see, for example, Brummer and Gorfine (2014).

In addition, sandboxes and innovation hubs may make it easier for firms to identify the regulatory and supervisory expectations applicable to them and to demonstrate compliance therewith.

Further, for the authorities, sandbox testing allows them to better understand financial innovations and what the regulatory framework means when applied to them. The insights obtained from innovation facilitators might even influence future regulation and supervisory approaches, as the European Securities and Markets Authority recognised in its July 2019 report on the licensing of Fintech business models.

The success of innovation facilitators will further depend on how they are used and operated.

In April 2019, the ESAs and the European Commission launched the European Forum for Innovation Facilitators (EFIF). Through the EFIF, the ESAs and national competent authorities will exchange experiences from engagement with firms through innovation facilitators, share Fintech-related know-how, and exchange views on the regulatory and supervisory treatment of innovative products, services and business models.

The expectation is that the EFIF will help to boost cross-border co-operation, co-ordination and potentially convergence, and thereby contribute to the number-one objective of the Commission's Fintech action plan: to enable innovative business models to scale up across the EU.

One way of how to mitigate the risk of newly developed services and products through digitalisation is through the regulatory sandboxes. A sandbox is a special regulatory arrangement that allows to test financial services and products as an outcome of the digitalisation. It gives both banks and regulators necessary time to evaluate the impact of the product (service) on bank business and also it protects costumers. The new products, services, newly developed technologies and applied business models are scrutinised through a set of tests that are designed in such a way that the regulators can control whether or not these new proposed initiatives meet the imposed regulatory requirements and also their implications for customers.

The advantage of applying this approach is that a regulatory sandbox should reduce the overall cost of innovative activities that include the wide use of the novel product, service, etc. It should also help the regulator to properly assess these new initiatives proposed by the firms by controlling for the set of imposed parameters that have to be met. The idea of sandbox was firstly introduced in 2015 in the UK. This idea was further expanding out of the UK as a successful and easily implemented tool for testing the new projects.

Regulatory sandboxes may also encourage competition and co-operation between incumbents and challengers to the benefit of excluded and under-served customers.

## 5.5 CONCLUSIONS

Fintech challenges and transforms the business models of traditional financial services providers, although it is too early to guess how precisely and how much the changes will ‘disrupt’ the ecosystem as a whole. Many Fintech firms are new on the market and operate as start-ups. The future development will prove whether these new companies will ‘survive’ their initial periods and their role within the market (Boot 2016; Gomber et al. 2017). That is a broad coverage of their activities or very specialised firms that provide services to the large and established financial institutions. More and more large traditional banks are investing in financial innovation and have set up Fintech units within their organisations. Some have acquired Fintech firms—including Fintech banks—or formed partnerships with Fintech firms to provide specialised services.

We may assume that the future of Fintech companies is undoubtedly very promising but there is a cloud that hangs over the industry. It is important to see how far policymakers will try to restrict Fintech industry through regulation. In other words, how successfully they will introduce the ‘rules of a game’ that ensure a ‘level playing field’ within the financial services industry. Regulation has to ensure that the customers will fully benefit from this remarkable and unique disruptive innovation process.

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# Fintech Unicorns

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## 6.1 INTRODUCTION

There has been a prodigious growth in the number of fintech firms operating in the global marketplace. Fintech, which is a pseudonym for financial-technology, is an encompassing term. However, while at a rudimentary level it simply bridges technology with finance, in reality it is synonymous with the cutting edge of computing technologies and their human interface. Many of the traditional hurdles regarding speed, reliability and security of internet-based transactions—noting reliable and safe internet is a critical factor for the expansion of fintech—have been overcome in recent years, at least to the point that the thresholds for users requirements have been largely satisfied, and their confidence earned.

The evidence of acceptability among potential users can be clearly seen within a surge in firms' engagement with fintech. To illustrate this Fig. 6.1 presents a snapshot of the growth in the number of firms that actively claim

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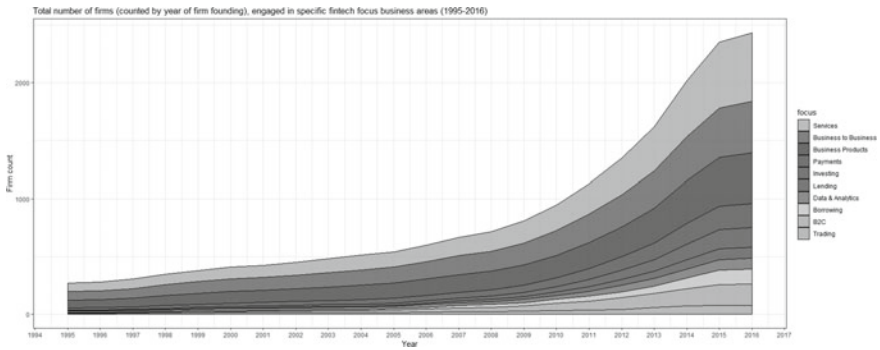
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**Fig. 6.1** The evolution of fintech and the business area focus of fintech firms through time

fintech within their business area focus. There is a persistently increasing trend, which accelerates considerably over the last decade of the sample. The trend is driven by two features—one being a proliferation of new entrants in the form of startups that are focused from their inception on fintech solutions. The other feature concerns the redefinition and/or reclassification of business area by existing firms, e.g. switching into fintech from more traditional finance. Similarly, there are technology focused firms that are stretching more actively into finance.

The internet plays no small role within the story of fintech's inception. The internet is among a raft of technologies that have paved the way for creative and innovative disruption within the financial services sector. Later in the chapter we will unpack these key technological milestones in more detail. For now, it serves enough of a purpose to simply understand some of the stylized facts regarding how the diffusion of internet connectivity has empirically aligned with a move towards increased number of transactions. Figure 6.2 illustrates the relationship between internet users (as a percentage of the population) and the share of cash-based transactions in the overall number of transactions.

There is a clear pattern of association, moreover the pattern strongly indicates that cash has uniformly decreased in its share of the total number of transactions, as the diffusion of internet becomes more complete. One can speculate that fintech is partly behind this story, among other things enabling the elimination or reduction of various transaction related costs, that permit fintech to be used for small and frequent every-day purchases. There are also likely to be various knowledge economies and agglomeration economies that exist between fintech and the information technology and telecommunications industry as a whole, therefore in developing one, the other automatically benefits.

The various changes in society are giving rise to a demand for new skills, and professionals with advanced analytical capabilities. The objectives of firms



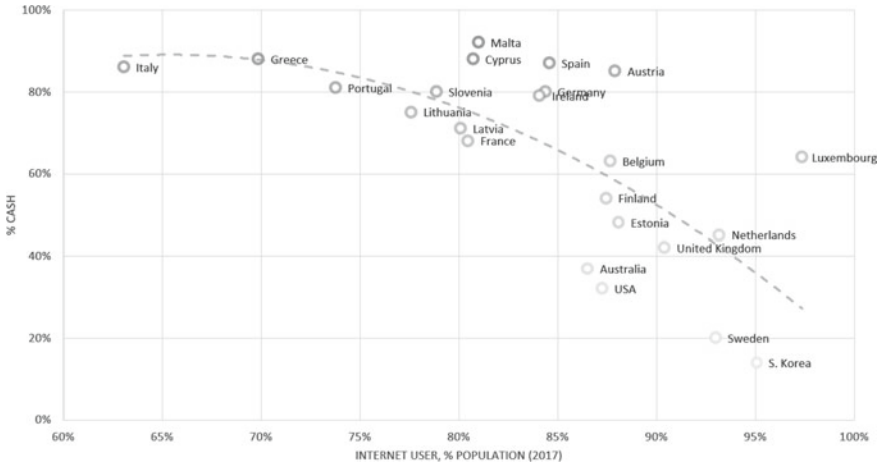


Fig. 6.2 Cash use vs internet penetration (August 3, 2019, *The Economist*)

working within fintech are twofold: first is to redefine traditional financial services, systems and infrastructures to be more compatible with advanced users' needs, i.e. to transition traditional 'fin' to fintech, the second is to devise innovative finance tools and solutions that were not feasible within the wide-scale deployment and acceptability of fintech. Table 6.1 illustrates how the roles in financial services are likely to evolve prior to 2022. On the decline are roles for data entry, bank tellers, financial analysts and accountants, while on the rise are data scientists and machine learning specialists, designers of 'user experience and human-machine interfaces' and digital transformation specialists.

Figure 6.3 takes a focussed look into the business area of fintech startups. This wordcloud summarizes bigrams (two-word sequences) and their frequency in one-line descriptions of fintech startups. The larger a term, the more commonly it appears within one-line descriptions. Financial services are of central importance, which alone is unsurprising. Looking down to smaller terms we see that payment services, both in general terms and more specifically for businesses are also prominent. There are many traditional functions, such as risk management, credit scoring, venture capital and others that are being addressed by fintech startups, further confirming their role as disruptors to traditional financial services firms. However, there are also many newer concepts visible, including crowdfunding, peer-to-peer lending, blockchain, digital economy and cryptocurrencies among others.

Turning specifically to fintech startups, Fig. 6.4 introduces a dimension in the growth of a unique type of startup known as a 'unicorn'. Unicorns are privately held (fintech) startups with a valuation exceeding USD \$1 billion. As will be discussed later in this chapter, these are extremely rare occurring types of startups, and a sought-after investment opportunity for many. The

**Table 6.1** Role changes in financial services workforce anticipated from 2018 to 2022<sup>a</sup>

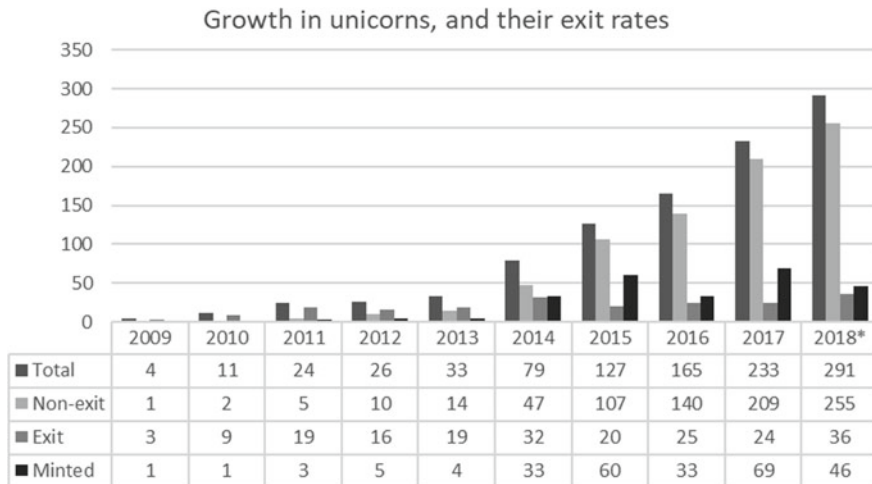
<i>Increasing roles in workforce from 2018 to 2022</i>	<i>Declining roles in workforce from 2018 to 2022</i>
<ul style="list-style-type: none"> <li>• Data analysts and scientists</li> <li>• AI and machine learning specialists</li> <li>• User experience and human-machine interaction designers</li> <li>• Digital transformation specialists</li> <li>• Sales and marketing professionals</li> <li>• Client information and customer service workers</li> <li>• Innovation professionals</li> <li>• Information technology services</li> <li>• Information security analysts</li> <li>• General and operation managers</li> </ul>	<ul style="list-style-type: none"> <li>• Data entry clerks</li> <li>• Administration and executive secretaries</li> <li>• Accounting, bookkeeping and payroll clerks</li> <li>• Business services and administration managers</li> <li>• Bank tellers and related clerks</li> <li>• Management and organization analysts</li> <li>• Financial analysts</li> <li>• Postal service clerks</li> <li>• Credit and loan officers</li> <li>• Accountants and auditors</li> </ul>

<sup>a</sup>The Future of Jobs, World Economic Forum 2018 (<http://reports.weforum.org/future-of-jobs-2018/financial-services-investors/>)

figure highlights several characteristics, including the total number of unicorns coming to market in a given year, the numbers that subsequently do and do not exit, and the number of those which are minted. The most eye-catching trends are the total number of startups, which rise from 4 in 2009 to 291 in 2018, as well as the number of non-exiting startups prior to 2014 were outweighed by the number of exiting firms, but since 2014, non-exiting firms clearly dominate the numbers which exit. As such one might begin to fall on the conclusion that the market has entered into a new phase since 2014, characterized by increasing success in developing sustainable startups.

Table 6.2 adds further definition to the trends contained in Fig. 6.4 giving an overview of the distribution of industries that unicorns are positioning themselves into, based on the non-exiting startups for 2018. The vast majority fall inside under ‘technology, media and telecommunication’ classification (78%). There are 12.2% explicitly focussed on fintech, making it the third largest stand-alone category, however this would undoubtedly be an underestimate of the share of fintech firms, since all of the categories under the ‘technology, media and telecommunications’ subheading might include a number of startups that also branch into the fintech space without making it their core industry focus— e.g. ‘big data, AI, BI & analytics’ or ‘eCommerce/Marketplace’ among others. Similarly, some of those unicorns falling





**Fig. 6.4** Total numbers of unicorn companies is based on the Global Unicorn Club and The Unicorn Exits Tracker from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. Unicorn exit means a unicorn is taken out of the list. The exit method included public listing, merger & acquisition and corporate majority

a general business perspective, fintech is a disruptive evolution of the financial services sector. Fintech is malleable, and can be moulded and shaped into product offerings that can directly compete with incumbent and traditional

In the remainder of this chapter we will sequentially build upon the preliminary analyses here in the introduction. Responding to the volume of fintech startups and also the speed and frequency with which they are transitioning into unicorns, it is clear that the evolution of the financial services sector will require innovative, transparent and responsive regulation to address the full range of challenges and needs facing key market players. It is within this context that the remainder of this chapter is developed. Specifically, the following sections of this chapter will delve more deeply into the factors that determined the primary evolution of the fintech industry, at the existing structure of the industry, and also into the future implications of fintech’s disruptive force to key players in the industry.

Section 6.2 directs attention on detailing the importance of fintech as a key driver for financial services and commerce. This will include extending discussion around the key drivers that have helped fintech become so important, ranging from the technological innovations, to the increased storage and availability of information, and into the importance of smart phones and mobile devices in providing desirable human–technology interfaces that people are willing to embrace.

Section 6.3 narrows attention more firmly on the disruption innovation process that lies behind fintech. This includes more elaborate discussion of

**Table 6.2** Total numbers of unicorn companies is based on the Global Unicorn Club from CB insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The Valuation of each industry is the sum of all unicorn values of that industry. The Average Value of each industry is calculated by the industry unicorn value divided by the number of unicorns in each industry

<i>Industry</i>	<i>No. of unicorns</i>	<i>Percentage</i>	<i>Valuation (\$B)</i>	<i>Valuation (%)</i>	<i>Average value (\$Bn)</i>
Internet/Mobile Software & Services	58	22.7%	115.9	14.1%	2.0
eCommerce/Marketplace	41	16.1%	157.0	19.1%	3.8
Fintech	31	12.2%	85.8	10.4%	2.8
Technology	21	8.2%	31.7	3.9%	1.5
Big data, AI, BI & Analytics	20	7.8%	56.3	6.8%	2.8
News, Social Media & Entertainment	18	7.1%	59.2	7.2%	3.3
Hardware	10	3.9%	48.4	5.9%	4.8
Sub Total-Technology, Media & Telecommunication	199	78.0%	554.4	67.3%	2.8
On-Demand	18	7.1%	172.3	20.9%	9.6
Healthcare	17	6.7%	39.7	4.8%	2.3
Others <sup>a</sup>	21	8.2%	56.8	6.9%	2.7
Total	255	100%	823.1	100%	3.2

*Source* The Global Unicorn Club-CB Insights, accessed on 26 July 2018

<sup>a</sup>Others included 3D Printing, Automobile, Beauty & grooming, Biotechnology, Business Products & Services, Clothing & Accessories, Collaboration & Project Management, Digital Health, Energy & Utilities, Food & Beverage, Gaming, Genomics, Management & Strategy Consulting, and Supply chain & Logistics

the past, present and future of key technologies and process innovations, extending the discussion on key technologies to cover aspects including: cloud computing; big data; artificial intelligence; blockchain and cybersecurity.

Section 6.4 draws a contrast in the fintech market structures for USA and China, two of the main regional hubs within the global market. This comparison is of more than notional interest. The markets for USA and China have markedly different characteristics, ranging from the underlying development, financing and ownership structures that are possible/common, through to the attitudes, preferences and cultural uniqueness of potential users of fintech in these different regions. Together Sects. 6.3 and 6.4 offer rich insights as to the structure of successful fintech business models, and how the ingredients to success can vary by region-specific characteristics. At the same time this comparison begins to inform the regulatory issues and bottlenecks that be deserving of attention and will be revisited in part in Sect. 6.6.

**Table 6.3** The top 10 fastest unicorn is based on the speed of a unicorn from fleximize. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The transformation speed of unicorn is the time needed for a company's \$1B valuation occurred after it was founded

<i>Company</i>	<i>Transformation speed</i>	<i>Business</i>
Jet.com	4 months	Shopping Website
Apus Group	7 months	Online loan provider
Rong360	7 months	Android App developer
Bei Bei	10 months	E-commerce
Illumio	12 months	Data Center and cybersecurity
Lwjw	12 months	Online Real Estate Marketplace
Loshow.com	12 months	Website offering deals on local goods and services
58 Daojia	13 months	Online provider of beauty, cleaning and delivery service
Lamabang	15 months	A Social Network for Mom
Uptake	16 months	Industrial analytics Company

Source The Speed of a Unicorn—Fleximize, see <https://fleximize.com/unicorns/>

Section 6.5 presents an analysis of the IPO successes of unicorns, used as a barometer of success for tech-startups, using a unique dataset focussed on Chinese IPO success. We model the primary research question as ‘what is the performance and development of fintech unicorns?’ The data permits a careful comparison between Fintech Unicorn and non-Fintech Unicorn subsamples. In addition, we compare Fintech Unicorn listed firms with non-Fintech Unicorn listed firms. The focus ultimately concerns itself with understanding how Fintech Unicorns perform relative to other modes of IPOs and more importantly to establish whether if Fintech Unicorns are successful in making money post-IPO, compared with other benchmarks.

Section 6.6 closes up the chapter with a summary on the key directions and future trends for the fintech industry and fintech unicorns. Some elaboration is given to the different roles that key market players might play going forward. In doing so, this section inadvertently reflects on the regulatory hurdles and bottlenecks, as well as a summary reflection of how the insights garnished around successful business models of fintech startups, and particularly fintech unicorns, may carry competitive implications for incumbent firms.

## 6.2 FINTECH AS A KEY DRIVER FOR FINANCIAL SERVICES AND COMMERCE

Fintech is reshaping the landscape of financial services industry rapidly in the last few years. New formidable players and startups with strong backing from venture capital have emerged with innovative disruption. CB Insights,

Global Fintech Report 2019 Q2, has reported 48 fintech unicorns valued at \$187 billion, while Ant Financial Services Group (which is not featured in CB Insights lists) was valued at \$150 billion in 2018. Traditional financial services companies with resilient business models and defensible economics are being challenged. Large asset-based financial institutions which offer poor user experience and high fees are being subjected to competition never seen before. Even regulators are opening the door to embrace newcomers into the industry in the name of financial inclusion, fee reduction and better user experience. For example, Hong Kong has recently issued 8 virtual bank licences for players with non-banking backgrounds, such as technology, telecoms and e-commerce. The goal was to introduce competition in order to stimulate innovation and to lower the cost of services for the public.

There are many forces that contribute to the rapid development of fintech in recent years. Wide adoption of internet and mobile devices have opened opportunities which have never been seen before. Maturity of technologies, such as cloud computing, big data, artificial intelligence, blockchain and smart internet devices have made an impact in many industries including financial services. Mass personal and private information leaks have dramatically increased the risk and exposure for many financial institutions; hence, financial institutions need to look for better ways to manage information and ensure customer's data privacy.<sup>1</sup> Stricter and complex regulation coupled with stronger enforcement effort have increased the burden of compliance, and financial institutions need to seek for better ways to effectively manage risk and compliance while keeping the rapidly increasing cost under control. In sum, there are four primary forces that have been driving fintech: (a) the supply of technology, (b) the demand for better user experience at a lower cost, (c) the fear of missing out (FOMO) among incumbents and investors and (d) the rising risk and cost for local and global compliance.

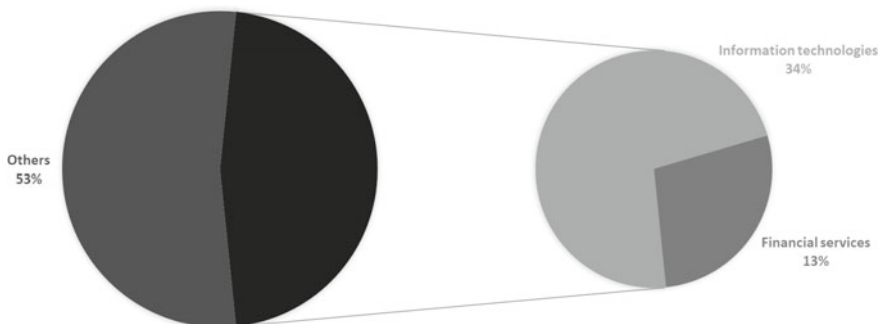
The term fintech derives from the abbreviation of 'financial technology'. Fintech is often used to refer to new players equipped with advanced technological capability entering into the financial services industry, or worded differently, as the application of technology to the practice of financial services. Fintech covers many functions in financial services which are traditionally offered by banks, insurers, brokerage, wealth management, etc. Despite the fact that these segments are traditionally regulated by different government bodies, the boundary walls among these regulated segments are rapidly falling due to the expansion of business by incumbents and the threat of new fintech entrants equipped with disruptive business models and technologies. For example, peer-to-peer lending crosses over both lending and investment, where traditionally, lending is carried out by banks and money lenders with both the lent funds and the customer's deposit being secured against the service provider or government's mandated deposit insurance fund.

In peer-to-peer lending, investor's funds are not necessarily secure, and peer-to-peer lenders earn their revenue by merely facilitate matching, and the subsequent transaction between investors (or the lenders) and borrowers.

Investors engaging with peer-to-peer lending platforms may have to bear the default risk with little guarantee or security. Furthermore, the size, volume and speed of loan generation are dramatically different than in traditional banks. For example, a China-listed peer-to-peer lender generated over 60,000 loans per day with an average loan size slightly over 2000 renminbi without any collateral.<sup>2</sup> Such an operating model is dramatically different than traditional bank's lending process. Fintech's fusion of finance with technology, and the subsequent invention of new business models, have not only reshaped the traditional financial services landscape but also posted new challenges for regulators. Some regulators are reacting slowly to the rapidly changing landscape while the fintech companies are pushing the boundaries. In sum, fintech is here and will continue to expand its presence in the form of new business model or new ways of providing traditional financial services. Incumbent firms are left with the decision to embrace fintech, or potentially suffer from a downfall similar to companies like Nokia's mobile phone business which failed to realize the impact of new technology and change in customer's behaviour and eventually went out of business.

### *6.2.1 Ascendance in Technology: Technology Penetration Has Reached Tipping Points Across Wide Range of Industries*

The Dow Jones Industrial Average (DJIA) is a regularly used proxy representing some of the largest publicly owned companies based in the USA. Since DJIA was first formulated in 26 May 1896, the index is composed of companies in industries such as oil and gas, tobacco and sugar and rubber and leather. Today, the market capitalization of DJIA constituent members is concentrated within two industries: information technologies and financial services companies. As illustrated in Fig. 6.5, the combined market capitalization is around 47%, with the share of information technologies more than double of financial services.



**Fig. 6.5** DJIA companies by market capitalization of major industries (total market capitalization: USD 7.6 Trillion, July 17, 2019)



However, the number of companies in information technologies and financial services are 5 and 5 respectively, totalling 10 out of the 30 companies comprising the DJIA as shown in Table 6.4. The growing dominance in information technologies represents a wide adoption of technologies across industries including financial services.

Seemingly, there is a trend where technology companies are entering into financial services to expand their growth. For example, Apple is integrating payment into its ecosystem with Apple Pay and Apple Card. Concurrently, companies in financial services are adopting technologies to deal with the

**Table 6.4** Dow Jones Industrial Average index members

<i>Company</i>	<i>Industry</i>	<i>Market capitalization (USD billions)</i>
Microsoft	Information technologies	\$1044.0
Apple	Information technologies	\$935.6
Cisco systems	Information technologies	\$244.9
Intel	Information technologies	\$221.1
IBM	Information technologies	\$126.9
Visa	Financial services	\$403.6
JPMorgan Chase	Financial services	\$369.8
American Express	Financial services	\$106.1
Goldman Sachs	Financial services	\$78.0
Travelers	Financial services	\$39.8
Boeing	Aerospace and defense	\$207.9
Nike	Apparel	\$137.5
Walt Disney	Broadcasting and entertainment	\$256.6
Dow Inc.	Chemical industry	\$38.6
United Technologies	Conglomerate	\$112.3
3M	Conglomerate	\$100.7
Caterpillar	Construction and mining equipment	\$77.6
Procter & Gamble	Consumer goods	\$290.8
Coca-Cola	Food	\$222.6
McDonald's	Food	\$163.2
UnitedHealth Group	Managed health care	\$253.4
ExxonMobil	Oil & gas	\$319.5
Chevron	Oil & gas	\$236.5
Johnson & Johnson	Pharmaceuticals	\$350.1
Pfizer	Pharmaceuticals	\$237.6
Merck & Company	Pharmaceuticals	\$210.9
Walmart	Retail	\$327.2
The Home Depot	Retail	\$237.2
Walgreens Boots Alliance	Retail	\$49.2
Verizon	Telecommunication	\$236.6

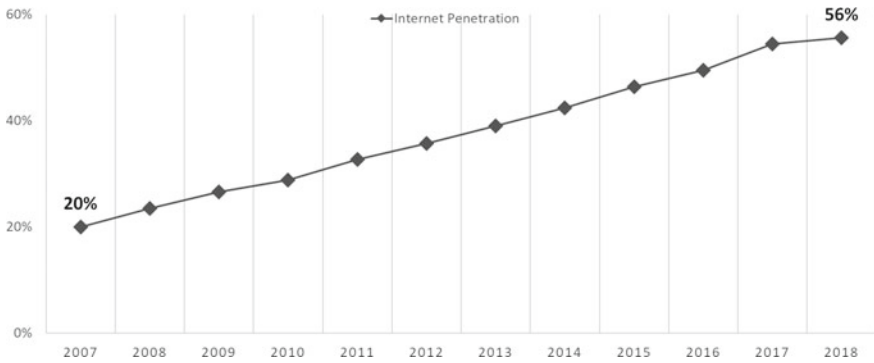


Fig. 6.6 Internet penetration (2007–2018)—sourced from [www.internetworldstats.com](http://www.internetworldstats.com)

growing regulatory requirements, and to stay competitive with both incumbents and the new entry of technology players. Technology has been advancing with unprecedented speed in the last couple of decades, and its accumulated scale and scope has impacted across all industries. This ascendance in technology has been and will be a significant driving force for productivity growth, impacting some industries more significantly than others.

### 6.2.2 *Availability of Information: Internet Penetration Is Pervasive*

Between 2007 and 2018, the penetration of internet users relative to the world population has increased from 20% to 56%, as illustrated in Fig. 6.6. Within this period, the number of internet users has more than tripled from 1.3 billion to 4.3 billion users. This means the majority of the world population now has access to information online. With easy availability of information, many aspects of consumer behaviour have changed, and the advantage of information asymmetry is diminishing. For example, consumers can learn and compare product features and its pricing online before making a purchase decision. In financial services, bank statements can be delivered electronically, saving millions on printing and postage. Trading and investment can also be conducted online; hence, this allows better customer reach and expansion of services.

### 6.2.3 *Accessibility Through Smart Mobile Devices: Smart Mobile Devices Have Revolutionized Human Behaviour Interaction with Information and Technology*

An important factor that was driving internet penetration is mobile technology. Since the launch of General Packet Radio Services (GPRS) in 2003, data access was made available to mobile devices at several thousand kilobits per

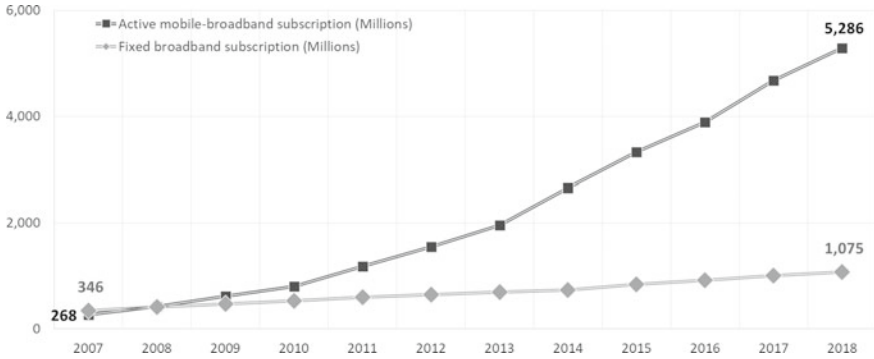


Fig. 6.7 Fixed and mobile broadband subscription worldwide (2007–2018)—data obtained from ITU 2018 statistics

second. However, the speed of GRPS still remains too slow for any meaningful mobile application and business models to thrive. Following the launch of the Apple iPhone in 2007, a product that transformed mobile devices to the form we all know today, and the move to 3.5G communications around late 2000 with speeds exceeding megabits per seconds, mobile application adoption started to explode as did the pervasive use of internet on mobile devices. Figure 6.7 shows that the mobile broadband subscription significantly outpaces fixed broadband subscription. This implies that internet penetration is strongly driven by mobile internet access. This ubiquitous accessibility dramatically changes user behaviours, creates new business models and opens opportunities in many services.

Examples of how mobile devices paired with powerful internet access are revolutionizing lifestyles can be found through: Uber’s business model allows taxi hailing through mobile application, Meituan’s business model makes it simple to order food delivery, Alipay and WeChat pay’s cashless eliminates cash payment through QR code, Apple pay and Android pay brings convenience to shoppers using NFC on mobile devices, and electronic know-your-customer (KYC) on-boards customers in financial services without visiting physical branch, etc. In less than 10 years, Uber and Meituan experience the fastest growth in terms of revenue and active users, and their market capitalization is over billions of dollars.<sup>3</sup> Alipay and WeChat is understood to facilitate over trillion renminbi in transaction value over mobile phones during 2018. None of these can be realized without today’s smartphone and mobile broadband technology. Furthermore, the shift from traditional banking to internet banking to mobile banking, from cash-based payment to cashless and mobile payment, from offline to online wealth management, and many more examples will further reshape the competitive landscape in financial services industry.

In terms of the future growth opportunities for fintech, the diffusion of mobile devices and high-speed internet means that some regions have demonstrably stronger growth prospects than others, such as the populous Asia

Pacific region. With close to 2.9 billion active mobile broadband subscription in Asia Pacific region and its share dominates 55% of the mobile broadband subscriptions worldwide, as shown in Fig. 6.8. This creates a strong platform for innovation and business opportunities that may be unique to this region.

In order to realize the potential of an industry, growing capital investment activities over a period is a good leading indicator for a rapidly developing industry. While venture capital investment accelerates the growth of fintech startups, corporate investment helps to subside fear of missing out for disruptive opportunities and to fast-forward organization learning for emerging opportunities. Merger and acquisition activity propel rapid growth to attain market dominance horizontally, vertically and geographically in order to strengthen competitiveness. Between the period of 2013 and 2018, the investment activity (including venture capital, private equity, and mergers and acquisitions) related to fintech has increased from USD 18.9 billion to USD 111.8 billion, representing 44% CAGR. This is illustrated in Fig. 6.9.

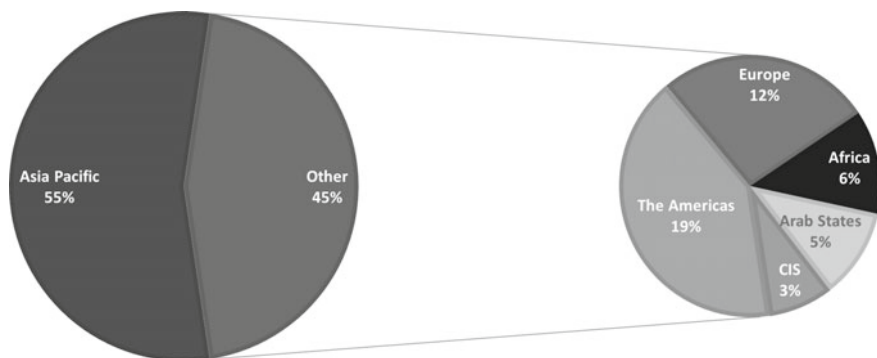


Fig. 6.8 Worldwide share of active mobile broadband subscription (2018), ITU

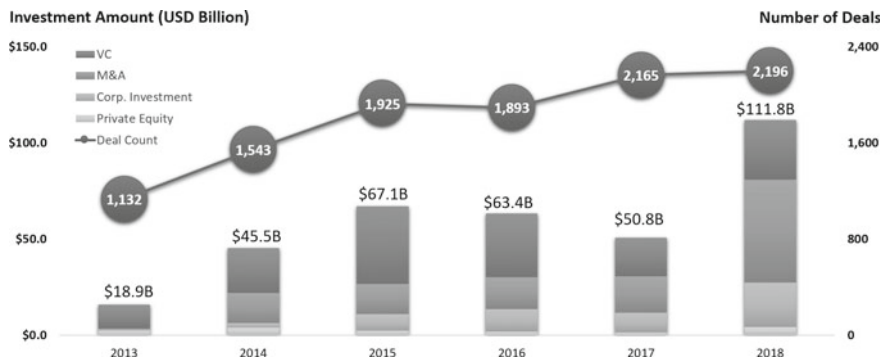


Fig. 6.9 Fintech investment activities worldwide (venture capital, private equity, and merger & acquisition) between 2013 and 2018

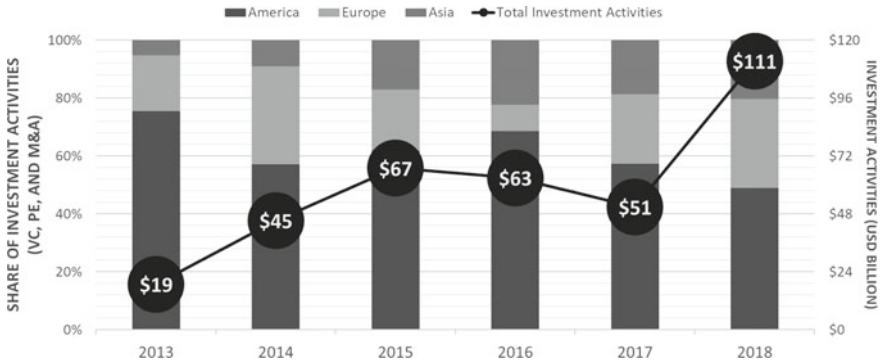


Fig. 6.10 Fintech investment activity by regions (2013–2018)

Among the share of investment activities within the three regions, America, Europe and Asia, America continues to dominate with growing shares from Asia as shown in Fig. 6.10. This trend is supportive of the idea presented above that technological innovations and business opportunities may be more prevalent in the region owing to the advanced internet, and extent of mobile device ownership.

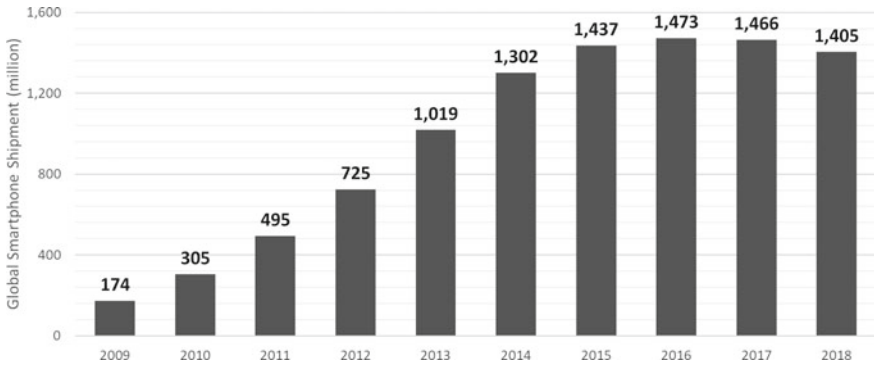
### 6.3 DISRUPTIVE INNOVATION BEHIND FINTECH

In this section, we expand discussion on the various technologies and process improvements that enable the sort of disruptive innovation behind the success of Fintech in recent years.

#### 6.3.1 *Smartphone Technologies*

It is difficult to imagine what a smartphone could be capable of, or how much it would have impacted the life of billions when the cellular phone was first made commercially available in 1983.<sup>4</sup> The cellular phone was designed to be a device to enable voice communication anywhere and anytime. Twenty-four years later, when Apple launched its first iPhone in 2007, the paradigm of a voice-based phone has changed to a smart, connected device with voice function among many other capabilities. By the time the iPhone 5 launched in 2012, smartphones had access to around 2.7 times more computing power than a supercomputer in 1985.<sup>5</sup>

With such computing power, the possibility for a wide variety of complex applications to be operated from a mobile device is easily realizable. Today, the number of mobile applications downloaded annually is in the order of hundreds of billions; billions of people use smartphones to surf the web, access a wide variety of services, communicate with video chat, play games, connect with friends around the world, take pictures, record videos, track fitness and



**Fig. 6.11** Global smartphone shipments 2009–2018 (*Source* IDC 2018)

the list goes on and on. Figure 6.11 shows the global smartphone shipment rate from 2009 to 2018. The annual shipment has increased from 174 million to 1.47 billion between 2009 and 2016, and this represents a compounded annual growth rate of 36%. At the same time, the established base of mobile broadband usership has exceeded 5 billion users around the world.

With such a large user base in combination with access to fintech in the form of mobile apps, financial services have been made simpler and easier. Banking customers no longer need to visit the bank and can conduct most transactions and core banking services online using mobile banking applications. Cashless payment can be made by scanning a QR code with a mobile phone's camera. Investment decisions and securities trading can be conducted using trading applications. Insurance can be purchased online without interacting with an agent face to face. Personal finance, like paying bills or making credit card payment or tracking transaction, can be made in seconds. Suspicious account activities are flagged in real-time and immediately targeted to minimize exposure from account hijacking or fraud. In sum, the benefits of smartphones to financial services are profound.

### 6.3.2 *Cloud Computing*

Cloud computing was built on two key technical concepts: time-sharing and virtualization. Ever since IBM first developed large-scale computer systems in 1952, computer users have been required to implement time-sharing and scheduling practices for computing resources so as to take advantage of the scarcity of computing resources. Today, computers are relatively inexpensive, and as a result the utilization of computing resources varies widely. Nonetheless, even today time-sharing allows for a fairer allocation of advanced

computing resources to those who are willing to pay for the usage. For enterprises, utilization of cloud computing translates capital investments into variable expenses, thus lowering the cost of ownership and hurdle for experimental innovation.

Virtualization creates virtual computers, virtual networks and virtual storage with any operating system over a real computer. This type of virtualization is known as virtual machine (VM), and the real computer is often referred as 'host'. Multiple VMs can be run on a single host. In theory, there is no limit to the number of VM over a host. An important characteristic is that each VM could have its own operating system on a single host. VM can be deployed easily on-demand. This allows time-sharing of VM on a single host extremely flexible. The flexibility of VM's makes time-sharing efficient.

In 2006, Amazon.com, Inc. (Amazon) embraced the time-sharing and virtualization concepts and built a new business model based on computing utility. This was in response to large investments that had gone into data-centers and hardware equipment prior to the internet bubble in 2000, and the realization after the bubble burst that these investments were illiquid and could not be redeployed or resold easily. The inefficiency and inflexibility made enterprise's future purchase decisions difficult. Customers can however utilize the 'spare' computing resources of Amazon on a pay-as-you-go or subscription model. This breakthrough business model attracted much attention from enterprises, universities, startups and governments. Two years later, both Google and Microsoft followed the same computing utility model, and many others came after. These computing utility models provided by third parties are commonly known as public cloud computing or simply public cloud.

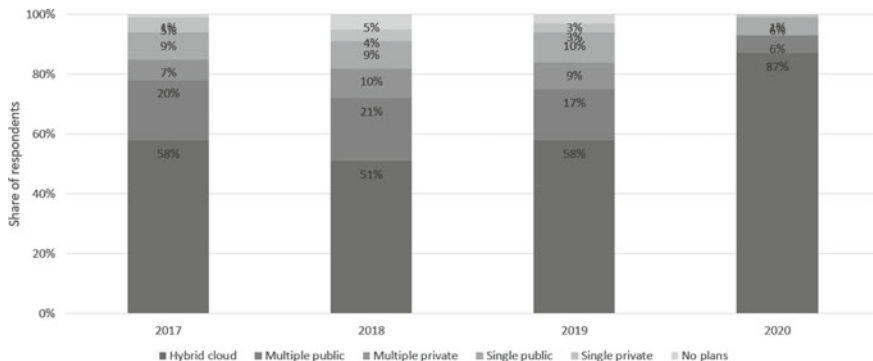
Cloud computing changes the landscape of how information technology is acquired, managed and deployed. The business model has helped to accelerate the creation of many startups and a key source of innovation within corporations. Cloud computing has not only lowered the total cost of ownership but also reduced the time of access to any variable amount of computing resource. It changes the traditional model of funding information technology adoption within an enterprise, from the model of capital expenditure (cash flow from financing) to flexible expenses (cash flow from operation). The shift in financing model changes the decision-making process and capital allocation within an enterprise. By 2018, average annual cloud spending for large (> 1000 employees) and small enterprises was around \$3.5 M and \$900 K respectively.<sup>6</sup> However, cloud computing penetration into heavily regulated industries remains a major challenge, especially for applications that require customer-specific information or highly confidential information.

For financial services industry, incumbents are accustomed to having absolute control over their information technology (IT) infrastructure. In addition to traditional means of network and computer access protection, physical isolation of equipment within self-owned datacenters has been an essential practice in protecting the institution's data and system integrity. Using public

cloud computing essentially relinquishes the physical control and potentially exposes access of IT systems and data to cloud computing providers. For years, despite the assurance from the public cloud computing providers, security measure is still considered inadequate compared to self-operated datacenters. Furthermore, adoption by providers in financial services is further complicated by unclear guidance from regulators. Despite the fact that some regulators have not explicitly restricted financial institutions in adopting public cloud computing, some regulators have not provided clear guidance on the use of public cloud computing.

From a regulator’s standpoint, it is the responsibility of the financial institutions to secure their IT systems regardless of whether public cloud computing is adopted or not. That is, regulators should not play any role that might be seen to relax the security standards. The fiduciary liability and data privacy protection remains the responsibility of the financial institution, not the public cloud providers or the regulator. The dilemma of shared ownership of data and computing resources remains today. Until recently, a number of cloud computing providers are willing to offer dedicated and physically secure data-center services to financial institution in order to overcome this dilemma and to gain market share. An additional regulatory concern arises in relation to hybrid cloud computing, which combines public and private clouds into a single resource, which can be popular where highly sensitive application and data are stored within premises of financial institutions and less critical applications are run from public clouds. An example of hybrid cloud would be to use GPUs from public cloud for artificial intelligence application with no data footprint left on public cloud after processing is completed. Figure 6.12 shows the percentage of application workloads running from public cloud, private cloud and co-located (hybrid) clouds.

For non-incumbents in financial services, cloud computing posts extreme advantages to gain market share and to establish new business models. With



**Fig. 6.12** Percentage of application workloads shifting to public cloud (Source Morgan Stanley. <https://www.morganstanley.com/ideas/cloud-cybersecurity>)



almost unlimited scalability offered by cloud computing, startups can quickly launch new services and agilely adapt to customer needs. This flexibility is one of the driving forces that creates over 48 fintech unicorns valued at \$187 billion in the last few years; none of which builds their own data-center.<sup>7</sup> In sum, cloud computing is a major paradigm shift in computing that not only benefits financial services industry, but many other enterprises in non-finance field. It represents an essential driving force for productivity, innovation and cost-saving for enterprises and serves as underlying pillars for other technological innovation, such as artificial intelligence and big data.

### 6.3.3 *Big Data*

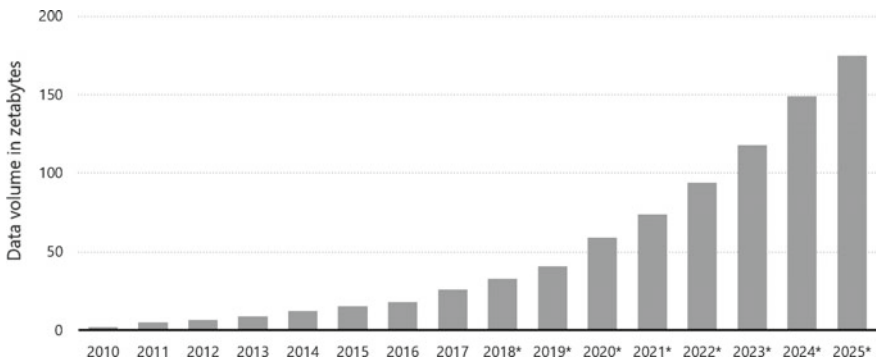
The term big data was first introduced in the mid 1990s, but the general adoption did not start until 2004 when two engineers from Google published a paper which discusses the use of MapReduce to collect and analyze website data for search and optimization.<sup>8</sup> MapReduce is a programming model that explores large-scale parallelization and distributed processing, it up-roots traditional understandings of how data is stored and retrieved into a massively parallel storage system. The success of Google search and its ability to manage, store and retrieve massive amounts of data in a fraction of a second has always fascinated engineers. When this secret was broadly revealed, many engineers sought to leverage the technology for new applications. This breakthrough opens opportunities for many applications that were previously thought to be unrealizable. As such, the adoption of big data has been able to accelerate since the ability to use the data within reasonable timeframes has been unlocked. Not only does it enable massive data collection, but it also builds the foundation for the requirements in learning for artificial intelligence (AI), where massive data collection is necessary to properly train an AI machine.

Before big data, traditional data had to be meticulously identified and classified in order to efficiently store, retrieve, analyze and process. Furthermore, programming instructions have to be properly aligned with the data structure in order for both to work in harmony, and modification of data structures may require modification of programming instructions and vice versa. With big data, data can be structured, semi-structured and unstructured. Relationships between data and programming instructions do not require strong and rigid links. Data formats can be expanded to almost any type. Unstructured data can be collected, stored, analyzed and processed at any time, and programming instructions can be deferred to a much later time before any hypothesis is made to extract insight from the dataset. As such, enterprises can collect massive amounts of data, then wait for the ‘right’ time to conduct proper research or investigation to determine the value of the collected data.

In addition to the characteristic that delivers the implementation advantage of modern application design, big data can be identified with three important characteristics: volume, variety and velocity. Each will be discussed below.

Data volume is the quantity of generated and stored data, generally measured in bytes. Research estimates that the combined data stored in traditional and cloud datacenters, enterprise-hardened infrastructure (like cell towers and branch offices) and end-point devices (such as personal computers, smartphones, and IoT devices) would grow from 33 to 175 zettabytes between 2018 and 2025. This trend is illustrated in Fig. 6.13. There are many sources driving the explosion of data stored, including but not limited to the use of media (such as videos and images), business requirements (such as compliance, audit trails, event monitoring), service personalization (such as customer's behavioral data), growth of smart devices (such as smartphones, tablets, 'Internet-of-Things' devices), replication of data (such as synchronization, multiple revision and backup in cloud) and dramatic increase in the number of internet and mobile users, etc.

Data variety refers to the large variety of data types or formats used. Examples are text files, videos, images, audio, etc. Previously, when information technology penetration is low and processing power is limited, the type of applications that could be developed was also limited. With rapid growth of processing power, a large variety of applications, including those that require large data formats, become available to businesses and consumers. For example, the most popular video sharing site YouTube, which started in 2005, has 500 h of video uploaded per minute in 2019.<sup>9</sup> In addition to data, many businesses have collected a tremendous of metadata (data about data) as part of the compliance, user behavioural analytics, or management reporting. An example for the compliance requirement would be Sarbanes Oxley Act. The regulation requires all financial reports to include internal control reports. As such, network activity, database activity, login activity, account activity, user activity and information access activity must be monitored, logged and audited. Logging these activities generated large amounts of information unrelated to the business data. Unfortunately, there is no clear guidance as to the



**Fig. 6.13** Annual size of the global datasphere (*Source* Data Age 2025, IDC, November 2018)

detail or breadth of such additional data. As such, many IT teams take an approach of logging almost everything whenever possible. For user behavioral analytics, businesses constantly want to improve customer engagement, personalize services and increase per customer revenue. By using big data analysis, businesses are able to identify unobvious insights and to establish systematic and personalized approaches to better serve their customers.

Data velocity refers to the speed at which data is generated, processed, and stored. Research firms forecast that 150 billion devices will connect around the globe by 2025, and that over 30% of the data stored are generated real-time from these devices.<sup>10</sup> This trend is illustrated in Fig. 6.14. At that speed, it translates to around 1 digital interaction every 18 s per person. Digital interaction may not imply direct human interaction with a device, it could mean data collected from background activities, such as user location, duration of reading a specific section of an article, etc. Traditional design of IT systems would not be capable of storing data at such speeds; hence, new big data systems must be deployed in businesses to cater for this trend.

Despite the wide adoption for big data, there remain many challenges, such as data sanitization, data explosion and sample selection bias. Because data collected are mostly unstructured, the data quality and definition can be quite poor. Hence, data engineers still have to spend a tremendous amount of effort to clean up data in order for proper processing. Some informal surveys indicate that organization sometimes spend over 50% of their engineering resources for data sanitization. As tools become more readily available, some organizations tend to collect data whenever they can in fear of missing out something important. It is estimated by various surveys that over 60% of the collected data are never analyzed or processed.<sup>11</sup>

Lastly, selection bias is gradually becoming a problem especially when it comes to using big data for artificial intelligence application. Depending on the frictions involved with data collection, easily accessible data are collected more frequently than less accessible data. As such, collected data starts to show a bias towards easily collectible datasets. The implications of this can be highlighted

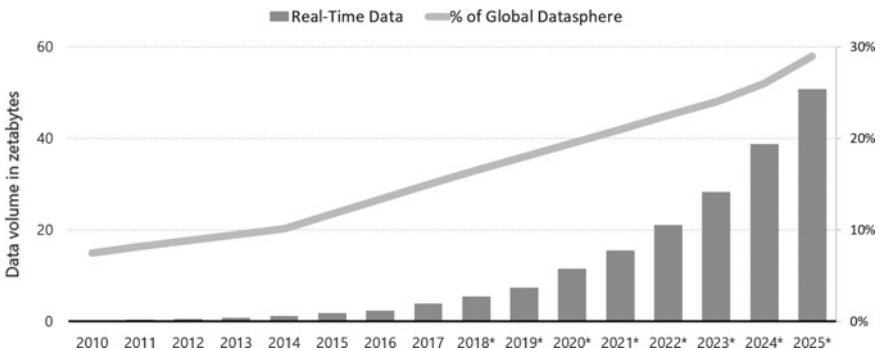


Fig. 6.14 Annual real-time data generation (Source IDC, November 2018)

through the lens of a simple example in insurance fraud analysis: a financial institution may want to collect equal numbers of fraud and normal cases in order to assess selection biases related to fraud. However, the reality is that the number of fraud cases is far less than normal cases, and by collecting all cases, some determining factors may be skewed heavily towards the normal cases. This could make fraud identification using artificial intelligence difficult without careful and bespoke adjustments to accommodate sample biases.

### 6.3.4 *Artificial Intelligence*

Ever since the term ‘artificial intelligence’ was coined by John McCarthy in 1956, the imaginings of what AI could achieve vary widely from HAL 9000, a machine in the movie *2001: A Space Odyssey* which had intelligence exceeded that of human beings, to Skynet from the movie *Terminator*, a self-aware artificial intelligence machine which decided to exterminate the human race. Perhaps, artificial intelligence may attain self-awareness and self-preservation one day. Until then, AI is nowhere close to what is depicted in scientific fiction.

The main difference between AI and conventional programming algorithms is that AI does not require explicit programming instructions. That is, the algorithms detect patterns and learn how to make and improve predictions and recommendations. The learning process requires a tremendous amount of data to maximize effectiveness. The dataset, in some way, therefore anchors the learning scope of AI. For example, AI can learn the face of all students within a university through the students’ portrait, yearbook, or photos taken during the school’s activities. But outside of the student population, it would not be able to recognize anyone else. As such it is a simple realization that the fundamental workings of AI work in a very similar to the human brain, which also would not recognize a face it has never seen before. However, the capacity of AI for learning can humble that of a single human, and given an almost infinite amount of data, AI can learn continuously with capacity and duration limited only by the computing resources provided, that is, processing power, algorithm and storage. As a computer does not need to rest, its learning capacity would far exceed that of a human. Hence, in theory, AI has almost infinite learning capacity.

The utilization of AI consists of two main processes: machine learning, or sometimes known as training, and machine prediction. Machine learning is the process when the machine is configured to learn designated or undesignated characteristics from massive amount of data. During the machine learning process, the machine reads the dataset repeatedly and iterates the interim results until a convergent state is reached. This is extremely computationally intensive and time consuming even with large-scale computing resources. Some machine training takes days, weeks or even months to complete. Machine prediction is the process whereby the machine/AI is presented with a dataset and asked to generate an outcome (classification of the input data) based on prior learning. For example, when a radiologist wants to train an

AI machine to identify cancer cells from a large number of images, he or she presents these images as a learning dataset to the AI machine. The AI machine will invest a tremendous amount of computing resources to learn and to identify the characteristics of cancer cells. When the training is complete, the radiologist can present the images of a suspected cancer patient to the trained machine. Based on what the AI machine has learned, it predicts whether the patient's image contains cancer cells. Since the prediction is based on the training dataset, the accuracy of the prediction is highly contingent on the availability and quality of the training dataset. Furthermore, even when the initial training for an AI system is complete, engineers can continue to add new data for the AI to review and learn, however cannot remove previously learned data. Unlearning is a research topic in machine learning; hence, current state of the art for unlearning literally means re-running the entire dataset with exclusion of the undesired data.

After over 60 years of development, the adoption of AI has substantially accelerated in the last few years. Today, AI is being applied across diverse applications, such as autonomous vehicles, speech recognition, lie detection, voice and face authentication, medical diagnosis, etc. For fintech, it has been known for applications such as know-your-customer onboarding, credit risk assessment, fraud detection, robo-advisory, automobile smart claim and cybersecurity. The accelerated adoption of AI was contributed by many factors, including public awareness, availability of cloud computing and big data, and breakthrough in how AI is applied to a problem.

The performance of AI has been demonstrated under the public spotlight. In 2011, the public took notice of IBM's Watson machine which competed and won against two of the best performers of all time in the TV show Jeopardy. The public quickly became aware that computers have the capacity to outperform humans in knowledge or memory-based games. Business started paying serious attention to AI in 2015 when AlphaGo played its first match against reigning three-time European Champion in a 3000 years old chess game known as Go and won the first ever game against a professional. By 2017, AlphaGo beat the world number one player. The number of combinations involved in Go was thought to be so large that even the world's fastest supercomputer cannot possibly compute all possible combinations in moves to beat an opponent within a reasonable time. Unlike the memory-based game that IBM's Watson played, AlphaGo raised the bar to a much higher level of artificial intelligence application. The human defeat was made possible by a completely different approach—replacing hand-crafted rules with a deep neural network and algorithms that can learn how to discover new knowledge within the settings. As businesses and governments witnessed how a computer can legitimately outperform the 'intelligence' of the best human in an extremely complex game, they are more willing to explore wider and more complex applications. AI has now moved from the realm of pure research or science fiction to reality.

Technically, there are four key elements that drive the newly founded success and future adoption of AI: huge computing power, cloud computing, big data and smarter algorithms. Most algorithms used in artificial intelligence require access to large amounts of computing power. Many of these computations are processed by graphics processing units (GPU) which exploit data parallelization and can process over 10 trillion floating-point operations per second. As a reference, a high-end smartphone in 2019 can process 5 trillion floating-point operations per second in order to perform an authentication using facial recognition. This computing power is necessary in order to sift through and to process massive amounts of data quickly. Often time, in order to shorten the processing time, a large number of GPUs are utilized concurrently on disjointed datasets. For effective utilization of the GPUs resource, many companies adopt cloud computing, taking advantage of time-sharing for large-scale computing resources and allowing shorter computation time without incurring substantial investments or suffering from idle resources. As AI requires large number of datasets to train the machine, an efficient and economical solution is necessary. Big data technologies offer efficient data storage for structured and unstructured data of extremely large scales, and both facilitates and accelerates the adoption of AI. New algorithm development also plays a significant role. AlphaGo was built on computer learning algorithms without explicit programming instructions. Specifically, AlphaGo's algorithm is designed to learn by itself. Such breakthroughs in algorithm design are necessary because of the limited number of programmers and data scientists, limited knowledge, unfathomable data complexity size and sometimes ambiguous problem definition. Algorithms need to be regularly invented or adapted in order to cater for different applications.

Furthermore, the learning process can be parallelized; therefore, it can learn multiple datasets concurrently. This characteristic is very similar to combining the intelligence of multiple human experts into one. Imagine integrating 1000 best radiologists in one AI learning machine, then, have the same AI learning machine performs diagnosis for millions of people concurrently using the knowledge of these best 1000 radiologists. In fintech, for example, AI can sift through millions of cases to identify hundreds of potential fraud patterns, a task that was either performed by well-trained professionals or computer programs with very specific programming instructions which need to adapt regularly over time.

Another important aspect of AI is unsupervised learning, which really stands out compared to traditional algorithms. In the past, if you present a pattern to a computer algorithm, a programmer or data scientist has to explicitly state the intended outcome. For example, presenting a large dataset of animal pictures to an algorithm, then, the data scientist has to identify each animal individually in order for the machine to learn. This identification process is known as tagging or annotating. If a picture dataset has thousands of animals, then, the data scientist has to help the computer program to identify every animal, like tagging a dog, a cat, etc. This learning process is called supervised

learning where data scientist directs the relationship between given dataset and its intended outcome. Supervised learning works well when relationship between given dataset and its intended outcome is well known. Unsupervised learning completely removes this inefficiency, it defers the tagging or annotation process. For the same example, the AI algorithm could simply sift through all animals within the dataset. Then, it automatically identifies similarity among the animals in the pictures. Although the algorithm does not know which one is a dog or a cat, it would algorithmically group dogs in a category and cats in another category. Note that this categorization process is not exact, that is, if the picture of a real dog looks like a cat, the algorithm would categorize this dog as a cat. Furthermore, this categorization needs not to be disjointed. That is, overlapping categories are allowed. Afterwards, data scientist can classify that animals within a specific category are dogs. Then, the machine would know all animals within the marked category are dogs. Imagine applying the same capability to a fraud detection scenario in fintech. AI can simply learn all the cases without knowing which case is a potential fraud. However, the AI machine would group different patterns into multiple categories. When a fraud specialist identifies a fraud pattern, it would simply tag the case, or the pattern associated with the case. Immediately, all previous and future cases with similar fraud pattern would be identified by the AI machine as potential fraud without having any human expert sniffing through all the cases. With thousands and perhaps even millions of cases, AI can perform the task efficiently and effectively by simply providing computing resources to the AI machine. The potential gain is not only the saving in cost of labour, but also in eliminating variation in the consistency of judgement by human workers.

Reinforcement learning is another major advancement of AI. The learning process is very similar to learning by mistake, and the challenge is how to characterize a mistake algorithmically. Imagine you present a set of scenarios to an AI learning machine, instead of tagging which outcome is correct, a set of criteria is provided to allow the machine to self-evaluate which outcome is better. Reinforcement learning is best applied to problems where the solution is not known, or the incoming dataset is too large or indeterministic. Chess is a good example where reinforcement learning applies. Because of the large number of possible responses related to an opponent's move, it is computationally expensive to evaluate all possible scenarios. Instead of having a computer to exhaustively search for the best response, a set of criteria is given to examine which outcome is a better response compared to others. Reinforcement learning could try 10, or 100, or even 1000 possible responses, then, examine which is the best response. The number of trials can then be made to vary based on the availability of computing resources or dataset. Reinforcement learning works best when the dataset is insufficient or possible the input set is extremely large, and the output relationship can be ambiguous or ill-defined. For the chess example, the output relationship is ambiguous given the large number of considerations to evaluate whether an outcome is better or not. Today, reinforcement learning is applied to many applications, such as

autonomous driving, optimal treatment for health conditions, predictive maintenance in manufacturing, robotics, etc. In fintech, reinforcement learning can be applied to behavioural analytics in cybersecurity, dynamic portfolio construction, monitoring for anti-money laundering activities, authentication using facial or voice recognition, etc.

One of the pioneers in using artificial intelligence technology to process automobile insurance claims is Chinese insurance company Ping An. Its Smart Fast Claim had handled close to 5 million automobile claims in the first half of 2017.<sup>12</sup> It uses high-precision image recognition to assess the damage cost and shortens the processing time for claims from three days to 30 minutes.

AI also has its shortfalls. First, because of the large computing power requirements, AI consumes a vast amount of energy. The carbon footprint for training a single AI is as much as 284 tons of carbon dioxide equivalent—five times the lifetime emission of an average car.<sup>13</sup> Although many are working on power reduction during computation, the accelerated adoption of AI from diverse industries may exceed the improvements of power reduction. This would be no different for fintech applications. Second, most machine learning functions are restricted by the available data and not transposable to applications for which the data are not directly relevant. For example, AI that was trained to identify brain cancer radiology image would not know how to identify lung cancer. AlphaGo's self-learning ability was the result of a well-defined scope in a strategic game like chess. Most of the practical or interesting applications in fintech are not as well-defined as chess. For example, in a dynamic portfolio allocation application, the range of factors to consider include the underlying fundamentals of an asset, investors' overall sentiment, monetary and fiscal policy, government policy, substitution and complementary market effects and many unaccounted variables may affect the future performance. Third, trained AI does not know how to forget. Similar to a human, once you have seen what a dog looks like, it is not easy to forget about the image of a dog. For AI machines to forget, it may mean a 'brain-wipe', that is, deleting the trained AI, then implement a complete retraining. The time and effort could be horrendous when an incorrect dataset is included within the training process. Fourth, it may be difficult to combine AI training. For example, if one AI machine is trained to recognize a dog, and another AI machine is trained to recognize a cat, one cannot simply combine the two AI machines learning, to recognize a dog and a cat, without incurring any additional computation or retraining. For fintech's application such as fraud detection, it could mean rebuilding the entire training if certain features within the dataset need to be added later. Lastly, AI machine learning is not the same as reasoning. For example, a trained AI may predict a patient has a high likelihood of cancer after examining his or her radiology image. But it cannot explain its reason to a physician. Hence, if the physician does not concur with the AI machine's finding, it creates a dilemma as to who/which is correct. This characteristic makes AI difficult to apply to certain applications. Imagine an AI machine tells an investor when to buy and sell with 95% accuracy, but it fails to explain what



signals generate a buy or sell condition. Should the investor fully trust the AI machine or revert to his or her personal judgement based on the recommendation of the AI machine. Furthermore, in the event of a filed complaint to a regulator regarding misguided investment advice, the service provider may not be able to provide proper justification as to why the advice was offered in the first place. Although new applications and algorithms are being developed to facilitate careful reasoning processes within AI, they are far from widely applied yet.

### 6.3.5 *Blockchain*

Among all new technologies for finance, blockchain probably has the shortest history. It started in October 2008 where a person with a pseudonym Satoshi Nakamoto published the article ‘Bitcoin: A Peer-to-Peer Electronic Cash System’. The paper described a digital currency implementation using a set of well-known cryptographic algorithms and protocols that is fully decentralized, censorship-proofed and open to any party to participate. The timing coincided with the Global Financial Crisis where there was rising distrust against government’s managed financial system, as such the interest for an alternate monetary system grew. Throughout the rapid rise of Bitcoin price from almost nothing to a peak of around US\$20,000 and with market capitalization over US\$300 billion in December 2017, many financial institutions became afraid of missing out on a disruptive force that may change their existing playfield. Some institutions operating in areas with lighter regulatory burden started investing into digital currency such as Bitcoin, and others were exploring better use of blockchain—the underlying technology behind Bitcoin.

What makes Bitcoin differ from many prior digital currencies is its openness, decentralization, robustness and balance of incentives. Unlike some of its predecessors, Bitcoin’s implementation is completely open-sourced, and its design and architecture are publicly disclosed. This openness attracts a large development community in building, maintaining and sustaining the ecosystem. The decentralized architecture of Bitcoin not only enables full replication of its ledger (the ledger is where bitcoin system stores all its transaction records), but also avoids censorship from small number of participating parties, including government. As a result, no single government or organization can control or interfere with its operations and outcomes easily.

Bitcoin’s protocol is very robust against most cyberattacks. The most well-known method of attack is 51% attack, where an attacker must gain over 50% of the computing resources used in mining in order to alter the outcome. The computing resources required to mine a block of Bitcoin are expressed in hashing rate. Although the hash rate fluctuates, the long-term trend of hash rate is to increase over time due to rivalry among Bitcoin miners. As of August 2019, the hashing rate has exceeded 80 million tera-hash or  $80 \times 10^{18}$  hashes per second. With a typical computer which has a single core can process around 20 million hashes per second, a brute-force attack would require

approximately 3.3 billion equivalent computer cores to launch a successful 51% attack within 10 minutes.<sup>14</sup> Even with the availability of cloud computing resources, the cost to launch such attacks out-weights the gain.

The incentive system built for Bitcoin is what has ensured its continuity since its inception in 2008 and avoided it disappearing as a fad. Participating entities within the Bitcoin ecosystem consist of buyers, sellers, wallets, exchanges and miners. When a buyer wants to buy and a seller wants to sell, the wallet helps to safeguard the private key that would generate transaction requests for the buyer and seller that go to an exchange in order to find a bid-ask match.<sup>15</sup> A successful match constitutes a transaction, and this is followed by miners who are competing to validate the transaction. When a miner has successfully completed the validation, the miner will earn Bitcoins, the exchange would earn a transaction fee, the wallet would earn either a subscription fee or a hardware purchase, and the buyer and seller would gain respective utility from the transaction in the usual manner. Inspired by Bitcoin's approach, many other digital currencies have emerged that can offer better efficiency and technical properties than Bitcoin; nevertheless, most of them retain the same fundamental incentive system in order to sustain the longevity of the digital currency.

Blockchain is the underlying technology that drives the success and maintains the robustness of Bitcoin, but blockchain applications need not be applied only to digital currency. This turns out to be extremely important because when financial institutions were to deploy blockchain applications, having digital currency may fall under strict regulatory scrutiny, i.e. the ability to use blockchain within fintech applications without needing to be tied to cryptocurrency helps to avoid regulatory scrutiny. Bitcoin and other digital currencies require miners to perform heavy computational work in order to validate and maintain the integrity of every transaction, and miners will be rewarded with digital currency. The gain in the value of digital currency must be higher than the cost it takes for miners to validate the transaction in order to sustain an economically viable ecosystem. In a non-digital currency blockchain application, or enterprise blockchain application, the role of miner is replaced by a validator. Validators are pre-designated parties who are eligible to participate in the transaction validation process. They monitor and cross-check each other to defend the integrity of the enterprise blockchain application and to ensure no validators are cheating or colluding. The most common platforms that enterprise blockchain have been built upon are shown in Table 6.5.

Generally, enterprise blockchain platforms can be used to build any type of desired application. Often time, financial institutions choose a specific platform based on its suitability of specific application with respect to the platform's offerings and the availability of engineers who are knowledgeable to implement the solution. As blockchain requires a more in-depth understanding on the platform architecture and some of its programming language is relatively new, identifying knowledgeable engineers for blockchain applications development can be a challenge. Among all the attributes, operation mode is an

**Table 6.5** Enterprise blockchain platforms

<i>Key attributes</i>	<i>Enterprise ethereum alliance</i>	<i>Hyperledger</i>	<i>Corda</i>
Application positioning	Generic	B2B/Enterprise	Financial services
Operation mode	Permission-less	Permission-based	Permission-based
Governance organization	Developer community	Linux foundation	R3 Company
Storage mode	Fully distributed	Modular architecture	Selective distributed
Consensus protocol	Proof-of-work/Proof-of-stake	Flexible, Practical Byzantine Fault Tolerance	Notary Node, transaction-level
Smart contract	Solidity	GoLang/Java	Kotlin/Java
Data privacy protection	None, full transparency	Confidential	Confidential
Digital currency	Ethereum	None	None

important attribute that differentiates the accessibility of application. Applications that adopt Ethereum tend to be open or permission-less, that is, any party can participate in the blockchain application. There is almost no censorship and its continuity relies on the community which participates in contributing to and maintaining the system. Permission-based or restricted blockchain systems narrow the access to eligible parties. Often these are parties who co-develop and co-maintain the system for a specific purpose. For example, a blockchain system that authenticates the issuance of insurance policies may only allow insurers to have write access to the blockchain, while other restricted parties, such as government or individual policy holder may have limited read access.

Another important attribute is storage mode. The blockchain architecture behind Bitcoin or Ethereum adopts a fully distributed storage approach where the data associated with each transaction within the ledger is fully replicated across all nodes that store the ledger. The overall storage cost is high, but this is one of the key requirements that maintains the integrity of the system where every player can check every other player for any transaction at any time. For enterprise applications, a full replication is not desirable due to potential leak of proprietary or sensitive information on the ledger, and optimization of storage overhead. As such, limited information as well as a message signatures are selectively stored on the blockchain to allow participating parties to validate the integrity of the data without revealing sensitive information.

The last and most important attribute is the consensus protocol which has significant implication for the integrity and efficiency of the blockchain application. Consensus protocol is a computer communication protocol that is used for distributed computing devices to agree upon a common data value. Imagine if a group of individuals who each has his or her unique number in

mind, but each has to convince all other parties within the group to agree upon the number that he or she holds, or to side with a number that another party holds. This turns out to be a relatively difficult problem in fault tolerant computing. Consensus protocol is designed to achieve this objective efficiently. The blockchain in Bitcoin solves the consensus problem by using a consensus protocol known as proof-of-work. Essentially, a party self-selects to compete in solving a well-defined mathematical puzzle that is computationally intensive. The party who is willing to invest a large amount of computing resource to compete has a higher probability of winning. Because of the nature of randomness within the mathematical puzzle, even the party who has the largest amount of computing resource is not guaranteed to win every time. Since proof-of-work is computationally intensive, many enterprise applications choose to use an alternative approach to tackle the consensus problem. Unfortunately, there is no other approach that dominates (based on the number of transactions) like that used in Bitcoin. Each of the alternative approach carries its trade-off, though all aim to reduce the computational requirements brought by proof-of-work.

Blockchain is best applied to problems where parties need to share information or to conduct transaction but do not fully trust each other. An example where blockchain may not be effective would be within the existing consumer banking system. When an individual deposits money into a bank, he or she trusts the bank and the regulation that is put behind the banking system to protect his or her money. Since a high degree of trust exists in consumer banking system, blockchain is not needed. An example where blockchain would be highly applicable in financial services is auto insurance policy authentication. Many countries require drivers to purchase insurance and show proof-of-insurance when the auto licence is renewed. Because auto insurance is often sold through third parties or agents in a highly competitive market, it is difficult for a policy holder to identify whether an issued policy is genuine without checking with the insurer directly. Such direct inquiry is rarely conducted. This invites opportunities for criminals to falsify policy. Insurers are obviously incentivized to deter such practices because an uninsured counterparty means that an insured party will have to payout for the fraudulent policy. A simple solution is to have all insurers share their policy so that they can jointly detect potential fraud with full transparency. However, such sharing may invite competing insurers to outbid each other or to redirect their customers. With this complex problem, an enterprise blockchain solution would mitigate the problem of revealing customer information to competition and significantly reduce the likelihood of auto insurance fraud. Moreover, insurers can freely choose to run their blockchain application and issue insurance policy through the blockchain. Since this is a permission-based blockchain, only eligible insurers can write, and all other parties can validate the authenticity of the insurance policy. An additional advantage is non-repudiation where an insurer cannot deny its issuance of the policy. This

means that a government licencing office can ascertain that an insurance policy is legitimately issued by an eligible insurer.

### 6.3.6 *Cybersecurity*

The market for cybersecurity is estimated to worth more than US\$200 billion. As a process, cybersecurity is applied within a wide range of industries, and its role in financial services is extremely important due to the rapid growth in the number and sophistication of cyber threats.<sup>16</sup> Many activities within financial services involve monetary transactions, are bound by regulations, and often require the provision of personal identifiable information (PII). As a result, financial services firms have made significant investment in cybersecurity. Risk qualification, i.e. defining the benefits to cybersecurity, is a challenge because firms' spending in cybersecurity cannot be directly linked to customer's impact, profit or revenue growth, it merely serves as risk mitigation for potential threats. However, due to many high-profile cyberattacks and data leaks in recent years, board members and senior management can no longer neglect the importance of cybersecurity despite it being hard to quantify the return. Nonetheless, qualifying the investment is sometimes couched in terms of whether a firm has spent reasonable effort in protecting its customer's information. The term 'reasonable effort' is however subject to interpretation in a court of law in the event of a breach.

As a thorough discussion of cybersecurity could be very lengthy, only core areas relevant to fintech will be highlighted here. Financial services firms are slowly embracing the principle of security by design, rather than patching the loopholes aftermath. Firms are expanding the level of resources dedicated to cyber defence, including employing dedicated cybersecurity officers and engineers. Key issues to discuss here will include containerization, identity as a service, and behaviour analytics for cyber threat signals.

Containerization-as-a-service has been gaining considerable traction in the last few years among software development communities, and is rapidly moving to the mainstream. Application containerization enables enterprises to create and manage distributed services with flexible scalability. This means an enterprise can deliver services to the cloud rapidly, manage a wide range of concurrent services, scale the performance dynamically based on real-time demand and save on total cost of ownership during the service lifetime. For example, when a large number of users are accessing banking services during peak hours, containerization technology would scale up the number of front-end virtual servers automatically in order to maintain an acceptable response time and service level. This is achieved by shifting the less loaded computing resources to the services that need more resources. By dynamically adjusting these resources through containerization, an enterprise would be able to more effectively utilize its computing resources and manage costs. Unfortunately, the adoption of containerization introduces a new cybersecurity risk. For example, Tesla suffered a crypto mining attack after its cloud

computing settings for container deployment were accidentally exposed on Amazon Web Services in 2018. A cyberattack followed which was characterized by hijacking the victim's computing resources for the intense computation used in crypto mining, by forcing containerization to prioritize other services. The victim suffered from significantly lower computing resources allocated to, and hence higher costs (lower returns) for the computing hours spent for crypto mining. Thus, work in this area is still evolving and new emerging products are being designed to manage the security, redistribute resources, and monitor performance and availability of containers. The value of this was recently highlighted in 2018, when IBM acquired open-source enterprise software company RedHat for \$34 Billion, owing to their innovations in containerization.

The two most widely adopted forms of identity as a service would be Single-Sign-On (SSO) and two-factor authentication. The growth of identity as a service is mainly driven by the wide adoption of software-as-a-service through web or mobile applications. SSO allows user to easily access multiple services with a single authentication instead of multiple usernames and passwords. This ease of use introduces a single point of failure whereby a cyber-attacker can compromise a single authentication point in order to gain access to all services registered under a single-sign-on service. Two-factor authentication is widely promoted by security professionals based on the principle of defense in depth. Under two-factor authentication, a cyber-attacker needs to gain access at multiple points in order to compromise an account, therefore reducing the probability of success. An ATM card is an early realization of two-factor authentication where an attacker has to gain access to your ATM card (or card number) and then your PIN in order to withdraw cash from an ATM machine. Today, the most commonly adopted approach would be to use a one-time-code through SMS or electronic mail as a second factor. Nowadays two-factor authentication has been adopted by many financial institutions when users conduct transactions through the internet or mobile banking.

Recent developments on authentication and access have been extended with artificial intelligence and zero trust network access (ZTNA). For example, using facial or voice recognition has been gaining popularity. ZTNA essentially redefines application access using a two-tier authentication and access model. The main advantage of ZTNA is that service providers which offer this service cannot gain access to a user's account. Hence, even when the ZTNA service provider is compromised by a cyber-attacker, the user's account is not affected. These developments are highly likely to be adopted by financial institutions because of the increasing number of cyber threats. Financial institutions are continuously looking for more user-friendly and more secure means for accessing financial services in order to acquire and retain customers and to suffice regulatory compliance.

Using behavioural analytics combined with artificial intelligence is a growing force in the cyber defence protocols of fintech and financial institutions. There is no doubt that the motive behind most cyberattacks is monetary

gain. As such, financial institutions are a constant target. Cyber attackers use many different means to infiltrate the defences put up by cyber security engineers within financial institutions. In late 2013, Target's infamous breach could have been avoided if engineers were paying attention to network logging activity. Unfortunately, the information was logged but not actively monitored. Monitoring network activity can be a huge and insurmountable task. The amount of activity log data generated is vast and its source can originate from networks, servers, smart devices, mobile phones, computers, clouds, etc. Moreover, a financial institution has to monitor not only its own systems and employees' computers and devices, but also its users and customers. With artificial intelligence and big data, this problem becomes more manageable. Artificial intelligence systems would be able to identify the critical areas for monitoring. Big data technology would help to gather, consolidate, store and organize the vast amount of data in a highly efficient and cost-effective manner. Then, artificial intelligence would be further used to scan, monitor, identify and alert anomalous activity or pattern-breaking behaviour that could potentially be a threat of data leak. For example, a user who would normally access his or her account in the morning at head office in Asia is found to be accessing the account in Europe, the system may step up the authentication process before granting access or simply block the access completely. Similarly, a customer who detected making multiple purchases online within a short time-period that are both abnormally large for the consumer and with an unknown retailer, the financial institution could take action to block the transaction or initiate a direct contact with the customer in order to verify the transaction. These types of behavioural analytics can be further improved by sharing behavioural patterns among corporations in order to enrich the knowledge base of the tool.

In sum, cybersecurity is a core component for secure delivery of financial services. Managing smooth and scalable service delivery, great user experience in authentication and access, and protection of data through monitoring, identification, and mitigation of behavioural events are essential and prolonged tasks within a financial service company.

## 6.4 FINTECH IN USA AND CHINA

Comparing fintech companies between USA and China carries a certain degree of difficulty due to diverse differences that exist between the two economies. Furthermore, survival bias may impact the extent of available data for comparison since survival rates differ between these two markets, and the success rate of startups remains relatively low. Hence, here in order to avoid such biases we adopt a methodology of comparing the top 50 from both territories, as defined by leading market commentators.

Both Forbes and KPMG published a list of top 50 fintech companies in the USA and China respectively. By assigning and comparing common attributes associated to each of these companies, a high-level qualitative analysis can be

carried out in order to evaluate the difference of fintech companies between the two countries. The attributes we examine are carefully chosen to reflect the nature of the fintech business. Tables 6.6 and 6.7 show Forbes' Most Innovative Fintech Companies for the USA in 2019, and KPMG's Leading Fintech 50 for China in 2018 respectively, both tables also reporting the assigned attributes associated with each company.

The selected attributes are common across both lists, and are chosen to represent the core business nature of each company. The attributes are divided into two main categories: customer type attributes and non-customer type attributes. For example, customer type attributes such as B2B (business to business), B2C (business to consumer) and B2B2C (business to business to consumer) are used to represent whether the targeted customer for the fintech company is business or consumer. While B2B companies focus on selling to enterprise customers, and B2C on selling to consumers as customers, the new category of B2B2C is a subcategory of B2B that targets companies which aim to facilitate business to their consumer base, i.e. the customer's customer. These three attributes are relevant because they reflect the respective customer's needs and the potential scope of technology application within each market. Table 6.8 shows the result of customer type attributes.

For the attributes related to customer type (B2B, B2C and B2B2C), China has more overlap with B2B and B2C than that of the USA. Although some fintech companies in China are going after both B2B and B2C, this does not imply competition with their B2B customers. On the contrary, these companies need to interact with 'C' in order to provide better value to their B2B customers. In the USA, such overlap is almost non-existent. Perhaps, this is an indication that fintech companies in the USA are more technologically independent in approaching their customers, or companies in China are faced with certain hurdles in accessing information on 'C'. This difference becomes more obvious when it comes to the discussion of non-customer type attributes.

The comparison of non-customer type attributes further highlights the extent of differences between the two economies. With regard to the six following classifications areas: (i) technology enablers; (ii) credit risk management; (iii) payment, point-of-sales, and card services; (iv) cybersecurity; (v) personal finance and new banking; and (vi) backed by 'giant', the number of companies associated with each attribute are shown in Table 6.9. There are more platform enablers in China than that of the USA. This may imply the maturity of the technology development community differs in each of the countries. The USA has accumulated a large group of developers and innovators for new technologies over the years, while China has been lagging behind in terms of technology talents during adoption and developed the latest technologies. Hence, technology enablers are more prevalent in China, and they help to bridge the technology gap for companies which would like to adopt technology but lag talents. By concentrating the technology know-how within these enabling companies, less tech-savvy companies can benefit from innovation enabled by technology without retaining a large number of technology



**Table 6.6** The most innovative fintech companies in 2019

<i>Company name</i>	<i>Business areas</i>
Acorns	B2C/Investment/Card services
Addepar	B2B/Investment/Financial Advisor
Affirm	B2B2C/Financing/Purchase Loan
Axoni	B2B/Investment/Blockchain
Ayasdi	B2B/Compliance/Regtech/AML
Behavox	B2B/Cybersecurity/Office Automation
Betterment	B2C/Investment/Robo-Advisor/Retirement
Bitfury	B2C/Investment/Blockchain/Cryptocurrency
Blend	B2C/Insurance/Home
Bolt	B2B/Payment/Point-of-Sales/Fraud Detection
Brex	B2B/B2B2C/Payment/Point-of-Sales/Card services
Cadre	B2B/B2B2C/Payment/Card services
Carta	B2C/Personal Finance/Portfolio Management
Chime	B2C/B2B2C/Personal Finance/Card services
Circle	B2C/Investment/Blockchain/Cryptocurrency
Coinbase	B2C/Investment/Blockchain/Cryptocurrency
Credit Karma	B2B/B2B2C/Credit Risk Management
Cross River	B2C/Payment/New Banking
Digital Reasoning	B2B/Cybersecurity/Fraud Detection
Earnin	B2C/Financing/Consumer Loan
Enigma	B2B/Cybersecurity/Fraud Detection
Even	B2C/Personal Finance
Flywire	B2B/Remittance
Forter	B2B/B2B2C/Credit Risk Management
Fundrise	B2C/Investment/Crowd Funding
Gemini	B2C/Investment/Blockchain/Cryptocurrency
Guideline	B2B/B2B2C/Investment/Financial Advisor/Retirement
iCapital Network	B2C/Investment/Portfolio Management
IEX Group	B2B/B2B2C/Investment/Trading
Kabbage	B2B/B2B2C/Financing
Lemonade	B2C/Insurance/Home
LendingHome	B2C/Financing/Mortgage/Bridge Loan
Marqeta	B2B/B2B2C/Credit Risk Management/Payment/Card services
Nova Credit	B2B/Credit Risk Management
Opendoor	B2C/Investment/Trading/Home
Personal Capital	B2C/Personal Finance/Robo-Advisor/Retirement
Plaid	B2B/Platform Enabler
Poynt	B2B/Payment/Point-of-Sales
Remitly	B2C/Remittance

(continued)

**Table 6.6** (continued)

<i>Company name</i>	<i>Business areas</i>
Ripple	B2C/Investment/Blockchain/Cryptocurrency
Robinhood	B2C/Investment/Trading
Roofstock	B2B/Investment/Robo-Advisor/Home
Root Insurance	B2C/Insurance/Auto
Stash	B2C/Investment/Trading
Stripe	B2B/Payment/Point-of-Sales
Symphony	B2B/Cybersecurity/Office Automation
Tala	B2C/Financing/Micro-loan
Toast	B2B/Payment/Point-of-Sales/Food
Tradeshift	B2B/Payment/Supply Chain
TransferWise	B2B/B2B2C/Remittance

*Source* Forbes, United States

talents. Therefore, the B2B customers of China's fintech companies rely more on the technology platform enabler. Thus, this translates to a higher degree of stickiness or dependence. For customers of US fintech companies, they are less dependent on new technology providers compared to the case in China. It is worth noting that technology giants such as Google, Amazon and Microsoft play an important role as platform enablers in the USA. These giants are too big to be listed as the top Fintech companies in the USA; nevertheless, such technology giants are less pervasive in China due to various reasons, including maturity of the tech industry. It is worth noting however that Alibaba, a Chinese e-commerce giant, has become a formidable, cloud computing player in China.

Credit risk scoring is a well-developed market inside the USA, while China has been gradually building up the capabilities over the years. Because of the less mature market in credit risk management and difference in the definition of credit worthiness within Chinese culture, China has more fintech companies in this area than that of the USA.

Payment, point-of-sales, and card services are inter-related because of their association with consumer consumption, and consumer consumption represents a large percentage of GDP in both the USA and China. Much of the previously established infrastructure in payment and point-of-sales are gradually being made obsolete by the advance of new technologies and change in consumer behaviour. Merchants in the USA are no longer looking for simple point-of-sales solution with credit card or cash. They are rapidly adopting advancement payment solutions, credit services and customer behaviour tracking in order to better serve their customers and to improve customers' retention. As such, fintech companies in these areas are facilitating or replacing current system in the USA. Furthermore, some payment or point-of-sales solutions are uniquely tailored for small-medium enterprises

**Table 6.7** 2018 China leading fintech 50 company report

<i>Company name</i>	<i>Assigned attributes</i>
Aibao Technology	B2C/Insurance/Self-serviced
White Knight	B2B/B2B2C/Credit Risk Management/Fraud Detection
Bairong	B2B/Credit Risk Management/Financing/Loan cycle management
aiBank	B2C/Financing/New Banking
BaoZhunNiu	B2C/Insurance/Platform Enabler
IceKredit	B2B/B2B2C/Credit Risk Management
BUBI Blockchain	B2B/Platform Enabler/Blockchain
Dianrong	B2B/B2B2C/Financing/P2P lending
Doubao Technology	B2B/Insurance/Platform Enabler
Du Xiaoman Financial	B2B/Platform Enabler/Tech Giant
OnChain	B2B/Platform Enabler/Blockchain
Fumi Technology	B2C/Investment/Trading
Futu Securities	B2B/Financial Services/Tech Giant
HouBank.com	B2B/B2B2C/Credit Risk Management/P2P lending/Micro-loan
Tigerobo	B2C/Investment/Research
Huize Insurance	B2B/Insurance/Platform Enabler
Geo	B2B/Platform Enabler
jinfuzi	B2C/Investment/Portfolio Management
JDDigits	Platform Enabler/Tech Giant
Investoday	B2B/Investment/Research
OneConnect	B2B/Platform Enabler/Tech Giant
TigerBrokers	B2C/Investment/Trading
Lianlian Pay	B2B/B2B2C/Payment/Remittance/Credit Risk Management
Lufax	B2C/Financing/P2P lending
Mashang Finance	B2B/Platform Enabler
Ant Financial	B2B/B2C/Payment/P2P lending/Tech Giant
MioTech	B2B/Investment/Research
Qiancheng Technology	B2B/B2C/B2B2C/Credit Risk Management
BigtreeFinance	B2B/Platform Enabler/Blockchain
iPayLinks	B2B/Remittance/Payment
Supwin Tech	B2B/B2B2C/Investment/Portfolio Management
ChinaScope	B2B/Consultancy
Suning Financial Services	B2B/B2C/Financing/Tech Giant
Tencent Financial Technology	B2B/B2C/Platform Enabler/Tech Giant
TalkingData	B2B/Platform Enabler
TianChuangCredit	B2B/Credit Risk Management/Platform Enabler
Beagledata	B2B/Platform Enabler

(continued)

**Table 6.7** (continued)

<i>Company name</i>	<i>Assigned attributes</i>
Tongdun	B2B/B2B2C/Credit Risk Management
PayEgis	B2B/Cybersecurity/Identity Access Management
DataYes	B2B/B2C/Investment/Robo-Advisor
Vzoom Credit	B2B/B2B2C/Credit Risk Management
WeBank	B2C/New Banking
WeLab	B2C/Financing/New Banking
Xfintech	B2B/Investment/Securitization
The Umbrella	B2C/Insurance
Credit Force	B2B/B2B2C/Credit Risk Management
Snowball Finance Inc	B2C/Investment/Trading
Sunrate	B2C/Investment/Trading/FX
YofishFintech	B2B/B2C/Platform Enabler
Zhongan	B2C/Financing/Auto

*Source* KPMG

**Table 6.8** Number of fintech companies in customer type attributes

<i>Customer type attributes</i>	<i>China</i>	<i>USA</i>
B2B	35	25
B2C	25	24
B2B2C	10	11

**Table 6.9** The most innovative fintech companies in 2019

<i>Non-customer type attributes</i>	<i>China</i>	<i>USA</i>
Platform Enabler	16	1
Investment	11	17
Trading	4	4
Robo-Advisor	1	3
Credit Risk Management	10	4
Blockchain	3	6
Cryptocurrency	0	6
Payment	3	9
Point-of-Sales	0	5
Card Services	0	5
Cybersecurity	1	4
Personal Finance	0	4
New Banking	3	1
Backed by “Giant”	7	0

*Source* Forbes, United States

(SMEs) who historically were not able to access advanced and intelligent business solutions owing to cost barriers. With almost no information technology investment, these SMEs can now rapidly start their business online or offline without building any point-of-sales or payment system. The situation in China is very different. As a relative late comer to fintech, two payment giants Alipay and WeChat Pay have pretty much dominated the entire payment and point-of-sales market in the last decade, with cash transaction almost completely eliminated from most daily consumption activities. In addition, the credit card market is less developed in China. The number of Chinese fintech companies in these transaction-related areas are less due to strong incumbents and historically less access to credit.

There are more cybersecurity companies in the USA than in China. The reason can be traced to several important differences between the two economies. First, China has the Great Firewall which filters and/or blocks almost all internet traffic from the outside world. Second, the Chinese government controls all the telecom and communications infrastructure through state-owned enterprises, as such, internet traffic, its source and destination identity are entirely traceable; which creates a baseline deterrence against malicious attackers. Furthermore, public and internet surveillance by the Chinese government is a well-known policy, and many companies such as Tencent or Sina, are required to cooperate with government in implementing proper surveillance and censorship. Third, many financial institutions and technology companies have implemented an IT service ‘lock-down’ approach within the company. For example, many employees are not allowed to access the internet or even email directly when working behind the company’s firewall. Such an approach has significantly reduced the risk of cyberattacks using conventional methods. Fourth, widely used phishing attacks are a prominent method for penetrating a company network through email; however, this attack vector becomes less effective within China where China’s main communication tool has become Tencent’s WeChat, which has largely replaced traditional email. In fact, electronic direct marketing through email has proven ineffective in China. Electronic direct marketing companies such as Hubspot and Marketo which build their lead-generation through media, such as email, LinkedIn or search-engine optimization have failed to penetrate the Chinese market partly because of this. In contrast, some technology players which build lead-generation through WeChat have gradually been gaining traction in China.

Personal finance and new banking are different between the two countries. While the USA emphasizes an open standard approach of accessing and managing personal financial information, open standards for financial services in mainland China do not yet exist. In the USA, consumers can employ a third-party provider to integrate multiple accounts into one single application that can facilitate managing multiple accounts and transactions. In mainland China, each individual bank account has to be accessed separately, and consumers have to deal with multiple user experiences provided by different banks. When traditional banks in China fail to adopt open standards in fintech quickly enough to

adapt to changing consumer needs, new technology-oriented banks or financial institutions may take up the opportunity by providing a much better banking experience than traditional banks. As such, there are more fintech companies in the USA that focus on personal finance, while China fintech companies would go after local banking licence or circumvent regulatory loopholes in order to launch their personal finance services.

All fintech companies in the USA are startups funded by venture capital funding, though some may be also partly backed by financial institution's venture fund with minority stake. However, a number of fintech companies in China are spin-offs of existing technology companies or retail giants, with a majority stake owned by the parent companies. The spin-off approach in China aims to allow more independent growth of the fintech companies but concurrently backed by the reputation or customer synergy of the parent companies. The backing not only creates confidence with consumers, businesses and government but also allows partnership with relevant players to strengthen the value propositions and the positioning of the fintech company. This type of approach not only facilitates rapid organic and non-organic growth, but also gives rise to a more flexible financial dependence structure with the parent company.

In sum, fintech companies are different between China and the USA due to the varying maturity of financial services industry and also to material differences in social and economic structures. While the USA has a more well-established financial services industry, the Chinese incumbents in financial services, as a late comer to advanced financial services, have the opportunity to innovate and in turn to leapfrog the adoption of fintech. With less mature technology relate talent in the labour-pool, platform enablers in China still need to diffuse technological know-how from a few 'elites' that filter knowledge to a broader financial services industry in order to maintain a strong pace of technology adoption. Faced with a less sophisticated credit rating system, China's fintech companies attempt to create their own commercial credit rating systems using social networks and massive amount of public and private transaction data. With a relatively closed internet community, a communication system that does not depend on email, and a heavily monitored internet, China does not need to forge strong cybersecurity requirements in financial services at the moment. In order to create better financial products or services for customers, China's 'giants', armed with large consumer base, are making good use of well-connected social networks, commerce and e-commerce, spin-off subsidiaries and partner with other players to strengthen their value propositions to acquire share in a rapidly growing market. While the differences between fintech companies in the USA and China are abundant, they do not dictate which business models or which types of companies are better, they exist merely to better serve their customers in each respective market.

## 6.5 IPOS OF UNICORNS AS A PERFORMANCE INDICATOR FOR TECH STARTUPS: THE CASE OF CHINA<sup>17</sup>

### 6.5.1 *Understanding Unicorns*

A unicorn is a privately held startup company with a valuation of over USD 1 billion. Once a unicorn can exit through an IPO, being acquired by a listed company, or merged with another company, it will be taken out of the list regardless of the lifespan of the company. In this section, we explore how the success of Chinese unicorns can be reflected by exit channels and data.

The term ‘Unicorns’ was coined by Aileen Lee, a long-time tech venture capitalist and the founder of Cowboy Ventures. In 2013, Lee wanted to know the probability of finding a high growth startup founded in the 2000s with big valuations to invest in. Therefore, unicorns are most likely tech-oriented private firms with high growth potential. Since then, she used ‘unicorn’—a powerful and mythical creature, to describe the statistical rarity of such successful ventures. This terminology has widely been used in the press after Lee’s findings were published on TechCrunch. Aileen reports that only 1 in 1538, or 0.07% of all the venture-backed companies in the USA attained valuations of more than USD\$1 billion. The figure has since grown to 0.14% and people started to have concern that the technology industry may once again be in a bubble (Salvador 2015). With the rate of emergence of unicorns accelerating, the rarity of these USD\$1 billion-valued companies has decreased. New terms including decacorn and hectocorn have been coined to represent such companies with valuations of over \$10 billion and \$100 billion respectively.

#### 6.5.1.1 *Global Development of Unicorns*

A key indicator determining the development of unicorns is the number of unicorns in the global marketplace. Table 6.10 shows the total numbers of unicorn companies based on The Global unicorn Club and The Unicorn Exits Tracker from CB Insights. The data shows the number of unicorns (excluding exit) around the world for the past 10 years and there are 398 unicorns in the world. The total value of unicorns estimated by CB Insights is US\$1.23 trillion. Due to data availability, Table 6.10 shows Unicorn which still exists as of 12 September 2019. Exited Unicorns which do not appear in the Global Unicorn Club as of 12 September 2018 are not included in the total number of Unicorns.

Table 6.10 shows that the increase in the number of unicorns remains steady between 2009 and 2013. Unicorns started to proliferate during 2014, where the total count expanded approximately 9 times. The growth rate for the number of unicorns remained high for the following years. While falling short of the all-time record number of unicorns in 2016, a resurgence was seen in 2017 and 2018, with 67 and 123 companies joining the unicorn club respectively. Until 12 September 2019, there were already 92 new members minted. The overall number of unicorns has a dramatic increase due to the

**Table 6.10** Total numbers of unicorn companies (2009–2019) is based on The Global Unicorn Club and The Unicorn Exits Tracker from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. Unicorn exit means a unicorn is taken out of the list. The exit method included public listing, merger & acquisition and corporate majority

<i>Year</i>	<i>Total no. of unicorns (excluding exits)<sup>a</sup></i>	<i>Total no. of unicorns (including exits)</i>	<i>New unicorns minted</i>	<i>Unicorn exits<sup>b</sup></i>
2019 <sup>a</sup>	398	398	92	0
2018	306	343	123	37
2017	183	207	67	24
2016	116	141	29	25
2015	87	107	49	20
2014	38	70	27	32
2013	11	30	3	19
2012	8	24	4	16
2011	4	23	3	19
2010	1	10	1	9
2009	0	3	0	3

<sup>a</sup>as of 12 September 2019

<sup>b</sup>as of 12 September 2018

*Source* The Global Unicorn Club-CB Insights; The Unicorn Exits Tracker-CB Insights

large number of unicorns minted during these years. I should however be kept in mind that the data contained in CB Insight Exit Tracker does not record the date of joining the Unicorn Club for any of the exited unicorns. Therefore, we are not able to find out the year that a startup transformed into a unicorn (i.e. achieve a USD\$1 Billion valuation). We then add back the exited unicorns in each year back to the overall unicorn population to come up with the total number of unicorns including exit. Including exit activity, the total number of unicorns has multiplied substantially by 132 times over the sample period.

Table 6.11 shows the Industry Composition of unicorn Companies based on The Global unicorn Club from CB Insights. The number of unicorns from the top 4 industries (E-Commerce-12.1%, Fintech-11.8%, Internet Software & Services-11.6%, AI-11.1%) accounted for 46.4% of the unicorns. Although there are only 6% of Auto & transportation related unicorns, they are composed of US\$122.7B, or 10% of the total valuation of unicorns (US\$1226.2B), ranking the highest average valuation of US\$5.1B among all industries. The second and third highest average unicorn valuations by industry are hardware (US\$4.4B) and consumer & retail (US\$4.4B) respectively.

Table 6.12 shows the regional distribution of unicorns. The USA and China are the major seedbeds of unicorns, being home to nearly 75% of all unicorns. Although the number of unicorns in the UK is far behind those seen in



**Table 6.11** 2019 industry compositions of global unicorns<sup>a</sup>. Total numbers of unicorn companies is based on The Global Unicorn Club from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The Valuation of each industry is the sum of all unicorn values of that industry. The Average Value of each industry is calculated by the industry unicorn value divided by the number of unicorns in each industry

<i>Industry</i>	<i># of unicorns</i>	<i>%</i>	<i>Valuation (\$B)</i>	<i>Valuation %</i>	<i>Average value (\$B)</i>
E-Commerce	48	12.1%	129.8	10.6%	2.7
Fintech	47	11.8%	146.8	12.0%	3.1
Internet software & services	46	11.6%	81.7	6.7%	1.8
Artificial intelligence	44	11.1%	163.6	13.3%	3.7
Supply chain, logistics, & delivery	28	7.0%	80.0	6.5%	2.9
Health	28	7.0%	71.2	5.8%	2.5
Auto & transportation	24	6.0%	122.7	10.0%	5.1
Mobile & telecommunications	21	5.3%	36.8	3.0%	1.8
Consumer & retail	18	4.5%	78.8	6.4%	4.4
Data management & analytics	16	4.0%	37.4	3.0%	2.3
Hardware	14	3.5%	62.0	5.1%	4.4
Travel	12	3.0%	49.2	4.0%	4.1
Edtech	12	3.0%	20.9	1.7%	1.7
Cybersecurity	11	2.8%	18.0	1.5%	1.6
Other	29	7.3%	127.3	10.4%	4.4
Total	398	100%	1226.2	100%	3.1

<sup>a</sup>as of 12 September 2019

Source The Global Unicorn Club-CB Insights

the USA and China, it still ranks third place among all the countries. The remaining 23 countries come to around 21.4% of the number of unicorns, and are fairly uniformly scattered across different continents. In terms of valuation, unicorns in the USA and China are estimated to worth \$604B and \$362B respectively, making up almost 79% of the US\$1226 total valuation of unicorns. The valuation scale and distribution is roughly proportional to the number of unicorns in each country.

### 6.5.1.2 Unicorn Investors

There are three major types of investors for unicorns. Each has a different risk exposure, investment size, investment timing and investment form. As the regulation and transparency are much lower in the private sector, investing in private companies carries a much higher risk and return than traditional

**Table 6.12** 2019 regional distributions of unicorns<sup>a</sup>. Total numbers of unicorn companies is based on The Global Unicorn Club from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The Valuation of each country is the sum of all unicorn values from that Country

<i>Industry</i>	<i># of unicorns</i>	<i>%</i>	<i>Valuation (\$B)</i>	<i>Valuation %</i>	<i>Average value (\$B)</i>
United States	194	48.7%	603.6	49.2%	3.1
China	99	24.9%	362.2	29.5%	3.7
United Kingdom	20	5.0%	50.6	4.1%	2.5
India	19	4.8%	54.8	4.5%	2.9
Germany	10	2.5%	20.6	1.7%	2.1
South Korea	9	2.3%	29.6	2.4%	3.3
Israel	6	1.5%	7.9	0.6%	1.3
France	5	1.3%	6.0	0.5%	1.2
Brazil	4	1.0%	13.0	1.1%	3.3
Switzerland	4	1.0%	10.0	0.8%	2.5
Indonesia	4	1.0%	20.0	1.6%	5.0
Japan	3	0.8%	4.1	0.3%	1.4
Australia	3	0.8%	4.5	0.4%	1.5
Singapore	2	0.5%	15.6	1.3%	7.8
Hong Kong	2	0.5%	2.0	0.2%	1.0
Others	14	3.5%	21.7	1.8%	1.6
Total	398	100%	1226.2	100%	3.1

<sup>a</sup>as of 12 September 2019

*Source* The Global Unicorn Club-CB Insights

investments like listed stocks or fixed income securities. Table 6.13 shows the characteristics of these three types of unicorn investors. Angel/Seed investors have the highest level of risk because the stage of investment is so early that even no revenue is generated from the target firm. The screening criteria focus on the business prospects rather than the profitability of the company. For this reason, the investment team is composed of mainly entrepreneurs and past company founders who are familiar with the target's business and have faith in the target (or their own vision). To compensate for high risk, the expected return is 100 times the investment.

Venture capitalists invest in the later stage of a startup company. At this stage, the target started to generate revenue but does not yet make profit. The target gradually forms its business model and is expected to grow up very fast. The investment size may be in the US\$10's of millions, and much higher than that of seed/angel investors. The target started to attract the attention of bankers and financial professionals. Making investment solely by evaluating target's growth rate and market share potentially contains high risk, therefore the expected return is still fairly high, and expected to be around 10 times of the investment.

**Table 6.13** Private equity vs venture capital vs angel and seed investors

<i>Description</i>	<i>Angel/seed investor</i>	<i>Venture capital</i>	<i>Private equity</i>
Stage of business	Founding, startup, pre-revenue	Early stage, pre-profitability	Mid to later stage, profitable, cash flow
Size of investment	\$10 k to a few million	A few million to 10's of millions	A few million to billions
Type of investment	Equity, SAFE	Equity, convertible debt	Equity with leverage
Investment team	Entrepreneurs/past founders	Mix of entrepreneurs and bankers/finance professionals	Bankers/finance professionals
Risk level	Very high risk, high chance of losing all money	High risk, moderate chance of losing all money	Moderate risk, low chance of losing all money
Expected return	100x	10x	>15% IRR
Investment screening	Founders, Total available market, market share potential, no. of users	Founders, market share potential, revenue, margin growths, growth rate	EBITDA, cash flow, IRR

*Source* Private Equity vs Venture Capital, Angel/Seed Investors—Corporate Finance Institute

Private equity funds carry moderate risk comparing against angel or venture capital. The target company reaches a mid or later stage of development, and is often close to exit. The business model of the target is quite mature such that the business size can be expanded by self-raising capital. At this stage, the investment can be ranged from a few millions to even billions of dollars. While the unicorn is often profitable, EBITDA (earnings before interest, tax, depreciation and amortization), cash flow and IRR (internal rate of return) can be reliably used for investment screening. Considering the lower risk level compared with angel- or venture-capital stages, the expected IRR for PE funds can be as little as 15%. Table 6.14 shows the top 10 unicorn Investors based on The Global unicorn Club from CB Insights. Sequoia Capital which captured 39 unicorns has the most unicorns in its portfolio. The second and third most unicorn captured investors are SoftBank (21) and Tencent (15) respectively.

### 6.5.1.3 *The Existing Strategies of Unicorns*

In general, the objective of private firms is to reach the IPO stage to raise capital for further expansion, and to provide an exit for tie-up capital for the founding shareholders and early stage institutional investors. The invention of unicorns has changed dramatically the concept of when a company should aim to launch via an IPO, based on reaching the necessary milestone and qualifications of going public as a unicorn. Moreover experiences from some noteworthy unicorns including Facebook and Didi Chuxing, are causing unicorns also to consider delaying their IPO as long as possible since they

**Table 6.14** 2019 top unicorn investors in the world<sup>a</sup>. Top unicorn investors in the world is based on The Global Unicorn Club from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The number of unicorns in the portfolio is consolidated from the select investors

<i>Investors</i>	<i># of Unicorns in Portfolio</i>	<i>Investor 'group' includes:</i>
Sequoia Capital	39	Sequoia Capital, Sequoia Capital China, & Sequoia Capital India
Softbank Group	21	Softbank Group included Softbank Corp., and Softbank Group
Tencent	15	Tencent included Tencent and Tencent Holdings.
New Enterprise Associates	14	
Tiger Global	14	Tiger Global included Tiger Global and Tiger Global Management.
Accel	13	Accel included Accel, Accel Partners, and Accel India
Andreessen Horowitz	13	
Google	11	Google included Google, Google Capital, and Google Venture
Alibaba Group	10	Alibaba Group, Alibaba Entrepreneurs Fund & Alibaba Pictures Group
Qiming Venture Partners	10	

<sup>a</sup>as of 26 July 2019

*Source* The Global Unicorn Club-CB Insights

believe they can receive sufficient private equity funding without rushing to IPO. In this case, unicorns have pseudo market value based on the private equity capital injection formula.

Currently the market for unicorns, especially in China, appears to have reached its 'glory days' and is now going through a consolidation phase. Nevertheless, recent unicorns that have gone through some exit channels such as IPOs and acquisitions have demonstrated a respectable level of success. Therefore, we examine the exit pattern of unicorns as a measurement of success for private tech firms. The exit activity data were collected from CB Insight-The Unicorn Exits Tracker, which lists six methods to exit.

1. Acquired: The unicorn is acquired by another company.
2. Corporate Majority: A listed company acquired the majority equity stake of the unicorn.

3. Financial Acquisition: Private equities/investors acquired the majority equity stake of the unicorn.
4. IPO: Initial public offering. The unicorn goes public.
5. Merger: The acquired unicorn ceases to exist and becomes part of the acquiring company.
6. Reverse-Merger: Back-Door IPO. The unicorn acquired a public company.

To simplify the exit methods, we combine the six methods into public listing (includes IPO and Reverse-Merger) and M&As (included Acquired, Corporate Majority, Financial Acquisition, and Merger).

Table 6.15 shows the Industry Composition and the method of unicorn exit. Among 204 unicorns exits, 124 filed for public listing, making this the most common exit channel for unicorns. The other method is through merger and acquisition, composing 39% of all the exits as of the first quarter of 2019. 100 unicorn exits were from Internet Software & Services industry which

**Table 6.15** Industry composition of global unicorn exits (2009–2018)<sup>a</sup>. The unicorn exit methods are based on the Unicorn Exits Tracker from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The exit methods include a public listing (Initial Public Offering or Back Door IPO) and M&A (Merger, Acquired, Reverse Merger, Corporate Majority, and Acquisition Financing). The exit value of each industry is the sum of all unicorn exit values of that industry with the same exit method. The average exit value of each industry is calculated by the industry unicorn exit value divided by the number of unicorns exited in each industry

<i>Industry</i>	<i>Exit method</i>	<i># of unicorns</i>	<i>%</i>	<i>Exit value (\$B)</i>	<i>Average exit value (\$B)</i>
Internet Software & Services	M&A	32	16%	89.8	2.8
	Public Listing	68	33%	564.5	8.3
Media, Mobile & Telecommunications	M&A	12	6%	42.4	3.5
	Public Listing	12	6%	59.6	5.0
Healthcare	M&A	23	11%	54.9	2.4
	Public Listing	11	5%	15.1	1.4
Others	M&A	9	4%	14.8	1.6
	Public Listing	25	12%	124.0	5.0
Hardware	M&A	4	2%	4.9	1.2
	Public Listing	8	4%	15.2	1.9
Total	M&A	80	39%	206.8	2.6
	Public Listing	124	61%	778.4	6.3

<sup>a</sup>as of 12 September 2019

Source The Unicorn Exits Tracker-CB Insights

accounts for almost half of the total number of unicorn exits. Healthcare and media, and the mobile & telecommunications industries are the second and third most common industries for an exiting unicorn with 34 and 24 unicorns exited respectively.

Table 6.15 also shows the exit value of unicorn by industry. Public listing (exit value: \$778B) had a higher exit value than M&A (exit value: \$207B). The exit value of unicorns from the Internet Software & Services industry accounted for two-third of the total exit value. Although the healthcare industry had more unicorns exit, its exit value (\$70B) was less than for media, mobile & telecommunication (exit Value: \$102B). Healthcare is the only industry where M&A had a higher popularity (frequency) and average exit value than public listing as the exit method.

Table 6.16 shows that most of the exits occurred in unicorns headquartered in the USA and China, which could be due to their leading unicorn count. The USA had the largest number of unicorn exits (134) and highest exit value (\$451.7B). While Chinese unicorn exits accounted for 14.3% of the

**Table 6.16** Regional distributions of unicorn exit (2009–2018)<sup>a</sup>. The unicorn exit methods are based on the Unicorn Exits Tracker from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The Exit methods include a public listing (Initial Public Offering or Back Door IPO) and M&A (Merger, Acquired, Reverse Merger, Corporate Majority, and Acquisition Financing). The Exit Value of each country is the sum of all unicorn exit values of that country. The Average Exit Value of each country is calculated by the country unicorn exit value divided by the number of unicorns exited in each country

<i>Industry</i>	<i># of Unicorns</i>	<i>%</i>	<i>Exit value (\$B)</i>	<i>Exit value (%)</i>	<i>Average exit value (\$B)</i>
United States	134	65.7%	451.7	45.8%	3.4
China	30	14.7%	365.8	37.1%	12.2
United Kingdom	7	3.4%	14.9	1.5%	2.1
Germany	5	2.5%	23.8	2.4%	4.8
Netherlands	4	2.0%	18.3	1.9%	4.6
Canada	2	1.0%	2.4	0.2%	1.2
Finland	2	1.0%	4.1	0.4%	2.1
Russian Federation	2	1.0%	4.0	0.4%	2.0
Singapore	2	1.0%	6.3	0.6%	3.1
Sweden	2	1.0%	31.7	3.2%	15.9
Japan	2	1.0%	13.7	1.4%	6.9
Others	12	5.9%	48.6	4.9%	4.0
Total	204	100%	985.2	100%	4.8

<sup>a</sup>as of 12 September 2019

Source The Unicorn Exits Tracker-CB Insights

total unicorn exit, the exit value of China unicorns accounted for 37% of the total.

## 6.5.2 *Unicorns in China*

A new unicorn company is born in China every three days, and most of these companies are in the internet industry, and based in Beijing (Global Times, 2018). In this section, we will explore the China dimension of unicorns more closely and compare China with the USA and see how their differences influence unicorns. Then, we will access the unique challenges faced by unicorns in China.

### 6.5.2.1 *Understanding Unicorns in China Through Data*

Table 6.17 shows the population of unicorns in China by industry based on information from the Hurun Greater China Unicorn Index. It also shows the industry composition of unicorns in China. Internet Service is holding the greatest number of unicorns among all sectors, with these unicorns making up 20.8% of the total number and 17.2% of the total valuation. The valuation of unicorns in Internet Finance is making up 31.7% of the total value while the number of unicorns reflects only 9.9% of the total unicorn seats, thus resulting in a highest average valuation of RMB82.1 billion. The reason behind internet finance's high average valuation is Ant Finance which had the highest valuation of RMB 1trillion (Second place Bytedance was valued RMB 500billion). The News & entertainment sector is having the third highest total valuation with an average valuation at RMB778 billion and RMB48.6 billion respectively. There are 10.9% of unicorns focusing on e-Commerce, however, they only make up 5.2% of the total valuation, hence giving rise to a relatively low average valuation of RMB12.1 billion. With only two companies, the robotics industry has the second highest average valuation of RMB65 billion.

Table 6.18 shows the regional distribution of unicorns in China. Beijing is the major seedbed of unicorns in China, with 82 unicorns making up 40.6% of the total count, followed by Shanghai and Hangzhou, with 45 and 19 unicorns respectively. Although 22.3% of unicorns were found in Shanghai, their valuation only makes up 16.6% of the total amount. With RMB19.1 billion average valuation, Hangzhou ranks the highest among all regions in China and the reason behind is again the highest valuation of Ant Financial.

### 6.5.2.2 *Comparing Unicorns in China and the USA*

Table 6.19 confirms that most unicorns exited by public listing (China 77%, US 55%) and with a higher average exit value than M&A (China 4.3 x, US 1.9x). Unicorns exiting by M&A are more common in the USA (China 23%, US 45%). Software & Technology Services is a popular industry for unicorns in both USA & China (30% & 27%) with similar exit values in both countries. Healthcare is a common industry for unicorn exit in the USA (24 exits), while China only had 1 exit. China unicorns had higher average exit value than the

**Table 6.17** 2019 industry compositions of unicorn companies in China<sup>a</sup>. Total numbers of unicorn companies in China is based on Hurun Greater China Unicorn Index 2019 Q1 & Hurun China Future Unicorns 2019 Q1 in association with Shimao Qianhai Center. A unicorn company is a private company with a valuation of over USD1 billion (~RMB7 billion). The Valuation of each industry is the sum of all unicorn values of that industry. The Average Value of each industry is calculated by the industry unicorn value divided by the number of unicorns in each industry

<i>Industry</i>	<i># of unicorns</i>	<i>%</i>	<i>Valuation (\$B)</i>	<i>Valuation (%)</i>	<i>Average value (\$B)</i>
Internet service	42	20.8%	888	17.2%	21.1
eCommerce	22	10.9%	267	5.2%	12.1
Internet finance	20	9.9%	1642	31.7%	82.1
News & entertainment	16	7.9%	778	15.0%	48.6
Healthcare	16	7.9%	244	4.7%	15.3
Logistics	15	7.4%	343	6.6%	22.9
AI	15	7.4%	189	3.7%	12.6
Transportation	12	5.9%	184	3.6%	15.3
Big data	11	5.4%	83	1.6%	7.5
Education	10	5.0%	112	2.2%	11.2
Real estate service	6	3.0%	104	2.0%	17.3
Hardware	5	2.5%	72	1.4%	14.4
New retail	5	2.5%	51	1.0%	10.2
Blockchain	3	1.5%	72	1.4%	24.0
Robotics	2	1.0%	130	2.5%	65.0
Game	1	0.5%	10	0.2%	10.0
New Energy	1	0.5%	7	0.1%	7.0
Total	202	100%	5176	100%	25.6

<sup>a</sup>as of 7 May 2019

*Source* Hurun Greater China Unicorn Index 2019 Q1 & Hurun China Future Unicorns 2019 Q1

US unicorns in both IPO and M&A exit. China unicorns in certain industries even had 10 times the average exit value than the US unicorns, e.g. Consumer (Public Listing: China US\$30.9 billion, US US\$1.7 billion). Table 6.20 shows the distribution of exited unicorns by industry and revenue source. Only 20% of exited Chinese unicorns had foreign revenue sources, comparing to 80% of such unicorns in the USA. The Software & Technology Services; Hardware and Communications are among those industries with heavy foreign revenue sources.

We argue that the substantially lower percentage of foreign income for Chinese unicorns relative to that of the USA is due to their limited abilities to market their products/technology overseas. We believe that such a limitation is mainly a result of the business model of Chinese unicorns, which heavily



**Table 6.18** 2019 Regional distribution of Unicorn Companies in China<sup>a</sup>. Total Numbers of Unicorn Companies in China is based on Hurun Greater China Unicorn Index 2019 Q1 & Hurun China Future Unicorns 2019 Q1 in association with Shimao Qianhai Center. A unicorn company is a private company with a valuation of over USD1 billion (~ RMB7 billion). The Valuation of each industry is the sum of all unicorn values of that region. The Average Value of each industry is calculated by the regional unicorn value divided by the number of unicorns in each regional

<i>Industry</i>	<i># of Unicorns</i>	<i>%</i>	<i>Valuation (\$B)</i>	<i>Valuation (%)</i>	<i>Average value (\$B)</i>
Beijing	82	40.6%	2051	39.6%	25.0
Shanghai	45	22.3%	858	16.6%	19.1
Hangzhou	19	9.4%	1288	24.9%	67.8
Shenzhen	16	7.9%	429	8.3%	26.8
Nanjing	11	5.4%	183	3.5%	16.6
Guangzhou	8	4.0%	100	1.9%	12.5
Chengdu	4	2.0%	31	0.6%	7.8
Hong Kong	4	2.0%	28	0.5%	7.0
Tianjin	3	1.5%	110	2.1%	36.7
Others	10	5.0%	98	1.9%	9.8
Total	202	100%	5176	100%	25.6

<sup>a</sup>as of 7 May 2019

*Source* Hurun Greater China Unicorn Index 2019 Q1 & Hurun China Future Unicorns 2019 Q1

revolves around the consumer behaviour and Chinese lifestyle, making it difficult to open up overseas markets. On the other hand, unicorns in the US focus on general technology which can be used globally. It is questionable whether Chinese unicorns can adapt their business models to capture overseas market interest/activity in the near future. Such an observation leads to the conclusion that Chinese unicorns are grown through a business model focusing on current local consumer behaviour and lifestyle activities based on culture preferences. It will be very difficult for these unicorns to be sustainable if these local preferences change—or equivalently if they were tested in different regions where consumers have different preferences. Chinese unicorns need to focus more on general technology that can be scaled and adopted by international clients. Rapid expansion targeted to local market conditions is a double-edged sword for Chinese unicorns.

### 6.5.2.3 *Fintech-Related Unicorns*

In this final subsection, we explore the role of some additional focused summaries of fintech-related unicorns in the whole unicorn population. Due to the scarcity of fintech unicorns as defined by CB Insights, here we expand the fintech subsample by including unicorns that produce goods and services that can be used by financial institutions such as payment gateway, consumer

**Table 6.19** Exited unicorns distribution by exit method and industry (2009–2018)<sup>a</sup>. The unicorn exit methods are based on the Unicorn Exits Tracker from CB Insights. The Exit methods include a public listing (Initial Public Offering or Back Door IPO) and M&A (Merger, Acquired, Reverse Merger, Corporate Majority, and Acquisition Financing). The Exit Value of each country is the sum of all unicorn exit values of that country. The Average Exit Value of each country is calculated by the country unicorn exit value divided by the number of unicorns exited in each country. The Industry classification is according to Bloomberg Industry Classification System<sup>b</sup>

<i>Country</i>	<i>Industry</i>	<i>Exit Method</i>	<i># of Unicorns</i>	<i>%</i>	<i>Exit Value (\$B)</i>	<i>Average exit value (\$B)</i>
China	Consumer	M&A	2	7%	11.2	5.6
		Public Listing	8	27%	247.0	30.9
	Software & Technology Services	M&A	3	10%	6.6	2.2
		Public Listing	5	17%	11.3	2.3
	Hardware	M&A	0	0%	0.0	NA
		Public Listing	2	7%	58.9	29.4
	Health Care	M&A	0	0%	0.0	NA
		Public Listing	1	3%	1.2	1.2
	Communications	M&A	1	3%	3.6	3.6
		Public Listing	3	10%	7.2	2.4
	Financials	M&A	0	0%	0.0	NA
		Public Listing	3	10%	13.8	4.6
	Others	M&A	1	3%	2.7	2.7
		Public Listing	1	3%	2.4	2.4
	<b>Total</b>	<b>M&amp;A</b>	<b>7</b>	<b>23%</b>	<b>24.1</b>	<b>3.4</b>
	<b>Public Listing</b>	<b>23</b>	<b>77%</b>	<b>341.7</b>	<b>14.9</b>	
US	Consumer	M&A	9	7%	15.9	1.8
		Public Listing	11	8%	18.4	1.7
	Software & Technology Services	M&A	18	13%	53.8	3.0
		Public Listing	23	17%	65.0	2.8

(continued)

**Table 6.19** (continued)

<i>Country</i>	<i>Industry</i>	<i>Exit Method</i>	<i># of Unicorns</i>	<i>%</i>	<i>Exit Value (\$B)</i>	<i>Average exit value (\$B)</i>
	Hardware	M&A	4	3%	7.0	1.7
		Public Listing	11	8%	23.2	2.1
	Health Care	M&A	17	13%	41.3	2.4
		Public Listing	7	5%	9.8	1.4
	Communications	M&A	10	7%	15.5	1.6
		Public Listing	14	10%	177.7	12.7
	Financials	M&A	0	0%	0.0	NA
		Public Listing	6	4%	17.0	2.8
	Others	M&A	2	1%	3.8	1.9
		Public Listing	2	1%	3.2	1.6
	<b>Total</b>	<b>M&amp;A</b>	<b>60</b>	<b>45%</b>	<b>137.3</b>	<b>2.3</b>
		<b>Public Listing</b>	<b>74</b>	<b>55%</b>	<b>314.4</b>	<b>4.2</b>

<sup>a</sup>as of 12 September 2018

<sup>b</sup>Technology is further divided into Software & Technology Services and Hardware; Others included Industrials, Energy and Utilities

*Source* The Unicorn Exits Tracker- CB Insights, Bloomberg

finance and investment products. Moreover, we combine the unicorn populations from CB insight and Hurun. In doing so, we notice that a few significant unicorns in China (e.g. Ant Financial, Lufax) are excluded in CB insight's unicorn list. Table 6.21 shows the combined population of unicorns, 8.9% of Unicorns in China were Fintech related (21/236), while 12.9% of Unicorns in the USA were Fintech related (25/194). In terms of valuation Fintech-related unicorns have a higher average valuation than the non-Fintech-related unicorns. The valuation in China is much higher because of the existence of a few huge unicorns such as Ant Financial and Lufax.

Regarding the success of fintech unicorns in the exit process, Table 6.19 (presented earlier in this chapter) showed that China had 3—comparing against 6 in the USA—fintech unicorns that successfully exited over the period 2009–2018. All of these firms exited through public listing (IPO). Complementing this, Table 6.20 (also presented earlier in this chapter) additionally shows that none of the China unicorns recorded foreign revenue while 3 of US unicorn recorded foreign. (Unicorns with foreign revenue data in Bloomberg, China-2/3, US-8/9). Together, these facts point towards the conclusion that

**Table 6.20** Exited unicorns distribution by industry and revenue sources (2009–2018)<sup>a</sup>. The unicorn exit methods are based on the Unicorn Exits Tracker from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The Industry classification is according to Bloomberg Industry Classification System<sup>b</sup>. Company with foreign revenue means the % of revenue from foreign source is larger than 0 according to Bloomberg<sup>c</sup>

<i>Country</i>	<i>Industry</i>	<i>Exited unicorn without foreign revenue</i>	<i>Exited Unicorn with foreign revenue</i>
China	Consumer	4	1
	Software & Technology Services	2	1
	Hardware	1	1
	Health Care	0	0
	Communications	2	0
	Financials	2	0
	Others	1	0
	<b>Total</b>	<b>12</b>	<b>3</b>
	US	Consumer	4
Software & Technology Services		2	17
Hardware		0	9
Health Care		1	0
Communications		0	6
Financials		2	3
Others		1	0
<b>Total</b>		<b>10</b>	<b>41</b>

<sup>a</sup>as of 12 September 2018

<sup>b</sup>Technology is further divided into Software & Technology Services and Hardware; Others included Industrials, Energy and Utilities

<sup>c</sup>Only 66 Exited China & US Unicorns (Total:164) have the data of % of revenue from foreign source in Bloomberg

*Source* The Unicorn Exits Tracker- CB Insights, Bloomberg

fintech startups, although capturing an impressive share of the startup and unicorn success and valuation, are nonetheless not a dominant phenomenon. The implications of this, conditional on the expected growth in demand for advanced fintech solutions, is that there remains considerable room for growth in the market to be fostered.

To offer further evidence to this comparison between fintech unicorns in China in the USA, and additional understanding on the global distribution of fintech unicorns, Table 6.22 closes up the analysis with a reflection on the number of fintech unicorns by country for 2019. From this we can see that in 2019, China ranked fourth in terms of the number of unicorns, and even lower in terms of net value with countries including the UK, India, Sweden, Brazil and Germany all having a higher net value for their fintech unicorns in

**Table 6.21** 2019 fintech-related unicorns valuation China vs USA. Total numbers of unicorn companies is based on The Global Unicorn Club from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The Valuation of each country is the sum of all unicorn values of that country. Fintech related industry included unicorns from Fintech in CB insight

<i>Industry</i>	<i>Country</i>	<i>No. of unicorns (CB insight)</i>	<i>No. of unicorns in Hurun</i>	<i>Total no. of unicorns</i>	<i>Valuation in CB (\$B)</i>	<i>Valuation in Hurun (\$B)</i>	<i>Total valuation (\$B)</i>	<i>Average value (\$B)</i>
Fintech Related	China	2	19	21	2.9	240	243.3	11.59
	US	25	–	25	85.1	–	85.1	3.40
Non-Fintech	China	97	118	215	359.3	320	679.0	3.16
	US	169	–	169	518.5	–	518.5	3.07
Total	China	99	137	236	362.2	560	922.3	3.91
	US	194	–	194	603.6	–	603.6	3.11

<sup>a</sup>as of 12 September 2019

<sup>b</sup>as of Q1 2019, USD/CNY: 6.8

*Source* The Global Unicorn Club-CB Insights; Hurun Greater China Unicorn Index 2019 Q1 & Hurun China Future Unicorns 2019 Q1

**Table 6.22** 2019 fintech-related unicorns valuation globally<sup>a</sup>

<i>Country</i>	<i>No. of unicorns</i>	<i>Valuation (\$B)</i>	<i>Average value(\$B)</i>
United States	25	85.1	3.4
United Kingdom	9	20.9	2.3
India	3	12.8	4.3
China	2	2.9	1.4
Switzerland	2	2.0	1.0
Japan	1	1.0	1.0
Australia	1	1.0	1.0
Germany	1	3.5	3.5
South Korea	1	2.2	2.2
Brazil	1	10.0	10.0
Sweden	1	5.5	5.5
Total	47	146.8	3.1

<sup>a</sup>as of 12 September 2019

*Note* Total Numbers of Unicorn Companies is based on The Global Unicorn Club from CB Insights. A unicorn startup or unicorn company is a private company with a valuation of over \$1 billion. The Valuation of each country is the sum of all unicorn values of that country. Fintech-related industry included unicorns from Fintech in CB insight

*Source* The Global Unicorn Club- CB Insights

2019—though it should be noted that several of these countries have only one fintech unicorn. In total there are 47 fintech unicorns, taking a total valuation of US\$146.8 billion and an average valuation of US\$3.1 billion. In summary the global market for fintech remains populated with a good number of high value unicorns, with investment opportunities spread throughout the world. The markets in the UK and India are performing well in 2019, and India is potentially a high growth area given the population. Nonetheless, the pattern strongly points towards the USA as the dominant home of the fintech unicorn in 2019.

## 6.6 CONCLUSIONS: FUTURE TRENDS AND ROLES FOR STARTUPS, INCUMBENTS AND REGULATORS

In this closing section of the chapter we reflect on the core lessons that have emerged from our analyses contained within. In doing so we are able to develop some thoughts and insights around issues that need to be addressed, primarily by incumbent financial services firms and market regulators, in response to the increasingly variable business environment that fintech startups and fintech unicorns have spawned within the financial services industry.

### 6.6.1 *Fintech Is a Disruptor for Financial Services*

In drawing together conclusions, we must first recognize that fintech has ‘arrived’, and moreover that it has established an irrefutable position as a material disruptor for the financial services sector. Recent years have seen rapid growth in underlying technologies but also in the comfort among potential fintech users to embrace novel ways of blending technology with finance. The roles of lifestyle activity choices and culture have emerged as one of the determinants of successful fintech and helps to isolate and distil the differences between key regions such as China and the USA.

The pace and scale of success among fintech startups are both on a clear and strong upward trend, and create a need to reflect on the regulatory environment, especially to consider whether it is well poised to support the necessary and key roles that different market players might play going forward. Conditional on the stylized fact that startups are being well catered for, we narrow discussion on the issues facing regulators, and the consequences of the various lessons learned to incumbent firms.

### 6.6.2 *Procurement Processes Slow Fintech Adoption Within Financial Institutions*

For incumbent and traditional financial services firms, there is a general sense that internal procurement processes are relatively slow, lasting for four to six months or longer.<sup>18</sup> Mismatch of expectation or misalignment of knowledge have been argued to constitute major factors to slow adoption of fintech within

existing firms. Startups which present new fintech capabilities are not necessarily familiar, or perhaps more appropriately not bound by ‘traditional’ (or ‘conventional’) internal control structures. Accordingly they are nimbler in their approach towards business processes and well positioned to cut through the bureaucratic system and to obtain buy-in from multiple stakeholders in faster, more efficient and implicitly more cost-effective ways.

Business champions within incumbent financial institutions, i.e. those individuals tasked with identifying and introducing strategically important market innovations into the firm, may also lack the time and knowledge to assist the internal technology to develop. Moreover, as with any extreme and novel innovation, it can be a challenge to convince senior management of the potential benefits which new technology can bring to the organization. Further to this, it is clear that the regulatory environment for fintech is in a relatively infant stage, and that a lot of regulation complexity needs to be addressed, creating an air of cost/risk uncertainty and serving as an additional hurdle to adoption by incumbent firms. It is easy to turn down new approaches when there is doubt that they may draw regulatory scrutiny or potential fines due to conduct violations.

### *6.6.3 Fintech’s Disruption Is Confined (Unique) to Region or Countries*

Through the discussions within this chapter we have learned some important lessons concerning the role that region-specific characteristics play. The markets for USA and China have markedly different characteristics, and potential users of fintech in these regions differ according to their attitudes, preferences and cultural uniqueness of potential users of fintech in these different regions. This in turn influences the range of possible/common financing and ownership structures that can be used by fintech firms in different regions.

The challenge this introduces is that experiences gained by fintech firms operating in one region may not be transferable to other geographic contexts quickly or cheaply, if at all. Product solutions will need to be altered to overcome language barriers, but also to accommodate different users’ preferences that might alter the human–technology interface requirements. Having said this, there have been some notable exceptions, with some Chinese fintech company’s enjoying a late-comer advantage. A particularly prominent feature of the Chinese market context is that fintech development has been enjoying rapid growth in the last 10 years partly due to a relatively less developed regulatory environment. In this regard, China has been able to witness the development of international fintech-related industries and adapt similar fintech solutions tailored to the Chinese context. For example, electronic payment, such as Alipay and WeChat Pay, has practically replaced cash-based transaction in China—but emerged later than some of the earlier online payment platforms in the USA, such as PayPal. Recently, peer-to-peer lending

in China has provided liquidity to a credit tight market in order to fuel China's growth.

A salient component/determinant of fintech regionalization is that regulatory complexity within countries and regions is confining the development of fintech companies locally, rather than globally. This is not surprising, since regulation inevitably needs to be tailored to local market characteristics and aligned with region-specific policy and legal frameworks. Nonetheless there are prospects for fintech to provide lower friction international financing solutions and would seem to imply wisdom in re-questioning the capacity of global financial services regulations to embrace advanced and innovative fintech solutions in a safe and fair manner for new firms, incumbents and their customers.

#### 6.6.4 *Regulation Creates Frictions for Financial Institution's Fintech Adoption*

As with any industry, old or new, regulation imposes constraints and boundaries on market activity. Perhaps the most important in present times is that data collection and storage. There remain important and unanswered questions regarding the permissible depth of data collection and storage that should be allowed. How much data is it necessary or fair to collect? Such questions fall into a challenging grey area where ethics begin to become a question. For example, the use of facial recognition in shopping malls to build customer movement profiles from which footfall and potential revenue projects can be developed would be a sound use of AI, yet in some countries there are lively debates around the use of facial recognition in public spaces that have not yet reached a consensus.

We can think of other related debates also, going more towards the security of data storage. Cloud computing is becoming increasingly popular, but how wise is it to voluminous quantities of personal and private identifying information (PII) on public clouds. The cloud opens up new questions around how to protect user data, since it is always online, and therefore increasingly easier for hackers to find. Traditional physical access is no longer applicable. Moreover, from a regulators perspective there are new questions emerging around how to properly manage (or assign accountability for) fiduciary responsibility, since cloud computing infrastructure is largely not owned by financial services companies. In cases where loss of data, especially personal identifying data, gives rise to pecuniary losses, who is at fault? The distribution of ownership for liability becomes murky compared to the pre-fintech/pre-cloud era of financial services and could potentially require extensive and costly audit and arbitration to resolve.

The traditional vertical integration of technology for financial service providers will gradually be replaced by a hybrid computing environment. Data privacy protection will require new ways of deploying and storing data. While regulatory issues are known and being addressed, they remain to be addressed



in their entirety, and therefore may dissuade many incumbent financial service firms from embracing and deploying fintech solutions ‘en masse’.

### *6.6.5 Regulation Creates Opportunities for Fintech Development*

When a cup is filled halfway, one may see it as half full, others may see it as half empty. Despite regulation creating frictions in fintech development in some areas, it also creates opportunities in other areas. For example, initiatives from within the European Union such as the Payment Service Directive (PSD2), General Data Protection Regulation (GDPR), Fundamental Review of Trading Books (FRTB) and Central Securities Depositories Regulation (CSDR) are expected to create new opportunities for fintech companies in delivering compliance solution for the new regulations. The rising complexity, risk and cost of compliance may not be simply fulfilled easily by adding manpower. Hence, technology evolutions such as artificial intelligence, robotic process automation, and blockchain may create values.

### *6.6.6 Fintech Is an Enabler, not a Stand-Alone Business*

Fintech unicorns epitomize the disruptive potential of fintech as a whole towards the financial services sector and is generating huge uncertainty and risk to traditional financial services providers. However, an alternative lens on fintech is that it is not a stand-alone disruptor in its strictest sense, if at all. Rather, modern concepts of fintech can in many ways be thought of as advanced refinements on traditional financial services processes. There are a multitude of factors coalescing at around the same time, which include technological maturity of smart/mobile devices, enhancements in computer power and importantly data storage, development of mainstream big-data analytical capabilities and the introduction of increasingly secure electronic transaction tools such as blockchains. The value of technology is derived by proper application in solving real problems which will generate positive economic value. Artificial intelligence, blockchain, cloud computing and big data are technologies. They present huge opportunities in changing how financial services can be delivered. Used correctly, fintech can significantly optimize the cost performance of specific tasks with incumbent firms, without needing to alter the underlying product or service being offered to customers.

An exciting prospect is that fintech unlocks lower cost advanced financial services solutions. The potential value of this is not to be understated, since advanced banking, investment opportunities, life-long wealth planning and other financial services have often been confined to preferred banking customers with large enough savings to justify the expense to a bank for providing bespoke financial advice. Through automation, AI and fintech can vastly reduce the costs of providing a version of such services, making them accessible to a considerably larger fraction of the population. The subsequent

improvements in financial literacy and economic welfare which may ensue are an exciting prospect.

There are of course concerns that financial specialists have, e.g. financial analysts, concerning the potential role of fintech to provide automated/programmable analyst solutions, and these are legitimate. There will need to be a re-positioning of staff over time, with some roles become more machine-based, yet there will always be a human interface component to financial services provision. In summary, fintech will undoubtedly change the face of financial services, and the balance of personnel required in different service areas, but it cannot replace the functions of incumbent financial services providers. This is a positive closing note—it also means there is room for the incumbents in a stabilized market where fintech is pervasive.

## NOTES

1. Equifax data breach affected over 140 million people in 2017.
2. PPDai's 1H2017 operational metrics disclosed from S1-A filing (November 2017).
3. Uber has over 91 million monthly active platform consumers in 2018. Meituan has over 340 million annual transaction users in 2018. Data extracted from their respective IPO Prospectus. Meituan went public in 2018 with a pre-IPO valuation of \$52 billion; and Uber went public in 2019 with a pre-IPO valuation of \$82 billion.
4. [https://en.wikipedia.org/wiki/Mobile\\_phone](https://en.wikipedia.org/wiki/Mobile_phone).
5. <https://pages.experts-exchange.com/processing-power-compared>.
6. IDC Cloud Computing Survey 2018.
7. CB Insights, Global Fintech Report Q2 2019.
8. Jeffery Dean and Sanjay Ghemawat, "MapReduce: Simplified Data Processing on Large Clusters".
9. <https://www.businessofapps.com/data/youtube-statistics/> (500 hours of videos uploaded per minutes as of August 8, 2019).
10. IDC and Seagate, The Digitalization of the World from Edge to Core (November 2018), p. 13.
11. <https://techjury.net/stats-about/big-data-statistics/>.
12. <http://www.pingan.cn/en/common/news/article/1504687162470.shtml>.
13. <https://www.newscientist.com/article/2205779-creating-an-ai-can-be-five-times-worse-for-the-planet-than-a-car/>.
14.  $50\% * 80 \times 10^{18}$  hashes/  $20 \times 10^6$  hashes per second/ (10 minutes \* 60 seconds per minute). Bitcoin is designed to generate one block in approximately 10 minutes.
15. The digital wallet helps to manage private key for the user. Technically, user's balance is not stored in the wallet.
16. Statista, <https://www.statista.com/statistics/595182/worldwide-security-as-a-service-market-size/>.
17. We thank Ken Lam in conducting the data collection and drafting some of the discussion and analysis for this section.
18. Survey conducted by Accenture's Fintech Innovation lab in June 2018.

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# Fintech, Bigtech and Banks in India and Africa

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## 7.1 INTRODUCTION

The development of the fintech ecosystem has affected all economies in the world. This disruption has affected the leadership of the traditional banks as incumbents in the benefits of bigtech and niche-start-ups. If the initial take off took place in US, the move quickly spread to Europe, Japan and China (Skan et al. 2016). Nevertheless, this chapter will not deal with well-established fintech ecosystems (FE) but on the rising FE based in Africa and India.

Africa and India are well known for sharing the same challenges for their similar low average income and lack of financial inclusiveness (Beck et al. 2015; Demirgüç-Kunt et al. 2018).

Now, more interestingly, apart from their initial late maturation of their fintech ecosystem (FE), it has to be noted that these two FEs are the ones registering the higher growth in the last years at a worldwide scale (CB Insights 2020). Moreover, India and Africa share some relevant development in terms of digital payments, personal finance, alternative lending and financing (Statista 2020).

To understand the current untapped potential of fintech in Africa and in India, it is key to shed light to the previous banking context of these economies. The aim of this paper will be to show that external factors such as

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the Enron crisis in 2001, the subprime crisis and the threat of the expansion of foreign companies locally paved the way to a set of decisions in traditional retail banks be they in Africa and India that explain the high dynamism of both fintech ecosystems.

More precisely, four main insights will be developed:

1. Globally all entities did move toward Corporate Social Responsibility (CSR, further) and sustainability since 2001. Nevertheless the focus became a strategic axis for Indian banks to keep control on their domestic territory through microfinance and self-help groups (SHGs) as the threat concerning the entry of foreign banks appears. To manage this capillarity in rural areas, strong investments in IT were required.
2. In the case of African institutions, the focus on CSR from the inclusive growth did not materialize as fast as in India. On the contrary, the competitor landscape changed drastically with the leave of French and English banks prioritizing their development in Asia whereas Chinese banks did expand into the continent. Priority to external growth and the replication of the business model was given. To manage this expansion, strong investments in Mergers & Acquisitions (M&A) were required.
3. Further to the subprime crisis, the race to digitization and big data led to many innovations and open banking that favored bigtech and telcos on the first hand and innovation based on low fixed costs and therefore start-ups specialized in small vertical silos on the other hand. This dual movement at the global scale has provoked a huge disruption in the financial sector. Regional fintechs, be they in Africa and in India, tried to take advantage of these trends to get rid of the leadership of current incumbents.
4. The role of the public sector will be highlighted as well to understand the differences between the makings of these two financial ecosystems. Many initiatives took place in India whereas the role of the State was less globally less obvious despite outstanding exceptions.

To proceed, a set of definitions will be provided first as well as the magnitudes concerning the data of both financial ecosystems. Second, the insights concerning the reason why incumbent position deteriorated will be explained first through the cost of IT in India to ensure the capillarity and the cost of M&A in Africa to take advantage of the new competitive landscape. Third, the focus will be set on the new role of big tech and start-ups in the African and Indian FEs. Fourth, a brief focus on the role of the public sector will be endeavored. A synthesis will be then provided to illustrate the different FEs in Africa and India.

## 7.2 DEFINITIONS AND MAGNITUDES OF THE FINTECH ECOSYSTEMS IN AFRICA AND INDIA IN COMPARISON WITH THE GLOBAL FINTECH ECOSYSTEM

In this paper, the definition that will be used for fintech is “the new technology and innovation that aims to compete with traditional financial methods in the delivery of financial services. (...) Financial technology companies consist of both start-ups and established financial and technology companies trying to replace or enhance the usage of financial services provided by existing financial companies” (EFMA, Cap Gemini & LinkedIn 2017).

If the fintech sector is traditionally divided into 4 segments, this paper only considers large technology ecosystems (or bigtech), new entrants and start-ups and incumbent financial institutions as the paper dives more into the disruption around traditional banks, be they retail or wholesale. Infrastructure providers will not be taken into account here as such hence.

To gather the extent of the fintech revolution, it is fundamental to gather its dual dimension through the opening up the financial value chain (Sy 2019). In that sense, McKinsey (2016) considered that global banking revenues would grow in the next years by 300 billion USD as new opportunities. However, as shown in Table 7.1, the consultancy indicates that incumbents could lower their current fees and margins between 10% and 25% in the industrialized countries where the fintech revolution takes place first excepted within the mobile payment segment where M-PESA led the change first in 2007 in Kenya (Demirgüç- Kunt et al. 2018). The Schumpeterian revolution should impact mainly the payment, asset and wealth management and consumer finance segments at a worldwide scale with incumbents in dire straits and disruptive players being identified as GAFAM/BATX telcos and start-ups. PWC (2016)

**Table 7.1** Fee and margin reduction in revolutionary digitization scenario

Fee and margin reduction in revolutionary digitization scenario Percent											
		U.S.	U.K.	China	Japan	Euro-zone	Other developed	Eastern Europe	MEA	Latin America	Other EM Asia
<b>Retail</b>	Consumer finance	13.9	13.8	7.7	25.1	9.7	10.5	11.3	2.3	11.1	3.4
	Mortgage	2.5	5.1	1.0	4.4	3.7	3.2	1.0	0.2	1.6	0.6
	Checking deposits	1.0	1.4	0.4	1.4	0.6	0.9	0.3	0.1	0.1	0.0
	Term deposits	3.8	5.1	0.0	5.1	3.9	3.9	5.5	1.5	8.9	2.3
<b>Corporate</b>	Cash management	0.5	0.7	0.2	0.7	0.5	0.5	0.2	0.1	0.1	0.1
	Corporate lending	0.7	0.9	0.8	0.7	0.7	0.7	0.6	0.1	0.1	0.2
<b>Payments</b>	Payments	17.3	23.6	8.6	23.6	18.1	18.0	8.6	2.3	3.6	3.6
<b>WM</b>	Asset/wealth management	16.6	21.7	3.9	21.7	16.6	16.6	3.9	1.1	1.6	1.6

Source: McKinsey Panorama – Global Banking Pools

Source McKinsey (2016)

set up some similar forecasts shedding light that 28% of the total business of banking and payment was at risk by 2020.

In that sense, it is relevant to see the potential of fintech was analyzed in detail for all industrialized countries and China whereas the potential of India and the different countries of Africa was not systematically scrutinized by major consultancies as the following surveys indicate in the mid-2010s. In the vast majority of cases, the unique African countries to be considered were Angola, Egypt, Mauritius, Morocco, Nigeria, Togo, Egypt, Mauritius, Morocco, Nigeria, Togo, Kenya and South Africa (McKinsey 2016, 2018; Wyman 2016a,b; EFMA, Cap Gemini, & EY 2017, 2019; KPMG, NASSCOM & CII 2016–2020; PWC 2016; CB Insights 2020; Statista 2019, 2020).

Analyzing the financial ecosystems at worldwide scale, it is clear that excepted for (1) personal finance, and more specifically in robo-advisory, and (2) the quality of the services existing around the Silicon Valley and New York ecosystems (venture capitalists and private equity), China took the lead in all segments, far ahead of US and EU as Table 7.2 indicates (Statista 2020). This drastic change enabled by the quick adoption of mobile payments initially through Alipay and then Antfinancial and Tencenpay demonstrates the acceleration of the change within the financial sphere as well as the existing possibilities to create relevant financial ecosystems for the rest of emerging markets apart from China.

In that sense, if India is a worldwide power concerning ICT, and more particularly BPO, in Bangalore, Tamil Nadu and NCR region (near Delhi), the transactions within its financial ecosystems are inferior to the African ones excepted for mobile point of sales (POS) payments, as the templates indicate infra.

However, the year-on-year growth is superior in India than in Africa in the domain of digital payments, be it for mobile POS Payments and Digital Payments whereas the growth in Africa is higher in the domain of Personal Finance, Alternative Lending and Alternative Finance in terms of Transaction value (Table 7.3).

**Table 7.2** Comparing African and Indian fintech ecosystems with leading FEs in the world

	China				US				Europe + Russian Federation			
	Transaction value (billion USD)	Growth YOY (%)	Users (millions)	Growth YOY (%)	Transaction value (billion USD)	Growth YOY (%)	Users (millions)	Growth YOY (%)	Transaction value (billion USD)	Growth YOY (%)	Users (millions)	Growth YOY (%)
Digital payments	1929	22.80	871	4.30	1058	10.10	281	3.90	802.9	9.90	609	2.20
Mobile POS payments	793	36.50	540.8	7.50	116	33.30	31.8	9.60	48	37.30	51.7	12.00
Digital commerce	1135	14.80	871	4.30	942	7.80	280	3.90	754.7	8.50	609	2.20
Personal finance	317	73.20	56	63.20	1069	39.40	11.56	19.50	90.8	40.40	5.5	27.80
Alternative lending	265.8	19.50	0.069	14.50	33.5	3.00	1.7	2.80	8.6	-2.20	0.001	8.00
Alternative financing	8.2	25.20	0.011	25.90	1.2	-8.30	0.07	5.10	2.7	20.3	0.117	10.50

Source Statista (2020). Accessed on May 12



**Table 7.3** Comparing fintech ecosystems in India and Africa

	India				Africa			
	Transaction value (billion USD)	Growth YOY (%)	Users (millions)	Growth YOY (%)	Transaction value (billion USD)	Growth YOY (%)	Users (millions)	Growth YOY (%)
Digital payments	81	25.30	554	7.80	96.8	15.40	416	9.10
Mobile POS payments	9.6	61.60	488	20.90	4.7	41.00	17.3	16.60
Digital commerce	71	21.60	554	7.80	92.1	14.30	415.9	9.10
Personal finance	1.5	29.20	0.25	34.60	1.7	42.60	0.53	31.90
Alternative lending	0.125	5.70	0.069	4.20	0.507	14.30	0.057	10.10
Alternative financing	0.002	1.30	0.0158	31.00	0.0033	28.90	0.0389	17.50

Source Author elaboration from Statista (2020). Accessed on May 12, 2020

If these elements may be surprising at first sight, it has to be taken into consideration that if India and Africa have similar GDP per capita (2009 USD in nominal vs. 1884 USD in nominal) (World Bank 2020), the big 5 (Nigeria, South Africa, Egypt, Algeria and Morocco) have a GDP per capita much higher and that could be similar to the major Indian metropolis i.e. Delhi, Mumbai, Bangalore, Chennai and Calcutta.

But, above all, the distinction from the regions, India and Africa, comes from the quick adoption of mobile payment in Africa instead of using traditional banking. Moreover, the level of bancarization has increased substantially in India from 36 to 80% in the last decade (World Bank Findex 2018). In Africa, as the penetration of mobile banking was extremely strong, it has curtailed the progression of the bancarization that went up from 23 to 48% (McKinsey 2018).

A closer highlight to the African regions will enable us to pinpoint a relevant insight in terms of the regional leading FEs. As Kenya embraced first the mobile payment, it could have been expected that it would have kept its first mover advantage. Nevertheless, it is not any longer the case with transactions that are more than twice as important for digital payments in Western Africa as in East Africa, countries such as Nigeria, Ghana, Ivory Coast and Senegal being the driving force. As the second most relevant player in Africa, it has to be noted the presence of North Africa with 3 out of the big 5 (Egypt, Algeria and Morocco). And only as fourth player within the continent is Southern Africa slightly above East Africa in terms of transaction value (Table 7.4).

#### Regions in Africa:

North Africa includes Algeria, Egypt, Morocco, Sudan and Tunisia

Eastern Africa includes Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Seychelles, Tanzania, Uganda, Zambia, Zimbabwe

Southern Africa includes Botswana, Lesotho, Mauritius, Namibia and South Africa

**Table 7.4** Distinguo concerning digital payments among major African regions

Region	Transaction value (billion USD)	Growth YoY (%)	Users (millions)	Growth YoY (%)
North Africa	28.4	12.2	108.5	3.9
East Africa	14.9	16.0	79.9	6.3
Southern Africa	10.6	14.1	41.4	8.0
West Africa	34.5	17.6	164	13.5
Central Africa	7.9	19.3	22.2	16.8
Total	96.3		416	

Source: Statista (2020). Accessed on May 12, 2020

Western Africa includes Benin, Burkina Faso, Gambia, Ghana, Guinea, Ivory Coast, Niger, Nigeria, Senegal, Sierra Leone, Togo

Central Africa includes Angola, Cameroon, Chad, Eq. Guinea, Gabon and Republic of Congo.

As such, these elements enable us to conclude that without considering at this stage the influence of the incumbents, the benchmark of M-PESA that already took place in the mid-2000s throughout the continent has prevented Kenya to grow faster than its counterparts even though it is the 6th economy in terms of financial services within the continent. The relatively low GDP per capita in Kenya compared to the rest of the leading countries—that counts with much higher GDP per capita (50% minimum higher)—has been without any doubt an element that has prevented Kenyan companies from consolidating in mobile payment at a continental scale (Table 7.5).

The combination of the data concerning (1) expansion of the FE in Africa and (2) the current size of the major African incumbents indicates clearly that South African banks did not initially bet on mobile payments on the contrary of their continental counterparts hoping to close the gap later. Nevertheless, they have not managed to proceed. The African case implies (1) the difficulty to keep the lead as the first mover within this industry (see the Kenyan case) and (2) the necessity to jump into the new initiatives at the right momentum (see the North African + Western African cases vs. South African case).

The Indian case provides different insights as the banking landscape offers a mix of state-owned banks and Indian private banks apart from the presence of foreign banks. Among the top 10 banks, 5 are state owned (State bank of India, the biggest in India, Bank of Baroda, Canara Bank, Punjab National Bank and Bank of India) and 5 are from the private sector (HDFC Bank, ICICI, Axis Bank, Kotak Mahindra Bank and Yes Bank) (Gupta 2018, 2019). Globally speaking, in terms of assets and tier 1 capital, the Indian banks are much bigger than African banks but much smaller than Chinese banks.

**Table 7.5** Origin of top 100 banks in Africa

	<i>Number of banks within top 100 African banks</i>	<i>Total assets (billion USD)</i>	<i>Tier 1 capital (billion USD)</i>	<i>Profit before tax (billion USD)</i>
Algeria	5	59	4	1.2
Angola	7	48	4	0.8
Egypt	14	204	15	4.6
Kenya	10	33	4.5	1.2
Mauritius	7	29	2	0.5
Morocco	9	166	9	2.5
Nigeria	14	111	11	2.9
South Africa	8	495	39	10.5
Tunisie	9	32	1	0.6
Others	15	68	25.5	1.7
Total	100	1,245	105	26.5

*Source* The Banker (2019)

As it will be commented later, the strong push given by the Indian government—that will be commented in Sect. 7.4—may unleash the full power of Indian financial ecosystem.

### 7.3 IT AND M&A OR HOW THE INCUMBENT POSITION DETERIORATED RESPECTIVELY IN INDIA AND AFRICA TO ANTICIPATE THE NEW COMPETITIVE LANDSCAPE

In this section, the light is shed first on how traditional banks did not integrate fully corporate social responsibility (CSR, further) but remained focused on their traditional business model. The emergence of microcredit and further on microfinance and mobile payment could have paved the way to new solutions where the potential of inclusive growth had become a core element in the strategy of the incumbents but it was not fully used until recently.

India has been a market that has been traditionally protected even after the end of the license raj system in 1991, where strong local players were definitely protected from any newcomer. Therefore, from the 1990s, as foreign competitors entered their local markets, Indian incumbents were forced to develop overseas. Initially, the BPO became critical to recognize Indian expertise mainly with consultancies such as Infosys, TCS and Wipro in relation with the activities they set up with American banks. Moreover, some local retail banks—such as ICICI—expanded worldwide from this period. Then the subprime crisis and the attempt of foreign banks to expand into India led Indian local banks embrace a race to capillarity within India as the growth potential of India was recognized. This focus became a strategic axis for Indian banks to keep control on their domestic territory. To manage this capillarity

in rural areas, strong investments in IT were required. The result in terms of bancarization in India is patent with an increase from 36% to 80% in the last decade (World Bank Findex 2018). Moreover, the decision to favor microfinance and self-help groups among rural population and women entrepreneurs among others has favored an increase of the financial literacy within India. Many rural areas remain uncovered yet by branches as the difficulties for incumbents go much beyond this financial literacy with the average GDP per capita being at 2000 USD per capita and a still high level of illiteracy.

Despite this huge strain to offer a strong linkage of all India, foreign banks did manage to enter the local financial landscape representing 33% of all banks established in the country with already 5.5% of all assets (RBI 2019).

The move toward an increase of digital payments was all but smooth. Indeed, the demonetization reform set up by Prime Minister Narendra Modi to force Indians to adopt mobile payment in November 2016 was extremely dramatic as overnight, bills of 500 INR and 1,000 INR became worthless. This drastic reform provoked a long lasting inflexion in the growth path of India and not even the public expenditures re-boosted Indian growth. As this government implemented a tax called “Goods & Service Tax” (GST) on top of it on all products and services to lower the importance of informal economy (what might have been a good idea to strengthen fiscal income a priori), many uncertainties surged. In that sense, the all but benevolent reforms of the Indian government to force local consumers to move toward digital payments have generated a temporary reluctance to move in that direction.

As for Indian institutions, there was among the African incumbents the willingness to integrate CSR. And, as in many Western countries, the initial interest concerning CSR was after 2001 and the Enron crisis. Therefore, the focus on CSR using microcredit and later microfinance did not materialize as fast as in India. Moreover, the Enron crisis paved the way to the Sarbanes-Oxley Law, Act of 2002 that considers that CEO and CFO are necessarily aware and as such responsible for any misbehavior occurring within their company. This conception led to a much more defensive approach of CSR where the critical issue was no more to gain a new source of competitive advantage but to avoid any misbehavior and to map all possible risks to develop in house solutions to them.

In the same decade, the competitor landscape changed drastically with the leave of French and English banks prioritizing their development in Asia at the expenses of Africa. Interestingly, this move happened when Chinese banks did expand into the continent as an aftermath of the positioning of Chinese commodities and infrastructure state-owned enterprises (SOEs) locally.

So, if it is true that traditional retail banks in Africa have focused on CSR and sustainability since 2001, most of them put the scope of their activity in creating a new business model based on external growth and M&A thanks

to the opportunity provided first by the leave of French and British banks—and later by the acquisition of local banks within Africa. This opportunity enabled these companies to become regional players for the first time in their history. As a matter of example, Moroccan banks—Attijariwafa bank, BCP and BMCE—did expand like that each of them in more than ten countries. The performance of African banks in that sense is impressive as their aggregate pre-tax profits increased from 4 billion USD in 2000 to more than 20 billion USD in 2019 (Caplen 2020) thanks mainly to the incumbents of South Africa, Egypt, Morocco, Nigeria and Kenya. It is not surprising then that Africa has become the second-fastest worldwide banking market in terms of growth and profit (McKinsey 2018).

But, the opportunity of “inclusive growth” has not been fully integrated. If this concept was coined for the first time in 2000 by Kakwani and Pernia, it did become more relevant in the 2010s when local African banks were more on the search of new targets for M&A than on emerging middle class. Indeed, as the potential of internal growth is much lower compared to external growth, it explains why these new pockets of growth were not given the credentials they deserved.

#### 7.4 BIG DATA, DIGITIZATION AND VERTICAL SILOS AS KEY SUCCESS FACTORS OF THE BIGTECH AND START-UPS IN THE ADVENT OF THE FUTURE FINANCIAL LANDSCAPE

The subprime crisis and the sovereign debt crisis did affect the global banking competitive landscape lowering profits and generating a set of new regulatory barriers (e.g. Basel III) to mitigate risks and avoid an uncontrolled race to profits.

As such, many banks suffered deterioration of their activity and had no other alternative than to be acquired. Therefore, even for Indian and African banks that did not have such financial muscle as their Western or Chinese counterparts, the race to M&A kept on.

But, as such, they did not pay the relevant attention to big data initially as they should on the contrary of telcos, start-ups and bigtech. First, telcos managed to use the big data and the incipient success of mobile payment in Africa. As it was already commented supra, many African players such as Orange in Ivory Coast benchmarked M-Pesa in Kenya and launched their own solution in this field. If traditionally banks get protected by the government, the fact that the launching of new licenses was a new source of income for the government, Therefore, the barrier to entry into the banking sector was over.

As the advent of mobile payment in Africa was not dependent on smartphones but on basic phones, African telcos managed to exploit and develop an excellent case of frugal innovation. Indeed, with 20% without phone, it has managed to increase mobile money account by more than 20% on an average in Sub-Saharan Africa between 2014 and 2017 (World Bank Findex 2018).

Moreover, the acquisition of smartphones has almost triplicated in Ghana and Senegal between the same period while it has increased by 150% in South Africa, Nigeria, Kenya and Tanzania (Pew Research Center 2018); what gives more opportunities to local start-ups to take off.

In the Indian case, it is the bancarization that happened first, the payments in the POS that happen later jointly with the increase of the terminals. It has to be noted that the sales of mobile phone went up from 524 to 820 million units between 2013 and 2019 (CB Insights 2020).

As such, many opportunities were raised between telcos and apps created by start-ups exploiting small vertical silos for which the last ones enjoy low fixed cost in comparison with the incumbents'. Hence, McKinsey (2018) demonstrated that if the cost to acquire a new customer is 300 USD, it is 5 USD for a digital attacker.

The potential of the Indian FE is extremely relevant as it did have a higher level of growth than the Chinese FE in terms of deal activity in the first quarter of 2020. Similarly, the deal volume in the African FE did triplicate between 2015 and 2019, being superior to the Australian FE and reaching half the South American FE (CB Insights 2020).

This dual movement at the global scale has provoked a huge disruption in the financial sector. Regional fintechs, be they in Africa and in India, tried to take advantage of these trends to get rid of the leadership of current incumbents and finally bigtech saw the opportunities. First, Chinese BATXs (Baidu, Alibaba, Tencent & Xiaomi) posited in Africa. It has happened mainly in Eastern Africa through their mobile payment system Alibaba's Alipay and Tencent's Tencenpay. If American GAFAMs (Google Amazon, Facebook, Apple & Microsoft) did pay until recently more attention to China, it has to be said that India is given always more importance for instance in Apple, what was already the case for Google. More interestingly even, Apple has decided to replicate its own ecosystem to Africa with Apple Music being open in more than twenty countries locally from April 2020. Last but not least, a set of Japanese and Indian companies have decided to ally not let Chinese firms win the battle in Africa.

In that sense, it seems the surge from hidden success stories be they in India or in Africa will become always more complex. Indeed, India is always more monitored by many consulting studies and Africa has managed to raise an exponential new interest in the last five years concerning its financial ecosystem. Both elements confirm the new potential of both financial ecosystems.

The surge and development of both Indian and African financial ecosystems offer huge opportunities at local level. Nevertheless, there is a potential threat that newcomers in these countries hack these new opportunities directly for their benefits.

## 7.5 THE ROLE OF THE PUBLIC SECTOR IN THE NEW FINANCIAL LANDSCAPE

The role of the public sector has been considered until this section as the regulation maker at international and at national levels. The current role of Indian and African leaders still remains modest in relation to the population they represent. Now the disruption within the fintech sector occurred when the States decided to deliver licenses to telcos what paves the way to an alliance between telcos and start-ups. Therefore the role of the States was critical in the recent blossoming of these ecosystems.

But the potential of the States can even go further as the Indian experience relates it. If Modi's reform concerning the demonetization and the GST had an overall negative impact on the economic growth of India at least in the following two years of their implementation, the creation of the India Stack under the government leadership may change the global perception of the Indian ecosystem, and not only at the financial level. This system is based on 4 layers:

1. The unique identification Authority of India or Aadhaar. It is a presence-less layer and it has been used partially for the last election.
2. The Department of Electronics and Information Technology that defines the paper-less layer with digital locker and digital signature.
3. The National Payments Corporation of India that defines the cash-less layer for financial transactions. The system is compounded by a Unified Payments Interface (UPI), the Aadhaar Payment Bridge, the Aadhaar enabled payment system and the Bharat Bill of payment systems. As a matter of fact, "878 million bank accounts have been linked with Aadhaar till March 2018" and "transactions using UPI in value terms rose from INR 0.5 million to over INR 542 billion between 2016 to 2018" (KPMG, CII & NASSCOM 2018).
4. All this system is supervised and regulated by the Reserve Bank of India.

As the Indian government combines this new ecosystem with initiatives like the Government eMarketplace (GeM) for licitations and E-way Bills for procurement among others, the Indian FE has been substantially empowered by the Government activity.

Some relevant initiatives took place in Africa as well but the size of these countries has prevented them from building such robust ecosystems as in the Indian case.

## 7.6 CONCLUSION

Even though the organization of the geographic space is different, comparing Fintech in India and Africa provides a framework where the disruption takes place in a different context (see *infra* summary of findings). If banks in

India have managed until recently to preserve better micro sphere of activity, this phenomenon was made possible thanks to huge IT investments that enabled the capillarity to reach 80% by 2020. Nevertheless, the existence of entrepreneurial ecosystems around Bangalore, Delhi, Mumbai, Chennai and Hyderabad paved the way to deals in venture capitals that should be relevant in the upcoming years as the Modi administration has favored new margins of maneuver with the presence-less, paper-less and cash-less initiatives.

In the case of Africa, national incumbents were right to consider M&A when French & English banks left Africa for Asia as it has enabled them to become regional players. Nevertheless, as this phenomenon coincided with the digitization and the mobile payment revolution provoked by M-PESA, all telcos managed to enter mobile payments with the support of local fintech. As it was a source of new income for governments, the barriers to entry that used to protect incumbents disappeared.

As a matter of fact, in both regions, the competitive landscape has evolved in a much favorable aspect for consumers and the customer experience should be a major stake in this open banking scenario where the influence of bigtech may increase drastically in the upcoming years (Table 7.6).



**Table 7.6** Summary of fintech ecosystem in Africa and India

	<i>Africa</i>	<i>India</i>
Similar initial background	<p>Implemented mobile payment worldwide even though China is the global leader</p> <ol style="list-style-type: none"> <li>1. A set of 54 Countries with inhabitants with low income and low digital readiness</li> <li>2. Similar population (1.2 billion people) than India</li> <li>3. High growth despite not top tier banks nor IT top clusters at worldwide level</li> </ol>	<p>In 2019 last quarter, Indian deals in VC in fintech were superior to Chinese ones</p> <p>A set of 33 States and UT with inhabitants with low income and low digital readiness</p> <p>Similar population (1.35 billion people) than Africa</p> <p>High growth despite not top tier banks but high skills in IT (BPO) at worldwide level</p>
Impact of 2001 Enron crisis to embrace CSR on incumbents	<ol style="list-style-type: none"> <li>1. Treble bottom line policies were set up but mainly the focus was defensive as a reference to the Sarbanes-Oxley Act</li> </ol>	<p>Microcredit and later microfinance—as these policies were invented in Bangladesh—endeavoured incumbents to set up CSR strategies but not core to the business</p>
Impact of 2007 crisis + threats from foreign traditional banks expansion on incumbents	<p>4 movements:</p> <p>Low impact from US crisis</p> <p>The leave of French and English banks gave the opportunity to African players to become regional players</p> <p>With the arrival of Chinese Commodities and infrastructure SOEs, the Chinese banks and BATX followed</p> <p>The digitization provided new opportunities for telcos.</p> <p>With the new licence, telcos + local start-ups entered the incumbent markets</p>	<p>4 movements:</p> <p>US markets get closed temporarily and strong impact on IT consultancies but moderate impact on incumbents</p> <p>Recenter on India as the initial internationalization move that occurred in 1991 forced Indian incumbent to insist more on local opportunities</p> <p>Threat of international players to move into India</p> <p>Indian incumbent answer comes from strong linkage of capillarity to empower bancarization and favor mobile payment</p>

(continued)

**Table 7.6** (continued)

	<i>Africa</i>	<i>India</i>
State influence > possible PPP	Mainly on the telcos licence to organize the disruption against incumbents through the alliance between telcos and startups	Strong influence of th State. Negative in terms of growth generation due to reforms that were not truly managed (demonetization and GST) but strong possibilities with the advent of Stack India layers from Aadhaar to UPI
Big tech influence	Chinese bigtech interfered as a consequence of the development of commodities and infrastructure companies Among the BATX, the presence of Alibaba and Tencent should be highlighted Apple has decided to develop its own ecosystem in 20 African countries	Limited role of BATX and GAFAM in the financial sphere However, strong influence in the telco sector with Xiaomi and to a lesser extent Oppo Willingness of Google and Apple to increase their participation locally
Role of telecommunication in fintech Disruption	The new licences are a source of income for local governments > interest of success Worldwide Disruption in mobile payment linked to M-PESA in Kenya and Tanzania Replication of M-PESA at a regional scale > end of first mover advantage in mobile payment Alliance of telcos with local fintech to disrupt the incumbents	The new licences are a source of income for local governments > nevertheless, these licences are often provided to local conglomerates. Poor impact The incumbents managed to keep up their influence developing a strong linkage throughout the country The high capillarity has prevented until now the incumbents to loose too much marketshare with telcos, bigtech and startups
Local fintech	Payment as the major silo to create an alliance with regional telcos	Payment in POS as the major source of opportunity

*Source* Author elaboration

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# Fintech and the Real Economy: Lessons from the Middle East, North Africa, Afghanistan, and Pakistan (MENAP) Region

*Inutu Lukonga*

## 8.1 INTRODUCTION

Development of micro, small, and medium-sized enterprises (SMEs) has become the centerpiece of strategies to achieve inclusive growth in the Middle East, North Africa, Afghanistan, and Pakistan (MENAP) region. Countries across the region are, in varying degrees, faced with high youth unemployment rates, declining capacity of the public sector to absorb new labor entrants, lower and volatile oil prices, and widening income disparities. Against this backdrop, policymakers have been designing strategies to catalyze the growth of SMEs with a view to create jobs and ensure that growth is inclusive. In commodity-dependent economies, promotion of SMEs is also intended to help diversify economies.

Strategies to promote SMEs in the MENAP region aimed at easing barriers to entry, growth, and exit of businesses. Toward these objectives, many countries tried to reduce the time and costs of starting businesses by establishing one-stop shops and online platforms as well as reducing capital requirements (World Bank 2019). They also created incentives to enhance access to bank

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The views expressed in this paper are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

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finance by establishing credit guarantees and strengthening financial infrastructures—credit registries/bureaus, collateral registries, and insolvency regimes. Some countries also implemented reforms to develop non-bank funding sources, including alternative equity markets for SMEs, venture capital, micro-finance, and leasing. Increasingly, countries have also been providing business support, such as facilitating SMEs access to public procurement and export markets, and supporting innovation through incubators, accelerators, and training, etc. Dedicated institutions were also established (Lukonga 2020).

But despite the multitude of incentives, SMEs continue to face barriers to growth and their contribution to employment remains below potential. SMEs continue to experience challenges accessing financing and the business environment has not been sufficiently enabling. The enterprises also face internal constraints related to weak managerial capacities and are not able to attract the talent needed to support their operations and innovate (Saleem 2017). These constraints have manifested in the concentration of SMEs in low capital-intensive activities that are low value adding, such as trade and services and in the predominance of microenterprises that generate limited employment opportunities and are low paying. Educated youths, therefore, prefer to take up jobs in the public sector and large corporations that offer better salaries and benefits.

This modest success in boosting SMEs growth can be attributed to incomplete reforms, but frictions in the strategy also played an important role. Development of financial infrastructures—credit bureaus, collateral registries, and insolvency regimes—remain incomplete. Limited progress has also been made in developing venture capital and crowdfunding regulations. The SME strategy exhibits inherent tensions. For example, bank lending, which the reforms focused on, is influenced by shareholder returns and is not suitable for lending to SMEs that are characterized by high credit risk and low returns. Credit guarantee schemes faced implementation challenges (Sharekh 2018), but the schemes also only mitigate credit risk and not the high maintenance costs which banks cite as a major constraint to lending to SMEs. Alternative equity markets are not effective in MENAP because of the predominance of microenterprises and the preference, in some cases, to own rather than grow companies. The lack of audited accounts, which banks cited as a major constraint to lending to SMEs, has received little attention and statistics on SME demographics are lacking, thus policies have not been evidence-based (Lukonga 2020).

The COVID-19 pandemic has added to the challenges that SMEs in MENAP face and threatens to accentuate already elevated levels of unemployment in the region. The SMEs are concentrated in sectors that have been badly hit by measures to contain the spread of the virus—such as trade, tourism, and transportation. Most SMEs have also not digitalized their business operations, thus the “great lockdown” threatens to bring business operations to a sudden standstill. With microenterprises predominating the SME sector, the level of cashflows is unlikely to withstand substantial periods of business disruptions.

In addition, since SMEs are the predominant form of business and significant contributors to employment, a weakening of the SMEs productive capacity has potential to significantly increase unemployment.

For SMEs to be the engines of inclusive growth in MENAP countries, a rethinking of SME development strategies is needed that puts digitalization at the center of reforms.<sup>1</sup> Digital technologies have potential to boost the growth of SMEs as well as enhance their resilience to shocks. Empirical studies show that technology can enhance operational efficiencies, innovation, access to international markets, and overall productivity (Accenture 2016; OECD 2017; WTO 2019). Digital innovations can also help unlock funding for SMEs, improve government efficiencies, and integrate women in the labor force (Watson et al. 2018). The “great lockdown” to contain the spread of COVID-19 has brought to the fore how digital technologies can facilitate business continuity and enhance resilience to shocks. But equally important, digital technologies are rapidly transforming consumer expectations and the business environment. SMEs, therefore, need to adapt to remain competitive in the digital economy.

This chapter aims to identify the policy mix that can enable MENAP SMEs to leverage digital technologies to boost growth and promote inclusive growth. The analysis addresses three principal questions relating to the digitalization of SMEs in MENAP:

- Can digital technologies usher in a new era of resilience, growth, and quality employment generation among SMEs?
- How digitalized are SMEs and what constraints do they face in digitalizing their businesses?
- What policy mix can enable SMEs to leverage digital technologies to boost their growth and achieve inclusive growth, and what role should the government play?

The assessment applies benchmarking techniques and gap analysis to evaluate the performance of MENAP SMEs and identify needed policies. The review covers 21 of the 24 countries that make up the MENAP region.<sup>2</sup> The analysis is based on both primary and secondary data sources from central bank reports, presentations by senior government officials, World Bank enterprise surveys and other studies, as well as information obtained through seminars at the IMF, World Bank and the MENA region.

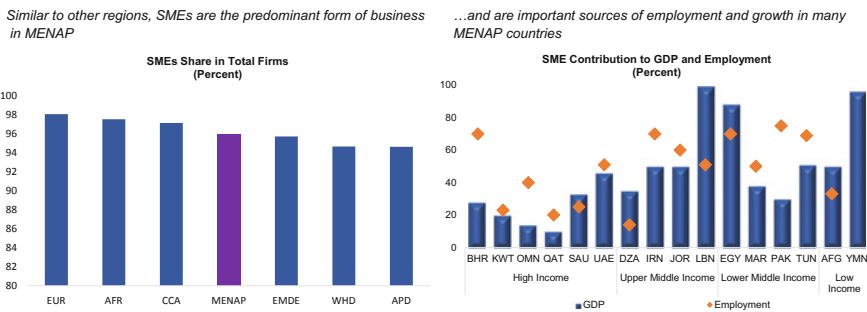
The chapter is organized as follows: Section 8.2 provides an overview of the landscape for SMEs in MENAP, focusing on their structure, performance, and constraints to growth and employment contribution. Section 8.3 discusses the benefits of SMEs adopting digital technologies, reviews digitalization trends of MENAP SMEs and the broader economy, and identifies the factors that hamper digital transformation among SMEs. Section 8.4 summarizes the findings and discusses policy strategies to enable SMEs to leverage

digital technologies to boost their growth and employment creation, thereby facilitate inclusive growth.

## 8.2 THE MENAP SME LANDSCAPE

### 8.2.1 Economic Significance of SMEs and Structure

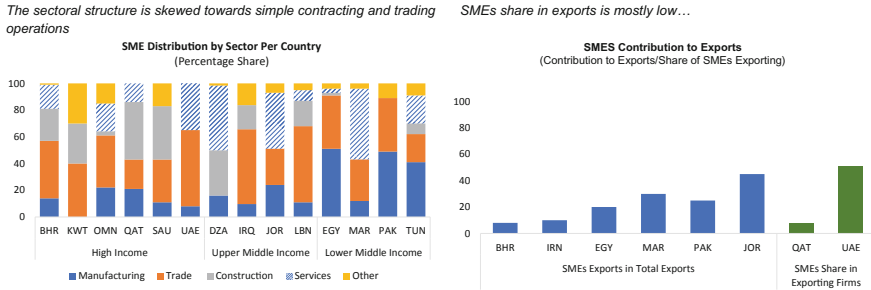
As with other regions, SMEs are the predominant form of businesses in MENAP and are significant contributors to employment and GDP. SMEs, on average, account for over 90% of total businesses in the MENAP region (Fig. 8.1). The share of employment accounted for by SMEs ranges from the low teens in Algeria to more than 50% in several countries (Bahrain, UAE, Iran, Jordan, Lebanon, Egypt, Pakistan, Tunisia). SME contributions to GDP range from a low of 10% in Qatar to more than 70% in some of the oil-importing countries (Egypt, Tunisia, Yemen). The significance of SMEs in the economies is even greater when the informal sector is considered (Saleem 2017).



**Fig. 8.1** Economic significance of SMEs in MENAP (Source World Bank Enterprise Surveys, latest available data. Note EDE = Emerging and Developing Europe; SSA = Sub-Saharan Africa; CCA = Caucasus and Central Asia; MENAP = Middle East, North Africa, Afghanistan, and Pakistan; EMDE = Emerging Markets and Developing Economies; LAC = Latin America and the Carribean; EDA = Emerging and Developing Asia; SME = small and medium-sized enterprise. Source World Bank, Saudi Gazette citing Bloovo.com, Allied Investment Partners. Note Data labels use International Organization for Standardization [ISO] codes)

SMEs in MENAP are concentrated in selected sectors and their business operations mostly target the domestic sector (Fig. 8.2).<sup>3</sup> Trade, retail distribution, and simple contracting account for over 70% of the business activities in most countries (World Bank 2017). SME exports account for 16% of overall exports in the Middle East and indirect exports through participation in global value chains (GVC) are estimated at 2.4% (WTO 2019). Across the region, there are significant cross-country differences in the importance of exports in SMEs sales with Jordan, Morocco, and UAE recording notable magnitudes of

exports (Fig. 8.2). This overall gravitation of SMEs toward the domestic trade and service sectors, in part, reflects the fact that these sectors have low entry costs and resource requirements.



**Fig. 8.2** Scale and composition of SMEs in MENAP (*Sources* World Bank and official publications. *Note* Data labels use International Organization for Standardization [ISO] codes. *Source* Various National Reports. *Note* Data labels use International Organization for Standardization [ISO] codes)

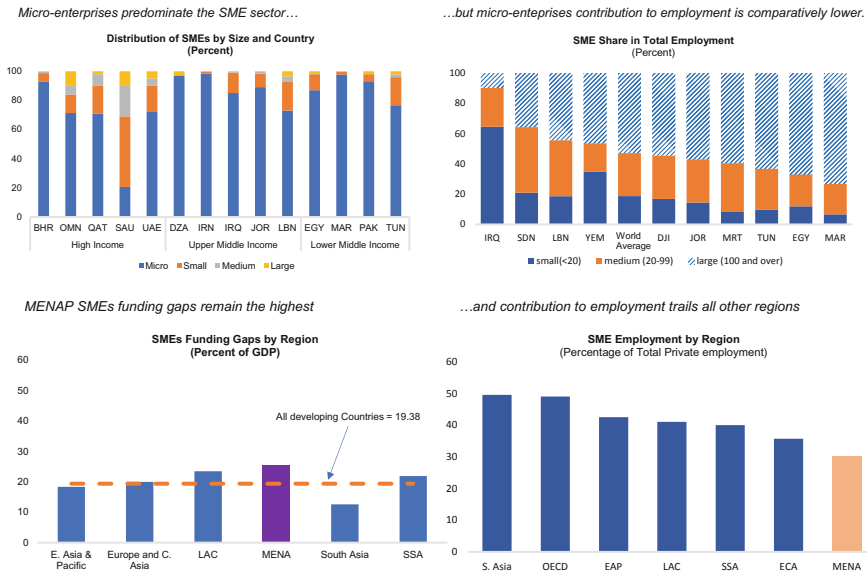
Startups are growing rapidly in number and scale, but activities are concentrated in a few countries. Investments in startups increased at a compound annual growth rate of 22.5% between 2015 and 2019 and the number of startups worth over US\$100 million also increased (Magnit 2019). The activities are, however, geographically concentrated, with eight countries (Bahrain, Egypt, Jordan, Lebanon, Oman, Saudi Arabia, Tunisia, and UAE) accounting for over 85 percent of all startups and the UAE alone accounting for a third of the activities. The startups are creating employment but not in magnitudes that significantly reduce unemployment levels among the youth (WAMDA 2016).

### 8.2.2 Constraints to SMEs Growth and Employment Generation

The growth of SMEs in MENAP has been hampered by both external and internal constraints. Limited access to finance is the most commonly cited factor but unfavorable business environments, and talent gaps are also reported to be important. Other constraints tend to be more country-specific and include corruption, unreliable supply of electricity, high tax rates, competition from imports, lack of access to public procurement, high interest rates, political instability and informality (Saleem 2017; IFC 2017; WEF 2016).

These constraints have contributed to the predominance of micro enterprises and the lower shares of SME employment relative to other regions (Fig. 8.3). Microenterprises account for the bulk of the SMEs in most MENAP countries and the contribution of SMEs to employment trails other regions. Funding gaps for SMEs in MENAP are also higher than other regions. The SME sector in MENAP is, therefore, highly vulnerable to economic shocks due to limited capital buffers, weak governance, and limited digital capabilities. The vulnerabilities posed by the lack of digital capabilities have become





**Fig. 8.3** Comparative performance of SMEs (*Source* World Bank Enterprise Surveys, Latest Available. *Note* Data labels use International Organization for Standardization [ISO] codes. *Source* World Bank and various country reports. *Note* Data labels use International Organization for Standardization [ISO] codes. *Source* World Bank. *Note* Data labels use International Organization for Standardization [ISO] codes)

more visible as the “great lockdown” halted the business operations of SMEs that are not able to work remotely.

MENAP SMEs could, therefore, benefit from greater adoption of digital technologies to boost growth and employment generation. Digitalization could help microenterprises scale up faster with favorable consequences for employment generation of the quality that can attract educated youth. Digitalization of business operations can foster greater resilience by enabling business continuity in pandemics. More critically, digital technologies are changing the way firms do business as well as consumer expectations, thus digitalization is no longer an option for SMEs in MENAP but a strategic imperative to remain competitive.

### 8.3 DIGITALIZATION OF MENAP SMEs—OPPORTUNITIES, TRENDS, AND CONSTRAINTS

#### 8.3.1 Salient Issues

The OECD (2019a) defines digitalization as the use of data, digital technologies, and interconnections that result in new or changes to existing activities. The conversion of analogue data and processes into a machine-readable

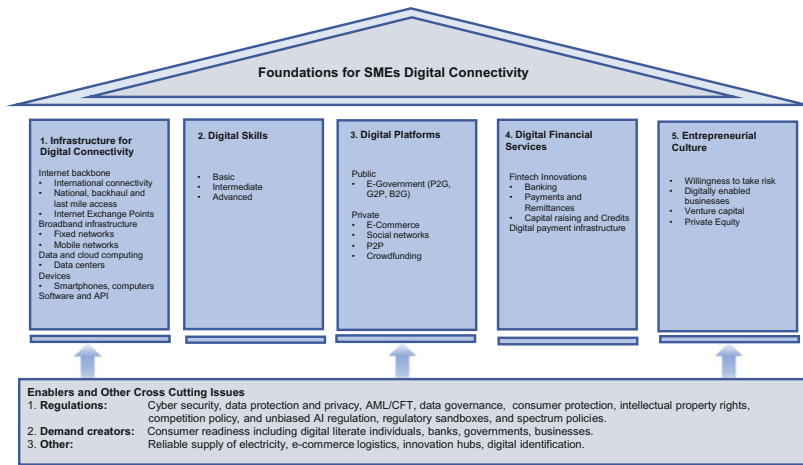
format—known as digitization—has made gathering, storing, and managing data amenable to algorithmic management, while the proliferation of devices and sensors has increased capacity for acquiring and managing data—termed as “big data” and “Internet of Things (IoT).” In this highly connected environment, algorithms create value from data and the data improve algorithms, leading to “machine learning (ML)” and the development of Artificial Intelligence (AI). Distributed ledger technology (blockchain) enables open shared and distributed public record of information that cannot be altered. Cloud technology, with its cost-efficient processing capabilities and data storage possibilities, unlocks the potential of blockchain, AI, and IoT.

The growing interaction between data, algorithms, things, and people translates into a “data-driven” or digital economy and society. This transformation makes data a resource and an asset to be traded that underpins the trade of other goods and services. The new generation of technologies—Big data, IoT, AI, ML, cloud computing, and blockchain—are also transforming how value is created, how businesses are connected, how goods and services are delivered, and the speed with which services reach end users and across borders. With digitally savvy millennials accounting for large shares of the populations, consumer expectations have changed to increasingly value goods and services, not just for their utility and cost, but also for the speed and convenience with which they are delivered. Businesses that do not digitalize, therefore, risk being marginalized.

Broadband internet is a critical input in the transition to the digital economy. It is the foundation for digital services, applications, and business models and is a pre-requisite for the adoption of other digital technologies. Broadband networks encompass international, domestic backbone and backhaul, and local access connectivity.<sup>4</sup> All three network components need to be in place and optimally utilized to facilitate access to affordable and reliable broadband connectivity that can support digitalization of businesses, including SMEs. Internet Exchange Points (IXPs) are also vital for improving the affordability and quality of broadband connectivity, within and between countries, as they ensure that Internet traffic remains “local” thereby keeping costs and latency low.

SMEs’ growth prospects can be significantly boosted by digitalizing their operations. Going online enables SMEs to reach new clients and markets at low cost, reduce communication costs, and conduct business during the lockdowns. Big data, cloud computing, IoT, AI, and ML improve efficiencies, reduce capital expenditures and operational costs, and speed up cross-border transactions (OECD 2019b). Through these channels, broadband internet and digital technologies help firms scale up faster, increase employment, and boost output growth.

But for digital dividends to materialize, countries need robust digital ecosystems. The principal elements of the ecosystem include availability of affordable high-speed internet, a labor force that has digital skills, digital platforms to connect businesses with consumers, and digital financial services. Other



**Fig. 8.4** Pillars of a digital ecosystem for enterprises (*Source* World Bank and Author)

important elements include digital identities (IDs) and interoperable digital payment systems to facilitate transactions, digitally literate consumers, affordable devices, and entrepreneurial culture. There is also need for a reliable supply of electricity, e-commerce logistics, and digital identification and data centers for cloud computing. A robust regulatory framework is also needed that promotes innovation while mitigating risks, such as cyber risks, data protection and privacy, consumer protection, fraud, and money laundering (Fig. 8.4).

### 8.3.2 *Benefits and Risks of Digitalizing MENAP SMEs*

Digital solutions can directly boost MENAP SMEs’ growth and employment creation and contribute to the realization of the policy objective of inclusive growth. Efficiency and productivity gains enabled by digital technologies can help accelerate the migration of SMEs from microenterprises to larger firms that are more resilient and competitive with greater scope to create employment. Specifically:

- Broadband internet can help SMEs reach a larger market at low cost and allow for business continuity during the lockdown.
- IoT enables efficiencies in stock management and transportation, while Global Positioning System (GPS) Apps can help ease logistical challenges and promote e-commerce.<sup>5</sup>
- Cloud-based services can help alleviate financial and talent constraints by reducing ICT upfront capital expenditures, provide ICT expertise, improve digital security, and benefit from lower cost cloud-based communication services.

- Big data analytics can improve customer service.

Besides the job creation arising from SME growth, digitalization promises other employment advantages. Digital jobs and skills are better able to adjust to new technological demands. The jobs are also likely to come with a more flexible working culture that allows self-employment and remote work, giving women and youth more opportunities to participate in the labor force. Additionally, these jobs can help countries realize national plans for digitizing their economies (PwC 2017). Thus far, the total number of jobs created by startups in MENAP is still small, but technology-enabled businesses have potential to generate employment opportunities through network effects.<sup>6</sup>

Digital technologies can also facilitate SMEs' access to credit and ease a key impediment to their growth. Electronic payments create a digital trail of transactions that enables banks to lend to SMEs against cashflows if audited accounts and collateral are unavailable. Digitizing payments across supply chains can also help SMEs optimize account receivables and free up cash flows for working capital. Big data enhances banks' credit risk assessment capabilities, improves AML/CFT compliance, which can reduce wholesale de-risking that has disproportionately impacted SME lending, and enables banks to create products tailored to SMEs. Blockchain facilitates faster cross border payments and the establishment of reliable electronic registries of leased and moveable assets, thereby enabling SMEs to pledge moveable collateral.<sup>7</sup> Digital innovations—Crowdfunding and P2P platforms—help provide alternative funding sources.

A digital government reduces costs and improves outcomes. E-government services can enhance the quality of interactions with businesses and citizens, such as facilitating more transparent tender processes, and reducing time for business registration and tax compliance. Internet and other digital applications (AI, ML) can facilitate electronic reporting and the development of structural and demographic statistics on SMEs to provide perspectives on entry, exit, growth, and job creation. More granular data on SMEs facilitates evidence-based policies and better monitoring and analysis of regulatory policy impact, which improves the effectiveness of SME policies. Moreover, the significant size of the public sector in most countries and the pervasiveness of making payments to, or receiving payments from, governments mean that when authorities introduce digital payment options, they can influence the behavior of a mass of individuals, incentivizing them to switch to digital payments.

Digital innovations in payments can help facilitate efficiencies in domestic and cross-border trade. Digital payments infrastructures enable real time payments that increase operational efficiencies and blockchain has emerged as a key technology to facilitate international remittances and other cross-border transactions. Payment instruments (credit and debit cards) also alleviate payment delays and reduce cash management costs.

Digital dividends can, however, be neutralized if risks are not well managed (IMF 2019). The “data-driven” economy and society has made data an asset to be traded and a resource that underpins trade of goods and services. How to fully exploit the potential of data to stimulate innovation and productivity while protecting privacy, intellectual property rights, and ensuring security is a new challenge. Increasing connectivity and dependence on technology also increases IT risks, and broadens the threat landscape for cybercrime, digital fraud, money laundering, biased AI decisions, as well as fake news, such as deep fake.<sup>8</sup> SMEs have not been the target of cybercriminals, but they lack in-house IT expertise to monitor and secure their networks and devices. Further, without appropriate retooling programs, automation can also displace labor and increase unemployment.

### 8.3.3 Status of MENAP SMEs Digital Transformation

Businesses, in MENAP, have generally been slow to adopt the internet to boost productivity despite many governments’ initiatives to promote digitalization. The digitalization process has not followed the path typically seen in other markets where consumers moved online and businesses immediately followed, enabling a gradual development of the digital ecosystem. In MENAP, mass internet adoption, especially in the GCC, took off around the mid-2000s, but businesses only began to digitalize after 2010 (Fabre et al.). The internet continues to be used mostly for entertainment and to communicate and much less to make transactions or to innovate, thus businesses trail governments and consumers in internet usage (McKinsey 2016).

SMEs in MENAP are increasing their digital presence, but their overall footprint remains small (Fig. 8.5). Despite the increase in internet usage among the population, only 15–25% of SMEs in MENAP had online web presence at the end of 2012 (Deloitte 2014), and recent surveys indicate that these shares have only marginally changed (WTO 2019). Use of social media

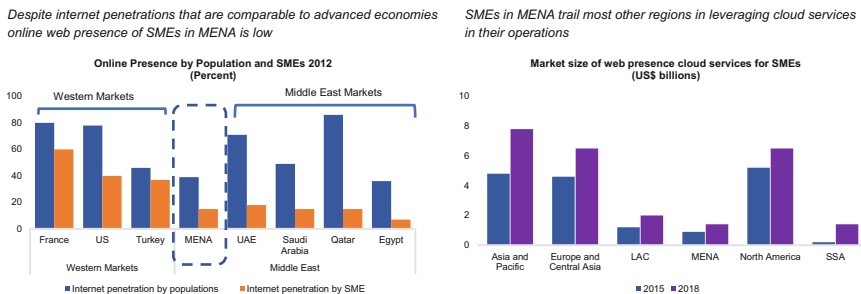
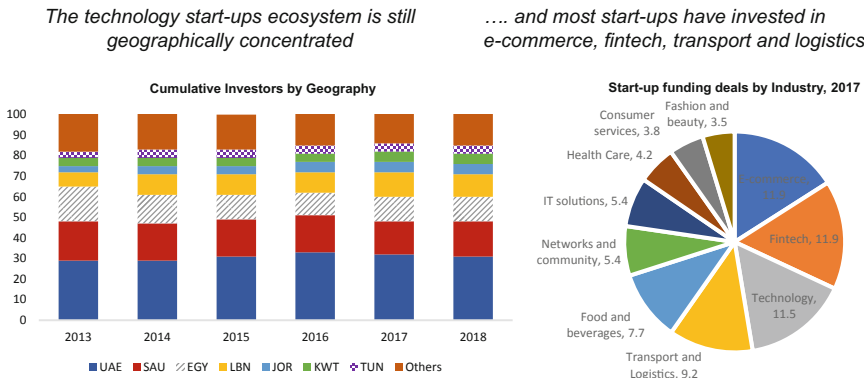


Fig. 8.5 Web presence and cloud adoption by MENAP SMEs (Source Google Survey [2013] and Deloitte [2018]. Source Statistica 2019)

platforms such as Instagram and Pinterest by SMEs has increased, but the technological absorption at the firm level shows that firms in the middle to lower income countries are lagging in embracing technologies in their business operations (WEF 2019). Data centers have been established that are facilitating the adoption of cloud computing but deployment of cloud services by SMEs remains low.<sup>9</sup>

Interest in e-commerce is growing but the share of SMEs that have embraced online trading as a consumer sales channel and the share of e-commerce transactions in SMEs total sales remain small. Data on e-commerce transactions by SMEs are scanty, but overall e-commerce transactions for the MENA region accounts for less than 2% of total sales and less than 1% of the global e-commerce market (Fabre et al. 2019). The UAE, Saudi Arabia, and Egypt account for 80% of the MENA e-commerce market followed distantly by other GCC countries (Bahrain, Kuwait, Oman, and Qatar). Governments in several countries (GCC, Egypt, Pakistan, Jordan, Tunisia, Lebanon) have begun to formulate policies to promote e-commerce, big retail companies are increasing online sales, and several e-commerce platforms have emerged, but SMEs are still largely absent from virtual marketplaces (US Export. Gov).<sup>10</sup>

Technology startups and technology-enabled businesses are increasing but activities remain concentrated in a few countries (Fig. 8.6). Boosted by government and other initiatives, investment in technology startups grew at an annual compound growth rate of 36.6%. UAE accounts for 31% of all deals and 70% of funding in the region. Other countries with significant digital startup ecosystems include Saudi Arabia, Egypt, and Lebanon followed distantly by Iran, Jordan, Kuwait, Tunisia, and Bahrain. E-commerce, Fintech, technology, and transport logistics account for half the investments (Magnit 2019).



**Fig. 8.6** The digital technology start-up ecosystem in MENAP (Source Arabnet Business Intelligence, Dubai SME. Note The State of Digital Investments in MENA 2013–2018. Source Statistica)

### *8.3.4 The Digital Ecosystem for SMEs and Constraints to Digitalization*

SMEs in MENAP are at different stages of digital transformation but, generally, the preconditions for effective use of new technologies are missing in many countries. The SMEs face significant constraints on the supply side but demand factors also play an important role in slowing the digitalization process.

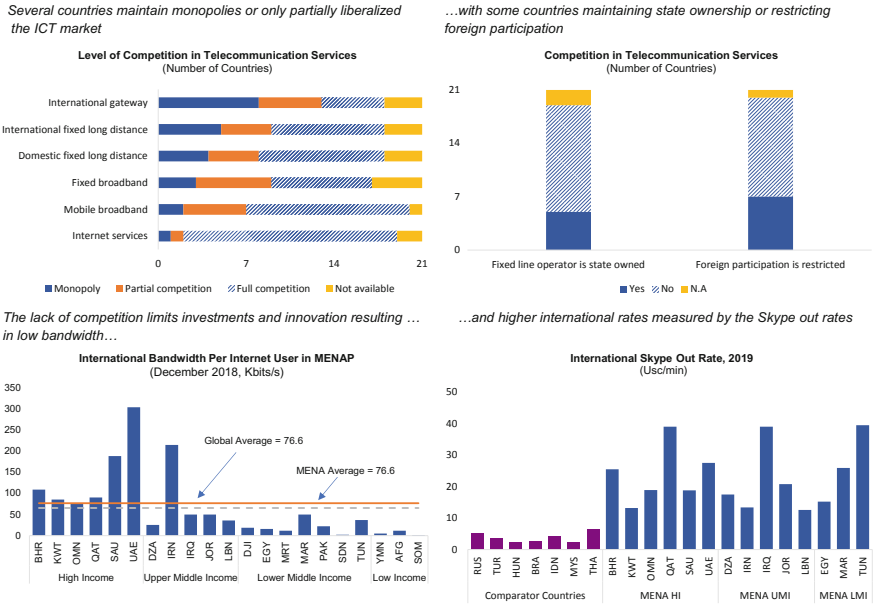
### *8.3.5 The Digital Landscape in MENAP and Supply-Side Constraints*

The preconditions for the development of information and digital economy are lacking in many countries, particularly in the non-GCC MENA countries. Access to international connectivity is good but barriers to entry and competition have constrained capacity utilization. These barriers are resulting in underinvestment in national backbone infrastructures and inefficiencies across the internet value chain that manifest in low broadband penetration rates and unaffordable internet services. Progress has also been slow in developing digital financial infrastructures, e-commerce logistics, enabling regulations, digital skills gaps, and entrepreneurial culture are just emerging.

All countries have easy access to international fiber-optic networks. The region is strategically positioned with respect to international connectivity as most of the submarine fiber optic cable infrastructure linking Europe and China crosses the Mediterranean Sea, the Sinai Peninsula, descends through the Red Sea, and through the Yemen-Djibouti strait to reach the Arabian Peninsula. This infrastructure is complemented by terrestrial cables built across the Middle East to provide alternative connectivity between Asia and Europe (World Bank 2014, 2018). Most data traffic is, therefore, transferred internationally through submarine cables, with terrestrial fiber, microwave, and satellite transmission accounting for a smaller amount.

Effective use of this good international connectivity infrastructure is, however, constrained by lack of competition and open access regulations. Several MENAP countries restrict access to international gateways and international fixed long-distance lines in the form of monopolies and other restrictions to competition (Fig. 8.7). Entry barriers constrain investment and result in capacity underutilization of international bandwidth and higher international charges, which spill over to downstream domestic markets.

The domestic telecom market has been increasingly liberalized, but some countries continue to maintain restrictions that constrain investments and increase inefficiencies. For instance, a few countries (Djibouti) maintain monopolies across the whole value chain. About a third of the countries still restrict competition in their mobile and fixed broadband markets through monopolies, state ownership, or limits on foreign ownership and control (Fig. 8.7). Restrictions on peering and network development coupled with limited market contestability have also constrained the development of Internet Exchange Points (IXPs), resulting in domestic networks having to



**Fig. 8.7** Entry barriers in MENAP telecom market (*Source* ITU. *Note* No restrictions to foreign participation. *Source* ITU. *Note* Data labels use International Organization for Standardization [ISO] codes. *Source* Skype, <http://www.skype.com>. *Note* Data labels use International Organization for Standardization [ISO] codes. HI = High Income, UMI = Upper Middle Income, LMI = Lower Middle Income, LI = Low Income)

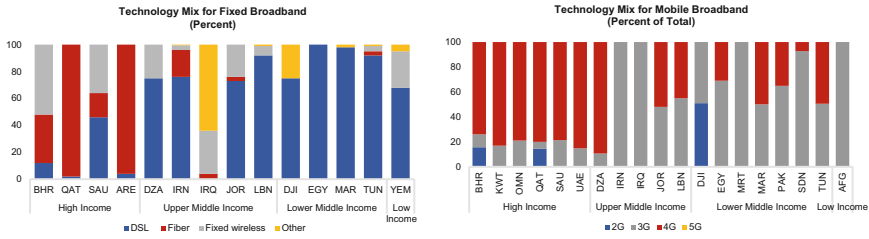
send local traffic to Europe to exchange data before backhauling it to the Middle East. Internet services, therefore, exhibit lower latency, high costs, constrained bandwidth, and low speed, which limits the adoption of cloud services.

Entry barriers and high capital investment requirements have slowed the deployment of advanced network technologies which impact the adoption of digital technologies. Fixed broadband markets are largely underdeveloped with very countries (UAE, Qatar) currently deploying fiber optic-based access technologies. Greater progress has been made in developing the mobile broadband market but the agenda for further action remains large. A few countries (Saudi Arabia, Bahrain) have launched 5G, several countries (GCC, Algeria, Jordan, and Lebanon) have rolled out the higher speed fourth generation of mobile telecommunication technology (4G) but most low-income countries still rely on 3G technologies that are slower (Fig. 8.8). In countries with monopolies across the broadband value chain (Djibouti) or with geopolitical tensions (Iraq, Afghanistan, Yemen), access is limited, network quality is poor and internet costs are higher. Slow internet constrains adoption of cloud services, AI, and IoT.



In the fixed broadband market, where entry barriers are prevalent, few countries (UAE and Qatar) deploy fiber optic technologies

In the more competitive mobile markets, several countries have migrated to 4G technologies although progress is uneven

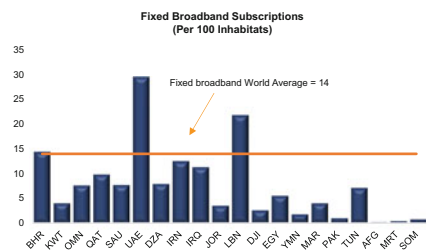
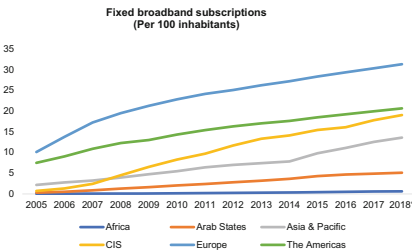


**Fig. 8.8** ICT infrastructure in MENAP countries (Source Telegeography, World Bank 2018. Note Data labels use International Organization for Standardization [ISO] codes. Source Fitch Solutions, Telecommunication Country Reports. Note Data labels use International Organization for Standardization [ISO] codes)

Access to broadband internet is limited in some countries, particularly in the lower income countries, and this constrains SMEs’ ability to embrace digital solutions, including e-commerce. Fixed broadband subscriptions are the second lowest in the world after Sub-Saharan Africa (SSA) and, with few exceptions (UAE, Lebanon), all countries trail global averages. Mobile broadband has become the predominant platform for internet access, but subscriptions trail all other regions after SSA (Fig. 8.9). Within MENAP,

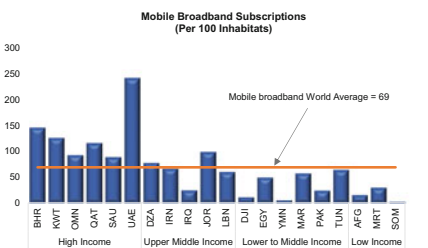
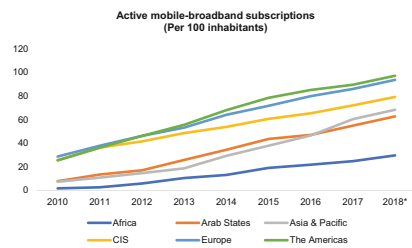
Access to fixed broadband is the second lowest in the world after SSA...

... and very few countries (UAE, Lebanon) have subscriptions above world averages



Access to mobile broadband, though increasing rapidly, is still among the lowest after SSA

Within the region, a digital divide has emerged with the GCC and Jordan exceeding global averages and the rest trailing behind.

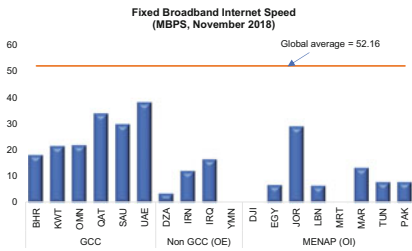


**Fig. 8.9** Access to broadband internet (Source ITU. Note CIS = Commonwealth of Independent States. Source ITU. Note: Data labels use International Organization for Standardization [ISO] codes. Source ITU. Note CIS = Commonwealth of Independent States)

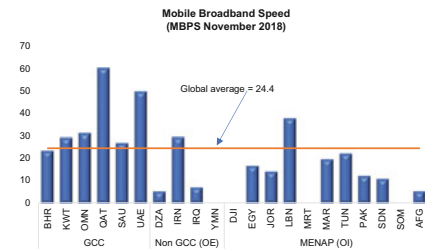
subscriptions are higher in the GCC and Jordan, while other countries are below the global average. Deploying infrastructure for rural coverage remains an economic challenge for many countries, thus a rural–urban digital divide has emerged.

Network quality and reliability continues to improve but remains a challenge, especially in the lower income countries, and this adversely impacts internet usage and adoption of digital solutions. Internet-connection-speeds in MENA for fixed broadband are below global averages for all countries, and the subscriptions are mostly at speeds below 10 Mbit/s,<sup>11</sup> reflecting the slow transition to fiber optics. For mobile broadband, the GCC, Iran, and Jordan are among the few countries where the speeds are above global averages (Fig. 8.10), reflecting advancements in rolling out 4G and spectrum allocation, especially above 1 GHz. For some countries general restrictions designed to limit the influence of social media negatively impact network reliability. Low download speeds constrain e-commerce which requires high bandwidth to download images and videos. The low speeds coupled with regulatory constraints and insufficient local hyper-scale data center further inhibit the growth of bandwidth reliant technologies, such as cloud computing, IoT, and AI.

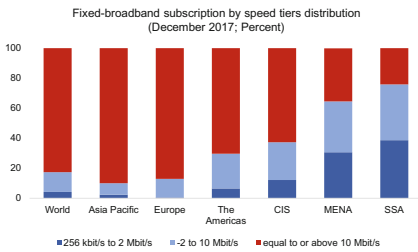
Average internet speeds for fixed broadband trail global averages...



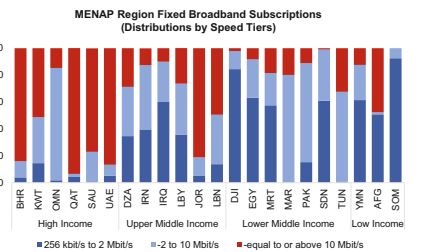
... similarly mobile broadband speeds for most MENAP countries are below global averages except for the GCC, Iran and Lebanon.



Most fixed broadband subscriptions are at speeds below 10 Mbit/s which are lower than other regions outside SSA



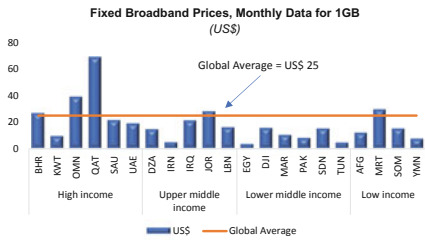
Across the region, only a few countries (Bahrain, Qatar, UAE and Jordan) provide internet at speeds above 10 Mbit/s



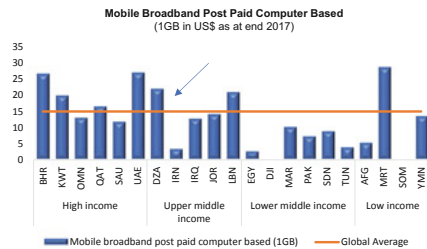
**Fig. 8.10** Internet speed (*Source* Speedtest Global Index. *Note* Data labels use International Organization for Standardization [ISO] codes. *Source* ITU. *Note* CIS = Commonwealth of Independent States; MENA = Middle East and North Africa; SSA = Sub-Saharan Africa)

The high cost of internet also hampers SMEs’ digital transformation. The average cost of broadband packages has been declining but remains unaffordable in several low-income countries (Fig. 8.11). Constrained access to the international gateway and the absence of IXPs in many countries also contribute to higher international internet costs. Limited competition in some countries (UAE) and underdeveloped technological infrastructure (Mauritania) also push up prices and limit capacity to provide businesses with affordable bandwidth. With regional bandwidth costs several times higher than many other countries, businesses could face challenges developing cloud-centric business models or competing.

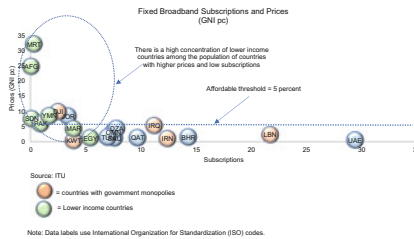
Though fixed broad band prices are mostly lower than the global average



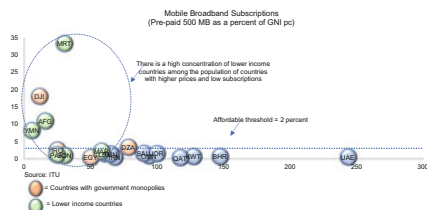
... the cost of mobile broadband remains higher than global averages in several countries



Fixed broadband prices are above the affordability threshold in several countries, particularly in the low income countries and the high prices are associated with low subscriptions



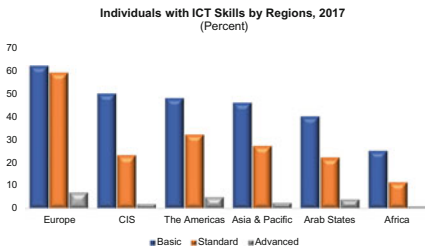
Mobile broadband prices are similarly unaffordable in several countries particularly in the lower income countries and subscriptions for this group are equally lower



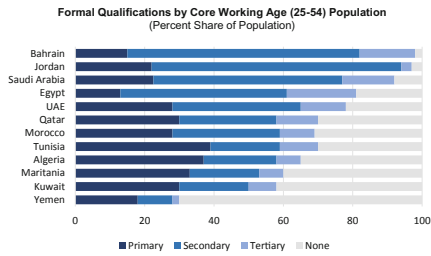
**Fig. 8.11** Broadband prices (Source ITU. Note Data labels use International Organization for Standardization [ISO] codes)

The large and growing digital skill gaps constitute another major challenge for SMEs’ ability to compete for IT skills and adopt digital solutions. The MENAP region rates the second lowest after SSA in basic, standard, and advanced digital skills (Fig. 8.12). The skill gaps cut across the region, but low-income and conflict countries face more fundamental challenges in developing their human capital through education (WEF 2016). In addition to the ability to invest in education, higher income countries (GCC) also attract expatriates but some countries (Lebanon, Egypt), with high levels of digital expertise suffer brain drain. The digital skill gaps are reportedly more acute in the areas of cloud, AI, machine learning, mobile technologies, blockchain, data analytics, and advanced security (Galviz 2020). A misalignment between

ICT skills in MENA are lower than in most other regions...



... and some countries (Jordan, Egypt) with high education levels suffer brain drain

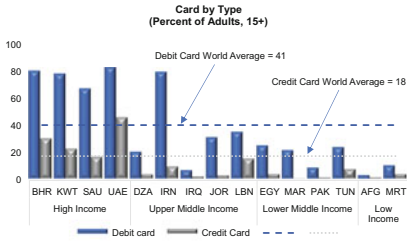


**Fig. 8.12** ICT digital skills (*Source* WEF and the Global Competitiveness Report 2019. *Source* World Economic Forum, Human Capital Index 2016)

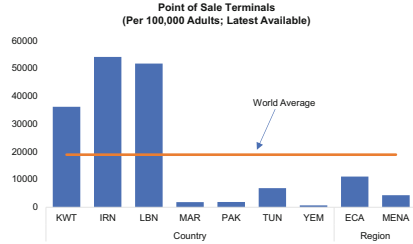
educational curriculum and labor market demands together with the rapid pace of technology contributes to the gaps (EY 2015; Bricker 2019). Public sector digital transformation projects in some countries (GCC, Egypt, Jordan, Lebanon, Tunisia, Pakistan) will increase demand for IT skills relative to supply (EY 2015).

Digital financial services (DFS), though growing rapidly, do not yet provide a strong foundation for SME digital transformation across the region. The infrastructure critical for SMEs to accept electronic payments—such as Point of Sale (POS) terminals—have limited penetration, in part, reflecting restrictions on the role of agents in financial services delivery. Few countries (Jordan, Egypt, and Morocco) have achieved interoperability in their mobile payments systems. Digital payment instruments (credit and debit cards) are also still limited in most non-GCC countries. Debit cards, which are more prevalent, are not accepted in e-commerce transactions. Fintech innovations are still concentrated in seven countries (UAE, Saudi Arabia, Bahrain, Egypt, Iran, Jordan, and Lebanon) and are focused more on payments and less on the provision of credits, such as P2P and crowdfunding (Fig. 8.13). Banks’ capacity to assess digital projects also remains limited.

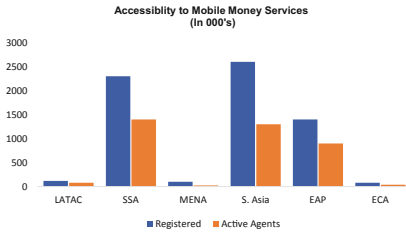
With the exception of the GCC and Iran, credit and debit cards are not yet prevalent



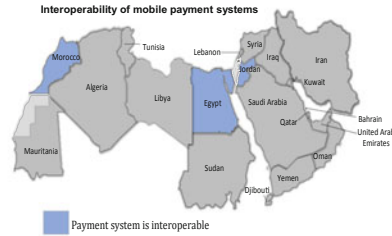
POS needed for consumers to pay electronically are relatively scarce in several countries



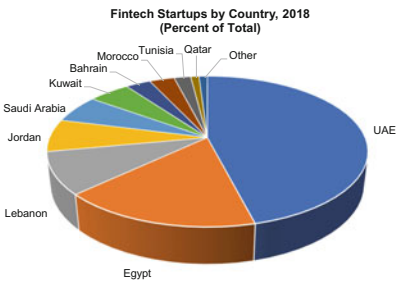
The infrastructure facilitating access is equally underdeveloped...



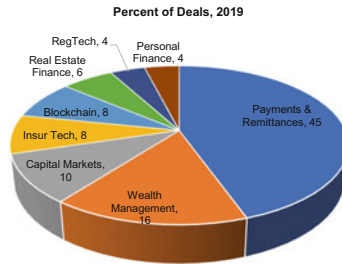
...and few countries have interoperable mobile payment systems.



But fintech activity remain concentrated in a few countries

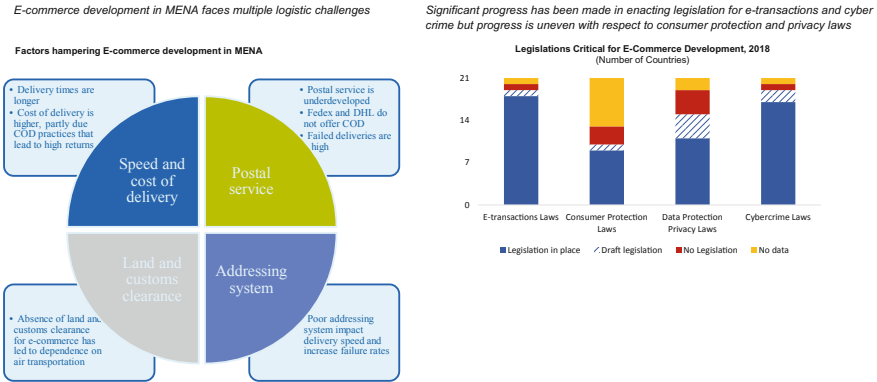


Innovations are focused on payment and much less on lending...



**Fig. 8.13** Digital payment infrastructure and finance (Source World Bank Findex Database. Note Data labels use International Organization for Standardization [ISO] codes. Source World Bank. Source GSMA. Source Magnitt and Abu Dhabi Global Market, MENA Fintech Venture Report)

The importance of e-commerce is well recognized in the region, but preconditions are lacking in most countries (Fig. 8.14).<sup>12</sup> In 2016, the Arab Federation of e-commerce was established to develop the MENA’s e-commerce sector.<sup>13</sup> However, e-commerce logistics—unified address systems, area codes, postal service, land customs—are deficient, and this hampers last-mile delivery,<sup>14</sup> causes delays in delivery, and increases dependence on more expensive air-shipments (Fabre 2019). Online marketplaces and digital payment instruments are limited while many SMEs lack the skills to develop effective websites. Outside of the GCC, many countries in MENAP have large shares of unbanked and unconnected populations which limits demand.



**Fig. 8.14** Factors constraining e-commerce development in MENAP (Source Google and Bain, White Paper 2018)

Legislative measures for e-transactions and cybercrime are largely in place, but less progress has been made with respect to consumer protection and data protection and privacy legislation. Several countries, for instance, the GCC and Jordan have launched digital signature services which should help increase e-commerce.

Digital government or e-government strategies have become prevalent, but few have developed nationwide digital strategies (McKinsey 2016). At the end of 2018, half the countries ranked very high (Bahrain, UAE) or high (Jordan, Iran, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, and Tunisia) on the UN E-government development index. With respect to online provision of government services, seven countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE, and Tunisia) rank very high followed by Egypt, Iran, Morocco, and Pakistan. The strategies, however, mostly focus on the digitization of government services, which is a good starting point, but few countries (Egypt and Oman) have nationwide digital strategies (McKinsey 2016). Similarly, few countries (Saudi Arabia) have developed online services that target SMEs.<sup>15</sup>

### 8.3.6 Demand-Side Constraints

Demand-side constraints currently constitute the immediate impediment to the digitalization of SMEs in MENAP. The large digital “usage gap” that is several multiples of the “coverage gap” suggests that the constraints to digital adoption go beyond coverage.<sup>16</sup> In particular, while the coverage gap has significantly declined, the “usage gap” increased before plateauing at an elevated level. Lack of internal digital capabilities, high cost of broadband internet, knowledge gaps in SMEs about suitable digital solutions, financial constraints, and limited implementation capacity are some of the factors constraining demand for digital solutions by SMEs. The readiness of

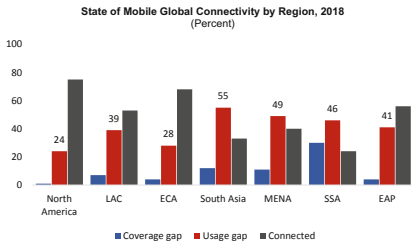
consumers is another limiting factor. There is still widespread lack of trust in digital payments which, in part, reflects concerns with cyber risks and privacy breaches which is coupled, in some cases, with a lack of devices to access internet.

The lack of internal digital capabilities and knowledge gaps among SMEs in MENAP are, in part, a reflection of the disproportionate impact of skill gaps on SMEs. While the MENAP region faces digital skill gaps in general, the scale of SMEs and limited financial resources make it difficult to compete for talent with big corporations and governments that offer higher wages.

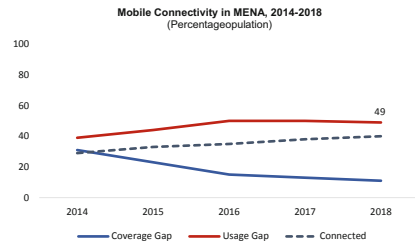
Consumers in many of the non-GCC frontier markets are not well equipped to adopt digital solutions needed to support SMEs' digital transformation. In many lower income countries, half the population do not have access to affordable quality internet and unconnected persons cannot participate in the digital economy. Ownership of smartphones and other internet-enabled devices is also uneven along income lines with the higher income countries (GCC) exhibiting high penetration rates (Fig. 8.15). The cost of internet-enabled devices has not fallen sufficiently and remains a key barrier to mobile ownership in lower income countries (GSMA 2019).

Lack of trust, slow pace of modernizing the banking sector, and regulatory gaps also constrain adoption of digital payments. Consumers still do not trust websites to handle their information and are unaware of their consumer rights, thus Cash on Delivery (COD) is the preferred method of payment even for online purchases (Fig. 8.15). Countries with low penetration of debit and credit cards have been associated with low adoption of digital payments. Moreover, most telecoms-led mobile digital wallets that are available in the region offer basic functions, such as person-to-person credit transfer, but they do not yet support online payments. Restrictive regulations that limit non-banks from issuing e-money also constrain adoption and usage of mobile money (Lukonga 2018).

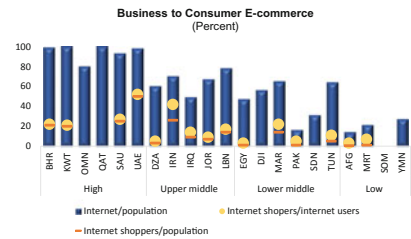
The MENA has the second highest usage gap globally and the usage gap exceeds the coverage gap suggesting that demand constraints are binding



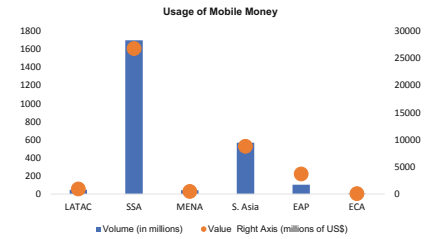
Moreover, while the coverage gaps has been declining, the usage gap increased before plateauing at elevated levels



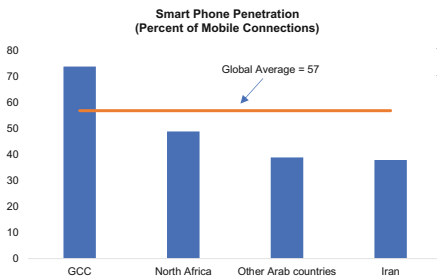
The share of internet shoppers in relation to internet users and populations is low for most countries



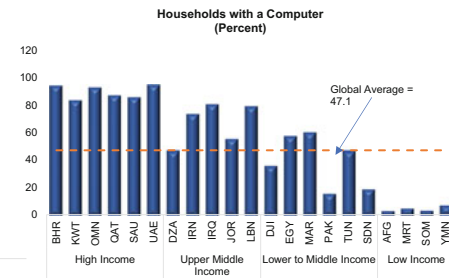
...and usage of mobile money is much lower than many other regions



Higher smartphone penetration in the GCC also facilitate internet usage



Households with computers and capability to participate in the digital economy are mostly in the higher income



**Fig. 8.15** Consumer readiness (*Source* GSMA. *Note* EAP = East Asia and Pacific, ECA = Europe and Central Asia; MENA = Middle East and North Africa; S. Asia = South Asia; SSA = Sub-Saharan Africa. *Source* UNCTAD. *Source* GSMA. 2017. The Mobile Economy Middle East and North Africa. *Note* Data labels use International Organization for Standardization [ISO] codes. GCC = Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE. North Africa = Mauritania, Morocco, Algeria, Tunisia, Libya, Egypt other Arab countries = Somalia, Sudan, Jordan, Syria, Iraq, Lebanon, Palestine. *Source* ITU. *Note* Data labels use International Organization for Standardization [ISO] codes. *Source* Bain & Co. Commerce in MENA Opportunity beyond the Hype. *Source* World Bank Findex Database)



There is a lack of trust in e-payments that has resulted in consumers preferring Cash on Delivery (CoD) ... and outside the GCC and Iran, use of digital payments is limited

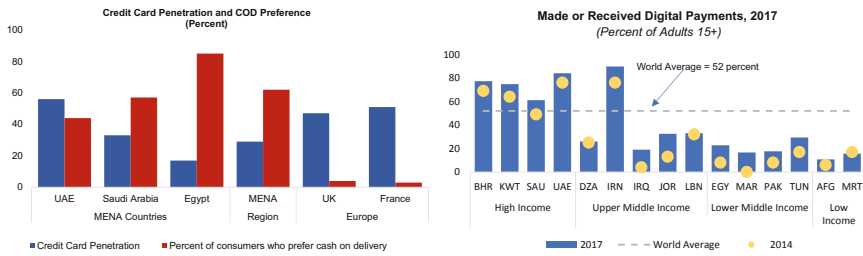


Fig. 8.15 (continued)

### 8.4 CONCLUSIONS AND POLICY OPTIONS

Policies to promote SME growth and contribution to employment have not had the envisioned success, thus a fundamental rethinking of the strategy is needed. Partial implementation of reforms and idiosyncratic factors contributed to the underperformance, but frictions in the design of SME policies also played important roles. A perpetuation of the same strategy, therefore, cannot yield the needed growth in SMEs and in employment. In a rapidly digitalizing global economy, the growing digital divide will increase inequalities between countries and firms without a digital presence can become marginalized.

Digital technologies promise to be a game changer in boosting the growth of businesses and their resilience to shocks, but technology by itself will not lead to broadly shared prosperity. Transformational visions outlined by some of the countries are the right path forward but there is a need to move from e-government-focused digital initiatives to full digital economy development (McKinsey 2016), and for more countries to create the needed enabling environment to foster digital innovation. Firms will need to embrace agility through digital to address the ever-faster changing business environment. Overall, a well-articulated strategy that addresses supply and demand constraints to digital adoption by businesses and sustained efforts to implement financial sector and business support reforms is the key to success.

#### 8.4.1 An Enabling Environment for the Digitalization of SMEs in MENAP

Digital ecosystems have developed unevenly across the MENAP region, thus the priorities for countries differ. The GCC has achieved a high level of connectivity and broadband penetration, but the scope remains to strengthen other elements of the digital ecosystems for SMEs and develop the frameworks for adoption of cloud technologies and services. For most other countries the connectivity infrastructure remains inadequate, access and usage of broadband

internet remains a challenge for large segments of the populations, and the digital ecosystem exhibit major gaps, thus the reform agenda is much broader.

Investments in ICT and other digital infrastructures should be a top priority, and universal access to affordable high-speed quality internet a key objective. The GCC has achieved high levels of 4G coverage and network performance, but could benefit from further investment in fiber networks, cloud computing, IXPs, and data centers, as well as improved spectrum allocation and increased competition. For most other countries, improving access and quality of internet is a priority, and this requires removing barriers to entry and competition across the value chain—eliminating monopoly status over the international gateway, liberalizing the market for building and operating domestic backbone networks, encouraging open access to networks for fixed international and domestic long distance, and allowing competition in end-user connectivity. These measures, along with initiatives related to decreasing costs, are crucial to creating a favorable investment climate and boosting infrastructure rollout.

Educational and labor market reforms should be accelerated and aligned with industry needs to reduce the digital skill gaps. Efforts should focus on increasing the supply of digital skilled staff to enable businesses to fill positions and the labor force to participate in the digital economy. Creation of digital curricula and seamless learning pathways from primary schools to higher education and into employment will be essential (McKinsey 2016). This entails mandating Science, Technology, Engineering, and Mathematics (STEM) subjects in school curriculums, providing technical and vocational education and training through public–private partnerships. The fast pace of digital evolution also requires that investments in education provide lifelong access to learning opportunities. Easing labor restrictions to facilitate expatriates in highly technical areas can also help reduce the skill gaps in the immediate term.

Digital financials services (DFS) are the lifeblood for digitalization and require policies that promote innovation policies while mitigating the risks. Banks need to develop expertise in assessing digital projects, but governments can create an enabling environment by ensuring that reforms address the regulatory constraints that impede innovation as well as investments in the payment infrastructures. More specifically:

- Central banks, in collaboration with financial institutions, should strive to have retail digital payment systems that are interoperable and facilitate real time, convenient, safe, and ubiquitous payment services.
- Regulations should facilitate the establishment of P2P and crowdfunding platforms, payment gateways, and Points of Sale (PoS) terminals.
- Regulators should step up oversight activities of digital financial services to fully monitor and ensure safety, efficiency, and reliability of DFS and engage telecom regulators to enhance operational reliability of DFS.

- Collaboration with telecom regulators can help enhance operational reliability of DFS, particularly in remote and rural areas, which may pose operational risks that could adversely affect agent and customer confidence in DFS.
- Regulatory sandboxes can help enhance supervisory communications with market participants, accelerate digital transformation of traditional entities, and improve their knowledge of technologies, market development, and application of regulatory and supervisory frameworks. Risks will, however, need to be addressed, including ensuring an even playing field between fully regulated entities and those operating in the sandbox to avoid regulatory arbitrage (Wilson and Anastasiia 2019).

Digital government or e-government strategies should go beyond digitization of government services to include national strategies. Digitalizing government services can also help in collection of data for effective policy formulation. Electronic procurement can stimulate the modernization of SMEs and provide incentives for SME use of ICTs and e-commerce.

Other infrastructure gaps will need to be closed. There is a need to address logistics challenges such as inadequate warehouse coverage, scarcity in regional distribution centers, weaknesses in postal services, and lack of postal codes as well as limitations in land and customs clearance. As internet requires a reliable supply of electricity, infrastructure gaps in the energy sector, though not discussed in the paper, will need to be addressed.

The large internet “usage gap” indicates that demand constraints are binding, thus policies to promote SMEs’ uptake of digital solutions are needed. Gaps in digital skills and know-how call for awareness campaigns on the benefits of digital technologies; promoting relevant content, including in Arabic; providing SMEs with training facilities in ICT; and holding digital literacy programs to enable consumers to participate in the digital revolution while avoiding fraud and costly mistakes. Barriers relating to affordability of ICT services call for policies that encourage competition and a review of how ICT taxation impacts affordability of devices. Trust is also fundamental to SMEs adopting digital technologies, thus coherent strategies for digital security and privacy and online consumer protection are critical. In addition, internet cannot function without electricity, thus ensuring reliability of electricity supply should be an equal priority.

There is merit in reviewing regulatory and supervisory frameworks to ensure that they allow the appropriate and safe use of innovative technologies. Investments in ICT and payment infrastructure should be complemented with regulations for e-transactions, consumer protection, and data privacy so as to balance the need for firms to collect and analyze data for innovation and efficiency gains with the concerns about security, privacy, and data governance as well as e-signatures and e-contract laws. Other areas deserving attention are electronic signature laws, contract enforcement, insolvency, intellectual property laws, KYC requirements, and cross-border remittances.

The rural-urban digital divide requires government intervention. The digital divide threatens to widen income inequalities and render the policy objective of inclusive growth elusive. National digital strategies should have clear targets to achieve universal affordable high-speed internet, and policies should address the commercial viability of rural telecom infrastructure rollout.

#### *8.4.2 Financial Sector and Business Environment Reforms*

For digital benefits to materialize, further reforms are needed in the financial sector and business environment. Five reform areas warrant attention, including deepening the financial sectors, ensuring coherence in policy mix, improving the business environment, strengthening the institutional support framework, and developing SME statistics.

Financial sectors need further development to strengthen financial infrastructures, non-bank financial segments, and capital markets. Further efforts are needed to deepen and broaden the coverage of credit registries and bureaus to include SMEs, to modernize the insolvency regime to avoid criminalizing bankruptcy that occurs as part of normal business operations and reduce the time for resolution and improve recovery rates. There is also a need to enact secured transactions laws for moveable collateral to allow a broader range of collaterals (immovable and movables) with clear priority rankings of claims over collateral supported by electronic registries that make priority interests publicly known. Improvements are needed to regulatory frameworks for microfinance, factoring, and leasing. Corporate bond markets, private equity, and venture capital have room for improvement in all countries (McKinsey 2016). Regulators should also ensure comparable supervisory approaches across financial institutions, albeit on a proportional basis.

Macro and regulatory policies need careful calibration to ensure a coherent policy mix and minimize unintended consequences. Interest rate caps can discourage bank lending to SMEs since it limits the ability to price risk appropriately, thus a relaxation of interest rate caps is needed. Policies to promote bank lending to SMEs should be balanced to ensure that financial inclusion objectives are not achieved at the cost of financial stability. Public sector wages should be reviewed from the perspective of competitiveness. Government borrowing to finance fiscal deficits should take account of the risks of crowding out the private sector, especially SMEs.

The institutional support framework for SMEs needs streamlining and to be refocused. There is a need to address fragmentation and overlapping mandates, improve coordination and establish a formal definition of SMEs that is consistently applied. SME support policies should tilt from providing soft financing toward enabling SMEs to qualify for financing by enhancing their managerial capabilities. There is a need to institutionalize programs such as business incubators to assist entrepreneurs effect their ideas and raise the level of patentable

innovation. Regulatory impact studies should be undertaken at regular intervals and special incentives should be given to SME scale ups or “gazelles” that have potential to create quality job opportunities.

More systematic and regular compilation of SME data is needed to facilitate policy formulation that is evidence-based. This requires information on the number of firms—characteristics of the SMEs by size, gender, age and education, their sectoral distribution, their contribution to output and employment, new entries and exits, gender participation, and bank credit to SMEs and SMEs share of NPLs.

## NOTES

1. Digitalization is the use of data, digital technologies, and interconnections to create business or change existing activities.
2. The three countries not covered include Syria, Libya and West Bank and Gaza (WBG).
3. There is no universally agreed definition of SMEs
4. International and regional infrastructure provides connection to the rest of the world, the national backbone and backhaul then carriers traffic from international gateways to other regions of the country, and access networks or local loop provides the links between the domestic backbone to the customers, and uses either fixed or mobile broadband technologies.
5. Many countries in MENAP don't have postal codes and this makes locating an unfamiliar residential address very challenging when delivering products ordered online. New apps with GPS functionality can now help locate a recipient using their phone numbers and ease last minute delivery challenges.
6. For example, Alibaba has 30,000 employees, but provides a platform for more than 10 million ancillary jobs. Uber has a few hundred coders, but it supports the livelihoods of around 1 million on-demand drivers (World Bank 2016).
7. For instance, Georgia has successfully created an electronic land and property registry using blockchain.
8. In MENAP, cyber-attacks particularly targeting the GCC have been increasing (Symantec 2019). Policy makers are giving these risks increasing attention, but many countries have not developed solid digital strategies.
9. Data centers and cloud services are provided by Microsoft, Amazon Web Services (AWS), Oracle, Alibaba, and SAP.
10. In Bahrain local merchants are not utilizing online-platforms, so customers purchase goods from other markets. In Kuwait, most e-transactions are related to banking or brokerage services. Overall, the products mostly traded in online sales are consumer electronics, computers, fashion accessories, women's apparel, cosmetics perfumers, etc.
11. While there are no defined thresholds for what constitutes reasonable high-quality services, regulators consider download speeds above 10 Mbps as decent broadband speed and 30 Mbps is considered superfast (GSMA 2019).
12. To thrive, E-commerce needs to be supported by high speed internet, logistics and trade facilitation, e-payment, e-platforms, skill development, talent, awareness, e-procurement and legal and regulation governing e-transactions, data protection and privacy, consumer protection and cybersecurity.

13. The Arab Federation represents 14 countries across the broader MENA region. Some countries (Saudi Arabia, Egypt) have also embarked on national strategies to promote e-commerce among SMEs.
14. Innovative solutions that use GPS functionality to locate customers using their phones are in early stages.
15. Saudi Arabia's digital portal Etimad enables easy access for all SMEs to government tenders, ensure fair competition, increase transparency and greater opportunities.
16. The "usage gaps" captures the disparity between people who live in areas covered by mobile broadband but who are not using internet.

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## Blockchain Technology and Cyber Risk





# Alternative Data in FinTech and Business Intelligence

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## 9.1 INTRODUCTION

Alternative data is transforming the financial industry in insurance, crowd-funding, investment management processes, etc. Most asset managers, including hedge funds, mutual funds, foundations, and pension funds, start to realize the complex forces driving this digital transformation. Investment managers that do not follow this seismic shift and update their investment processes are increasingly facing strategic risks and disintermediation: they may very well be outmaneuvered by existing and new competitors who build their processes around alternative data. Understanding the value created from alternative data and participation in this trend provides strategic opportunities for both industry and academia. Big data is generally characterized by high volume, velocity, and variety; hence, they often require specific technology and analytical tools, e.g., Machine Learning and Natural Language Processing, for transformation into value (De Mauro et al. 2016). The recent advances in

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data storage, cloud computing, and statistical tools have gradually reduced costs of gathering data, spurring numerous third-party data aggregators and collectors. This gives rise to alternative data that are not from standard statements or reports, or are unstructured in terms of format. While alternative data have been actively explored in computer science and engineering fields (e.g., voice recognition and machine translation), researchers in finance and business economics have only started to devote attention to them in the past decade.

Given the large number of studies on the emergent field of alternative data and the lack of well-established frameworks for analysis, this chapter provides a brief introduction to a few major types of alternative data, as well as the methods and examples of analyzing or utilizing them, in academic research or practice.

We start with textual data and analytics, which have been used in finance and accounting since the dawn of the century. We discuss the various approaches, the data sources, and recent developments. We then move on to examine images, another form of unstructured data that is available in abundance before touching on audio and video data.

Another non-mutually exclusive major category of alternative data entails digital footprints. The ubiquitous adoption and usage of smart and connected mobile, web, and sensor technologies today have completely changed the way individuals behave and make decisions. These smart technologies have led to the pervasive digitization of individual behavior across digital and physical environments at a very fine-grained level (e.g., social media activities and digital word-of-mouth, online search and clickstream, online and mobile shopping, mobile app activities, and location trajectories), all of which we term as “digital footprints.” This information can provide a new lens through which practitioners in the financial industry can better monitor, understand, and optimize human decision-making in the market. By looking into these digital footprints of human beings and their interactions with technologies, managers and policymakers can design more effective strategies for financial platforms to improve the profitability and economic welfare of institutions.

Finally, we discuss the Internet of Things (IoT), which has become prominent in tech innovations and represents a dominant source of alternative data. Widely regarded as a breakthrough in improving consumer lives and retail industry efficiency, the IoT is prevalent in business activities such as manufacturing, logistics, personalized recommendation, etc. With its development comes data collected from decentralized crowds. IoTs can track customers’ real-time location to better understand their behavior, generating micro-level information to better predict the future performance of corporations. New technological solutions developed based on the IoT for retailers enable the exploration of authentic customer’ behaviors and cheaper marketing opportunities across the world. Whether these innovations take the form of customer experience improvements or business process optimization, the possibilities for IoT are endless and not yet fully understood. We intend to provide

some insights into IoT's huge potential by illustrating several examples of IoT-powered data applications.

The aforementioned alternative data exhibit several common features. First, they are ad hoc, non-standard, with large volumes and large dispersion in terms of data quality. Therefore, we need new tools such as neural-network-based natural language processing and cloud computation. We also need to be very careful in the collection and pre-processing of data for meaningful information retrieval.

Second, alternative data are also often generated jointly by large crowds. In that regard, they are hard to manipulate because individuals all have limited influence on the process. For example, it is easy for someone to fake a personal phone number, but the location data collected by mobile service providers are hard to tamper with. Even if one manipulates his or her location, it constitutes just one data point in a data set with millions of observations, and would thus hardly affect any aggregate analysis.

Finally, alternative data are more diverse and available compared to mainstream numerical data. This means small firms and new entrants may utilize them to have an edge in this nascent stage of industry evolution. This encourages competition and facilitates financial inclusion. Moreover, these data enable them to fill missing markets and better serve the unbanked and historically disadvantaged populations (e.g., thin-filed users, low-income or less-educated people), who otherwise may not receive access to financial services due to no/low historical financial credits in a traditional setting. Therefore, the emergence of alternative data has impacts on the real economy with welfare consequences.

The remainder of the article is organized as follows: Sect. 8.2 discusses a few common forms of alternative data; Sect. 8.3 introduces research and uses cases on digital footprints; Sect. 8.4 surveys applications of data generated from the Internet of Things; finally, Sect. 8.5 summarizes promising future directions for research and for industry development.

## 9.2 TEXTS, IMAGES, VOICES, AND VIDEOS

### 9.2.1 *Textual Data and Analyses*

Texts are perhaps the most salient alternative data used in finance and business economics. News articles remain a rich source of information in textual formats. The Wall Street Journal's data are widely used in academic studies, as are The New York Times and the Financial Times. News not only conveys information through each article, but also reveals hidden structures of corporate networks (Schwenkler and Zheng 2019).

Beside news in general, firm-specific news from Factiva could complement corporate filings such as 10K and 10Q (Management Discussion and Analysis

[MD&A], Risk Factor Discussions, etc.) for cross-sectional analysis. Conference call transcripts, analyst reports, IPO prospectus, patent data, and tweets are all alternative data sources.

Earlier studies using textual data are typically count-based and rely on the researchers to predefine a relevant dictionary or word list. Antweiler and Frank (2004), Tetlock (2007), and Loughran and McDonald (2011) are notable pioneering studies. Given the maturity of textual analysis in finance and business economics, for survey articles on text-based analysis in economics, sociology, and political science, we refer the readers to Gentzkow et al. (2017), Evans and Aceves (2016), and Grimmer and Stewart (2013). In particular, Gentzkow et al. (2017) point out that new techniques are needed to deal with the large-scale and complex nature of textual data.

Machine learning is such a technique that is increasingly used in textual analysis. One unsupervised learning tool, Topic Modeling (typically implemented using Latent Dirichlet Allocation [LDA] first introduced by Blei et al. [2003]), has gained popularity in economic and finance studies (Huang et al. 2017; Jegadeesh and Wu 2017). The algorithm lets data self-generate topics and themes. Word embedding from the natural language processing (NLP) literature presents an alternative machine learning tool. Such neural networks language models preserve the syntactic and semantic structure well while maintaining computational tractability. Cong et al. (2019) develop a textual-factor framework to allow projections of numerical or textual information onto a space spanned by a set of interpretable textual factors; Cong et al. (2019), and Hanley and Hoberg (2019) further combine LDA and word2vec to measure corporate governance and systemic risks in the economy.

The various textual analysis tools originated in economics, statistics, and computer science each have advantages and limitations, as illustrated in Fig. 9.1. Cong et al. (2019) contain general discussions of tradeoffs involved, as well as recent developments on word embedding, customized and dynamic count-based methods, and other cutting-edge statistical tools.

Reproduced from Cong et al. (2019), Fig. 9.1. Textual analysis in economics and finance is traditionally count-based, whereas statistical models for analyzing texts often involve inference and regression models that are transparent. More recently, advances in machine learning and natural language processing, especially in deep learning, allow researchers to use black-box machine learning tools to extract information from texts.

### 9.2.2 *Images*

Another popular alternative data related to finance is satellite imagery. Image recognition techniques, particularly deep learning algorithms like Convolutional Neural Networks (CNNs), are adopted to process the satellite images. In recent years, many innovative usages of satellite imagery to cross-validate the business metrics, e.g., revenue and store traffic, have emerged.

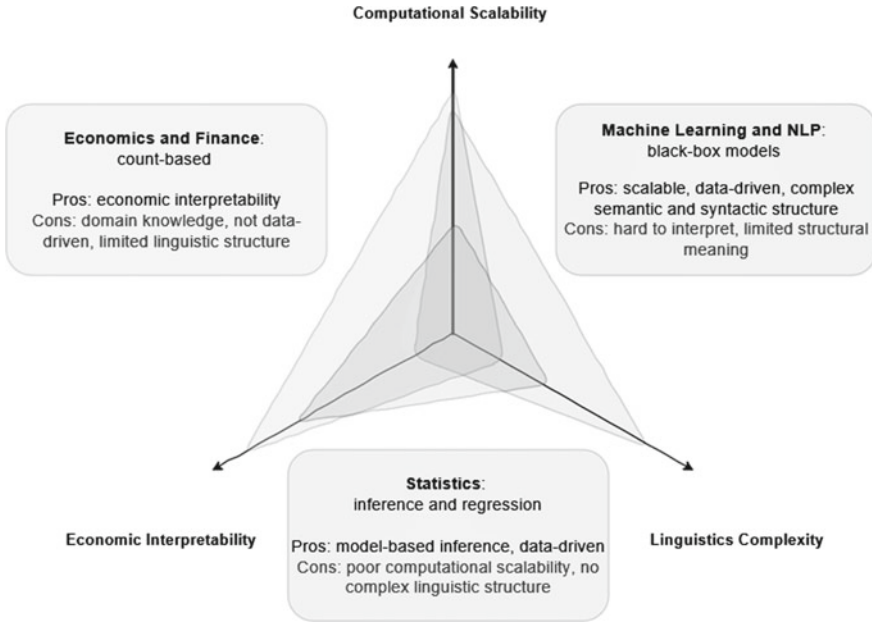


Fig. 9.1 Tradeoffs in various approaches to analyzing texts

Satellite firms provide preprocessing datasets for many sectors. Orbital Insight, founded in 2013, offers satellite data with broad sector applications (OrbitalInsight 2020). Kpler, founded in 2009, offers global oil & gas cargo flow data using satellite, government, and other public registry sources (Kpler 2020). Rsmetrics focuses on metals and commodities, real estate and industrial sector applications (Rsmetrics 2020). For example, RS Metrics is using satellite images of Tesla’s production lots to gauge how many cars are being produced and shipped. Machine learning algorithms not only are able to discern between various Tesla vehicle models, but also are able to tell which cars are still parked in the same space and have not been moved between images.

Spire Global, founded in 2010, offers AIS Data providing 3 years of past and real-time positional data for the worlds shipping fleet, satellite collected ADS-B data for aircraft tracking, and GPS-RO Profiles which enable more precise weather forecasting (Spireglobal 2020). Umbra Lab and ICEYE generate raw satellite data using micro-satellite technology that captures imagery regardless of weather conditions (Umbralab 2020; ICEYE 2019).

SpaceKnow, founded in 2014, provides ultra large-scale planetary analysis through the use of satellite imagery (Spaceknow 2019). It parses satellite imagery and has machine learning algorithms that automatically identify objects like cars, boats, trees, and even swimming pools. The usefulness of this tool is evident in examples like SpaceKnow’s Satellite Manufacturing Index (SMI) which is said to be superior to China’s Purchasing Managers Index

(PMI). The PMI is an index compiled by the National Bureau of Statistics of China which compiles the results of a monthly survey of enterprises' purchasing managers. SpaceKnow's SMI uses an algorithm that compares satellite images of more than 6,000 industrial facilities, and produces a result that's remarkably correlated to the index China produces.

Researchers in finance and accounting have recently started to exploit satellite images. For example, Zhu (2019) examines whether the availability of alternative data improves price informativeness and helps discipline corporate managers. Specifically, the author uses satellite images that provide normalized car counts in parking lots of retailers to find out if a reduction in formation acquisition through alternative data increases long-run price informativeness. To the extent that alternative data provide more information about future profitability of projects available, they can also discipline the manager to make better real investment decisions. The author finds evidence for both phenomena.

Beside satellite images, profile photos are also used in business-related studies. Willis and Todorov (2006) show that people typically make up their minds after a 100-ms exposure to a face. Graham et al. (2016) show that perceived competence plays a more important role than "beauty" in CEO selection and compensation. Bai et al. (2019) find that mutual fund managers who appear "confident" outperform their peers. X. Huang et al. (2018) find that the likelihood of funding increases with entrepreneurs' apparent competence.

Other literature uses facial features as a proxy for testosterone level to study the biological foundation of economic decision-making. For example, Jia et al. (2014) find that male CEO's facial width to height ratio (fWHR) positively correlates with the propensity of financial misreporting. He et al. (2019) document that the fWHR of Chinese male sell-side analysts is associated with higher forecast accuracy. Teoh et al. (2019) apply social psychology models and machine learning techniques to the LinkedIn profile pictures of U.S. sell-side analysts to study how facial traits affect analyst's behavior and performance.

### 9.2.3 *Voices and Videos*

The tools for analyzing images in finance and economics research are typically simple, with some exceptions using cutting-edge machine learning tools. Compared to images that are static, voices and videos are much harder to analyze and require more advanced analytics. Research in this area is just starting.

Mayew and Venkatachalam (2012) measure managerial affective states during earnings conference calls by analyzing conference call audio files using vocal emotion analysis software. They find that, when managers are scrutinized by analysts during conference calls, positive and negative affects displayed by managers are informative about the firm's financial future. Analysts do

not incorporate this information when forecasting near-term earnings. When making stock recommendation changes, however, analysts incorporate positive but not negative affects. Their study demonstrates that managerial vocal cues or expressions in conference calls contain useful information about a firm's fundamentals, incremental to both quantitative earnings information and qualitative "soft" information conveyed by linguistic content during the question and answer portion of earnings conference calls.

Another voice data application is the automation of call center operations through voice-enabled automation which provides a massive cost-cutting opportunity for insurance companies. Insurance companies can conduct sentiment analysis to identify certain customer traits and needs based on the emotion and tone in the customer's voice. Accenture developed a systematic method to detect the emotion of customers from voice signal data (Petrushin 2007). These types of improvements in voice processing not only offer cost reduction but also introduce game-changing innovations.

### 9.3 DIGITAL FOOTPRINTS

In recent years, the high penetration of mobile devices and internet access has offered new and unparalleled sources of fine-grained user-behavior data such as individuals' cellphone usage, online and mobile activities (e.g., web browsing, click-stream and tap-stream, shopping, and payment), social media and social network activities, GPS locations, and movement trajectories. We term these data "digital footprints" of users. In this section, we take financial credit risk assessment as an example, and discuss how such new sources of alternative data can be leveraged to improve financial predictions, profitability, and social welfare.

#### 9.3.1 *Motivation*

Conventional data typically cover data from a credit bureau, a credit application, or a lender's own records on existing consumers. Alternative data, instead, come from public social media sites or private applications and devices, and might not directly relate to a consumer's credit behavior. Nevertheless, such new, rich sources of data could show significant potential to complement the conventional data in enhancing the accuracy of existing credit risk assessment (Carroll and Rehmani 2017). Moreover, recent studies have found that credit risk prediction suffers from unintended biases due to potential correlations between input (observed) features and sensitive attributes (such as race, gender, or income) (e.g., Barocas and Selbst 2016; Dobbie et al. 2018; Fu et al. 2019). To some extent, such correlations are due to a lack of control over unobservable factors. Leveraging alternative new sources of behavioral data can enable better control for individual features previously omitted from models, thus reducing biases in credit risk prediction.

Furthermore, prior work on financial credit risk prediction (e.g., Serrano-Cinca et al. 2015) mostly used training data heavily biased toward successfully approved loan applicants whose credit risks had been perceived to be low enough for loan approval (“approved samples” hereafter), as applications initially perceived to be high risk, on the other hand, tend to be immediately rejected, with the result that no further loan payment data on these applicants is to be recorded or included in model training later. Obviously, running credit risk models using approved samples alone can be rather problematic. Approved samples, compared with a true population of loan applicants, tend to have lower probabilities of default and may have significantly different socio-economic characteristics (e.g., higher income, better educated). The patterns or relationships learned from such biased samples might have limited generalizability, and hence may lead to poor predictive performance for new applicants. Moreover, if initially approved samples are biased (intentionally or unintentionally) toward certain sensitive attributes, such errors could be further amplified when training with such samples.

Motivated by the current challenges facing financial service markets, it is important for financial platforms to explore whether and how this new source of users’ digital footprint data can help alleviate these concerns. Can digital footprint data help improve predictive performance in microloan credit risk assessment? Moreover, which type of information is the most valuable? Besides, can such digital footprint data help alleviate concerns about training-sample bias (i.e., using approved samples only for model training)? How can we leverage this new type of alternative data to achieve more accurate risk assessment, better financial performance, and, ultimately, higher social welfare for financial platforms?

Note that it remains costly for financial service providers to acquire, store, and process information (Loufield et al. 2018). To obtain an individual’s information from multiple sources, financial service providers have to establish close relations with third-party data providers such as social media providers, telecommunication companies, and mobile network operators, as well as other specialized data vendors. Moreover, the increasing size and complexity of alternative, and mostly semi-structured or unstructured, information often requires sophisticated techniques and multiple players to turn it into something of value. Last but not least, financial service providers might face potential information privacy concerns and security regulations. Therefore, the ability to evaluate the credit risk of borrowers with minimally accessible information is key to the burgeoning microloan market.

In other words, given a plethora of structured and unstructured individual behavioral data available across various channels, what information is most valuable to the financial credit market? This is a major challenge for many financial platforms today. In a recent study (Lu et al. 2020), the authors examined and compared the values from various types of digital footprint data for credit risk assessment. The authors provided, for microloan platforms, important managerial insights into what information is the most valuable, and hence,



should be efficiently combined with conventional data to maximize profits and minimize potential prediction bias. We will discuss this in more detail in the following subsections.

### 9.3.2 *Recent Progress*

In the past, financial risk assessment focused on conventional features such as loan characteristics, borrower characteristics, credit history, and social capital (Mersland and Strøm 2010) argued that a larger loan amount is associated with a higher probability of loan default. Everett (2015) found a positive relationship between interest rates and default risks. Serrano-Cinca et al. (2015) compared the default risks of 14 loan purposes and ranked them from most risky (e.g., small businesses) to least risky (e.g., weddings). Based on a field experiment in India, Field and Pande (2008) found that the type of repayment schedule (i.e., weekly or monthly repayment) had no effect on delinquency or default. Getter (2003) showed that the size of a household's payment burden (i.e., monthly payments relative to monthly income) had an insignificant effect on delinquency and only a very small effect on default behavior.

Regarding personal (borrower) characteristics, both hard and soft information showed effectiveness for evaluation of default risks (Emekter et al. 2015). Hard information refers to structured and quantifiable information. Examples include the borrower's credit scores and demographic information (Gross and Souleles 2002; Iyer et al. 2015; Lin et al. 2013; Ravina 2007). Specifically, Ravina (2007) discovered that low credit scores and low incomes were related to high default rates. Gross and Souleles (2002) revealed a significantly positive correlation between borrowers' ages and default risks. On the other hand, soft information covers unstructured information, such as loan histories, current circumstances, and social networks (Collier and Hampshire 2010; Iyer et al. 2015). For example, Lin et al. (2013) observed that friendship within a social network was associated with a lower ex-post default rate.

With more access to digital footprint data such as cellphone usage and social media information in recent years, several scholars have studied default risk prediction. Tan et al. (2016) and Mehrotra et al. (2017) utilized phone usage data, browsing logs, and mobility traces to evaluate borrowers' credit risks. Their empirical findings suggested that the accuracy of default prediction increased by approximately 4% after incorporating users' cellphone call and SMS (text message) network data. Lu et al. (2020) and Ma et al. (2018) found that phone usage patterns, including telecommunication patterns, mobility patterns, and app usage patterns, offered predictive capability for loan defaults. In the study of Björkegren and Grissen (2017), individuals in the highest quantile of risk as indicated by behavioral signatures in mobile phone data were 2.8 times more likely to default than those in the lowest quantile. Regarding the usage of social media information, Tan and Phan (2018) showed that incorporating social network information could improve creditworthiness prediction in microfinance by up to 300%. Yuan et al. (2018)

proposed a parallel topic modeling method for user-behavioral pattern mining on microblog data, having found that it outperformed traditional credit scoring methods. Ge et al. (2017) examined the predictive values of borrowers' self-disclosure on social media accounts and a more active social media presence (e.g., having larger social networks and posting more messages).

### 9.3.3 *A Case Study of Microloan Risk Management*

In this section, we discuss in detail a case study by Lu et al. (2020) on leveraging user digital footprint data to improve microloan risk management. In this study, the authors cooperated with a major microloan company in an Asian country to conduct a large field experiment from December 2 to 22, 2017.

One critical challenge in designing and evaluating financial risk models is that the counterfactual scenarios are completely unobserved—when someone's loan application is rejected, platforms do not observe any further loan repayment behavior of this applicant in the future. This can cause at least two issues. First, platforms cannot evaluate the “what-if” scenarios in the real-world setting—what if we approved a different set of loan applications? Would that lead to a lower default rate and better profitability? These counterfactual scenarios are impossible to observe because platforms simply do not record these alternative applicants' loan repayment behavior if their applications got rejected in the first place. Second, an even deeper issue is that the training data used for model training only contain the “approved sample” from the previous practice. Those counterfactual cases (i.e., applicants who got rejected) will never enter the training data. This may lead to serious problems if the approved sample is systematically different from the counterfactual cases in certain “sensitive” dimensions such as race or gender. Risk assessment models based on partially biased training data may lead to unexpected financial bias or service inequality.

To alleviate these concerns, Lu et al. (2020) partnered with the financial platform and designed a novel “mega-experiment.” During the experimental period, the platform approved loan applications from all applicants (as opposed to the usual situation wherein only 40–45% of applicants are approved based on the personal experience of platform staff). It is worth noting that by approving all loan applications and tracking borrowers' repayment behaviors over time, the authors are able to recover all possible counterfactual cases—those applicants whom, under normal circumstances, would be rejected. This unique “mega-experimental” setting enables the authors to form an unbiased sample for model training by including behavioral patterns from the entire loan applicant population, and also allows for evaluation of the risk assessment model under various counterfactual scenarios that otherwise would go unobserved. The authors then collected a fine-grained dataset with detailed user digital footprint records from all loan applicants during the experimental period.

Furthermore, when calculating the profits of a microloan platform, the authors consider not only the losses from defaults but also the revenues from delinquent fine payments. Therefore, unlike previous studies with default indicators only (e.g., Duarte et al. 2012), they define a multiclass categorical credit risk indicator that captures the following borrowers' repayment behaviors: being delinquent, delinquent but not in default, and in default. The authors also consider the repayment rate and profit per loan (or loan profit) as alternative numerical credit indicators.

Given that their data cover multiple information sources, they construct and extract, as inspired from the existing literature, more than 100 features covering four main categories: commonly adopted conventional data (e.g., borrower demographic and socio-economic characteristics, credit history, and loan attributes), online activities (e.g., shopping), mobile activities (e.g., cell-phone usage and location mobility traces), and social media activities. Those features were applied to the training of different state-of-the-art machine learning models and identify the values of different sources of information for credit risk assessment in the contexts of delinquent and default cases. For comparison, similar analyses were conducted using approved samples collected from the same platform. This comparison between the approved samples and the full applicant sample enables the authors to identify the potential financial impact of training-sample bias.

This empirical analysis yields several interesting findings. First, the prediction results show that among the four sets of features constructed, mobile activities, particularly cellphone usage and mobility trajectory features, present the highest predictive power, followed by online shopping activities. For social media users, social media presence and sentiment are also valuable in predicting users' repayment behavior. Interestingly, at a more granular level, among all of the alternative data-related features, consumption of gaming-related products (e.g., game app usage, amounts spent on game cards) ranks at the top.

Second, a platform welfare analysis indicates that, when predicting borrowers' credit risks with cellphone usage and mobility trace information, the corresponding loan permission strategy yields 15% more revenue gains to the microloan platform than does the case with conventional features only. The platform can achieve a further 7% revenue gain when making loan approval decisions based on credit risk prediction with all of the feature sets. In addition, under certain loan approval rates, loan permission strategies based on the predicted delinquent-but-not-in-default probabilities or numerical repayment rates and loan profits can bring higher revenue gains than the current industry practice that is based primarily on the predicted default probabilities. This finding confirms that on the premise of accurate risk prediction with alternative data, lending to borrowers with a certain level of delinquency risk, despite a relatively high default risk, can also yield positive economic gains.

Third, this study demonstrates that bias indeed exists if only approved samples are used or only conventional data are used for model training, which

can lead to significant losses of not only prediction accuracy but also economic gains for microloan platforms. Interestingly, these existing approaches tend to favor higher income and more-educated applicants from areas with a more developed economy. By leveraging alternative data, microloan platforms are more likely to include lower income and less-educated loan applicants from less-developed geographical areas—those historically disadvantaged populations that have been largely neglected in the past. This case study thus demonstrates the tremendous potential of leveraging alternative data to alleviate such inequality in the financial service markets while achieving higher platform revenues in the meantime.

The contributions of this case study are multifold. First, it is the first study to investigate the predictive power and financial value of multidimensional alternative data (including cellphone and mobile app usage, mobility trajectories, shopping behavior, and social media information) for borrowers' credit risk assessment and microloan platforms' revenue enhancement. Second, while previous studies simply focused on default probability, this study contributes to the literature with more sophisticated credit risk indicators. This extra information allows us to examine the trade-off between profits from delinquency and losses from default. Third, the unique field-experimental setting can examine “what-if” counterfactual scenarios under different loan permission strategies. By comparing the final rankings of loan applicants based on the predicted risk scores (i.e., the recommended approved loans) generated by different models, data or training sets, financial platforms can interpret not only “what” strategies but also “why” these strategies perform better and lead to higher economic returns to platforms. Such interpretability is critical and can help institutions understand where potential prediction bias and economic loss may come from, and how to address them. Fourth, such an approach enables microloan platforms to easily adopt cost-effective solutions based on what is easier to implement in practice. For example, training-sample bias has been a major challenge in both prior research and industry practice, due to practical data limitations. Incorporating alternative data can largely offset potential economic losses caused by training-sample bias and can lead to a significant improvement in platform revenues even when platforms have no access to the unbiased full sample of loan applicants during model training.

## 9.4 APPLICATIONS OF IoT-BASED DATA

### 9.4.1 *IoT-Based Alternative Data*

Advances in the Internet of Things (IoT) have empowered almost every industry to become more efficient and smart. Due to the large amount of alternative data produced, IoT adoption has opened up a completely new landscape in many sectors, including finance. For example, contemporary farming uses LIDAR technology (a surveying method that measures distance to a target by illuminating the target with laser light and measuring the reflected light with

a sensor), typically used in autonomous driving cars, to identify insects while robots pick weeds with the aid of computer vision. Videos, images, and voice capture technology can help farmers monitor the growing process of crops. Construction technology startups, using artificial intelligence and the IoT, have made construction work more like a manufacturing process. Versatile Natures, an Israeli company, offers a holistic view of a construction project by mounting IoT sensors under the hook of a crane (Versatile 2020). The sensors constantly collect and analyze data, with the goal of giving site managers actionable insights such as information on materials, redundancies, construction progress, and crane utilization. Inspirit IoT, an IoT startup from Illinois, aims to reduce the impact of on-site environments on workers' safety and construction schedules by implementing an AI-based algorithm over a traditional monitoring system to detect safety concerns (InspiritIoT 2020). Inspirit IoT makes sensors that measure environmental metrics, including temperature, humidity, carbon monoxide, etc. IoT's penetration into industries such as retail and wholesale, and hence a sustainable growing opportunity in finance, can be attributed to the following advantages by IoT.

#### *9.4.1.1 Improved Customer Experience*

Today, many retailers have increased their interaction with customers, but the IoT will bring a more personalized and meaningful experience. As ordinary "objects" become smart devices, the customer experience becomes fully digital, creating a growing trend of personalization. Relying on this interconnected environment, companies can design and create products and services centered on each consumer with data rendered from IoT.

#### *9.4.1.2 Optimized Supply Chain Operations*

"Industrial Internet" describes how companies can use cloud computing, mobile telecommunication, big data, and other technologies to closely integrate digital space with the real world, thereby improving operational efficiency and fostering innovation. It is expected that by 2030, the combination of industrial Internet and IoT devices will create an additional value of more than \$14 trillion for the global economy.

In the face of increasingly complex supply chains, the growing importance of digital channels, and rising customer requirements, connected devices and products provide an opportunity for retailers to optimize operations. For example, wireless RF technology can improve the accuracy of inventory tracking, while data visualization technology makes it easier for employees to track the location of products in the supply chain. Merchants can even offer this service to customers, for example, to support customers in reviewing the progress of orders in the production and distribution process.

Store managers can also use online smart price tags to adjust pricing in real time, such as lowering the price of a promotional product or a poorly selling product, or increasing the price of a sought-after product. A fully integrated pricing system will help retailers better achieve price synchronization

between shelves, checkouts, and various channels, ensuring that online stores and physical stores are priced consistently.

In addition, merchants can integrate other IoT devices in the supply chain to further improve store operations and reduce costs. For example, sensors based on IoT technology can help store managers monitor and adjust lighting brightness and temperature to achieve energy savings and cost reductions while improving customer comfort.

Sensors can automate many of the tasks that currently need to be done manually, such as tracking inventory of individual items or adjusting prices, which will give salespeople more time to communicate with customers and further enhance in-store services.

As the above have clearly indicated, IoT technology helps firms to better understand once fragmented scenarios, leading to an improvement of business as a whole. From a FinTech perspective, the broad applications of IoT remain in the retail industry in which firms have the direct desire and incentives to push forward. The IoT has been maturing such that there are currently enough IoT sensors and devices that firms can start experimenting at a scale showing what the technology is truly capable of in various industries. As such, an enormous scale of alternative data is produced, intentionally or unintentionally, offering opportunities to study corporate business from multiple angles. This was utilized in the postcrisis period that was characterized by a low-interest rate environment such that investors spent large amounts of resources and capital in identifying anomalies through the alternative data of the IoT and rapid funding of their new discoveries.

We will discuss how IoT-based data is created and utilized in multiple business settings.

#### *9.4.2 The Advance of the IoT-Driven Retail Industry*

The retail industry caters to hundreds of millions of people each year. It also gathers and maintains multitudes of data—point of sales transactions, customer details like addresses, reviews on e-commerce websites, browsing history, vendor details, product details, etc. Given the proven effectiveness of the use of data to create sophisticated and accurate systems that learn through experience, it makes sense that retailers, with all the data in their possession, make use of this data and current technology to create vastly personalized buying experiences for customers, more efficient inventory and delivery processes, and increasingly secure environments for purchasing products.

E-commerce dramatically shifts the strategy and structure of firms that are active in domestic and international markets as companies race toward the digitization of their business processes (Koh et al. 2006). These shifts create new opportunities for small- and medium- sized enterprises (SMEs) that want to compete with the major incumbent players in markets. Most of them heavily rely on the technical assistance from large high-tech firms or market places, e.g., Google or Amazon, where customer relationships are nourished

and supported by digital tools. Retailers may have a lot of issues—ranging from inventory to location to customer service—but one of the largest challenges arises from unnecessary marketing failures that are fully self-inflicted. For instance, the brand is often “lost” from the moment of a product entering into the sales channel.

In the four key aspects of the retail business—product, efficiency, store, and sales—online brand promotion and e-commerce have gradually visualized the effective marketing of products and their impacts. In online stores and marketing, due to the complex and diverse sources of store traffic, it is often difficult to effectively precipitate user assets, while the effect of offline promotion is hard to track, resulting in the separation of online and offline data information. From a financial planning and marketing budgeting perspective, the question of who are the consumers at the other end of the product, often becomes a blind spot for the brand to perceive the user, making it extremely challenging to convert the sales into non-switching or long-term consumers. That, coupled with the problems of frauds, low-quality replica, and other issues, alongside the interference from certain unlicensed middlemen make the marketing cost of brand investment out of the real value of the target end users and service providers. Researchers (e.g., Peng 2012) have classified the factors tied to marketing failures into three major groups, including competition-specific, institution-specific, and resource-specific factors, that condition online retail companies’ online strategies. These failures, unfortunately, though retail involves unlimited exogenous factors and multiple issues, stand out to become problems that arise from a failure to construct a clear and aligned story, strategy, and system as well as an inability to embrace the desire of customers.

Success in the retail industry has always been tough, but the current battleground in globalization or deglobalization presents new challenges and opportunities in a faster manner to all of the participants. Advertisements have been deemed “smart” as the internet with wide-bandwidth communication powers up the fast customization and deployment of ads with precision targeting of customers given their preferences and behaviors, learned from historical personal data or personal network research. Every company in every sector, including retail, is essentially advertising their dependence on big data. When constructing any transaction there are several steps that must be taken, either in a specific order, or in parallel, so a snag in one step tends to snowball into more problems down the line. Merchants, manufacturers, advertising agencies, logistics companies, and IT innovators hope that by adopting IoT solutions to cut costs, trace transportation, and use limited sale and marketing resources more efficiently, they can turn the capricious, fragmented, and spatially distributed world of e-commerce and retail into something more closely resembling what it is supposed to be—a service process for individuals. The focus is not only on how to sell goods or deliver faster, but also on turning retail and e-commerce into a regimented process that can be better understood and optimized. Amazon, for example, has a reputation for operating on a large scale of online presence and it has facilitated such a presence

through the emphasis on offline merchants and supply chain optimization with reinforcement from IoT solutions since 2014.

Like other industries which have undergone a digital revolution, thanks to the fast advance of IoT technology and blockchain, many aspects of the retail industry are also being revolutionized. Today, home appliances, home security and comfort products, and even health care products are becoming part of the IoT ecosystem. Retailers in home décor or consumer electronics can not only increase the sales of these connected devices, such as Home Depot, which has more than 600 “smart” products, but also leverage the data provided by these devices to extend the business scope to consumers’ homes.

Some retailers are taking advantage of various interconnected products by becoming an integrated platform. The basic idea of these platforms is to make it easier for customers to communicate to each other’s home devices. For example, Lowe’s launched the “Smart Home Hub,” the Iris platform, which can communicate with any device via networking technologies such as WIFI, ZigBee, or Z-Wave. The platform also has an open interface so manufacturers can interface with their products. Iris has enabled Lowe’s to compete directly with telecom providers such as AT&T and Verizon, while also creating new opportunities for the company—working with manufacturers to integrate products into the Iris platform. In addition, Home Depot’s Wink and Staples’ Connect as well as other platforms are also being released.

Other types of retailers, such as grocery stores, can build or collaborate with such platforms. Connected platform provides retailers with another channel for direct interaction with customers, opening up a hidden treasure trove of customer data. This information covers almost every aspect of home life—from electricity use to consumption trends.

Under this context, the remaining chapter will focus on how IoT data is used by retailers and wholesalers, utilizing machine learning and deep learning algorithms to identify potential business locations, the creation of personalized recommendations on e-commerce websites and mobile applications, and how the data are used to identify and track both products and customers.

This practice of leveraging existing models (and/or creating newer ones) and algorithms to explore data to learn from experience has manifested in many ways in finance applications. The applications of machine learning, and more recently deep learning, have come a long way from targeting using predictive analytics in 2002 to targeting customers with emails about products it believed they would want next (Coussement and Van den Poel 2009), to Amazon using computer vision to create a frictionless grocery-buying experience for its customers (Grewal et al. 2017).

#### 9.4.3 *Categories of Data from IoT Ecosystem*

In general, data from the IoT can be categorized based on the properties of the sensing, including, but not limited to, geolocation data from GPS, imaging data from video sensors, and data generated from other devices.



#### 9.4.3.1 *Geolocation-Based IoT Applications*

Due to the wide adoption of smartphones in consumers throughout every country, the once seemingly impossible-to-acquire information on consumers' geolocation data can now be easily collected through either GPS, WiFi, or other wireless signals (Zhang et al. 2020). Advanced techniques, including machine learning, are then applied to geolocation data to extract insights which may be valuable for businesses and investors. It is estimated that there are 2 billion smartphone users in the world. The smartphone that people carry everywhere is in fact a tracking device that knows more about where people go and daily habits than even they do. Tracking people's smartphone locations is just one way that companies can acquire analytical insights.

Many companies in this sector are currently focusing on tracking bundle traffic in and around store locations. There are direct and indirect ways of collecting this geolocation data. The direct way collects data by tracking the location of users' cellphones. This kind of data can typically be purchased from mobile service providers, e.g., T-Mobile or Verizon, China Mobile, etc. The indirect way involves placing mobile advertisements on goods, e.g., bar codes or QR codes, so that a consumer's location can be instantly reported when they are triggered or scanned. Firms using the direct way include AirSage and Advan Research, while examples of the latter include Tencent and Walmart.

#### 9.4.3.2 *Case in Focus: AirSage*

AirSage specializes in collecting and analyzing anonymous location data, such as cell phone and GPS data, to identify patterns (Smith et al. 2005). It does so by tracking mobile phone data using patented technology to capture and analyze mobile phone signal tower data. It has secured location data from various sources, including smartphone SDKs, fleet, and navigation systems. The data provided include both real-time and historical data.

AirSage distinguishes data based on transportation, travel and tourism, and commercial real estate. The company processes more than 15 billion mobile device locations everyday with the widest coverage of any location-based service provider in the United States. Note that data features a group breakdown on anonymous origin/destination matrix with time stamps.

In travel and tourism applications, AirSage's data will help identify visitor demographics, behaviors, and build seasonality trends with historical data in destination markets. AirSage covers most of the metro areas in the United States, so that anonymous devices in almost every city can be retrieved.

The GPS coordinates of cell phones collected over the course of a week, a month, etc., allow analysts to get an estimate of the number of visitors in a certain season. Analysts can then improve the accuracy of predictions for top-line revenue by combining the geolocation intelligence data as a proxy. Such cases include Six-flags, Disney, and Lululemon, all of which are publicly traded companies.

One outstanding firm for utilizing the indirect approach to collect consumer location and behavior profiling data is China's Tencent via its

Code system. Unlike the direct way, in which the location information is directly retrieved from the apps on smartphones attached to users, the indirect approach records the location of goods, through which the end-user profiles and locations can be acquired.

#### 9.4.3.3 *Case in Focus 2: Tencent Code Solution*

With years of development in the consumer market of China, Tencent has evolved into one of the largest Internet-based value-added services providers in China. By adopting its latest cloud technology and IoT platform, Tencent has established large-scale, stable, and robust infrastructure and capabilities, complemented by online security, artificial intelligence, big data analytics, location-based services, and other proprietary technologies, to support ecosystem partners across various industries (Rong et al. 2015).

Like Amazon, Tencent has accumulated a presence in the Consumer Internet ecosystem over the years, building its strength in developing the largest consumer market in the world. The massive Weixin and QQ user bases serve as the “digital gateway” for industries, while official accounts, mini programs, mobile payments, marketing solutions, and WeChat Work serve as the “digital tools” that connect developers and enterprises to potential customers. One such example is the implementation of code tracking systems in the retail industry.

Tencent Smart Retail introduced the full-code digital marketing package which helped the retail industry to “seek people by goods” and better connect users. Though seemingly simple at first look, it involves a very sophisticated system. The core concept is that Tencent’s products are digitized at the core, so each product has a unique digital ID, which will then allow the merchants to track the life cycle of each individual good.

In marketing—despite the inability to establish direct connections with consumers, the difficulty in managing channel terminals, and the lack of long-term operation mechanisms for digital assets—the application of Tencent Optima in different scenarios will help brands build full-chain digital management and solve the above problems. “No Field Verification” provides a completely new solution: goods to connect people. Through Tencent, every bottle of select beverages is printed with a QR code. The code can be entered into the official code system to make coupons. In this way, the brand realizes the visualization of offline users, allowing target consumers to connect, acquire insight, and operate. At the same time, goods have also broken through the original single consumer goods’ attributes, becoming a direct communication medium between brands and consumers. Regardless of whether consumers buy online or offline, they can use the products themselves to achieve further connection with the brand. This is also an important activity to make brand marketing activities no longer strongly dependent on the field.

#### 9.4.3.4 *Image-Based IoT Applications*

Other than geolocation data, image sensors have been widely used in collecting alternative data. In this section, different from the geospatial image data we discuss earlier, we mainly focus on the image data from IoT devices typically in home appliances and retail business.

The most popular motivation involved in creating such a dataset is the anticipation that information exploited from the dataset analytics will help to make recommendations to consumers to drive revenue or to better understand customers. Almost every retailer has a website or mobile app that utilizes recommendation systems to suggest products to consumers. Most of these systems use text-based data to provide such recommendations. This data primarily includes customer details like their demographics (age, gender, address, etc.) and their purchase history. For these algorithms to work, each product has data tags for its category. Using the data from each consumer, scores are created for products, then products with the highest scores are recommended to each consumer. These values would only exist for products that a customer had already bought and were created using the consumer's information online. However, offline stores will not be able to monitor this type of traffic without image-based sensors. So why can not traditional retailers be enabled with a similar technology? Thanks to the advancement of IoT technology and deep learning neural networks, image-based sensing data can be captured and analyzed with relatively low costs and high efficiency. Some companies started investigating into this domain. One retail analytics startup called Nomi developed their sensor platform that tracks customer behavior in traditional brick-and-mortar retail stores. Each arriving person in the store is assigned a tracking identifier using its advanced video camera. The cloud-based software analytic system then links the person's movements across Brickstream sensors, following the person wherever they go. The 3D sensors on the Nomi platform can see past overlapping objects to provide a truly accurate measurement of what people are actually doing in the store. With more than 140,000 sensors being used in stores located in more than 60 countries, Nomi's image data has a truly remarkable value proposition for retailers.

#### 9.4.3.5 *Other IoT Data Analytics*

In retail industry, one easily accessible category of data is Point of Sale (POS or ePOS) data. Retailers today collaborate with suppliers and share sales and inventory information in order to increase profits. The most common source of shared data is driven from the UPCs scanned at checkout registers. POS data is typically sent electronically from retailers and distributors in transactions known as EDI 852 and EDI 867 or through vendor portals in files generated from their internal data warehouses. By summing up the Point of Sale (POS) data of approximately 2,000 American supermarket stores from 2001 to 2012 for every company, Ishikawa et al. (2016) compared the growth rate of the POS sales data with each company's actual sales. They discovered that the growth rates in quarterly sales for companies whose anchor products are daily

necessities in the United States were strongly related to the POS data's growth rate, thus demonstrating that nowcast (real-time observation of company sales) is possible, at least for this type of business enterprise.

Recent progress in the retail industry includes autonomous shopping centers powered by advances in computer vision technique. AmazonGo is a prime example of this. AmazonGo stores do not have any human staff or cash registers. Consumers enter these stores, pick up the groceries that they need and leave. Many aspects of this seemingly simple operation require the use of computer vision:

1. Customers need to be identified using facial recognition as soon as they enter the store.
2. Every product that is removed from the shelf needs to be accounted for. This operation has two aspects: the customer picking up the product needs to be identified, and the correct amount needs to be added to the customer's bill.
3. The product removed from the shelf must be accounted for and replaced with an identical item from the inventory.

Data from the purchase can be used to recommend products to the consumer in the future. Identification and tracking of customers and products require computer vision algorithms and fusion sensors to work in perfect conjunction to achieve accurate results. Every time a product is picked up, sensors need to detect the reduction in weight and pressure on the shelf, and the vision algorithms at work need to identify which product has been taken from the shelf.

Other retailers also use images and videos to create better shopping experiences for use in stores. Candy retailer Lolli & Pops leverages facial recognition to identify loyalty program members as they enter the store and proceeds to provide them with personalized recommendations. Walmart uses video data to monitor missed scans during checkouts and potential thefts. Schnuck Markets uses robots to monitor shelves and take stock of inventory.

Since there are many retailers that operate on-ground stores, there are many variations of technology being used to simplify product tracking and checkout. Many retailers use bar-code scanners at self-checkout counters. However, that still requires the consumer to individually scan each item. Redmon et al. (2016) propose a method called YOLO (You Only Look Once), which uses shape detection and categorization to identify all the products in a consumer's cart. This method consists of two CNNs. The first CNN is a GoogleNet-inspired network that classifies products into 17 predefined shapes, and then an R-CNN is used to classify the shapes into categorized products. The time taken to detect and classify the objects is approximately 69.3 ms per frame and is done with approximately 75% test accuracy.

IBM, partnering with Tesco, implemented a project that focused on monitoring products on shelves and using images to differentiate between similar products placed close to one another (Marder et al. 2015). It focuses on addressing two common problems encountered while detecting objects on shelves:

1. Images used in training sets are usually high-quality studio photos compared to the real-time lower quality images that need to be classified in stores.
2. Many products of the same type look alike, shape detection and categorization can be difficult for such products.

The model proposes a complex method that takes images from shelves and performs an initial classification of the products on the shelves. However, these classifications are not specific classifications, but similarity groups. Once products are grouped, features are extracted from the images and are used to classify the products more specifically.

## 9.5 CONCLUDING REMARKS AND FUTURE DIRECTIONS

To conclude, we summarize the key takeaways of the discussion in this overview of research in economics and business-related fields utilizing alternative data. We reviewed the merits and scope of the different categories of alternative data and the methodologies that have been considered. In particular, we highlight textual analysis in corporate finance, image processing in financial markets and governance, digital footprints from social media and mobile devices, and IoT-based data retrieval and applications.

- Textual analysis increasingly requires advanced tools. Dynamic dictionaries/word lists and methodologies that effectively integrate domain expertise with effective information extraction from data are likely to become widely used.
- Dynamic alternative data such as videos and audios could provide valuable interaction to researchers and practitioners. Machine learning tools for analyzing them are available and represent rich information sources for social scientists to explore. While computer vision has not yet reached the same accuracy as the human eye, it has proved to be a viable automated alternative to traditional methods of engaging with customers. This has further resulted in cutting-edge research being carried out to improve existing applications and create new ones.
- Alternative data and their associated processing tools could prove fundamental in explainable AI and interpretation of complex, black-box machine learning models.

- Crowd-sourced data and individuals' "digital footprints" such as users' cellphone usage, online and mobile activities, social media, and social network activities, can be leveraged to improve financial predictions, profitability, and social welfare, for example, in credit risk assessment.
- IoT, as one of the breakthrough techniques in retail and wholesale industries, has been a powerful venue for financial analytics. The geolocation, image and transaction data streams from over 400 retailers and distributors have only been part of the alternative data that have been utilized. Within five years, the consensus view is that IoT data will become the largest volume of alternative data for finance analytics. Both new challenges and opportunities will emerge as more dynamic and advanced IoT devices are developed.
- It remains open how regulators and institutions can best address data privacy issues. More generally, it is a holy grail in data science to have multiparty usage of data while preserving privacy. Related are tools for merging traditional data with alternative data.
- In the spirit of the Lucas Critique, researchers should examine how the use of alternative data and research findings affect the data-generating process itself, together with subsequent socio-economic implications.

This article by no means illustrates all possibilities provided by the potential and large scale of alternative data. Given the pace of development in blockchain technology, deep learning techniques, and IoT technology, we expect research in this area would also evolve quickly. That said, the general trend and utility of using alternative data are here to stay and are likely to significantly impact the world of FinTech and business intelligence.

**Acknowledgements** We thank Samuel Petruzzi for excellent research assistance. This research was funded in part by the Ewing Marion Kauffman Foundation and R. C. Evans Fellowship. The contents of this publication are solely the responsibility of the authors.

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# Bitcoin and Other Blockchain Technologies: Mechanisms, Governance, and Applications

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## 10.1 INTRODUCTION

Bitcoin is a digital payment token. The Bitcoin system is relatively easy to use. Anyone can download the Bitcoin software from [www.bitcoin.org](http://www.bitcoin.org) and create a Bitcoin address to send and receive Bitcoins with. Each address can receive Bitcoins freely but sending the Bitcoins held in an address requires having the password for that address. In this way, a Bitcoin address is very similar to a bank account holding a Bitcoin balance.

The key difference, though, is that there is no bank. In fact, no single person or entity is in charge of this system. Each Bitcoin address settles Bitcoin transfers with any other address based purely on the software. Fundamentally, this is all there is to Bitcoin.

On the face of it, then, this may not seem to be much of a technological advance at all, let alone one that deserves any attention. Indeed, the only curiosity it seems to merit is why the artificial Bitcoin tokens can be worth any real money at all. After all, these Bitcoin balances are nothing more than transferable tokens in a virtual system, without any direct use even in its own virtual world. Yet, various websites and exchanges can allow the purchase or sale of Bitcoin from or into all major traditional (or “fiat”) currencies such as US dollars, Euros, or Pounds sterling. At the time of writing, each whole unit of Bitcoin is worth around US\$12,500, making the collective Bitcoin balances of the entire system worth some US\$240 billion.

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However, the nature of the Bitcoin technology is not commonly understood (Vergne and Swain 2017). As academic disciplines begin to form views toward Bitcoin and related technologies (e.g., Mai et al. 2016; Wang and Vergne 2017), it is important to understand the nature of this and similar technologies and their potential so that they can be judged and discussed.

The fundamental technology is genuinely new, in both concept and terminology, so a full appreciation of it is difficult to summarise as there has been nothing quite like it before. Hence, there has also not been a short yet comprehensive discussion of how Bitcoin and related technologies work in sufficient technical detail for a full picture of its nature.

In this chapter, I attempt to do this in a technically accessible manner that also sheds light on the possibilities and limits of the technology. I first discuss the motivation and mechanisms of blockchain technologies using Bitcoin as an illustrative example. Then I move on to key issues of governance in such systems. I finish by discussing some categories of current applications of blockchain technology. Along the way, I also try to clarify the terminology so often used in relation to Bitcoin and blockchains.

## 10.2 HOW BITCOIN WORKS

### 10.2.1 *Motivation of Bitcoin and the Goal of Decentralization*

The key innovation and defining feature of the Bitcoin system is decentralization. That is, no single entity is responsible for the technology's operations and functioning. To understand the nature of Bitcoin and decentralized technologies, it is important to appreciate the initial motivation of Bitcoin as a payment system that can evade government control.

Technology enthusiasts have long envisioned a digital payment and currency system outside government control and outside traditional banking institutions. One of the earliest such groups of proponents was known as the “cypherpunks” (sic), who believed strongly in the freedom and privacy aspects that a digital currency system could provide (Assange 2012; Hughes 1993). Such a system was also spawned by a mistrust of traditional central banking policy. This motivation was especially prominent after the quantitative easing—or money printing—following the Financial Crisis of 2007–2008. It was thought that a digital currency system like Bitcoin could be outside the control of central banks and hence could not be inflated at their discretion (Nakamoto 2008). Until the creation of Bitcoin on January 3, 2009, however, every conceived alternative digital currency system had failed to succeed.

The key aspect to Bitcoin's success is achieving decentralization. The entire Bitcoin currency system is run and maintained without any centralized entity (Narayanan et al. 2016). The Bitcoin system runs off the collective computing resources of anybody who runs the Bitcoin software. The software is also completely open-source and anyone can contribute new updates to it. Crucially, no single entity is legally responsible for it.

Technologically, decentralization affords the substantial advantage of resilience. The system can survive the failure of any individual computer in the network or even the failure of a majority of the computers. As long as at least one computer continues to run the software, the Bitcoin system can in theory survive and be revived. Thus, the irreversible shutdown of such a system with a distributed user base is highly unlikely.

However, decentralization—of having no key legal or physical entity that is responsible for the system—was primarily intended to avoid legal problems. Centralized systems that sought to operate beyond government control—as Bitcoin wanted to—have had a painful history of government shutdowns and legal punishment for any identifiable individuals involved (Ly 2014; Mullan 2014). Examples of government-circumventing technology that had identifiable individuals included e-gold (digital currency), Napster (sharing of copyrighted music), and Megaupload (sharing of copyrighted video). All these technological projects experienced dramatic shutdowns and asset seizures by governments and subsequent legal sagas for the individuals responsible (Meek 2007; Pepitone 2011; Williams 2012). This bleak fate of technologists that sought to operate outside government control is likely why the creator of Bitcoin used only the pseudonym Satoshi Nakamoto. The true identity of Satoshi Nakamoto remains unknown to this day.

Decentralized technology, in contrast—notably the copyright-circumventing file-sharing system BitTorrent—has proven highly elusive to the government crackdown. Started in 2001, BitTorrent has never been successfully taken down, despite powerful attempts by governments around the globe. High-profile legal action, government shutdowns, and police raids on individual entities involved with BitTorrent have occurred in countries such as Finland (Cullen 2004), Hong Kong (Bradsher 2005), Singapore (Liew 2007), Slovenia (Van der Sar 2006), Sweden (Kiss 2009), and the United States (Borland 2004). In each case, though, the decentralized BitTorrent network kept going because it does not depend on any individual entity (or even a majority of entities) to operate.

BitTorrent remains in operation even today, sharing a vast library of music, books, movies, software, and other files in flagrant violation of copyright laws. In contrast to centralized file-sharing systems such as Napster and Megaupload, BitTorrent uses decentralization by breaking every shared file into many pieces and storing them on the decentralized hard disks of many users running the software. Most of the time, a complete version of a copyrighted file is not downloaded from any single person and the size of the network also makes any single individual difficult to target. But the collective effect is sharing copyrighted files. To achieve decentralization, BitTorrent uses error-checking algorithms to easily check that reconstituted large files are correct. Indeed, for a file broken into 1,000 pieces and stored on 1,000 different computers, the difference of a single bit in any single piece can be quickly detected using error-checking algorithms so that the integrity of the reconstructed file can be maintained.

The experience of BitTorrent suggests that decentralization in the digital domain is both possible and resilient against government intervention, the key intent of Bitcoin. Satoshi Nakamoto likely named Bitcoin in homage to BitTorrent, and uses the same principles of decentralization and error-checking to create a system that is immune to government interference. However, Bitcoin aims to achieve almost the opposite technological goal of BitTorrent. Instead of sharing copies of files in a decentralized system, Bitcoin needed almost the opposite technological goal of preventing the copying or counterfeiting of the Bitcoin digital currency in a decentralized system. The solution to this hurdle came to be known as the Blockchain.

### 10.2.2 *The Use of the Blockchain to Prevent Counterfeiting*

Unlike BitTorrent, where the goal is to freely copy identical files among users, a digital currency system such as Bitcoin must essentially do the opposite and prevent users from counterfeiting—that is, copying—units of the currency. Historically, preventing currency counterfeiting required either irreplaceable physical currency (such as gold coins) or a trusted centralized entity (like a central bank) with the sole enforceable authority to mint the currency. Neither method is compatible with the goals of Bitcoin. Anything digital can be easily copied, and Bitcoin was specifically intended to operate without a trusted central authority. Indeed, Bitcoin is even called “trustless” precisely because of not relying on any trusted centralized authority to validate the currency. So how, then, can anyone tell the difference between an authentic Bitcoin and a copy of one?

Using a slight twist on an established concept, Bitcoin solves this counterfeiting problem by keeping an *entirely public and validated history of all Bitcoin transactions from the very beginning of the Bitcoin system*. Thus, every Bitcoin would have a fully public chain of provenance. Any Bitcoin amount without such a chain of provenance is not valid and rejected by the Bitcoin software. In fact, any amount of Bitcoin is actually *defined* to be a *unique history of transactions* on this public ledger of transactions (Nakamoto 2008).

(Perhaps not at first sight, but this definition of Bitcoin also has the important result that units of Bitcoin are infinitely divisible. This point will be discussed a bit more later.)

The complete history of Bitcoin transactions is kept in a large *unencrypted* text file that is downloaded with the Bitcoin software to every computer in the Bitcoin network, and this file is subsequently updated approximately every 10 minutes on all computers with the addition of new “blocks” of transactions that have occurred since the previous update. Any transfer of Bitcoin is only recognized by any computer if the provenance of the Bitcoin can be traced in this history file to the Bitcoin address sending it. Nobody, then, can claim to have Bitcoin that does not have a publicly verifiable origin according to this file.

This large transaction history file is called, famously, the “Blockchain”. (I will capitalize the word Blockchain when referring specifically to the Bitcoin system, and use the word “blockchain” to refer to analogous files in other systems). The Blockchain literally contains the details of every transaction of all the Bitcoins in existence, from the very beginning—or “genesis”—of the Bitcoin system. Unlike files on BitTorrent, the Blockchain file is not broken into pieces. The Blockchain is stored as identical copies on every computer in the Bitcoin system, with error-checking algorithms set to make sure each copy is identical.

A key feature of the Blockchain (and any other blockchain) is that it is regularly updated across a distributed network of computers. The Blockchain is updated on every computer with the latest block of new transactions approximately every 10 minutes. After each additional block, error-checking algorithms are reset on the enlarged Blockchain so that the new file becomes the official record, locked by error-checking algorithms until the next update.

As a technical detail, each block of new transactions is currently limited to 1 Mb in size. Transactions beyond what can be recorded into 1 Mb will need to wait for a later block to be recorded onto the Blockchain. Hence, the Blockchain will increase at most by 1 Mb every 10 minutes. There is no limit on the total size of the Blockchain as it continues to grow forever in size. This is not regarded as a limitation because the availability of storage is believed to continue to grow along with it. The current Blockchain is already large. At the time of writing the file is over 305 Gb.

Thus, the entire Bitcoin system centers on this large text file called the Blockchain that updates every 10 minutes. By the definition of Bitcoin, this text file itself also keeps track of the balance of Bitcoins at each address.

Regularly updating a large file reliably across many computers in itself is not particularly difficult, and this is not the key innovation of Bitcoin. What makes this task difficult is that Bitcoin is *decentralized*. So, if there is no central administrator, who starts the next update and who decides what transactions are to be included?

Bitcoin uses a “consensus protocol” to decide updates to the Blockchain. This is the central innovation of the Bitcoin system and is discussed next.

### 10.3 GOVERNANCE

Given the decentralized nature of the Bitcoin system, the rules of collective decision-making or governance among the participants are crucial to its functioning. In fact, the central innovation of Bitcoin is its decentralized governance. There are three interlocking aspects of decentralized governance on the Bitcoin network: the consensus protocol, participation incentives, and network upgrades.

### 10.3.1 *The Consensus Protocol*

Every 10 minutes or so, the Blockchain adds another 1 Mb block of official transactions. At any given time in between, computers that wish to transfer Bitcoin broadcast of their proposed transaction to the network. Any computer in the network can then consolidate these proposed transfers and propose a new block of transactions onto the Blockchain. These block proposals can differ when there are more proposed transactions than the size limit of the next block. But only one new block will be deemed the official next block on the Blockchain. So the Bitcoin system needs to agree on which transactions to officially record in the next block and which to defer. (If there are fewer than 1 Mb of new transactions, below the block size limit, then all transaction proposals could be included in the next block, but there can still be differences in the order of transactions in blocks proposed by different computers.)

The rules of agreeing on which proposed block is the official next block on the Blockchain is called finding “consensus” among all the computers. Bitcoin finds consensus using a mechanism called “Proof-of-Work” that—effectively—takes as official the block proposed by the computer that has paid the highest price before submitting its proposed block. This price paid is not paid to the Bitcoin network but is measured roughly in terms of the amount of electricity that the computer burned. This needs some elaboration.

When a computer tries to propose a new block to the Blockchain, it includes with that request a long numeric code that is the output of a *deliberately heavy but utterly useless computation exercise*. The specific computation exercise is a variation of a trial-and-error computation called Hashcash, with the output code designed to correlate to how many useless computations (and hence electricity) that computer’s CPU did, hence creating the name Proof-of-Work. The Bitcoin network will then accept the block in proportional probability to the electricity burned by the proposing computer. So, effectively, the entire Bitcoin network records the block of transactions proposed by computers that burned the most electricity. In other words, computers willing to run the maximum number of useless computations tend to get their proposed blocks chosen as the next official block.

This might appear to be a strange protocol. But these are the current consensus rules in the Bitcoin software. The procedure to recognize the most expensively produced block is intended to make the entire official Blockchain computationally expensive to change once established. Any computer wishing to alter a block of transactions would have to spend at least as much computational energy to reverse it, and even then it is probabilistic that its amended version is chosen. With a large network, this effectively eliminates the chance of malicious actors trying to change the official Blockchain.

A computer can propose the next block to contain any transactions, not just transactions related to its own Bitcoin address. In general, computers mostly propose other people’s transactions. But if it burns so much electricity to propose a block, why would anyone willingly use his or her computer to do this?



### 10.3.2 *Mining Incentives*

Not every computer in the Bitcoin network burns electricity and proposes new blocks. Each participant can set the Bitcoin software on his or her computer to do this or not. Doing the useless computations and proposing new blocks is called “mining.” It incurs electricity cost but is central to keeping the Blockchain current and the Bitcoin system operational, so those who do it need some incentive to participate in this activity.

The mining incentive comes in two parts. First, and most naturally, those who wish to make a transaction in the Bitcoin system can offer a fee in Bitcoin. This fee will go to the computer that successfully mines the transaction onto the Blockchain.

Second, at the moment, the Bitcoin system also offers a reward of new Bitcoins for mining. This is also the only way to create new Bitcoins. The reward of new Bitcoins (currently 6.25 Bitcoins, worth some US\$80,000 at time of writing) is given to the computer that successfully mines each next block, which is in turn selected probabilistically in proportion to the amount of processing the computer does. The Bitcoin rewards halve approximately every 4 years until a total of 21 million Bitcoins have been created (at time of writing, over 18.5 million Bitcoins have already been created).

After all the 21 million Bitcoins have been created, anyone who sends a transaction will need to offer a fee in Bitcoin to serve as the reward to miners. This transaction fee will then be the only incentive for mining.

While any computer with the Bitcoin software can mine, more powerful computers can do more processing and are hence more likely to get the mining rewards. For an idea of scale, a high-end laptop doing full-time mining can expect a reward once every few years at time of writing. If more computers join the network and provide more collective computation power, the difficulty in the mining process is increased automatically so mining will become less profitable in Bitcoin units. If computers leave the network and reduce collective computation power, the difficulty in the mining process is reduced automatically so mining will become more profitable in Bitcoin units.

There are three points to note in this system.

First, the incentive within the Bitcoin system is more Bitcoins. This is the only token that the system can create or allocate by itself. It cannot, for example, reward Euros. Hence, any incentives in the system are completely within the system itself.

Second, the electricity consumption in Bitcoin mining is perhaps the only link between the Bitcoin system to any fiat monetary value. Some might argue that because it takes a certain amount of real electricity to produce each Bitcoin, Bitcoin should be worth at least a certain amount in terms of fiat currency. Others would counter that just because electricity was used in creating something like Bitcoin does not make the output necessarily valuable. After all, the Bitcoin computations were deliberately set to be wasteful,

and generating large amounts of random numbers can burn electricity without creating value.

Third, it is commonly believed that the total Bitcoin supply is limited. This is due to the cap of 21 million Bitcoins that can be mined. But Bitcoin supply is actually *not* limited. Each Bitcoin is infinitely divisible subject only to limits on the digital representation of small fractions, and even this technical limit can be overcome. So there is in theory no limit to the amount of Bitcoin that can circulate. Even if the world completely turns to Bitcoin as a currency, a single Bitcoin is enough to cover the entire global economy, with each transaction conducted in very fine fractional Bitcoin dust. As Bitcoin is just a token, it can be arbitrarily rescaled.

### 10.3.3 *Network Evolution and Upgrades*

On top of the consensus and incentive structures of Bitcoin lies high-level governance issues of how the entire Bitcoin system works. Everything about Bitcoin is encoded in software, and software can be changed. Bitcoin is a live open-source project on the collaborative development website [www.github.com](http://www.github.com) with code that anyone can contribute to. If that is the case, how can Bitcoin prevent malicious actors from changing the software? At the same time, how can legitimate software upgrades be implemented? Who decides which version of the software is the official version?

Changes to the Bitcoin software can alter the consensus protocol, the incentive structure, or any other aspect of the Bitcoin system. Many major changes became increasingly necessary. For example, a possible upgrade is to compress or otherwise reduce the size of the Blockchain, perhaps by splitting it into smaller chunks. Another example is to increase the existing block size or capacity. At the same time, there can be malicious changes such as a change to transfers all Bitcoin to one particular address.

As a decentralized system, Bitcoin ultimately relies on majority voting to organize changes to the software itself. Whenever the Bitcoin software is amended, users on the network must choose to download the new software or continue on the older version. The Bitcoin network will deem legitimate the version of the software—and hence the version of the Blockchain—that at least 50% of the computers (by mining power) are using. So, the Bitcoin system treats the majority choice as official. If somehow over 50% of the network runs a malicious or fraudulent version of the software (for example, a version that transfers all Bitcoins owned by the minority to the majority), then even this unscrupulous version will go through as official.

However, in this case of tyranny of the majority, the decentralization of Bitcoin offers a unique additional safeguard of sorts. The minority that was harmed can refuse to use the new software and continue to use the original software and the original Blockchain. Two Bitcoin systems will then be created with the two groups going separate ways with different blockchains into the future. The Blockchain, by its nature, has an infinite backup system so

it can revert and continue from an earlier point. When this happens—when the users decide to go separate ways with different software versions and different blockchains—it is called a “fork.”

In fact, for decentralized technologies, instances of technological decisions resulting in disagreements that are not resolved are quite common. In such cases, entire systems may break off as forks into two or more branches, each with their own communities of supporters. By convention, the larger branch tends to keep the original name. Examples include the fork of Bitcoin Cash from Bitcoin and, subsequently, the fork of Bitcoin Gold from Bitcoin. A system called Bitcoin SV later forked out of Bitcoin Cash. Each of these forks was the result of disagreements on software features. All these systems now run in parallel.

Thus, in the decentralized Bitcoin system, because no single entity can unilaterally impose any changes, there is an important and distinctive element of democratic voting on possible new versions of the software. Software versions that only a minority of the computers in the network support will not be implemented. Such collective decision-making due to majority voting has been recognized in other contexts as inefficient (e.g., Arrow 1950; Gibbard 1973; Satterthwaite 1975) and is a major deterrent to Bitcoin development in contrast to systems controlled by a centralized decision-maker. But the Bitcoin system also offers the unique remedy that the minority is free to fork out into their own system.

As the Bitcoin network increases in size, it gets harder and harder to change the rules of the system by majority vote and more forks have been emerging. This forking mechanism is rather unique, and the ultimate implications of this governance model are yet to be seen.

## 10.4 SOME CATEGORIES OF CURRENT BLOCKCHAIN APPLICATIONS

The defining feature of Bitcoin is a decentralized network coordinated by a large shared document that all participants refer to, agree on, and collectively update (a blockchain). The blockchain for Bitcoin simply keeps track of transactions between addresses. But with some thinking, such a shared document can be used to coordinate other decentralized activities. I now discuss some categories of existing applications of blockchains.

In most of these blockchain projects, participants need to be incentivized to contribute some resource to maintaining the blockchain. Usually, as with Bitcoin, this is done via a system of internal fees or rewards. These blockchain projects thus invent various exchangeable tokens—also called “coins,” “alt-coins,” or “cryptocurrencies”—to serve as units of these incentives. As with units of Bitcoin, units of these token rewards are completely arbitrary but their names often serve to identify the blockchain projects.

I now discuss five broad types of current blockchain projects. There are also others. I discuss each with some examples.

### 10.4.1 *Payment Systems*

The most established use of blockchains are payment systems, which was the original intent of Bitcoin.

Bitcoin itself has no direct use. The Bitcoin system does very little aside from transferring Bitcoin between its addresses. But if participants in the Bitcoin system—by some convention or market force—can agree that Bitcoins can be exchanged for some value in fiat currency, then Bitcoin can indeed serve as a valid payment system to transfer between owners of Bitcoin addresses. Furthermore, as intended with decentralization, this system is resilient against the failure. Bitcoin as a payment system is fully in operation now, with Bitcoin having a clear (but volatile) market exchange value against fiat currencies like the US Dollar.

This established and functional use of Bitcoin as a payment system spawned several other payment systems based on the blockchain concept. These payment systems are also some of the most functional of the blockchain projects that exist currently.

Most of the other blockchain projects are designed in response to some perceived shortcoming in the Bitcoin design.

For example, one notable shortcoming of Bitcoin is that transfers are relatively slow and unsuitable for small sums (due to fees). It takes at least 10 minutes and often hours for a transaction to be added to the Blockchain and for this to be checked and confirmed, especially when the network is congested. Other coins such as Litecoin, Stellar, and Ripple are designed to process transactions faster and at smaller amounts. For example, Litecoin adds a new block of transactions every 2.5 minutes instead of every 10 minutes.

A second notable shortcoming is that Bitcoin is deliberately wasteful in its computational requirements. There have been some earlier attempts (such as Curecoin or Gridcoin) that aimed to harness this computation for scientific research. But a more recent development is to change the Proof-of-Work consensus protocol. For example, Peercoin is a blockchain project that incorporates another consensus protocol termed Proof-of-Stake, where those who already hold more Peercoin have a higher chance at getting their blocks mined onto the blockchain (and hence earn a mining fee or reward). But such a consensus protocol encourages hoarding and has since become less popular.

Finally, a third potential shortcoming is that Bitcoin is public. While individual addresses might be anonymous on the Blockchain, all transactions are fully traceable. Certain blockchain projects such as Monero and Dash are payment coins that make transaction records verifiable but private on their blockchains. While it may sound contradictory to have a public ledger of transactions that is also private, cryptographic coding methods can leave a verifiable and auditable public record of a transaction without actually revealing the destination or origin of the transaction.

At the time of writing, a majority of the largest blockchain networks are designed for payment transfers. These include Bitcoin and its forks, Litecoin, Ripple, Monero, and Stellar.

### *10.4.2 Resource Sharing*

Another category of current blockchain projects are designed for the trading of some decentralized resource, specifically a digital resource. This appears to be a highly suitable use for blockchains.

The most developed and functional projects in this category involve file storage. Examples include Storj, Siacoin, and Filecoin. The blockchains for these projects keep track of tokens that can buy the use of storage space on other people's computers. Similarly, by providing one's own extra hard disk space, one can earn these tokens (effectively renting out extra hard disk space). In both cases, the files are encrypted. The tokens can be spent or also traded. As such, these tokens should have a clear exchange value against fiat currencies because they can be spent for disk space use, which is a valuable service. Additionally, these systems also provide a clear advantage for decentralization—files stored on these systems can survive the downfall of any single computer in the network.

Another example in the resource-sharing category of blockchain applications is Orchid, which gives tokens that represent the use of VPN (Virtual Private Network) bandwidth. By allowing one's computer to be used as a VPN, one can earn Orchid coins. Similarly, Orchid coins can be spent to use someone else's computer as a VPN. Again, these tokens should have a clear exchange value since VPN provision is a valuable service to those who use it, for example to avoid firewalls. This is also another case where a clear advantage of decentralization exists, especially in regards to evading firewalls, because a different computer can provide the VPN on each use.

### *10.4.3 Smart Contracts*

This much more ambitious class of resource-sharing blockchain applications deserves a category of its own. This category refers to a range of projects including Ethereum and Tezos, both of which have coins that are worth billions of US Dollars in total. These projects are blockchain systems where the coins can be exchanged for processing resources within the network. These projects envision programming capability such that they can run computer code on the blockchain, with rewards given to computers that help run the code.

This programming ability can create automatic conditional transfers of the coin in what are ambitiously termed "smart contracts." Currently, the most practical application of these smart contracts is simple online gambling-like deals between any two users, where the network can compute and pay transfers according to exact predefined rules in a game of chance. For example, a digital

coin is flipped and A pays B 1 unit of the token if heads, otherwise B pays A 1 unit. A small computational fee will be taken by the computers in the network that helped execute this small computer program and also helped mine the transfer.

The nature or importance of such agreements is debatable from a contract law perspective (Mik 2019). But these smart contracts do allow in theory for automatically enforceable conditional transfers of tokens between any parties in a decentralized system. It is thus conceivable that more detailed arrangements can be created, including transformational applications in the world of finance. But it seems that decentralization naturally imposes a processing capacity limit on the complexity of such programs, at least for now with the current state of the technology.

#### 10.4.4 *Data Security*

Many administration, law, and finance activities in society rely on an official set of reference data that is regularly updated. This category of current blockchain applications envisions using blockchains to keep such data.

For example, a prominent case would be the land registry database. It is crucial that an authoritative database exists of who owns what land. Such a registry needs to be robust, accessible, and difficult to fraudulently alter. A possible way of accomplishing this, perhaps, is to put such data onto a blockchain that can be downloaded and kept up to date on any computer. Transactions can then be potentially updated between two parties without an authority that officially changes the register. Also, by using decentralization, it would ensure the continuity of the database in case an official entity errs, collapses, or becomes malicious.

That was the concept behind the blockchain project known as Bitland. But that project failed, and for now, functional blockchain projects purely to keep authoritative data in a decentralized way do not yet exist. Blockchain implementations of such projects suffer from several hindrances.

First, there is little innate incentive mechanism to encourage continuous participation by decentralized network users. It is unclear what the incentives are for someone to participate in maintaining a land registry blockchain, say. If the blockchain rewards digital coins for processing land transactions, it is unclear what those coins could then be spent on. This could be a situation where altruism comes into play in the maintenance of a blockchain as a public good. It is conceivable that every landowner wishes to maintain the integrity of the land registry and thus have some incentive to contribute some resources to keeping the land registry secure. But altruism may not be a reliable incentive.

Second, it is also unclear what the best consensus protocol should be. For example, if there are two competing land transactions trying to get onto the blockchain, Proof-of-Work seems unlikely to be the appropriate consensus protocol for validating one over the other.

Third, for very important information like land registry titles, the blockchain often must be authoritatively sanctioned in the first place. If that centralized authority withdraws consent, then the blockchain may no longer survive. Any blockchain that derives legitimacy from a centralized authority fails in its original purpose for decentralization.

#### 10.4.5 *Private Blockchains*

There is arguably a category of blockchain projects where the blockchains are actually not decentralized but controlled by some entity for its own use or gain. These are sometimes called “private blockchains,” where a closed network uses the system.

In a conceptual sense, a blockchain is originally intended to coordinate decentralized activities, so while these projects may still be technically blockchain applications, it is not clear if the use of a blockchain adds any general benefit when there are more direct means of coordination and control within a closed group.

However, the use of private blockchains can solve specific issues faced by organizations.

One example of such application is a recent travel health database exchange between the province of Guangdong in China and the self-governed Chinese territory of Macau (Feng 2020). By going through a blockchain, the two territories were able to share the Covid-19 status of 17 million cross-border travelers without nominally violating local data privacy laws because they did not directly exchange the data. The blockchains in this case were not open access and were clearly under the full control of the two authorities, but regulation prevented them from directly exchanging and using the data.

#### 10.4.6 *Further Potential*

Academics and enthusiasts are right to imagine all the possibilities of blockchain technology. As blockchains continue to evolve, there is palpable progress on not just the technical but also the organizational fronts.

Even within the most established system of Bitcoin, much potential is not yet realized. For example, being fully public records, the Bitcoin Blockchain can enable functions such as automatic taxation, audits, money laundering prevention, and other potential uses. There is indeed some irony that blockchain technology is now sometimes touted as a regulatory mechanism (Yermack 2017) when Bitcoin was originally designed to elude government control.

Regardless of how blockchains are applied, the biggest limitation of the technology remains its recognition. Whatever a blockchain is used for depends on the acceptance of a decentralized group of users. Thus, it must hold at least a threshold of real-world acceptance from a wide enough base. It can be argued that some of the biggest blockchain projects such as Bitcoin have

long crossed this threshold, but a lot of the other applications fail to take off not because the application was infeasible, but because the diffusion did not succeed.

## 10.5 CONCLUSION

Our discussion now brings us to summarize Bitcoin as a system to keep track of transferable tokens within the system itself. It is an innovative technology in terms of how it coordinates and incentivizes a vast number of decentralized participants via a blockchain to do this and keep the system going.

The link between Bitcoin and any real-world use, especially as a payment system, is then substantially based on popular belief. Some would say this then makes it akin to a castle on sand. But others argue that any fiat currency also requires such a belief in a similarly unfounded system.

Regardless, Bitcoin has now withstood the test of time in many ways. Not only has it recovered from hacks, thefts, forks, and scandals, but it has also weathered economic fluctuations and vagaries. The same cannot be said of many other blockchain projects. Some of those have potential, and others are perhaps doomed from the start. But it seems Bitcoin, at least, is here to stay.

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## Blockchain and Structured Products

*Andria van der Merwe and in memory of Christopher Culp*

### 11.1 AN INTRODUCTION TO DIGITAL STRUCTURED FINANCE

Many innovative structured products have been introduced that offer digital variations of more traditional structured products such as asset-backed loans and asset-backed securities. These digital structured products differ in their jurisdiction and the number of regulatory requirements, the type of trading venue (over-the-counter or exchange), and the risks. Because the blockchain is a fundamental building block of these innovations, these products are necessarily exposed to the inherent risks in the blockchain technology such as possible attack from hackers or a potential lack of market liquidity for the underlying cryptocurrencies.

The difference between these products and their traditional counterparts vary—some are simply decentralized, digital equivalents of traditional products such as the Treasury-backed closed-end fund while others borrow concepts from traditional finance but adjust these to be suitable for the digital, decentralized environment, for example, the DAI stablecoin and decentralized lending and borrowing. The growth in structured products is driven by a investors' search for yield. The 2020 pandemic has driven global interest rates to historically low levels. Some jurisdictions, such as the eurozone, are now in negative territory and others such as the US and UK could potentially follow.

One area in cryptocurrencies attracting huge attention is decentralized finance or DeFi. DeFi refers to the development of financial services such as

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Switzerland AG 2021

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M. Pompella and R. Matousek (eds.), *The Palgrave Handbook of FinTech and Blockchain*, [https://doi.org/10.1007/978-3-030-66433-6\\_11](https://doi.org/10.1007/978-3-030-66433-6_11)

lending and borrowing using smart contracts on the blockchain, which are automated enforceable agreements that don't need intermediaries like a bank or lawyer and use online blockchain technology instead. These types of products present examples of how innovation can be used to facilitate alternatives to traditional settlement, lending, and borrowing.

The treatment below focusses on a few exemplar products in each category, but there are many others of note that are not included. Two other interesting examples of digital structured products include the Grayscale Bitcoin Trust and Short LyCi.

The Grayscale Bitcoin Trust provides a secure structure to gain exposure to Bitcoin. Eligible shares are quoted on the OTCQX<sup>®</sup>, a marketplace operated by over-the-counter markets, and registered under Section 12(g) of the Securities Exchange Act of 1934. Investors can buy and sell shares through most traditional brokerage accounts at prices dictated by the market.<sup>1</sup> The ShortLyci is a way to bet against a market-cap-weighted basket of the top 25 cryptocurrencies. Purchasing the LyCi token means essentially shorting a basket of cryptocurrencies because the token increases in value when the price of the underlying basket decreases. This product provides dynamic and transparent repricing and rebalancing that is available to some retail investors also.<sup>2</sup>

## 11.2 TREASURY-BACKED DIGITAL PRODUCTS

The Arca U.S. Treasury Fund is an innovative, closed-end fund that offers shares to investors as digital securities that can be traded on the Ethereum blockchain. The Securities and Exchange Commission ("SEC") approved the Arca fund under the Investment Company Act of 1940 on July 6, 2020.<sup>3</sup> The Arca CEO of Arca described the SEC's announcement as a "transformative and groundbreaking step towards the integration of digital asset investing and traditional finance as it is a new form of regulated digital investment products that are made available to investors" (Otieno 2020).

A typical closed-end fund or more specifically, a closed-end company is one type of investment company. According to the SEC, closed-end funds have some unique features that distinguish it from the other two types of investment funds namely mutual funds and investment trusts.<sup>4</sup> Specifically, the investment portfolios of closed-end funds generally are managed by separate entities known as "investment advisers" that are registered with the SEC. Closed-end funds do not continuously offer their shares to investors for sale but rather, sell a fixed number of shares at one time. After the initial offering, these shares can be traded on a secondary market. The price of these secondary market shares is determined by the market and may be greater or less than the shares' net asset value (NAV). Closed-end fund shares generally are not redeemable which means that a closed-end fund is not required to buy its shares back from investors upon request. Some closed-end funds, commonly referred to

as interval funds, could however offer to repurchase their shares at specified intervals.

The Arca U.S. Treasury Fund has many of these features albeit issuing digital assets and offering the benefits and efficiency of blockchain technology. The Arca U.S. Treasury Fund invests 80% of its investment portfolio assets in interest-bearing, short-duration, U.S. Treasury securities. Like their traditional counterparts, the investment portfolio is managed by an investment advisor, the Chief Investment Officer of Arca. The Arca U.S. Treasury Fund entered into a custody agreement with a third-party custodian.<sup>5</sup>

The investment objective of the Treasury Fund is to maximize total return consistent with the preservation of capital. The fund issue shares to investors that differ from the shares of traditional closed-end funds in that these shares are digital securities tradable directly between investors on the Ethereum blockchain. The ArCoin is a special type of digital token based on the ERC-1404 protocol which places several restrictions on the token's activity and embeds additional measures of security over other tokens based on the ERC-20 protocol. For example, unlike Bitcoin that can be freely used in peer-to-peer transfers on the blockchain, ArcCoin can only be transferred to white-listed wallet addresses which in the case of the Arca U.S. Treasury Fund, that this means anti-money laundering/know your customer (AML/KYC) and other documentary clearance. The ArCoin can be purchased directly from fund using U.S. dollars but it can also be purchased directly from another ArCoin holder using any digital or fiat currency agreed upon by both parties.

The redemption price of ArCoin will be the net asset value of the Fund as of the close of regular trading on the New York Stock Exchange on the repurchase pricing date. In addition to selling their ArCoins, investors also earn period cashflows in the form of dividends and other distributions. Dividends are the net investment income on the Treasury securities in the investment portfolio and distributions are the net realized capital gains earned annually by the fund. An investor could also select to have their period distributions reinvested in additional ArCoin under the Fund's distribution reinvestment plan.

### 11.3 CRYPTOCURRENCY-BACKED PRODUCTS

A particular example of a cryptocurrency-backed product is the stablecoin Dai. Like other stablecoins, Dai seeks to reduce price volatility against a reference basket of assets with only a soft peg to the U.S. Dollar. Most stablecoins are backed by fiat currency such as the U.S. Dollar or a basket of fiat currencies but Dai is collateralized by the cryptocurrency Ether.<sup>6</sup> The name Dai is a transliteration of the Chinese character meaning to “lend or to provide capital for a loan.”<sup>7</sup> The stablecoin Dai can be traded and exchanged for other cryptocurrencies but it can also be used to generate interest on cryptocurrency through lending.

The Dai stablecoin is decentralized and based on a set of smart contracts referred to as Maker Vaults supported on the Ethereum blockchain.<sup>8</sup> Dai can be generated by anyone by depositing Ether collateral into Maker Vaults. The cryptocurrency becomes the collateral for a Dai loan to the user. The interest rate on this loan is known as the stability fee. This mechanism of Dai creation effectively means that the user effectively borrows Dai using cryptocurrency collateral to establish a collateralized debt position (“CDP”). Once created, Dai can be traded or exchanged for other cryptocurrencies or fiat currency. Initially, Maker Vaults only accepted the native cryptocurrency of the Ethereum blockchain, Ether but toward the end of 2019 introduced the idea of allowing other types of collateral also. The amount of collateral deposited is greater than the amount of Dai generated. For example, the loan-to-collateral value is currently 50% which means that the user needs to deposit \$150 worth of Ether for \$100 worth of Dai. If the collateral falls below 150%, the collateralized debt position is automatically liquidated.

The Maker protocol has several build-in mechanisms to guarantee that Dai remains stable against the dollar such as the Target Rate Feedback Mechanism (“TRFM”). For example, “if the Target Price of Dai is below \$1, the TRFM increases so that it can push the price of Dai back up. This causes the price of Dai to increase, which then causes the generation of Dai through CDPs to become more expensive.”<sup>9</sup> The feedback mechanisms require the smart contract to know the price of Ether at any point. The Dai stability mechanisms have performed well, with Dai reaching an all-time high price of \$1.11 on March 13, 2020, during the peak of the Covid-19 global market uncertainty.<sup>10</sup>

Several use cases of Dai have emerged. For example, investors that want to reduce the risk and volatility of their cryptocurrency portfolio could exchange Ether for Dai on a cryptocurrency exchange. Users could also deposit Ether in a Dai smart contract and receive a Dai. Dai lending, whereby the Dai holders lock their Dai into a Dai Savings Rate smart contract, is an alternative way to use Dai by earning interest. The interest accrues at a variable rate referred to as the Dai Savings Rate (“DSR”) and set by the Maker.<sup>11</sup> The Maker protocol uses the level of the DSR as a means to influence the demand for Dai. When the DSR is high, it would create demand for Dai but when DSR is low it would stimulate supply.<sup>12</sup> Historically, DSR varied between a high of 8.75% on February 4, 2020, to a low of zero percent on March 17, 2020, when the demand for Dai exceeds the supply.

#### 11.4 DECENTRALIZED, DIGITAL LENDING

Genesis Global Capital (“Genesis Capital”), a registered broker-dealer started offering lending of digital assets to institutional investors on March 1, 2018 (Genesis 2018) as a complement to their existing over-the-counter digital assets trading. Genesis Capital allows institutional investors such as hedge funds and trading firms the opportunity to borrow or lend Bitcoin, Ether, and other digital assets in large quantities over fixed-terms. Genesis capital

further launched fiat currency lending toward the end of 2018 whereby institutional investors can borrow cash against their cryptocurrency holdings. Genesis Capital lending grew from cumulative originations of \$1.11 billion on December 31, 2018, to over \$6 billion on March 31, 2020. Figure 11.1 shows a breakdown of their cumulative loan originations between borrowing and lending of digital assets. The amount of lending in digital assets continues to exceed the amount of borrowing in digital assets. Figure 11.1 also shows the number of active cash loans against institutional cryptocurrency holdings which is still smaller than the digital asset lending.

Digital asset loans are comparable to more traditional types of asset-backed loans, but the underlying cryptocurrency assets have relatively high volatility. The salient features of cryptocurrency-backed loans are compared to other asset-backed loans in Table 11.1. The interest rates on cryptocurrency-backed loans, represented here by loans against Bitcoin, are typically on the higher end when compared to loans against more traditional collateral such as future sales, fixed company assets, or equity or debt securities. The lender directly controls the cryptocurrency collateral in contrast to the traditional collateral which is not transferred but only pledged to the lender. The lender can therefore generate an additional return on the cryptocurrency collateral over the lifetime of the loan. Since the amount of collateral often exceeds the loan amount, as shown in Table 11.1 the loan-to-value of Bitcoin-backed lending was between 50 and 80% which creates a leverage effect further enhancing the return.

The high loan-to-value of Bitcoin-backed loans is commensurate with the relatively high volatility of Bitcoin (and other cryptocurrencies). The loans are also subject to margin calls in the event the loan-to-value ratio decrease

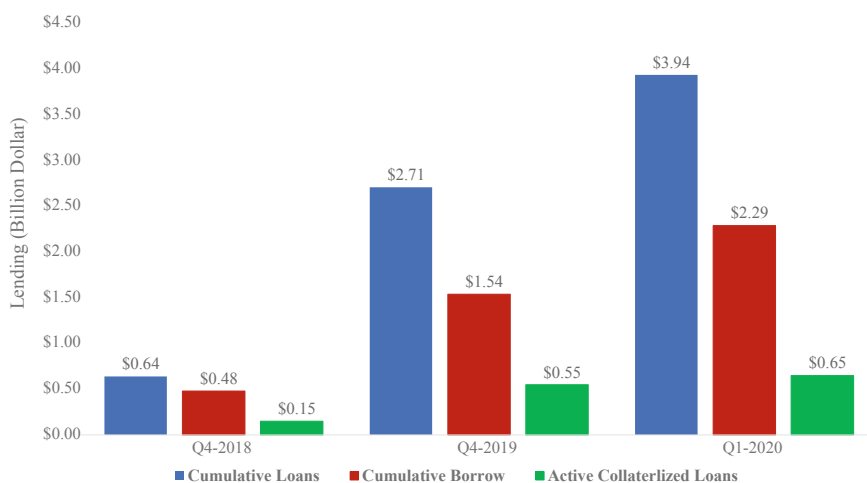


Fig. 11.1 Growth in Genesis Capital digital asset borrowing and lending

**Table 11.1** Comparison of asset-backed securities and digital asset loans

<i>Description</i>	<i>Asset-backed cash loans against</i>			
	<i>Bitcoin</i>	<i>Future cashflows from sales</i>	<i>Fixed assets such as property, equipment and inventory</i>	<i>Securities such as equity or debt</i>
Return on cash (spread to LIBOR)	5–8%	3–6%	7–9%	2–4%
Usability of the collateral assets	Usable	Unusable	Unusable	Usable
Return on collateral	3–5%	N/A	N/A	LIBOR + spread of between 2 and 4%
Loan-to-value ratio	50–80%	75–85%	50–75%	50–95%
Volatility of collateral	High	Low to medium	Low	Medium to high
Liquidity of collateral	Highly liquid	Generally illiquid	Generally illiquid	Highly liquid
Duration	0–2 years	1–5 years	1–5 years	0–5 years

*Source* Genesis Global Capital, Q3 2019, “Digital Asset Lending Snapshot,” *Genesis Quarterly Insights*

below the required levels. As explained by Genesis Capital, “[t]he attractiveness of bitcoin as collateral relies heavily on the lender’s competency with both holding bitcoin and managing margin calls and forced liquidations. If the price of bitcoin decreases rapidly, the lender needs to ensure the borrower adds more bitcoin collateral to back the loan or have a systematic selling solution in place if the price continues to fall” (Genesis Capital Q3 2019).

Cryptocurrency has characteristically high volatility which raises questions about the sufficiency of using that as collateral. One way to protect against high volatility is to require over-collateralization, which is what Genesis Capital did in their structure by requiring a high loan-to-value, of between 50 and 80%. For example, borrowing \$100 against Bitcoin, at a loan-to-value of 70% would require a deposit of \$170 worth of Bitcoin collateral. But, using over-collateralization as a means to counter high volatility, implicitly rely on a liquid market for cryptocurrency so that lenders and borrowers can freely trade should margin calls arise. Should the price of Bitcoin decrease to the point where loan-to-value is below the required ratio, the borrower would have to add more Bitcoin collateral, or the lender would need to have a systematic solution in place to sell the collateral.

The 2020 COVID-19 pandemic presented a natural stress test for digital lending. In March 2020 the global market conditions were uncertain and

volatility, including volatility for cryptocurrencies spiked. Digital asset lending however continued to grow, during the first quarter of 2020, Genesis Capital had over a billion in \$1B in active loans outstanding while experiencing no defaults, capital losses, or delinquencies at any point over the period (Genesis Capital Q1 2020).

Short-term lending would allow arbitrageurs to capitalize on short-term price dislocations in the cryptocurrency markets but as the cryptocurrency-backed lending matures the potential use cases are also expanding.

## 11.5 CONCLUSION

While digital structured products are still in their infancy, there is a growing interest in these products in particular from investors searching for higher-yielding assets in a low-interest-rate environment. Structured digital products such as Arca U.S. Treasury Closed-End Fund or the Genesis Capital cryptocurrency-backed lending are grounded in traditional financial principles enhanced with the efficiency of the blockchain. Others are novel applications of innovative blockchain technology, such as the Ethereum smart contract in the cryptocurrency-backed Dai stablecoin.

## NOTES

1. <https://grayscale.co/bitcoin-investment-trust/#market-performance>.
2. <https://dailyfintech.com/2019/11/11/innovative-crypto-structured-products-the-shortlyci-case/>.
3. <https://arcoin.arcalabs.com/arca-offers-the-first-sec-registered-fund-issuing-digital-securities>.
4. The distinguishing features of closed-end funds are from the SEC Closed-End Fund Information, <https://www.sec.gov/fast-answers/answersmfclosehtm.html>.
5. This section draws heavily from information on the ArcCoin website, <https://arcoin.arcalabs.com/faqs>.
6. Stablecoins are discussed in more detail in Chapter 20.
7. [https://www.reddit.com/r/MakerDAO/comments/5q98b1/%E8%B2%B8\\_dai/](https://www.reddit.com/r/MakerDAO/comments/5q98b1/%E8%B2%B8_dai/).
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# Categories and Functions of Crypto-Tokens

*Lin William Cong and Yizhou Xiao*

## 12.1 INTRODUCTION

Tokenomics concerns the emergence, pricing, usage, and implications of digital currencies and crypto-tokens. The phenomenal growth (and decline) of cryptocurrencies and token-based financing, the U.S. Security and Exchange Commission (SEC)'s lawsuits against KIN foundation and Telegram, Libra's debacle at the hearing of House of Representatives, and China's introduction of Digital Currency Electronic Payment (DCEP) system all reflect the lightning speed of industry development. The recent Covid-19 pandemic and the associated quantitative easing policies further spurred the discussion of cashless payments. Yet we are just starting to understand the economics of using tokens. Tokenomics therefore constitutes a fast-growing area of academic research with important implications for the industry and policymakers.

Putting tokenomics in the broad scheme of advancement in FinTech and digital economy, we notice an increasing preference for forming peer-to-peer connections that are instantaneous and open, which is transforming how people work, interact, transact, and consume. Over the past decades, digital platforms and online networks have risen to the challenge and reshaped the

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organization of economic activities. Some of the most valued companies such as Amazon, Facebook, Google, and Tencent are all platform businesses in some sense. Even traditional firms such as General Electric are exploring ways to adopt platform thinking to spur growth and improve performance. Naturally, digital platforms and networks give rise to the “gig/sharing economy” wherein on-demand workers from different physical locations get instantaneous payments instead of long-term employment contracts, consumers demand fast digital payment options both online and offline, and central banks and regulatory bodies vie for control with private enterprises. Successful platforms rely heavily on payment innovations (e.g., Alibaba and eBay) as the lack of trust among anonymous agents constitutes a major obstacle for business exchanges, not to mention the general benefits electronic payments bring to the society overall.

More recently, instead of relying on financial systems that are often arranged around a series of centralized parties like banks and payments, clearing and settlement systems, blockchain-based crypto-applications attempt to resolve the issue by creating the financial architecture for peer-to-peer transactions and interactions, and reorganizing society into a series of relatively decentralized networks. By providing decentralized consensus, blockchains allow peers unknown to and distant from one another to interact, transact, and contract without relying on a single centralized trusted third party. The technology can potentially better prevent a single point of failure and concentration of market power (Cong and He 2019), but still face many challenging issues (Chen et al. 2019).

Even though not always necessary, a majority of blockchain applications entail the use of cryptocurrencies and crypto-tokens. In the past few years, thousands of cryptocurrencies have been introduced and many central banks are actively exploring cryptocurrency and blockchain for retail and payment systems. In addition, blockchain-based crypto-tokens have also emerged as a popular means for financing digital platforms and innovative startups. The total market capitalization of all cryptocurrencies peaked at \$828 billion USD in 2017 and is at \$240 billion USD at the dawn of 2020, with a total trading volume \$8.8 trillion USD in the first quarter of 2020 alone. In what is known as Initial Coin Offerings (ICO), entrepreneurs sell “tokens” or “AppCoins” to dispersed investors around the globe. Despite the first ICO in 2013 raising a meager \$500 thousand and the sporadic activities over the next two years, 2016 saw 46 ICOs raising about \$100 m and according to CoinSchedule. In 2017, there were 235 Initial Coin Offerings. The year-end totals came in over \$3 billion raised in ICO. In August 2017, OmiseGO (OMG) and Qtum passed a US\$1 billion market cap, according to coinmarketcap.com, to become the first ERC20 tokens built on the Ethereum network and sold via an ICO to reach the unicorn status.

These trends lead to several general questions: What are these cryptocurrencies and tokens? What roles do tokens serve on platforms and in digital market places? Are they merely hypes and would disappear once investors’ fever

recedes? What fundamental values do they carry? What roles does blockchain technology play? Finally, what are the regulatory implications?

We provide a comprehensive categorization of crypto-tokens as observed in practice or being designed. In addition, we describe early studies aiming to answer these questions, including discussions on using tokens including platform finance, user adoption, stable coins, and early liquidity creation, with legal and regulatory implications. We then suggest some future directions of tokenomics research.

## 12.2 TOKEN CATEGORIES

Not all tokens are created equal. Several classifications have been proposed for crypto-tokens. “Security tokens” are mostly entitlements to future cash flows or returns the issuer generates, and are simply digital securities; “Utility tokens” usually carry the right to redeem a product or service on the platform; “work tokens” carry similar meaning, often used as licenses for developers to develop decentralized applications on the platform. However, while a majority of them are simply the required media of exchange and the “utility” comes from being able to interact with other users, no consensus has been reached on the proper classification of tokens. In fact, there is a lack of clarity, if not general confusion, in the media reference to these tokens.

To analyze the economics of using tokens, i.e., tokenomics, one has to first understand what tokens are. Interests in tokens surged with the development of blockchains in the past decade. Technically speaking, coins are cryptocurrencies native to each blockchain, and tokens could be derivative cryptocurrencies developed on top of a primary blockchain. That said, we are not interested in this technical distinction, neither are we restricting attention to blockchain-based tokens. Before we delve into the discussion, we recognize that cryptocurrencies that substitute fiat money have definitely garnered much media attention, and tokens are often backed by a specific startup company (in ICOs), or the technology of a platform (platform tokens), and assets of value can also be traded through tokens (e.g., Gold [HelloGold], oil [OilCoin], natural resource [El Petro]), for example, to lower the transaction costs of the underlying. Moreover, the key innovation of blockchain technology lies precisely in allowing peer-to-peer interactions in digital networks. A large fraction of tokens issued during ICOs in the past two years are indeed media of exchange on various platforms.

Generically speaking, tokens are contracts independent of identity and honored by some subset of participants in an economy. They have been long used on gaming platforms and social network apps. Although regulatory bodies such as the Securities and Exchange Commission (SEC) classifies tokens into security tokens and utility tokens, the actual classification is more nuanced based on how tokens derive value and function economically, which matters for how we should regulate their issuance and trading.

We now introduce the four major categories of tokens: The first category, perhaps also the best known, entails General Payment Tokens, which are what people have in mind when they discuss Bitcoin, Tether, Libra, etc. Here tokens are perceived as substitutes for fiat money or other liquid instruments such as treasury bills, and are used as monies. The valuation of such general payment tokens would be similar to how we value currencies. For example, money supply and velocity would be important determinants. Political considerations would also matter. A subset of general payment tokens also serve as store of value, if people perceive them as the “digital gold” due to the limited supply.

Second, digital platforms frequently “embed” tokens in their ecosystems, as Cong et al. (2018, 2019) point out. Such Platform Tokens are used as local means of payment on platforms that provide certain services or functions and constitute a majority of the ICOs in practice up till now. For example, Filecoin platform provides a marketplace and infrastructure for people with spare storage to meet up with people with the demand for storage. They then complete the transactions using Filecoin tokens. Users’ demand for the platform depends on how efficiently the platform maintains data privacy and matching efficiency. The platform token-supply policy and the endogenous demand for using the platforms would jointly determine the token price. That demand also drives token prices because, for any given supply of tokens, the demand would jointly determine the token price. In a sense, General Payment Tokens are an extreme form of Platform Tokens, with the general economy being the platform.

The third category of tokens involves product tokens. It means the holder of a token can redeem from the issuer (or a service provider) a pre-determined quantity of product/service. This is very much like corporate coupons or discount vouchers used by retail stores or airlines. Such product tokens exist but are not very common. Yet they may enable the entrepreneur to figure out potential demand from the market (crowdfunding platforms in general have this function), or to pre-commit to certain price for their products as a way to compete in the market, as we discuss shortly. The pricing of tokens here, with rational agents, should simply be the pricing of the products, given that the exchange rate between the product/service and tokens are pre-set at some ratio. Note that platforms on which the pricing of goods and services in terms of nominal amount of tokens is done centrally by platform owners would exhibit both product token and platform token features because tokens are used as means of payment and at the same time serve as coupons for redeeming services or products at rates pre-specified by the centralized platforms.

Finally, the fourth category of tokens is cash-flow-based tokens. That is what regulators or practitioners typically have in mind when they talk about security tokens. The tokens entitle the holder to certain rights to future cash flows from a business. Such tokens are essentially security contracts and should be properly regulated under security law. The valuation of this type of token is also straightforward: discounting future cash flows to the present time would do the job. Such security tokens can be useful for entrepreneurs because they

can potentially contract on revenues rather than profit (as in equity contracts). There could also be contingencies written in smart contracts that affect token value. Lambert et al. (2020) discuss some examples.

Table 12.1 provides an illustration of how tokens in practice can be classified into the aforementioned four categories. More detailed classification can be found in Cong and Petruzzi (2018), in which the authors manually classify 648 tokens based on information obtained from articles and official websites/whitepapers, following the framework in this section. This information was collected up till May of 2019. Frequently sourced websites for further information included coinmarketcap.com, coincentral.com, and coincheckup.com which provided summaries of tokens' intended purposes, corporate background, and technology.

**Table 12.1** Illustration of token classification scheme

<i>Code</i>	<i>Currency</i>	<i>Type of token</i>	<i>Information</i>
BNB	Binance Coin	Product	BNB can be used to pay for fees on the Binance exchange at a discount. Coins are burned to maintain stable price
BTC	Bitcoin	General payment	BTC is the original cryptocurrency. It is entirely peer-to-peer and lacks a central regulator
DOGE	Dogecoin	General payment	An inflationary coin with no cap on the number of coins that originated as a joke based off internet meme "doge"
ETH	Ethereum	Platform	Native token for the Ethereum platform for smart contracts, DApps, and tokens using the ERC20 standard
GAS	Gas	Product	A token distinct from NEO used to pay for operations on the NEO platform
KCS	KuCoin Shares	Security	An ERC20 token for the Kucoin exchange. Holders receive dividends from transaction fees and priority on the exchange
LTC	Litecoin	General payment	Inspired by BTC, LTC allows interblockchain exchange of different tokens through hashed timelock contracts
NEO	NEO	Platform	NEO token is used for governance of the NEO platform that has smart contracts, DApps and tokens using the NEP-5 standard
USDC	USD Coin	General payment	ERC20 stablecoin pegged to USD fully collateralized by USD reserves
XRP	Ripple	General payment	A centralized blockchain technology, XRP is intended for extremely liquid transactions for banks and payment providers

## 12.3 ECONOMIC ROLES OF TOKENS

Besides the reasoning for using tokens that we occasionally read from media articles, early studies on tokenomics reveal several important roles tokens play on digital platforms or within digital ecosystems with native means of payments.

### 12.3.1 *Token Embedding*

First, we describe how in decentralized networks, it is natural and typically observed in practice to introduce native currencies and agents actually hold them—a phenomenon Cong et al. (2018) termed “Token Embedding.”

In many existing blockchain applications, native coins are the required or favored medium of exchange. For example, it is cheaper to make international payments and settlements using Ripples (RXP) on the Ripple network; to make profit by providing validation services, OmiseGo (OMG) tokens are required as stakes on the OmiseGo blockchain; even though Ethereum platform allows other AppCoins and cryptocurrencies, many transactions and fundraising activities are still carried out using Ethers (ETH) because of the convenience and popularity.

Why do we need crypto-tokens in the ecosystem? Arguably, it is advantageous to adopt a standard unit of account in the ecosystem because it mitigates the risks of asset-liability mismatches if they are denoted in different units of account, which also leads to higher probability of default. Moreover, when agents in the economy meet and transact, it is hard to know all future partners’ identities, and using a unit of account that is likely to be compatible with future potential trading partners can be useful.

That said, the standard unit of account does not have to be a native token. So why a native token or currency? It goes back to the question of trust. In the virtual economy, agents are likely from around the globe, and using any fiat money is subject to particular countries’ legal and economic influences; moreover, to transact among parties unknown and non-trusting to one another, a crypto-coin relieves the concern of double-spending and misbehaving. Even with a centralized party operating the platform, it takes time to build trust and resources to maintain that transfers and transactions on the platform are reliable.

Other than these technical or convenience reasons for using platform tokens to facilitate trusted transactions, are there novel economic reasons why a platform should use its native tokens? After all, using other cryptocurrencies can also circumvent the trust issues.

The answer lies in incentive provision in a decentralized system. Mediating the exchanges using other cryptocurrencies means the incentives provided to miners, validators, users—contributors to the stability, functionality, and prosperity of the ecosystem—may be heavily influenced by fluctuations in those currencies that are not directly linked to the blockchain protocol or platform

quality. Moreover, native tokens can be directly linked to history of transactions and events on the blockchain, a feature other cryptocurrencies can ill-provide.

One example is Filecoin (FIL) which is used as the sole means of payment in the network marketplace to reward miners for block creation in the Filecoin consensus process. Another example is Basic Attention Token (BAT). As Strategic Coin explains in its BAT token launch research report, BAT functions as a medium exchange between users, advertisers, and publishers who participate in the Brave browser ecosystem. Advertisers purchase ads using BAT tokens, which are then distributed among both publishers and browser users as compensation for hosting the ads and viewing them, respectively. Arguably these platforms can use Bitcoins or Ethers, but then the incentive designs and the currencies are not directly linked, which as we discuss next does not allow the ecosystem to grow as quickly as in the case with native tokens.

### 12.3.2 *Network Effects*

User-base externality is an integral feature in decentralized systems, P2P systems, and many digital platforms. One obvious manifestation of the user-base externality is the network effect of participation. The utility of using cryptocurrencies also goes up when more people use them. Examples also include social networks and payment networks such as Facebook, Twitter, WeChat, PayPal, and OmiseGO.

Another form of user-base externality is in the initial launching of projects/platforms. Achieving a critical mass is crucial in platform business. Unikrn with UnikoinGold is the decentralized token for betting on e-sports and gambling, and Augur, a decentralized prediction market, both required a critical user base to take off.

While network externality is a static form of user-base externality, inter-temporal forms are also commonplace. The fact that a larger user base today helps improve the technology tomorrow, and a larger anticipated user base tomorrow encourages greater investments today are examples of how user base externality can play an inter-temporal role.

Filecoin the data storage network, Dfinity the decentralized cloud computation, marketplace such as overstock (and its ICO), and infrastructure projects such as Ethereum also exhibit user-base externality. Network effects are important for token valuation because, in a sense, token values capture the worth of the ecosystem, just like how currency strength reflects a country's dominance.

Among the earliest studies touching on the network effects, Cong et al. (2018) directly model network effects in platform adoption and token pricing, Li and Mann (2020) study how ICOs break up the investment games into sequential games and therefore coordinate the investors. Pagnotta and Buraschi (2018) characterize the demand for Bitcoins and the supply of hashrate to price Bitcoin, while allowing network effect among users. Sockin



and Xiong (2019) similarly consider both miners and users in a model of cryptocurrencies with platform fragility induced by the users' network effect.

While intuitively, users' network effects should be positive, once we consider the other side of the coin—consensus generation on blockchains—there could be negative network effects. For example, more transactions and users would imply they would not all be quickly recorded into Bitcoin blocks. The delays in finality may hinder adoption, as Hinzen et al. (2019) explore.

### *12.3.3 Adoption and User Base*

Cong et al. (2018) show that tokens can accelerate the user adoption for promising platforms and reduce user base fluctuations, especially during the early stage of a platform's life cycle when users are endogenously adopting the platform. They enable early adopters to capitalize and benefit from the future prosperity of the platform. If a platform is improving over time, then future demand for it is high. That means future demand for its token is high, which drives up token price. Early adopters who hold tokens have an investment motive in addition to the usage value they derive, because they benefit from the token appreciation. This formalizes what practitioners typically coin "bootstrapping the community." Similarly, tokens precipitate demise for bad platforms.

Cong et al. (2018) also show a second role of tokens in stabilizing the user base. These roles of tokens are discussed for the first time and distinguish tokens from other securities people typically use. Whenever there is a negative technology shock to the platform, less people would adopt, implying that the room for increase in adoption in future goes up. The potential token appreciation from greater adoption in the future increases the investment motive of holding tokens token, buffering the reduction in token adoption due to the negative technology shock.

### *12.3.4 ICOs and Platform Finance*

Over the past few years, issuing tokens has been a popular way of raising funds for startup projects. Initial coin offerings (ICOs), the sales of cryptocurrency tokens to the general public, to crowdfund in the technology and blockchain industries, have become a heatedly debated topic. On the one hand, ICOs seem to be fraught with frauds and regulatory arbitrage. On the other hand, the mechanisms involved also appear to be distinct from existing fundraising channels.

ICOs appeared in 2014 but before 2017 were very sporadic (Adhami et al. 2018). Momtaz (2020) finds that the volume of funds raised in ICOs represented \$6 billion in 2017, which is only one fifth of the amount raised in Initial Public Offerings (IPOs) that year. Bourveau et al. (2018) identify 750 ICOs between April 2014 and May 2018 that collectively raised \$13 billion by startups in 50 countries. Among recent studies, Howell et al. (2020)

reveal that the liquidity of ICO tokens depends on certification (VC backing), entrepreneurial experience and background, disclosure (white paper/Github code/budget plan), and incentive compatibility in terms of vesting, etc. Whether ICOs reach all-or-nothing funding targets also plays an important role (Cong and Xiao 2018), which is corroborated by Lee et al. (2018).

Lyandres et al. (2019) construct a comprehensive dataset of ICOs to study the determinants of ICO success, post-ICO returns, volatility and liquidity, and evolution of ICO-based ventures' social media activity and productivity. The authors empirically demonstrate that ICOs experience underpricing and post-ICO returns consistent with theories explaining the IPO market. Other studies such as Momtaz (2020) and Benedetti and Kostovetsky (2018) similarly document ICO underpricing.

Another common theme that emerges is that ICO success depends on code availability and the extent of disclosure and description (e.g., Adhami et al. 2018; Fisch 2018; Amsden and Schweizer 2018; Deng et al. 2018).

Among theoretical studies that analyze how platforms use tokens to finance platform development, Cong et al. (2019) stands out because the authors go beyond ICOs and examine the dynamic issuance and allocation of tokens. In such a dynamic model of platform economy, tokens are issued and used as means of payment among users, contributors, and founding entrepreneurs. Dispersed record-keepers, open-source developers, crowdfunders, etc., provide on-demand contributions to the platform in exchange for token compensation. In this regard, the use of tokens by digital platforms can be related to corporate finance, because the platforms have to manage the dynamic growth and investment of the ecosystem, as well as issuing tokens to gather financing and contributions from players within the ecosystem.

In Cong et al. (2019), entrepreneurs maximize their surplus by managing token-supply dynamics, subject to the conditions that users break even intertemporally and the markets for on-demand contributions are competitive. The authors characterize the dynamic token allocation strategy and its implications on user base dynamics, endogenous platform growth, the level and volatility of token price and their dependence on broader liquidity conditions. A key mechanism is the divergence between insiders' (entrepreneurs') token valuation and that of outsiders (users and contributors)—when the valuation wedge falls, the platform maximizes its growth by issuing more tokens to contributors; when it rises to an endogenously determined threshold, entrepreneurs optimally burn tokens out of circulation to stabilize token value.

Mayer (2019) and Gryglewicz, Mayer, and Morellec (2019) build on neo-classical dynamic valuation framework in Cong et al. (2018, 2019) to introduce speculators, agency issues, and cash-flow-based tokens. In particular, Mayer (2019) demonstrates that speculators and users both contribute to platform success and their investments are substitutes in some circumstances and complement in others. Gryglewicz, Mayer, and Morellec (2019) show

that token financing is generally preferred to equity financing, unless the platform expects strong cash flows or faces severe financing needs and large agency conflicts. Moreover, financing with both equity and tokens are not optimal.

Finally, several models explore product tokens or security tokens. Chod and Lyandres (2019), Malinova and Park (2018), and Catalini and Gans (2018) offer the earliest discussions. Gan et al. (2020) make suggestions on how to design “asset-backed” ICOs—including optimal token floating and pricing for both utility and equity tokens (aka, Security Token Offerings, STOs). Lambert et al. (2020) provide a systematic discourse of STOs. Other variants of ICOs, such as Initial Exchange Offerings (IEOs) and Initial Decentralized Exchange Offerings (IDOs) are still being developed and constitute interesting future research discussions.

### *12.3.5 Alignment of Investment and Consumption, and Crowd-Based Mechanisms*

Another important observation in Cong et al. (2018) is that investors have both usage motive (using tokens as means of payment on a platform to conduct business activities) and investment motive (enjoying token price appreciation in anticipation of a platform’s future prosperity). Such an alignment is absent in conventional settings and has very much to do with the crowd-based nature of token usage.

This point is fully highlighted in Lee and Parlour (2019): the fact that in crowdfunding financiers and consumers can overlap implies that the typical holdup problem between financiers and entrepreneurs can be mitigated. The liquid token market enables resale for the consumers’ claims and helps fund long-term projects when consumers have short horizons. Goldstein et al. (2019) find similar impacts of alignments of financiers and consumers. What other forms of alignment exist and how tokens interact with them are just starting to be explored.

In addition to aligning consumers and financiers, crowd-based mechanisms can help with information aggregation. Catalini and Gans (2018) extend the demand aggregation function of crowdfunding to tokens. Bakos and Halaburda (2019) study how token tradability and broader crowdsourcing of due diligence affect the decision to use an ICO and demand discovery. Token tradability leverages that information and increases the amount that can be financed, thus enabling new ventures with higher development costs. Tsoukalas and Falk (2020) examine how blockchain-based platforms rely on token-weighted voting to efficiently crowdsource information from their users for a wide range of applications, including content curation and on-chain governance, harnessing the “wisdom” and “effort” of the crowd.

### 12.3.6 *Commitments to Contracts and Token Policy*

There are quite a number of papers discussing agency issues in ICOs or comparing ICOs to VC financing (e.g., Chod and Lyandres 2019; Malinova and Park 2018; Garratt and van Oordt 2019). They almost all explore tokens whose value is tied to the firm's revenue rather than profit, which either creates additional agency conflict or help to mitigate existing ones. Most of them treat the tokens as product tokens or security tokens that are cash-flow based. Even though currently most of the ICOs are either cryptocurrencies or platform currencies, the practice could change with the emergence of STOs.

More importantly, the ability to commit to sharing revenues reflects a distinguishing feature of the blockchain-based tokens: algorithmic commitment. Cong et al. (2019) discuss blockchain commitment at length. Smart contracting and the decentralized nature of many blockchain systems do enable commitment and automated enforcement of certain contracts. However, the commitment brought forth by blockchains is not panacea. The commitment space is limited and smart contracting can only incorporate limited contingencies as of now, not to mention that one needs oracles and the Internet of Things (IoTs) to feed signals onto blockchains. The venture, Quantstamp, is an example, which recently became embroiled in controversy when it did not adhere to a medium of exchange commitment for its platform for smart contracts and was accused of accepting other cryptocurrencies and US dollars for its services.

### 12.3.7 *Valuation, Volatility, and Stablecoins*

Creating coins or tokens that are stable in value has been the holy grail in the cryptocurrency industry, because only then cryptocurrencies can be used reliably as a store of value and unit of account. Tether, Libra, etc., use a collateralization mechanism, backing up the token value with other (basket of) assets. By using the tranche of other assets that is the least sensitive to information, the corresponding token price becomes stable. Tether claims to maintain 100% USD reserve as collateral to guarantee 1:1 exchange rate peg to USD. The Tether model necessarily entails the issuers to hold fiat money, which needs third party, like an auditing firm, to verify the reserve or depends on issuers' credibility. DAI similarly uses over-collateralization. By controlling the issuance of token bonds (another floating-rate cryptocurrency), Basis can moderate the price fluctuations of BaseCoins. These are not new discoveries by (financial) engineers, but mechanisms central bankers have contemplated for a long time. They are not perfect solutions, as central bankers have recognized earlier. Collateralization and tranching rely on reserving other assets and are subject to manipulation as was pointed out in Griffin and Shams (2020); open market operations still rely on the trust of a centralized party carrying out the operations.

These are in contrast with the mechanism in Cong et al. (2019), which shows that platform owners' endogenous token-supply policy moderates fluctuations in token price, making the token more stable. The authors highlight the role of the blockchain technology in enabling commitment to counter cyclical token-supply policies, and thus present a mechanism for stabilizing token values traditional centralized systems would not provide. The problem of creating a stablecoin is similar to the issue of maintaining an exchange rate peg. One potential advantage of stablecoin based on blockchains over fiat money is exactly that smart contracting potentially enables greater commitment to the dynamic token-supply policy. The policies written ex-ante with computer codes can help enforce the transfer of digital assets as well, once certain contingencies are met. Cong et al. (2019) and Routledge and Zetlin-Jones (2020) explore such blockchain-enabled commitment in creating stablecoins.

More fundamentally, one needs to understand the source of value of crypto-tokens in order to better understand token price volatility. To this end, Cong et al. (2018) provide the first dynamic pricing model of assets incorporating platform fundamentals, network externality, sources of price volatility, and user heterogeneity. The authors show that the value of tokens comes from the platform/network technology that they are associated with. For example, for a decentralized cloud computation blockchain on which users buy and sell spare computation power using the native tokens, token values come from users' demand for the platform. The authors highlight fundamental technological shocks for the platform and endogenous user adoption as sources of token return volatility. Therefore, they are not suitable as general payment money, but are instead a hybrid of money and investment asset without dividends (so returns come from capital gain and convenience flow), at least during the initial adoption stage.

Biais et al. (2019) also emphasize the fundamental value of Bitcoin from transactional benefits, and study the interaction among investors, miners, and hackers. Canidio (2018) touches on token price, but focus more on seignorage and agency issues in platform governance and ICOs. Pagnotta and Buraschi (2018), Canidio (2018), and Sockin and Xiong (2019) all identify multiplicities in token pricing, which could contribute to token price volatility. Saleh (2019) examines token price volatility and welfare in the context of proof-of-burn-based tokens, with an emphasis on the impacts of token-supply changes. Catalini and Gans (2018) examine the pricing of product tokens. Finally, cash-flow-based tokens can be valued using discounted cash-flow methods. And volatility in prices comes from fluctuations in the expected cash flows and discount rates.

### 12.3.8 *Markets for Tokens and Regulatory Issues*

A discussion of tokens would not be complete without discussing the markets for tokens, especially secondary markets that provide liquidity and discover

prices for tokens. Most of the earlier empirical studies focus on Bitcoin. For example, Makarov and Schoar (2020) state that the use of stablecoins like Tether instead of the corresponding fiat like USD can diminish the impact of capital controls. Market segmentation is also discussed by Shams (2020), who finds that the userbase is inherently tied to the investor base, resulting in amplification of demand shocks.

Liu and Tsyvinski (2018) and Liu et al. (2019) document basic risk and return patterns in the cryptocurrency markets. Lyandres et al. (2019) find that tokens behave like traditional securities. This is supported by evidence from Liu et al. (2019) who note that many of the known attributes of the equity market form successful long-short trading strategies for cryptocurrencies. However, the authors also find that Fama-French and Carhart four-factor models do not predict returns. In the same vein, Liu and Tsyvinski (2018) find the risk-return tradeoff of cryptocurrencies to be distinct from traditional assets, noting that returns are predicted mainly by investor attention and momentum. All of Liu and Tsyvinski (2018), Liu et al. (2019), and Shams (2020) confirm model predictions in Cong et al. (2018).

Several regulatory issues related to the issuance and trading of cryptocurrencies also warrant our attention. Our discussions on token categories and pre- versus post-launching the platform have direct implications on ICOs and Howey tests of token issuance (e.g., Cong et al. 2019). Mark Carney, the chairperson of the Financial Stability Board and the head of the Bank of England, warned that illegal manipulations such as wash trading, pump and dumps, and spoofing by bots are rampant in the secondary markets of crypto (Rodgers 2019).

In particular, unlike traditional markets, crypto exchanges, are largely unregulated. China banned all the crypto exchanges in 2017 and Japan issued licenses to 16 exchanges till now, but only less than 10 coins are allowed to be traded on these licensed exchanges. The United States has been exploring the optimal way to regulate cryptocurrency exchanges, with New York State's Bitlicensing leading the way. Singapore and Switzerland follow a strategy of incorporating cryptocurrency-related business into existing regulatory frameworks. However, for most of the countries, these token exchanges are still unregulated. Coinmarketcap lists over 300 token exchanges, about only around half have meaningful trading volume.

The centralized yet unregulated nature of crypto exchanges portends a high risk of manipulation. For example, Gandal et al. (2018) use transaction data leak from Mr. Gox to identify suspicious trading that impact Bitcoin price. Studies such as Cong et al. (2020) discuss how exchanges fake and inflate trading volume. Using universal statistical and behavioral principles, Cong et al. (2020) estimate that unregulated exchanges on average fake over 70% of the trading volume in late 2019, which amounts to over 1 trillion USD per month.

Speaking of market manipulations more generally, Foley et al. (2019) use transactions on Bitcoin blockchain and show that a significant amount of the

Bitcoin transactions are related to illegal transaction. Griffin and Shams (2020) investigate the trading activity of stablecoin Tether that is pegged to US dollar. The authors identify manipulative behaviors associated with the trading of Tether and Bitcoin. Li et al. (2019) analyze pump-and-dump trading in cryptocurrency markets.

Rather than comparing cryptocurrencies to the equity market, future studies may identify interesting patterns relating cryptocurrencies to currencies and commodities, given that general payment and platform tokens are essentially hybrid of money and investible assets. Regulatory issues arising from unique features of the cryptocurrency markets also warrant further examinations.

## 12.4 LOOKING AHEAD AND FUTURE RESEARCH DIRECTIONS

To conclude, we summarize the key takeaways from this introductory discussion of research about cryptocurrencies and tokens. We have categorized the major types of crypto-tokens and highlighted their distinguishing features. We next outline a few promising research directions on cryptocurrencies and the functions of digital tokens.

- Digital currencies are actively explored by central banks. A unified framework for analyzing digital currencies and electronic payments is yet to emerge. Obviously, exchange rate stability is important for digital currencies, as we mentioned earlier when discussing stablecoins. Beyond that, little is understood about how digital currency and electronic payments interact with fiat money and monetary policy, or about how they compete with one another. The distinction between account-based system and token-based system also likely matters for the implementation of digital currencies. Several recent articles such as Allen et al. (2020) provide the institutional background.
- It is useful to understand how tokens relate to Decentralized Finance (DeFi). In particular, how should people use tokens to manage platform growth, provide incentives in an open system, allocate cash and control rights, coordinate efforts, and mitigate agency issues? Can an autonomous system be designed that resolve the trust issue? What about auditability and data privacy issues in such digital networks? Bünz et al. (2018) and Cong et al. (2019) offer initial frameworks for further studies in this direction.
- While platform competitions have been discussed extensively in recent studies (e.g., Halaburda and Yehezkel 2013; Halaburda et al. 2018), how tokens reshape the competitive landscape and market power has just started to be explored. Although Gandal and Halaburda (2016) discuss cryptocurrency competition without necessarily invoking platforms, Lyandres (2019) offers one of the earliest discussions on the topic involving platform competition.

- It is important to clarify regulatory implications surrounding tokens, especially those related to informational issues and industry classification based on underlying functions and economic mechanisms. Manipulation issues in the cryptocurrency ecosystem continue constituting urgent problems for regulators and practitioners. Cong et al. (2020) explore these topics further.
- The design of community-based digital networks with digital tokens is just starting to be explored. Decentralization is a matter of degree, not a black or white dichotomy. A lot of the research has been devoted to cryptocurrencies on permissionless blockchains, but permissioned blockchain could achieve greater decentralization once we consider the tradeoffs involving scalability and net security. The roles of tokens on permissioned blockchains constitute an underexplored area of research.
- Further empirical studies of crypto assets may go beyond merely documenting stylized facts, which are constantly evolving in any case. We need to understand better whether crypto assets make a distinct asset class and empirically study the unique features. For example, network security in relation to token pricing is something other asset classes do not feature. Tokens' role in the staking economy is and is related to the concept of carry in other asset classes such as commodities or currencies (Cong et al. 2021).
- The token markets could also serve as testing grounds for traditional theories and industries. For example, due to the transparency and simple structure often present in cryptocurrencies at this stage of development of the industry, one may be able to test theories of retention, signaling, shock propagation across networks, etc. (e.g., Lee et al. 2018; Davydiuk et al. 2019; Schwenkler and Zheng 2020). We may also learn from the control/voting right allocation about voting system and crowd-based aggregation (e.g., Tsoukalas and Falk 2020).

This article by no means does justice in covering the fast-emerging literature on cryptocurrencies and digital tokens. Several survey articles including Halaburda et al. (2020) complement our discussion and provide additional sources of reference. Finally, a good platform for exploring the latest research is the Crypto and Blockchain Economics Forum ([www.cber-forum.org](http://www.cber-forum.org)).

**Acknowledgements** We thank Samuel Petruzzi and Youwei Yang for excellent research assistance. We also thank Maureen O'Hara for helpful comments. This research was funded in part by the Ewing Marion Kauffman Foundation. The contents of this publication are solely the responsibility of the authors.



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# Emerging Prudential Approaches to Enhance Banks' Cyber Resilience

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## 13.1 INTRODUCTION

Cybercrime is a significant threat to the stability of the financial system and the global economy. The financial system performs a number of key activities that support the real economy (e.g. deposit taking and lending, payments and settlement services, wholesale funding). Cyber incidents have shown that these activities can be disruptive by affecting the information and communication technologies (ICT) that financial firms extensively rely on and the data they process. McAfee (2018) puts the annual cost of cybercrime to the global economy at around \$600 billion while Accenture and Ponemon Institute (2019) estimates the global value at risk from cyber-attacks in 2019–2023 at approximately \$5 Trillion. The latter report also finds that despite the significant efforts by the financial services industry to enhance cyber resilience, the average cost of cybercrime per financial firm is estimated to be \$18.5 million (more than 40% higher than the average cost per company across all industries). In addition, the time required to resolve a cyber incident in financial

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This paper is an updated version of *FSI Insights No 2*: “Regulatory approaches to enhance banks’ cyber-security frameworks” by the same authors.

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firms has substantially increased (e.g. malware, up 89%; denial of service, up 63%). These developments reflect the evolving sophistication of cybercrime and the increasing availability of cyber-attack tools and methods at lower costs. The Covid-19 global lockdown has expanded the attack surface for cyber-threat actors and therefore created additional challenges in the quest to combat cybercrime.<sup>1</sup>

The Financial Stability Board (FSB 2018) defines cyber-risk as the combination of the probability of cyber incidents occurring and their impact. Cyber incidents are defined as events (whether resulting from malicious activity or not) that: (i) jeopardise the confidentiality, integrity and availability of an information system or the information the system processes, stores or transmits; or (ii) violate the security policies, security procedures or acceptable use policies.

The financial sector is arguably one of the sectors of the economy more exposed to cyber-risk given it is IT-intensive and highly dependent on information as a key input. Financial firms are also highly interconnected (including with other sectors) through the payment systems and provide products and services that are time-critical. Within the financial sector, banks typically have the most public-facing products and services. Bank systems' multiple points of contact with outside parties result in significant vulnerability to cyber-attacks, and could be used as entry points for attacks targeting other parts of the financial system.

In light of that, cyber resilience is a top priority for the financial services industry. The Deloitte's 2019 Global Risk Management Survey concluded the management of non-financial risks was assuming much greater importance at financial organisations and, among those, cybersecurity was a top concern. Moreover, close to 70% of respondents to the Deloitte's survey named cybersecurity as one of the three risks that would increase the most in importance for their business over the next two years, far more than for any other risk. Yet, only about one-half of the respondents felt their institutions were extremely effective or very effective in managing this risk.

Strengthening cyber resilience is a key area of attention for the official sector. Cybercrime is widely regarded as a national defence priority and a number of jurisdictions have put in place national policies or frameworks for strengthening the cybersecurity of critical sectors and institutions.<sup>2</sup> Central banks are developing analytical frameworks to understand the channels through which cyber-risk can grow from an operational disruption into a systemic event.<sup>3</sup> Bank supervisory authorities have come up with regulatory and supervisory frameworks to enhance the banking sector's resilience to cyber-attacks.

This paper presents the emerging regulatory and supervisory approaches to address banks' cyber resilience. First, the paper describes the international financial regulatory initiatives relevant for the regulation and supervision of cyber resilience. Second, it outlines the evolving approaches in the policy design of cyber resilience. Third, it presents the key regulatory requirements

implemented by banking authorities. Fourth, it explains the common supervisory frameworks and tools implemented around the world. Finally, the paper offers some policy considerations in implementing regulatory and supervisory approaches to enhance banks' cyber resilience frameworks.

### 13.2 INTERNATIONAL REGULATORY INITIATIVES

Given the borderless nature of cybercrime and its potential impact to the global financial system, cyber resilience has become an important area for international cooperation among standard-setting bodies (SSBs) and financial authorities. FSB (2017) placed the need to mitigate the adverse impact of cyber-risk on financial stability among the top three priority areas for future international cooperation. To facilitate this cooperation through a common language, the FSB published a *cyber lexicon* in 2018 comprising a set of approximately 50 core terms related to cyber resilience in the financial sector. A key point of reference for the official sector continues to be the 2016 Committee on Payments and Market Infrastructures (CPMI) and the International Organization of Securities Commissions (IOSCO) *Guidance on cyber resilience for financial market infrastructures* published in 2016. Although the purpose of this document is to provide supplemental guidance for financial market infrastructures to enhance their cyber resilience, its core elements (particularly those related to governance and risk management) are widely accepted across the financial sector. The work on cyber resilience by the G7 finance ministers and central bank governors (the G7) is another common point of reference for the financial industry and the official sector community despite its non-binding nature. In this regard, the 2016 G7 *Fundamental elements of cybersecurity for the financial sector* (G7 FE) has played a pivotal role in providing private and public sector entities with building blocks to design and implement sound cybersecurity policies and practices. To assess the actual performance of these policies and practices, the G7 FE was followed in 2017 by the G7 *Fundamental elements for effective assessment of cybersecurity in the financial sector* (G7 FEA). In 2018, the G7 adopted two documents that further elaborate on its fundamental elements publication by providing financial entities with: (i) a guide to assess their resilience against cyber incidents by using simulated tactics, techniques and procedures of real-life threat actors (threat-led penetration testing); and (ii) best practices to effectively manage cyber-risks posed by third parties.<sup>4</sup>

In addition, SSB's work on cyber resilience has focused on: (i) enhancing a mutual understanding of their members' efforts by taking stock of their cybersecurity regulations, guidance and supervisory practices; and (ii) addressing different components of cyber resilience or its oversight. With respect to the former, an example is the 2018 Basel Committee on Banking Supervision (BCBS) report entitled *Cyber-resilience: Range of Practices* that describes and compares the range of regulatory and supervisory cyber resilience practices across BCBS member jurisdictions. Another relevant example is the

2019 Report from the IOSCO Cyber Task Force. This report examined how IOSCO member jurisdictions were using internationally recognised cyber frameworks and how these frameworks could help address any gaps identified in IOSCO members' current regimes rather than proposing any new guidance. Regarding the latter, the FSB issued a report in 2020 on *Effective practices for cyber incident response and recovery*, which proposes a toolkit to guide financial institutions to respond to and recover from a cyber incident in a way that limit any related financial stability risks. Another example is the work of the International Association of Insurance Supervisors (IAIS) through its 2018 *Application Paper on Supervision of Insurer Cybersecurity*. This document provides guidance to IAIS member authorities seeking to develop or enhance their approach to supervising the cyber resilience of insurers.

The cross-border nature of cyber-risk requires a high degree of alignment in national regulatory expectations. No single firm or regulator can successfully tackle cyber-risk alone. The above-mentioned G7 and SSBs work are facilitating a helpful level of convergence and therefore are steps in the right direction. However, there is still much work to do in this area. Differing regulatory frameworks for cyber-risk across jurisdictions could have the same impact as conflicting regulations or could inadvertently create regulatory gaps. For banks operating in various jurisdictions, alignment of regulatory expectations would help them avoid conflicting guidance, some of which would be undertaken simply for compliance purposes without any real improvement in cybersecurity.

### 13.3 EMERGING APPROACHES FOR THE DESIGN OF CYBER RESILIENCE POLICIES

There are two extreme views on the regulation of banks' cyber-risk: one which sees no need for specific regulations, and the other which favours specific regulations. In the former, cyber-risk is viewed as any other risk and thus the general requirements for risk management (e.g. governance, setting of risk appetite, etc.), in particular IT, information security and operational risks, also apply. This view perceives the evolving nature of cyber-risk as not amenable to specific regulations, which would only become outdated and ineffective.<sup>5</sup> Regulations may also result in a compliance-based approach to dealing with cyber-risk. The latter view, on the other hand, emphasises the importance of providing structure through the regulation of cyber-risk in order to properly cope with its specificities and its growing relevance given the increasingly digitised nature of finance. In fact, specific regulations on cyber resilience are fairly recent and have been either introduced or proposed only in the last few years. In general, these are meant to supplement the more general regulations on IT, information security and operational risks.

One potential benefit of having specific regulations is that it can help ensure board and management buy-in. As regulation makes any issue more visible to boards and senior management, regulation on cyber-risk gives banks a stronger

incentive to continuously invest in improved cyber resilience. Banks' boards and senior management have the natural incentive to ensure sound cyber resilience given the potentially damaging monetary and reputational costs of cyber-attacks. However, boards and senior management may not always be forward-looking and may not appreciate the business implications of cyber-risk, and hence be inclined to subordinate cyber resilience to other business objectives in the absence of specific regulatory expectations.

However, the risk exists that specific regulations become too prescriptive, so that they fall behind both the constantly evolving threat from cyber-risk and advances in cyber-risk management. While prescriptive rules may be necessary in some areas, for example, by requiring banks' boards to establish a cyber-risk management framework and appetite, other areas are clearly less suitable for specific rules. Prescribing the use of a specific technology is one example; given the rate of technological change, any prescribed technology is likely to become rapidly outdated. Mandating a specific recovery time is another example where regulators need to be careful how banks go about implementing it. The aim is to prevent the lengthy disruption of critical financial operations, but an excessively stringent and rigid recovery time may prove counterproductive if this comes at the expense of banks' ability to thoroughly check that all their systems are no longer compromised.

In light of the trade-offs connected with issuing specific cyber regulations, there is an emerging regulatory approach that seeks to combine broad cyber resilience principles with a set of baseline requirements. This approach focuses more on "what expectations to achieve" and less on "how to achieve them."<sup>6</sup> It supports a regulatory framework that is flexible enough to be adjusted to the dynamic and evolving nature of cyber-risk while having clear supervisory expectations with respect to core aspects of governance and risk management that aim to enhance cyber resilience.

Regardless of the regulatory approach taken, the application of the proportionality principle should be given due consideration in the application of cyber resilience frameworks. Proportionality is defined as the application of simplified prudential rules to smaller and less complex banks to avoid excessive compliance costs without undermining key prudential safeguards.<sup>7</sup> Translating this concept to the cybersecurity world and considering that all banks are exposed to cybercrime, it would be important to identify key aspects of cyber resilience governance and risk management that should apply to all supervised firms regardless of their size, complexity and risk profile. At the same time, authorities should aim to have a clear idea about the extent to which systemically important banks and other institutions with a higher cyber-risk profile should be subject to heightened cyber resilience requirements.

Any cyber resilience framework should also be aligned with regulatory expectations on enterprise risk management and operational risk including operational resilience and ICT-related risks. A successful cyber-attack is very likely to affect people, processes and technology throughout a bank. At the



same time, sound operational risk management practices provide the foundation of a robust cyber resilience framework. As part of this, an effective response to and recovery from a cyber incident requires a sound operational resilience strategy. Therefore, it would be particularly challenging if cybersecurity were managed through its own set of responsibilities, policies and procedures, inconsistent with the overall risk management framework and operational risk approach. To mitigate this challenge, cyber-risk needs to be incorporated into the banks' enterprise-wide risk management framework and governance structure. Like any other bank risk, cyber-risk should be subject to the general risk management principles of risk identification, control, monitoring and mitigation. If necessary to help achieve this, supplemental guidelines may be issued applying or clarifying the application of the general risk management regulations to cyber-risk.

Existing technical standards on cyber and information security are a valuable point of reference for supervisory assessments of cybersecurity capabilities. For instance, the US National Institute of Standards and Technology (NIST) developed a cybersecurity framework in close cooperation with the private and public sectors. Consisting of a set of industry standards and best practices that help organisations manage cyber-risk, the framework is used voluntarily by organisations across the United States and has also received significant worldwide attention. As such, the NIST framework could be a valuable starting point for jurisdictions that decide to put in place or upgrade their approach to cybersecurity. Other influential technical standards in the cyber/information security community include the International Organisation for Standardisation and the International Electrotechnical Commission standards (in particular the ISO/IEC 27000 series on information security management, ISO 22301 on security and resilience and/or ISO 31000 on risk management); the Control Objectives for Information Technologies (COBIT) framework for IT governance and management; and the Center for Internet Security (CIS) Controls (which map into the NIST Framework). Relying on credible technical standards in which financial institutions may have already invested provides a solid foundation for any supervisory framework. Otherwise, adoption of supervisory assessment guidelines that differ considerably with existing technical standards could lead to confusing or conflicting approaches and result in unnecessary duplication of effort, leaving less resources for actual protection activities.

### 13.4 KEY REGULATORY REQUIREMENTS RELATING TO CYBER RESILIENCE

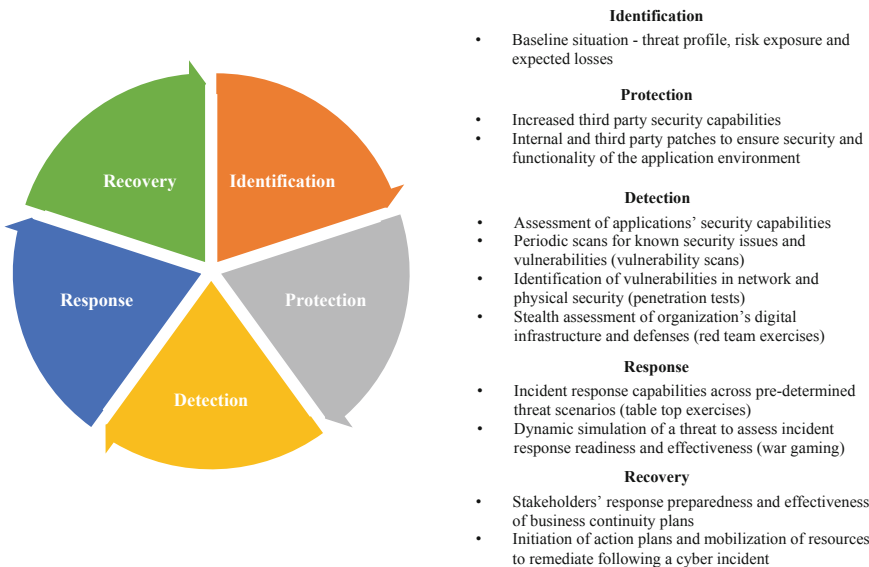
The tension between treating risks to cyber resilience the same as any other risks and the need for specific treatment given their significant implications has led to different regulatory approaches. This section discusses regulatory requirements and expectations in the area of cybersecurity strategy, governance and risk management; critical business services; cyber incident response and

recovery; cyber incident reporting and threat intelligence sharing; cybersecurity workforce and risk awareness; and third party dependencies.

### 13.4.1 Cybersecurity Strategy, Governance and Risk Management

Many regulators expect that banks' risk management frameworks and/or information security frameworks should cover risks to cyber resilience. As such, according to the 2018 BCBS report *Cyber-resilience: range of practices*, only a few regulators require banks to develop specific cybersecurity strategies that are separate from their information security strategies. For jurisdictions with specific regulatory requirements for cybersecurity strategies, the requirements typically follow the cybersecurity framework advocated in CPMI/IOSCO (2016) involving identification, protection, detection, response and recovery (see Fig. 13.1). Hence, these include general requirements on governance and oversight, risk ownership and accountability, information security or cyber hygiene measures (e.g. patch management procedures, access controls, identity management, etc.), periodic evaluation and monitoring of cybersecurity controls, incident response, business continuity and recovery planning.

Similarly, some regulators consider that existing general risk management frameworks already cover the roles and responsibilities of the board of directors (BoD) and senior management when it comes to addressing risks to cyber resilience. Other regulators, however, have issued specific regulatory guidance



**Fig. 13.1** Emerging cybersecurity framework (*Sources* CPMI-IOSCO [2016]; Oliver Wyman's approach as described in Mee and Morgan [2017])

and requirements addressing such roles and responsibilities in the context of cyber resilience.

While most regulators do not require banks to implement the “three lines of defence” risk governance model,<sup>8</sup> specific regulatory guidance and requirements relating to roles and responsibilities in the context of cyber resilience commonly expect clear accountability within banks for cyber-related issues. These involve documented policies on clear assignment of cyber-related management responsibilities relating to identification, protection, detection, response and recovery. However, not many specifically require the designation of a Chief Information Security Officer (CISO) or equivalent. One possible reason is the lack of information security professionals who could fill this position. In fact, the requirement issued by the New York State’s Department of Financial Services (DFSNY), for example, allows the CISO to be employed by a third-party service provider (i.e. not an employee) of the bank, subject to certain conditions.

Nevertheless, the designation of a CISO or equivalent is a common practice among large and globally active banks. The CISO oversees bank-wide cybersecurity. In some cases, the CISO reports to the Chief Risk Officer (CRO), in others to the Chief Information Officer (CIO). The former case would seem to be the natural choice since all of a bank’s risks should be within the CRO’s remit. However, CROs usually do not have a technology background and thus may not view cyber-risk as part of their remit, which may be narrowly defined as including only the traditional financial risks. In addition, some CROs might put more emphasis on compliance that might conflict with a CISO’s approach of implementing cyber and IT security controls that still allow technological innovation. CIOs, on the other hand, are familiar with technology but their position in business operations creates a conflict with the review function of risk management (i.e. having the first and second lines of defence under one person or function). Given the importance of cyber resilience, there is a case to be made therefore for having CISOs report directly to the Chief Executive Officer (CEO) or the BoD.

### 13.4.2 *Critical Business Services*

Regulators generally expect banks to be able to identify their critical business services/operations. At the national level, governments identify critical infrastructure and firms to which their national cybersecurity frameworks apply. Banks are expected to do the same at their own level. Banks should be able to map their business services to their supporting assets (including third-party services), and be able to classify their business services according to their criticality and sensitivity to cyber-risk. This enables the prioritisation of cybersecurity efforts on assets that support critical business services. Ideally, the entire bank should be protected but, given limited resources, banks should be able to target where to deploy their resources to maximise the benefits and ensure operational resilience.

### *13.4.3 Cyber Incident Response and Recovery*

Many regulators require banks to establish a framework for incident response and recovery. However, most requirements are not specific to cyber incidents with only a few regulators having cyber-specific business continuity and disaster recover requirements. Nevertheless, there is recognition that it is a question of when, not if, banks will experience a cyber-attack. This “assume breach” mentality is now replacing the traditional concept of building a strong perimeter to ward off a cyber-attack. The new threat environment, characterised by multiple points of potential entry for attacks, has reduced the effectiveness of the traditional security approach that relies solely on marshalling all of an institution’s security devices/detective capability to guard the perimeter. The assumption of breach approach complements the traditional measures with intrusion detection techniques as well as response measures (e.g. to prevent the extraction of critical data).

To help financial institutions enhance their cyber incident response and recovery, FSB (2020) provides guidance in this area. The report provides a “toolkit” of 49 effective practices, structured across seven components:

Governance—frames how cyber incident and recovery is organised and managed.

Planning and preparation—to establish and maintain capabilities to respond to cyber incidents, and to restore critical functions, processes, activities, systems and data affected by cyber incidents to normal operations.

Analysis—to ensure effective response and recovery activities, including forensic analysis, and to determine the severity, impact and root cause of the cyber incident to drive appropriate response and recovery activities.

Mitigation—to prevent the aggravation of the situation and eradicates cyber threats in a timely manner to alleviate their impact on business operations and services.

Restoration and recovery—to repair and restore systems or assets affected by a cyber incident to safely resume business-as-usual delivery of impacted services.

Coordination and communication—to establish processes to improve response and recovery capabilities through lessons learnt from past cyber incidents and from proactive tools, such as tabletop exercises, tests and drills.

Improvement—to coordinate with stakeholders to maintain good cyber situational awareness and enhance the cyber resilience of the ecosystem.

### *13.4.4 Cyber Incident Reporting and Threat Intelligence Sharing*

Cyber incident reporting by banks to regulators is a common regulatory requirement. Such reporting requirements have been established to achieve specific objectives, such as:

- Enable systemic risk monitoring of the financial industry by the regulator;

- Enhance or issue regulatory requirements/recommendations based on information collected;
- Allow appropriate oversight of incident resolution by regulators; and
- Facilitate further sharing of information with industry and regulators to develop a cyber incident response framework.

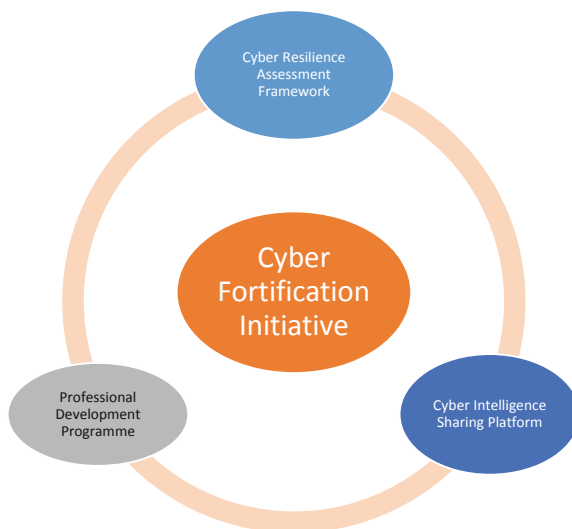
Some jurisdictions have specific requirements for the regulatory reporting of cyber incidents, subject to materiality (e.g. if the impact is deemed to be material enough to adversely impact the bank's operations) or the incident posing risk to a bank's critical business services. In other jurisdictions, cyber incidents are already captured in existing reporting requirements (e.g. events mandated by law or existing regulation to be reported to a government body or regulatory agency).<sup>9</sup> Moreover, there are different reporting frameworks ranging from formal communications to informal communications (e.g. free-text updates via email or verbal updates over the phone). In addition, there are differences in terms of taxonomy for reporting, reporting time frame (e.g. immediately, after two/four/72 hours after an incident), reporting templates and thresholds to trigger a report.

Cyber-threat intelligence sharing may not always be an explicit regulatory requirement, but it is encouraged and in most cases regulators play a role in facilitating the establishment of voluntary sharing mechanisms. Hong Kong is an example where regulations include an explicit requirement by incorporating in its Cyber Fortification Initiative (CFI) an element of effective infrastructure for sharing intelligence in which all banks are expected to participate (see Fig. 13.2). In other jurisdictions, while information-sharing may not be explicitly included in regulations, banks are "strongly encouraged" to participate in a sharing platform maintained by the authorities. In addition, banks may also be encouraged to participate in security information-sharing forums. Financial firms have also taken the initiative to establish their own efforts in this regard (e.g. through the Financial Services Information Sharing and Analysis Center (FS-ISAC)). In addition, the Society for Worldwide Interbank Financial Telecommunication (SWIFT) has established a Customer Security Programme (CSP) that requires, among other things, that user institutions share all relevant information as soon as possible if they have been targeted or breached. This forms part of their contractual obligations as SWIFT users.

#### *13.4.5 Cybersecurity Workforce and Risk Awareness*

Some regulators have specific standards that address the responsibilities of the cybersecurity workforce and functions, with particular attention to training and competencies. In other cases, regulators certify the information security professionals used by banks for their cybersecurity activities. One reason for the need for regulatory certification is the sensitive nature of these activities, given that the people involved will gain insights into a bank's defences. The UK, for example, has established CBEST accreditation for any information security

The HKMA's Cybersecurity Fortification Initiative (CFI) has three main elements:



- i. Cyber Resilience Assessment Framework – includes an inherent risk assessment, maturity assessment, and an intelligence-led cyber-attack simulation testing (iCAST);
- ii. Professional Development Programme – seeks to increase supply of qualified cyber-security professionals in Hong Kong; HKMA is working with the HK Institute of Bankers and the HK Applied Science and Technology Research Institute (ASTRI) to develop a localised certification scheme and training programme for cyber-security professionals; and
- iii. Cyber Intelligence Sharing Platform – seeks to provide an effective infrastructure for sharing intelligence on cyber-attacks; being set up by the HKMA together with the HK Association of Banks (HKAB) and ASTRI.

**Fig. 13.2** The Hong Kong Monetary Authority's (HKMA's) cybersecurity fortification initiative (*Source* HKMA: Cybersecurity Fortification Initiative, 24 May 2016; graphic by FSI)

professionals involved in CBEST testing. This is in addition to the Council for Registered Ethical Security Testers (CREST) accreditation established by the industry. Another reason is the limited number of information security professionals in most jurisdictions. In Hong Kong, this is being addressed by including a Professional Development Programme (PDP) in its CFI. While the PDP is a local certification and training programme, its aim is to increase the supply of qualified cybersecurity professionals in the country. The scarcity of qualified people in this area is also reflected in the DFSNY regulation that allows banks to use cybersecurity professionals employed by third parties.

The problem, though, is not only about the limited availability of people with technical knowledge of cybersecurity. A further problem is the limited cybersecurity awareness of staff within banks, which itself could potentially open the way for a cyber incident. In essence, cybersecurity is less about technology and more about people (e.g. it is people, not computers, who click

on suspicious links). But there has been too much focus on technical solutions, and less so on people and processes. To address this, many regulators are encouraging the development of a common risk culture to ensure effective cybersecurity. Regulators have issued guidance and requirements emphasising the importance of risk awareness and risk culture for staff and management at all levels, including the BoD as well as third party employees. These include regulatory requirements relating to cybersecurity awareness training and cyber-related staffing. These also include measures to reduce the risk of theft, fraud or misuse of facilities (e.g. screening and background verification process for new employees, mandatory reverification process for existing employees at certain intervals, etc.).

#### *13.4.6 Third-Party Dependencies*

Third parties are widely used by banks to provide services, systems or IT solutions that support banks' operations. Traditionally, third parties relate to the providers of outsourc ed activities. In the cybersecurity context, third parties can be defined in a much broader sense to include products and services that are typically not considered as outsourc ed (e.g. power supply, telecommunication lines, hardware, software) as well as interconnected counterparties (e.g. payment and settlement systems, trading platforms, central securities depositories and central counterparties). These third parties may hold or may be able to access non-public information of banks and its customers. In addition, cybersecurity vulnerabilities in these third parties could become channels of attack on banks. The security capabilities of third-party service providers are therefore critical elements of any cybersecurity framework.

In most cases, regulators use outsourc ing regulations to address third-party dependencies. Outsourc ing regulations typically require either prior notification or authorisation of material outsourcing activities, the maintenance of an inventory of outsourced functions and reports on measurements of service level agreements (SLAs) and the appropriate performance of controls. Some outsourcing regulations also require sub-outsourcing activities to be visible to regulated entities so that they can manage the associated risks. In addition, outsourcing regulations generally require that banks develop management-and/or board-approved outsourcing and contractual frameworks that define banks' outsourcing policies and governance and specify obligations of the institution and the service provider in an outsourcing agreement, respectively.

In cases where there are regulatory expectations on broader third-party dependencies, regulators typically expect that banks take into account business continuity and information confidentiality and integrity. This is to ensure the availability of critical systems and the security of sensitive data that are accessible to, or held by, third party service providers. Regulations stress the importance of aligning business continuity plans of critical third-party providers (and their subcontractors) with the needs and policies of the bank in terms of business continuity and security. Confidentiality and integrity of

information, on the other hand, are addressed in general data protection requirements, contractual terms that are explicitly required to include confidentiality agreement, and security requirements for safeguarding the bank's and its customers' information.

A growing number of jurisdictions also have specific regulatory requirements for the use of the cloud by banks. These range from requiring information transferred to the cloud be subject to a contractual clause and that different cloud-specific issues be considered to ensure data security, to more specific requirements on data location, data segregation, data use limitations, data security and treatment of data in case of exit from the third party arrangement. For example, specific expectations for control and location of data are starting to emerge. These may take the form of requirements that the location of at least one data centre for cloud computing services provided in the country or region be identified, or data ownership, control and location be identified and monitored as part of the service agreement. Some jurisdictions further require a contractual clause that reserves the right for banks to intervene at, or give directives to, the service provider. However, commonalities in specific technical and operational requirements are still not emerging. Authorities seem to be emphasising different aspects of controls to ensure information confidentiality and integrity, ranging from explicitly requiring encryption solutions for confidential data to be under the banks' control, regulating the transfers of data abroad, to requiring explicit client consent for data handling by third parties.

### 13.5 SUPERVISORY FRAMEWORKS AND TOOLS

Most supervisors follow a more traditional approach and are assessing cybersecurity as part of their ongoing risk-based supervisory activities. This typically involves evaluating whether banks meet a series of criteria, which may be based on the banks' scale, complexity, business model and findings from previous on-site examinations. Supervisors then assign banks a rating or to a category and then, based on that rating or category, determine any management recommendations or supervisory actions. More recently, some supervisory authorities have used thematic or specialised reviews on cybersecurity as a complement to their supervisory work. In such cases, supervisors have internal guidance for identifying circumstances when they should conduct a specific cybersecurity review on a bank. The guidance typically looks at the bank's own risk assessments, previous on-site examinations findings, responses to questionnaires and cyber incidents.

Whether supervisors conduct reviews of cybersecurity as part of general risk management or independently, the reviews tend to focus on strategy, governance, cybersecurity capabilities including controls, monitoring, detection and response and recovery. While regulatory requirements and expectations described above inform supervisory reviews on a number of these areas, supervisors use specific frameworks or tools in certain cases.



### 13.5.1 Controls, Monitoring and Detection

Supervisors assess banks' cybersecurity controls, monitoring and surveillance of emerging threats, including real-time detection capability and ability to detect adversaries before they move between systems. These assessments are based on frameworks established in existing industry standards mentioned in Sect. 13.3, such as the NIST, ISO, COBIT and CIS frameworks.

### 13.5.2 Testing of Cybersecurity Capabilities

Supervisory assessments include a challenge on banks' approaches to testing controls and the remediation of issues identified. This can include a review of banks' responses to a supervisory questionnaire, audit reports and control testing reports that may be part of a more formal testing programme. The CPMI/IOSCO *Guidance on cyber resilience for financial market infrastructures*, which has provided a coherent approach to improving cyber resilience in financial institutions more broadly, called for the establishment of a comprehensive cyber resilience framework that includes a testing programme to validate the framework's effectiveness. Such a testing programme could employ various testing methodologies and practices, such as:

- Vulnerability assessment—systematic examination of an information system, and its controls and processes, to determine the adequacy of security measures, identify security deficiencies, provide data from which to predict the effectiveness of proposed security measures and confirm the adequacy of such measures after implementation.
- Penetration testing—a test methodology in which assessors, using all available documentation (for example, system design, source code, manuals) and working under specific constraints, attempt to circumvent the security features of an information system.
- Red team testing (also referred to as threat-led penetration testing)—a controlled attempt to compromise the cyber resilience of an entity by simulating the tactics, techniques and procedures of real-life threat actors. It is based on targeted threat intelligence and focuses on an entity's people, processes and technology, with minimal foreknowledge and impact on operations.

While there is a range of testing methodologies and practices to validate an institution's cyber resilience capabilities, each with its own intended objective, there is recognition of the importance of red team testing. A number of jurisdictions have red team testing frameworks in place (see Table 13.1), although the objectives and implementation details may differ. The frameworks apply typically to large or critical financial institutions, but authorities may have discretion to include other financial institutions such as banks deemed risky from a supervisory perspective. The frameworks also differ in terms of whether

**Table 13.1** Key information on red team testing frameworks in selected jurisdictions

Jurisdiction	Framework	Year launched	Institutions covered	Threat intelligence and red team test providers		
				External parties?	Accreditation required?	Separate teams?
European Union	Threat Intelligence-Based Ethical Red Teaming (TIBER-EU)	2018	At the discretion of relevant national or European authorities	Yes	No	Yes
Hong Kong SAR	Intelligence-led Cyber Attack Simulation Testing (iCAST)	2016	Banks that aim to attain “intermediate” or “advanced” maturity level are required; banks with “high” or “medium” inherent risk are expected	Not necessarily	No	Not necessarily
Netherlands	TIBER-NL	2016	Institutions that are part of the core financial infrastructure, plus larger insurance and pension fund providers	Yes	No	Yes
Saudi Arabia	Financial Entities Ethical Red-Teaming (FEER)	2019	All regulated financial institutions are encouraged but, as a minimum, domestic systemically important institutions are required	Yes	Yes	No
Singapore	Adversarial Attack Simulation Exercises (AASE)	2018	All financial institutions are encouraged but larger ones are expected	Not necessarily	No, but encouraged	Not necessarily
United Kingdom	CBEST	2014	Critical financial institutions are expected; non-critical ones may opt in	Yes	Yes	Yes

*Source FSI Insights No 21:* Varying shades of red: how red team testing frameworks can enhance the cyber resilience of financial institutions

threat intelligence and red team test providers must be external to the financial institution, accredited and formally assessed.

Red team testing can strengthen institutions’ cyber resilience posture by, among others, having a methodology to establish remediation plans to address identified weaknesses; being able to better organise and process threat intelligence; fostering closer cooperation among different units; promoting stronger security awareness and culture; and raising accountability of the BoD and senior management on cybersecurity. For supervisors, red team testing provides for a mechanism to understand better financial institutions’ cyber resilience posture, as well as to identify common weaknesses and strengths across the industry. Nevertheless, there are challenges that need to be overcome, and certain facilitating conditions appear to be instrumental in supporting effective implementation of red team testing. Such conditions include a conducive governance structure, an engaged board of directors, a supportive risk culture and, critically, the availability of sound professional skills. A culture-related hurdle to overcome is getting firms and authorities to view a red team test as a “learn and improve” rather than a “pass or fail”

exercise. Other challenges in connection with red team testing include the high cost to firms, trust among the involved parties and data confidentiality.<sup>10</sup>

### *13.5.3 Cyber Incident Response and Recovery*

Supervisory evaluation of banks' cyber incident response and recovery plans focuses on how plans are triggered, banks' ability to implement the plans, and preservation of data and critical systems. In addition, in some jurisdictions, supervisors conduct a review of post-incident learning. Supervisors usually conduct this review through discussion of banks' response and root cause analysis. Moreover, in many jurisdictions, supervisors and banks use exercises to train and practice how they would respond to a cyber incident. For example, there is an annual financial sector operational resilience exercise in the UK, which incorporates cyber-specific scenarios. In Japan, supervisors and banks conduct tabletop exercises to improve cybersecurity and, in particular, communication and coordination of response mechanisms.

### *13.5.4 Cybersecurity Workforce*

Most supervisory authorities are in the early stages of implementing practices to monitor banks' cybersecurity workforce skills and resources. The range of supervisory practices includes assessment of staff expertise and background, assessment of staff training processes and assessment of adequacy of funding and resources to implement the bank's cybersecurity framework. Supervisors usually do these assessments during on-site examinations when they have the opportunity to talk with relevant cybersecurity specialists. Self-assessment questionnaires is also a common practice.

Attracting and retaining staff with cybersecurity expertise is also a key challenge for supervisory authorities. In 2015, the US Government Accountability Office reported that, while the country's largest deposit-taking institutions were generally examined by IT experts, medium and smaller institutions were sometimes reviewed by examiners with little or no IT training. According to the same report, US regulators recognised that, as some IT training is necessary for all examiners, efforts were under way to increase the number of staff with IT expertise and conduct more training. More generally, the 2017 Global Information Security Workforce Study, covering 2,620 cybersecurity professionals in the US federal government, reported that almost 70% of respondents indicated not having the staff necessary to address cyber threats, explaining that this was due mainly to difficulties in finding qualified personnel and retaining information security workers. The same study reports that the three most effective incentives for attracting and retaining cybersecurity staff are (i) offering training programmes or paying for security certification; (ii) improving compensation packages; and (iii) flexible work schedules.

### *13.5.5 Third-Party Dependencies*

Supervisory approaches to assessing cyber-related risks of third-party dependencies follow the same approach as supervising outsourcing activities. Supervisors may conduct such assessments during on-site examinations by reviewing the outsourcing framework, the applicable processes and the completeness and adequacy of specific risk assessments and contracts. Supervisors may also conduct such assessment as part of their off-site monitoring activities. Supervisors receive periodic statements or reports that assess the outsourcing policies and risks at the financial institution. These reports will typically contain statements on the existence and adequacy of outsourcing policies, processes, risk assessments and contracts.

The ability to supervise third parties directly, however, depends on whether supervisory powers extend to third parties. Supervisors in most jurisdictions put the onus on banks to ensure that the third parties they deal with have the same stringent security policies, procedures and controls that the supervisors expect of regulated firms. Some supervisors have oversight of third parties and can therefore assess for themselves the soundness of cybersecurity in these firms,<sup>11</sup> while others require SLAs between banks and third parties to include a clause that allows supervisors to examine the latter's systems. In either case, supervisors have been using traditional supervisory tools in order to ensure that regulatory expectations are met. These include thematic off-site reviews based on self-assessment questionnaires as well as on-site examinations, on the basis of either formal requirements or authority or cooperation from third parties.

### *13.5.6 Cybersecurity and Resilience Metrics*

Supervisors are still starting to develop metrics of the quality or level of cybersecurity and resilience of banks. The early metrics have focused on using information from reported incidents, surveys, testing activities and on-site inspections. However, none of these methodologies produce quantitative metrics or risk indicators comparable to those available for financial risks. Instead, these indicators provide broad information on banks' approach to building and ensuring cybersecurity and resilience. Moreover, a common drawback of the early methodologies is the tendency to focus on backward-looking indicators of the performance of the cybersecurity function. The nature of cyber-risk frustrates this approach because adversaries are dynamic and continuously adapt to responses and protective measures. There is an increasing recognition therefore of the need for forward-looking indicators as direct and indirect metrics of cybersecurity and resilience.

### *13.5.7 Cooperation and Collaboration Between Authorities*

Supervisory cooperation and collaboration is important in dealing with cyber-related issues. Supervisors in different jurisdictions appear to be actively exchanging practices. Supervisors also share information on cyber-related issues involving supervised firms with other supervisors, be they domestic or cross-border, as appropriate according to established mandatory or voluntary information-sharing arrangements. Supervisors may also share such information through the many informal and ad hoc supervisory communication channels that exist, such as supervisory colleges and memoranda of understanding. Information shared may include regulatory actions, responses and measures.

In addition, jurisdictions have generally set out standards and practices for critical infrastructure and entities (including banks) and regulators to share cybersecurity information with national security agencies. While most jurisdictions adopt a voluntary approach, a few jurisdictions established formal sharing requirements. Computer Emergency Readiness Team (CERT) or similar security agencies may act as focal points for cyber incident notification in a jurisdiction.

## 13.6 FUTURE POLICY CONSIDERATIONS

Given the cross-border nature of cyber crime and its potential impact on the global financial system, SSBs and international financial authorities have been focusing their attention on enhancing international cooperation on cyber resilience. This has led to widely accepted building blocks for the design, enhancement and implementation of sound cyber resilience policies and practices such as the FSB cyber lexicon, the CPMI-IOSCO Guidance on Cyber Resilience for Financial Market Infrastructures and the G7 publications on fundamental elements of cybersecurity for the financial sector, threat-led penetration testing and third-party cyber risk management. These are steps in the right direction to achieve a higher degree of alignment in national regulatory expectations but much more needs to be done on international regulatory convergence in order to enhance global cyber resilience.

Another key point of reference for any supervisory framework are technical standards on cyber- and information security such as the NIST framework, the ISO standards, the COBIT framework and the CIS controls. Given the limited availability of resources in the field of cybersecurity, particularly in regulatory and supervisory agencies, existing technical standards on cyber- and information security are useful starting points for regulators and supervisors. This also avoids having duplicative and/or conflicting expectations when it comes to cybersecurity, which will only distract from banks' cybersecurity activities, as resources will have to be deployed to understand what each differing standard and guideline means.

In terms of policy design, there are two broad approaches to regulate cyber resilience: relying on general risk management expectations and, in particular, operational risk management, operational resilience and ICT-related regulations; or issuing specific regulations to deal with cyber-risk. Regardless of the approach taken, due consideration should be given to the proportional application of the cyber resilience framework. This means identifying core governance and risk management aspects of the framework that should apply to smaller and less complex financial institutions. Moreover, any cyber resilience framework should be aligned with the regulatory expectations on enterprise risk management and operational resilience. In light of the strong interconnections between those areas and cyber resilience, it would be beneficial to have consistency in their regulatory approaches.

There are common regulatory expectations emerging among jurisdictions that have opted for issuing specific cyber resilience regulations. Regulators generally follow the cybersecurity framework advocated in CPMI/IOSCO (2016) involving identification, protection, detection, response and recovery and typically expect clear accountability on those and other aspects of the cyber resilience framework. As part of this framework, regulators expect banks to identify and effectively manage their critical business/services and third-party dependencies. Although cyber incident reporting is also a common requirement, the specific technical and operational requirements seem to differ across jurisdictions. Another common regulatory expectation is establishing an incident response and recovery framework but a limited number of authorities appear to require a cyber-specific framework. One of the main objectives of the FSB toolkit on cyber incident response and recovery is to enhance public and private sector practices in this area.

A critical element of any regulatory framework is to promote cybersecurity awareness among staff. There is a tendency on the part of both regulators/supervisors and banks to focus too much on technical solutions. Often overlooked is the relevance of the human factor. Policies should encourage banks to develop a framework that enhances awareness among staff about cyber-risk and establishes metrics to measure this awareness. This approach is particularly relevant for smaller jurisdictions with limited resources and threat intelligence capabilities, as well as for dealing with smaller banks.

Most supervisors are assessing cybersecurity as part of their ongoing risk-based supervisory activities, while others are complementing these with thematic or specialised reviews. Regardless of the supervisory approach taken, these reviews tend to focus on strategy, governance, cybersecurity capabilities including controls, monitoring, detection and response and recovery. While regulatory requirements and expectations described above inform supervisory reviews on a number of these areas, supervisors use specific frameworks or tools in certain cases. To test an institution's cyber resilience capabilities, supervisors are increasingly using vulnerability assessments, penetration testing, red team testing and other cyber resilience testing approaches. Despite the value

and different intended objectives of each of those testing approaches, there is growing recognition of the importance of red team testing.

It is necessary to explore further collaboration with the industry in strengthening banks' cybersecurity and to pursue greater cross-border cooperation. In some jurisdictions, regulators are working closely with the industry in creating or promoting platforms for intelligence sharing, developing a pool of cybersecurity professionals, and establishing guidelines on penetration testing. This could be a model that other jurisdictions could use, especially those with limited regulatory and supervisory resources, smaller banks, or a scarcity of cyber- and information security professionals. Moreover, given the scarcity of cybersecurity resources and the cross-border nature of cyber-risk, the need for supervisory cooperation cannot be overemphasised. In this regard, the BIS's Cyber Resilience Coordination Centre (CRCC) is expected to play a key role in facilitating cross-border cooperation. The CRCC seeks to provide a structured and careful approach to knowledge-sharing and collaboration between central banks in the area of cyber resilience. A core CRCC service is to provide a secure collaboration platform for information-sharing on multilateral cyber threats.

## NOTES

1. Crisanto and Prenio (2020).
2. For example, Singapore's Cybersecurity Strategy, Canada's Cybersecurity Standard, the US Department of Homeland Security's different initiatives to protect US critical infrastructure, South Africa's National Cybersecurity Policy Framework (NCPF); the Critical Infrastructure Protection in France.
3. For example, European Systemic Risk Board, Systemic Cyber Risk, February 2020; Bank of England, Could a Cyber Attack cause a Systemic Impact in the Financial Sector?, Q4 Quarterly Bulletin, 2018; US Office of Financial Research, Cybersecurity and Financial Stability: Risks and Resilience, February 2017. The academia is also actively involved in this area. See for example, Danielsson, J, Fouché, M and Macrae, R, Cyber Risk as Systemic Risk, 2016; Duffie, D. and Younger, J, Cyber Runs: How a Cyber Attack Could Affect U.S. Financial Institutions, 2019.
4. See G7 (2018a, b).
5. See Gracie (2014).
6. See Wilson et al. (2019).
7. See Castro Carvalho et al. (2017).
8. The "three lines of defence" risk governance model involves (1) business unit management as the first line; (2) independent risk management and compliance functions as the second line; and (3) an independent assurance function (internal and/or external audit) as the third line.
9. For example, the US Treasury Department's Financial Crime Enforcement Network (FINCEN) issued an Advisory on 25 October 2016 advising financial institutions to include cyber-related events in their Suspicious Activity Reports (SARs).
10. See Prenio et al. (2019) for more discussion on red team testing frameworks in different jurisdictions.

11. In the United States, the Bank Service Company Act (BSCA), 12 U.S.C. §1867(c) authorises the federal banking agencies to regulate and examine the performance of certain services by a third-party service provider for a depository institution “to the same extent as if such services were being performed by the depository institution itself on its own premises”.

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# Platform Development in Blockchains, Risks, and Regulation

*Zenu Sharma and Yun Zhu*

## 14.1 INTRODUCTION

Blockchains, a Distributed Ledger Technologies (DLT), have received significant attention in the recent years. They are a method of storing and updating data and maintaining a ledger of transactions. Blockchains/DLT are distributed in nature because they allow each peer to maintain a ledger of transactions without the presence of a trusted third party and are considered as a major innovation of recent years. Like other fundamental changes in the financial industry, such as transatlantic cable in 1866, the first credit card by Diners Club in 1950 and the first ATM from Barclays in 1967, blockchains are a part of the new technologies in the financial sector that are considered disruptive, including the use of big data, machine learning, and artificial intelligence. Blockchain and other digital ledger technologies (DLT) have also been used in creating numerous cryptocurrencies, payment applications, and various smart contracts.<sup>1</sup>

The major breakthrough of DLT/Blockchain can be traced to Satoshi Nakamoto, who in 2008 wrote the seminal paper on *Bitcoin*. Using cryptography and a unique solution to the Byzantine General's Problem, Nakamoto (2008) proposed a peer-to-peer, decentralized, public ledger of transactions where the peers approve and append transactions to the ledger and are

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M. Pompella and R. Matousek (eds.), *The Palgrave Handbook of FinTech  
and Blockchain*, [https://doi.org/10.1007/978-3-030-66433-6\\_14](https://doi.org/10.1007/978-3-030-66433-6_14)

rewarded with bitcoins, a currency native to the platform. The ledger of transactions, the Bitcoin blockchain, maintains a transparent and immutable record of transactions. Generalizing, a DLT/Blockchain can offer:

- An *immutable record*: Once transactions are appended to the blockchain, they cannot be modified or tampered with.
- *Disintermediation*: Since peers approve the transactions, there is no role for a third-party intermediary.

In a recent report, UK Government Office for Science highlighted three major opportunities offered by the DLT/Blockchain: enabling cryptocurrency exchange, managing smart contracts, and prompting efficiencies generated by new applications from third parties. There are growing numbers of applications using DLT/Blockchain in financial transactions, such as smart contracts, identity management, verification of records (BSI 2017).

This chapter integrates research on blockchain development, funding of blockchains through ICOs, risks and regulation of blockchains. For example, extant finance research on blockchain platforms has largely focussed on ICOs and their function as a source of capital for the cash-strapped entrepreneurs (Howell et al. 2018; Palm and Bergesen 2018; Amsden and Schweizer 2018). Even though finance literature has focused on the financing aspect of ICOs, blockchains deploying ICOs are only a subset of the larger blockchain ecosystem. Broadly, blockchains fall in two categories—permissioned and permissionless. A *permissionless* blockchain is an organizational form of blockchains in which anyone can join and have full rights to use it. Bitcoin is an example. In contrast, a *permissioned* blockchain restricts only to certain participants and imposes stringent restrictions on various read/write privileges on the blockchain. Business blockchains are mostly permissioned. Usually ICOs are used to fund permissionless blockchains. The platform development process also varies between a permissioned versus permissionless blockchain system.

In addition to discussing the funding and platform development aspects of blockchains, this chapter also discusses the various risks posed by this new technology. These risks and challenges posed by DLT/Blockchain primarily pertain to the adoption of the technology by users, governance challenges associated with integrity of data and security and privacy of users, identity management and lack of clarity on the terminology and perceived immaturity of the technology. For example, the perceived misunderstanding of the potential of blockchain technology has been reiterated by multiple sources (see, e.g., Andreasyan 2016). Finally, as the challenges and opportunities associated with Blockchain technologies increase, issues related to the governance of the market and agreement around “best practices” have become the focus of regulators. As discussed later, many challenges to the full adoption and use of DLT/Blockchain persist. In the last section, we identify appropriate policy

responses adopted by various governments in regulating DLT/Blockchain. The regulatory frameworks specifically associated with consumer protection, competition, and the enforceability of contracts, may involve legislation at not only the national but also international level.

In view of the historical digital transformation in the financial landscape, this chapter will provide a general picture of ICO (initial coin offering), in particular, its platform development phase, the recent developments and discussions in blockchain and DLT, and the regulation toward the blockchain technology/industry. In the next section we discuss the process of platform development in blockchains.

## 14.2 PLATFORM DEVELOPMENT

The process of platform development follows after the entrepreneur has completed the ideation stage, i.e. identified the problem and the goal and has selected the appropriate blockchain platform to build his/her solution on. For example, if the entrepreneur chooses to build a decentralized application, he/she can use Ethereum, which is a permissionless platform. Or if the entrepreneur is seeking to build an enterprise application, he/she can consider Hyperledger as a permissioned platform.

Wüst and Gervais (2017) provide a simple description of steps that summarizes the platform decision-making process. The authors develop an algorithm of simple steps that outline a choice to adopt a blockchain platform by a startup. First, the authors question whether the developers require a state of the of recent events. For example, whether it is sufficient to have a transaction log or whether it is important to identify the current account balances of each user. If the presence of a state is not paramount, then the adoption of a blockchain is futile. If however the state is paramount then the authors question whether there are multiple users involved and whether these users are known and can be trusted. It is optimal to adopt a permissionless blockchain when there are multiple users and there is a lack of trust. In this case a third-party intermediary is not necessary as the blockchain can adopt incentives within the platform to approve and append transactions in a transparent and anonymous way. An example of such a blockchain is bitcoin. If however some users can be trusted then a permissioned blockchain may be preferable. Even within the permissioned blockchain framework, the developers can choose between a public permissioned and a private permissioned blockchain. A public permissioned blockchain is relevant when public verifiability is key; otherwise a private permissioned blockchain may suffice.

### 14.2.1 *Permissioned Versus Permissionless*

A *permissionless* blockchain is also a public blockchain, meaning that it does not require peers to obtain permission to become part of the blockchain network. The members on the network approve and append transactions to

the ledger, and in exchange for their services the members are rewarded with a native cryptocurrency. The peers thus validate the transaction information stored on permissionless blockchains. Usually ICOs are part of the permissionless blockchain universe. In addition to funding the blockchain platform, ICOs also enhance member participation, which can be a critical factor for development of the blockchain platform. Consequently as several studies point out conventional focus on the capital is not the only reason a firm issues an ICO. Although (Feng et al. 2019), study information disclosures in 355 ICO white papers from 2016 to 2018, and document that only 55 out of the 355 tokens are linked to underlying products or services; of the remaining, 200 tokens are not directly linked and 100 do not require a blockchain.

A *permissioned* blockchain is “private.” In a permissioned blockchain, the members need to acquire permission to join. Further in a permissioned blockchain, anyone can view the transactions but only allowed participants can update and append transactions, which gives the owner of blockchain full control of the network. Permissioned blockchain finds applications in areas of insurance, intellectual property, security, supply chain, and medical records. Major players in the permissioned blockchain market include Hyperledger and R3CRV. *Hyperledger* is a Linux Foundation’s open source collective effort initiated to accelerate the development of cross-industry blockchain technologies. *R3CRV* is an enterprise blockchain software firm that was organized by more than 200 financial institutions to develop on the *Corda* blockchain. Corda’s white paper (blockchain platform of the R3CRV Consortium) states, “... the foundational object in our concept is a state object which is a digital document which records the existence, content and current state of an agreement between two or more parties. It is intended to be shared only with those who have a legitimate reason to see it. To ensure consistency in a global, shared system where not all data is visible to all participants, we rely heavily on secure cryptographic hashes to identify parties and data. The ledger is defined as a set of immutable state objects.”

Firms compare the cost of verification with the cost of networking when deciding between a permissionless versus permissioned blockchain (Catalini and Gans 2017) argue that the cost of verification occurs when a blockchain technology allows a participant to verify certain attributes of a transaction without revealing all the information to a third party. This is accomplished through zero-knowledge proof and it facilitates costless verification.<sup>2</sup> Another cost that the platform concerns about is the cost of networking. The network must create incentives for the members so they can verify the transactions costlessly. Both the cost of verification and the cost of networking are important in a permissionless blockchain. Therefore, in a permissionless blockchain, all the participants agree on one stake of the shared ledger without assigning all the rights to a single entity or few select entities. For this reason, bootstrapping, which pertains to building a self-sustaining system, during the initial adoption phase of the permissionless network, is important. In a permissioned blockchain, it is unnecessary to create a network of participants to approve

transactions as the entities developing the blockchain will keep control over who gets to verify or update the record.

Another issue that factors into the decision to have a permissioned versus permissionless blockchain is that of trust. Wüst and Gervai (2017) indicate that the key factors determining mutual trust are the issues of public verifiability, transparency, privacy, and integrity. Public verifiability implies that anyone can check whether the transactions are correct. Transparency refers to the process through which transactions are verified and whether the information is transparent to the observer. Privacy combines anonymity, which is defined as the ability to stay unidentifiable, pseudonymity, i.e. use of no real names, unlinkability, which pertains to the ability of a third party to link relationships between agents and their actions, undetectability, unobservability, and finally, integrity, which is whether the data has an immutable state. The authors conclude that the decision to have a permissioned or permissionless blockchain depends on the application scenario such as supply chain, banking, e-voting, Internet of things, and smart contracts. A business-to-business blockchain, for example, may have high trust, therefore is likely to organize itself as a permissioned blockchain. The gaming community in contrast has high levels of preference for anonymity and operates in a low trust environment and is therefore more likely to be permissionless. Similarly (Salviotti et al. 2018), analyze 460 released blockchains and assess the landscape in five categories such as industry, ownership, blockchain protocol, consensus mechanism, and type of application. The authors find that majority of certification, peer-to-peer content distribution, gaming, e-voting belonged to the permissionless blockchain system; and permissioned blockchains are found in areas of financial transactions, digital identity, digital rights, and platform tracking and control.

Accordingly, Sharma and Zhu (2020) find that the choice of issuing permissioned blockchain depends on the type of industry and the nature of its core business, for example, Finance (Intermediation and Fintech) sector is more likely to have a permissioned blockchain, whereas, Gaming sector is more likely to have a permissionless blockchain.

#### *14.2.2 Consensus Mechanism in Permissioned vs Permissionless Blockchains*

Consensus mechanism refers to the set of rules agreed up by the developers of the platform to approve and append transactions. Bitcoin uses “Proof of work,” as its consensus mechanism. In Bitcoin platform miners solve the SHA-256 puzzle, and the miner that expends most computational resources approves the next block and is rewarded through newly issued bitcoins. Therefore, the mechanism serves as an incentive to reward the peers to maintain and update the ledger.

Alternative consensus mechanism, for example, the one used in Peercoin is called Proof of Stake (PoS) mining, in which the administrators have the administrators control the system. The current consensus protocol for

Ethereum is Proof of Work (PoW). In contrast to permissionless blockchains which rely on PoS or PoW and several others, as the consensus mechanism among the peers to approve and append transactions, the permissioned blockchains typically rely on the practical Byzantine fault tolerance algorithm (pBFT), in which the consensus leader maintains internal state.

pBFT is a consensus algorithm introduced in the late 90s in Castro and Liskov (1999). It primarily focuses on providing a practical Byzantine state machine replication that tolerates Byzantine faults through an assumption that there are independent node failures and manipulated messages propagated by specific, independent nodes. pBFT was designed to work in asynchronous systems and is optimized to be highly efficient. For example, it is capable of processing thousands of requests per second with sub-millisecond increases in latency, and solves many problems associated with already available Byzantine Fault Tolerance solutions.

Unlike the permissionless blockchain network where every node is treated equally, nodes in a pBFT enabled distributed system are sequentially ordered with one node being the primary and others as secondary. A pBFT system can function on the condition that the maximum number of malicious nodes must not be greater than or equal to one-third of all the nodes in the system.

A typical pBFT consensus round comes in four phases: First, the client sends a request to the primary node; second, the primary node broadcasts the request to all the secondary nodes; third, all the nodes perform the service requested and then send back a reply to the client; fourth, the request is operated successfully when the client receives “ $m+1$ ” replies from different nodes in the network with the same result, where  $m$  is the maximum number of faulty nodes allowed.

Note that the primary node is changed during every pBFT consensus round. If the primary node failed to broadcast a request to the secondary nodes in time, it will be substituted. In addition, if needed, a majority of the honest nodes can vote on the legitimacy of the current primary node and replace it with the next leading node in line.

The advantages of pBFT over the traditional BFT is obvious. First, the pBFT is efficient. It can achieve distributed consensus without carrying out complex mathematical computations (as PoW in permissionless blockchains). Second, the transactions do not require multiple confirmations, in contrast to the 10 minutes confirmation circle in Bitcoin blockchain. Third, every node in the network takes part in responding to the request, thus every node can be incentivized leading to low variance in rewarding the nodes that help in decision-making. Note that the pBFT only works well in small-scaled network, this is because of its reliance on high communication with all the other nodes at every step that increases exponentially with every extra node in the network.

## 14.3 DIGITAL TOKENS, ICOs, AND PLATFORM BUILDING

### 14.3.1 *Digital Tokens*

SEC classifies digital tokens into three major categories—security tokens, utility tokens and cryptocurrencies.

- *Security token*—A security token, much like a financial security represents assets such as participation in real physical underlying companies, or revenue streams, or an entitlement to dividends or interest payments.
- *Utility token*—A utility token provides access to goods and services that the entrepreneur and the platform provide or will provide in the future. These tokens then can be used as a type of discount or premium access to the goods and services.
- *Cryptocurrencies*—Cryptocurrencies for example bitcoin or litecoin are not directly linked with underlying assets or cash flow, neither do they have further functions or links to exchange for exclusive goods or services. Instead, they are intended to provide many of the same functions as fiat currency without the backing of a government, physical assets or other legal entities.

Tokens are used for several purposes. For example, in a bitcoin framework the tokens are used as rewards to miners for maintaining the blockchain. They could also be used to execute special transactions such as spamming, providing proof of stake or simply to provide privileged access to the platform or the rights to participate in platform's development. Because these tokens are traded in the secondary market so they can be used on the platform to gain access to services and products they can be valued in the secondary market like securities. This creates a market for cryptocurrencies to serve as an alternative financing to the start-ups and is often compared to IPOs (initial public offering) (Howell et al. 2018) argue that ICOs are to serve as an alternative to venture capital or crowdfunding financing for start-ups. Whereas traditional cryptocurrency is a medium of exchange that is also a store of value like bitcoin, a security token or utility token resembles a presale similar to rewards on a crowdfunding platform. The authors look into utility tokens and compare the IPO process with the ICO process as it relates to the design choice in target proceeds, fraction of issuance sold, pricing mechanism, distribution method, lockups, investors' rights and exchange listing.

In a typical ICO where an entrepreneur is looking to start a blockchain-based platform by raising capital, she sees ICO as a substitute for angel or VC financing. Another reason that an entrepreneur raises ICO is that she believes that as the network will grow in size, the value of the tokens will increase and it will facilitate the creation of a fully functioning, self-sustainable decentralized platform. The first time an ICO came into existence was when J.R. Willet offered participants at a conference new coins in exchange for bitcoins and



promised that these new coins would represent an ownership stake of the new technology. J.R Willet raised 4740 BTC from 551 anonymous investors. Later he used these funds to build the platform (Boreiko and Sahdev 2018).

The process of raising money through ICO is fairly straightforward. Most ICOs are launched through Ethereum. Another popular blockchain is Waves. Once implemented, the buyers will submit bids for the token in a cryptocurrency, such as bitcoin or ether (the Ethereum blockchain's coin) from the digital wallets. The smart contract on the Ethereum blockchain is called a Dapp (decentralized app) which executes a smart contract between an entrepreneur and multiple investors. This smart contract will automatically remit tokens after the ICO is concluded. The specific Dapp for ICOs is called ERC20. Such a contract is relatively simple to create. Like all smart contracts after launch, the entrepreneur has no control over the tokens. ICOs are relatively free to issue compared to IPOs, where underwriting and disclosure run up to \$4 to \$28 million in fees. If the entrepreneur seeks funding through a crowdfunding market, the platform charges anywhere between 10 and 15% of the proceeds in fees (Preston 2018). A venture capitalist will in contrast seek equity stake, diluting owners' stake in the firm. ICOs do not dilute the owner's stake and are therefore particularly appealing for new blockchain platforms. Finally, the regulatory burden is minimal since no registration with SEC or other regulatory agencies is required.

Because most investors in ICOs are likely to be participants of the platform, they also fulfill the function of attracting media attention and marketing among potential customers. Thus, the process of ICO encourages and facilitates the platform participation, which can be critical for platform development and the success of the start-up.

A key document that is issued when an ICO is announced is the "white paper." This document is similar in spirit to the IPO prospectus. The white paper usually details the description of the platform, its core business, and a schedule of issuance and usage of the digital token. It is a crucial disclosure of information to the general public, the potential investors, and its future customers. Entrepreneurs adopt several other strategies similar to an IPO to further reduce asymmetric information, create incentives for the investors, and do marketing to ensure the success of token offering. These strategies include (1) bounty programs in which people who promote the ICOs on their social media platforms are rewarded with tokens; (2) pre-sale discounts, also known as start bonuses, to accumulate interest in the platform in the pre-ICO period; (3) marketing on the social media and tech-forum to promote general attention and solicit information flow.

It is worth noting that the growing enthusiasm on blockchain start-ups is tempered due to some serious concerns associated mainly with the scalability of the technology. For example, in the white paper of Satoshi Nakamoto, the blockchain network of Bitcoin takes approximately 10 minutes to validate all the transactions in the past "block." Such delay poses a significant challenge for real-world financial applications. However, with thousands of tech

start-ups and numerous tech experts working on this issue, light comes from permissioned blockchain platforms that have benefited some segments of the economy through their use for identity detection, supply chain management, digital-asset-backed lending, and securitization (Allen et al. 2020).

However, several theoretical papers argue that ICOs, in addition to being a mechanism to raise capital, create networking effects by engaging market participants, can be critical for bootstrapping a blockchain platform (Sockin and Xiong 2018; Li and Mann 2017; Bakos and Halaburda 2018).

### 14.3.2 *Platform Development in ICOs*

Insight into the importance of an ICO in developing a platform for the blockchain business can be gained through several theoretical papers written on this topic (Sockin and Xiong 2018) develop a model of cryptocurrency that analyzes the properties of utility tokens where the developer creates a cryptocurrency to facilitate the accumulation of membership of the platform. In their model, the authors show that the use of internal tokens, i.e. ICOs might be optimal in order to prevent coordination failures in platform building, and they also ensure future participation of the peer-to-peer platform that is yet to be built. In a similar vein (Bakos and Halaburda 2018), argue that cryptocurrencies play an important role in fostering platform adoption.

The problems associated with product development and adoption are typical in a traditional start-up business. These issues get even more aggravated in blockchain-based businesses which struggle for clarity around the usage and adoption of new technology. Therefore, when it comes to the decision to use ICO for marketing and financing, the entrepreneur is confronted with various strategies that will reduce the information asymmetry, build a trustful relationship, and successfully raise capital. A few papers center around modeling the ICO offering strategies, among which, start bonus to reward early commitment and social media-based marketing and promotion are two widely adopted ones (Sockin and Xiong 2018) analyze the properties of utility tokens where the developer creates a cryptocurrency to facilitate membership to the platform. In their model the members cannot trade outside the platform, therefore increasing the number of members increases their desire to be part of the platform. Cryptocurrency in this set up serves as a way to pay a fee to the miners to add blocks to the blockchain. Given these conditions, their model yields two equilibria. One with low cryptocurrency price and higher equilibrium cutoff and another with high cryptocurrency price and a low equilibrium cutoff (Li and Mann 2017) also show the use of internal tokens is ideal as it ensures future participation and prevents coordination failures in platform building. In their model, the adoption of pre-ICO token discounts gets the developer closer to a critical threshold (Bakos and Halaburda 2018) as stated before also argue that cryptocurrencies play an important role in fostering platform adoption. Specifically they show that potential users want to join a platform if they believe others also want to join, therefore only if the potential

users believe in the format of the platform, will the format facilitate a successful adoption.

Therefore, in addition to providing much need capital, the success of a platform depends on ICOs as it creates network effects that are brought on by platform building strategies. The success of the venture is contingent on early participation, ensuring post-launch participation, and liquidity. One of the ways that an entrepreneur can ensure future participation is by issuing pre-ICO discounts. These discounts, also known as start bonuses, are generally offered during presale to incentivize early contributions.

Since a large number of members on the platform are typically socially connected to the entrepreneur, it serves as the primary platform of information for ICOs (Li and Mann 2017) state that social networking is quintessential for platform success (Cong et al. 2017) similarly highlight the importance of networking effects in early stage adoption of social networks and payment networks. Further for legal reasons a viable option for the entrepreneur is to source capital from their network of friends and influencers, as there are limits to raising money from people with whom the entrepreneur doesn't have a pre-established relationship (Preston 2018). Anecdotal evidence on the role of social media platform comes from the launch of digital token by *KIK* messenger that launched its own cryptocurrency called *Kin* in Sept 2017. More than ten thousand individuals from 117 countries took part in the offering contributing a total of \$98 million, *Kin* happens to be most widely held cryptocurrency, as claimed by the company.

By examining over 8000 blockchain companies, Sharma and Zhu (2020) show that bigger sized ICOs are more likely to fail and/or achieve lower token sale price, the provision of start bonus also leads to the likelihood of an ICO failure. The involvement of VC backing plays a more subtle role: it positively affects the token sale price, but also leads to a higher chance of ICO failure. Furthermore, consistent with social networking effects predicted by theoretical models, social networking reduces the likelihood of failure and has a negative effect on the token sales price. On the other hand, in terms of the future market performance, the authors find that start bonuses are linked to lower volume and lower circulating supply, VC backing has a positive relationship with returns but a negative relationship with liquidity, and social networking also positively associated with volume traded and circulating supply.

### 14.3.3 *ICO Versus Airdrop*

ICOs traditionally launch utility tokens. Utility tokens, as stated earlier, are native cryptocurrencies that are accepted on the decentralized network in exchange for benefits or services (Sockin and Xiong 2018). An alternative to ICOs is "Airdrops." In an airdrop, the developer will drop her new cryptocurrency into wallets of existing holders of digital currency for free. The reason for such airdrops is to gain attention and acceptance from new followers. This allows the developer of new cryptocurrency to acquire a large user-base and a

wider disbursement of coins. Airdrops thus capitalize on the network effects by involving existing holders of a blockchain-based currency.

When the cryptocurrency is based on the improvement in protocols of existing cryptocurrencies, such as bitcoin, it is called a hard fork. *Litecoin* is a hard fork of Bitcoin, and the main technical distinction between Litecoin and Bitcoin is that Litecoin features a memory-hard mining puzzle.<sup>3</sup> Cryptocurrencies, such as Litecoin, come into existence through an airdrop. Sharma and Zhu (2020) find that permissionless cryptocurrencies are likely to conduct Airdrop, a finding consistent with Van Adrichem (2014) and Sockin and Xiong (2018) who also argue tokens are distributed free of charge and the initial token supply is controlled by the issuer with the hope of enlarging his/her database.

#### 14.4 MAJOR APPLICATIONS OF BLOCKCHAINS

Distributed ledger technology (DLT) is a term widely used to describe various record-keeping technologies, such as decentralized data architecture and cryptography, which allow the keeping and sharing records in a synchronized way while ensuring their integrity through the use of consensus-based validation protocols. The idea of blockchain was initially introduced by Habor and Stornetta (1991) to authenticate authorship of intellectual property. Being a specific type of DLT, a blockchain contains blocks of records that are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data. By design, a blockchain is resistant to modification of the data; however, there have been concerns around cybersecurity related to blockchain.

Transactions are created and exchanged by peers of the blockchain network and modify the state of the blockchain. As such, transactions can exchange information to execute arbitrary code within so called smart contracts, which are computerized protocols allowing terms contingent on decentralized consensus that are tamper proof and self-enforcing via automated execution (Szabo 1994; Cong et al. 2017). Cryptocurrency is one specific type of smart contracts.

With its tamper-resistant nature, blockchain technology presents a splendid blueprint of an ideal and futuristic financial industry where transaction costs, including the cost of trust, are greatly reduced. These costs range widely from information distribution, user identification, cybersecurity, legal and settlement procedures, regulation compliance, and anti-fraud regimes. The existing costs are the foundation to the commissions that banks, brokers, and other financial institutions charge. To reduce various costs, blockchain technology is being explored not only by institutional actors such as central banks, exchanges, clearinghouses, large banks, and asset management companies, but also by start-ups and large technology firms seeking to disrupt existing business models. Incumbent firms are hoping the technology can help them to secure their market share, while newcomers aim to provide competitive services with a

much-reduced cost. A large number of financial and non-financial applications building on the blockchain technology are the recent developments to give us a taste of future, some are reasonably mature, some are in the theoretical stage at most.

One unique and remarkable feature of blockchain is digital identification. With the digital signature built with Public Key Infrastructure (PKI), one can broadcast one's identity and be identified effectively and safely. This feature has profound implications, such as cross-border payment, voting mechanism, healthcare management, financial transaction, supply chain management to name a few. Here we discuss two fields of application, one financial, one non-financial.

The blockchain-based cross-border payment and clearance service are among the first wave of applications being developed. As noted by American Express, two main areas of blockchain activity that may have implications for businesses: international payment processing services involving bank-to-bank transfers and trade finance applications (including the use of "smart contracts").<sup>4</sup> While the commercial banks use SWIFT infrastructure for cross-board transactions, *Ripple* uses a blockchain-based protocol to connect existing bank ledgers to facilitate near real-time cross-border payments. Ripple may also reduce costs and provide additional pricing transparency by running instant auctions to source FX liquidity at the best price available. Developments in trade finance are seen in the Hong Kong Monetary Authority in Hong Kong to record shipping documents in a blockchain so as to give lenders greater confidence in the veracity of exporter claims and make letters of credit more available (HKMA 2016). Foxconn, the manufacturer of Apple products, bridges the cross-board payment with the supply chain and inventory management. It ventured into blockchain start-ups to encourage its suppliers to submit data to a blockchain ledger of transactions so as to improve coordination of production schedules and availability of parts. In return, the company is shortening the payment terms or providing internal loans on its own account to boost its suppliers' working capital and bypassing the role of banks altogether.

The voting mechanism is another seemingly natural field for the blockchain technology. With a unique digital signature, a voter can reliably be identified. And votes can be easily and securely counted. In 2005, Estonia became the first country in the world to hold nation-wide elections using internet-voting (i-Voting), and in 2007, it made headlines as the first country to use i-Voting in parliamentary elections. i-Voting is a system that allows voters to cast their ballots from any internet-connected computer anywhere in the world, completely unrelated to the electronic voting systems used elsewhere, which involve costly and problematic machinery. With the blockchain technology, such online voting system can be secured with tamper-resistant nature of the entire blockchain network, ensuring highest level of security and lowest possibility of being manipulated. Though theoretically promising, the blockchain-based voting system is not adopted in large democratic countries.

Over the past years in U.S., West Virginia, Denver, and Utah County, Utah has used blockchain-based mobile apps to allow military members and their families living overseas to cast absentee ballots using an iPhone, but not for general voters.

Regarding platform building, such applications, with their large-scale financial transactions and fairness obligation (accessibility to voting for each citizen), request significant amount of investment and commitment to hardware and software infrastructure, system reliability and sustainability, some of which are at the level of national security and secrecy.

## 14.5 POTENTIAL CHALLENGES AND RISKS

### 14.5.1 *Challenges Faced by DLT/Blockchain Technologies*

The problems associated with the proliferation of blockchain technologies concern themselves with underdevelopment of the technology and a lack of clarity associated with the technology. Industry views the DLT/Blockchain as immature technology (Pinna and Ruttenberg 2016) and few applications have progressed beyond the proof-of-concept state. This creates challenges for small businesses that want to transition to a blockchain-based solution. Further insufficient understanding of DLT/Blockchain among existing staff poses a significant challenge to widespread adoption. Lack of terminology and understanding adds to the cultural resistance by market participants. Financial institutions looking to adopt DLT/Blockchain must not only rethink strategies associated with workforce optimization, data center requirements, storage and networking capacity, but they also have to additionally confront uncertainty posed by disruptive technologies. As the market participants struggle to adopt innovative technologies, lack of viable models that have been tried and tested adds to the uncertainty. The technology reshuffle thus threatens existing jobs and incumbent players for survival.

For the existing blockchains there is clarity about how the technology should be governed. First, in case of permissionless blockchain, the nature of the ledger is that it creates an immutable record of transactions. And absent a central authority, there is no recourse for a counterparty in case of an error. An associated concern related to the immutability of the data is the management and removal of data should any participating individuals wish for their data to be removed. Further, since the participants interact on the platform using private keys, there are no protocols to protect the participants in case of theft or protection against vulnerability in case of a hack. For example, integrity of encryption used to protect data stored on the ledger can come under additional threat with potential quantum computing technologies which can render current encryption practices insufficient for secure data storage. In contrast, a permissioned ledger is slightly better off as the platform can agree to a governance structure however inefficiencies may arise when it comes to achieving consensus.

Another challenge that arises from the immature nature of the technology is the inability of these ledgers to interact with each other. The fragmented nature of the blockchains raises concerns regarding competition and interoperability. Further, in an attempt to create ledgers that speak to each other, organizations will also need to address the issue of integrity of data stored on the ledger and take appropriate steps to maintain privacy of the participants. On opposite spectrum of transparency is privacy and anonymity. The potential anonymity offered by blockchains makes itself vulnerable to illegal activity. Finally, there are implications for climate change given the energy demands of blockchain technologies. The distributed nature of blockchain is such that multiple copies of the ledger are maintained by the participants, and that means that ledger designs may be significantly more energy-intensive than traditional database alternatives.

#### 14.5.2 *Systemic Risk*

With the financial system growing in size and complexity over the years, its core purpose has always been a simple one: to mediate between suppliers of capital and users of capital. Individual financial institutions pursuing their own private interests sometimes impose costs on the public. The global financial crisis of 2008 exposed the great consequences of interconnectedness of financial institutions. This is called “systemic risk.” Once firms in a market are highly dependent on each other by, for example, relying on other participants for essential parts of their business or having contracts and agreements that require the cooperation (and solvency) of the other firms, then it will be more likely for shocks in one institution to spread to other institutions. The systemic risk induced argument, such as “too big to fail,” steers the direction of policy-making in the post-crisis period. Dodd-Frank Act, for example, aims to solve the “too big to fail” use in three ways. First is to prevent such institutions from being created in the first place by prohibiting certain concentrations of assets and liabilities within any one corporation. The second approach regulates the “too big to fail” institutions when they do arise to reduce the risks and costs associated with them. The last one prevents the government from bailing out failed financial firms.

The assumption underlying financial regulation in the post-crisis era has been that large financial institutions are the primary source of systemic risk in the financial industry. This assumption animates many of the key provisions of the Dodd-Frank Act. It has also driven much of the academic scholarship on financial regulation in recent years. However, the risks associated with the rise of Fintech firms, and the use of technology in general, such as blockchain, are commonly underestimated. One potential reason is that it is commonly perceived that Fintech firms are mainly start-up firms, whose stability poses limited risk on the financial system as a whole. However, the main force behind the technology-powered financial innovation comes from large and

long-standing financial institutions, and IT firms aiming to leverage the advantage in technology to set foot in financial industry. Either of the two may lead to uncontrollable consequences if the potential risks from innovation are not assessed and monitored.

The automated contract processing and removal of intermediaries also expose certain areas of unforeseen risk in the financial sector because they change the nature of financial interactions that are currently considered low risk and make the monitoring of systemic risk harder to estimate. Further, through the use of smart contracts, the assets are more often placed with a DLT/Blockchain and this may have consequences for liquidity in the market. An increase in off the ledger agreements between counter parties also aggravates problems associated with identity verification and appropriate permissions, methods of error correction, dispute arbitration, compliance, and legislation and finally assigning responsibility for the integrity of the system.

Though large financial institutions may be the primary engines of systemic risk, one cannot ignore the possibility that small, decentralized actors can present systemic risk problems as well. These lesser financial actors can create negative externalities for the wider economy in much the same way that large ones can. In fact, in many ways, small actors may have greater incentives and audacity to engage in excessively risky activities than more established and reputable ones.

In general, a few types of risks arise along with the advancement of blockchain technology. First is the consensus protocol risk. Blockchain is a new technology, new to both financial industry and IT industry. Its protocols can be hard to integrate into existing financial infrastructure or even for new projects built with traditional approaches. For example, protocols are created to set up boundary among various platforms, thus information sharing becomes even hard, such as between Hyperledger Fabric Protocol and Ethereum Protocol. In this case, one needs an integration layer to communicate with two different systems. This points out to the risk and the consequent costs associated with such lack of standardization. This is potentially one of the biggest risks that the current blockchain projects suffer from. These standards apply across the complete blockchain ecosystem including cryptocurrencies, various smart contract applications, frameworks, and so on. For example, with numerous cryptocurrencies available to trade, each is built on its independent blockchain network, under various white papers and protocols. This created a similar “exchange rate” issue as the real-world fiat currencies. The investors or coin-users have no proper protection against the investment, which makes ICOs a big gamble.

Second is the lack of regulation on the start-up Fintech firms. Currently, across the globe, there’s uncertainty around the regulatory requirements related to blockchain applications. Additionally, there may be regulatory risks associated with each use case, the type of participants in the network, and whether the framework allows domestic or cross-border transactions. This



could also include cross-border regulations related to privacy and data protection. As one of the most popular blockchain applications, cryptocurrencies are not (well) regulated. This not only poses personal financial risks for investors, most young and naïve, but seriously damages the existing monetary and fiscal policies. Most cryptocurrency prices are extremely volatile, compared with common equities. Bitcoin, for example, can see high movements that are beyond any investor's expectation, pointing out to the lack of fundamental value or pricing schemes in the new Fintech era.

The third is the information security risk. Right now, blockchain is being implemented in almost every sector, including the information sensitive industries, such as health sector, supply chain, and even government. While blockchain technology provides transaction security, it does not provide account/wallet security. The distributed database and the cryptographically sealed ledger prevent any corruption of data. However, value stored in any account is still susceptible for account takeover. Additionally, there are cyber security risks to the blockchain network if a malicious actor takes over 51% of the network nodes for a duration of time, especially in a closed permissioned framework. The security issue imposes additional challenge for IT operation. For example, existing policies and procedures will need to be updated to reflect new business processes. Additional technology concerns may include speed, scalability, and interface with legacy systems in implementing the technology.

## 14.6 BLOCKCHAIN REGULATION

A key goal for the policymaker to develop Fintech regulation is to design a policy framework that encourages and supports disruptive innovations so as to make society more inclusive financially and encourage economic growth but at the same time to provide adequate protection to individuals maintain the soundness of financial system (Allen et al. 2020). Brummer and Yadav (2019) provide a theoretical framework to test regulation of Fintech. The authors argue that Fintech regulation must comprise integrity of the market, simplicity of rules, and financial innovations. The authors further suggest that regulators can potentially achieve only two of the three objectives. If the regulator prioritizes Fintech innovations and provides simple and clear rules, it may compromise stability of the system. On the other hand, if regulators want to promote innovation and ensure stability of the system, it may need to devise a series of complex rules.

The idea of regulatory sandboxes has been widely implemented in the context of Fintech. A sandbox, in the world of computer security, is defined as a mechanism for separating running programs. This method is implemented in an effort to mitigate system failures or software vulnerabilities from spreading. In the same spirit, a Fintech regulatory sandbox allows firms to test new Fintech products and services in a real environment, with limited regulatory oversight. The Fintech applications can innovate within the “sandbox” but without potential harm to the general population or the financial system.

Ringe and Ruof (2019) propose a regulatory sandbox for Robo-advising, in which market participants test Robo-advice services in the real market, with real consumers, with scrutiny of the supervisor.

U.K.'s Financial Conduct Authority (FCA) implemented the first regulatory sandbox was in November 2015. During the years 2015 to 2017, the FCA accepted 146 such applications. Several other countries soon followed with practice—Canada, Malaysia, Singapore, Australia. Such an approach can be beneficial to experiment with groundbreaking innovation without spending significant resources to debate the social and economy costs of the new technology. However, Jagtiani and John (2018) in a recent paper highlight that the Fintech industry is more concerned about Fintech regulatory uncertainties rather than the lack of clarity than regulation itself.

In the United States, regulators provide guidance on various new technologies and offer institutional support structures to Fintech firms so they can navigate through the regulatory process (Allen et al. 2020). For example, the Commodity Futures Trading Commission (CFTC), has launched LabCFTC to promote responsible Fintech innovation and fair competition. The primary objective of LabCFTC is to be more accessible to Fintech innovators and serve as a platform to enhance the Commission's understanding of new technologies. SEC similarly set up a Strategic Hub for Innovation and Financial Technology (FinHub). FinHub is also tasked with increasing SEC's engagement with innovators, developers, and entrepreneurs, and effectively signals SEC's vision for Fintech space. In addition, SEC also created a working group on the application of blockchain to U.S. markets.

At the industry level, a range of standardization has been initiated across the globe into the different aspects of DLT/Blockchain. These activities include exploratory workshops and cross-industry collaboration initiatives. They provide a forum for the discussion of potential technical challenges around the widespread adoption of DLT. For example, ISO/TC 37 is a technical committee developed by DLT and blockchain developers from all sectors and are tasked to explore the potential for ISO (International Organization of Standardization) standards within the blockchain market. The Chain Open Standard is an open source protocol for design of ledgers in the financial sector (Chain Protocol 2020). R3CEV, as mentioned earlier is an initiative by a consortium of banks and financial intermediaries in the financial services arena that is involved in the development of DLT systems. Hyperledger, also mentioned previously is an open source collaborative effort hosted by Linux Foundation to advance cross-industry blockchain technologies through shared technical frameworks and infrastructure (Hyperledger 2020). Interledger protocol is specifically dedicated to payments systems between ledgers (Interledger 2020). Blockcerts focusses on zero knowledge proofs in the education and skills sector and provides an open standard for the creation of ledger-based certificates (Blockcerts 2020). Finally, International Telecommunication Union-led is a workshop that was scheduled by International Telecommunication Union (ITU) in March 2017 focused on exploring

security aspects of DLT/Blockchain, for potential consideration in future security standards. In summary, several consortiums have been formed to examine the full potential of blockchain applications and their relevance in the areas of B2B collaboration and security.

## 14.7 CONCLUSION

The recent advancements in financial technology warrant a wave of discussion in finance literature. However, such discussion is mainly in line with the hype in Bitcoin and other ICOs, which represents only a subset of the larger blockchain ecosystem (Howell et al. 2018; Palm and Bergesen 2018; Amsden and Schweizer 2018). This chapter provides a general picture of blockchain and its most popular application in ICOs. Our focus is particularly in the platform development phase of the blockchain network, its recent development and potential risks, and the view from the regulatory agencies.

We first give a brief discussion on the background of the platform development of blockchain system, with a unique focus on the difference of permissionless and permissioned blockchains, and evaluate the consensus mechanism of the permissioned system, which has more pronounced prospect in high-level applications. For the permissionless blockchains, we cover the most trending topic in various types of digital tokens, including Bitcoin and other popular cryptocurrencies, as well as the debate in choosing between ICO vs. Airdrop in developing a new token. We then examine the dark side of the technology by looking into various risks and challenges arising from the blockchain ecosystem, including the traditional systemic risk of the financial system. Consequently, with the challenges and opportunities associated with Blockchain technologies, we review a few policy responses adopted by various governments in regulating DLT/Blockchain, in issues related to consumer protection, competition and the enforceability of contracts, and cross-border coordination.

## NOTES

1. Cryptocurrencies are digital assets that serve the function of a medium of exchange and is secured through cryptography. Smart contracts are self-executing contracts that are intended to automatically execute the terms specified in a contract i.e. the agreement between a buyer and a seller.
2. A zero knowledge proof in cryptography is defined as a protocol in which a party can verify that certain information is accurate without having access to the said information.
3. *Litecoin* was launched in 2011, three years after Bitcoin. Litecoin is a leading altcoin in terms of overall popularity and user base. It is also the most widely forked codebase. In fact, it has been forked more times than Bitcoin itself. On the Bitcoin network, the members earn bitcoins through a process called mining. Miners competing to earn bitcoins solve a computationally hard puzzle called the SHA-256, and the miner who expends maximum resources to find the solution

to the cryptographic puzzle earns the mining reward along with rewards offered by market participants who include extra tip for the miner to approve and include their transaction in the block. The process of mining requires significantly large amount of computational resources and simply acquiring the hardware (ASICs Mining rigs) can be costly for an individual miner. The difficulty of the puzzle, which on average is solved by a miner every 10 minutes is also a source of latency in the network. Therefore, Litecoin, a hardfork of the Bitcoin protocol, was developed. The main technical distinction between Litecoin and Bitcoin is that Litecoin features a memory-hard mining puzzle (based on *scrypt*). In Litecoin blocks arrive every 2.5 minutes. Otherwise, Litecoin otherwise borrows as much as possible from Bitcoin. So, Litecoin, is strictly a medium of exchange like Bitcoin, and is a cryptocurrency on a permissionless blockchain.

4. <https://www.americanexpress.com/us/foreign-exchange/articles/blockchain-to-accelerate-payment-processing-services/>.

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# Blockchain and Cyber Risk: Identifying Areas of Cyber Risk and a Risk-Based Approach for Executives

*Charla Griffy-Brown, Mark W. S. Chun, Howard A. Miller, and Demetrios Lazarikos*

## 15.1 INTRODUCTION

Emerging Technologies continue to transform businesses. The high level of dependency on technology results in new business models and revenue streams but also new opportunities for cyber attack. One such emerging technology is blockchain. Blockchain, or distributed ledger technology, continues to disrupt healthcare, energy, manufacturing, and financial services sectors. This technology is sometimes referred to as a new industry “fabric” for financial transactions given that the enterprise architecture is unique. For the purpose of this research public blockchains are defined as “permissionless”. “Permissionless” means that data is publically available to anyone who participates in the network. Private blockchains are “permission based” platforms. These are established by groups of firms, individual firms or divisions within an organization (e.g., a consortia), and data can only be accessed by those users who are part of the consortia and can be properly authenticated (Piscini et al. 2017).

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While the technology has the potential to generate substantial process efficiencies in many industries, it is still not widely deployed or used. In fact, many companies have deployed the technology without considering the core transformative attributes of the distributed ledger. As more firms adopt, participate in, and leverage blockchain technologies, it becomes more critical to focus on security. Importantly, in today's transformed distributed workforce it is even more essential that issues of cybersecurity are embedded in technology deployment and use.

Cyber criminal enterprises are now very sophisticated (Griffy-Brown et al. 2017). Cybercrime is increasing in velocity and reach touching all industries and verticals. No locale, industry, or organization is safe from attackers who wish to compromise their data. Verizon's 2020 dataset illustrates this point (Verizon 2020). This report shows that in 2019, 55% of attacks were perpetrated by organized criminal groups (Verizon 2020). While 45% of these attacks were hacks, 22% were social attacks and errors were the causal events in 22% of these breaches. In addition 22% of attacks stole or used credentials. There were far more security incidents than data breaches, or security incidents which resulted in the confirmed disclosure (not just potential exposure) of data to an unauthorized party. Throughout 2020, it was clear that cyber criminals were attempting to steal valuable data such as intellectual property (IP), personal identifiable information (PII), health records, financial data. In addition, cyber criminals were also resorting to highly profitable strategies such as monetizing data access through the use of advanced ransomware techniques or by disrupting overall business operations through Distributed Denial of Service (DDoS) attacks (ENISA 2019). Understanding the nature and patterns of cyber criminal activity is essential in evaluating cyber risk and importantly must be considered for all emerging technologies including blockchain.

The blockchain architecture could help to improve cyber defense, as the platform can prevent fraudulent activities through consensus mechanisms. Furthermore, the technology can help to detect data tampering based on its underlying characteristics of immutability, transparency, auditability, data encryption & operational resilience (including no single point of failure). However, as Cillian Leonowicz, Senior Manager at Deloitte Ireland states "blockchain's characteristics do not provide an impenetrable panacea to all cyber ills, to think the same would be naïve at best, instead as with other technologies blockchain implementations and roll outs must include typical system and network cybersecurity controls, due diligence, practice and procedures" (Piscini et al. 2017). There is little evidence in the existing body of research literature on the topic of blockchain, the associated risks, and the extent to which these risks can be evaluated and incorporated into corporate decision-making. Hence the research questions for this investigation are: what are the risks associated with blockchain? How can these risks be evaluated and integrated into corporate decision-making?

To answer these questions we will build on previous research developing a risk-based approach for securing our current complex enterprise architecture and agile data center environments (Griffy-Brown et al. 2016). The research methodology involved a survey and interviews with 60 executives from 80 companies from Sept 2018–2019. This data was used to identify where information security decisions are being made in firms and what technologies are being deployed. In addition, we evaluated risks against the commonly held governing framework and definition for cybersecurity: Confidentiality, Integrity, and Availability (CIA). This triad is explained in addition to its alignment with theory as part of the theoretical construct for this paper in the identification of risk. This analysis, coupled with the survey and other data was used to evaluate where decisions are being made on blockchain risks. Based on these gaps we developed cyber-physical framework for executives to use. This research offers insight by methodically identifying and characterizing the main risks in blockchain and providing a practical framework and tools for making better security decisions involving this technology. This paper proposes a model for addressing security with the growth of blockchain and other emerging technologies. It suggests focusing on project life-cycle, the deployment process, and constantly asking questions to identify risk as part of the project management organization.

The existing blockchain security research primarily focuses on requirements and solutions for requirements or on the broader issues of emerging technology deployment and risk. Non-repudiation is widely discussed and cited (Kumar et al. 2011; Nishikawa et al. 2012; Tran et al. 2011) as is security auditing (Deshmukh et al. 2012; Gul et al. 2013; Munoz et al. 2012). More heavily published research focused on privacy, confidentiality, access, and control (Ilanchezhian et al. 2012). Cyber-Physical security research focused primarily on controls (Colbert 2017; Colbert and Huthinson 2016; Colbert and Kott 2016). Overall, in the applied business world, there is a need for broader thinking regarding risk, particularly in deployment, given the new business models and architecture like blockchain that companies are using.

Figure 15.1 explains that, over time, companies move from a reactive state to a proactive state with respect to cybersecurity. The first column, called



**Fig. 15.1** The information security maturity model (Source Griffy-Brown et al. 2016)



“Blocking and Tackling” refers to a completely reactive environment. It is characterized by a lack of support, underfunding, lack of staff, and lack of metrics for understanding what is happening in the IT environment with respect to cybersecurity. In this column, companies are typically just reacting after criminal behavior has occurred. The next column, called “Compliance Driven”, refers to a corporate environment in which a control-based approach is taken but this is driven by audit and regulation rather than positioning for emerging threats. The final column called “the Risk Based Approach”, refers to companies which are positioned proactively. They are using big data and behavioral analytics to understand and position themselves for potential threats. In this approach, businesses have a risk framework in place. In addition, widespread automation is in place and they are linking events across disciplines using dynamic controls, metrics, and processes aligned with the business. We situate this study in the context of what firms are doing in terms of cyber risk. By doing this, we understand more clearly where emerging technology deployment is in terms of firm decision-making around risk. With this in mind, we can begin to identify and evaluate blockchain.

This study is not an exhaustive look at securing blockchain or the standards required for deployment. What we hope to provide is an assessment of the current risks and equip executives for decision-making given the current dynamics of deployment. It is envisioned that the development of an approach will help executives and boards as they oversee the use of more specific standards and frameworks developed by National Institute of Standards and Technology (NIST), International Standards Organization (ISO), and other organizations.

The structure of this paper follows this logic. The next section will explain the theory used for the underlying conversations with executives around confidentiality, integrity, and availability risks. Then we will explain the methodology used to address the research questions. Following this, the company responses will be examined to characterize their cyber-physical risk posture according to the information security maturity model. The final section will explain the tools derived from executive discussions and processes for board oversight based on these discussions. Based on this analysis, companies can similarly use the framework and tools presented for developing an executive approach for dealing with cyber-physical risk, importantly shifting their thinking from risk minimization to risk optimization.

## 15.2 THEORY

An overarching theory is required to enable scholars and practitioners to address the cyber-physical security challenge from a holistic perspective. This holistic perspective would include blockchain and other emerging technologies that cross the cyber-physical spectrum. In most current studies the theory applied is largely related to creating technical controls or standards.

What is missing is a broader theoretical approach beyond the technical to encompass processes of decision-making and systemic interactions, particularly as they relate to risk. In this regard, researchers have recommended three potential theoretical approaches to address extended architecture challenges, particularly security. Recent studies in cyber-physical systems recommend the Systems Dynamics theory as a basis for developing standards and frameworks (Forrester 2007). Work in cyber-security and IoT validated this theory as something executives could relate to in terms of decision-making (Griffy-Brown et al. 2019). The current research in blockchain security builds on work published regarding the Risk-Based Approach (Miller and Griffy-Brown 2018) to see if this approach could extend to executive decision-making for complex emerging technologies such as blockchain. Based on the systems dynamics theory, the methodology was developed in which the current state of confidentiality, integrity, and availability (CIA) for blockchain was evaluated and a framework developed to continuously make design decisions to work toward a future state of optimized risk.

CIA has become a standard definition for cybersecurity. The three elements of the framework—confidentiality, integrity, and availability—underly controls put in place for cyber risk across all frameworks (including NIST, ISO, CIS20, etc.). *Confidentiality refers to measures* taken to guarantee that data is protected from unauthorized access. Privacy is required to be a basic design consideration by global regulation including the General Data Protection Regulation (GDPR). The level confidentiality can vary based on the data type and/or regulation. *Integrity refers* to safeguarding the accuracy of data as it moves through workflows. It includes protecting data from unauthorized deletion or modification, and measures to quickly reverse the damage if a breach were to occur. *Availability means* providing seamless, uninterrupted access to your users. This entails robust enterprise architecture and high-availability mechanisms built into system design.

### 15.3 METHODOLOGY

The data collection included a survey and structured and semi-structured interviews. Triangulation was used to verify the data. It involves multiple methods for collecting historical and longitudinal data (Yin 1994; Strauss and Corbin 2015). The data collected first involved the collection of empirical data collected from 80 individuals from 60 firms across 12 industry verticals and including small businesses as well as large businesses (Fig. 15.2). Data was collected from September 2018 to September 2019. Executives and business leaders were asked for interviews as part of this study.

Multiple sources of data such as participant observation and company supplied data were collected along with structured and semi-structured interviews. Coding included highlighting issues that appeared more than six times in the interviews to develop the framework for analysis as well as to identify emerging themes and recommended solutions. The names of organizations

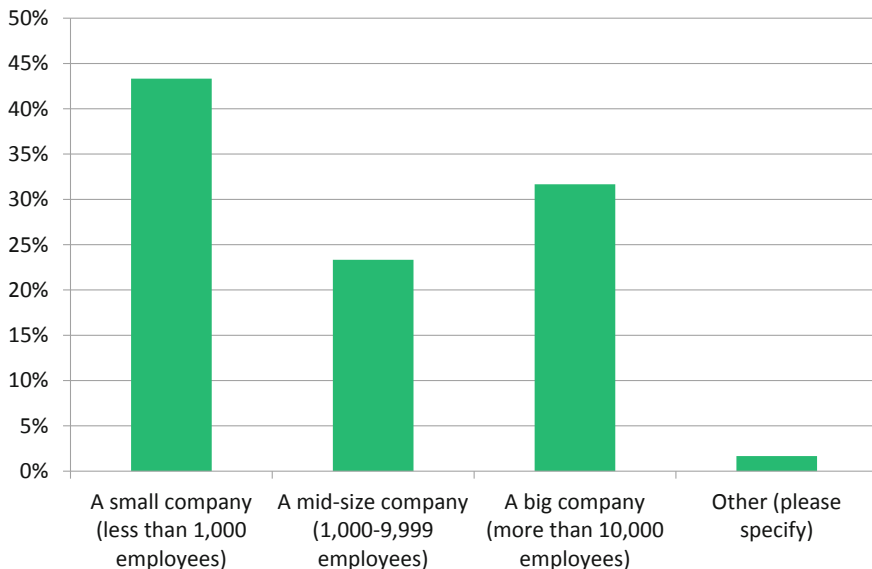


Fig. 15.2 Size of businesses surveyed (*Source* Authors' Survey)

have been kept confidential and anonymized in the reporting of the results, particularly given the sensitivity of the information security area.

In addition, the business leaders who responded were from across the organization and had high-level responsibilities within their organizations (Fig. 15.3).

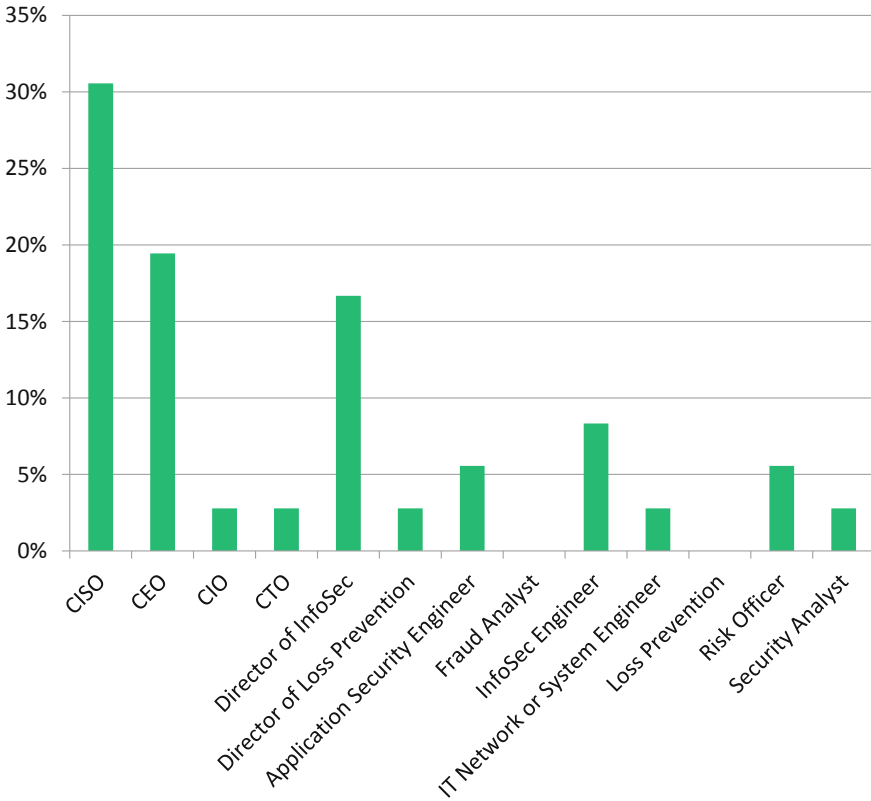
## 15.4 RESULTS

The first research question was: What are the risks associated with blockchain? To evaluate these risks we will use the governing principles of confidentiality, integrity, and availability (CIA) discussing areas of risk within each one. The analysis revealed and identified the de-coupled risks on the chain and off the chain seen in Table 15.1. All of these risks were validated in the qualitative analysis and interviews with business leaders. Through triangulation these risks were also validated through external resources and cases.

Each of these risks is discussed below in detail and classified in terms of the CIA framework.

### 15.4.1 Confidentiality

The National Institute of Standards and Technology (NIST) defines confidentiality as “the property that sensitive information is not disclosed to unauthorized individuals, entities, or processes” (Paulson and Byers 2019, p. 33). Organizations are concerned about ensuring that only interested and



**Fig. 15.3** Decision-making level of respondents (*Note* CISO-Chief Information Security Officer; CEO-Chief Executive Officer; CIO-Chief Information Officer; CTO-Chief Technology Officer. *Source* Authors’ Survey)

**Table 15.1** Blockchain risks identified

	Risks
On the Chain	<ol style="list-style-type: none"> <li>1. 51% attack (Sybil attack)</li> <li>2. Code vulnerabilities</li> <li>3. Code flaws</li> </ol>
Off the Chain	<ol style="list-style-type: none"> <li>1. Traditional Information Security Risks</li> <li>2. Insider threat</li> <li>3. physical security (ex. Tampering)</li> </ol>
Reputational	Compromised trust in the organization or access

authorized parties access the correct and appropriate data. This is one reason blockchain is implemented. However, in terms of confidentiality the identified risks include:

- Protecting blockchain network access (particularly for private blockchains)
- Data confidentiality
- Accessing the blockchain from multiple devices (which risks losing the private keys)
- Theft of private keys.

Protecting blockchain network access is essential for securing data access. This is particularly true of private blockchains. If an attacker gains access to a blockchain network and the data, the attacker may not be able to read or retrieve the data thus compromising data confidentiality. This is why, similar to all technologies deployed, authentication and authorization controls are required. To address the problem of data access, the business leaders interviewed suggested that private blockchains should require that appropriate security access controls are in place, similar to those for all technology deployments, to protect network and data access. In public blockchains there is no necessity to control network access as the chain protocols allow anyone to access and participate in the network. Public chains rely solely on encryption.

Public blockchain technology was originally created without specific access controls because of its public nature. Full encryption of blockchain data ensures data will not be accessible by unauthorized parties while this data is in transit (Piscini et al. 2017). As indicated earlier, private blockchains require that appropriate security controls are in place to protect network access. Some business leaders assumed that, because of its private nature, local networks and systems are already protected well behind an organization's perimeter by several internal security layers (such as firewalls, virtual private networks, VLANs, Intrusion Detection & Prevention Systems, etc.). This is insufficient. In fact, business leaders interviewed in the IT area mentioned the importance of other controls including access controls. In addition, cyber-physical security must include risks in supply-chain as this can also open unintended access. If blockchains become widely adopted, organizations will need to ensure they implement security controls to provide authentication, authorization, and encryption in order to properly protect data access.

The next issue after access is data confidentiality. If an attacker gains access to a blockchain network and the data, the attacker may not be able to read or retrieve the information thus compromising data confidentiality. This is because of the encryption of the data blocks applied to the data being transacted. The latest encryption standards use end to end encryption where authorized users have access the encrypted data through their private key.

However, if private keys are compromised, then there could be a problem with data confidentiality (Berke 2017).

Finally, the issues of the theft of private keys or a user losing a device with a private key on it, are very real risks. Blockchain users can back up their private key in a secondary place, but this also could be stolen. So the loss or theft of private keys is a significant risk. It should be noted that keys are used for several purposes in the blockchain ecosystem. They are used for protection of user information, confidentiality of data, and authentication and authorization to the network. Organizations need to be conscious that accessing their blockchain account from multiple devices puts them at a higher risk of losing control of their private keys. This dimension of risk is critical given the distributed workforce in 2020. To alleviate this risk it is essential users follow suitable key management procedures and firms develop secure key governance practices internally. This is fundamental to the security of the blockchain network.

#### 15.4.2 *Integrity*

NIST defines integrity as “guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity” (Paulson and Byers 2019, p. 45). Maintaining data consistency, and guaranteeing integrity, throughout its entire life-cycle is crucial in information systems. The first integrity risk is that of a Sybil attack also known as a 51% attack. The consensus model protocols associated with the technology present organizations with a further level of assurance over the security of the data, as generally 51% (Privacy Canada 2019) of users in public and private blockchains need to agree that a transaction is valid before it is then subsequently added to the platform. The 51% attack occurs when one of the nodes increases processing power and is executing a significantly higher number of transactions. Organizations can implement further mechanisms to prevent and control ledger splitting in the event of a 51% cyber control attack occurring. Data encryption, hash comparison (data digesting), or the use of digital signing, are some examples of how system owners can assure the integrity of the data, regardless of the stage it is in (in transit, at rest, and in use). Blockchain’s built-in characteristics, immutability, and traceability, already provide organizations with a means to ensure data integrity.

The immutability of blockchain technology means that it can be regarded as secure because it enables users to trust that the transactions stored on the tamper proof ledger are valid. This is the very definition of integrity. The combination of sequential hashing and cryptography along with its decentralized structure makes it very challenging for any party to tamper with blockchain (Piscini et al. 2017). This provides organizations using the technology with assurance about the integrity and truthfulness of the data. However, there are other considerations for risk when it comes to this concept of data immutability. For example, companies must consider how blockchains

comply with data privacy laws. How does a firm implement the right to be forgotten in a blockchain since it guarantees that nothing will be erased? Related to this is the fact that every blockchain transaction is digitally signed and timestamped. This means that organizations can trace back to a specific time period for each transaction and identify the corresponding party. This feature relates to an important information security property: non-repudiation, which is the assurance that someone cannot duplicate the authenticity of their signature on a file or the authorship of a transaction that they originated. This blockchain functionality certainly increases the reliability of the system (detection of tamper attempts or fraudulent transactions) but its immutability could pose risks within certain privacy regulations.

Another risk for blockchain is the increased cyber-physical attack surface given smart contracts. Smart contracts are used to facilitate, verify, or enforce rules between parties. This allows for straight through processing and interactions with other smart contracts. However, architecture provides a large surface area for attack. This means that an attack on one smart contract could have a domino effect on other parts of the platform. This could be in the language itself or the implementation of contracts. Because blockchain brings a new paradigm to software development, secure development standards and practices (such as implementing secure coding and security testing) need to be implemented (and updated) to account for the entire cyber-physical life-cycle. Risk-based methodologies including the entire life-cycle is required in order to minimize the threat of a critical bug during the life-cycle of smart contracts which would compromise integrity.

### 15.4.3 *Availability*

NIST defines availability as “ensuring timely and reliable access to and use of information” (Paulson and Byers 2019, p. 56). Service availability is a key risk for blockchain. Cyberattacks attempting to impact technology services availability are easy to execute and are increasing. Distributed Denial of Services (DDoS), one of the most common types of attacks, causes the most disruption to internet services and hence blockchain-enabled solutions (Piscini et al. 2017). The resulting implications are that services are disrupted and become unresponsive. This can generate increasing losses, and costs, to businesses. DDoS attacks on blockchain are not like regular attacks because blockchain is a distributed platform. These attacks attempt to overpower the network with large volumes of small transactions. The decentralization and peer-to-peer characteristics of the technology make it harder to disrupt than conventional distributed application architectures. Nonetheless, blockchain is still subject to DDoS attacks and blockchain is even more vulnerable because high availability is essential for operation.

Even though a blockchain network is considered to have no single point of failure, organizations could still face risks from external events outside of their control. For example, a global internet outage would disrupt even a

public blockchain network creating outages which could impact an organization's operations as with any other technology. Blockchain does have a high level of resilience given its distributed nature because if a node is taken down, data is still accessible via other nodes within the network. This is because all nodes maintain a full copy of the ledger at all times, thus solving the Byzantine General's problem (How to Solve the Byzantine Generals Problems 2014) of false consensus. However, the network is not "bullet-proof". Since 2007, cyber criminals have used different attack vectors to jeopardize the stability of blockchains. The Bitcoin network was attacked using transaction malleability, which means that transactions are in a pending validation status and this resulted in significant disruption in 2014. Transaction malleability remains a destabilizing attack vector. In 2016, an attacker exploited the smart contracts in Ethereum, and the way they can be used. They effectively created an overflow in the network so that the creation of blocks, and validation of transactions were severely impacted, slowing the network and completely disrupting availability (Rizzo 2016). These attacks on availability pose significant risks for blockchain and decision-makers must develop ways to address them using a risk-based approach.

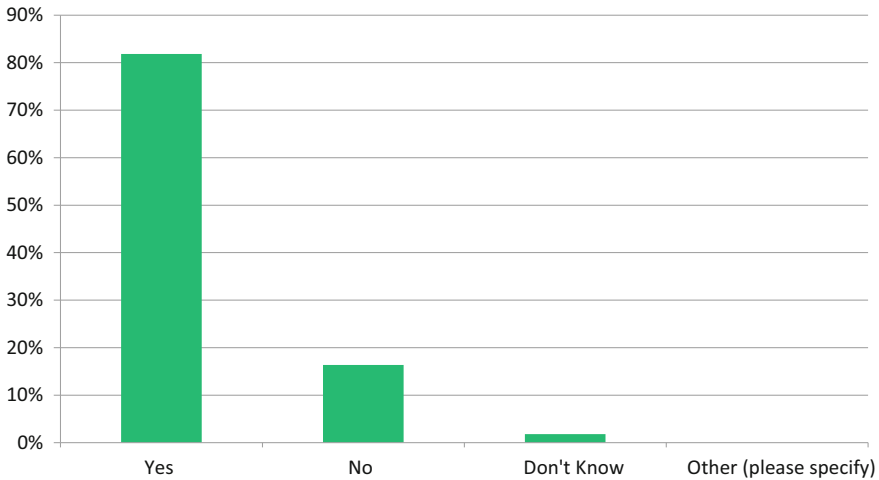
#### 15.4.4 *Decision-Making and Risk in Firms*

Although some of blockchains underlying capabilities provide data confidentiality, integrity, and availability, just like other systems, cybersecurity controls and standards need to be adopted for organizations using blockchains within their technical infrastructure in order to protect their organizations from external attacks. Therefore, how can we translate these cybersecurity vulnerabilities in terms of confidentiality, integrity, and availability into the evaluation of risk in a way that executives and decision-makers understand? This meaningful question arose from considering blockchain through these governing principles focused into on the next research question. It then developed into an approach that decision-makers could use for ongoing corporate risk evaluation when deploying blockchain.

The second research question was: How can these risks be evaluated and integrated into corporate decision-making? In order to answer this question, first decision-makers and the process of decision-making around cyber risk need to be understood. The results (Fig. 15.4) showed that in this self-reported categorization, 80% identified themselves as incorporating cyber risk into their risk management framework which is an increase over 2016 where most indicated that they were focusing on cyber risk from the perspective of compliance (Deshmukh et al. 2012; Griffy-Brown et al. 2019).

Interviews indicated that one primary impediment remaining to advancing the risk-based approach was the CFO and other leadership understanding the importance of this approach for strategic development of the business. The use of audit and regulation occurred when the IT and information security





**Fig. 15.4** Cyber risk as part of the management framework (*Source* Authors' Survey)

groups needed funding for special projects in order to achieve business alignment. Now that compliance and regulations are increasing it will be important to understand the investment in information security from the compliance versus risk perspective given that compliance is increasing in cost. Additionally, while for most of the companies in this study, emerging technology deployment fell into a broad category of “other,” IoT was identified independently. Figure 15.5 shows that only about 10% of the companies invested in the “other” category which includes blockchain.

What is even more significant is the elevation of cyber risk to the board level (Fig. 15.6). Nearly 65% of the respondents replied that the board was involved in their cybersecurity oversight.

Given these changes in oversight, a different security approach and framework for cybersecurity is required. This framework for new technologies such as blockchain must be advanced beyond the IT department into enterprise operations, culture, and decision-making. Importantly, a framework is required that speaks the language of executives and boardrooms: risk.

## 15.5 FINDINGS: THE EXTENDED RISK-BASED APPROACH FOR BLOCKCHAIN DEPLOYMENT

Executives and business leaders when interviewed about their cyber-physical risk explained that while they were developing compliance systems for their digital systems using frameworks from NIST, ISO, CIS20, and others, they were unsure how to extend this to encompass their cyber-physical needs. They universally mentioned the need for better overall processes, particularly

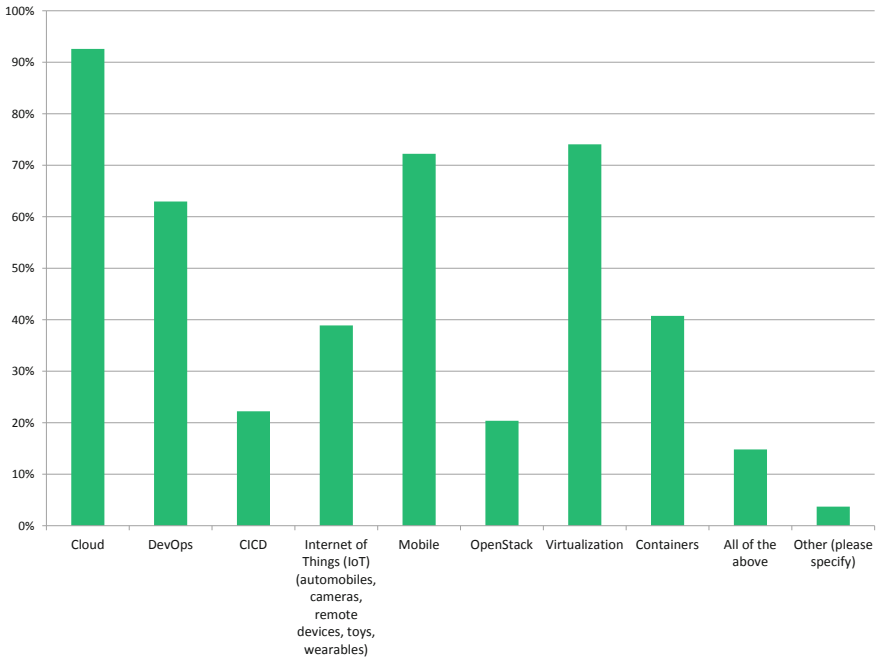


Fig. 15.5 The emerging technologies firms are working with currently (*Source* Authors' Survey)

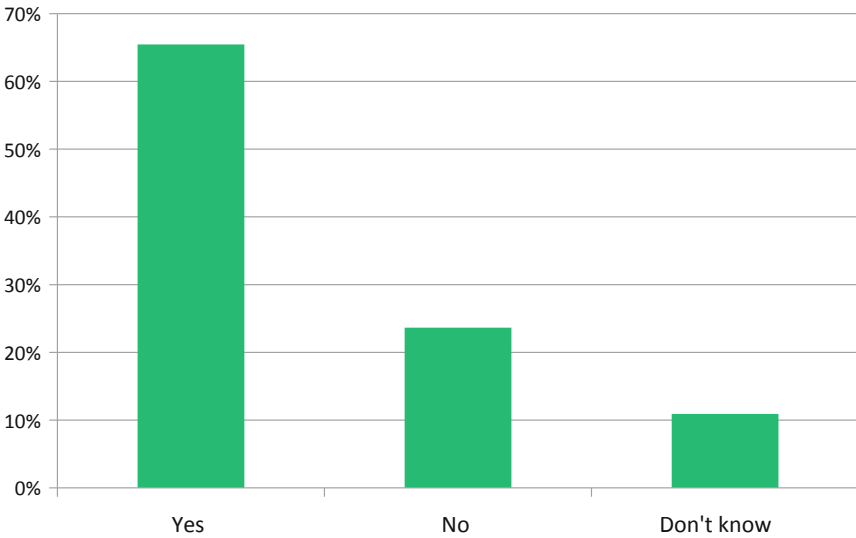


Fig. 15.6 Board oversight for cybersecurity (*Source* Authors' Survey)

connected to agile or waterfall project management. Connecting the decision-making throughout a component life-cycle was identified as a critical need. In addition, a decision-making process connected to the Risk-Based Approach was a natural leap in business thinking. The executives and business leaders felt that an entirely new approach was not required, but instead suggested an extension of the risk-based approach. A broader rather than more specific control/compliance-based approach was sought because of the rapid change in emerging technologies such as blockchain being incorporated and then exiting the architectural landscape. Therefore, an approach which would extend risk beyond project development throughout the software life-cycle was developed. The Extended Risk-Based Approach which resulted is demonstrated in Fig. 15.7.

In this framework, in addition to the Risk-Based Approach described in earlier research, every device or software implementation would follow a process for risk evaluation throughout its life-cycle and in the case of some technologies, training and configuration questions also fall under scrutiny as elements of risk. This would be linked to budgeting and the ongoing security posture of the firm. This Extended Risk-Based Approach would create a risk ecosystem as enterprise architecture develops. The advantage is that budgets are built with life-cycle risk in mind as well as the interaction of cyber risk exposures in an ecosystem. This would be coupled with and amplify the user-behavior analytics and cross-discipline monitoring which is part of the original approach. Furthermore, this approach builds on the SD theory, potentially incorporating risk into the modelling of the relationships at all three levels described in this theory.



Fig. 15.7 Extended Risk-based approach: Securing physical or any emerging technology throughout its life-cycle (Source Griffy-Brown et al. 2020)

## 15.6 CONCLUSION

This research explored the blockchain from the perspective of cyber risk. The focus was first identifying risk at a high level using CIA. The next step was examining what is happening in business to provide a practical approach for business leaders to follow in securing this new interconnected digital landscape. The final step was a broad approach and process so executives and teams could begin to tackle the deployment of blockchain while standards continue to develop. This work identified a holistic theoretical approach that resonated with business practice. Systems Dynamics theory is a strong foundation for building-out multi-level processes into the Extended Risk-Based Approach. This theory and the resulting approach suggest that enterprise risk is an optimal control problem, not a max-min problem requiring ongoing project and process risk evaluation across the enterprise. These results extend the application of theory and provide new optics for considering enterprise risk for not only protecting the bottom-line but adding to the top-line as part of a dynamic system. Furthermore, this theory and the identification of the risk using CIA and the qualitative data were the foundation for placing the life-cycle management process at the center of risk evaluation. The quantitative results showed that more businesses are taking a Risk-Based Approach and that there is greater board oversight. It also showed that blockchain is still in the early stages of deployment. This new architecture and the new risks it engenders are an important transition in cyber-physical risk from just being part of the IT function to being a consideration across the enterprise which, indeed, is where it belongs. The qualitative research built on these results to develop an extended approach through conversations with business leaders and executives to arrive at a broad life-cycle approach as well as a process for board oversight future research can delve into specific industry segment cyber-physical risks as well as the development of appropriate standards and controls. This study provides a process and approach for business executives and board members to use in order to provide oversight for cyber-physical risk as companies continue to deploy emerging technologies.

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# Blockchain in Financial Services



# FinTech and Financial Intermediation

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## 16.1 INTRODUCTION

Recent years have seen the financial technology (or “FinTech”) industry gaining considerable traction. As it will become clearer by the end of this chapter, this interest is shared amongst all economic agents, from policy-makers, regulators and firms surrounding the financial services arena, to central banks and the general population. An example of the latter’s realization though can be witnessed in Fig. 16.1, which shows searches of the term “FinTech” in Google by the general population in the horizon 2004M1–2019M12. Seemingly, by the end of 2019, the interest in this trending trajectory has reached fifteen years high. So, a question that may naturally arise at this point is what exactly is “FinTech” and why the sudden hype?

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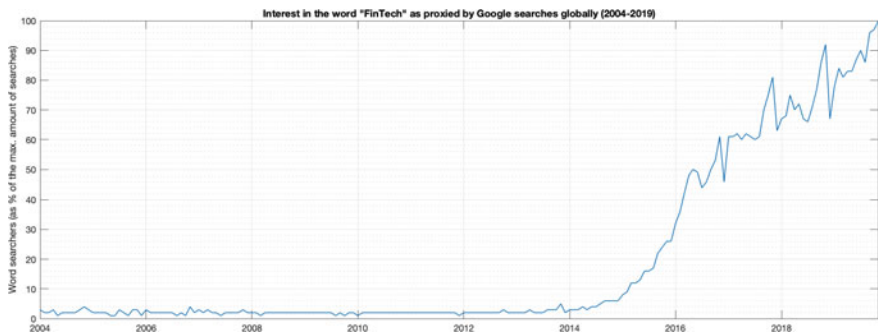
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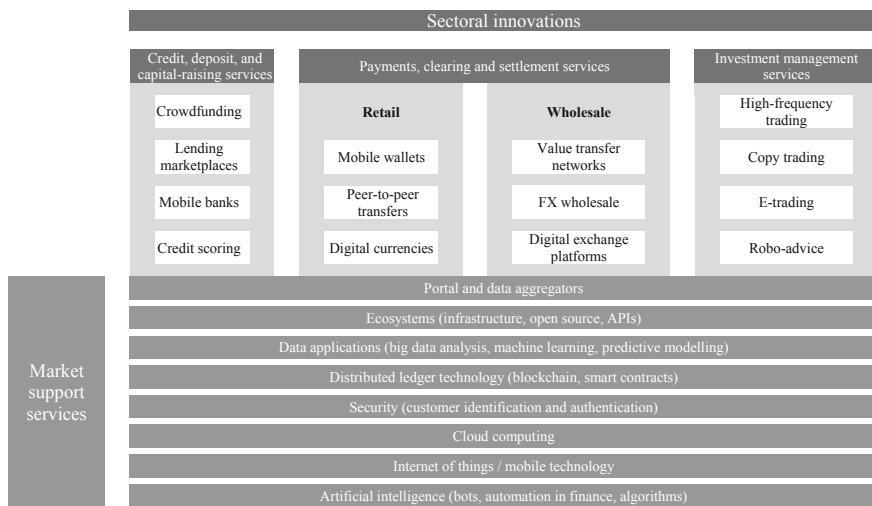
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**Fig. 16.1** Interest in the word “FinTech” as proxied by Google searches globally (*Source* Authors’ elaboration on Google’s Google Trends service. The data are monthly and concern the period January 2004–December 2019)

The Financial Stability Board (FSB) defines “FinTech” as “technology-enabled innovation in financial services that could result in new business models, applications, processes, or products with an associated material effect on the provision of financial services” (FSB 2017b, p. 7).<sup>1</sup> According to the Basel Committee on Banking Supervision (BCBS 2018), categorization of FinTech innovations includes three product sectors (to be detailed in later subsections of this chapter), as well as market support services. The product sectors relate directly to banking services, whilst the market support services related to innovations and new technologies that play a significant role in FinTech developments (see Fig. 16.2). As far as their interaction or collision with intermediaries is concerned, in a nutshell, the views seem mixed.



**Fig. 16.2** Sectors of innovative services (*Source* Adopted from BCBS 2018, p. 9)

Some estimate that a critical share of banks' revenues—especially from retail activities—is at risk over the following years (McKinsey & Company 2015a), and others claim that banks will be able to absorb or outcompete the new competitors instead, whilst improving their own efficiency and capabilities by the adoption of new business models (Dermine 2016).

Indeed, the focus on FinTech and their interaction with intermediaries has come under the spotlight recently, given the outburst of interest showed on FinTech innovation, particularly related to the features this new set of players bring in the financial services arena. A number of reports suggest that FinTech innovations can lower costs, provide a faster provision and improve the quality of financial services, reach the unbanked around the world, and even create a more diverse and stable credit landscape (Economist 2015; Walport 2015; European Commission 2017). Reasonably, the industry has grown at an exponential rate around the globe. This can be easily observed if one looks at how investment in FinTech has more than quadrupled in the last decade. In particular, a report by KPMG (2019) points to a figure of 37.9 bill. USD having been invested in FinTech in 2019, compared to approximately 9 bill. USD in 2010. A similarly noteworthy increase can be witnessed from a consumer's perspective, with the average adoption of FinTech globally being tripled in just four years (64% in 2019 compared to 16% in 2015) according to a report from EY (2019).

FinTech credit is also growing rapidly during recent years, with some economies noting a noticeably larger growth, such as China, the United States and the United Kingdom (see Table 16.1). It provides an alternative source of funding for businesses and consumers and may improve access to credit for underserved segments (Claessens et al. 2018).<sup>2</sup>

One reason why FinTech spread so quickly in recent times might have to do with timing. After a point where banks struggled recovering from an economic downturn due to the global financial crisis, FinTech offered a plethora of solutions, aggressively bridging the gaps of customers' needs where traditional bank systems had fallen short (Busch and Moreno 2014; Dietz et al. 2015). At the same time, trust in financial services incumbents—whilst on the recovering trajectory—is still heavily hit (Edelman 2019), and according to the same survey it is significantly lower to that of the Technology sector, in which technological colossuses such as Google, Amazon and Apple are starting to enter the FinTech arena. Coupled with the fact that FinTechs are generally not capital intensive, and that they play on an uneven, regulatory-wise, field compared to banking institutions (Deloitte 2015; Stulz 2019), this might have been a recipe accelerating FinTechs' growth over the past decade.

On top of FinTechs, in recent years, the entry of technology companies into the financial services (“BigTech”<sup>3</sup> or “TechFins”) has also been notable. In particular, BigTechs boast a unique business model attributed to the combination of two main elements: *network effects* (generated by e-commerce platforms, messaging applications, search engines, etc.), and *technology* (i.e. artificial intelligence through the use of big data). BigTechs may

**Table 16.1** FinTech credit volumes by country

Jurisdiction	<i>Level (USD, in millions)</i>		<i>Annualized growth</i>	<i>Memo: Volume per</i>
	2013	2016	2013–16 (%)	capital in 2016 (USD)
Australia	12	549	258	22.5
Brazil	1	61	294	0.3
Canada	8	169	176	4.7
Chile	12	93	98	5.1
China	5547	240,905	252	174.2
Colombia	...	131	...	2.7
Estonia	...	83	...	63.0
Finland	...	119	...	21.7
France	59	338	79	5.2
Georgia	...	111	...	30.1
Germany	48	233	69	2.8
India	4	90	182	0.1
Ireland	...	81	...	17.3
Israel	...	33	...	3.9
Italy	0	114	...	1.9
Japan	79	380	69	3.0
Korea	1	368	617	7.2
Mexico	1	106	373	0.9
Netherlands	48	165	51	9.7
New Zealand	<1	190	668	40.1
Nigeria	...	36	...	0.2
Poland	...	35	...	0.9
Singapore	0	101	...	18.0
Spain	4	85	177	1.8
Sweden	...	7	...	0.7
United Kingdom	906	6068	88	92.4
United States	3757	32,414	105	100.2
World	10,555	283,529	199	50.5
Memo:				
Africa and Middle East	42	134	47	0.2
Asia-Pacific (ex China)	98	1757	162	1.0
Americas (ex US)	22	612	203	1.1
Central and eastern Europe	14	120	105	0.5
Europe (ex GB)	266	1639	83	2.6
Latin America and Caribbean	14	442	216	0.8
Nordics	112	214	24	10.1

*Source* Adopted from Claessens et al. 2018, p. 49

enhance competition and financial inclusion, especially in emerging markets and developing economies, and they may contribute to the overall efficiency of the current state of financial services. An example is that they possess an information advantage in credit scoring over credit bureaus (Frost et al. 2019).

The drivers of BigTech activity in finance may be generally similar to those of FinTech activity. Broadly, these can be broken down into demand and supply factors. The most important factors on the demand side could be, e.g. unmet customer demand and consumer preferences, whilst on the supply side they could be, e.g. access to data, technological advantage, access to funding, lack of regulation and lack of competition (Frost et al. 2019). The rapid growth of said services in finance will undoubtedly bring changes that have both benefits and drawbacks, and possible risks for the financial system (FSB 2017b, 2019; Frost et al. 2019).

Naturally though, when a new popular trend emerges, particularly one emerging in an economically significant area like the financial services; discussions around the changes it brings tend to follow suit. FinTech, as its name suggests, marks the collision of two vastly large and important worlds; *technology* and *finance*, and with these two worlds colliding into a newly formed corporate embrace, there exists the possibility of two outcomes: *disruption* or *synergy* (Galvin et al. 2018).

In this chapter, we discuss how the three main product sectors of FinTech are so far seen interacting—and potentially disrupting—key segments of financial intermediaries. In particular, in what follows, Sect. 16.2 provides a discussion on credit, deposit and capital raising services, Sect. 16.3 discusses the payments, clearing and settlement segment, Sect. 16.4 reviews the investment management services and Sect. 16.5 provides an overview of FinTech regulation and financial stability aspects. Finally, Sect. 16.6 summarizes and concludes this chapter.

## 16.2 CREDIT, DEPOSIT AND CAPITAL RAISING SERVICES

Deposits and lending are the core products of the banking sector. Banks receive deposits by their customers and use them to finance loans. This value chain has been in place for years, however recent sector trends includes: (i) downward interest rate trajectory, initially driven by the fall-out from the global financial crisis and the euro area sovereign debt crisis and currently due to global growth uncertainty and persistently low inflation, (ii) growth in low-principal financing, as a result of the decreasing loans service cost, (iii) keen focus on customers, as the changing customer preferences towards digital and personal advice may result in changing revenue models for depository and lending institutions and (iv) shift in financing to capital markets, as the deleveraging of depository institutions continues to be emphasized by regulatory and supervisory bodies. Moreover, banking sector operations have been challenged by increasing pressures from: (i) new digital competitors, (ii) sustained low trust and consumer confidence, (iii) sustained cost pressures across banking

operations, iv) significant global unbanked and underbanked populations and (v) high costs of misconduct. Obviously, as is stated in the report by the World Economic Forum (2018, p. 88), core banking margins are under significant pressure, caused by increased regulatory burdens, accommodative monetary policy and new competitors. In fact, the same report claims that artificial intelligence can improve banks' profitability through the delivery of personalized advice at scale and the transformation of lending operations, by focusing retail banking on improving customer outcomes, increase the efficiency and scale of retail lending, and offer automated working-capital solutions for commercial clients. As customer experiences are increasingly informed by algorithms, deposit accounts may no longer form the centre of the banking experience for customers. The emerging ability of platform solutions to deliver digital advisory may make them the natural owners of customer relationships in retail banking. As roles in advisory and adjudication functions become re-engineered, the shape of teams and the composition of talent in these areas will be transformed. New decision-making models will make lending decisions more accurate but will also raise ethical questions regarding potential biases and decision opaqueness. A reliance on data for financial decision-making will raise questions about the treatment of personal identifiable information (World Economic Forum 2018).

Another domain that may face pressure from FinTech is that of lending, especially in underserved segments, as a range of innovative lending platforms, namely P2P and marketplace lenders, have surfaced in jurisdictions around the world (Claessens et al. 2018). Peer-to-peer (P2P) lending platforms facilitate the provision of loans by individual investors (peers) rather than financial institutions (Bachmann et al. 2011). These platforms have access to online methods of client interaction, new data sources and methodologies to analyse data and new business models. Available data seem to indicate that, despite rapid growth, FinTech credit still appears to be small proportionally to the overall credit in most areas around the world, including China, Korea and the United Kingdom (see FSB 2019). Credit quality of P2P lending platforms has also been a concern. Nevertheless, cooperation between incumbents and FinTech firms has been seen in a number of markets, such as the outsourcing of some lending activities to FinTech (World Economic Forum 2017), whilst FinTech firms benefit from access to incumbents' client base and reputation. Lending platforms have also entered segments where they have no competition from banks (i.e. amongst unbanked clients who may not apply for loans) and underserved segments (e.g. small businesses, subprime customers, potential clients with insufficient credit history) (FSB 2019).

On the same note, new entrants could be seen as significant disruptors of the lending market, but nevertheless do not appear poised to bring innovations to scale. For instance new adjudication techniques have significantly expanded access to credit for underbanked, "thin-file" and subprime customers (new sources of data, more effectively use of data, more agile credit models untested due to lack of credit cycles), resulting in individuals and

small business borrowers to expect their lender to deliver the seamless digital origination and rapid adjudication pioneered by leading FinTechs (improved processes, legacy technology increase costs, partnerships as cost-saver), and non-financial platforms are emerging as an important source of underwriting data and a point of distribution for credit (increasing customer engagement, increasing data collection, risk of new entrants). However, funding costs is a disadvantage for marketplace lenders compared to traditional banks, and raise questions about the model's sustainability due to high customer gaining costs, high funding costs for marketplaces and funding instability (World Economic Forum 2017).

Despite said innovations, the online lending model is essentially so far limited by high and unstable funding costs in its capability versus banking institutions. The need for a stable funding source, such as that of deposits for banks, will push online lenders to obtain banking licences, lest an alternative funding source arise. Customer expectations have been reoriented by Marketplace lenders and firms' technology. In particular, it is expected that large lenders offer simple credit origination experiences, where a mixture of aesthetic design and automation offers customers with a frictionless application experience and a rapid response. These lenders make great use of data to further the effectiveness and efficiency of their adjudication processes. That is as they make use of new sources of data to underwrite applications whose risks could not be previously assessed, and reduce underwriting costs by automating key data collection and analysis process. Moving forward, lenders will increasingly look for new signals and data to be used in their lending decisions (World Economic Forum 2017).

Utilizing distributed ledger technology (DLT) to automate syndicate formation, underwriting and the disbursement of funds can reduce loan issuance timeframe and operational risk. According to the World Economic Forum (2016) report, implications for financial institutions includes: (i) forming syndicates through smart contracts can increase speed and provide regulators with a real-time view, facilitating AML/KYC, (ii) performing risk underwriting through DLT can considerably reduce resources required for these activities and (iii) smart contracts can facilitate real-time loan funding and automated servicing activities, without the need for intermediaries. Critical conditions for implementation includes: building risk rating frameworks for syndicate selection, standardizing diligence and underwriting templates, and providing access to financial details on the distributed ledger. Moreover, operational simplification of Trade Finance that might be achieved by utilizing DLT to store financial details, can facilitate the real-time approvals, create new financing structures, reduce counterparty risk and facilitate faster settlement. The following are some examples of the implications for financial institutions: (i) storing financial details on the ledger can automate the creation and management of credit facilities through smart contracts, (ii) DLT can improve real-time visibility to the transaction to better institute regulatory and customs oversight, (iii) DLT use will allow direct interaction between import

and export banks, eliminating the role of correspondent banks. Nonetheless, there are again some critical conditions for implementation which include: (i) providing transparency into trade finance agreements, (ii) allowing interoperability with legacy platforms and (iii) rewriting regulatory guidance and legal frameworks (World Economic Forum 2016).

Capital raising utilizing smart contracts to automate regulator reporting can minimize the need for point-in-time stress tests, reduce market volatility and increase Contingent Convertible “CoCo” bond issuance. Implications for financial institutions includes: (i) tokenizing bond instruments when asking capital from investors may enable them to do informed decisions motivated by data, (ii) smart contracts can alert regulators when loan absorption has to be activated, minimizing necessity for point-in-time stress tests and (iii) providing investors with transparency into loan absorption can reduce uncertainty, related to “CoCo” bonds. Critical conditions for implementation includes: standardizing attributes for soliciting investments, streamlining trigger calculations across financial institutions and developing processes to act on real-time trigger notifications (World Economic Forum 2016).

Banks have made significant steps to modernize their IT systems and develop their digital offering, by transforming traditional business models. A new architecture called “Industry Stacks” is emerging representing a shift from competition amongst vertically integrated banks to horizontal competition at each layer of the banking business (Boston Consulting Group 2016). As a result, amongst others, customers’ visits into branches to do their banking are dropping significantly, since they are made for more complicated issues (BBA and Accenture 2015). Banking digitization provides potential opportunities for revenue generation, cost saving and customer experience (McKinsey & Company 2015b).

The regulatory environment for marketplace lending platforms is highly fragmented. Therefore, to foster the growth of an international industry and to limit regulatory arbitrage, the harmonization of regulation and standards is necessary (World Economic Forum 2015). At the same time, the costs of funding pressure exist and will increase, whilst banks’ low-cost funding model provides them a competitive advantage (World Economic Forum 2016; Deloitte 2016). Additionally, half of the world’s bank customers are using FinTech companies, thus the latter continue to gain momentum. Therefore, banks’ sustainability in the digital era depends on their ability to respond to the threats and opportunities of FinTech innovation. Strategies adopted by the major banks around the globe in 2013–2014 highlight these trends, and included: (i) start-up programs to incubate FinTech companies (43%), (ii) partnering with FinTech companies (20%), (iii) set up venture funds to fund FinTech companies (20%), (iv) acquired FinTech companies (10%) and (v) launched own FinTech subsidiaries (7%) (Medium 2015).

The rising prominence of e-commerce, the Internet of Things (IoT), big data and increased computational power resulted in expediting the surfacing

of alternative credit scoring models to estimate creditworthiness in retail portfolios. These models can make use of customers' data from a plethora of sources, e.g. social media, other lenders, enterprise customer data, publicly available data, geolocation, mobile data, web data and behavioural data. In particular, these data sources can be utilized to evaluate qualitative concepts and predict potential borrower's probability of default.<sup>4</sup> Several FinTech startups take advantage of this opportunity by leveraging large amounts of data to produce advanced credit scoring models, which assess customer's creditworthiness faster even in cases where typical data are not available. It remains to see if machine learning credit scoring models will be more accurate than the existing ones, and if the credit acceptance rates of institutions that use them will be revised (EBA 2018).

### 16.3 PAYMENTS AND CLEARING AND SETTLEMENT SERVICES

Banks have a multifaceted functionality that extends beyond one's classic perception of them bridging borrowers and lenders. One of their key functions is the provision of a payment mechanism for their customers, which in its most simplistic version is essentially a bookkeeping activity of debiting and crediting of customers' accounts. However simple it may sound, factoring in half a trillion non-cash transactions globally (World Payment Report 2019), and the inherent complexity of payment systems—all under the promise of delivering a safe and fast transaction between the payer and the beneficiary within—or cross-border, this function surely gets complex. The payment system of banks as we know it today started in the sixteenth century. Whilst in principle it remains structurally similar to its very inception, technological developments in the past 50 years transformed its core functions, making it distinguishably more efficient and safer (Ali et al. 2014).<sup>5</sup> In fact, banks have been traditionally responsible for huge innovations that transformed the financial industry, such as the inception of the credit cards in the 1950s and the ATMs in the 1970s (Chishti and Barberis 2016). The rapid technological developments that transformed the banks' business model and systems in the past continue to do so nowadays, to the edge of also threatening it. This section is thus dedicated to describing how the progressive entry of new players taking advantage of innovative technologies in the payment arena is seen as a disruptive factor of the *status quo* of banking institutions traditionally leading this segment.

Admittedly, there are several examples to choose to show how disruption could occur in this field. Busch and Moreno (2014) mention a few distinctive ones of technological colossuses that excel in making use of and advancing technology (BigTechs) which grew their business models and disrupted other fields than they were originally introduced in as a venture for future growth. Similarly, BigTech, as well as FinTech companies alike, all often generalized under the term “non-banks”, have been challenging the banking sector, the growth and profitability of which were shook after the global financial crisis. Quoting Busch and Moreno (2014): “As banks recover from the downturn,



non-banks are taking advantage by proceeding aggressively with digital innovations and capturing more and more of the banking value chain". In fact, a recent report by Accenture (2019) estimates a fraction of as high as 15% of banks' global payments revenues could be displaced by "non-bank" competitors taking advantage of innovations in digital payments. A complementary survey by PwC (2016a) claims payments is probably the most disrupted factor over the next couple of years, which might be reasonable given that it has attracted the most significant investments globally (KPMG 2018b). In fact, 34 out of the top 100 FinTech leading innovators "to watch" in 2018 are operating in this segment (KPMG 2018a).<sup>6</sup>

What is more, a recent report by EY (2019) finds that the money transfer and payments segment of FinTechs are by far the most widespread amongst consumers, with 96% of survey participants globally being aware of such FinTech services, and 75% of all consumers reported using one or more FinTech services in this segment. This is a staggering adoption percentage, and by far the highest one according to the report (adoption rate in other segments ranged much lower, between 27 and 48% in 2019). In fact, it is also the highest growing one, as its adoption was only at a mere 18% back in 2015, i.e. more than a quadruple change. Interestingly, the same report (EY 2019) notes that consumers might have been using FinTech innovations in this segment, such as the use of mobile wallets, P2P mobile payments or Foreign exchange payments without even realizing it.

This disruption in the payments segment is noteworthy given that payments make up to a quarter of traditional bank revenues (Busch and Moreno 2014). Indeed, a report by Deloitte (2015) mentions the major risk faced by EU banks with the entry of FinTech players is located particularly in the payments segment. As it states, the issue banks face here is slightly less profound than one may assume. In particular, the main underlying issue is not exactly that payments comprise a quarter of retail banking revenues, but that they are a main avenue of strategic importance for bank-client relationships and an opening for banks to sell a whole range of other products, such as loans, credit cards, savings accounts and even mortgages. According to the same report, where FinTechs excel is the offer of an easier, simpler and swifter user experience, for example in using mobile apps. This is actually one of their key features, add PwC (2016b), with these firms offering not just a payment transaction—much like any bank—but a whole experience associated with shopping, money management around discretionary spending and money transfer tools.

Interestingly, customer-driven innovations and experiences like these offered by FinTechs are something that surveyed customers think is a requirement nowadays (Accenture 2019), as using techniques from the fields of Machine Learning means offering of tailor-made suggestions and information for consumers, such as suggestions for money management based on consumers' historic transactions. Indeed, customers might have started raising the bar of services they require of their banks. Indeed, according to a survey

of bank executives, customer expectations is deemed as the most disruptive factor, with almost 71% of surveyed executives sharing this point (Capgemini 2018). Indeed, consumers are more aware nowadays and even happy to share their data with financial service providers in understanding how useful they might be; but they require a premium service to make up for that (Accenture 2017).

On the same note, a survey conducted by EY (2019) on how FinTech has redefined the rules in the financial services industry finds that customers prefer app-based products that are tailor-made for them despite concerns about personal data security. The same survey attempts to portray a metric of disruption, with respondents of the survey claiming that they increasingly start to look at other available non-bank services beyond their banking institutions. In particular, about a mere 58% of FinTech users and 62% of non-FinTech users surveyed said that their bank is the first option to go to when considering a new service, with other surveyed individuals being open to other offers. Admittedly, this is a percentage that can be reasonably deemed low, particularly considering that only barely half of banks' customers have a positive experience from traditional bank services (Capgemini 2018). Regardless of this disruption at a first glance though, when they were asked about their bank's business strategy, 91.3% of bank executives declared the intention of a collaboration with FinTechs, and another 4.3% declared intention of acquisition, with only a 4.4% declaring direct competition against FinTechs in general (Capgemini 2017). A conjecture one could make here would be that given the pie increases in this segment, banks might also see FinTechs as enablers to share the pie with, rather than just sheer competitors to compete against.

Academic studies on this segment are actually scarce. On a general note, Bunea et al. (2016) look at US banks' annual reports in an effort to find bank managers' perception of FinTech disruption. Whilst so many reports are talking about disruption and the entry of a new set of players in the financial services arena, according to the authors' study, there has actually been no mention of the "FinTech" term in the annual reports of US banks prior to 2016. They find that only 14 banks (representing 3% of the US banking sector by count, though accounting for about a third of its assets) do acknowledge the threat or share their concerns about the disruptions to be faced. According to Stulz (2019), one of the reasons FinTechs met with such a success is that, unlike banks, FinTechs' innovation is based on something that is not capital intensive. Quoting Stulz (2019, p. 12): "The implementation of digital and big data technologies can often be done with almost no capital at all – the critical facilities can be rented at low cost by accessing cloud services." At the same time, FinTech firms can easily scale up their procedures, as "with digital technologies, the marginal cost of one more customer is generally fairly trivial" (Stulz, p. 12). In a review study by Milian et al. (2019) covering the general notion of FinTech, the authors found that whilst security concerns were generally spread across the whole range of FinTech segments in academic studies, payments were deemed top in terms of potential concerns, which comes in

contrast to the perceived risk consumers think of in an older survey (Accenture 2017).

Additionally, Pantelieieva et al. (2019) discuss how traditional banking clashes nowadays with BigTechs and FinTechs who bring more opportunities to the market of modern financial products and services. In what they call as “digital transformation” of financial intermediation, one of the main trends driving it is the provision of alternative types of payment that expand cashless payments and transaction channels. Similarly, Thakor (2020) discusses how the payments segment is disrupting the banking traditional exercise due to the increasing use of digital wallets (such as PayPal) that simply replace physical wallets in both online and offline uses through the use of a mobile phone. According to the author, however, the major disruption of banks by FinTechs in this segment will mainly come from developing countries, where the fraction of the population using a banking system is already relatively small, giving an example of the “M-Pesa” solution in Kenya, which allows users to send payments to sellers and withdraw deposits for regular money.

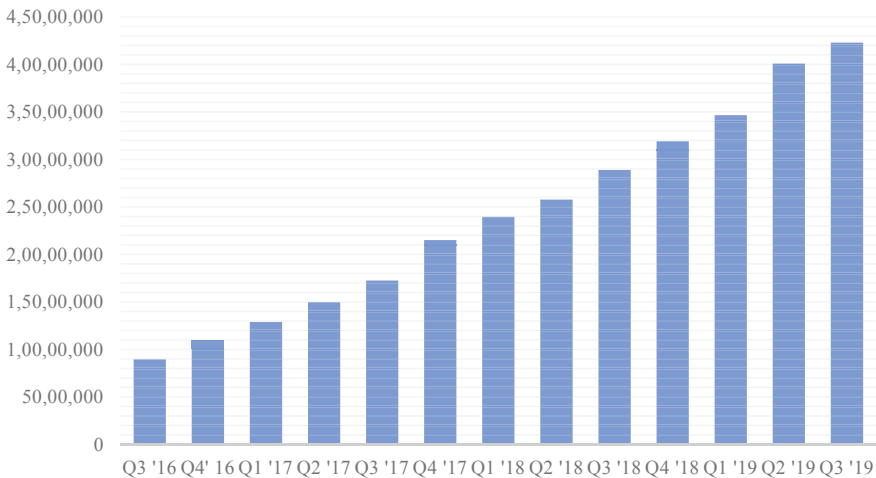
Last, but not least, despite the widespread disruption in this segment brought by non-banks, their key enabler in such disruption might have been that they are playing on an uneven field, as they are less regulated than banks and thus bear less related costs (Stulz 2019). As a report by Deloitte (2015) mentions, an example is that banks are subject to stricter regulations, such as fair treatment of customers, lack of discrimination in service offering and universal availability. On the contrary, non-banks are not subject to heavy regulations imposed on credit institutions and thus can cherry-pick the most attractive services. What is more, as the report mentions they do so even at a minimal cost, without having to own any kind of infrastructure of bank branches, accept deposits or provide processing capacity.

Turning to the second and complementary part of the FinTech’s product sector analysed in this section, “clearing” is a very important issue in the modern payment systems. Banks may receive and send thousands of payments daily on behalf of their customers’ accounts, yet not all happen within the same bank. Between intermediaries debiting and crediting accounts, it creates a level of counterparty risk that requires a third intermediary to act as a settlement agent. This is often the central bank of a country, in which commercial and other banks hold an account in, so the former ensures that the payee receives the full value owed by the payer. Both the central bank and the commercial intermediaries have a ledger to keep records of these transactions and the net settlement, and this is the essence of a *centralized system*, with the central ledger being the clearing agent, and the subsequent parties of this hierarchy keeping internal ledgers for their accounts. This system has been developed as a solution to the counterparty risk reduction and the avoidance of “double-payments” and, historically, this system has been the most efficient (see Norman et al. 2011, for a detailed discussion). However, the recent emergence of a variety of developments in payment technologies and alternative currencies has introduced the notion of a *decentralized* structure

that relies on cryptography rather than a central agent (Ali et al. 2014). This section discusses this new hype and its perceived effectiveness and trend in the following years.

The decentralized system has been widely spread as a notion with the introduction of bitcoin back in 2009, a privately developed, web-based currency and payment system that does not require a bank to be the intermediary when processing payments. It is often called a “cryptocurrency” as it is based on cryptography techniques to securely validate transactions. Users of this digital currency do not disclose their identity and simply maintain a digital wallet on their computers and trade or exchange this currency for traditional goods and services. The spread of bitcoin has been sudden, particularly after 2015. A survey by Blockchain published in Statista estimates the number of blockchain wallet users at over 40 million, a threefold increase from the same figure back in 2016 (see Fig. 16.3). Of course, there are other cryptocurrencies in circulation, but Bitcoin has been the first and more widespread since its very inception. What is important to understand at this stage is not the introduction of this digital currency per se, but the innovation that it brings. Ali et al. (2014, p. 266) describe how the whole process works in a nutshell, giving the following example:

“A user, wishing to make a payment, issues payment instructions that are disseminated across the network of other users. Standard cryptographic techniques make it possible for users to verify that the transaction is valid— that the would-be payer owns the currency in question. Special users in the network, known as “miners”, gather together blocks of transactions and compete to verify them. In return for this service, miners that successfully verify a block



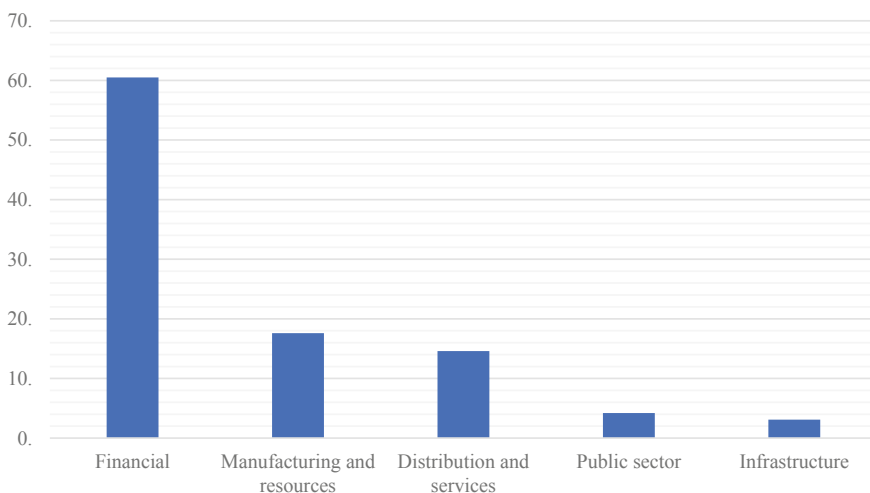
**Fig. 16.3** Number of Blockchain wallet users worldwide (Source Blockchain.info [published in Statista])

of transactions receive both an allocation of newly created currency and any transaction fees offered by parties to the transactions under question”.

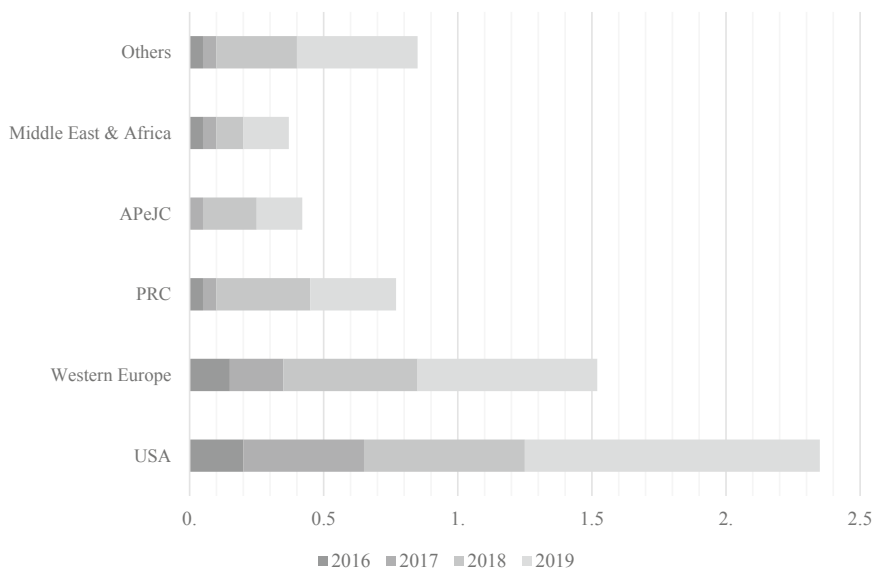
Essentially, instead of a “centralized” system (and thus a centralized ledger), cryptocurrencies are based on a “distributed ledger” that is more efficient and less costly (for a detailed explanation of how the system works see Ali et al. 2014, pp. 268–269).

Of course, bitcoin introduced both a new digital currency and a decentralized system. Whilst the former is interesting on its own, the weight here bears on the latter (i.e. DLT), the innovation behind which may-theoretically- even be feasible to be adopted by central banks that could issue digital-only liabilities in an equivalent ledger system (Haldane and Qvigstad 2016). DLT has the potential to challenge the banking and payment infrastructure, including the store and transfer of value, and have consequently received large interest by the academic community (Nakamoto 2008). Reasonably, the financial sector has highly invested in such technology, and in fact holds the highest shares of investments in the blockchain market value (see Fig. 16.4) according to the International Data Corporation (IDC). It is noteworthy that the global spending on such solutions has increased to more than 2.5 billion according to the same source (see Fig. 16.5), with the United States holding the lion share, and Western European countries following suit.

With the technology potentially being able to change the future of how payments are settled, a report by McKinsey & Company (2018) tries to shed light on how these emerging trends might shape the future of cross-border payments in particular, as the capacity, safety and, of course, the speed of which is instrumental for the growth of the global economy. The expectations this



**Fig. 16.4** Blockchain market value share in 2018, by sector (in %) (Source International Data Corporation (IDC), published in Statista)



**Fig. 16.5** Global blockchain solutions spending 2016–2019 by region (in \$ bill) (*Source* International Data Corporation [IDC], published in Statista)

new technology brings with respect to its effects on efficiency, cost alleviation and safety of the banking industry are huge (Guo and Liang 2016). As an illustrative case, Guo and Liang (2016) refer to British Standard Chartered, which through a blockchain platform managed to implement a cross-border transaction in 10 s, a settlement process that would otherwise have taken a banking network 2 days to complete. McKinsey additionally mentions an expected reduction of at least 42% in cross-border transaction costs (as cited in Guo and Liang 2016). Admittedly, these are both significant gains, but is there a disruptive factor for banks?

An interesting view is mentioned in a discussion by Tapscott and Kirkland (2016). The authors share a question on whether the financial services industry is actually up for disruption, or for transformation. For instance, JPMorgan has been working on a spin-off of its main technology, “Quorum”, its own customized version of blockchain technology, in order to achieve maximum efficiency in clearing cross-border payments (Arnold and McLanahan 2018). Guo and Liang (2016) mention several further examples of banking institutions involved in funding and/or supporting innovation on this front, whilst even central banks have been experimenting with his technology (see MAS 2019, for an overview of the Ubin project of Monetary Authority of Singapore; and He 2017, for a speech about DLT adoption by central banks).

Undoubtedly, there are several positive outcomes to take from DLT, but also several issues to be noted (see BIS 2017, for an analytical framework explaining both). That is to say that DLT is not a panacea, and instead should

be viewed as one of many technologies that will form the foundation of next-generation financial services infrastructure. In a position paper discussing its thoughts on distributed ledger technology (DLT) (SWIFT 2017), SWIFT estimates that, whilst it is promising indeed, this technology is not yet mature, and huge R&D work is needed before it can be applied at the scale required by the financial industry.

Indeed, DLT applications will differ by use case, as each case may leverage this promising technology in alternative ways and for a diverse range of benefits. For instance, “Digital Identity” is a significant enabler to broaden applications to new verticals. “Digital Fiat” (legal tender), alongside additional emerging capabilities, has the capacity to enlarge benefits. Of course, one should have in mind that the most impactful DLT applications to come will certainly necessitate deep collaboration between incumbents, innovators and regulators, reasonably adding to this complexity and delaying of their actual implementation. What is more, as the World Economic Forum (2016) report suggests, new financial services infrastructure built on DLT will redraw processes and call into question orthodoxies that are deemed foundational to today’s business models.

What one can tell with certainty at this point is that the hype behind decentralized systems is definitely existent and puts DLT in the spotlight, even in the next couple of years. However, do not take it *prima facie*, as when and if there is going to be a disruption is really on the unknown side so far (Tapscott and Kirkland 2016).

## 16.4 INVESTMENT MANAGEMENT SERVICES

Another field where Financial Technology has successfully contributed is the one of wealth management. In more detail, through the advancement and disruption of technology and in particular, through Big Data, Artificial Intelligence (AI) and Machine Learning (ML), the investment management landscape has encountered pronounced changes over the last decade. In fact, according to PwC’s global FinTech survey, respondents believe that the field of asset and wealth management is the third more likely field to be disrupted by technology. This growing trend is also reflected by the magnitude of adoption of such services by the public. The 2015 McKinsey and Company report on virtual advisory services reveals that in the United States 40% out of 45% of individuals who changed to another wealth management firm within a two-year time frame, swapped to firms providing digital investment management services. In addition to that, the same report indicates that a great portion of individuals are comfortable with using automated advisory services irrespective of age and wealth level.

Over the past decade or so, a variety of systems and techniques have been developed, which have enhanced current approaches applied in investment advice and financial planning services. The availability of large amounts of data has encouraged the need of developing advanced methods to manage them.

Both traditional data, such as stock market or corporate reporting data, and non-traditional data, such as social media, audio or textual data, have increased in volume and velocity. Consequently, this has urged the need of developing methods to mine, handle and analyse these data in an accurate and a timely manner. In regard to the investment management arena, this means that having access to richer and alternative type of data, provides further insight to analysts and investors in regard to future firm performance and trends. For instance, the ability to analyse lengthy analysts' reports or conference call transcripts could be a challenging and time-consuming procedure for a human analyst. However, with the use of computer-based programs developed to analyse such context in an accurate and rigorous manner could provide valuable information to an investor. The aforementioned advancements contribute to facilitating an analyst's job, whilst enhancing the ability of making more informed and spherical investment recommendations to a client. In addition to the rise in availability of the aforementioned data, financial technology innovation has enabled the improvement of decision-making applications in the broader area of wealth management. In particular, the large volume of unstructured data has encouraged the need of appropriate ways of handling and analysing them beyond the use of traditional statistical and modelling techniques. The development of more sophisticated approaches has led to the design of programs and algorithms that have the ability to "learn" how to complete a variety of complex tasks over time. Moreover, these continue to learn through repetition of that task ending up with highly trained models, which in many instances surpass the human capability. These advancements in Artificial Intelligence and Machine Learning have, therefore, created new investment opportunities, as well as different approaches in the technical side of things—such as portfolio optimization and risk management techniques. Therefore, the combination of Big data and Machine learning techniques, along with traditional statistical methods have contributed to the investment planning and analysis process greatly.

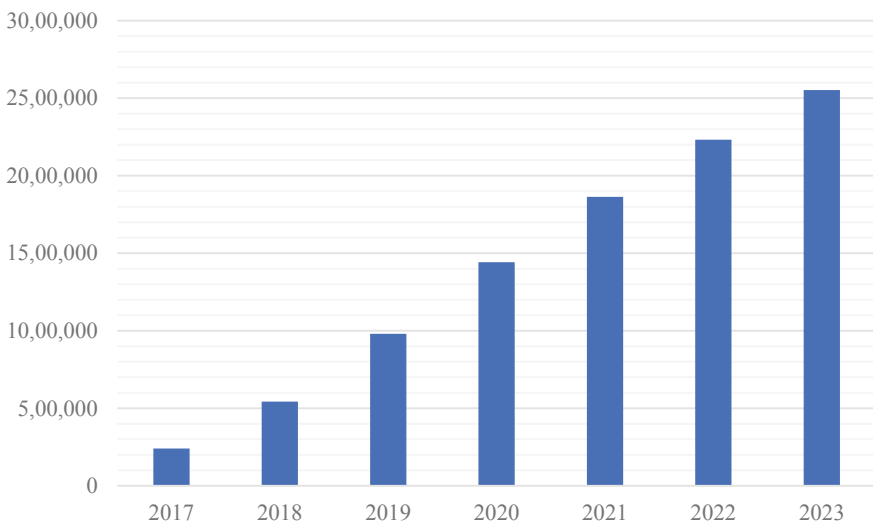
A particular area that Financial Technology has thrived is that of investment advisory services. The area is best known as "wealth tech" and involves a variety of services aiming to provide investment planning and advice with limited human interaction. One of the most successful solutions that emerged during the last decade includes automated wealth advisors, known as Robo-advisors. According to Tertilt and Scholz (2018), the term Robo-advisor can be defined as "[...] online investment advisory, which is driven by algorithms and rational logic and excludes emotionally biased decisions". To put it differently, Robo-advisors are digital asset manager solutions that provide investment recommendations, which are generated by algorithms. Their key characteristic is that they are independent from human influence of any kind. It is worth noting that the presence of Robo-advisors is growing at an accelerated pace. According to a report on Robo-advice by Deutsche Bank (2016) the market offers a growth potential. In particular, in 2015 Assets Under Management by Robo-advisors were approximately around US \$30 billion and are



projected to reach up to US \$500 billion by 2020. In addition, a growing trend has been reported in regard to amounts in assets under management by automated advisors (see Fig. 16.6), with amount values reaching US\$ 980,541 in 2019 and are projected to grow at 47.1% in 2020 according to the Digital Market Outlook report by Statista. It is worth mentioning that these solutions have either emerged independently through online platforms or as parts of large banks or asset management firms.

Robo-advisors intend to provide automated advice on wealth management and investment strategies based on the use of portfolio management algorithms. The typical business model of these companies is to provide investment advice without—or with limited—the presence of human advisors via an online platform and at a low cost. Therefore, this enables the provision of investment advice services at a lower cost and account minimum than those required when opting for traditional human advisory services.

The ultimate output of this application is to provide investment advice to individuals tailored around their own characteristics and preferences, with greater access and at lower cost. One of the great advantages of Robo-advisory services, therefore, is their accessibility to the broader public and in particular to individuals who are willing to invest, but have restricted amounts of initial capital. In the traditional investment management business model, both initial capital for investment and advisory fees are high. In the automated advisory sector, the majority of providers would require a minimum investment of lower magnitude in comparison to the traditional management services, whilst fees



**Fig. 16.6** Asset under Management in Robo-advisors market (in million US\$ worldwide) (Source Statista)

are generally less than 1% of the initial investment amount (Deutsche Bank Report 2016).

Automated investment advice can be available either as incumbents of large banks or investment companies or as stand-alone firms. Interestingly, such companies are present in mature as well as emerging markets (McKinsey & Company 2015b). For instance, Santander, ABN AMRO and Nordea are examples of European Banks and Fidelity, E\*Trade and Charles Schwab are examples of US banks that provide in-house automated investment advisory services in mature markets. Similar set-ups are available in emerging markets, such as Brazil and Taiwan. Stand-alone companies are also marking their presence in the automated wealth advisor market. Evidence provided by the McKinsey & Company (2015b) report, such companies cover a variety of regions, with the US and European market being more active.

Turning to the practical aspect and function of automated investment advisors, the starting point is to gather information in regard to the characteristics and preferences of the investor, as in the “traditional” human-based investment advisory services. The type of information gathered relates to some basic background information (e.g. sources of income, working status, liabilities, age, etc.), return preference, risk tolerance and desired amount to be invested. Therefore, a key starting point in automated investment advice requires individuals to fill in certain questionnaires providing such information. It is worth noting that Tertilt et al. (2018) highlight the fact that there is room for further improvement as far as the investor’s risk assessment is concerned. In particular, they suggest that Robo-advisors are not currently taking into consideration all information available and denote that this is an area that requires further research. Once the above information is gathered, the company’s investing algorithm considers and evaluates this information and subsequently produces certain choices and weights that are used to form several recommendations. The type of products available vary from asset allocation, trade execution, portfolio optimization, to rebalancing for investor portfolios.

Interestingly, Robo-advisory services are able to provide both active and passive types of portfolio management. However, it appears that in most cases recommendations are based on passive management styles. The investment recommendations may involve a variety of asset classes such as stocks, bonds, commodities, futures as well as real-estate. Given that the area of Robo-advisory is still at an early stage, the majority of cases involve recommendation of Exchange-Traded Funds (ETFs), rather than other financial products (Deutsche Bank Report 2016). In general, it appears that automated wealth advisors tend to provide more conservative investment advice. It is worth mentioning that Robo-advisors could be either fully automated digital wealth managers or adviser-assisted digital wealth managers. In the first case, there is no human involvement whatsoever and all processes are digital and are based on algorithms. This type of advisors is intending to provide investment advice at low costs and recommend portfolios that are usually composed by ETFs. On the other hand, the latter case refers to a mixture of both a

digital and human adviser, which in most cases would be virtual (e.g. by the phone or video chat or e-mail). The adviser would provide fundamental advice on financial planning and occasional reviews through online channels. The feature that is additional in this type of advice is that the human advisor can provide an additional analysis and advice tailored around the investor's needs and preferences.

Of course, there are certain benefits and drawbacks tied to automated investment management services. As mentioned earlier, the key advantage of automated wealth advisors is that they require low fees and amount of starting capital, especially when compared to "traditional" advisory services. This enables individual investors from a broader range of income to have access to advisory services, thus, closing the gap in the availability and quality of advisers for less wealthy individuals. However, there are some disadvantages that could be outlined. First, automated advisors are not currently able to include an abundance of information into their recommendation. That is, there is need for more work to be done on how automated advisors can incorporate information available from a variety of ranges. Second, unlike the human advisor, Robo-advisors are not able to provide their reasoning behind their choice of recommendation. Moreover, there are still issues of trust in the sense that investors may still not feel as comfortable for an algorithm to be managing their wealth, especially as their portfolio increases in terms of size and complexity.

On a more general note, the automated wealth advisory landscape is still of small magnitude but is expected to grow rapidly in the following years as seen earlier. The convenience, efficiency and potential cost-cutting gives a competitive advantage to firms that have adopted such approaches, posing a potential threat to traditional advisory firms. This in turn, has urged some "traditional" advisory firms to expand their activities including automated investment advice to their clients. Despite the projected growth route of this industry, there are still various areas that need to be improved, mainly relating to the quality of advice provided and the accuracy of risk assessments utilized by the algorithms in place. Therefore, in order to move forward it is essential for firms engaging in automated investment advice to adopt practices that provide advice tailored around client preferences and profiles, using a range of sources (e.g. social media, psychometrics, etc.), whilst focusing on enhancing risk assessment techniques. For the above to be achieved heavier implementation of Artificial Intelligence and Machine Learning techniques will be an indispensable element. Last but not least, a major challenge and area of concern—as in most segments of Financial Technology—is that of regulation. It is essential to highlight that the Robo-advisory field relies massively on the gathering and analysis of data that are not considered in the traditional approach, either due to the lack of ways of gathering this data or due to the complexity of analysing it for instance. Therefore, investment professionals need to have a deep understanding of the legal and ethical factors that relate to collecting and analysing such data. Scrampling data that could be used to assess a client's profile from the

web could be an example. This, therefore, creates a certain scale of complexity and conflict, that regulators across the globe are called to deal with.

## 16.5 REGULATION AND FINANCIAL STABILITY

Digital technologies can be applied to solve regulatory and compliance requirements more efficiently than with the use of existing capabilities. This is known as “RegTech”, which is defined by the Institute of International Finance as “the use of new technologies to solve regulatory and compliance burdens more effectively and efficiently”. A second definition given by the European Banking Authority is that of “a commonly recognized term for technologies that can be used by market participants to follow regulatory and compliance requirements more effectively and efficiently”.

Definitions aside, interestingly, there exists no international agreement on financial regulatory standards or policies for FinTech credit lending. In several jurisdictions where FinTech credit markets have surfaced, authorities have stepped to address risks and endorse benefits, in line with their respective mandates. A few authorities have acted within existing frameworks, whilst others have set rules particularly focused on FinTech credit. Although not common, there have been public sector tax policies to promote FinTech credit and accelerate its development. Table 16.2 provides an overview of those actions (CGFS and FSB 2017). These changes started appearing in 2015, with some being very recent (i.e. Brazil and Mexico introduced new rules and licensing practices in 2018). Licences to operate FinTech credit platforms can be subject to general requirements for adequate governance and risk management arrangements, as well as targeted rules (i.e. those for managing client money). Minimum capital requirements have been imposed in Spain, United Kingdom and Switzerland and, as of 2016, the Chinese authorities began introducing new rules to prohibit high-risk business models and practices, and mandated filing and information disclosure requirements (Claessens et al. 2018).

The surface of FinTech credit markets fronts wider monitoring challenges. Indeed, as this segment develops, it will become more apparent that there is a need to integrate FinTech developments into financial stability assessment frameworks. The FSB emphasizes the significance of monitoring potential related macro-financial vulnerabilities, together with the role of FinTech credit and changes in market structure (FSB 2017b). Latest reports, like that of the US Department of the Treasury (2018), also pinpoint the necessity to monitor FinTech credit developments. Collaboration amongst different authorities could in fact result in better and quicker knowledge shared from each authority’s monitoring process and regulatory experiences.

The European Banking Authority (EBA) published the findings of an analysis on issues relating to access to the market for FinTech firms (see EBA 2019 report). The report in question focused on the monitoring of national developments on the regulatory perimeter, the national regulatory status of FinTech

**Table 16.2** Selected features of dedicated FinTech credit policy frameworks

<i>Jurisdiction</i>	<i>Tax incentives</i>	<i>Regulations<sup>a</sup></i>	<i>Licensing/Authorization<sup>a</sup></i>	<i>Investor Protections<sup>a</sup></i>	<i>Risk management Requirements<sup>1</sup></i>
Australia	–	–	–	–	–
Brazil	–	✓	✓	✓	–
Canada	–	–	–	–	–
Chile	–	–✓	–	–	–
China	✓	✓	✓	✓	✓
Estonia	–	–	–	✓	–
Finland	–	✓	✓	–	–
France	✓	✓	✓	✓	✓
Germany	–	–	–	–	–
Japan	✓	–	–	–	–
Korea	–	–	–	–	–
Mexico	–	✓	✓	–	✓
Netherlands	–	–	–	✓	–
New Zealand	–	✓	✓	–	✓
Singapore	–	–	–	–	–
Spain	–	✓	✓	–	✓
Switzerland <sup>b</sup>	–	✓	✓	✓	✓
United Kingdom	✓	✓	✓	✓	✓
United States	–	–	–	–	–

*Source* Adopted from Claessens et al. 2018, p. 44

<sup>a</sup>Specific rules for FinTech lending that are separate from those pre-existing rules for other financial intermediaries

<sup>b</sup>New rules effective from 2019

firms, as well as the approaches followed by EU Member State national competent authorities (NCAs) when they grant authorization under CRD IV, PSD2 and EMD2. The analysis seems to conclude with two developments. First, the move of certain activities (e.g. payment initiation services and account information services) from not being subject to any regulatory framework to being subject to PSD2, after its transposition into national law. Second, with the exception of crowdfunding and, up to some extent activities related to crypto assets, the ancillary/non-financial nature of the services and activities provided by FinTech firms not subject to any regulatory framework (EBA 2019).

European Central Bank published a consolidated version of its guide to assessments of licence applications. The guide applies to all licence applications to become a credit institution within the meaning of the Capital Requirements Regulation, including, but not limited to, initial authorizations for credit institutions, applications from FinTech companies, authorizations in the context of

mergers and acquisitions, bridge bank applications and licence extensions. A primary objective of this guide is to promote awareness, as well as to enhance the transparency of the assessment criteria and processes for the establishment of a credit institution within the single supervisory mechanism (ECB 2019).

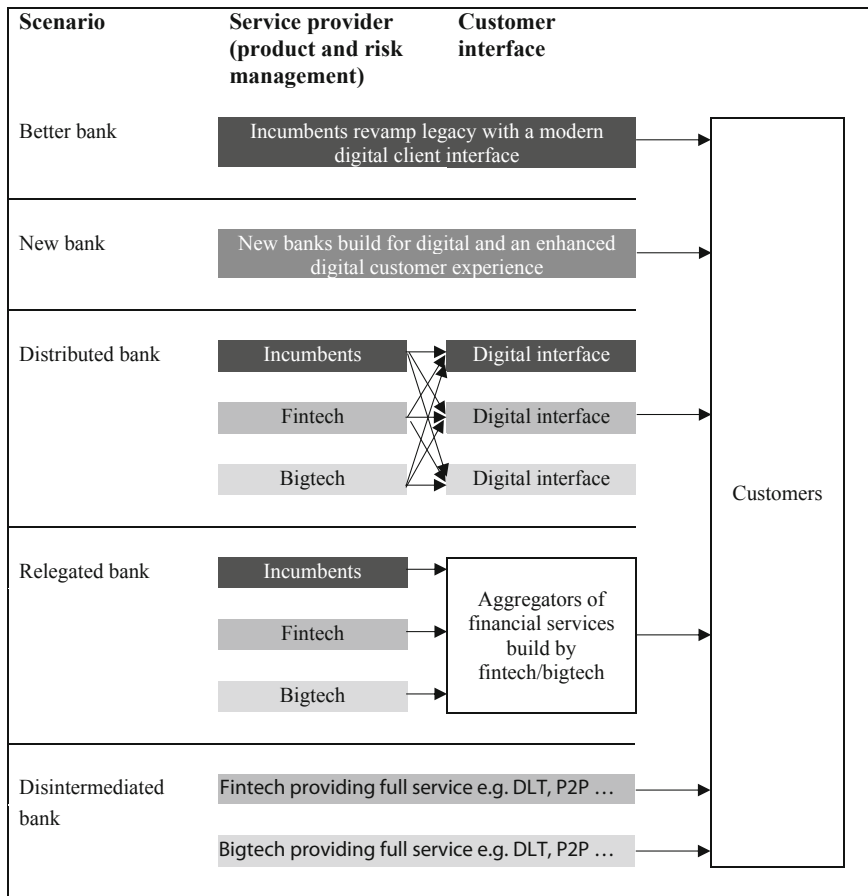
## 16.6 CONCLUSIONS

The FinTech innovation has truly captured the interest of various agents in the economy over the past decade. The accelerating hype can be observed in several forms, starting from simple interest in the general population, to product adoption rates and investment indicators. The three product sectors seem to relate directly to banking services, which, combined with the exponentially accelerated hype over the past five years, yield the question of whether this wave of innovation brings any sort of disruption in financial intermediaries' business models.

The early views and estimations are somewhat mixed on this front, and they may be dependent on the specific product sector and/or for a specific market segment. It is true indeed that FinTechs have so far enjoyed a booming period, which can be attributed to a declining post-crisis consumer trust on intermediaries, and the lack of strict regulating frameworks like those surrounding traditional banks. Yet, with the spotlight on this industry and the gradual entry of BigTechs in the arena, this may well change in the near future.

To assess the impact of the evolution of FinTech products and services on the banking industry, five scenarios describing the potential impact of FinTech on banks were identified as part of an industry-wide scenario analysis (see Fig. 16.7). These include: (i) the better bank (modernization and digitization of incumbent players), (ii) the new bank (replacement of incumbents by challenger banks), (iii) the distributed bank (fragmentation of financial services amongst specialized FinTech firms and incumbent banks), (iv) the relegated bank (incumbent banks become commoditized service providers and customer relationships are owned by new intermediaries) and (v) the disintermediated bank (banks have become irrelevant as customers interact directly with individual financial services providers) (see BCBS 2018).

Behind the hype and fears about disrupting factors, the question that arises is whether the FinTech is a true “revolution”, or if it simply remains a mere “evolution”. Our views align with the opinion shared in the work of Harker (2017, p. 4) in that: “there’s definitely some very interesting and potentially game-changing innovation coming out of FinTech. But FinTech overall is actually just natural market evolution and the assumptions about disruption—or indeed, creative destruction—are, with apologies to Schumpeter, probably out of proportion”. Indeed, some early signs and executives’ thoughts seem to lean towards intermediaries adapting, evolving and even cooperating with innovating FinTech players, rather than directly competing against. After all, let us not forget that, when a pie increases in a market, it may as well be the



Color code indication:

- incumbent banks
- new players
- specialised fintech companies
- bigtech companies

**Fig. 16.7** Overview of the five scenarios and the role players (*Source* Adopted from BCBS 2018, p. 16)

case that everyone’s share is enlarged, even if unequally. Hence, banks generally open to innovation and challenge may as well simply “have their cake and eat it too”.

### NOTES

1. A Glossary of Financial Innovation terminology has been compiled by the European Banking Authority (EBA), including common terms and their definitions from existing international bodies e.g. FSB, BCBS (see <https://eba.europa.eu/sites/default/documents/files/documents/10180/2270404/72036f35-beac-4d44-acf1-2875c12b709e/Glossary%20for%20Financial%20Innovation.pdf>).

2. The size of an economy's FinTech credit market is positively related to its income level, and negatively related to the competitiveness of its banking system and the stringency of its banking regulation.
3. The term includes the large four US multinational companies: *Google, Amazon, Facebook* and *Apple*.
4. In a recent report (see FSB 2017a), the FSB concluded that machine learning applications can be actually very promising should their specific risks are properly managed.
5. An interesting piece describing the evolution of today's payment technology through its very first variant can be found in the authors' study, see Ali et al. (2014, pp. 263–264).
6. A similar list is offered by Forbes, with 12 FinTech companies from the payment segment making it to the Top 50 list for 2019 (see <https://www.forbes.com/fintech/2019/#b40f2282b4c6>).

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# Financial Disintermediation: The Case of Peer-to-Peer Lending

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## 17.1 INTRODUCTION

This chapter focuses on innovations in technology used by finance and banking companies specifically designed to replace established industry middlemen, otherwise known as “financial disintermediation.” In this context, we present a high-level review of innovations such as blockchain, smart contracts, artificial intelligence, and machine learning approaches. Also, we explore a case study in peer-to-peer (P2P) lending for a more in-depth analysis of how these technological advances, working in tandem, can help streamline operations, mitigate risk and enhance credit scoring methodologies. In the case of P2P lending, the modernization of credit through the use of online lending platforms enables lenders to loan funds directly to borrowers without the need to rely on traditional brick-and-mortar intermediaries, demonstrating the underlying appeal of this new technology (Zaki 2019). The potential of these technological innovations to disintermediate or disrupt the market is unpredictable, but looking at other examples of financial innovation can provide a benchmark for comparison.

The structure of this chapter is organized as follows: Sect. 2 provides a review of the use of blockchain in financial services as well as its outlook. In Sect. 3, we discuss P2P lending in a broader context regarding credit risk

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M. Pompella and R. Matousek (eds.), *The Palgrave Handbook of FinTech and Blockchain*, [https://doi.org/10.1007/978-3-030-66433-6\\_17](https://doi.org/10.1007/978-3-030-66433-6_17)

management. We analyze essential risk management methods recently applied by P2P platforms and also present a case study on the use of blockchain in the P2P lending market. Within this context, we review the key advantages, such as cost reduction, time management, competitive interest rates, flexibility, and better credit risk management on P2P lending blockchain-based platforms against their disadvantages, including the infancy of blockchain, regulatory uncertainty, the inherent risks of P2P platforms, and the riskiness for an investor. In addition, we provide a brief review of classifier methods that rely on collecting datasets for decision trees which allow for analysis dependent on the quality of the data itself. However, aggregating collections of decision tree results, such as with random forest analysis, could provide the ability to analyze numerous portfolios of P2P lenders over time, a perspective that could lead to less biased and more robust predictive insights. Finally, Sect. 4 concludes the chapter and states the final remarks.

## 17.2 THE USE OF BLOCKCHAIN IN FINANCIAL SERVICES

### 17.2.1 *Blockchain Basics*

The introduction of a widely accepted historical record of transactions, such as blockchain, is most appealing in a market where the expertise in identifying authenticity, and the availability of accurate records, is already fractured and subject to fraud. For example, in the global art market (estimated to have \$67.4 billion in sales in 2018<sup>1</sup>), art collectors find the idea of an “immaculate provenance” compelling, whether dealing with art as collateral for a loan, estate planning, or reclaiming plundered art. If every piece of art or collectible could be known, identified, and tracked, it would be virtually impossible to steal art. Besides, selling and buying art would be much faster since it would be effortless to confirm and transfer ownership. This concept is starting to take hold in the art world, where social media publicizes the ownership of famous art and has become just as important as bills of sale to document ownership. In this case, social media is like a distributive ledger or blockchain driven by a “consensus of replicated, shared, and synchronized digital data geographically spread across multiple sites, countries, or institutions...with no central administrator or centralized data storage”<sup>2</sup> and is the natural outcome of millions of people sharing data on the internet seeking to record transactions, opinions, and events. The idea that public knowledge on the internet can be used to validate ownership and record transfers is becoming more viable in the business world as well. For instance, Volvo Cars announced in November 2019 that it would now track ethically sourced cobalt for car batteries using blockchain to ensure traceability in their supply chain.<sup>3</sup>

One of the most well-known applications of distributive ledgers is “blockchain,” a type of decentralized record-keeping technology that uniquely builds a chain of individual blocks (e.g., 1 MB of transaction details) of data where each sequential block is dependent on its connection to the preceding

blocks of data, thus “chaining” each block in place. The method of creating the ID of these blocks of data is referred to as a “hash” (a type of cryptographic signature using a proof-of-work consensus algorithm) and the unique link between blocks incorporates the hash based on the specific data from the previous block of data into the following hash or ID of the new block of data. If the data in a single block were changed, its hash would change as well, requiring a new hash to be incorporated in every subsequent block of data all the way to the end of the chain and confirmed by every owner of the chain.

Consequently, the use of the hash identification methodology, the effort required to create and organize these blocks, as well as the fact that numerous copies of the record exist work in concert to prevent the unauthorized manipulation of data in these chains serve to create an “immaculate provenance.” To borrow from a popular analogy on the internet, record-keeping using blockchain is like hundreds of people sitting in a public venue each with a spreadsheet where they all identically track the events happening on stage—and each spreadsheet has to tally to the same results before the next event can be recorded. If the results of a single spreadsheet do not reach the same tally, that spreadsheet is excluded from the ledger until its results are corrected to match the other spreadsheets.

While blockchain is typically referenced in regard to cryptocurrencies (like Bitcoin or tokens), consensus mechanisms (e.g., proof of work or proof of stake), and mining, these topics are outside the scope of this chapter. For this discussion, blockchain is a stand-alone technology that functions independently from cryptocurrencies and is growing in popularity as a platform to record all manners of assets and intellectual property, from mortgages to medical records to votes. As global business environments and governments have begun adapting to the ubiquity of the internet, blockchain is growing in popularity. PWC’s 2018 survey of 600 executives from 15 territories finds that 84% of the respondent organizations are already involved in blockchain technology. On a related note, Gartner estimates that blockchain will produce annual business value over US \$3 trillion by 2030.<sup>4</sup> Blockchain has become the preferred method of reliable information consolidation and communication between data-creators and end-users, especially from the legal, accounting, and financial services perspective, as described below.

## 17.2.2 *Current Uses of Blockchain*

### 17.2.2.1 *Accounting Perspective*

Significant advances in the use of blockchain are prevalent in the accounting and financial services sectors. Businesses can use publicly available blockchain platforms, such as Hyperledger (an open-source, Linux-based blockchain platform with a graphic user interface)<sup>5</sup> proprietary blockchain platforms or commercially available private blockchain programs. It is interesting to note that within the business world, the use of double-entry accounting evolves into triple-entry accounting when blockchain is introduced as the golden source

of information for each transaction or group of transactions. An example of such a service would be dLoc (launched by Smartrac in 2016), a document authentication and verification system that can reliably authenticate essential documents, including birth certificates, land titles, and medical records. Using this type of service could allow any organization that issues vital records, contracts, and tax records to leverage blockchain technology and the trust of well-established cryptography standards for data protection and security.

Within the accounting field, the audit, assurance, attest, and internal control functions are impacted most by a distributive ledger and blockchain technologies. The common practice in auditing is to sample data, especially voluminous data, to provide confirmation. By relying on a blockchain, whether public or private, all data in the chain is subject to continuous audit—in real-time—and the need to rely on samples is greatly diminished. Consequently, if leases, certificates, medical records, mortgage titles, or other documents evidencing an event or transaction are stored on a blockchain, then the role of the auditor seeking independent, third-party verification (and related fees) could be significantly minimized since this information is already stored and easily available for validation. It is conventionally thought that blockchains are immutable, unhackable, and permanent records. This fact may facilitate (or greatly limit) the costs and role of auditors, investigators, and other similar types of attestation until future hackers develop new methods to manipulate data.

#### 17.2.2.2 *Legal Perspective*

From a legal perspective, one of the most significant advances to date is that blockchain is now gaining global recognition as a viable form of evidence in court cases. One example is the Governor of the State of Tennessee, who signed Bill 1662 into law in 2018 that identifies blockchain data as legally binding.<sup>6</sup> Bill 1662 describes blockchain as “*distributed ledger technology that uses a distributed, decentralized, shared, and replicated ledger, which may be public or private, permissioned or permissionless, or driven by tokenized crypto economics or tokenless. The data on the ledger is protected with cryptography, is immutable and auditable, and provides an uncensored truth.*” Similarly, in China in 2018, the Hangzhou Internet Court decided that records stored on a *blockchain* are sufficient to be legally *accepted* as evidence by the *court*.<sup>7</sup>

By allowing blockchain-secured data or other data recorded electronically in distributed ledgers to be admitted into evidence, the courts have begun solidifying the role of this technology into the legal and business landscape. It is noted that while other jurisdictions are adding legislation or laws to support the use of blockchain, there may be variances among laws, including their application and definitions, leading to a need for legislative uniformity in the future.

### 17.2.2.3 *Financial Services Perspective*

Applications for blockchain in the banking and finance industries can encompass currency exchanges, securities settlements, payment processing, and even counterparty clearing systems. Virtually all aspects of record-keeping and transaction data (e.g., stock purchases) could now be handled through electronic records supported by blockchain technology. A well-designed blockchain does more than just eliminate “middle office” intermediaries, reduce costs, and increase transparency. It also offers record validation at significantly increased speeds, consensus, and traceability for many business processes. For example, instead of settling securities trades using contemporary T + 1 or T + 3 timing, a trade clearing blockchain could facilitate real-time, automated settlements.

### 17.2.3 *Prospects of Blockchain in Financial Services*

The key to future blockchain developments in financial services will rely heavily on the evolution of smart contracts (defined as unique archives of transactions enhanced with self-executing instructions) and decentralized applications (DApps) or distributed, open-source software applications that run on a peer-to-peer (P2P) network and are supported by a blockchain distributed ledger, thus facilitating scalable and quick, securely deployed applications.<sup>8</sup> Established legal rules define how agreements need to be structured, executed, and adjudicated. The transition of today’s legal contracts, documents, and related procedures into smart contracts will allow contract terms embedded into the code of the smart contract to automatically enforce the terms of the agreement, such as the transfer of funds, under predetermined conditions or triggers. For example, with a loan contract, the instructions in the smart contract can trigger the timely collection of interest payments automatically from the borrower’s account for transfer to the lender’s account. A well-known DApp is Ethereum,<sup>9</sup> which enables a single blockchain to host numerous applications rather than having to create a new blockchain for every new application. Collectively, the use of smart contracts and DApps support the exponential growth of private or public permissioned blockchains networks to handle interactions between institutions that are known to each other.<sup>10</sup>

The ability to extract meaningful insights from the data stored within, and influenced by, smart contracts means that the markets for remittances, payments, and risk scoring can be updated to provide real-time tracking of fund flows, a critical internal control needed to monitor fraud prevention and support anti-money laundering efforts. McKinsey (2018) states that retail banking blockchain technology offers enhanced capabilities in the following three areas: data handling, disintermediation, and establishing trust, especially within the following retail use cases: remittances, know-your-customer (KYC)/ID fraud prevention, and risk scoring. These three use cases form the core aspects of managing P2P platforms (exclusive of their respective technology). Based on Rosati and Čuk (2018), we have identified five business areas dependent on P2P blockchain technology for further review



below: payments and remittances, credit and lending, trading and settlement, compliance, and record management.

### 17.2.3.1 *Payments and Remittances*

Zaki (2019) estimates that global revenues from cross-border payments amounted to USD 223 billion and the average fee on transaction values was 3% as of year-end 2018, which corresponds to estimates by McKinsey (2018). By enabling P2P payments and by offering 24/7 settlements, blockchain can reduce transaction costs and risk while bringing (almost) real-time settlements and increased transparency and traceability (Buitenhek 2016). Two examples within the global financial market that highlight these opportunities include:

- the Society for Worldwide Interbank Financial Telecommunications (SWIFT), which works with banks and blockchain firms to use its Global Payments Innovation initiative (GPI) to improve the cross-border payments experience (representing a payment flow of approximately \$300 billion daily<sup>11</sup>), and
- the Interbank Information Network (comprised of over 300+ banks as of August 2019<sup>12</sup>), a cross-border, scalable, blockchain-based P2P payments service launched in 2017 by the Australia and New Zealand Banking Group, JPMorgan Chase, and Royal Bank of Canada (McKinsey 2018).

### 17.2.3.2 *Credit and Lending*

Technological advances, from blockchain to mobile platforms to cryptocurrency-based collateral, are rapidly changing the credit and lending landscape. In a traditional lending environment, financial intermediaries—such as banks, consumer loan providers, or mutual funds—are positioned between the lender-savers and the borrower-spenders and facilitate fund transfers from one to the other (Mishkin 2019). However, Larios-Hernández (2017) concludes that blockchain can replace traditional intermediaries and that new intermediaries (e.g., P2P lending platforms) can lower the transaction costs of lending and business financing, even as they take on risk and implementation start-up costs. Therefore, as long as the new intermediaries adopt “best practices”—defined as the code underlying these technology innovations is tested and trustworthy and the data contributed by the users is accurate—the new intermediaries, such as blockchain- and artificial intelligence-managed systems, will continue to disrupt established intermediaries.

### 17.2.3.3 *Trading and Settlement*

DTCC is the leading American post-trade processing and settlement company and also manages record keeping and payments for \$11 trillion of credit derivatives and is used by over 2,500 buy-side firms such as mutual funds and asset managers in more than 70 countries<sup>13</sup>. One of DTCC’s goals is

to establish a cloud-based foundation to re-platform from a traditional main-frame system with dependencies on relational databases to a permissioned, distributed ledger technology-based peer-to-peer network for processing credit derivatives. The purpose of this transformation is to use technology, such as smart contracts, to mitigate risk, enhance efficiency, rationalize costs, and introduce common standards for governance. The goal is to optimize quality control in credit derivative processing and servicing in a secured, prudent, and audit-ready manner. The P2P audience includes “dealers, buy-side firms, central counterparties, vendors and service providers such as custodians and middleware companies across multiple platforms.”

To support this goal and advance credit derivative trade processing and clearing in the future, DTCC partnered with IBM and two start-ups (Axoni and R3<sup>14</sup>) to build the Trade Information Warehouse (“TIW”) by using smart contracts and distributed ledgers in the post-trade processing of credit derivatives. Axoni provides the distributed ledger infrastructure and smart contract applications built on the AxCore blockchain protocol, with R3 acting as a solution advisor.<sup>15</sup>

The TIW is cloud-based, scalable, flexible, and a comparatively cost-efficient solution. TIW’s essential functions were confirmed in a proof of concept in 2016 and include smart contracts for servicing credit default assets through payment calculations, centralizing settlements for credit event processing (e.g., restructuring events, renaming events, and reorganizations) and tracking trade processing with records kept on a permissioned (private) P2P distributed ledger. The final implementation of this visionary technology will depend on extensive testing and validation in the future.

#### *17.2.3.4 Compliance*

Compliance is another area where blockchain can be applied. It is important to note that while facilitating the validity, accuracy and security of financial records may be enhanced through the use of blockchain, the parties involved in the actual provision of accounting, financial services, or transactions are still responsible for applying all relevant regulations, such as complying with very costly Anti-Money Laundering rules (AML), sanctions, KYC, and data privacy (e.g., The General Data Protection Regulation (EU) 2016/679 known as “GDPR” in the European Union) rules. In 2018, Thomson Reuters estimated that some major financial institutions spend up to \$500 million annually on KYC and customer due diligence<sup>16</sup> thus rendering the expense of investing in and building blockchains that maintain validated client identity records suddenly reasonable in comparison.

#### *17.2.3.5 Record Management*

Last but not least, blockchain can be used to optimize record management and streamline communications. There are numerous multibillion-dollar markets, such as with mortgages or loan pools, that are still supported by extensive paper-based documentation. Within the securitization market, defined as

the passing through of assets with similar parameters into a specially set-up trust (pool) company (Mejstrik et al. 2014), closing a transaction is heavily dependent on postal services or FedEx to transmit original documents and confirmations among bankers, legal and compliance teams, sales and marketing teams, investors, the sponsor, the seller of assets, the depositor, the issuing entity, and possibly other parties. With smart contracts and blockchains implemented as a “record management intermediary,” the documentation process could be expedited significantly.

### 17.3 PEER-TO-PEER LENDING

In this section, we discuss basic terms including peer-to-peer (P2P) lending, credit scoring, and methods applied in credit risk management on P2P platforms. Moreover, we present a short case study on the use of blockchain within the credit risk management practices of P2P platforms.

#### 17.3.1 *Basics Terms*

##### 17.3.1.1 *Peer-to-Peer Lending*

P2P lending is a new, online-based financial intermediary connecting people willing to borrow with people willing to lend their money (Teplý and Polena 2020). On a related note, Bachmann et al. (2011) define P2P as “*the loan origination process between private individuals on online platforms where financial institutions operate only as intermediates.*”

Leveraging high-tech and lowered interest rates, these loan platforms arose to fill the lending gaps that emerged after banks pulled back from riskier loans after the global financial crisis of 2008. There are competing hypotheses for explaining the rapid emergence of P2P lending platforms in recent years. Havrylchuk et al. (2016) present three hypotheses as possible reasons. Their first hypothesis is “competition-related.” The online-based P2P lending platforms can operate efficiently with low financial intermediation costs, which enables them to offer lower interest rates to borrowers and still provide higher returns to lenders than traditional banks. Namvar (2013), Wu (2014), and Tsai et al. (2014) are all advocates of this hypothesis. The second hypothesis, referred to as “crisis-related,” is connected to the 2007–2009 global financial crisis (“GFC”), when banks limited their supply of credit, which led to credit rationing. Mills and McCarthy (2014) mainly support this hypothesis. Moreover, Atz and Bholat (2016) state that mistrust in the banking industry after financial crises could favor P2P lending for lenders as well as for borrowers. The third hypothesis, called “internet-related,” explores the readiness of society to use online-based financial services without the need for a customer to visit a brick-and-mortar bank branch. In conclusion, Havrylchuk et al. (2016)’s findings support the competition-related hypothesis as the primary hypothesis for the rise in P2P lending.

P2P has attracted the attention of many researchers and practitioners in recent years due to the interest in applying proper credit risk management techniques across various platforms (Teplý and Polena 2020). In the sections that follow, we will describe the terms and classification algorithms for the assessment of borrower creditworthiness on P2P platforms.

#### *17.3.1.2 Relevant Research*

The majority of scientific papers based on publicly available P2P lending data use a source called Prosper data. Prosper was the first P2P lending platform that made its P2P lending data public in 2007. Bachmann et al. (2011) explain that the availability of Prosper P2P lending data to the public has triggered a cascade of scientific contributions and interest in P2P lending. The popularity of Prosper data was initially due to its social network features and the Dutch auction for interest rate determination that used to be part of the Prosper P2P lending platform. Prosper removed the social network features from its platform after the Securities and Exchange Commission (SEC) issued a regulation in 2008 limiting social media disclosures.

Similarly, the Dutch auction system for interest rate determination has been removed from Prosper as well. The optimal interest rates for borrowers are currently determined by Prosper, which is presently considered to be the leading standard for P2P lending platforms. Despite the early popularity of Prosper data, P2P lending data from Lending Club is now more popular because it is of better quality and presents data on a higher number of independent variables.

The research based on P2P lending data can be divided into four areas. The first area of research focuses on circumstances before the loans were funded. This research is primarily based on Prosper data issued before 2008 because the data included social features and the Dutch auction system, as discussed in the previous paragraph. Freedman and Jin (2014) and Lin et al. (2013) point out the importance of social network connections for loan funding success and the associated interest rate. People with better social network connections are more likely to get their loans funded and have lower interest rates.

Furthermore, Duarte et al. (2012) found out that borrowers who included their photos and were perceived to be trustworthy were more likely to get funded. The second area of research examines the determinants of the borrower's default. Serrano-Cinca et al. (2015) and Carmichael (2014) confirmed that several factors, such as annual income or loan purpose, are significant variables for predicting borrower's default rates. The third research area is portfolio management based on P2P lending data. For instance, Singh et al. (2008) used decision tree analysis to divided P2P lending loans into different groups based on the loans' risk and return. They then calculated the optimal portfolio based on these groups. The fourth and final area of research focuses on the comparison of classification methods based on P2P lending data.

### 17.3.1.3 Case Study—Lending Process at the Lending Club

Knowledge of the lending process at the Lending Club can help a reader better understand what the criteria are for loan application approvals. Moreover, the reader gets to know the way the Lending Club data are generated. The borrower's credit characteristics, such as the FICO score, needed for loan application approval, have changed several times so far. The primary criterion that is expected to be a minimum requirement for the borrower's loan application at Lending Club is the value of the FICO score. The minimum FICO application score should be at least 600, while the FICO score ranges from 300 to 850. The higher the FICO score is, the more creditworthy is the borrower. The borrower's credit file information in the national credit bureaus in the United States is the primary source for FICO score computation. The exact formula for FICO score calculation is, however, a secret.

Nevertheless, it has been disclosed that the FICO score is computed based on the following five components with associated weights in percentage: 35% payment history, 30% debt burden, 15% length of credit history, 10% type of credit used, and 10% of recent credit inquiries. After passing the minimum requirements for loan approval described above, the borrower needs to provide some more information about himself or herself and the loan purpose. At first, the borrower is asked about his or her self-reported annual income. Afterward, the borrower should choose his or her current home situation with possible options: mortgage, rent, own, or other. Next, the employment status is checked. The length of employment is known from a borrower file based on his or her Social Security Number (SSN). Concerning the loan information, the borrower is asked for a loan amount, a loan purpose (e.g., use of proceeds), and a loan description. The information about loan purpose is mandatory. The loan description is optional and is, therefore, often left blank. Our descriptive statistics show that the median length of the loan description is 0 and the mean value is 103 characters.

Credit scoring systems typically only look at borrower characteristics and do not take into account macroeconomic factors. Under normal conditions, default rates for borrowers with high FICO scores may be quite low, but this will likely change as growth slows during economic cycles and unemployment rates increase. Since P2P loans are typically unsecured loans, borrowers who lose their jobs may neither be willing or able to repay loans due to the loss of income, meaning that the credit score essentially becomes an option, or proxy, for the ability of the borrower to secure income. Therefore, from the investor perspective, credit scores and grades assigned by the Lending Club must be complemented by econometric models to properly assess default rates and return potential under varying macro conditions. It should be noted that we only have meaningful performance data for unsecured consumer loans beginning from around 2010 when the economy started to recover after the great recession in the United States. At that time, the unemployment rate started to decrease. Still, the majority of historical data are for loans issued in or after 2012, when the economy fully recovered. Therefore, a model based on purely

historical data will likely underestimate default rates under stress conditions. Indeed, we may see cumulative default rates on such loans in the 40–50% range during a future recession, as was the case for second lien mortgage loans (they can be considered unsecured loans) in the United States during the past recession.

Based on the aforementioned borrower’s credit file information and his or her inputs, Lending Club’s credit scoring algorithm determines a borrower’s creditworthiness. An assigned credit grade with a related interest rate represents the borrower’s creditworthiness. Immediately after being scored, a loan listing offer with an obtained interest rate is offered to the borrower. If the borrower accepts the given loan offer, the loan is listed on the Lending Club platform. A potential lender can right away find and fund the loan among the Lending Club loan listings. During the loan funding period, the borrower might be asked by Lending Club to verify his or her self-reported annual income. However, if the loan is funded in the meantime, then the loan is issued and verification is no longer needed. 65.1% of loans in our final data set are verified. The default rate of verified loans is surprisingly higher (17.8%) than the default rate of unverified loans (12.3%). Other loan attributes can drive this; specifically, verified loans have lower FICO scores or higher debt-to-income ratios. Also, lenders’ underwriting standards are changing over time and it is generally believed that since the recession, underwriting standards had been severely tightened, however, banks and financial companies are slowly loosening underwriting standards now. Therefore, loans originated in 2018–2019 may be somewhat riskier than those from 2013–2014 vintages. The Lending Club might know based on the borrower’s credit file if the verification is needed or not. If the borrower, however, fails to verify his or her self-reported information, the Lending Club removes the listed loan from its platform.

### 17.3.2 *Credit Risk Management Applied in P2P Platforms*

This section reviews the key credit risk management methods used in P2P platforms. First, we discuss the basic terms of credit risk management. Second, we describe the theory underlying all key eight individual classifiers. Finally, we introduce and briefly describe the performance measurement techniques used to quantify the performance of the classifiers.

#### 17.3.2.1 *Basic Terms*

Anderson (2007) defines the term credit scoring as divided into two parts—credit and scoring. The first word, credit, comes from the Latin word *credo*. *Credo* means “I trust” or “I believe” in Latin. The word credit as we use it today, means “buy now and pay later.” The second word, scoring, refers to the use of numerical methods that helps us to assign a rank to order cases to be able to differentiate between their qualities. In other words, scoring is a method, which assigns a score or a grade describing case quality. By combining

the meaning of credit and scoring, Anderson (2007) states that credit scoring is the use of statistical models to transform relevant data into a numerical score describing or correlating to the likelihood of a prospective borrower's default.

Abdou and Pointon (2011) say that even though the history of credit can be traced back to around 2000 BC, the history of credit scoring is very recent. They estimate the length of credit scoring history to be only about six decades. Moreover, Abdou and Pointon (2011) add that credit scoring literature is minimal. According to them, the use of credit scoring started to be broadly accessible at the beginning of the twenty-first century. The increased popularity of credit scoring has been intensified by recent, significant technological advancements and by the introduction of advanced credit scoring techniques. Credit scoring falls into the risk management category of banks and other financial institutions (Polena 2017). Apart from that, credit scoring is regarded as an indispensable part of risk management by helping to optimize the expected profit from clients.

Serrano-Cinca et al. (2015) define credit risk in P2P lending as the risk that the borrower fails to make the loan payments (redemption and interest payments) to the lender as agreed. The expected profit can be maximized when borrower default is minimized. To minimize the risk of a borrower's default, it is necessary to decrease the information asymmetry between borrowers and lenders. Borrowers have more information than lenders about the borrower's ability to pay back liabilities. Therefore, borrowers are asked to provide information about themselves and the loan purpose as a part of their loan application. The loan application process at the Lending Club is described in the next section. Based on the loan application information, a credit scoring model can predict the borrower's creditworthiness. Nevertheless, to be able to predict the borrower's creditworthiness, the credit scoring model must be modeled on comparable past loan application data with known repayment results.

### 17.3.2.2 *Classification Techniques*

The discussion about credit scoring would not be complete without first addressing the role that artificial intelligence and machine learning play in analyzing data to derive insights into borrower behavior and default patterns. Defined as "*the theory and development of computer systems able to perform tasks that normally require human intelligence,*"<sup>17</sup> artificial intelligence has exponentially increased the use of sophisticated algorithms and classifiers to "cluster and add a classification layer on top of data" that is already stored and managed.<sup>18</sup> The classifiers rely on artificial intelligence, or a machine learning approach, that adapts algorithms and data sorting techniques to make sense of complex relationships between numerous variables. The classifier results are used to identify patterns in the data and facilitate decisions about forecasting default rates and credit scoring variability. The crux of the relationship between the classifiers and the P2P platforms is to analyze borrower and lender behavior to the point where their future behavior can be predicted with a high

degree of accuracy during varying economic cycles and market conditions, similar to the way advertisers now target ads to viewers on the internet. *Consequently, the use of classifier methodologies facilitates more in-depth analysis of borrower behavior, creditworthiness, and increasingly more accurate predictions of potential defaults.*

The classification techniques can be divided into three groups based on the type of algorithm they use: linear, nonlinear, or rule-based algorithms. First, Logistic Regression (LR) and Linear Discriminant Analysis (LDA) are classification techniques based on linear algorithms. Second, classifiers using a nonlinear algorithm are described next (Support Vector Machine [SVM], Artificial Neural Network [ANN], k-Nearest Neighbor [k-NN], Naïve Bayes [NB], and Bayesian Network [B-Net]). Finally, the last group of rule-based classifiers contains Classification And Regression Tree (CART) and Random Forest (RF). A comprehensive description of our classifiers is beyond the scope of this chapter. Our brief review of classifiers highlights the most widely known classifier algorithms while adding key references to relevant literature.

#### *Logistic Regression*

Logistic Regression is the most widely used classification technique for credit scoring. This algorithm is even considered to be an industry standard for classification (Ala'raj and Abbod 2015). Among the main advantages of Logistic Regression is the ease of implementation, a relatively high predictive power and a clear interpretation of input variables value for prediction.

#### *Linear Discriminant Analysis*

There are two competing approaches to explain Linear Discriminant Analysis (LDA). These approaches are from Welch (1939) and Fisher (1936). One can explain LDA in two steps. In the first step, we describe the general idea behind LDA and provide an example with a single input variable. In the second step, LDA is introduced as a solution for more generalized cases with multiple inputs and multiple classes (for more details, see Kuhn and Johnson 2013).

#### *Support Vector Machine*

Support Vector Machine (SVM) is a very versatile and effective algorithm. It can be used for classification, regression, and novelty detection. Although categorized as a nonlinear classification technique, SVM can be considered a connection between linear and nonlinear classifiers (Wendler and Grottrup 2016). As described in Karatzoglou et al. (2006), SVM uses a simple linear method to classify data in a high-dimensional feature space, which is derived by nonlinear methods from the original input space. In other words, input data are transformed into the high-dimensional feature space in which the data are linearly separable.

#### *Artificial Neural Network*

Like SVM, an Artificial Neural Network (ANN) is a black-box algorithm. The ANN's algorithm is hardly comprehensible and interpretable because of its neuron mechanism with hidden layers. Despite its black box nature, ANN remains a very well-known and powerful algorithm that might be applied to a variety of complex problems (Wendler and Grottrup 2016).



*k-Nearest Neighbors*

The *k*-Nearest Neighbors (*k*-NN) is one of the simplest classification methods, according to Wendler and Grottrup (2016). To classify a new observation from a testing set, the *k*-NN classifier simply identifies *k*-nearest observations from the training sample. Hence the name *k*-Nearest Neighbors and the prediction for a new observation is made based on the mean class of *k*-NN from the training set. Kuhn and Johnson (2013) add that the class prediction can be based on the median class of *k*-Nearest Neighbors instead of mean class. In our book, we use the mean class prediction, which is more common.

*Naïve Bayes and Bayesian Network*

The last two nonlinear classifiers in our classifier descriptions are Naïve Bayes and Bayesian Network. These two classifiers are very similar because they both use a Bayes rule and differ only in the strength of assumptions made. The building block of Naïve Bayes and Bayesian Network is the Bayes rule, also known as Bayes theorem (Kuhn and Johnson 2013).

*Classification and Regression Tree*

Classification And Regression Tree (CART) belongs to a rule-based classifiers class. The rule-based classifiers, including Random Forest (RF), have a different approach to classification than classifiers based on linear or nonlinear algorithms. Wendler and Grottrup (2016) say that rule-based classifiers try to find rules, hence the name, or structures in raw data for the determination of the final class. The classification technique is then based on the found rules. These rules can usually be represented by decision trees that are easily interpretable and understandable. There are various versions of decision trees. These versions mainly differ in the method of node splitting. The CART uses the binary splitting method, which means that each non-leaf node splits into two new branches, as described in Wendler and Grottrup (2016). The node splitting is determined with the split dispersion measure called the Gini coefficient.

*Random Forest*

Random Forest (RF) is the only homogenous ensemble classifier in this chapter. All other classifiers here are individual classifiers. The homogenous ensemble classifiers combine the prediction results of multiple base models. This approach is supposed to increase the predictive performance of such classifiers. Lessmann et al. (2015) describe homogenous ensemble classification as a two stages process. A set of base models is created in the first stage. In the second stage, the final prediction is made by a combination of base model predictions.

### 17.3.3 Performance Measurement

There are six different performance measurements to evaluate classifier performance. These performance measurements, which are often listed in the literature, might be divided into three groups. The first group of performance

measurements evaluates the correctness of categorical classifier predictions, such as Percentage Correctly Classified (PCC) or Kolmogorov–Smirnov statistics (KS). The second group contains performance measurements that evaluate the accuracy of classifier probability predictions, such as the Brier score (BS). The performance measurements using the discriminatory ability of classifier, such as Area Under the Curve (AUC), Partial Gini index (PG), and H-measure (H), belong to the last group. The classifiers' performance results based on several performance measurements from different measurement groups are more robust than results based on one performance measurement or the performance measurement from the same group.

#### *Percentage Correctly Classified*

The most important and widely used performance measurement derived from a confusion matrix is, however, called Accuracy or Percentage Correctly Classified (PCC). As the name suggests, the PCC measures the percentage of correctly classified cases in a confusion matrix. This performance measurement was used for credit risk management in the P2P lending by, for instance, Wu (2014), Chang et al. (2015), and Malekipirbazari and Aksakalli (2015).

#### *Kolmogorov–Smirnov Statistics*

The Kolmogorov–Smirnov statistics (KS) are from the same performance measurement group as Percentage Correctly Classified. Furthermore, the Kolmogorov–Smirnov statistics use the classifiers predicted probability, too, but with a fixed threshold value. Mays (2001) describes Kolmogorov–Smirnov statistics as the maximum difference between the cumulative distribution function of negative and positive cases.

#### *Brier Score*

The Brier Score (BS) assesses the accuracy of classifiers' probability prediction. The BS can be described as the mean squared error of probability prediction and the true outcome. For more information about the BS, we refer to Hernandez-Orallo et al. (2011) and Rufibach (2010).

#### *Area Under the Curve*

The Area Under the Curve (AUC) is a well-known and widely used performance measure. The Area Under the Curve (AUC) measures the area under the Receiver Operating Characteristic curve (ROC). The ROC curve is based on two performance measurements derived from the confusion matrix. These measurements are True Positive Rate (TPR) and False Positive Rate (FPR).

#### *Partial Gini Index*

It should be highlighted at the beginning that there is a difference between a classical Gini index and a Partial Gini (PG) index. It can be shown that the classical Gini index is the only linear transformation of the Area Under the Curve (AUC) mentioned earlier. It means that we would get the same classifiers ranking by using the classical Gini index as by using the AUC measure (Wendler and Grottrup 2016).

#### *H-Measure*

**Table 17.1** Advantages and disadvantages of blockchain P2P lending platforms

<i>Advantages</i>	<i>Disadvantages</i>
Cost reduction	Infancy of blockchain
Time management (by using smart contracts)	Regulatory uncertainty
Competitive interest rates	Inherent risks
Flexibility	Risky asset for an investor
Credit risk management	Constraints to correcting errors

*Source* Authors

Even though the AUC is a very popular performance measurement, there is one serious deficiency in this measurement, according to Hand (2009). Specifically, he argues that the fundamental incoherence of misclassification costs usage is the main deficiency of AUC. It means that different misclassification cost distributions are applied for different classifiers. Hand (2009) states that this fact causes fundamental incoherence because the relative severity of misclassification costs depends on the choice of the classifier. Hand (2009) proposes performance measurement, called an H-measure, as a remedy for AUC's imperfection.

The main advantage of H-measure is that it uses a weight function that is independent of classifier probability score distribution. This weight function used in H-measure is a Beta distribution. Hand (2009) states that using the Beta distribution in H-measure makes the classifier comparison fair.

In addition to performance metrics described above, market participants always perform back-testing by running the model as of a historical date and then comparing predicted default rates with actual realized default rates. Root Mean Squared Error (RMSE) or cumulative error percentage is often used to measure the ultimate model performance. The reason for that is that the model may start to deviate from actual data using the most recent data. The Area Under the Receiver Operating Characteristics (AUROC) results may still look appealing, but an experienced modeler will know that it is time to adjust the model since the market environment has changed, or the model was overfit.

### 17.3.4 Case Study on the Use of Blockchain in P2P Lending

In this section, we discuss the current use of blockchain in P2P lending and present key advantages and disadvantages of P2P lending blockchain platforms below (Table 17.1). Moreover, we estimate the market potential of this technology in P2P lending.

#### 17.3.4.1 Advantages of P2P Lending Blockchain Platforms

First, blockchain could reduce costs by allowing the borrowers to deal with lenders directly (Takyar 2019). The P2P lending platforms do not provide their own capital for loans, but instead, expedite the connection between

lenders with excess funds and borrowers who meet eligibility criteria based on proprietary algorithm-based rating methodologies to assess creditworthiness. Generally, these platforms market to different groups of borrowers, from students to professionals to small business owners and the loans vary in terms of amounts, tenure, and interest rates. The convergence of lending and technology allow P2P lenders to eliminate the limitations that the “analog” version of bank lending depends on, specifically intermediaries (such as loan officers, underwriters, loan processors, document managers) and the fixed costs associated with brick-and-mortar locations, which add to the time and expense of applying for traditional loans.

Second, blockchain could accelerate the entire loan process by encoding regulation-based rules, in addition to payment terms, into their smart contracts (Takyar 2019). A distinguishing characteristic of P2P platforms is their reliance on smart contracts to record the loan details and supporting documents on blockchain to streamline operations. For example, a popular platform called Lendoid allows borrowers to initiate a loan request transaction by selecting a loan amount and by uploading verifiable documents to support a credit evaluation. Lendoid uses a proprietary methodology and multiple verification sources to assign a quality (credit) score or ranking of the borrower’s creditworthiness and verifying collateral for that transaction. Once a lender selects the loan transaction, the loan amount is transferred from the lender’s account to the borrower’s account and a smart contract format is executed to track a unique set of self-executing instructions pertaining to the loan contract and future payments (or default) by issuing payment notices, collecting repayments, updating the records, and reporting defaults for collection.

Third, the P2P loan platforms might offer competitive rates compared to traditional bank-based lending because of lower costs and shorter process times, as discussed above. However, like traditional lenders, the P2P platforms are still for-profit businesses that operate by charging origination fees (typically 1–5%), spreads above interest rates to borrowers and service fees to lenders, and charge very high collection fees (e.g., litigation fees of up to 40% on delinquent loans) when defaults occur, currently at about 7–8% of loans extended. By way of comparison, in September 2019, interest rates from Prosper varied from 5% for low-risk debtors to 12% for high-risk debtors.<sup>19</sup> The only well-known exception to date is Kiva, a not-for-profit loan platform that does not charge interest.<sup>20</sup> Another significant aspect of P2P lending platforms is their focus on secondary market sales of loan portfolios, generating alternate sources of revenue.

Fourth, smart contracts could auto-generate competitive interest rates based on the profile of a borrower, which implies flexibility in the charged interest rate (Takyar 2019). This would allow P2P platforms to offer fast, market-sensitive, customized offers for borrowers, a practice that more traditional bank lenders have yet to adopt at a scalable level.

Fifth, credit risk management of P2P platforms can be improved through blockchain. In the beginning, we should state that blockchain cannot enhance

borrower's creditworthiness but can reduce a probability of borrower's default on agreed cash-flows through improving transaction settlement, credit risk assessments, and effective execution of collateral (Hoogmartens 2018). Regarding the scope of this chapter, we will focus on better credit risk management, i.e., how blockchain can be superior to the abovementioned classification techniques and performance measurements recently applied in P2P platforms. Hoogmartens (2018) lists three main areas where blockchain can enhance P2P platform operations: (i) blockchain-based creditworthiness assessments, (ii) blockchain and real-time accounting, and (iii) historical data-keeping.

However, it is not very clear how the blockchain itself can provide better credit management. In essence, blockchain is a data structure resembling a linked list. It will still use the same inputs, such as borrower characteristics (e.g., FICO score, employment status, etc.) and one of the classification techniques discussed above to derive default probabilities. We believe that a properly implemented blockchain will improve surveillance. For example, with a blockchain recording loan details, the borrower payment status will be updated in real-time so credit risk managers can track the performance of their portfolios and observe the percentage of delinquent loans in real-time.

#### *17.3.4.2 Disadvantages of P2P Lending Blockchain Platforms*

There are four main disadvantages to P2P lending blockchain platforms: the infancy of blockchain, regulatory uncertainty, underlying risks, and risky investment. First, the infancy and expense of blockchain remain challenges. The market for P2P lending through digital assets heavily depends on the blockchain technology adoption (Zaki 2019). It might take ten or more years until this technology is widely accepted and validated, thereby constraining the growth of P2P platforms.

Second, P2P lending blockchain platforms are facing regulatory uncertainty. Many global regulators apply the "hands-off" approach at present. To date, there are neither strategies nor legislation planned to regulate blockchain on the P2P lending blockchain platforms; however, some theoretical studies exist. For instance, Auer (2019) proposes embedded supervision of distributed ledger technology (blockchain) in finance, i.e., a regulatory framework that provides for compliance in tokenized markets to be automatically monitored by reading the market's ledger, thus reducing the need for firms to collect, verify and deliver data actively.

Third, there are several risks associated with P2P lending that might also be applied to P2P lending blockchain platforms. Hoogmartens (2018) lists seven principal risks of P2P lending: credit risk, fraud, money laundering, hacking, liquidity risk, conflict of interest, and operational risk. We will add one more risk—counterparty risk—since there is no central authority responsible for fixing technical problems with a blockchain P2P platform. On the other hand, this fact could be mitigated by a reliable guarantor of the P2P platform to increase its credibility.

Fourth, investments through P2P can be risky since P2P loans are usually unsecured and credit risk assessment is ultimately left to lenders (Hoogmartens 2018). Although the current term for lenders on P2P platforms is “investors,” it is challenging to consider these types of transactions as constituting a true alternative asset class at this time since the risks, such as returns, liquidity, and taxes, can outweigh the benefits. However, credit risk of P2P platforms can be mitigated through diversification of loan portfolios and compensation funds. Under the compensation scheme, each borrower contributes a percentage of their overall loan into a compensation fund from which lenders are compensated if a borrower is unable to pay back the loan (Lenz 2016).

In terms of screening for lenders who can absorb losses, the P2P market relies on lenders to essentially regulate themselves. For example, the private credit market has grown from about \$42.4 billion in 2000 to approximately \$770 billion in 2018, with estimates topping \$1 trillion by 2020.<sup>21</sup> This indicates a strong appetite from private equity investors, funds and other sophisticated buyers accepting this kind of risk for yields generally ranging on average from 15–18% (based on our research) while excluding individuals or retail investors.

In fact, in America, financial advisors who sell securities must assess the appropriateness of an investment for a particular individual, taking into account their income, savings, and ability to withstand risk. Consequently, many higher-yielding investments are not available to retail investors because the due diligence required, the inherent risks, and the need for specialized knowledge and skills to assess such an investment. For example, retail investors cannot purchase non-agency bonds backed by residential mortgage loans. This type of investment is only available to investors with the designation of Qualified Institutional Buyers (QIB) because assessing prepayment, default, and other kinds of risks associated with those securities requires a certain degree of sophistication and ability to perform statistical modeling. Other investments are available for retail investors, but only to those who are considered qualified (or accredited) investors. Qualified investors must pass the knowledge and income tests and demonstrate that they have an annual income of USD 200,000 or more. It is doubtful that most retail investors can adequately assess the full scope of investment risks associated with P2P. Therefore, we can anticipate stricter regulations to protect investors going forward, such as those already implemented in China where thousands of P2P platforms went defunct by 2018 after a previous period of exponential growth.<sup>22</sup>

Specifically, despite the interest earned by lenders (a median return of 4.5% reported by Lendit in August 2019<sup>23</sup>), returns on equities over time still provides higher historical returns. From a cost perspective, competitors like Vanguard offer diversified portfolios of stocks or bonds with equivalent or higher returns (on average) for fees as low as 0.05% per year, or approximately a twentieth of Lending Club’s fees. Also, the occasion to cash out or liquidate loans can be limited to nonexistent, often requiring discounts and delays if at all possible. Diversification on the P2P platforms across ratings

levels and borrowers is accessible but needs to be handled manually by the lender, reflecting an effort that lenders may find to be time-consuming. And finally, in the United States interest revenue from loans is taxed at the same rate as income (e.g., 30%), whereas income from investments is taxed currently at 15%. Some lending platforms alleviate the tax consequences by allowing self-directed, tax incentivized Individual Retirement Accounts (IRAs) for loan investments, but the option is not yet widely accepted. In addition, some critics highlight economic and market risk, suggesting that the P2P platforms attract borrowers who have exhausted other funding alternatives and that a future recession or economic upheaval could exacerbate default rates.

#### 17.3.4.3 *Market Potential*

With interest rates in the United States trending lower and banks tightening credit to all but the largest and most established clients, the rise of nontraditional sources of lending has expanded. The opportunity to combine technology with lending has led to the growth and popularity of P2P lending platforms on the internet with many relying on internet-based platforms to match lenders with borrowers and on blockchain to record smart contract transactions to facilitate unsecured personal loans to be made between two previously unknown parties at competitive interest rates.

The number of P2P platforms differs region by region globally. As of 31 August 2019, the total amount of P2P amounted to 192; out of that, 114 were platforms from Europe, 31 from North America and 21 from Asia (Table 17.2).

From low amounts in last years, the funding of Top 80 P2P lending and equity platforms amounted to USD 100 billion as of 31 August 2019. Out of that, the Lending Club (US company) was the largest P2P platform with USD 50.3 billion funding follow by another US company Prosper and Funding Circle (UK company), as depicted in Table 17.3.

Recently, there are dozens of blockchain-based cryptocurrency P2P lending platforms such as Dharma, ETHlend, or Maker (Table 17.4). In accordance with expert opinions, we estimate that the funding of P2P platforms will increase from a recent USD 150 billion to USD 200 billion by 2025 (out

**Table 17.2** The number of P2P platforms around the world (as of 31 August 2019)

<i>Continent</i>	<i>Number of P2P platforms</i>
Europe	114
North America	31
Asia	21
South America	13
Australia	11
Africa	2
Total	192

*Source* Authors based on P2P Marketdata

**Table 17.3** TOP 10 P2P platforms around the world (as of 31 August 2019)

<i>Ranking</i>	<i>Platform Name</i>	<i>Total Funding (USD bn)</i>	<i>Currency</i>	<i>Country</i>	<i>Crowdfunding Type*</i>
1	Lending Club	50.30	USD	USA	Consumer (Lending)
2	Prosper	15.42	USD	USA	Consumer (Lending)
3	Funding Circle (UK)	6.57	GBP	UK	Business (Lending)
4	Zopa	5.69	GBP	UK	Consumer (Lending)
5	RateSetter	4.30	GBP	UK	Consumer (Lending)
6	Mintos	3.51	EUR	Latvia	Originators (Lending)
7	Funding Circle (US)	2.33	USD	USA	Business (Lending)
8	Sharestates	1.88	USD	USA	Real Estate (Lending)
9	Maneo	1.55	JPY	Japan	Business (Lending)
10	Assetz capital	1.06	GBP	UK	Business (Lending)

**Table 17.4** Examples of crypto P2P lending platforms

<i>Name</i>	<i>Description</i>
Dharma	A platform for building globally accessible lending products using programmable, tokenized debt
ETHLend	Decentralized P2P lending platform that allows people all over the world to get a loan or become a lender
Maker	A decentralized stablecoin, collateral loans, and community governance
Salt Lending	The original blockchain-based loan, collateralizing blockchain assets
Unchained Capital	Blockchain financial services company offering cash loans to long-term cryptocurrency holders in a secure, fast, and transparent manner

*Source* Authors

of that, we forecast a 10% market share of P2P blockchain-based platforms or USD 15 billion in absolute terms).

## 17.4 CONCLUSION

In this chapter, we discussed both the recent and the potential uses of blockchain from accounting, legal, and financial perspectives and briefly



reviewed smart contracts, a high-level summary of classifiers and risk scoring methodologies. We have used the example of disintermediation in P2P lending as a case study. Five business areas dependent on P2P blockchain technology have been identified as promising in financial services: payments and remittances, credit and lending, trading and settlement, compliance, and record management.

Against the theoretical background on credit risk management applied on the P2P lending platforms, we described the performance measurement techniques based on classifiers to forecast loan defaults and refine credit scoring. Three main areas, in which “blockchain as a service” can be superior are the following: blockchain-based creditworthiness assessments, blockchain and real-time accounting, and historical data-keeping. It is important to note that while the integrity of blockchain code may withstand hacking attempts, the transaction data itself must be accurate and devoid of fraud for the value of blockchain to be recognized. At this time, there is no centralized way to remove or adjust transaction history on blockchain based on fraud, error, or identity theft, which suggests that the credibility of blockchain may be challenged in the future.

Considering the expenses incurred in successful implementation and the need to establish best practices, these use of these platforms (and related smart contracts, blockchain, and AI) may face growth constraints during market downturns including the recent COVID-19 crisis. Specifically, during the current market instability exacerbated by combination of the novel coronavirus, an oil price war, interest rates near zero and looming economic recession (or depression), the U.S. Securities and Exchange Commission has begun to increase its scrutiny over private lending to compensate for the possibility of growing defaults and a lack of transparency since these loans are negotiated privately, purchased through intermediary platforms and unemployment is skyrocketing. In response, the P2P platforms have emphasized the relative stability of the secured loan portfolios available on their platforms, compared to investing in the highly volatile stock markets during this period, claiming that diversification, maintaining underwriting standards, and competitive interest rates will continue to attract both lenders and borrowers.

At the end of this chapter, we estimated that the funding of P2P platforms will increase from a recent USD 100 billion to USD 150 billion by 2025 (of which we forecast a 10% market share of P2P blockchain-based platforms or USD 15 billion in absolute terms). These numbers suggest that investment in P2P blockchain-based platforms will rise in the coming years and disrupt more traditional lending establishments relying on “analog” credit scoring methodologies. In terms of potential disintermediation, we believe that a catalyst to exponential growth of the P2P platforms in the future would be if the private credit market, comprised of high-net-worth individuals offering direct loans (e.g., loans in excess of USD 50 million+) in exchange for high yields, were to adopt P2P platforms as their foremost vehicle for extending credit,

managing their portfolios, and collecting on defaults. Given that the multibillion global scope of private debt funds, this could provide a strong impetus for the growth and development of P2P platforms despite market instability. Future research will undoubtedly analyze the upcoming trends in loan defaults or investments to provide real insight on P2P platforms during unprecedented market conditions.

**Acknowledgements** This research was supported by the Czech Science Foundation (Project No. GA 18-05244S) and the University of Economics in Prague (Project No. VŠE IP100040). We also thank Oleg Koriachkin for his valuable comments.

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# Fintech and Blockchain Based Innovation: Technology Driven Business Models and Disruption

*Maurizio Pompella and Lorenzo Costantino*

## 18.1 INTRODUCTION

This chapter has evolved during the development of the handbook: the authors started with an analysis of how blockchain and fintech are poised to advance finance and banking and not necessarily disrupt them as some observers pointed out. The authors were mainly concerned with discerning the viability of the concept of “Uberization of banking” based on the comparison of the possible impact of blockchain and fintech to banking derived from models of sharing economy that has impacted mobility and lodging.

While completing such analysis, the COVID-19 pandemic struck, affecting each and every social and economic domain. Leaving aside the social and health impact, the pandemic is generating economic shocks with deeper and wider implications than any other crisis since the Great Depression. Such economic shocks are affecting also the blockchain and fintech space, with a dual positive effect: the first months of the COVID-19 seems to on the one hand enhancing the visibility of useful applications while on the other hand ridding the sector of fancy ones.

The authors hence investigated the potential positive impact of COVID-19 on the blockchain and fintech space as the wave that rids the system from

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initiatives that one could consider extravagant as well as the determination of the value of some companies (primarily ICT-based start-ups) based on what some market observers referred to as “fantasy valuations”.

What COVID-19 is changing, and what kind of “New Normality” we should expect from the pandemic is summarized in Part 2 (Chapter 22), where a few directions for policymakers and regulators are provided. That is the ideal prosecution of the present this Chapter.

\* \* \*

The advent of increased computing and processing capability, cloud technologies and enhanced connectivity led to the development of blockchain technologies and applications. The adoption of blockchain in various fields—from logistics to health and finance—also generated increased expectations on their potential to not only improve but even disrupt entire sectors. The phenomenon of “sharing economy” in sectors like hospitality and urban mobility have spurred such expectations, leading to the development of concepts like “uberization of banking” to describe the inevitable disruption of “mainstream” banking and financial sectors thanks to blockchain applications and fintech solutions.

As such, blockchain and fintech have been often referred to as the “silver bullet” applications that could revolutionize the processes behind financial intermediation and unhinge the role of financial intermediaries and banks—both central and commercial. Such expectations were based on the genuine belief that the new “ecosystem” based on blockchain and fintech was bringing about enhanced transparency, safe data flows and trusted sharing of information, coupled with real-time capabilities and a truly decentralized mechanism of securing transactions. The enhanced security that comes with the mechanism of blockchain, by which not one single participant can “control” or manipulate the transactions, increased the expectation.

A booming economy together with euphoric investors contributed to the escalation of such expectations to hype for anything that was blockchain and fintech related. By this new mantra, distributed ledgers were destined to break the conventional wisdom not only in financial intermediation, but also innovative business models, new ventures and so on. Nonetheless, as in many waves of innovation, blockchain and fintech generated opportunities also for less virtuous initiatives, opening the door for creative means and ways to take advantage of unaware market participants, and potentially generating opportunities for recklessness.

In a sense, while generating virtuous mechanisms that address information asymmetries (the transparency and seamless sharing of information), blockchain and fintech also increased the role of regulatory and supervisory agencies.

Our primary research problem hinges on the interest in gauging whether the technological developments and innovations that are bringing about new



patterns of banking and financial intermediation equate to the developments and disruptions observed in the sectors of mobility and lodging and understanding whether such a comparison is at all meaningful. But we will try, at the same time, to address the questions about the consequences on Fintech of the current COVID-19 emergency.

The pandemic represents the external shock that leads to the selection process that strengthens the virtuous applications and ventures while revealing the inefficiencies of the mundane ones. The pandemic is functioning as the “reset button” for the sector: the pandemic is “filtering” the industry, tantamount to the dot-com bubble for the ICT sector in the late 1990s/early 2000s and the Great Financial Crisis for the banking and financial sectors in the late 2000s.

In a sense, COVID-19 is triggering market selectivity and investors’ decisions towards those applications that prove useful at the expense of applications that are appealing but not necessary. Hence, blockchain and fintech applications emerge and consolidate to secure and accelerate supply/value chains’ viability, promote and facilitate health surveillance, secure data processing and sharing, provide continuity to education and health services, as well as promote eCommerce and financial intermediation.

## 18.2 NEW FORMS OF INNOVATION AND TECHNOLOGY-DRIVEN BUSINESS MODELS

That is not the first time that information technology and the engineering of procedures populate the world of finance. This time, however, the process follows new channels and pursues different objectives. The spread of structured finance that followed the former applications of ICT, has shown all its limits with the lack of information (asymmetric information) derived from a poorly intelligible innovation (and consequently useless, or even harmful, from a social perspective). The benefits brought by the opportunities and the variety of products made possible by ICT reached only a few market actors, at the same time imposing huge costs on the community, as a result of the financial crisis.

From this perspective, the diffusion of the “culture of distributed databases” (better, of the Distributed Ledger Technology—DLT) represents a revolutionary philosophy, because its foundation lies in the immediate, simultaneous and shared dissemination of information related to any “market fact”, so making information asymmetries virtually impossible, or reducing them drastically. Nevertheless, the most known blockchain applications relate for instance to cryptocurrencies that already provide ground for information asymmetries to materialize widely.

According to the new logic, which applies to an endless series of economically relevant cases, the role of networks (networking) becomes predominant. The “ledger”, which traces the transactions and retains a memory that may be relied on against third parties (thus validating any transaction), passes from

the hands of the individual certifier (bank, insurance, public register, etc.) to a series of nodes (servers), thus making the process irreversible and frauds impossible, as well as misappropriation of funds. Everyone knows everything about each transaction, at the moment when it is finalized.

Given that ICT for Finance and “Fintech” are intimately connected, they do represent two different phenomena. On one hand, ICT means the use of informatics in the financial sector, on the other hand, Fintech identifies some sort of business model, some sort of revolutionary way of intermediating funds and influence markets, a new philosophy.

Fintech and the Blockchain technologies developed at different paces in various ecosystems in Western Europe, the United States of America, China and Russia, just to mention a few of the global hubs of these technologies.

Whatever article or volume had been produced by academics risks becoming “obsolete” in a relatively short time so that the literature related to this topic is often not qualitatively reliable. Instead, as a consequence of the interest by innovators, investors and financial markets’ participants, considerable literature about cryptocurrencies has been developing during the last few years. Cryptocurrencies represent a somehow marginal implementation of Blockchain as a concept and technology. This is why this contribution would be original in comparison with previously published works, as it deals with Fintech (as a business model) and the technology behind cryptocurrencies, and not just with cryptocurrencies themselves.

As mentioned, many observers, especially from the fintech sector and mass media, have found inspiration in similarly disruptive technologies and applications in other industries, such as mobility and lodging, to describe the disruption potential of DLT and blockchain on banking and finance.<sup>1</sup> The global health and economic emergency triggered by the pandemic has inevitably deflated the debate over the sharing economy models and their potentially disruptive impact in the finance and banking sectors.

Some have even gone further to predict a revolutionizing disruption of the banking and financial systems, mimicking the impact of Uber and Airbnb on a traditional sector that was transformed and “disrupted”. This line of thought has led to the expression of “Uberization of banks”, by which it is expected that traditional banking will be disrupted in the same way Uber transformed—and is transforming—the mobility sector.

Here we will refer to Uber as the symbolic representative of the cohort of Transportation Network Companies (TNC) that rely on Internet technologies to connect mobility service providers (often unlicensed) to users. There are a plethora of Transport Network Companies that operate on the concept of “sharing economy” and use technology platforms to connect drivers with users, such as Bolt, Cabify, Careem, DiDi, Gett, Grab, Haxi, Lyft, Pathao and Uber. By the same token, we refer to Airbnb as representative of the short-term rental and accommodation facilitation companies such as FlipKey, HomeAway, HomeToGo, HouseTrip, Tripping.com, VRBO and

Wimdu. Notwithstanding the presence of many TNCs, the term “Uberization” has been increasingly associated with disruptive features, and that in this chapter is used to question the viability of the concept to describe potentially disruptive dynamics for the finance and banking industries.

The rise in the phenomenon of the “sharing economy” empowered by technology applications and “always-on connectivity” is spurring creativity and innovation in several sectors, among which on-demand services, fashion and food delivery seem to land themselves to potential creative disruptions.<sup>2</sup>

At first sight, one should recognize that similarities do exist and also provide interesting examples of user-driven mechanisms such as monitoring and feedback loops. One of the theoretical underpinnings of our approach is the delegated monitoring (Diamond 1984), in which individuals delegate the role of monitoring to a bank/intermediary rather than independently monitoring borrowers.<sup>3</sup>

Let’s assess then the real implications and changes that the second wave of technological innovation is bringing into the banking and financial systems and put forward a method to evaluate the impact of new technologies, their actual degree of disruption and potential regulatory implications. This part of the contribution wishes to stir the debate on the disruptive impact of innovation on the banking and financial sectors and, with a certain attitude to deflate the hype while providing options to gauge the disruptive (or rather, innovative) impact that new technologies and practices can have on financial innovation.

### 18.3 STYLIZED FACTS

Since the 1950s, the debate about the role and function of financial intermediaries revolved around the key themes of the social role of banks, their relevance and contribution to socio-economic development. In academic circles, innovative—and at times, provocative—thinking led to questioning the essence of banks, suggesting even the option of not needing banks in the first place, representing a useless layer of intermediation in the circulation of money and facilitation of credit. This “innovative” thinking was also gaining momentum on the premise of growing concerns about the issue of asymmetry of information that has always characterized the debate about the role of financial intermediaries and facilitation of financial intermediation, that took place at a later stage since the 1970s and 1980s.

Such thinking is currently being revamped by the second wave of technological developments that are investing the financial and banking sector with innovations such as blockchain, fintech and peer-to-peer intermediation that have an impact on banks as well as Non-Banking Financial Intermediaries, users, etc. Such phenomenon is not relegated only to financial intermediation and banking services, but interests also the non-banking financial intermediaries, above all the insurance sector that is poised to be affected by technology applications such as big-data and the Internet of Things.

The first wave of technological development of the 1980s and 1990s (often referred to as “FinTech 1.0”) changed the financial and banking sector by providing innovative tools and solutions that made intermediation easier and faster, and led to new business models and interaction modalities between banks and clients (Abubakar et al. 2012).<sup>4</sup>

In some instances, the technological advancements led to the fast obsolescence of what were considered successful applications: above all the example of phone banking that was, in a relatively short period of time, replaced by the advent of faster and more reliable connectivity coupled with—almost—ubiquitous ICT hardware. Specifically, the advent of smartphones allowed the introduction of “home banking” superseding “phone banking” thanks to increased convenience for customers and cost-cutting opportunities for providers.

The first technology revolution of the industry changed the way banks and clients interacted and accelerated the development of new products. On the one hand, technologies led to the categorization of functions within the banking sector, defining clearer boundaries and interactions between the so-called front-office and back-office. On the other, technologies allowed to by-pass “internal intermediaries” within the financial institutions between the bank and the client (automated transactions through machines and personal computers) as well as developing new products (electronic payment systems that are also challenging the validity and use of plastic money, although credit cards remain the underlying and backing mechanism for such innovative payments).

Another considerable impact of the first wave of technological change came from the advancements in a computational capacity that allowed the development of innovative financial products thanks to enhanced means and methods to gather, collate, crunch and process large amounts and flows of data. Technological advancements coupled with innovative modeling techniques led to the proliferation of financially engineered products that, in different forms and for various reasons, paved the way to the financial crisis with the banks and financial intermediaries as the main perpetrators (Nejad 2016).<sup>5</sup> Nonetheless, the origin and motivation for derivatives was a virtuous (since the 1920s in the Chicago trading floor) mechanism for hedging operational and business risks. The evolution of such instruments leads to financial engineering and structured finance *strictu* sensu that resulted in a mechanism to raise funds irrespective of the creditworthiness of companies beyond the scope of conventional forms of “on balance sheet securities” (bond, debt and equity) (Jobst 2005),<sup>6</sup> reversing the innate purpose of structured finance.

Thanks to technological advancements, the introduction of innovations in forms of payment such as credit/debit cards and automation in transaction intermediation such as phone and e-Banking were accompanied by innovation in financial products. Such innovative products covered the whole cycle of banking services and financial intermediation, from saving and investment products like ETFs and structured products, lending that was enhanced

by automated credit scoring and algorithms to accelerate creditworthiness assessment and risk management techniques that used derivatives and asset securitization.

Securitization and related financial products were soon deemed the main culprit of the financial crisis, notwithstanding that financial innovation was just one prong of a multifaceted system that led to the global financial crisis (i.e. excessive risk-taking by financial firms, uncontrolled information asymmetries, increased complexity of structured financial products combined with weak corporate governance systems and relaxed regulatory oversight and/or lagging regulation).

The second wave of technology innovations that are now interesting to the financial sector and banks are the above-mentioned DLTs and blockchain (See Table 18.1 for a comparison between technology waves). Such innovations are poised to redefine the way financial intermediation is structured and carried out, potentially overcoming barriers to access to financial services, facilitating interaction and by-passing intermediaries.

Ledgers have been used since ancient times to keep track and record transactions, ensure certainty and provide transparency in commerce and finance. In the financial industry, each bank and financial intermediary keeps its own repository of information and data about transactions, assets and actors.

This requires the presence of intermediaries that ensured interoperability, transparency and certainty of the transaction, such as clearing houses. Among the most relevant technological revolution in banking and financial intermediation is the introduction of electronic ledgers that informatized and automated the crucial function within banks to keep track and record transactions.

The FinTech 2.0 technologies promise to transform the way information about assets and transactions are collected, collated, stored, processed and shared: the concept of distributed ledgers allows the processing of data across shared ledgers (record of data) across different parties that are linked through the Internet. This generates a network that, coupled with cryptography and algorithms, allows to process and record data in an absolute manner, as none of the participants in the network can revert operations and none of the participants in the network has the sole control of information, data and processes.

This epitomizes the value of DLTs as the “killer application” to overcome the steps and actors of traditional intermediation and the need for a third party that centralizes interactions with inevitable layers and associated transaction costs and processing time.

As such, the DTL seems to have the potential of eliminating the need for intermediaries breaking the silos of individual repositories of information, replacing them with a transparent and safe mechanism.

These innovative features of DLT and blockchains are triggering a vivid debate among practitioners and academia on the potentially disruptive impact on traditional banking and finance.<sup>7</sup>

**Table 18.1** Mapping the waves of technology revolutions in banking & finance

	<i>Traditional Banking</i>	<i>First ICT Innovations FinTech 1.0</i>	<i>Blockchain &amp; Banks FinTech 2.0</i>
Consumer Experience	<ul style="list-style-type: none"> <li>- Uniform scenarios</li> <li>- Homogenous service</li> <li>- Poor customer experience</li> </ul>	<ul style="list-style-type: none"> <li>- Rich scenarios</li> <li>- Personalized service</li> <li>- Good customer experience</li> </ul>	<ul style="list-style-type: none"> <li>- Rich scenarios</li> <li>- Personalized service</li> <li>- Good customer experience</li> </ul>
Efficiency	<ul style="list-style-type: none"> <li>- Many intermediate links</li> <li>- Complex clearing process</li> <li>- Low efficiency</li> </ul>	<ul style="list-style-type: none"> <li>- Many intermediate links</li> <li>- Complex clearing process</li> <li>- Low efficiency</li> </ul>	<ul style="list-style-type: none"> <li>- Point-to-point transmission, disintermediation</li> <li>- Distributed ledger, transaction = clearing</li> <li>- High efficiency</li> </ul>
Cost	<ul style="list-style-type: none"> <li>- Large amount of manual inspection costs</li> </ul>	<ul style="list-style-type: none"> <li>- Small amount of manual inspection</li> <li>- Many intermediate links</li> <li>- High costs</li> </ul>	<ul style="list-style-type: none"> <li>- Completely automated</li> <li>- Disintermediation</li> <li>- Low costs</li> </ul>
Safety	<ul style="list-style-type: none"> <li>- Centralized data storage Can be tampered</li> <li>- Easy to leak users' personal information</li> <li>- Poor safety</li> </ul>	<ul style="list-style-type: none"> <li>- Centralized data storage can be tampered</li> <li>- Easy to leak users' personal information</li> <li>- Poor safety</li> </ul>	<ul style="list-style-type: none"> <li>- Distributed data storage Cannot be tampered</li> <li>- Use of asymmetric encryption</li> <li>- Users' personal information is more secure</li> <li>- Good safety</li> </ul>

*Source* Own elaboration based on World Economic Forum, 2016

The topics for debate all revolve around the key themes of safety, stability, consumer protection, need for regulation and depth of public sector intervention, the role of governing bodies and regulatory authorities such as Central Banks and so on. Some of them (depth of public-sector involvement and role of Central Banks) being always debated upon by practitioners and scholars.

### 18.4 TECHNOLOGY ADVANCEMENTS AND HUMAN TEMPTATIONS: RECKLESS SECURITIZATION MORPHING INTO TOKENOMICS?

As mentioned above referring to the role given to securitization in the context of the global financial crisis, the “financialization” and financial engineering changed the playing field of traditional fundraising and risk management for both corporate and retail financial intermediation. This phenomenon paved the way for a new paradigm shift from “risk warehousing” to externalization.

The use of DLTs spurred the development of innovative financial services and products, among which the one that goes under the name of “tokenomics”, the framework in which digital tokens are used by blockchain projects to raise capital. Tokenomics hence is an innovative form of fundraising that hinges on blockchain technology: a new model of Initial Coin Offering (ICO) is gaining momentum especially in the sphere of innovative start-ups in high-tech sectors.

In “tokenomics” an initiator (i.e. a company) launches the creation of tokens to raise capital through an ICO for a business proposition that is based on the use of the tokens. As opposed to an Initial Public Offering (IPO) by which investors acquire shares of a company, in an ICO the investor purchases tokens that may become tradable at a later stage (this would be a “security token” that entitles to a share of the company once the business becomes operational) and/or entitles the bearer to access products or services provided by the company (in this case it would be a “utility token”). Tokens are denominated in a cryptocurrency that then allows for the trading and exchange of the tokens within and outside the ICO’s ecosystem for which they were created.

Notwithstanding the increasing popularity of ICOs, uncertainty persists with regard to the nature of the tokens, often referred to as “crypto assets”, which are difficult to classify as a commodity, currency or investment/security. Such uncertainty has relevant ramifications for various elements of investors’ protection, liability, and so on. The definition of “crypto-asset” in itself is deceiving and is dangerously close to the neologisms of structured finance, such as “alternative”, “hybrid”, “grey”, “repackaged”, “synthetic”, “contingent”, “collateralized”, “parallel”, “backed”, “linked” and even the most commonly used “over the counter”. The interest in tokenomics for this chapter stems from its ability to capture and represent the features of the never-ending struggle between virtuous and bad finance. Virtuous finance representing the quest for solutions that enhance transparency, increase intermediation, lower risks and ultimately provide for stability with virtuous redistribution mechanisms. Bad finance describing products and processes that end up generating unnecessary risks and funnel money through obscure channels and mechanisms that ultimately lead to shocks and crisis that not only halt development but also limit innovation while triggering uneven redistribution.

The innovative instrument of ICOs has raised interest as an alternative means for SME financing and its potential has been initially investigated in a recent OECD study that highlights a few salient challenges, in particular in the domain of valuation of tokens.<sup>8</sup>

If tokens are considered as currencies, their valuation would hinge on the cash and/or cryptocurrency of reference: this would lead to instability due to the high volatility of the cryptocurrencies (just as a reference, Bitcoin recently traded above 50,000 USD, up from the 3.500 valuation of March 2020).

If the ICO issues utility tokens, their value would be based on the commercial value of the service/product to be launched by the initiator: this would

imply a high degree of uncertainty as a function of the type of service/product whose value can be of difficult estimation.

If the token is an investment (security or equity stake), the value of the token would rely upon the company's valuation, and also in this case there is a high degree of uncertainty as ICOs' initiating companies are seldom evaluated using traditional corporate finance techniques and investment metrics.

ICOs are an innovative instrument, and it is hence too early to draw conclusions on their robustness and validity. Nonetheless, recent studies of ICO examples raise concerns about their viability. While in principle tokens valuation should follow market dynamics to establish a "fair value", initial comparative studies indicate that tokens' valuation hinges upon simplistic indicators, such as Twitter followers and social media activity, rather than robust business metrics.

Moreover, the same research provides interesting insights on returns and survival rates of ICOs, with average returns of 179% between ICO price and the value of the token on its first day of trading, while less than 50% of projects surviving after 120 days from ICO.

The purpose here is not to delve into the aspects of ICOs and tokenomics, reference to which is made to lead to a key message of concern: tokenomics and ICOs provide worrisome similarities to the misuse of securitization that contributed to triggering the global financial crisis, in combination with excessive risk-taking, dramatic information asymmetries, complexity of financial products, weak governance mechanisms and loose regulatory oversight.

Using the lenses of a sceptical reader, ICOs may provide dangerous entry points for reckless initiatives. With the intent of being provocative, tokenomics appear as "no-asset-backed securities" (or "Nothing-Backed Securities", NBSs) denominated in cryptocurrencies in an unregulated environment.

As such, notwithstanding the great merit of ICOs as innovative financial instruments that are poised to provide new forms of intermediation, it appears that tokenomics is a mechanism still in its infancy that requires a clear definition of actors, products and services for it to materialize its potential.

The above considerations lead to the vexing issue about regulatory frameworks and attitudes for DLTs, blockchain and crypto-currencies.

#### **Tokenomics up to the Facts**

In addition to funding pressures and lower investors' confidence, increased regulatory scrutiny is putting DLG, blockchain and tokenomics under pressure. The case of the unregistered ICO launched by Telegram to finance the Telegram Open Network (TON) is a crucially relevant case that promises to shed light over ICOs and tokenomics.

Back in the spring of 2018, Telegram raised approximately \$1.7 billion from investors globally, including professional investors from the USA.<sup>9</sup> In October 2019, the SEC filed a legal complaint<sup>10</sup> against Telegram and halted the sale on the grounds that the ICO was a vehicle to issue securities. Specifically,



the SEC alleges that the “gram tokens” are unregistered securities: paragraph 3 of the complaint clearly profiles the grams as securities and not digital currency as at the moment of issuance there were no products and services that could be purchased with the grams. Moreover, the SEC claims that investors’ expectations to profit from the TON categorizes the grams as securities.

With a March 24, 2020 order,<sup>11</sup> the Court agrees with the SEC that Telegram’s Grams is an offering of securities under the so-called “Howey test”. The order also granted an immediate injunction preventing Telegram from distributing Gram tokens to investors.

The legal case is evolving with the parties engaging in fruitful dialogue. According to a court order of May 8, 2020 Telegram has agreed to collaborate with the SEC and will disclose relevant documentation of the 2018 ICOs as well as provide information. The proceedings and results of this legal case will surely set a precedent for the industry as a whole and provide guidance to ICOs and develop the concept of tokenomics. Operationally, the setbacks of the TON ICO led Telegram to further delay the launch of TON to 2021.

The case of the TON ICO is gaining attention and traction for the entire fintech industry. Irrespective of the outcome, regulators are sending clear messages that the attention is high and that innovation does not necessarily mean disruption at all costs.

The fundamentals of regulation, investors’ protection and oversight remain. What this example puts forward is the need to investigate the adequacy of norms and regulations that were developed for different times and products. The debate should also focus on whether the advent of technology and financial innovation could thrive in the current regulatory environment, always with the ultimate goal of promoting innovation, generating efficiencies while protecting investors and consumers.

## 18.5 THE REGULATORY LANDSCAPE

The use of distributed ledgers and the involvement of many actors scattered across various networks in a virtually uncontrollable mechanism, lends blockchain applications—in particular cryptocurrencies—for being used in transactions often associated with not very transparent, if not outright illegal, activities. The adoption of cryptocurrencies has seen a spike in those countries characterized by high political instability and corruption, a case in point for all is the case of Venezuela. A World Bank paper<sup>12</sup> establishes statistically significant inverse correlations between bitcoin adoption and the four elements of “Rule of Law”, “Regulatory Quality”, “Political Stability” and “Control of Corruption”.

Cryptocurrencies and ICO volumes are in aggregate still negligible to be considered a systemic risk for the global financial system. Nonetheless, regulators are on the alert and constantly monitor the evolution of the DLT and cryptocurrencies. In addition to investors’ protection and transparency, other priority concerns relate to Know Your Customer, money laundering, financing

of terrorism and other illicit activities. In this sense, Central Banks, regulatory authorities and supervisory bodies are all keen to ring-fence potential negative impact and, in most instances, maintain the behaviour of external observers.

More recently, regulators and policymakers increasingly became interested in monitoring the evolution of cryptocurrency and blockchain technology, not only for their potential advancements in the industry but also for possible implications in consumer protection. Cryptocurrency and blockchain was high on the agenda of the meeting of the Central Banks' representatives of the G20 countries in Buenos Aires in 2018. Paragraph 25 of the G20 Joint Statement and G20 Leaders' Declaration is all about DLTs, blockchain and cryptocurrencies: "We look forward to continued progress on achieving resilient non-bank financial intermediation. We will step up efforts to ensure that the potential benefits of technology in the financial sector can be realized while risks are mitigated. We will regulate crypto-assets for anti-money laundering and countering the financing of terrorism in line with FATF standards and we will consider other responses as needed".

The G20 statement is representative of a generalized policy shift from a previously softer stance to a more proactive attitude towards regulation and "other responses" on a need basis and on either individual (i.e. country/ies specific) or collective (i.e. international efforts under the aegis of international fora and/or organizations) initiatives.

Nonetheless, regulatory approaches towards cryptocurrencies are still developing, with a handful of countries with outright bans of the technology to a few countries devising control systems and mechanisms. The most recent and reliable effort to take stock of regulation of cryptocurrencies at international and global is the USA Library of Congress' survey of cryptocurrency regulation around the world of 2018 that provides a very interesting picture of the regulatory landscape and diverse attitude towards blockchain, cryptocurrencies and ICOs.

A first takeaway is the fragmentation in the definitions and terms used to describe the same phenomena: digital currency (Argentina, Thailand, and Australia), virtual commodity (Canada, China, Taiwan), crypto-token (Germany), payment token (Switzerland), cyber currency (Italy and Lebanon), electronic currency (Colombia and Lebanon), and virtual asset (Honduras and Mexico).

Second, the survey reveals that most of the countries have official notices to warn investors and consumers about the risks associated with innovative financial instruments, products and investments based on DLTs, blockchain, ICO or cryptocurrency. Such warnings establish direct linkages between such innovative products and potential frauds, corruption, illicit activities, money laundering and terrorism financing.

Conversely, in a handful of countries cryptocurrencies are accepted as a means of payment: in selected Swiss local authorities, cryptocurrencies are accepted as a means of payment by government agencies. The Isle of Man and Mexico allow cryptocurrencies as a means of payment along with their

national currency. The government of Antigua and Barbuda allows the funding of projects and charities through government-supported ICOs.

Some countries also address ICOs: banning them (mainly China, Macau, Pakistan) or trying to define regulatory boundaries of ICOs, like New Zealand where obligations may apply depending on whether the token offered is categorized as a debt security, equity security, managed investment product, or derivative (Fig. 18.1).

The regulatory landscape is poised to evolve as technology solutions and products will become more mature, widespread and significant (both in terms of number and volumes of intermediation). As highlighted by the G20 Statement, there is growing attention on the part of governments and regulatory agencies/authorities to clear the ground from uncertainties and safeguard investors while reducing the risks of illicit behaviours.

Like any evolution, blockchain technologies will have an impact on products, processes and intermediaries, hence we foresee a “transformation” rather than a “disruption”, in which once technology solutions are tested and validated, and once business models are mature, trusted intermediaries (i.e. the incumbents at the various layers of financial intermediation) will adopt those solutions, technologies and business models to provide “intermediation” services (with the understanding that the concept of intermediation, number and types of actors may vary as a result of such an evolution).

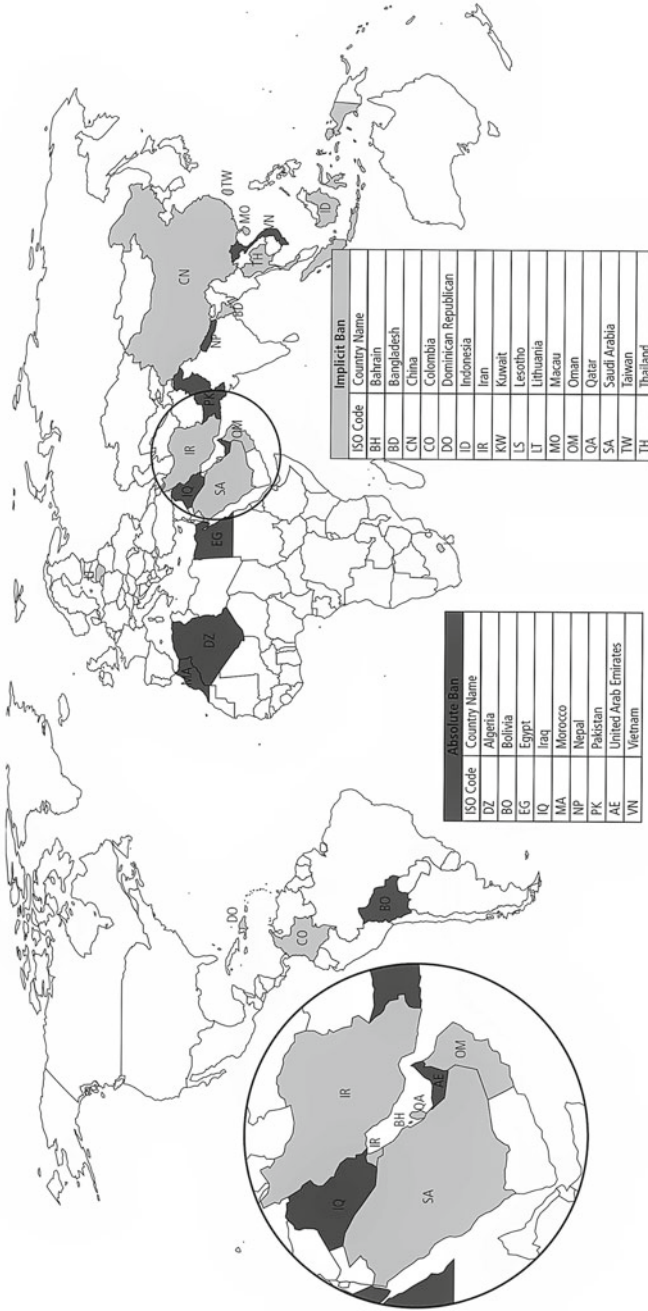
The technology advancements provide a unique opportunity for regulators to intervene and play a leading role in shaping applications, services and products. While a “risk-based” approach of regulatory intervention once issues arise allows for innovation and product development, the fluid nature of blockchain innovations and the fast pace of market introduction may call for a more proactive approach of regulators.

Rather than following industry evolutions and providing regulatory patches, regulatory agencies could define guiding principles and operational guidelines that industry should follow to strike the balance between innovation, market discipline and investors protection.

The development of regulatory safeguards and the definition of implementation boundaries would provide certainty to operators and market participants. The approach of regulatory sandboxes could provide a “safe space” for the development and testing of innovative systems and products: the establishment of a “controlled environment” for innovation has merits.

The recent establishment of the Global Financial Innovation Network<sup>13</sup> is an encouraging sign. Nonetheless, regulatory sandboxes are not a silver bullet solution to complex policy and regulatory challenges.<sup>14</sup> Sandboxes should not be a substitute for regulators’ responsibility of defining policies, setting priorities and objectives and policing the market.

Regulatory agencies have the authority and legitimacy to intervene beforehand and become a player in the innovation process: this can be achieved through dialogue and consultation with industry and market participants; the process of objective and priority setting. Particularly relevant and crucial is



**Fig. 18.1** Cryptocurrencies' legal status around the world, 2018 (*Source* Regulation of Cryptocurrency Around the World, June 2018; The Law Library of Congress, Global Legal Research Center)

the current context and historical moment of a pandemic revolution that is calling also for a different role of regulators, hitherto tasked with the challenging task of policing the market and preserving stability. The pandemic may pave the way for regulators to undertake more aggressive approaches by virtue of the (unfortunate) “reset” that the COVID-19 emergency is playing, not only in the finance and banking sectors. The positive by-product of the pandemic is in the option provided to regulators to enforce a selective approach towards financial intermediaries and actors—including financial innovators in the domains of blockchain and fintech—by establishing thresholds that allow only those actors with clearly identified features to operate and put forward innovations that streamline and improve intermediation, such as capitalization, technology endowment, consumer protection and so on.

## 18.6 MORE ON DISRUPTION

### 18.6.1 *Extrapolating from Transport Network Companies in the Mobility Sector*

Reference to the term “Uberization of banking” links the disruption (or changes) that Uber brought about in the mobility industry, facilitating the way people choose solutions and pay for their mobility needs. What appears to be a “democratization” process, in reality is leading towards a consolidation of what was a highly fragmented industry, with a plethora of service providers that now converge towards the use of a single platform—Uber—to seek customers.

The real impact of Uber, hence, seems to be a disaggregation of the supply with a consolidation of the demand and vertical integrations.<sup>15</sup>

Uber has empowered individual drivers to provide mobility services irrespective of licensing requirements so that an unauthorized driver can offer riding services. On the demand side, Uber has centralized and consolidated the market, channelling requests through a single platform. What is worth noting in the case of urban mobility, is that the providers still need to abide by regulations while providing their services, namely the drivers still need to comply with road-code and traffic regulations.

Translating this model in the financial intermediation system, Table 18.2 below provides a synopsis of actors involved in Mobility, Lodging, and Financial Services sectors DLTs provide a platform to “decentralize” supply, enabling multiple participants to provide financing to a single entity, but once the financing is provided there is no “regulatory net” policing the transaction, i.e. there are no “road-codes” and “traffic regulations” still governing the relationship between supplier(s) and recipient of financing. While not being necessarily unregulated, this would result in financial intermediation occurring in a grey area with softened regulatory pressures, which would be coherent with a non-invasive regulatory approach that would risk to limit innovation and curb potentially positive socio-economic spill overs. This resembles in

financial intermediation the phenomenon of “shadow banking” (Adrian and Jones 2018).<sup>16</sup>

This leads to an evident vacuum that generates inherent risks.

Still using the analogy of Uber, the transaction of urban mobility is typically characterized by elements that would be foreign to a DLT facilitated financial intermediation, such as:

- Clearly identified pick-up location;
- Clear destination;
- Predefined and agreed terms and conditions, such as fares, indicative duration of the service, characteristics of the means of transport, etc.;
- Precautionary measures, such as cancelling the order or interrupting the service;
- Recourse mechanisms such as complaints mechanisms with the centralized application;
- Regulatory certainty, or predictability, as most typically Uber transactions do not have a cross-border nature, being both Point A and Point B in the same jurisdiction;
- Feedback loops that allow to rate the provider, serve the purpose of building reputation, transparency and reliability.

This last element of feedback loops appears to be a crucial and pivotal element of applications like Uber in the mobility sector. Feedback helps generate trust in a mechanism of “self-regulation” sustained by users (both providers and clients) and facilitated by the platform that behaves as an “honest broker”, as an entrusted entity or third party. Such third party’s “authority” is supported by the continued use of participants (both providers and clients) in a mechanism that is initiated and self-sustained to establish reputation and legitimacy. The model above establishes clear incentives to behave from all the participants thanks to the immediacy of the transaction, clarity of conditions and ability to provide feedback.

Nonetheless, the feedback mechanism also provides for vulnerability in the mechanisms of online reputation due to possible fake and/or biased reviews.<sup>17</sup>

All in all, the typical Uber transaction would resort to transportation services from point A to point B with recourse mechanisms to manage contingencies and the plausible expectation that the provider (and the user) still has an incentive to behave due to enforced regulations that constraint the provider (road-code and traffic regulations). Moreover, the negligible nature of the service (short-haul mobility) and the amount of the transaction may compensate for any inconvenience.

None of those elements above would considerably apply to financial intermediation that would entail more significant implications: financial intermediation could entail more meaningful transactions both qualitatively (a loan on which a business venture or an education may depend upon, as opposed

to a short ride from Point A to Point B) and quantitatively (intermediation of thousands of EUR as opposed to a transaction of dozens of EUR).

When it comes to comparing Uber or other TNCs to banking and financial intermediation, more considerations come to mind along with a series of elements that may not find direct application in the context of financial intermediation facilitated by DLTs:

- The mobility service provider, while not (necessarily) fully licensed to provide mobility services, at the very least holds a drivers’ license certifying her/his ability to operate a vehicle, a condition certified by a public authority;
- The car used to deliver the service is (or should be) in appropriate conditions for circulation, a situation of “fit for purpose” that is certified by competent authorities accredited by public agencies;
- The provider of the service is bound to rules and regulations that apply to any car in circulation (as mentioned above);
- The user has relevant knowledge about the provider (allowing for feedback, complaint and recourse mechanisms);
- The user has full real-time traffic information to discern routing options and assess quality of service;
- The provider has full knowledge of the user: name, contact info, order history, and most importantly has certainty about the payment.

In the example provided above, the application addresses asymmetries of information and provides for a high degree of transparency that may not necessarily be guaranteed in the case of financial intermediation, unless with the direct inclusion of certification mechanisms that provide for reliability (such as drivers’ license, traffic regulations, car conditions, etc. mentioned above).

As an application that allows for democratization of service provision, Transport Network Companies may also provide opportunities for loopholes to replicate traditional business models in an unregulated environment. A phenomenon that is currently developing—and is almost unknown or not noticed—is the mechanism of structured Uber providers, with an investor that establishes an informal company with a fleet of cars that are rented to drivers. Drivers sign up as TNC providers, and in addition to paying the daily rental

**Table 18.2** Defining the Participants

	<i>Mobility</i>	<i>Lodging</i>	<i>Financial Services</i>
Users	Individual	Tourist	Corporate Retail
Provider	Individual	Individual	Individual
Incumbent	Taxi	Hotels	Banks

of the car to the informal company, pay the due commission to the application and a commission to the owner of the car. This model is replicating a traditional taxi company but in a completely unregulated setting, whereby the owner of the fleet completely by-passes incorporation laws, licensing requirements, fiscal reporting and employment regulations.

While not representative of the entire model of sharing economy of systems based on Network Transport Companies, the example above can provide valuable insight on how DLTs could provide opportunities to by-pass regulation and control mechanisms established to govern financial intermediation, provide certainty and ensure consumer protection.

The “shadow providers” would hence be able to break into service provision avoiding regulatory and/or market barriers to entry that would not otherwise allow them to operate.

The advent of technology innovation may raise concerns about the risks associated with innovative means of financial intermediation and innovative financial products. Extrapolating from the example above, for instance, a similarity can be drawn into a case where a large holder of funds (regulated or not) could use DLTs or other innovations to enter the mainstream financial intermediation segment by-passing regulations and oversight measures put in place by regulatory agencies for sake of transparency and consumer protection.

When looking at the impact of applications like Uber to the mobility sector, there are tangible and concrete examples of efficiencies that were brought about at systemic level:

- Widened the supply, empowering drivers to offer services irrespective of a licensing requirement;
- Lowered costs of service thanks to (unconventional) competition;
- Increased transparency by allowing feedback mechanisms of rating;

Transport Network Companies are also triggering regulatory efforts in many countries, each with different approaches towards licensing and/or fiscal requirements up to banning of TNC services.

### *18.6.2 Short-Term Rental Application in the Accommodation and Lodging Sector*

Other applications that are considered to have disrupted traditional sectors are the applications that opened up the lodging industry.<sup>18</sup> We will refer to Airbnb as the most widely recognized application representative of the short-term rental segment.

Short-term rental applications allow private providers to offer accommodation and short-term rental of properties outside of the mainstream hotel sector. While in the mobility segment, the service provided by the incumbent and the new providers are very similar (a car ride), in the case of hospitality



the service of the short-term rental providers may differ considerably from the traditional hotel services (for instance, hotels may provide additional services such as room service, food and beverage, concierge and so on). Airbnb is often referred to as an example of an Internet-based service firm whose disruption in a traditional sector can serve as an example of how DLTs can disrupt traditional banking and financial services.

A key feature of applications like Airbnb is the feedback loops that allow users to rate providers, establishing a branding and reputation to establish trust and reliability. Another interesting feature is the process of “self-regulation” that is characterizing those applications, with service suppliers defining terms of use and policies, as well as different pricing schemes. In a sense, the feedback mechanisms, coupled with the self-regulatory approach, are somehow compensating for the lack of regulatory supervision and licensing requirements: providers establish rules and terms of use that are transparently communicated to potential users; users provide feedback about their experience.

This combination addresses asymmetries of information and provides a functioning model that promotes intermediation while widening supply and potentially lowering costs.

In the case of Airbnb, what was an initially unregulated and uncontrolled phenomenon is evolving into a more mainstream service provision, due to the perceived potential negative socio-economic impact (depopulation of neighbourhoods) consumer protection concerns (safety regulations) and fiscal implications (taxation and revenues for public finances, especially at city level).

A new phenomenon among city and local governments is to regulate the phenomenon of short rentals: the trend is not prohibition but rather control, with cities establishing requirements concerning number of guests, occupancy rates, compliance with minimum safety requirements and/or residency requirements from the tenant. Most of those efforts aim to minimizing neighbourhood impacts rather than regulating the unconventional lodging sector. Key challenges persist on the implementation and enforcement mechanisms (Nieuwland and Melik 2018).<sup>19</sup>

The debate about the real positive socio-economic impact of Airbnb is far from over: recent studies challenge some of the efficiencies brought about by Airbnb and suggest that a regulatory approach should be considered to level the playing field of the lodging sector as well as mitigating possible negative social impacts (Bivens 2019).<sup>20</sup> In December 2018, the City of Los Angeles approved an ordinance regulating short-term rentals, allowing only primary residents for a maximum of 120 days of occupancy. Other cities around the world, like Paris, Barcelona, New York, have regulated short-term rentals.

## 18.7 SUMMING-UP FROM SHARING ECONOMY MODELS

When looking at the evolution of technology and its impact on the banking system, it is possible to argue that technology greatly impacted the rationale

for the real existence of banks as financial intermediaries. When defining the rationale for banks' role, technology has already challenged two of the three main grounds for the existence of banks.

1. Money circulation: banks have always existed to ensure certainty and predictability in the circulation of money;
2. Credit capacity: attitude of banks to repackage risky assets in form of risk-free deposits thanks to their experience, competence and technology.
3. Information Asymmetry Management (new view).

Having technology and service evolutions already undermined the pillar of money circulation and somehow affected the credit capacity, the key research question here remains as to whether the DLTs will make banks and financial intermediaries obsolete.

Elaborating on the similarities suggested by observers that the process of "Uberization" of banks has started and is inevitable, we provide an alternative perspective, suggesting that DLTs definitely provide fertile grounds to streamline financial intermediation but will not replace banks as we know them for the years to come.

A first consideration to be made is that neither Uber nor Airbnb has replaced taxis and hotels; those applications widened competition allowing new entrants (unconventional providers) into traditional markets. Their greatest merit is that they triggered and accelerated efficiencies that are beneficial to both supply and demand sides, leading to:

- Further segmentation and specialization of services from incumbent providers that face an innovative competitive pressure;
- Enhanced economic opportunities for new entrants;
- Lower barriers to entry in heavily regulated and traditional industries;
- Innovative public policies and regulatory approaches, including industry self-regulation.

The evolution of Uber in the mobility sector provides interesting elements and similarities. The case of Uber is an interesting model that allows observing an initial disruption of the sector (mobility services provided openly and without limitations). Uber has then evolved from disruptive to a "mature" mechanism in which the business model is the same (transportation services from Point A to Point B) but with an evolution in the service provision. Such evolution of service provision has created an innovative playing field in which incumbents (official taxi providers) resisted or adjusted to new competitive pressures. In the meantime, this playing field has allowed new entrants to compete with Uber, testified by the proliferation of similar platforms in different geographical contexts.

An interesting case in point is provided by Uber entry into the Russian and CIS markets: rather than entering the market with its brand name, Uber opted for a merger with Yandex.Taxi to start operations in 127 cities in Russia, Armenia, Azerbaijan, Belarus, Georgia and Kazakhstan. Such partnership does not preclude competition nor coexistence of different operational models. In countries like Armenia, there is room for other Transport Network Companies such as the local GG Taxi service provider. In the countries where Yandex.Taxi operates, users can use indifferently Yandex.Taxi and Uber, on which drivers from official taxi companies, licensed drivers and “free-lancers” advertise their services indifferently (example of coexistence).

A similar model of disruption, maturity and diverse playing field may possibly occur in banking and financial intermediation. New technologies are poised to sustain the development of new products and business models, improving service provision with possibly a plethora of new entrants that will potentially consolidate (or simply disappear due to competitive pressures and maturing of the market) and incumbents that will adjust to new products, means and technologies. The question will be to see which services, with which operational modalities and technologies such innovations will occur and how effectively will affect consumers’ choices and behaviours. Moreover, banks and financial intermediaries not only enjoy incumbent position in the market but also have a competitive advantage by having experience, expertise and ICT savviness and investment capacity.

Hence, rather than “disruption” that will lead to the disappearance of banks, we shall prepare for a new way of banking and financial intermediation provided by new entrants and a new way of “doing banking” with traditional banks innovating and adjusting servicing and products. Hence, we suggest that the advent of new technologies will not necessarily disrupt the banking and financial intermediation, rather will trigger innovation and evolutions that may lead to a “new breed of banks and financial intermediaries” that will adjust to those evolutions and embed such innovations.

A similarity that can be drawn from the examples of Uber and Airbnb is their initial disruption, evolution into maturity and an adjustment period that led to a segmentation of the market, increased competition, differentiation in service provision and, to a certain extent, increased transparency and trust.

The applications like Uber and Airbnb that disrupted mobility and lodging industries provide interesting inputs into the debate of how technology can change banking and finance, but remain far from being the role model as similar impacts cannot be reasonably expected: while DLTs can improve certainty, transparency and efficiency in intermediation, banks will remain a key player in financial intermediation, adopting (and adapting) DLTs and new technologies to widen their service provision.

A second consideration is that both Uber and Airbnb led to regulatory efforts to provide a levelling playing field and ensuring minimum consumer protection and safety standards. While in some cases regulatory efforts were promoted by interest groups representing the incumbents of the traditional

sectors (i.e. taxi and hotel companies), safety and consumer protection, together with fiscal and revenue concerns, are leading to diverse regulatory approaches that are still evolving.

Examples of regulatory approaches vary. A local legislation passed in New York City in December 2018 caps the number of for-hire vehicles per year and sets a minimum wage for drivers. In different states of Australia, Transport Network Companies' operators are subjected to different requirements that range from background checks of drivers, vehicle inspections to insurance requirements and payment of fees. In the Member States of the European Union, there is a high degree of fragmentation in regulatory approaches to Transport Network Companies, with different approaches from banning to laissez-faire. A recent judgement from the Court of Justice of the European Union of December 2017 (Case C-434/15 *Asociación Profesional Elite Taxi v Uber Systems Spain SL*) ruled that Uber services are tantamount to taxi services, rather than a mere digital intermediation service, letting individual Member States to regulate it as such.<sup>21</sup>

This reflects the evolving nature of those applications from “disruptive” to “mature” models of intermediation in traditional sectors. The gradual public sector intervention is also an indication of a public policy and regulatory approach of letting the market evolve to gauge the social and economic impact of those applications before devising regulatory frameworks.

Notwithstanding the above concerns, an interesting feature of Uber and Airbnb is in the relationship between provider and user that is facilitated by a network with functionalities that can apply to the financial intermediation world, such as:

- Transparent information;
- Clear terms and conditions;
- Feedback loops;
- Reputation-based transactions.

The above elements, translated in financial intermediation environments, could provide interesting inputs into an innovative mechanism in which the interaction between “Principal” and “Agent” is reversed.

## 18.8 CONCLUDING FINDINGS

Uberization of banking has been often referred to as the disruptive impact of new technologies and applications such as DLTs, Blockchain and cryptocurrencies on the banking sector and financial intermediation. Nevertheless, the term in itself is neither appropriate nor relevant.

First, there is an issue of definitions: Uber as well as other transportation network companies have not “disrupted” the urban mobility sector. Rather than interrupting, altering or destroying the sector, those companies

are complementing and transforming the industry with innovative business models that are pushing for innovation (and revision) of market dynamics and regulatory approaches. As such, disruption may not be the most appropriate way to describe the impact of those innovations on traditional industries and sectors.

Second, the dynamics of banking and financial intermediation do not lend themselves to being associated with the intermediation in urban mobility, hence making the reference to “Uber” in banking and finance daring. Financial intermediation is about financial empowerment and inclusion: financial transactions concern key aspects of people’s life (education, health, employment, business, and so on) that require and demand certainty, regulatory oversight and protection. In a typical Uber ride, the small monetary value of the transaction and the short duration of the service alter the dynamics of consumer protection: by nature, the transactions, industries and even the new technologies/innovative services are different. Safety concerns are associated with any transportation activity; reportedly the rate of accidents and safety issues involving a Uber ride remains low. According to the Uber “Safety Report”, in the years 2017 and 2018 combined a total of 97 fatal crashes with 107 total deaths were related to a Uber ride in the USA. In the same period, 99.9% of Uber rides were “safe” and only 1.4% of trips had a support request of any kind, most frequently for issues such as lost items, refunds, or route feedback. As per safety concerns, reportedly only 0.0003% of rides had a report of a critical safety incident.

Third, banking and finance have been evolving over the past decades with the advent of new technologies and products. As such, banks appear to be well-positioned to absorb—and adjust to—any disruptive impact of DLTs and blockchain by developing new services and capitalizing on their dominant position by embedding those technologies and services. Nevertheless, a few key elements of the rationale for the existence of banks are challenged by those innovations: DLTs and blockchain are yet another novelty that undermines the money function of banks. More, these technologies are poised to becoming an effective means to manage information asymmetries to the benefit of transparency.

On a separate note, there is the need to “distinguish” between blockchain and cryptocurrencies. Blockchain applications can provide valuable solutions in specific segments, such as certainty of transactions (not only financial but also administrative, especially in the case of sectors and/or countries affected by low transparency and high levels of corruption), “serving the underserved” (blockchain applications for cross-border payments and financial intermediation that could overcome the lack of reliable payment systems and banking infrastructure, as is the case of remittances), overcoming fragmentations along value chains (as could be the case of international trade and commercial transactions with multiple layers of intermediation). Those positive elements of blockchain may be undermined by the low awareness and understanding of

the technologies involved: often blockchain is indifferently associated with cryptocurrencies by the general public.

In addition, tokenomics and its dynamics dangerously resemble the reckless financial product innovation that contributed, together with many concurring factors, to the international financial crisis. The lack of a regulatory framework, the hype of innovative financial instruments (in addition always associated with “high-tech” or other appealing ventures) coupled with no supervision and governance mechanisms may lend tokenomics to providing opportunities and venues for financial frauds. This may serve as an entry point for industry participants and regulators to seek innovative mechanisms of consumer/investor protection, as the concept of tokenomics is undermining and reversing yet again the models of creditworthiness, financial and business decision-making based on due diligence assessment and valuation.

The above stresses the need to tackle regulatory aspects: it is exactly in this domain that lies the real disruption of DLTs, blockchain and cryptocurrency. Those technologies and innovations are triggering diverse approaches that range from banning to laissez-faire. While regulation may hinder innovation limiting the ability of technology to push the boundaries of new services and applications, consumer protection, transparency and money laundering are all legitimate concerns of regulators. Identifying the right balance and regulatory depth will be the most pressing challenge.

In the current regulatory vacuum, alternative measures can be undertaken to prevent—or at least minimize the impact of—possible negative applications of the new technologies and services: increased awareness among the public (tailored for specific target groups) as well as transparency about information and data available on new products and services. Although, this last element of transparency and availability of information would in any case require some forms of monitoring (ideally from a public agency) and/or impose some forms of reporting. Just as an example, ICOs could be reported and/or prepared with relevant and meaningful information disclosure clauses and procedures. Light reporting requirements may be developed for those businesses, ventures and initiatives benefitting from ICOs to monitor their survival rates.

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# Digital Currencies and Payment Systems: Chinese Way into Internationalisation of the Renminbi

*Ewa Dziwok*

When the winds of change blow, some people build walls and others build windmills.

Chinese proverb

## 19.1 INTRODUCTION

In recent years, financial markets have been facing a huge increase of new technologies that have initiated the debate about their impact on the nature of money and payment methods (Casey et al. 2018).

Globalisation caused a significant increase of global payments shared among four main regions. An undisputed leader in the Asia-Pacific region that shown in 2017 almost half of global payments revenues (WTO 2019). But the impetus of these payments is different—Eastern European and African developing nations have achieved single-digit development while Western Europe noticed a decrease, Latin America has been the fastest-growing industry with double-digit increasing in 2017. North America, has become the first region to carry out more than half of its payment transactions electronically but the growth rate is not impressive. The numbers shown above confirm important changes in payment systems and financial techniques which have taken place in recent years as an effect of technical innovation and digitalisation (Petralia et al. 2019).

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M. Pompella and R. Matousek (eds.), *The Palgrave Handbook of FinTech and Blockchain*, [https://doi.org/10.1007/978-3-030-66433-6\\_19](https://doi.org/10.1007/978-3-030-66433-6_19)

Although digitalisation could be understood in a broad sense, in case of money there are four major areas (Bofinger 2018), where digitalisation could transform the traditional forms of money and credit: the substitution of cash with electronic money; the substitution of traditional bank deposits and bank notes with cryptocurrencies; the substitution of bank deposits with central bank deposits for everyone (“universal reserves”); and the substitution of bank lending with peer-to-peer lending on the basis of digital platforms. A movement from traditional payments to online and mobile services (digital ones) was driven by three main powers: evolving technology (digital revolution), changes in financial regulation and market structure and shifting customer expectations and other demand factors (e.g. De Haan et al. 2015; Frost et al. 2019; Frost 2020).

Evolution in digital payment systems occurs in two main directions: an improvement of conventional payment platform and development of decentralised ones, based on distributed ledger technology and cryptography. A conventional system uses existing centralised and hierarchical market infrastructure to securely transfer payments. An existence of third parties with a central authority acting as a clearing institution that constitutes additional costs for customers and a significant amount of revenues for banks. Despite of the variety of developments like mobile phone payments, e-wallets, etc. a basic idea of the centralised structure remain unchanged. The distributed ledger technology (DLT) and cryptography enabled transfer of payments through decentralised book-keeping system without a middlemen or trusted authority. A payment instruction is shared over a network of users, known as miners, who verify a validity of transaction with the use of cryptographic techniques. After verification, the blocks are add to the ledger (blockchain) and the transaction is conducted. Cryptography enables to hide the details of the transaction shared in open network while a blockchain structure let solve a double-spending problem (Ali et al. 2014a).

Digitalisation changed the way how money is transferred and changed money itself—recently we observe a huge increase of different types of digital currencies and new ways of digital payments. Digitalisation has been changing the world we have already known.

The use of digital payments cut and minimise transaction costs across borders, increase currency competition and, in the process, may redefine the international monetary system and show new ways to internationalise existing currencies. Digitalisation—besides of an increase in international payments and innovations—has an important influence on financial inclusion of societies.

But digitalisation of money and systems is not connected only with advantages. The risk included in digital money is connected with financial stability, integrity, monetary policy transmission and cross-border regulations (Duffie 2019).

The chapter is constructed as follows: the first part describes types of digital currencies and ways of digital payments, the second looks closer into central bank digital currency as a promising digital medium of exchange, the third describes how China has been using new opportunities offered by digital currencies and digital payments for an internationalisation of the renminbi.

## 19.2 DIGITAL CURRENCIES AND NEW PAYMENT SYSTEMS

Both money and payment system are integrally connected with each other. For any asset to exist as a medium of exchange, a secure method of transferring this asset is needed—the payment system. This system, if it does not exchange physical banknotes or coins, requires an account book (a ledger)—a place to record stored values.

The classification of digital money differs alongside the world. In spite of the fact that they all are called money (digital) they are usually do not fit the necessary criteria. To be classified as money, an asset has to satisfy three crucial features: to be a unit of account, a store of value and a medium of exchange. To achieve these criteria the asset should be widely used and stable.

The difficulties in description of digital money was underlined by Camera (2017). Some sources (Fung and Halaburda 2016) use the terms “e-money”, “digital money”, “cryptocurrency” and “virtual currency” interchangeably while others try to find the features that make it possible to distinguish them. Barrdear and Kumhof (2016) for example, defined “digital currency as any electronic form of money, or medium of exchange, that features a distributed ledger and a decentralised payment system”.

The Committee on Payments and Market Infrastructures (CPMI) in the Bank for International Settlements (BIS) defined digital currencies as “assets with their value determined by supply and demand, similar in concept to commodities but with zero intrinsic value”. Although it meets the broad definition of e-money—“value stored in electronic device that can be used to make payments” (CPMI 2015)—in many countries it usually does not satisfy the local legal jurisdiction of money itself. It is observed for example in European Union (EU) where to be classified as a e-money the currency should be denominated or tied to a sovereign currency, issued in exchange for funds, issued by any individual or institution, and backed by an authority (European Parliament and Council 2009). In this way the distinction between digital money and e-money is possible (Claeys et al. 2018).

A place of digital money in a wide range of different types of money was recently done by Bech and Garrat (2017), and Adrian and Mancini-Griffoli (2019) who classified different forms of money through so called money tree taking into account its features: type (claim or object), value (fixed or market value redemptions), backstop (government or private) and technology (centralised or decentralised) (Table 19.1).

**Table 19.1** Types of digital money

	<i>Issuer—Private Sector</i>		<i>Issuer—Central Bank</i>
	<i>Variable rate of exchange to cash</i>	<i>Fixed rate of exchange to cash</i>	
Conventional payment technology	<ul style="list-style-type: none"> <li>• Loyalty points</li> <li>• Gaming tokens</li> </ul>	<ul style="list-style-type: none"> <li>• Commercial bank accounts</li> <li>• Mobile wallets</li> <li>• Preloaded card</li> </ul>	<ul style="list-style-type: none"> <li>• E-krona (Sweden)</li> <li>• Dinero electronico</li> </ul>
Distributed ledger technology	<ul style="list-style-type: none"> <li>• Bitcoin</li> <li>• Ethers</li> </ul>	<ul style="list-style-type: none"> <li>• Tether</li> </ul>	<ul style="list-style-type: none"> <li>• Project Ubin, Jasper</li> <li>• Digital fiat currency (Brasil)</li> </ul>
Partially distributed ledger technology		<ul style="list-style-type: none"> <li>• Libra</li> </ul>	<ul style="list-style-type: none"> <li>• sCBDC</li> <li>• hybrid CBDC</li> </ul>

*Source* own computation

a. Private issued centralised digital currency

Until the end of the twentieth century everyone who wanted to send money to another person had to use the intermediary (an institution ready to participate in sending money thorough existing net of counterparties). To ensure that money will not be used twice (so-called double-spent problem) there is a need of existence a central institution (e.g. a central bank). Generally the whole idea is based on trust that the central clearing institution is reliable to verify the transaction and protect the data. Among private issued currencies based on conventional technology one can find two types: linked to fiat currency at par value, and at variable rate of exchange.

Any development of bank’s digital products like mobile wallets, preloaded cards, still need the customer’s access to the traditional bank account. The digital money just changed its place from a bank account to a mobile device but it is still part of money collected on the personal account. A natural beneficiary of the traditional payments was a banking system that has been collecting the transaction fees throughout years.

A development of fintech and bigtech institutions that is observed lately caused changes among the intermediary role. A huge increase of social networks, and a change of behaviour of younger generations linked to them, caused a tremendous opportunity for both side. The twenty-first century is the beginning of bilateral cooperation between tech institution and social network providers. It was a huge chance for financially excluded regions in Africa, Asia and South America.

The most spectacular effect of such operations are relationships AliPay-Alibaba, and WeChat Pay-Tencent in China. First idea was just to enable transactions between the users of the network (peer-to-peer) but to do this,

there is a need to create customers account system (the link between real cash and digital money). In fact they become a substitution of bank especially in area where the access to the bank is limited (90% of Kenyans over the age of 14 use M-Pesa).

Private sector is also an issuer of conventional digital currency with variable exchange rate to cash. One of the example could be a range of loyalty points that usually let the owner to exchange points for goods and services. In spite of the fact that usually the exchange for the fiat money is not possible, the second market exists and the volatility of exchange rate is high. Another example is a huge market of virtual currencies (in-game currencies) created inside the virtual world. Although most of them are not changeable (for fiat money) there are some exception like Linden dollars (currency issued in game called Second Life), which can be exchanged with real money (US dollars or euro) outside the platform, or for virtual goods and services within the platform. The popularity of goods and virtual money has contributed to the creation of a new branch of industry (gold farming), and since 2003 one can observe specialised companies (gold farms), located mainly in China, which employees produce (as participants of virtual games) demanded goods and services (Lehdonvirta 2009).

#### b. Private issued decentralised digital currency

The idea of distributed ledger enabled a creation of an internally managed transfer system among members of this system (peer-to-peer). If in addition, a cryptographic methods are employed into the process, the digital currency used for transfers is called cryptocurrency (Houben and Snyers 2018, 2020). To withdraw money from the platform there is a need to establish an exchange with national currency (at variable or fixed rate). A role of a clearing house is taken over by a network which verifies transaction between two participants who are involved into the net (have the account and possibility to exchange cash into cryptocurrency). Usually, the payment that is to be transferred is divided into several steps:

- an exchange of the amount of money into cryptocurrency at variable or fixed rate (stable);
- establishing the transaction fee for the network that successfully verifies the transaction (the higher it is the more attractive to be verified as the first one);
- broadcasting the transaction across the network (with the use of cryptography) on “best-efforts” basis (closest to the initiator of the transaction);
- verification of the block of transactions after which the winning (fastest) group receive transaction fee and additional reward in form of cryptocurrency (mining);

- the payment is delivered into the account of the creditor and could be exchange for cash.

Despite the fact that at first glance the transaction seems to be split randomly among network participants, the closer the relationship with the initiator of the transaction, the greater probability to receive a verification order (and earning opportunities). In addition, the speed of verification matters, as well as a total share of the computing power of the network. If the group of network's participants represents the majority, it could overtake an important part of potential profits.

A rapid and huge popularity of cryptocurrency is sometimes connected with the crisis of 2007–2009 and less trust in banking institutions and a whole systems. Since then, one can observe a minor increase of transfer payments through well know payment systems (the number of correspondent banks fell by 20% between 2011 and 2018), while the total value of payments increased (Rice et al. 2020). The reason is that banks make their payments through less regulated informal networks and cryptocurrency platforms. The anonymity of cryptocurrency's technology causes the risk of money laundering, terrorist financing and tax evasion. Moreover, the use of cryptocurrencies increase financial and social instability (Danielsson 2018; FRB 2018).

Bitcoin is the first, functioning till now, privately issued, digital currency with limited supply. Currently, there are several hundred cryptocurrencies, known as Altcoins (alternative to Bitcoin) generally divided into two types (Milne 2018, p. 43). First group is explicitly based on Bitcoin and utilises its original open-source protocol to issue new coin with different characteristics (e.g. Litecoin). Second group has its own distributed ledger (e.g. Ethereum, Ripple, Stellar). Another division (Gerba and Rubio 2019) let establish two groups of cryptocurrencies: with variable rate of exchange (like Bitcoin or Ether) or with the fixed (stable) rate (Tether, DAI).

A significant volatility in exchange rate with traditional currencies caused that such cryptocurrencies like Bitcoin are not commonly accepted as a unit of account. Even though they are extremely popular in emerging markets. Almost 60% of Bitcoin exchange with traditional currencies was against the Chinese renminbi, with 32% traded against the US dollar and 3% against the euro (Ali et al.).

- c. Private issued hybrid (partially decentralised) digital currency—stablecoins

The opportunities associated with privately issued currencies led some global tech giants to establish digital currencies in the form of stablecoins. Stablecoins that are created in a cooperation with big and fin-tech companies differ from other cryptocurrencies in three fundamental ways. First, their rate of exchange is fixed and denominated in some unit of account. Second,



taking into account weaknesses of DLT (energy consuming, anonymity), new stablecoins would be based on more centralised systems to authenticate transactions. Third, they can be immediately used thanks to already existed, huge mass of users scattered around the world. So they represent main features of a global currency—universal access, open architecture, and transnational transfer system.

The question arises whether a private issued digital stable currency could replace the classic one. A lot depends on its attractiveness as a medium of exchange and stable store of value. The most promising project of stable coin is Facebook's Libra (Libra Association 2020). In plans, Libra networks tend to create a classical digital currency area (DCA) in sense that was introduced by Brunnermeier et al. (2019).

An implementation of alternative stablecoins causes a lot of risks (Lipton 2019). The most significant is a decreasing role of banks as intermediaries. The next is the appearance of new market leaders that use their network to provide services and manage data—there is a need to establish protection, control and transparent ownership rules. Another risk is tied with using a stablecoin inside weakly developed economies—a trend to switch into new, more reliable currency could emerge, as well as money laundering or financial instability.

To protect the economy against some of these risk a “narrow banking” approach is proposed (Bindseil 2020) that assumes maintaining of the reserves at the central bank by stable coins providers. The idea was already implemented by the People's Bank of China that requires AliPay and WeChat Pay (payment providers) to meet these condition (together with financial integrity, interoperability, security, and data protection).

### 19.3 CENTRAL BANK DIGITAL CURRENCY

Central bank digital currency (CBDC) can be generally defined as an electronic central bank liability denominated in an existing (legally recognised) unit of account that can be used to settle payments or as a store of value (CPMI 2018), being digital money of legal tender available for the general public.

The idea of central bank digital currency (CBDC) presume that the central bank turn out to be the possessor of depositors accounts and have the full control over money transfers between the accounts (Fiedler et al. 2019). Keeping control over the monetary policy transmission mechanism (considering digital money flows) central bank is able to apply unconventional monetary policy tools like negative rates. An additional benefit is an opportunity to collect and monitor the payment behaviour of retailers (buying, credit, and saving). What is more, an issue of the CBDC could help to avoid the risks of new forms of private money creation, such as Libra (Bank of England 2020). The biggest losers are commercial banks, which not only lose access to data on customer behaviour, but also the opportunity to create money (Stevens 2017; Meaning et al. 2018). To meet the conditions of trust and

medium of exchange a central bank digital currency should represent (Auer and Böhme 2020, p. 87) scalability, accessibility, convenience, resilience and privacy (the CBDC pyramid).

Central banks systematically investigate the attractiveness and possibilities to launch their own digital currencies. Historically, there was an issue of the digital currency to commercial banks through conventional technology (settlement account systems). Since then a central bank utilised either government-owned postal bank or authorised mobile phone operators (Dinero Electrónico launched by central bank in Ecuador) or the wallet app (e-Peso in Uruguay), (CBDC WG 2019, pp. 20–30). In all these cases the issued money was delivered to retail uses through existing intermediaries.

An increasing digitalisation of societies enable central banks to analyse possibilities to use the DLT in the process of a CBDC. Several central banks have already started to experiment with issuing digital currency based on DLT, among others were initiatives of ECB, Brasil, Cambodia, Ukraine, the Monetary Authority of Singapore (Ubin), the Bank of Canada (Jasper) but the results were still unsatisfactory. One of the main problems is the balance between cost and control on the necessary technological environment.

The biggest problem for central banks that plan to issue a CBDC is a need to build, manage and maintain a whole payment system. It makes central banks to be involved in many tasks which are now delivered by commercial banks and payments providers. The idea of synthetic central bank digital currency (sCBDC), based on a public–private partnership enables to spread the tasks among the partners (BIS 2019). With this solution the central could focuses on its core functions while private (usually from fintech sector) offers its clients technical support (e.g. Swedish e-krona as a Riksbank’s project with Accenture).

It is worth to notice that several central banks work on cross-border payments at the international level to support retail transactions through the banking system (Project Stella between ECB and Bank of Japan, Project Lion Rock-Inthanon between Hong Kong Monetary Authority and Bank of Thailand). In spite of the fact that results of these trials are mixed, it is quite visible that CBDC could change macroeconomic outcome, especially among cross-border transactions (Niepelt 2018).

## 19.4 QUO VADIS CHINA?

The currency could be assessed as international if it is accepted in one of following forms: as a global store of value, a reserve instrument, or as a medium of exchange. In classical cash world the creation of one global currency is impossible, mainly because of different regulations. In addition, it is difficult to indicate the period when there was more than one dominant international currency (Eichengreen 2008, p. 226).

In digital world rules are not the same—no borders, and benefits connected with digital technology make transactions faster, cheaper and easier to do. It

simplifies global recognition of different currencies that could either replace or coexist with a local currency. The emergence of a world digital currency is possible and real.

China ambitions to enforce the role of yuan are not new—the path into full internationalisation was taken for decades and started 1979 from its first step “open door policy”. It speeded up with launching “go global” policy in 1999 which is strictly visible in progress of FDI level (Buckley et al. 2010, p. 82). Changes in China were occurring parallel with the processes in the entire world economy—integration of financial systems, tightening of multi-lateral exchange and increasing of cross-border financial flows (Gilpin 2001, p. 277).

Global financial crisis paradoxically speeded up that process thanks to the fact that China was not affected as much as the rest of world (Gao and Yu 2011). Chinese authorities utilised that time to commence a number of initiatives that let diminish their dependence on the U.S. dollar and to simplify the use of its own currency abroad. It includes an issue of renminbi (RMB) RMB-denominated assets (mostly bonds), as well as large volumes of currency swap agreements. In consequence, several foreign central banks started to add renminbi to their foreign exchange reserves.

The question arises whether it is enough to make Chinese renminbi (RMB) a desirable reserve instrument, store of value and medium of exchange. Following Huang et al. (2015), there is a need to fulfil several conditions that are crucial to be assessed as an international currency: “economic importance in the world—share of global GDP and trade; openness and depth of financial markets; and credibility of economic and legal systems” (Huang et al. 2015).

The importance of Chinese economy is not disputed—it is highly probable that China becomes the largest economy in the world over the coming decade. The idea of spreading yuan abroad could be confirmed by several initiatives that have been existing with success for several years. The most spectacular is Belt and Road project that has been providing (since 2013) large loans to weaker developed countries. The report prepared by Horn et al. (2019) estimates that China holds over 5 trillion dollars of debt owed by other countries. Furthermore, Swift’s June 2019 report analyses the latest impressive growth in payments using China’s currency in Asia, Europe and Africa (Swift 2019).

The visible step that made the renminbi closer to become commonly recognised currency is its inclusion in the IMF’s SDR (Special Drawing Rights) basket with representation of 10.92%. On October 1, 2016, Chinese yuan officially became a world reserve currency. Furthermore, on April 1, 2020, Chinese decision-makers lifted restrictions for foreign institutions to run independently their financial businesses in China. It means that asset management companies as well as investment banking industry achieved the access to the local financial market that’s potential is estimated 45 trillion dollars.

A new Chinese Five-Year plan (2021–2025) that aims to drive the transformation of China into new era, assumes a rapid and efficient change towards a

high-quality growth that embodies advanced technology, services and sustainability (Neuweg and Stern 2019). Research and innovation regarding digital currencies was mentioned in the plan to make Shenzhen, the technology hub next to Hong Kong, into a world-class city by 2025. It covers, among others, the following goals:

Support the development of innovative applications such as digital currency research and mobile payments in Shenzhen.

Promote interconnection and mutual recognition of financial markets in Hong Kong and Macao.

Pioneer the advancement of RMB internationalization and explore innovative cross-border financial supervision.

(Central Committee of the Communist Party of China 2019).

In addition, the use of central bank digital currency would definitely support and simplify the project of internationalisation. Chinese preparations for implementation a central bank digital currency last at least from 2014 when the research centre was established by People's Bank of China (PBOC). An idea behind a Chinese CDCB assumes that it will be fixed to the physical currency and omit the use of standard blockchain to protect its sovereignty and keep control over the details of transactions. It is based on Chinese experience being a world leader in trade finance blockchains.

Recent regulatory changes in China speeded up preparations to launch its digital currency and Alipay was required to switch to clearing company UnionPay (state-owned). On March 24, 2020, it was announced that the PBOC had finished a construction of basic functions for the new currency and had already begun a legislation process concerning on its implementation.

All these activities, together with a new digital currency, could cause that China will not dominate existing financial system but bypass it (Yang and Chen 2019).

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# Cryptocurrencies and Other Digital Asset Investments

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## 20.1 AN INTRODUCTION OF THE CRYPTO-ECONOMY

A particular blockchain is a public ledger of digitized information such as a record of the cumulative purchases and sales among Bitcoin participants. A cryptocurrency such as bitcoin is the “digital asset” purchased and sold among participants in the crypto-economy. Whereas every cryptocurrency must have an associated blockchain, certain types of blockchains may have value on their own even without the explicit trading of digital assets for example to store medical records (Halamka et al. 2017) or facilitate the clearing of repurchase agreements (Smith 2017). The application of blockchain technology beyond cryptocurrency typically involves private or permissioned blockchain that are controlled by a centralized entity or consortium of entities to governs the exchange of information among participants such as the entity’s clients.

The crypto-economy typically consists of four, interrelated components: (i) the distributed ledger or blockchain; (ii) the digital assets such as bitcoin; (iii) the active participants or “miners”; and (iv) the passive participants or users. A particular blockchain is comprised of blocks or groups of cryptocurrency transactions. A particular transaction represents the purchase or sale of cryptocurrency between two participants. The number of transactions per block varies—e.g., the original Bitcoin protocol allowed up to 2,000 transactions per block. Only settled transactions are included in a block appended to the

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blockchain so that the speed with which new blocks are created effectively determine the time it would take to settle a particular transaction.

An important feature of the Bitcoin protocol is that it is designed to create a deliberate, fixed maximum supply of digital assets in a deterministic and controlled fashion. The blockchain protocol associated with Bitcoin controls the number of new coins created per block, and the frequency with which new blocks are added to the blockchain. The supply of bitcoin is therefore is not a direct function of the price of or demand for Bitcoin. For example, the total aggregate supply of bitcoin is capped at 21 million and the number of new coins created with every new block decrease deterministically, according to a formula in the protocol. According to some calculations, 99% of all new bitcoins will have been created by 2032 (Burniske and Tatar 2018). The amount of time needed to reach the total supply is somewhat misleading because the Bitcoin protocol can be adjusted to generate a smaller number of newly minted bitcoins per block. Because of its digital nature, bitcoin is infinitely divisible so that even a fractional number of coins per block are feasible.<sup>1</sup> The technical details of the Bitcoin protocol are beyond the scope of this chapter, but it is important to recognize that new bitcoins are being created in an orderly, predictable way. Yet the demand for cryptocurrency is theoretically unlimited, resulting in a perceived scarcity that adds value to bitcoin.

The third component of the crypto-economy is the active participants, in the case of Bitcoin, the miners, that are responsible for “building” the particular blockchain. The challenge of the blockchain design is to devise a protocol that will establish consensus among geographically dispersed miners (active nodes) with competing incentives in the absence of a contracting or central authority to resolve disputes among miners.<sup>2</sup> Agreeing on the group of transactions to be included in a block and therefore appended to the blockchain is not as simple as ordering cryptocurrency purchases and sales according to their timestamps. Transacting participants broadcast transactions and/or requests to buy or sell cryptocurrency to all nodes on a particular blockchain; but, because of the geographically, distributed nature of blockchain participants, the latency or time delay between the submission of a transaction and its receipt by other nodes can differ widely depending on their physical locations. Latency differences render transaction timestamps an ineffective means for ordering transactions (Narayanan et al. 2016). Moreover, the ordering of purchases and sales should obey certain rules, for example, transactions that double-spend the same Bitcoins or any other type of malicious transactions should not be confirmed and added to the blockchain.

The Bitcoin blockchain relies on a cryptographic principle referred to as “proof-of-work” to facilitate trust and coordination among miners and ensure that only a legitimate transaction is confirmed (Nakamoto). The Bitcoin proof-of-work algorithm requires miners to expend considerable computational capacity to solve a complex, mathematical puzzle. This puzzle is not necessarily difficult to solve, but the solution requires a significant amount

of costly computational power which requires the miners to purchase special hardware systems. Bitcoin miners compete with each other to receive the transaction fees and any newly minted coins associated with a particular block of transactions. An increase in the number of competing miners could further increase the computational power.

The fourth component of the crypto-economy is the individual participants. These participants are linked to the crypto-economy through a wallet.<sup>3</sup> Each wallet is identified by a number similar to a digital bank account number, referred to as the public key. The public key is further uniquely linked to a private key. While the public key is shared and visible to other participants the private key is not public and not shared but it is necessary to approve any transfer of bitcoin out of the wallet. Wallets have a dual purpose, first, wallets can be used to securely store, send, and receive cryptocurrencies. Similar to a bank account, a wallet is essentially a record of unspent bitcoins. Wallets also provide a user interface to track the balance of cryptocurrency holdings and automate certain functions, such as estimating what fee to pay to achieve a desired transaction confirmation time. Table 20.1 shows the contents of a particular bitcoin wallet identified by its public key, 12ib7dApVFvg82TXKycWBNpN8kFyiAN1dr.<sup>4</sup> The private key for this wallet is stored by the owner and not publicly available. This wallet was created on May 13, 2010. Bitcoins were last received by this wallet on February 20, 2018, and were last sent out from this wallet on July 24, 2010. As of August 19, 2020, most coins in this wallet remain unspent—viz., out of 52,700 Bitcoins received, only 21,700 were sent/sold.

A participant can have multiple wallets for the same or different cryptocurrencies. Other participants use centralized wallets on exchange or payment platforms that pool funds together into a limited number of large wallets or addresses. Linking wallets to individuals or even determining estimates of the exact number of cryptocurrency users from the number of created wallets therefore presents a number of challenges without additional non-public information.

**Table 20.1** Example of the contents of a bitcoin wallet

<i>Wallet 967</i>	<i>Number of bitcoin</i>	<i>First transaction</i>	<i>Last transaction</i>
Balance	31.0 K BTC		
Received	52.7 K BTC	5/13/2010	2/20/2018
Sent	21.7 K BTC	6/2/2010	7/24/2010

## 20.2 AN OVERVIEW OF CRYPTOCURRENCY DIGITAL ASSETS—COINS, TOKENS, AND DERIVATIVES

### 20.2.1 *Bitcoin and Altcoins*

The investment landscape for cryptocurrencies or digital assets more generally has expanded well beyond the Bitcoin that Satoshi Nakamoto, the pseudonymous developer conceptualized in his 2009 whitepaper. Cryptocurrencies have grown into a multi-billion dollar market with thousands of listed cryptocurrencies.<sup>5</sup> Not all cryptocurrencies are created equal and an investor needs to understand the available digital asset landscape in order to identify potential investment opportunities. Moreover, digital assets comprise a heterogeneous set of products including simple variations of Bitcoin such as most altcoins, for example, the altcoin, Litecoin, is recorded on a variation of Bitcoin blockchain. Other contracts represent more substantive variations including new types of blockchain such as Ethereum which enables programmable “smart contracts” that in turn enabled the growth in Initial Coin Offerings (“ICO”) tokens. While the nomenclature is not yet standardized, there often are technological and other differences between coins and tokens. Coins typically have their blockchains, whereas tokens are issued on an existing platform, often one that enables smart contracts.

This evolution in products can be attributed to a few reasons. Bitcoin is not perfect—new cryptocurrencies are developed to address specific limitations of Bitcoin such as the high computation cost of the proof-of-work protocol, the relatively small number of transactions per second, or the limit on the number of transactions per block. Bitcoin is based on open-source software which means that the source code is publicly available and that it can be studied, changed, and improved by anyone with the necessary technical skills. The crypto-economy is also relatively unregulated further leading to low barriers to entry—the first step in creating a new cryptocurrency is typically the publication of a whitepaper that establishes the rules, the creation of new blocks, the procedure for supplying new cryptocurrency, and the mechanism for reaching consensus among active participants.

A challenge in introducing a successful, new cryptocurrency, and its associated blockchain, is to attract sufficient demand from participants using the cryptocurrency and active participants (such as miners) willing to expend resources to generate and maintain the blockchain. Despite the large number of cryptocurrencies being introduced, there are only a relatively small number of successful currencies. Table 20.2 shows the market capitalization and share for the top ten coins as of June 30, 2019. The combined market share of the top five coins was 91% as of July 31, 2020 with Bitcoin’s share still much larger than that of the other coins.

The discussion below focuses on a sample of cryptocurrencies that has some unique feature not shared by Bitcoin. The crypto-economy also includes over-the-counter type derivatives, structured products, and tokens generated

**Table 20.2** Market share of bitcoin and other Altcoins as of July 31, 2020

<i>Cryptocurrency</i>	<i>Market capitalization</i>	<i>Market share<sup>a</sup> (%)</i>
Bitcoin	\$208,301,738,184	70.90
Ethereum	\$38,461,983,022	13.10
XRP	\$11,293,810,672	3.80
Bitcoin Cash	\$5,562,323,569	1.90
Bitcoin SV	\$4,230,697,934	1.40
Litecoin	\$3,776,500,072	1.30
Cardano	\$3,592,104,122	1.20
Binance Coin	\$2,960,333,142	1.00
EOS	\$2,885,995,745	1.00
Tezos	\$2,095,922,196	0.70

<sup>a</sup>Denominator is the aggregate market of the top 20 cryptocurrency coins

Source CoinMarketCap

through what is referred to as Initial Coin Offerings (“ICO”) discussed in earlier chapters.

### *Litecoin (LTC)*

Litecoin borrowed the main concepts from Bitcoin but improved some features of the blockchain protocol to enable faster transaction confirmations.<sup>6</sup> The time lapse between Litecoin blocks is 2.5 minutes or approximately four times faster than Bitcoin blocks. Because blocks are issued four times as fast this means that Litecoin can handle a higher transaction volume. The total amount of Litecoin released will therefore be four times greater than that of Bitcoin in the same period—Litecoin will converge upon a fixed 84 million units whereas Bitcoin will converge upon 21 million units. Burniske and Takar remarked in their comparison of bitcoin (BTC) and litecoin (LTC), “a unit of litecoin will be one-fourth as valuable as a unit of bitcoin because there are four times as many units outstanding. This is important, because all cryptocurrencies differ in their supply schedules, [so that] the direct price of each crypto-asset should not be compared if trying to ascertain the appreciation potential of an asset. Litecoin is nimbler than Bitcoin because it stores a fraction of the monetary value” (Burniske and Takar 2018).

### *Ripple*

The founders describe Ripple as an “open-source, permissionless and decentralized blockchain technology that can settle transactions in 3–5s.”<sup>7</sup> According to the company website, Ripple provides payment settlement, money transfer, and currency exchange mostly for large banks and money service businesses. Ripple also has its native cryptocurrency, XRP that can be exchanged for other cryptocurrencies or fiat currency.

## Ethereum

Ethereum is a decentralized computing platform based on an innovative proof-of-stake consensus mechanism. The Ethereum blockchain also hosts the ERC-20 tokens that enable developers to create digital applications or “smart contracts.” The native cryptocurrency of Ethereum is called Ether (ETH). Ether can be exchanged for other cryptocurrency or fiat currency, but it is also the “digital oil” or payment unit for the fees need to modify a smart contract.

### 20.2.2 Stablecoins

Stablecoins are a type of cryptocurrency, that as the name suggests, seek to stabilize the price by linking the value to an underlying basket of assets. In some regards, stablecoins are the digital equivalent of stable value funds but their design is rather complex and typically involves the broader crypto-economy. Stablecoin issuance, redemption and stabilizing mechanisms, type and design of the user interface, and transfer of stablecoins to the broader crypto-economy involve a governing body, exchanges, wallet providers, payment system operators, smart contracts, and a Blockchain (G7 Working Group on Stablecoins, BIS 2019).

Table 20.3 shows a list of stablecoins backed by U.S. dollar deposits (stablecoins could also be backed by crypto collateral for the example the DAI that was discussed in Chapter 11).

Stablecoins differ in how the underlying basket of assets is secured. The basket of assets could be backed by a central entity, such as the Tether Treasury for USDT, a decentralized system of governance (multiple users can issue stablecoins), such as USDC or backed by FDIC-insured banks (PAX and BUSD), or escrow accounts (TUSD). An escrow account reduces settlement risk for both the purchaser and seller of the stablecoins. Suppose an investor wants to buy one stablecoin, she would deposit a dollar (the assumed stablecoin price) in an escrow account. The issuer would deposit a TUSD coin in the account, which is sent to the purchaser and upon verification of the receipt, the dollar is transferred to the issuer (Lyons and Viswanath-Natraj 2020).

**Table 20.3** Properties of top stablecoins

<i>Stablecoin</i>	<i>Symbol</i>	<i>Basket of assets</i>
Tether	USDT	100% USD Deposits held in centralized Tether Treasury
USD coin	USDC	100% USD Deposits in decentralized (private) accounts
Paxos standard	PAX	100% USD Deposits held by FDIC-insured banks
Binance USD coin	BUSD	100% USD Deposits held by FDIC-insured banks
True USD	TUSD	100% USD Deposits held in escrow accounts

Another technical difference among stablecoins is the governing body's choice in stabilizing mechanism. While in theory, stablecoin prices are constant, market frictions including settlement delays and rebalancing the collateral basket could introduce some price volatility in stablecoins.

### 20.2.3 *Cryptocurrencies Derivatives—Bitcoin Futures*

The Chicago Mercantile Exchange (CME) and the Chicago Board of Trade (CBOT) were some of the first regulated exchanges to enter the digital asset market with the launch of cash-settled bitcoin futures in 2017. Bitcoin futures opened the market to broader institutional involvement—increasing from 45 funds with over \$7 billion in assets in 2016 to over 2020 funds in 2018 (Faucette et al. 2018). Futures also enabled participants to short bitcoin (Hale et al. 2018).

The CME lists monthly contracts for six consecutive months and two additional December contract months. If the six consecutive months include December, it lists only one additional December contract month. The contract trades on CME Globex from 18:00 Eastern time to 17:00 Eastern time Friday with an hour break every trading day. Individual contracts equal five bitcoin per contract. CME bitcoin futures are cash-settled to the CME CF Bitcoin Reference Rate (BRR) that is calculated using a volume-weighted median price of trades collected from approved exchanges including Coinbase Pro, Bitstamp, Kraken, and itBit and Kraken between 15:00 and 16:00.<sup>8</sup> The CME also provides a real-time index for bitcoin, the CME CF Bitcoin Real-Time Index (BRTI) that is updated every second.<sup>9</sup>

On September 22, 2019, the Intercontinental Exchange (ICE), launched the Bakkt futures, which unlike the CME's cash-settled futures are physically settled. The other contract features of the Bakkt futures are also different. ICE lists monthly contracts for 12 consecutive contract months. The Bakkt bitcoin futures contract size equals one bitcoin and upon the final settlement date, bitcoin is delivered to the Bakkt Warehouse.<sup>10</sup>

Figure 20.1 shows the growth in bitcoin futures open interest at the CME over time. Trading volumes in CME bitcoin futures currently exceeds Bakkt futures volumes, the consensus view is that the CME still dominates in terms of price discovery (Aleti and Mizrach 2020).

## 20.3 CRYPTOCURRENCY VERSUS FIAT CURRENCY

Satoshi Nakamoto described his vision for cryptocurrency as “[a] purely peer-to-peer version of electronic cash [that] would allow online payments to be sent directly from one party to another without going through a financial institution” (Nakamoto). Satoshi's description has contributed to the confusion in the popular press and among investors about what to make of cryptocurrency. Is bitcoin fiat currency (money)?

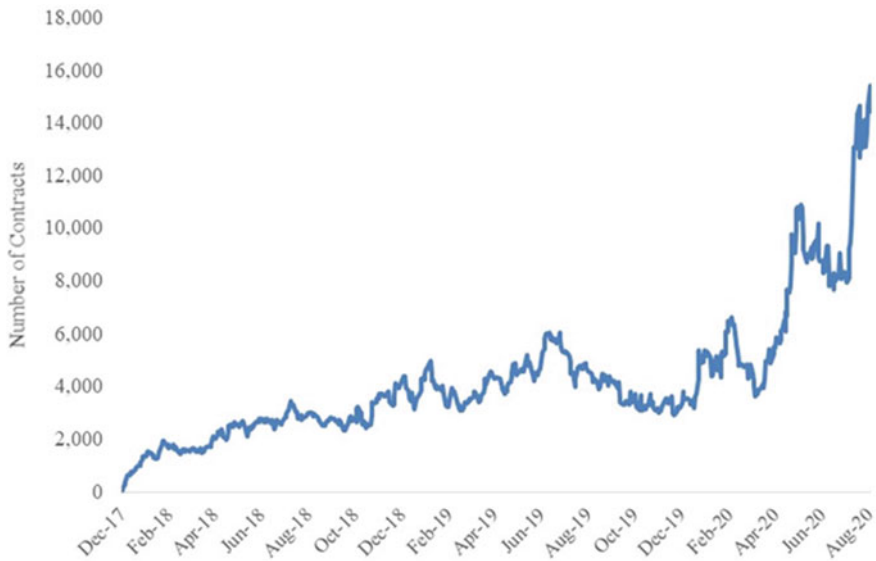


Fig. 20.1 Open interest of CME bitcoin futures

Economists define money based on what can be done with it. Fiat currency such as the U.S. dollar functions as a store of value, a medium of exchange, and a unit of account in the global economy (Mankiw 2007). As we explain in more detail below, cryptocurrency fails as fiat currency because it does not have the characteristics economists typically associate with fiat money.<sup>11</sup> A study by the Bank of Canada reached this conclusion by analyzing the competition and network effects between cryptocurrencies (Gandal and Halaburda 2014). Research by Yermack (2013) and Glaser et. al. (2014) reached a similar conclusion further observed that cryptocurrencies behave more like speculative investments.

### 20.3.1 Store of Value

Absent inflation, money provides some security that it can be used for purchases on future dates. In other words, one dollar bill today will be one dollar bill tomorrow, even if its value may be lower than one dollar today due to the effect of the time value of money. Money can be saved and used to smooth the purchasing of physical goods and services over time.<sup>12</sup>

In contrast, there is no guarantee that the value of a Bitcoin today will be the same tomorrow. The Bitcoin to USD exchange rate has been very volatile (see next section for more detail) which inhibits its use as a means to smooth purchases over time. Moreover, “[B]itcoin’s daily exchange rate with the U.S. Dollar has virtually zero correlation with the Dollar’s exchange



rates against other prominent currencies such as the Euro, Yen, Swiss Franc, or British Pound” (Yermack 2013).

Cryptocurrency also has other characteristics that make it fundamentally different than money. Whereas the quantity of money is controlled by central banks and affected by macroeconomic trends, the quantity of Bitcoin is deterministic and as explained before, the supply is embedded in the blockchain protocol, so that the value is not affected by macroeconomic events in the same way the quantity of money would be (Ali et al. 2014).

### 20.3.2 *Medium of Exchange*

People can use a “medium of exchange” as a commonly and widely accepted means for transacting purchases and sales. Cryptocurrency indeed functions as a medium of exchange within the confines of the crypto-economy on the blockchain, but *only* for participants in the blockchain. Can it replace money in the retail economy more generally?

The U.S. government recognizes the U.S. dollar as a legal tender but does not recognize cryptocurrencies such as Bitcoin as legal tender. For example, one cannot pay one’s U.S. federal income taxes in bitcoin. Some developments might however suggest that bitcoin is making headway as a medium of exchange. Thirteen retailers including Amazon, Expedia, and Microsoft are accepting bitcoin as a form of payment.<sup>13</sup> Nevertheless, the number of merchants willing to accept payment in cryptocurrency is still incredibly small relative to the global retail world. The digital currency exchange Coinbase released a service for merchants to accept cryptocurrency, including bitcoin, as a form of payment.<sup>14</sup>

Payment platforms such as credit cards include procedures to reverse or dispute unwanted transactions post-trade, but the Bitcoin protocol is designed without such procedures so that unwanted purchases or payments cannot be undone so that Bitcoin transactions are irreversible (Böhme et al. 2015).

### 20.3.3 *Unit of Account*

A unit of account is a common base for expressing the prices of goods and services. In the United States, prices of goods and services are always quoted in dollars and cents. The most important aspect of “money” as a unit of account is that it must be nearly universally accepted as the basis for the quotation of the prices of goods and services, which makes it easy to compare prices of alternative goods. For example, a \$1 apple is twice as expensive as a 50 cent apple.

The digital nature of bitcoin means that each bitcoin is divisible into smaller units. The smallest unit of a bitcoin is a Satoshi equal to one-hundredth millions of a bitcoin. Machines can easily keep track of numbers with several decimal digits, but it is very challenging for most humans to keep track of prices to eight decimals. For example, a \$4.95 Starbucks latte would cost

0.00041634 bitcoin,<sup>15</sup> making it very challenging for people to compare the prices of different goods. A coffee at Starbucks (0.00041634 bitcoin) is more expensive than coffee at Dunkin (0.00024812 bitcoin) but it is very challenging for most humans to tell how much more expensive the Starbucks latte is.

The high volatility of the exchange rate for cryptocurrency to USD further undermines its role as a medium of exchange in the broader economy because it changes more often (and with larger relative larger sizes) than the frequency with which many merchants update their posted prices (Carlton 1979). Although some merchants may accept cryptocurrency payments at the prevailing exchange rates, many will still prefer to post and adjust prices in dollars. Until that changes, sticky prices for many goods and services will remain a significant barrier to cryptocurrencies such as Bitcoin becoming a standard unit of account.

#### 20.3.4 *If Not Money—Then What?*

The consensus view is that most bitcoins are not used as a means of payment outside the confines of the crypto-economy. The Bank of International Settlements found that cryptocurrencies “do not reliably provide the standard functions of money and are unsafe to rely on as a medium of exchange of a store of value” (G7 Working Group on Stablecoins, BIS 2019). The authors Ron and Shamir observed that the majority of mined Bitcoins remain unspent or took more than one year to be spent, which would not be true if Bitcoin was being used as money (Ron and Shamir 2013). If participants purchased bitcoin with the primary intention of using it as a substitute for money, one would expect that purchasers of bitcoin would use it to buy goods and services so that the majority of bitcoin holdings would be circulated rather than locked up in wallets. Empirical results show the exact opposite—most bitcoins are held and not spent.

Cryptocurrencies can be a good alternative investment, especially in terms of bringing diversification to portfolios (Trimborn et al. 2019). Other evidence suggests that some interest in cryptocurrencies is also driven by speculative or “excitement-seeking” traders wanting to increase their overall levels of risk in their search for higher returns (Breitmayer et al. 2019). The cryptocurrency markets have historically been dominated by individuals, but several institutions have entered or expressed an interest in entering this market. Fidelity Digital Assets is the digital asset arm of Fidelity, the \$7.2 trillion asset management giant offers custody, trading, and service for digital asset investments, including bitcoin. TD Ameritrade (Fuscaldo 2018) and DRW Trading are also avid public supporters of cryptocurrency (Del Castillo 2018).

Stablecoins may be the one exception since these are not plagued by the high price volatility of other cryptocurrencies and may indeed be used as a vehicle currency in the cryptocurrency markets and potentially also in the economy more generally (Lyons and Viswanath-Natraj 2020). The interest in

using stablecoins to facilitate cross-border payments in the broader economy is growing. France and Germany both have initiatives looking at a special type of stablecoin referred to as central bank digital currency.<sup>16</sup>

## 20.4 CRYPTOCURRENCY AS ALTERNATIVE INVESTMENTS

Potential investors should recognize differences and similarities between cryptocurrencies and other more traditional assets to ensure that the desired level of portfolio diversification is being achieved when adding digital assets.

This section compares the historical, ex-post risk and return of Bitcoin and more traditional asset classes, namely stocks, bonds, foreign exchange, and commodities. This analysis uses aggregate market indices to represent each of these assets.<sup>17</sup>

Table 20.4 shows summary statistics for monthly returns for the period January 2014 through September 2018.<sup>18</sup> The return on bitcoin is higher than that of the other assets, but the high return is tempered by a high volatility. Table 20.4 also shows that bitcoin is uncorrelated with foreign exchange and negatively correlated with corporate debt. Stocks and commodities show a small positive correlation with bitcoin over this period.<sup>19,20</sup>

The quantitative analysis shows that the statistical properties of the historical return and its distributional features are different than that of the other more traditional investments. Bitcoin can therefore add some diversification to an investment portfolio. But how would bitcoin perform on a risk-adjusted basis?

The Sharpe and Sortino ratios are two basic risk-adjusted return measures. The Sharpe ratio measures return per unit of risk (measured using standard deviation). According to this ratio, stocks outperformed bitcoin on a risk-adjusted basis.<sup>21</sup> The Sharpe ratio considers the risk of the asset without distinguishing between upside and downside risks (Sharpe 1994). For assets with normal distributions and no fat tails it makes sense to include both upside and downside risks. For assets with skewed or fat-tailed distributions such as bitcoin, the Sortino ratio is also useful. The Sortino ratio, like the Sharpe ratio is a measure of risk-adjusted return but unlike the Sharpe ratio reflects only downside risk or the standard deviation of returns below a specified target level

**Table 20.4** Monthly return statistics

<i>Statistic</i>	<i>Bitcoin</i>	<i>Stock</i>	<i>Commodity</i>	<i>Foreign exchange</i>	<i>Corporate debt</i>
Mean return (%)	6.29	1.01	0.34	0.32	0.23
Volatility (%)	5.47	0.08	0.63	0.03	0.01
Kurtosis	0.35	0.6	1.48	-0.37	1.48
Skewness	0.66	-0.01	0.3	0.03	-0.35
Correlation with bitcoin	1	0.18	0.1	0.06	-0.06

*Sources* Morningstar, Bloomberg and CoinMarketCap

**Table 20.5** Performance ratios of assets

<i>Statistic</i>	<i>Bitcoin</i>	<i>Stock</i>	<i>Commodity</i>	<i>Foreign exchange</i>	<i>Corporate debt</i>
Sharpe ratio	0.27	0.35	0.16	0.15	0.15
Sortino ratio	0.17	0.18	0.03	0.1	0.1

*Sources* Morningstar, Bloomberg and CoinMarketCap

(Culp and Mensink 1999). The analyses below show the Sortino ratio relative to the 30-day Treasury return target level. The Sortino ratio is intuitively appealing because investors would typically be more interested in knowing the ratio of expected returns to downside risk (i.e., the risk of underperformance or loss instead of upside risk). The Sortino ratio is lower than the Sharpe ratio for all assets. Using the Sharpe ratio, stocks outperformed the other assets, including Bitcoin but the performance of Bitcoin is on-par with the stock under the more conservative measure of risk (Table 20.5).

Academic studies found that on average, the returns and volatilities of altcoins are also high and that altcoin returns are correlated with Bitcoin return but not with more traditional assets such as gold and stocks (Hu et al. 2019). As explained by Hu, “many altcoins do not trade directly against fiat currencies, but against bitcoin itself. Purchasing any of these altcoins thus may require purchases in bitcoin, which may drive the common price movement.” On average, the aggregate high correlations between Bitcoin with the other altcoins in the Hu-study imply that returns of altcoins and bitcoin reflect a common systematic risk. This has important implications for portfolio diversification and risk assessment. The persistent low correlations of the return of cryptocurrency and more traditional assets suggest that cryptocurrency are attractive alternative investments, but it would also expose investors to the novel risks embedded in crypto-economy that are not captured by a ratio analysis.

Investors in cryptocurrency should therefore be cognizant of the salient risks associated with cryptocurrency. In addition to the relatively high price volatility discussed before, cryptocurrency is also exposed to inherent risks of the protocol whereas other risks are more mundane, such as the settle-ment/confirmation of transactions on the blockchain. For example, a Bitcoin transaction is not final until the transaction has been confirmed by at least six miners and does not settle until it has been included in a block and appended to the blockchain, which can take up to ten minutes per block (Böhme et al. 2015). The average ten minute inter-block time lapse further places an upper limit on the transaction speed.<sup>22</sup>

The Bitcoin protocol, moreover, relies on an expensive process of proof-of-work to reach consensus among anonymous, decentralized parties. As described before, miners maintain the blockchain but compete for the

economic reward of doing so. For example, allegedly colluding miners controlling more than 50% of the blockchain could potentially prevent transactions from being confirmed or enable double-spending (this is called launching a “51% attack”) (Narayanan et al. 2016). Budish explained that if Bitcoin blockchain becomes large enough, the gains from a majority attack by miners could outweigh the cost of maintaining the blockchain, which limits the scalability of the current Bitcoin blockchain (Budish 2018). While not a current risk per se, investors should consider this limitation when adding Bitcoin to their long-term investment portfolio.

Acknowledging the limitations of Bitcoin is important but it should not detract from the value of cryptocurrency more generally. Some limitations of the Bitcoin blockchain have been overcome with subsequent evolutions of cryptocurrency technology. For example, Ethereum replaced the Bitcoin proof-of-work protocol with a proof-of-stake protocol, in principle, making the Ethereum blockchain more efficient and readily scalable (Buterin).

## 20.5 VALUE OF CRYPTOCURRENCY INVESTMENTS

Market participants are still grappling with defining the exact source of value of cryptocurrency. That being said, some progress has been made. No formal, widely accepted formula currently exists to price bitcoins and altcoins, a thorough understanding of the sources of value are still in their infancy. In fact, stripping away the technical complexities behind digital assets, cryptocurrency at its most basic is nothing but a random number. Critics argue that cryptocurrency has no underlying fundamentals that can serve as a benchmark of its intrinsic value (Garcia et al. 2014). Unlike debt or equity, cryptocurrencies are not issued by or tied to any particular publicly traded company and its underlying assets and cash flows. While it is true that the stock of companies such as Microsoft or Amazon may derive some of their value from intangible characteristics such as the brand name of the company (Myers 1977), investors can still estimate the expected prices using assumptions of future cash flows and company fundamentals. A logical question then is why cryptocurrency has any monetary value—the price of a single Bitcoin was \$11,889.38 as of August 20, 2020.<sup>23</sup>

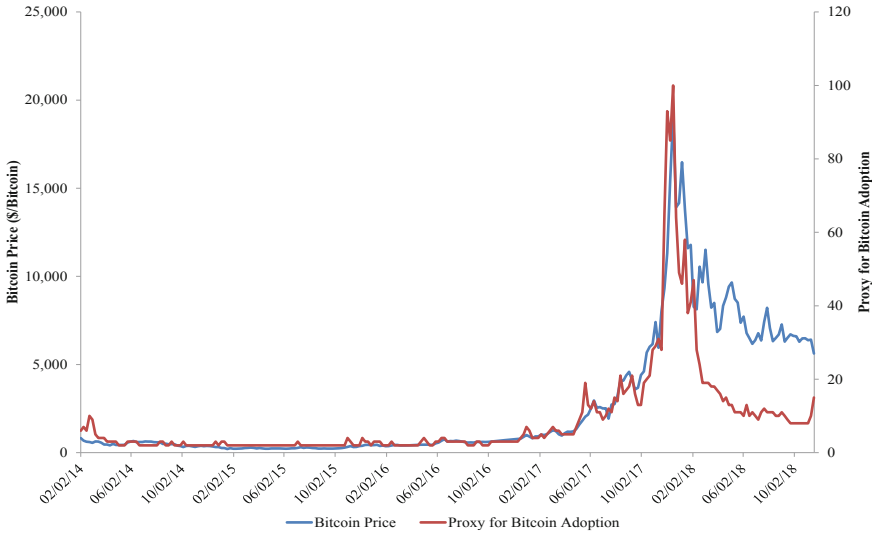
Financial economics could be useful here. A central tenet of asset pricing is that the price of an asset is the expected present value of future cash flows (Cochrane 2002). Cryptocurrencies do not have future cash flow. Price is however above zero, so some market participants see some value in holding it despite the possibility of a lower expected return in the future or put differently, cryptocurrencies have a convenience yield (Cochrane 2002; Hu et al. 2019). The supply of cryptocurrency is limited and deterministically determined by the particular protocol and implementation, which introduces a perceived scarcity value. Different coins have different implementations and different supply dynamics so that the convenience yield most likely varies across coins. The supply of bitcoin and altcoins are either fixed or changing

deterministically and not affected by price so that changes in price are a good indication of the changes in demand. At an aggregate level, higher demand leads to higher price *ceteris paribus*. It is possible that some of the demand could be driven by speculation but could there be some other more fundamental explanation for the demand? There are a few possible explanations to consider here. Cryptocurrencies investments could add diversification to an investment portfolio. Because every cryptocurrency must have an associated blockchain, demand could therefore be driven by technology and the functioning of this decentralized, digital network.

To date, the most plausible explanation of value creation has been network externalities meaning that cryptocurrency is intricately linked to the perceived worth or expected value it has among the transacting participants on the related blockchain. An everyday analogy is a digital, social network such as Facebook. The commodity of exchange on Facebook is personal information posted by members that can be viewed by other members. A Facebook member's utility or value depends on the number of other members that are willing to comment on and exchange personal information with that member. To wit, if none of your friends are Facebook members, then what is the value of posting pictures of your exotic African safari? Similar to the Facebook example, bitcoin has value because a sufficient number of blockchain participants derive economic utility from the Bitcoin crypto-economy (Garcia et al. 2014).<sup>24</sup>

Robert Metcalfe, the inventor of the Ethernet protocol, suggested a simple relationship between the value of a network and the number of users of the network. Now known as Metcalfe's Law, the postulated relationship in Metcalfe's Law indicates that the value of a network is proportional to the square of the number of users of the network. Metcalfe's Law has successfully been applied to Facebook and other social networks (Zhang et al. 2015). Dr. Ken Alabi and Robert Lee of Fundstrat both found that Metcalfe's Law can be used to gain insight into the network value hypothesis of cryptocurrency (Alabi 2017).<sup>25</sup> Positive network effects are present if the value of a product increases with the number of users. Figure 20.2 shows an application of Metcalfe's Law to bitcoin for the period February 2014 through February 2018. Figure 20.1 shows the bitcoin price versus a proxy for the worldwide interest in bitcoin, approximated as the square of the Google Trends score of searches using the term "bitcoin."<sup>26</sup> An increased number of searches could be generated by increased coverage of mainstream media or interest by investors who are gathering information on Bitcoin. The correlation between Bitcoin price and its adoption rate is 0.82 for the period February 2014 through November 2018.<sup>27</sup>

Aimed with this insight, developers at Coinmetrics spearheaded a quantitative measure of value, the network value of transactions ("NTV") which some market participants consider a useful indicator of value.<sup>28</sup> This ratio is a single number summarizing the relationship between a cryptocurrency's price and the monetary value that the crypto-economy offers its users.



**Fig. 20.2** Bitcoin price versus bitcoin adoption (Bitcoin adoption (relative volume of Google searches), Google trends; *Source* Bitcoin closing price from Coinmarkets)

The NTV is based on two readily observable metrics—the market capitalization of the particular coin and its average transaction volume. Investors can use this ratio to detect over-and-under valuation of a particular cryptocurrency, but it can also be used to measure the relative performance of different cryptocurrencies versus other asset classes such as equities.<sup>29</sup> Network value transactions are comparable to stock price multiples such as the price-to-earnings (“PE”) ratio used by equity investors to evaluate the performance of stocks. The PE ratio is a single number summarizing the relationship between a stock’s price, or the dollar invested, relative to the value the investor derives from it (Stowe et al. 2007). The transaction volume measures the value that users associate with a particular coin. The relevant transaction volumes here are the on-blockchain transactions and not exchange-traded cryptocurrency that occurs on the internal network of the exchange and are off-blockchain. On-blockchain transaction volume is a superior measure of value because much of the trading at bitcoin exchanges is speculative and not necessarily representative of user value.

The market capitalization or network value measured as the price of bitcoin times the amount of cryptocurrency coins in circulation is a proxy for the monetary value of the crypto-economy.

$$\text{Market Cap} = \text{Price} \times \text{Circulating Supply}$$

Combining these two measures leads to a single metric that captures dollar invested relative to user utility,

$$\text{Network Value to Transactions} = \text{NTV} = \frac{\text{Network Value}}{\text{Daily Transaction Volume}}$$

The calculations in Fig. 20.2 show a slightly refined version of the NTV defined as,

$$\text{NTV} = \frac{\text{Network Value}}{90\text{Day Moving Average of Daily Transaction Volume}}$$

Using a 90-day moving average of transaction volume provides a better approximation of the fundamental value of the network. Proponents of the Bitcoin NTV suggest that it can be used to detect price bubbles—more specifically, an NTV greater than 20 typically preceded price corrections. The intuition behind NTV is simple: if the value of the network grows faster than the number of users or the value of the network to its users (assuming no other value-enhancing developments), that indicates a bubble (according to NTV).

Figure 20.3 shows the NTV versus bitcoin’s price for the period 2013 through June 2020. Price corrections of 75% in Fall 2013 and 21% during Spring 2014 clearly followed after NTV exceeded 20. The significant correction during Fall 2013 coincided with the problems at the then-dominant Mt. Gox exchange. It is interesting that NTV barely exceeded 20 prior to the December 2017 price correction (as of February 15, 2018, the price fell approximately 66% from the high price in December 2017). The CME and the



Fig. 20.3 Bitcoin price versus NTV ratio (Source Coinmarketcap, Blockchain.com)



Chicago Board Options Exchange (CBOE) launched Bitcoin futures, respectively, on December 17 and December 10, 2017. This episode shows that other market developments not measured by the NTV on-chain transactions caused the price corrections that may not necessarily coincide with an NTV greater than 20.

## 20.6 STYLIZED FACTS OF CRYPTOCURRENCY MARKET STRUCTURE

Cryptocurrencies essentially trade 24 hours per day, seven days per week between a diverse set of participants globally. Cryptocurrency such as bitcoin can be traded “on-chain”—in an over-the-counter (“OTC”) market in which brokers facilitate transactions directly between participants (Lielacher 2018). Transactions in the brokered market are typically large (on the order of \$100,000), non-anonymous and customizable to high-net worth individuals. Cryptocurrency can also be traded “off-chain” at a centralized cryptocurrency exchange. Such venues allow participants to exchange cryptocurrency for fiat currency or for other cryptocurrencies. There are numerous cryptocurrency exchanges worldwide—some exchanges facilitate trading between users and the exchange while others allow peer-to-peer order book trading.<sup>30</sup>

The cryptocurrency exchange landscape has not yet stabilized in terms of the number of exchanges or the services offered by each. Exchanges differ in the number of and types of trading pairs offered, the comprehensiveness of security features, the amount and types of fees, the availability of any dispute resolution, and the quality of market liquidity. Table 20.6 compares a number of features of cryptocurrency exchanges—each of these exchanges requires a two-factor authentication on all trade executions. The number of trading pairs varies from 29 at Bitstamp to over 700 at Binance. Cryptocurrency exchanges

**Table 20.6** Features of select cryptocurrency exchanges

<i>Cryptocurrency exchange</i>	<i>Trading type</i>	<i>Number of markets</i>	<i>Maker fee<sup>a</sup> (%)</i>	<i>Taker fee<sup>a</sup> (%)</i>
Bitstamp	Mostly Fiat/Crypto	29	0	0.1–0.25
Coinbase Pro	Fiat/Crypto and Crypto/Crypto	81	0	0.10–0.30
Bitfinex	Fiat/Crypto and Crypto/Crypto	268	0–0.1	0.055–0.2
Bitrex	Fiat/Crypto and Crypto/Crypto	477	0–0.2	0.08–0.20
Binance	Stablecoin/Crypto and Crypto/Crypto	708	0.02–0.1	0.04–0.1

<sup>a</sup>A range is shown where fees are based on the 30-day traded volume

Source <https://coinmarketcap.com/rankings/exchanges/>

follow a fee structure that is common in some equity markets also where fees to providers of market liquidity (“maker fees”) are typically lower than fees to users consuming liquidity (“taker fee”). The exchange also implements volume discounts whereby fees are lower for participants with higher trading volumes at the particular exchange. Exchanges also use this fee structure as a means to incentivize repeated trade at the same exchange.

Market microstructure identifies the features of a liquid market as tightness of bid-ask spread, depth, and resiliency. A tight bid-ask spread enables a market participant to enter or exit a position at short notice. Market depth indicates that a desired volume of transactions can be immediately executed without introducing slippage to the price, and market resiliency measures the speed with which prices revert to their equilibrium levels following any transaction flow. Market depth and resiliency indicate the market’s ability to absorb significant volumes without adverse effects on prices. Different market structures necessarily involve a trade-off between these various dimensions (van der Merwe 2015). To fully capture the multi-dimensional aspect of market liquidity consider the aggregated traded volume, the average bid-ask spread, and the average number of trades per minute at 10 exchanges for the two-year period ending on June 26, 2019. As Table 20.7 shows, more than 80% of the aggregate volume was traded at the top five exchanges during the period. The table also shows the bid-ask spread, measured at the best bid and offer, and the slippage at ten BTC worth of orders removed from the best bid and offer and at 100 BTC worth of orders from the best bid and offer. The latter measures the depth of the market. The average trades per minute measures the speed of trading.

**Table 20.7** Market liquidity at ten cryptocurrency exchanges

<i>Cryptocurrency exchange</i>	<i>Aggregate traded volume (BTC)</i>	<i>Bid-ask spread (%)</i>	<i>Bid-ask spread (%) at 10 BTC</i>	<i>Bid-ask spread (%) at 100 BTC</i>	<i>Average trades per minute</i>
Bitfinex	24,100,992	0.01	0.13	0.7	52.58
Coinbase Pro	10,555,969	0.01	0.12	0.88	47.17
Bitstamp	8,255,488	0.08	0.29	1.09	19.26
Kraken	4,552,625	0.05	0.38	1.81	12.93
Gemini	4,114,432	0.03	0.23	1.16	9.17
HitBTC	2,474,448	0.12	1.16	8.52	9.98
Bit-x	2,244,662	1.94	3.13	7.99	1.27
itBit	2,144,388	0.06	0.4	3.29	2.85
CEX.IO	686,393	0.15	1.07	9.33	7.38
EXMO	374,352	0.26	3.01	31.12	6.32

Source [https://data.bitcoinity.org/markets/exchanges/USD/2y#rank\\_desc](https://data.bitcoinity.org/markets/exchanges/USD/2y#rank_desc)

## 20.7 STYLIZED FACTS OF CRYPTOCURRENCY TRADING VOLUME AND PRICES

As of 2020, developments in the cryptocurrency markets have been driven by innovation and this natural evolution has been unhindered by any overarching regulations. Trading of cryptocurrency occurs 24 out of 24 hours at several exchanges around the globe. Some aspects of the global cryptocurrency market are still relatively unregulated and much of the current trading volumes are self-reported by exchanges.

Hougan et al analyzed reported trading volumes of 81 exchanges and found that as much as 95% of the Bitcoin trading volume on 71 of the exchanges in their sample represented non-economic trading (Hougan et al. 2019). Hougan and his co-authors identified non-economic or fake trades as trades printing between the bid and ask, multiple hours and days with zero volume, and an approximate monotonic trading volume meaning that an identical amount of trading printed every hour of every day. The 10 exchanges with economic trading volume according to this study are shown in Table 20.8. Due to capital controls in Korea, no Korean exchanges were included in the Hougan study.

The Blockchain Transparency Institute also analyzed trading volumes but included all cryptocurrencies not just Bitcoin using their proprietary algorithms to detect non-economic or trading such as wash trades (trades with themselves). As of April 2019, the Blockchain Transparency Institute found an overlap in the list of exchanges identified by Hougan et al. (they continue to update their lists of exchanges).<sup>31</sup>

The trusted cryptocurrency spot market identified by these studies is therefore substantially smaller and in the case of bitcoin, substantially more U.S.-centric. The regulatory status of the ten exchanges with real trading volume is remarkably different. Nine of the ten exchanges in Table 20.8 are regulated by the U.S. Department of Treasury's Financial Crimes Enforcement Network (FinCEN) division under its Money Services Businesses regulation, and six

**Table 20.8** Exchanges with economic volume as of April 2019

<i>Exchange</i>	<i>Average daily volume</i>	<i>Domicile</i>
Binance	\$217,602,085	Malta
Bitfinex	\$78,164,783	Hong Kong
Coinbase	\$73,225,467	U.S.
Kraken	\$61,267,275	U.S.
Bitstamp	\$58,635,892	U.K.
Bitflyer	\$26,984,684	Japan
Gemini	\$14,581,046	U.S.
ItBit	\$12,150,837	U.S.
Bittrex	\$7,806,571	U.S.
Poloniex	\$4,069,706	U.S.

are regulated by the New York State Department of Financial Services under the BitLicense program. While these regulations do not compare directly to the regulations that attend national securities exchanges or futures exchanges, they do convey certain critical protections. In 2019, Binance partnered with IdentityMind, whose “platform enables digital currency exchanges to comply with know your customer (KYC) and AML regulations worldwide.” IdentityMind’s risk and compliance platform allows real-time onboarding, transaction monitoring, and case management for digital currency exchanges.<sup>32</sup>

Practitioners are also more likely to rely on prices from exchanges with real trading volumes. SFOX a prime dealer and trading platform provides order routing and trading algorithms for best execution across multiple exchanges. SFOX is incented to highlight as many executable trades as possible, as it makes money off of trading volume. Nonetheless, it only tracks prices on eight exchanges, all of which are members of the ten exchanges shown in Table 20.8. The CME publishes two indices to determine the settlement prices of their cash-settled bitcoin futures. The indices’ constituent exchanges include Bitstamp, Coinbase Pro, itBit, and Kraken which were identified as having economic trading volumes (CME Benchmarks 2020). There are many cryptocurrency exchanges, but the real market is much more concentrated.

In the traditional capital markets, traders may execute fake trades to drive up prices. For example, Aggarwal and Wu (2006) note that manipulations often entail a number of mechanisms such as wash trades and rumors. Regarding wash trades, they report: “Manipulators often try to create an artificially high price through wash trades.” Aloosh and Li (2019) analyzed cryptocurrency wash trades confirming the existence of cryptocurrency exchanges with uneconomic volumes but more importantly showing that exchange commits wash trading not necessarily to manipulate price but rather to inflate apparent trading volume. Data aggregators like CoinMarketCap report data on cryptocurrency exchanges and typically rank exchanges by trading volumes.<sup>33</sup> Another reason for cryptocurrency exchanges reporting uneconomic volumes is to attract listing fees from initial coin offerings. During the ICO boom of 2017 and 2018, it was common for newly listed coins to pay significant fees to list their tokens on various exchanges.<sup>34</sup> Notwithstanding the motivation for doing so, the prevalence of uneconomic volume in cryptocurrency markets should raise questions about the possibility of distortions in cryptocurrency prices even on exchanges with economic trading activities as discussed below.

### 20.7.1 *Are Prices Distorted by Uneconomic Trading Volumes?*

A necessary condition of equilibrium in traditional financial markets is the principle of no-arbitrage or the simultaneous purchase and sale of the same, or essentially similar, product at advantageously different prices at two different venues” (Sharpe and Alexander 1990). According to this theory, you should be able to buy a cryptocurrency at the exchange with a low price and instantaneously sell it at a different exchange with a higher price for a profit. In

practice, such a transaction would entail risks and would require some capital investment both of which are assumed to be irrelevant in theoretical arbitrage. The theory of no-arbitrage provides unique insights into financial markets and should in principle do the same for cryptocurrency markets and aid the understanding of how prices are related across exchanges.

Hougan et al. analyzed the Bitcoin spot market using two criteria for demonstrating no-arbitrage proposed by the U.S. Securities and Exchange Commission namely, the close alignment of prices across different trading venues and the speed with which price differences converge. The Hougan study found that “institutional-quality arbitrageurs and algorithmic programs are in place that monitor the system and identify and capitalize on any pricing discrepancies” so that prices among the ten exchanges in Tables 20.8 trade closely together and also that disparities are rapidly arbitrated away (Hougan et al. 2019). The Federal Reserve Bank of San Francisco suggests that the launch of CME’s bitcoin futures in December 2017 improved the efficiency of the bitcoin spot market because it would enable potential arbitrageurs to establish short positions in bitcoin (Hale et al. 2018). In an alternative arbitrage strategy, analyzed by Makarov and Schoar, a participant:

hold a positive balance of bitcoins at two different exchanges and simultaneously buy and sell bitcoins across the two exchanges whenever the price on one exchange deviates from that on the other. Naturally, the bitcoin balance of the arbitrageur will go down on the exchange where the price of bitcoin is high (since this is where she would sell bitcoin) and increase on the exchange where the price is low. To replenish it, the arbitrageur needs to transfer bitcoins from the exchange with high bitcoin balance to the one with low balance and vice versa for capital. In an ideal world, she would like to instantaneously shift trading gains from exchanges where she sold bitcoin to the ones where bitcoin is cheap and then repeat the arbitrage transaction. (Makarov and Schoar 2020)

This strategy depends critically on how quickly, or if the arbitrageur can transfer capital from one account to another. The rules surrounding fund withdrawal at cryptocurrency exchanges vary (Samson and Stafford 2017):

Coinbase, the most popular US exchange, ‘temporarily disabled’ buying and selling midway through the trading day on Friday, citing ‘today’s *high traffic*’. It warned customers trying to withdraw funds into accounts denominated in euros to expect delays of up to 10 days owing to the ‘extremely high volume of transactions.’

Makarov and Schoar (2020) showed that country-level capital controls can limit cross-border arbitrage and lead to price deviations for the same cryptocurrency at difference exchanges domiciled in different countries. The effects of capital impediments on asset prices are well documented for the traditional financial markets (Shleifer and Vishny 1997; Duffie 2010; Mitchell and Pulvino 2012). For cryptocurrencies, the apparent failure of no-arbitrage

conditions could also exist for other reasons such as differences in trading fees, withdrawal times, and withdrawal fees, particularity for fiat currencies, across exchange even within the same jurisdictions.

The one unanswered question is whether uneconomic trading volumes affects pricing in the real spot market. If arbitrage could exist between exchanges with non-economic volume and the real spot market, the invisible hand of arbitrage could spread the impact of the fake exchange's prices across the rest of the market. Exchanges with fake volumes typically do not have any meaningful liquidity and arbitrage across exchanges with economic trading would fail to align prices across these exchanges. The consensus view is that the exchanges with fake volume would not influence prices on exchanges with real volume (Hougan et al. 2019) because exchanges with a preponderance of fake volume cannot and do not participate in the coordinated central liquidity pool or automatically influence the consolidated price just by having a different price of their own.

An important corollary to the no-arbitrage hypothesis is the efficient market hypothesis which basically says that asset prices should change only in response to news about fundamentals or put differently, asset prices should follow a random walk. The challenge with cryptocurrency markets is that “fundamentals” are not clearly defined and similarly, what constitutes new information in the crypto-economy? Furthermore, additional empirical research on the time-series properties of cryptocurrency prices is needed to establish that such prices exhibit the random walk behavior characteristic of efficient markets.

## 20.8 CONCLUSION

The real innovation behind cryptocurrency is the blockchain, which enables user-to-user trading among decentralized participants and settlement and recordkeeping of such transactions without a trusted, centralized authority. Transactions are settled by a collection of anonymous, active participants referred to as miners. The price of cryptocurrency is closely linked to the number of participants assigning value to it by engaging in trading.

Cryptocurrency is not fiat money, but it could be used as a medium of exchange in the crypto-economy. In the broader economy, cryptocurrency functions as a digital, intangible asset with little resemblance to most traditional asset classes. From an economic perspective, cryptocurrency shares the limited supply characteristic of non-renewable commodities—in the case of cryptocurrency the limited supply is an artificial scarcity embedded in the protocol design.

Cryptocurrency may add diversity to an investment portfolio because of its low correlation with more traditional assets. A potential investor should however recognize the qualitative and quantitative risks typically associated with an investment in cryptocurrency such as the high price volatility and unique market structure.

## NOTES

1. A potential area for future research is whether the infinite divisibility of bitcoin would be viable without devaluation of the currency.
2. By contrast, only certain, permissioned entities are allowed access to the typical private or permissioned blockchain. See Burnside and Takar (2018).
3. The first step to trading cryptocurrency is the creation of a wallet, which simply entails downloading software to your digital device.
4. <https://www.blockchain.com/btc/address/12ib7dApVFvg82TXKycWBNpN8kFyiANldr>.
5. Coinmarketcap, <https://coinmarketcap.com/rankings/> (last accessed on August 19, 2020).
6. Litecoin uses a different hashing algorithm that improves on the time-power efficiency of Bitcoin's mining. <https://arstechnica.com/information-technology/2013/05/wary-of-bitcoin-a-guide-to-some-other-cryptocurrencies/> (last accessed on August 20, 2020).
7. <https://ripple.com/xrp>. The classification of XRP as a cryptocurrency or digital assets was a hotly debated topic at the time of this publication. See, for example, <https://www.coindesk.com/xrp-security-ripple-debates-explained>.
8. [https://www.cmegroup.com/trading/equity-index/us-index/bitcoin\\_contract\\_specifications.html](https://www.cmegroup.com/trading/equity-index/us-index/bitcoin_contract_specifications.html); see also, <https://www.cmegroup.com/confluence/display/EPICSANDBOX/Bitcoin>.
9. <https://www.cmegroup.com/education/articles-and-reports/analysis-of-cme-cf-bitcoin-reference-rate.html>.
10. <https://www.theice.com/products/72035464/Bakkt-Bitcoin-USD-Monthly-Futures-Contract>.
11. We use money here to refer to fiat currency such as the U.S. dollar, Euro or British Pound.
12. Money can also be deposited at a bank or in a certificate of deposit to earn interest over time.
13. <https://cryptonews.com/guides/who-accepts-bitcoin.htm> (last accessed on August 20, 2020).
14. "Coinbase Releases Tool for Merchants to Accept Cryptocurrencies," *Bloomberg News*, February 14, 2018. Bitcoin Comes to Whole Foods, Major Retailers in Coup for Digital Currency," Jeff John Roberts, *Fortune*, May 13, 2019. <http://www.fortune.com/2019/05/13/bitcoin-comes-to-whole-foods-major-retailers-in-coup-for-digital-currency>.
15. The price in dollar is converted to the price in bitcoin using the exchange rate of \$11,889.38 \$/BTC as of August 20, 2020 from CoinMarketCap.
16. <https://cointelegraph.com/news/driven-by-financial-institutions-stablecoin-acceptance-turns-a-corner>.
17. Stock is represented using the Ibbotson U.S. Large Stock Total Return Index from Morningstar; debt is represented using the Investment Grade Bond Index; foreign exchange is represented using the average of the equal weighted monthly return of exchange rates of USD versus Euro, Yen and GBP respectively published by Morningstar; and commodities are represented using Bloomberg WTI Crude Oil Sub-Index Total Return.
18. January 2014 was selected so as to be well after the bankruptcy date of the Mt. Gox cryptocurrency exchange in February 2013.

19. Kurtosis measures the size of the tails of the distribution relative to the tails of the standard normal distribution. Skewness measures the symmetry of the return distribution around zero. Volatility is measured as the standard deviation of the return and it is a proxy for the risk in asset returns.
20. Correlation varies between minus one and plus one.
21. The Sharpe ratio is defined as the return on the asset in excess of the risk free rate (30-day U.S. Treasury return) divided by the standard deviation of returns. Volatility measures the total risk in the asset, including systemic and idiosyncratic risks. A higher Sharpe ratio represents a higher risk adjusted return.
22. There are typically two measures of on-chain bitcoin transactions. The confirmation time refers to the time it takes for a transaction to transfer between wallets. The other is the amount of transactions per section, which determines the scalability of the network. <https://medium.com/coinmonks/understanding-cryptocurrency-transaction-speeds-f9731fd93cb3>.
23. Price of BTC as of August 20, 2020 from CoinMarketCap.
24. Garcia, Tessone, Mavrodiev, and Perony presented an analysis supporting the network hypothesis of cryptocurrency analysis showed that the value of Bitcoin is causally linked to “social factors, which are composed by the interactions between the actors of the market.” Garcia’s analysis ended in October 2013 and they used the Bitcoin to USD price from the now bankrupt exchange Mt. Gox.
25. FundStrat top strategist Rob Lee introduced the idea of applying Metcalfe’s Law to value Bitcoin. See <http://www.businessinsider.com/bitcoin-price-how-to-value-fundstrat-tom-lee-2017-10>.
26. The Google Trends score measures the absolute volume of a search term relative to the number of searches received by Google. The highest value of the score is 100. No quantitative measurement is assigned to the score though it measures the relative popularity of the search term over the specified time period. See <http://searchanalysisguide.blogspot.com/2013/04/understanding-google-trends.html?m=1>.
27. The correlation is statistically significant at the 1% level. Correlation measures the strength of a linear relationship between two variables and the correlation typically lies between one or minus one. If there is no linear relationship between two variables the correlation is zero.
28. This ratio was introduced and developed and refined by Coin metrics and Cryptolab Capital. See <https://medium.com/cryptolab/https-medium-com-kalich-kin-rethinking-nvt-ratio-2cf810df0ab0>.
29. The equivalent of the NTV ratio for equities would measure market capitalization to sales volume. <https://www.norupp.com/nvt-ratio-and-nvt-signal-ratio-detect-bitcoin-bubbles/>.
30. As of June 2019, CoinMarketCap reported volume on 258 exchanges. See <https://coinmarketcap.com/rankings/exchanges/>.
31. <https://www.bti.live/reports-april2019/>.
32. <https://www.binance.com/en/terms>.
33. The CoinMarketCap is described as “the highest traffic website in our space, and the biggest referrer for all exchanges.” Changpeng Zhao, posting on Twitter as @CZ\_binance, a verified Twitter account, on March 18, 2019. [https://twitter.com/cz\\_binance/status/1107833648802197504](https://twitter.com/cz_binance/status/1107833648802197504).



34. “CRYPTO: Token and Coin Exchange Listing Fees,” Autonomous Next, April 3, 2018. <https://next.autonomous.com/thoughts/crypto-exchange-listing-fees>.

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# How Does Digital Transformation Improve Customer Experience?

*Spencer Li*

## 21.1 INTRODUCTION

Digital transformation is inevitably the hottest directive and strategy in management, FinTech, Blockchain, and customer experience to achieve their stated goals sustainably. For instance, digital transformation changes a simple function such as sales order or warehouse, or coordinates transformation across functional areas, such as customer experience or digitization of products and services. Regardless of the focus, challenges, and top priorities the CEO facing, digital transformation is changing the entire industry globally. Among many executives today, transforming business in the digital age is a top priority. The main key factor of digital transformation is how to maintain repeatability and sustainability.

Disruptive technologies drive digital change to affect the way of living. Let us review the landscape of disruptive technologies and digital transformation.

On average, most corporates strongly believe that by 2020, half of their revenue will come from digital channels. Also, the World Economic Forum forecasts that by 2025, the total economic value of digital transformation to business and society will exceed \$100 trillion [1]. From any perspective, the most significant growth opportunity that most organizations can grasp the golden growth opportunity in these fast-growing digital markets.

The latest trends in digital transformation reflect particularly rare lessons in business and technology over the past few years. These lessons gave us insights to learn. During the digital transformation process, the stakeholders can learn

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a lot of lessons and insights to avoid many painful, costly, and time-consuming implementations in the process. Smart organizations can reduce their workload and fewer mistakes by adopting a learning organization.

“Digital transformation will be a crucial Component of Top-Level Data Strategies” [2]. We have now realized that a digital transformation is a data-driven approach to working to create a competitive advantage in all aspects of their business. An oil exploration and production companies can use the data to perform wellhead drilling adjustments hourly instead of daily to maximize oilfield production.

In recent years, some corporate digital transformation projects told us the applications were quite repetitive and not even innovative enough, just like copying similar ideas from the public domain and their competitors. In some cases, the readiness for innovation management and strategies are pre-mature, and the persons-in-charge lacks innovation management and implementation experience. For each revolution like the industrial revolution, it takes years to transform and fine-tune methodologies, design, planning, implementation, and results review.

Ernst & Young advocates choosing an innovation adoption framework to implement innovative initiatives. “The process must be driven from the top, encouraging innovation and building lessons learned into the processes. An innovation adoption framework is needed to support innovation, with clear accountabilities, decision-making frameworks, and criteria for success. New ideas should be encouraged, and suggestions for innovation should be welcomed via internal social media. Hackathons are also great ways to encourage staff to develop and articulate innovative ideas”[3] (Fig. 21.1).

Agile development is one of the most popular ways to implement an innovative pilot project. It helps the SCRUM team to build a minimum viable product (MVP) as soon as possible. It enables an agile and iterative way to collect feedback and suggestions to further products and services evolve.

Disruptive technologies like Blockchain, FinTech, 5G, IoT are driving forces to cultivate different stakeholders to adopt different viable technologies to achieve their own goals and gain their competitive advantages in the earlier stages compared with their competitors.

In 2020, digital transformation is a real drive to the customer journey. 2020 signifies the center stage and paramount importance of a fresh new class of disruptive technologies impacting the societies and the world. Following disruptive technologies are the most significant ones driving digital transformation in 2020.

## 5G

2020 will be the year of 5G. Amongst significant players, AT&T, Ericsson, Huawei, LG, Nokia, Qualcomm, Samsung, and Verizon, Huawei seems to be a global 5G deployment leader, particularly in some countries like Germany, China, UK. With 5G infrastructure in place and launching of more Android

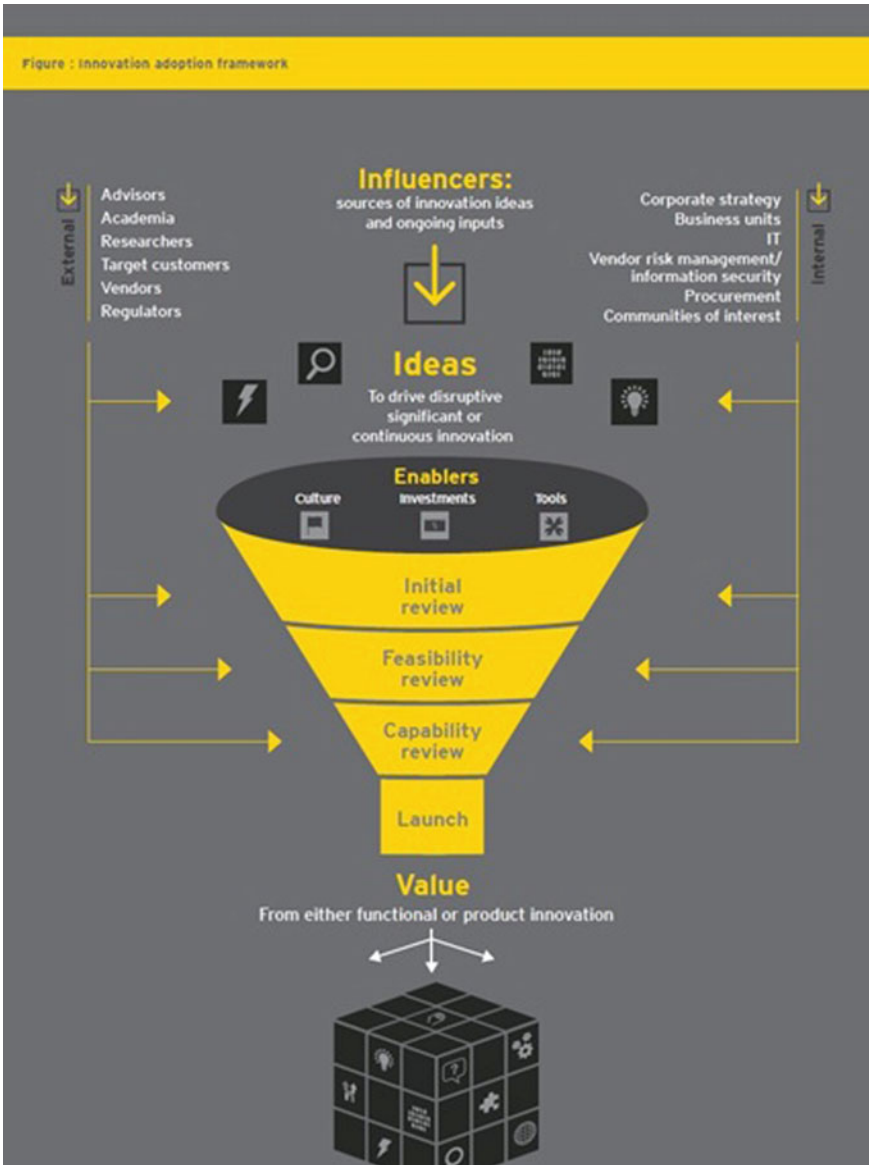


Fig. 21.1 Innovation adoption framework (Source EY)

mobile phones, a faster and reliable broadband speed (10× to 20× faster than 4G) and cellular networks drive and accelerate the advancements and better customer experience in all initiatives of smart cities, smart manufacturing, smart inventory, smart medicals, intelligent transportation, etc.

### *Blockchain and Crypto-currencies*

Blockchain will continue to be a trend in 2020 because recent research suggested that “global spending on AI will reach \$57.6 billion by 2020, and 51% of businesses will be making the transition to AI with blockchain integration” [4].

More than \$1.5 billion investment in blockchain technology like Ethereum and Hyperledge, Libra, etc., with an increasing trend in continuous Blockchain investment.

Hacker Noon [5] predicts several blockchain trends. Among the most important are:

- **New Business Ecosystem**

Digital ecosystems are growing by building digital partnerships among different stakeholders using their core business functions. “For instance, a blockchain-based image rights management platform by Kodak, food safety, intellectual property and royalties, and real estate/asset management” [5].

- **Machine and Human-readable Smart Contracts**

Ricardian is one of the leading players in this business sector. “In 1994, Nick Szabo first proposed the concept of smart contracts. Nick said that a smart contract is a computerized transaction protocol that executes the terms of a contract. The general objectives of smart contract design are to satisfy common contractual conditions (such as payment terms, liens, confidentiality, and even enforcement), minimize exceptions, both malicious and accidental, and minimize the need for trusted intermediaries. Stated economic goals include lowering fraud loss, arbitration and enforcement costs, and other transaction costs” [6].

- **Emerging Importance of BaaS (Blockchain as a Service)**

Cloud-based services can let companies leverage the power of blockchain. For example, AWS (Amazon Web Services) has applied blockchain technology as BaaS for its subscription-based services. Many players like Microsoft, IBM, and China’s Alibaba have already participated in this kind of business of BaaS.

- **Hybrid Blockchain**

Whatever the combination of public, private, NGO, and NPO Blockchain, Blockchain offers cheaper services and faster operations by multi-disciplines, multi-industries collaboration operations.

- **Tokenization of Assets on Blockchain**

The Digital Transformation Trends 2020 report, from Digital Leaders, forecasted “ownership of assets can be monitored in tech like a Blockchain, and will be on the rise in 2020” [5].

### *Artificial Intelligence and Machine Learning*

Three independent value propositions speed, scale, and convenience determine the value of artificial intelligence and machine learning for data analysis. Speed and scale have the advantage of automatically analyzing large amounts of information and data, rather than assigning personal data analysts to complete tasks. AI and machine learning algorithms are very good at data analysis and can work in the cloud. It can now analyze complex datasets in a fraction of the time it used to take just two years ago.

In terms of convenience, adding AI and machine learning to analysis tools makes them intuitive, easy to use, and more reliable.

### *Faster WiFi*

In 2020, 5G and WiFi6 bring us much speedier processing and wireless connection speeds, which are the perfect fit for faster connectivity for office and home. WiFi6 offers 3× faster in download speeds than 5G. With faster speed, WiFi6 provides at least three advantages:

- The increasing number of connected devices up to 50 compared with the existing limit of WiFi5 10 devices;
- WiFi6 networks offer better quality and faster data volume;
- WiFi6 will be the de facto standard for most corporates and SMEs for their company communication network.

### *Cloud*

A recent report pointed out that “Cloud computing has made forays for years already, and it changes the business models of IT giants like Microsoft and IBM to adopt it” [7]. However, powered by the growth of quantum and cloud spending, TechGenix [5] firmly believes that Cloud computing is a rapidly changing ICT environment. To keep up with this digital transformation, business leaders need to be more adaptable than ever.

The report also predicted that “the rise of cloud services like PaaS (Platform as a Service), IaaS (Infrastructure as a Service), and SaaS (Software as a Service) illustrate the demand for the simplicity of cloud computing services offered by the cloud. TechGenix predicts that PaaS usage will rise from 32% in 2016 to 56% this year, and points out that open source is the trend in ICT development” [5].

### *Big Data*

A recent report warned out that “companies that still aren’t investing heavily in analytics by 2020 probably won’t be in business in 2021. There is far



too much valuable customer data to be collected, processed, and turned into insights for any company to remain competitive without making full use of modern analytics tools” [8].

Using traditional thinking without data analytics is no longer a practical business solution for business executives.

This report told us why “we see a consolidation of analytics capabilities across the tech world, from Salesforce acquiring Tableau, to Microsoft creating its Power Platform” [7]. “Every major tech company has already figured out that the future is in data—most specifically, the real-time processing of it—and so, regardless of what industry you’re in, analytics will again be one of the most dominant focal points of digital transformation in 2020” [9].

## 21.2 DIGITAL TRANSFORMATION

### 21.2.1 *Digital Transformation Era Comes*

As mentioned in previous chapters, disruptive technologies like Blockchain, FinTech, 5G, IoT are driving forces to cultivate different stakeholders for an innovative culture. The executives adopt different viable technologies to achieve their own goals and to gain their competitive advantages in the earlier stages compared with their competitors.

In recent years, some corporate digital transformation projects pointed out that some digital transformation applications were quite repetitive and not even innovative enough due to lack of originality. In some cases, the organization’s readiness for innovation management and strategies is pre-mature. The persons-in-charge lacks innovation management and implementation experience. For each revolution like the industrial revolution, it takes years to transform and fine-tune methodologies, design, planning, implementation, and results review.

According to Accenture Technology Vision (2017–2019), “DARQ Power was the next set of technologies every company would need to master” [10].

#### **Trend 1: DARQ POWER—Understanding the DNA of DARQ**

Corporates ought to understand the new capabilities of DARQ technologies (Distributed Ledger Technology, Artificial Intelligence, Extended Reality, and Quantum Computing). By implementing these technologies together, corporates can capitalize on the value of DARQ technologies by launching meaningful and productive pilot projects. Finally, leaders will transform their corporates into maturity.

“Across the DARQ technologies, investments and adoption are rising steadily. Virtual Reality (VR) and Augmented Reality (AR) saw a 12 percent increase in investment between 2016 and 2017, reaching \$3 billion that year; in the first three months of 2018, companies invested \$750 million in AR/VR startups. Distributed ledger investments are exploding, with Blockchain and

Cryptocurrency-focused startups alone collecting almost \$3.9 billion in investments in the first three quarters of 2018—nearly three times the total for all of 2017” [10].

Accenture Technology Vision (2017–2019) stated that “SMAC technologies, covering social, mobile, analytics and cloud, are dominant in 2019 and onwards. They can allow the business to have the required capabilities to understand consumers and partners at a deeper level than ever before” [10].

For example, mobile and cloud can let users enjoy digital services anywhere. Cloud provides many choices of on-demand computing services like SaaS, PaaS. Analytics can optimize products and services to increase efficiency and reduce costs.

Evidenced from eighty-nine percent of businesses adopting one or more DARQ technologies, it is the first wave for companies to apply DARQ technologies to drive differentiation.

## **Trend 2: GET TO KNOW ME**

The recent report stated that “technology identities are driven by digital demographics, which reflect consumers’ choices across a variety of devices and services. 83% of business and IT executives agree that digital demographics give their organizations a new way to identify market opportunities for unmet customer needs” [10].

The digital era offers clear snapshots of customers at a single point in time. However, the post-digital era will deliver digital services with a holistic view of customers’ digital activities, preferences, personal needs, and goals.

“In the post-Digital world, differentiation comes from applying digital in powerful new ways. The technologies needed to innovate and differentiate beyond the foundational adoption of digital tools and concepts. It’s an era where building trust with customers, employees, business partners, and communities through a responsible approach to technology is the top priority for all C-suite executives who want to grow and succeed” [11].

“The shift toward technology-driven experiences has already begun in earnest. IKEA built an augmented reality app that allows customers to browse the company’s catalog and place 3D renderings of furniture directly in their physical environment” [12].

People entrust digital services to pay utility bills, online shop, chat with friends, receive the news, control the lights and appliances in their homes, work. Disruptive technologies accelerate social movements recently. “In 2019, for the first time, US consumers will spend more time with their mobile devices than they do watching TV. Smartphones account for 70% of that mobile time—21% of total time spent with media in the US—and continue to attract minutes. The average US adult will spend 2 hours, 55 minutes on a smartphone in 2019, a 9-minute increase from 2018. Among smartphone users in the US, time spent with their device is 3 hours, 10 minutes per day” [10].

Seamless integration of technologies into the customer journey will play as competitive advantages against competitors. “Look at the difference in the

ways people use voice technology: among US adults, 70 percent use voice services to play music, 31 percent use them for smart home commands, and just 17 percent use them for food delivery or takeout” [13]. In the digital age, successful adoption of technology can build a living, individualized view of each consumer, whereas it drives productive, continuous, experience-based customer relationships.

“North American life insurance company John Hancock has found technology identities to be so valuable that it has done away with the traditional life insurance model. Now, the company offers interactive life insurance policies that incorporate clients’ fitness and health data through wearable devices” [10]. John Hancock’s “Vitality program policyholders qualify for discounts when they hit specific exercise targets and can get personalized premiums and rewards for their activity” [10].

“Vitality” program is a successful case of adopting new technologies to differentiate insurance company among themselves. “The average customer with a traditional insurance plan engages with their life insurance company one to two times per year. The new Vitality policyholders engage with John Hancock more than 500 times per year” [14].

Accenture Technology Vision (2017–2019) reported that “41% of executives strongly agree that understanding consumers’ behaviors around technology will be critical for their organizations to increase customer loyalty” [14]. Therefore personalization of product and service offerings by using technologies can drive customer loyalty. Executives can further promote the development of new personalized business models based entirely on the technical characteristics of customers. Necessarily, companies must earn consumer trust and loyalty by assessing customer needs based on the company’s opportunities—this will require uninterrupted cyclical action.

### 21.2.2 *Digital Transformation Strategies*

Refer to the article “A roadmap for a digital transformation,” March 2019, By Tanguy Catlin, Johannes-Tobias Lorenz, Bob Sternfels, and Paul Willmott; there are three stages and ten guiding principles of digital transformation.

#### **Defining value (Stage 1)**

“CEOs must understand the magnitude of the undertaking, management commitment, and investments, and then they are making the right direction on digital transformation to achieve their goals” [10].

There are three principles in Stage 1.

##### **Principle 1—Secure senior management commitment**

The primary pre-requisite requirement is the CEO’s commitment. The CEO must set the digital transformation as the top priority with clear vision statements. Of course, all executives and leaders are accountable for target milestones.

ING branded its transformation, “Think Forward.” In the Investor Day 2019 on 25 March 2019, Ralph Hamers, CEO of ING, said that “Think Forward has been accelerated through structural changes while ING is acting as a platform. ING is delivering on the right strategy and continuing its transformation into a dynamic digital player. It captures the value embedded in our platform and unlocks value through its key accelerators” [15].

To drive the digital transformation, CEOs must be single-minded and aggressive. “Their direction is provocative, disruptive, ambitious” [16].

**Principle 2—Set clear, ambitious targets**

“Investments are linked to clear, ambitious targets. They help with measurable and achievable results. First, it needs to quantify what digital technology can deliver. Second, setting clear targets, in the beginning, prevents slippage and delay on digital transformation milestones. And third, it imposes discipline on the process of deciding which initiatives to pursue maximum impact. Targets are needed for each source of value creation—cost savings, revenues, improved performance of agents, and satisfaction of employees and customers—and for new ways of working and the new capabilities required” [15].

**Principle 3—Secure investment**

Digital transformation requires a huge investment. Ernst & Young said that “investment in digital technology is expected to reach an eye-watering \$2 trillion by 2022” [15]. “Importantly, companies will need to allocate investment both to improve the current business and to build new businesses as the insurance model evolves. To acquire expertise in new fields and keep abreast of innovation, for instance, insurers will need to invest in partnerships or a venture capital arm, perhaps both, as well as in their innovation labs” [15].

## Launch and acceleration (Stage 2)

There are always resources constraints different initiatives in the corporates. When the digital transformation encounters various obstacles, without top management commitment, the digital transformation may be treated as a non-urgent task and will be further delayed or postponed. Corporates must secure enough resources before projects being kick-off. Top management, like a chief information officer (CIO) or chief digital officer (CDO), should lead the team with organizational re-structure embracing digital culture.

There are four principles in Stage 2.

**Principle 4—Start with lighthouse projects**

To kick-off the digital transformation journey, it is strongly advisable to start with projects achieving cost-saving and, or productivity, gained with affordable risk. Some projects may be chosen in the areas of process

re-engineering in customer services, sales order processing and administration. The management and whole digital transformation will feel excited about the outcomes like cost savings can be as high as fifty percent, and effectiveness, measured in return on investment, can rise by as much as ten percentage points.

**Principle 5—Appoint a high-caliber launch team**

“The importance of securing a high-caliber launch team, often under a CDO, cannot be overstated. A CDO can prove invaluable coordination on digital transformation—avoiding duplication by devising a methodology for the redesign of customer journeys that can be replicated across the organization as digitization efforts are extended, for example.

The corporates are facing a challenge in recruiting the digital talent of the highest caliber in data scientist and customer journey. One way to meet the challenge is to start by hiring a renowned expert to attract other team members to join. Some companies hire recruitment agencies that specialize in design thinking.

People’s leadership skills are essential too. Transformation is not just about tipping everything upside down, reinventing products, and disrupting value chains. It is partly about balancing old and new and integrating fresh talent with old, valued hands” [15].

**Principle 6—Organize to promote new, agile ways of working**

Building a digital unit independently of the organization will foster new working methods for digital success like “agile product development, test-and-learn methods that speed progress while keeping the focus on customers, and cross-functional teams that pool-specific types of expertise” [15].

Talent development is a crucial management practice for the digital unit. With top management commitment and corporate vision, a digital group can recruit and retain those digital experts while offering them “freedom from incumbents’ organizational constraints and the support of like-minded colleagues” [15].

**Principle 7—Organize to promote new, agile ways of working**

Agile ways of working and thinking require fast, collaborative, empowered digital skills. A new corporate culture must focus on the customer journey. However, it is not an easy organizational reform task. “Recent McKinsey research has shown that 46 percent of financial services executives feel cultural or behavioral change is the biggest challenge they face in pursuing their digital strategies” [15].

It is a good starting point, “How does this create value for the customer?” before we decide to make a change.

### Scaling up (Stage 3)

At the 18-month point, the digital transformation seems on the right track. The corporates should launch a set of initiatives on a large-scale to materialize their values further to get a better Return on Investment. This full range of digital transformation will devise an entirely new operating model for the organization.

There are three principles in Stage 3.

#### **Principle 8—Sequence initiatives for quick returns**

Fast return is vital to adopt digital transformation strategies in long term. The more value the digital transformation achieves, the more financially viable it is and the more support it receives. Therefore, it is imperative to adopt manageable digital initiatives to promote the performance of the core business while improving the source of future business growth. That is why the management prioritizes simple pilot firstly and always expects a faster payback period with cost savings.

Tracking returns is critical to ensuring that all available value is captured. When the plan is successful and delivers the expected financial benefits and increased productivity, the board and the senior team should have the courage to advance to achieve more goals.

#### **Principle 9—Build capabilities**

Skills and systems will need to be improved. A lot of internal training will also be required. Business leaders will need to understand the strategic value of IT. Ultimately, however, it's essential to help all employees rethink how they work because the end-result of digital transformation is a company-wide agile operating model.

#### **Principle 10—Adopt a new operating model**

They will need a network structure that is organized around sources of value, giving product managers the power to make decisions with cross-functional implications. The team is dynamic. When they capture the potential benefit, they will be disbanded and then restructured around new sources of revenue growth or cost reductions. Some companies call them SCRUM teams.

The entire organization, not just the IT organization, will adopt an agile working method. There is always an IT backlog. The IT strategy encourages early prototyping decisions related to technology architecture, data architecture, and platform decisions. Cycle time and costs will be reduced.

Digital transformation focuses on technological change. The organization's talent development needs to provide more flexible, empowered, and meaningful career paths.

### 21.2.3 *Digital Services in Practice*

Technology innovation always inspires leaders and companies to evaluate current business strategy, business plans, existing resources, internal task environment, and external task environment. Some operational changes achieve competitive advantages in the long run.

In the digital transformation era, agile computing and cloud can speed up the development of new business models and platforms for global business operations. One of the critical success factors is to keep an innovation management culture that nurtures flexibility and adaptation to changing business and technologies by maintaining agility effectively.

Hence different types of digital services and customer experience are being implemented by various industries. The following section will elaborate on these industries briefly.

According to G2 Crowd, some industries have been affected by digital transformation in 2019. They are “AI, Big Data, and RPA, Agtech, AR/VR, Cybersecurity, Content Management, ERP, Fintech, HR, etc.” [15].

Following is the real case in Hong Kong using new digital services to be shared with readers. “Wealth Mind HK” specializes in the distribution and rental of heavy construction equipment and machinery in Asia for more than 20 years. One of the challenges facing is to collect rental income quickly to improve its liquidity to expand its growing rental business. “Coinstreet Partners helped them to structure a fixed-income tokenized debt Security Token Offering that is secured by equipment title and rental cash flow. Security Token Offering investors will be entitled to bi-annual coupons at a fixed interest rate (which can be paid by any major fiat currencies or stablecoins), guaranteed redemption of principal with 3 years’ maturity, and the possible upside of profit-sharing from underlying assets” [17]. Security Token Offering provides a trading exchange for the investor.

This arrangement is an asset tokenization in which “tokenized assets, digitized securities or security tokens are created through distributed ledger technology. Under the current system, many pre-unicorn opportunities are only available to big VC and PE funds with special relationships. In the new system moving forward, similar opportunities can be made available to smaller investors around the world. The vision of financial inclusion can become a reality much quicker in this new token economy” [18] (Fig. 21.2).

## 21.3 CUSTOMER EXPERIENCE AND CUSTOMER SATISFACTION

A recent report from McKinsey “has highlighted the importance of optimizing customer journeys rather than merely focusing on touchpoints. It tells companies ought to “identify and understand the customer’s journey” [18]. It adds, “It means paying attention to the complete, end-to-end experience customers have with a company from their perspective. Too many companies focus on individual interaction touchpoints devoted to billing, onboarding, service calls,

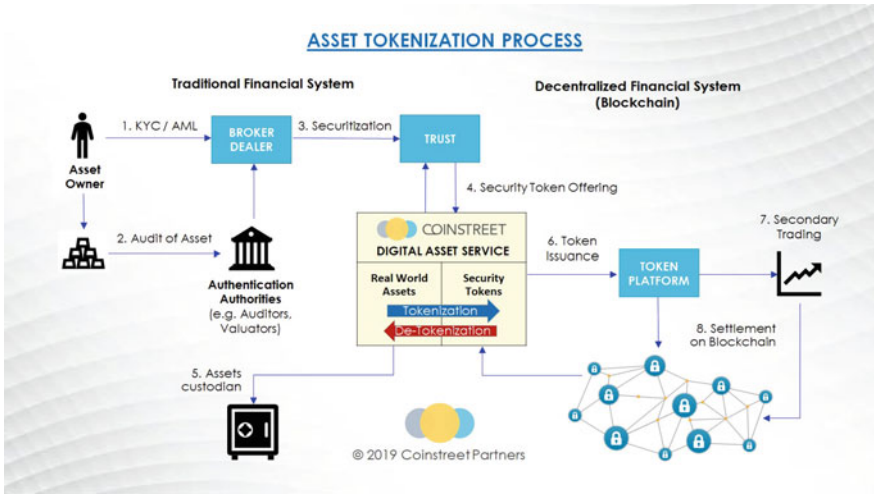


Fig. 21.2 Asset tokenization process (Source Coinstreet Partners)

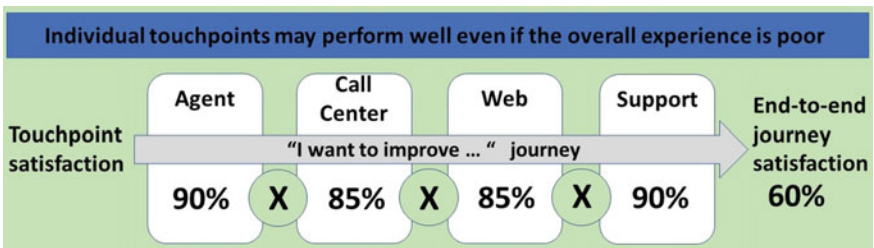


Fig. 21.3 Touchpoints satisfaction vs. End-to-End journey satisfaction (Source McKinsey Digital Labs)

and the like. In contrast, a customer journey spans a progression of touchpoints and has a clearly defined beginning and end” [19]. McKinsey’s research concludes that “customer journeys are more strongly correlated with business outcomes rather than touchpoints” [19].

A recent McKinsey survey found out that higher customer satisfaction with customer journeys rather than only touchpoints. For instance, it found that “seventy-three percent and sixty-one percent higher customer satisfaction in health insurance and hotels respectively more likely when journeys work well than when only touchpoints do” [4] McKinsey’s survey said that customer experience companies through end-to-end experiences, not touchpoints. Although each touchpoint may satisfy customers well, the overall experience may be reduced due to the multiplier effect of each touchpoint in each stage in a multi-stage customer journey (Fig. 21.3).





**Fig. 21.4** Six hallmarks of a customer experience transformation (*Source* McKinsey & Company)

The “Six hallmarks of a customer-experience transformation” conduct the digital customer transformation by six steps to improve the customer journey (Fig. 21.4).

Six steps include “(1) Define a clear customer experience aspiration, value proposition, and common purpose; (2) Develop a deep understanding of what matters to customers to inform journey redesign; (3) Use behavioral psychology to manage customer experience; (4) Innovate journeys, including digital and design thinking; (5) Use customer journeys to empower the front line; and (6) Define journey metrics and the governance system to improve the journey and its journey design continuously” [20].

We discover that an efficient and effective customer journey is a continuous and innovative improvement in delivering better customer experience. Let us explore more on the customer journey in the next section.

### 21.3.1 Customer Journey

“In TM Forum’s customer experience survey in the fall of 2015, 98% of all respondents understood the importance of customer journeys to their businesses either belong to two categories— very important and important” [20].

An enjoyable customer journey should have elements of customer care, customer experience, and customer-centricity to achieve the final goal of customer satisfaction with buying products and services (Fig. 21.5).

### A successful customer journey drives better customer satisfaction

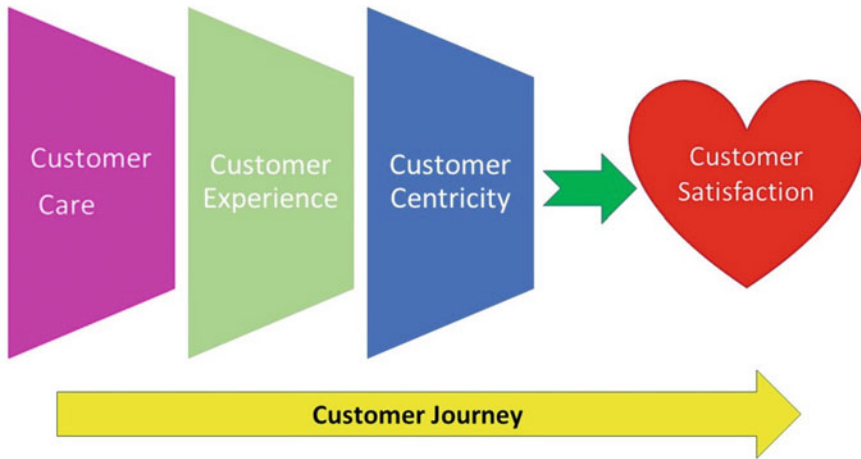


Fig. 21.5 Successful customer journey (*Source* Author)

#### The benefits of customer journeys

Rob Rich, Managing Director, Insights Research, TM Forum, pointed out that “customer journey is helping companies to think about the way customers do, and to uncover inconsistencies across channels or touchpoints, and to understand how context is maintained as consumers hop from channel to channel” [19]

“By analyzing the journey trends of adept customers, companies could discover more efficient paths to accomplishing goals. It can facilitate or organizational effectiveness as journeys often involve touchpoints that are operated by disparate departments. It helps preparations for omnichannel by creating a robust set of journeys that can act as test cases for an omnichannel solution” [19].

#### How to improve customer journeys

Understanding the importance of setting up customer journeys, not so many corporate executives can implement good customer journeys to suit their business goals. One paper “Perspectives, When ecosystems collide, innovation explodes” clearly advises how to improve customer journeys.

- The author Rob Rich said that “firstly, the company must understand what customers want and do from an ‘outside-in’ perspective.”<sup>47</sup> Secondly, “the company recognizes that some journeys are more important than others. Depending on the target customer base and their behavior, specific customer journeys can improve their experiences.”<sup>48</sup> In other words, prioritization is crucial for success. “Thirdly, the company must simplify operations by analyzing customer journeys, and it can help

to improve overall customer satisfaction. Finally, the company can quickly achieve its Key Performance Indicators (KPIs) like increased conversion rates, higher transaction values, and process-oriented cost” [19].

Customer Journey Mapping—the heart of Digital Transformation—Wharton School of the University of Pennsylvania summarizes the points of delight and opportunity along the customer journey. It is an excellent reference model for the corporate executives and strategists to design the digital transformation and customer experience roadmap by adopting suitable technology enablers.

“Patti Williams, a Wharton professor of marketing, points out that journeys help companies understand consumer decision-making. It reveals the types of information, sources, emotions, and other factors that can influence them and their choices” [19].

Williams said that “Journey mappings are deep, embedded consumer insights” [21] and customer journey mapping is a vital transformation tool for business. She added that “Consumer journey mapping is at the center of all consumer-focused organizations and can transform many businesses” [21] “Consumer journey mapping is a multilayered understanding of consumers making choices in a contextual setting offers companies the opportunity to change practices in a way that reflects the reality of consumer decision making” [21].

Siddharth Gaikwad, Dell Digital Business Services, added that “The key is to see how much personalization you can provide and how much of it you can contextualize around a given customer in a way that delights them, but at the same time is not intrusive” [21].

Like many strategic decisions, a good customer journey must solicit senior management’s commitment. A successful customer journey map requires time and close collaboration. The effectiveness of a customer journey map depends in part on the extent to which managers are involved in the map creation process, and the future time they can predict when analyzing customer insights.

Transforming customer journey map discoveries into actionable insights into digital touchpoints requires brainstorming by senior members across functions, which is often easier planned than executed. Busy executives are usually busy with operations, and many organizations work on silos—so the most crucial coordination can be challenging. Storytelling and classification cards can quickly inspire, motivate, and create stickiness between different groups, helping them stay on track.

Typically, there are six phases in a typical customer journey as below:

### **Awareness**

“This is where the consumer first encounters your brand. It marks the first point at which you are considered a possible solution for them” [21].

They may see an ad on social media or hear about your company from an existing outside press.

### **Acquisition**

“Acquisition means that consumer turns into a lead through some sort of interaction with your product or services. They might follow a link to your website and create an account, or download your company’s app. They might opt-into a free trial or subscribe to an email newsletter” [22].

### **Onboarding**

“Customers who have just made their first purchase are at the height of their interest in your brand. Customers are excited about building a relationship and getting to know them better. You might have them complete a profile, providing data that will help you personalize your outreach and recommend other features, services, or products” [22]. The key is to offer help, not hype. You want the messages you send to be relevant, not intrusive.

### **Engagement**

“Engagement is the longest phase of the customer journey and the most important one to get right. Keeping customers engaged is key to building a loyal following. Are your customers continuing to purchase old favorites? Are they staying updated with new releases? Delivering new experiences and highly personalized content keeps the relationship fresh and interesting” [22].

### **Retention**

“Retention is where you recognize that members of your audience are at risk of leaving, determine why they are losing interest, and either keep them from wandering off the trail or make it easy for them to come back in the future. Data can help you notice when engagement dips and tools like exit surveys can provide insights for future outreach” [22].

### **Advocacy**

“Advocacy is the way the customer speaks about their experience with your brand. There are few, if any, statements as powerful as a word from a happy customer. Giving customers opportunities to provide feedback and reviews at the right time can give your brand a big boost” [22].

## **Customer Journey Map**

“The key to optimizing the customer journey is data. Consumers expect personalized user experiences across many channels: email, mobile, social, advertising, and the web. But you need to collect and track the right information to deliver that” [22].

“It is best to start with a map that reflects your specific business model. A customer journey map is a diagram showing each typical point of interaction during the six stages of customer engagement” [22]. Your map should be based on what happens, not what should happen, to get maximum benefit.

“Mapping your customers’ journeys helps to focus stakeholders on the big picture and remind them how their efforts affect each other. It can also help

teams deliver consistent experiences throughout the customer journey. For example, if different departments support customers using different interfaces, it can be jarring for customers” [22].

“Maps ultimately allow you to build logic into consumer interactions and automatically move customers down different paths based on their profiles, buying histories, locations, expressed preferences, or other indicators. Routes or branches on the map can show different experiences that might be triggered based on customer behavior” [22].

“Customer journey maps should evolve. Journey analytics will show you what is and isn’t working so you can continually improve interactions and design a better user experience. The result will be satisfied customers who spend more money, are more willing to recommend the brand, and are less likely to drift away” [22].

There are six steps of customer journey mapping. They are:

**Identify your audience**

“Before you can take your customers on a meaningful journey with your brand, you have to know who they are and what their pain points” [22].

**Define the steps**

“What is the typical progression through each phase of a journey with your specific brand? Get granular and identify all of the interactions a typical customer has from pre-purchase to usage and post-purchase phases” [22].

**List your brand’s touchpoints**

“What are the physical and digital places where customers experience your brand? Each one of them is an opportunity to leave a positive or negative impression of your brand” [22].

**Identify the data you want to track**

“To optimize your customer journey, you need intuitive and actionable data about your clients and campaigns” [22].

**Think about your content**

“Great customer relationships are rarely built on a hard sell. Customers want information that is genuinely interesting, helpful, and relevant to their lives. Spend some time thinking about resources you can offer and ways you can provide value to your audience” [22].

**Choose your channels**

Your chances of connecting with customers are most significant if you meet them where they are. Knowing which platform they use every day can guide your strategy.

### 21.3.2 *Customer Experience*

The reality of digital customers is coming to us. Recently, there have been “mobile-only” customers who prefer digital and mobile tools. “With mobile

banking and tools, virtual customer service” [22], and powerful shopping experience, the line between the online and offline world is becoming increasingly blurred every day. Without digital channels, serving customers is almost impossible.

The prospect of an effective digital customer experience strategy (DX) has attracted many companies, but the reality is that many companies are still immature for digital customer experience strategies. Digital experience strategies require brands to think differently about their customer engagement methods and determine how digital fits the entire customer journey. “Adding digital tools on top of marketing, sales, or service interactions is not enough” [23]. They don’t consider their customers’ perspectives themselves, and in some cases, add unnecessary complexity to the business.

Gartner said that “81% of executives said their companies would mostly or completely compete based on customer experience in two years. 22% of executives said that their customer experience efforts had exceeded customers’ expectations” [23].

A comprehensive customer journey requires a defined customer experience strategy. By incorporating the CX (Customer Experience) strategy into the overall customer journey strategy, the company will be closer to frictionless, omnichannel customer experience. With frictionless experience, the client can quickly meet his needs or completely solve his problems in any channel without having to jump over obstacles or overcome obstacles.

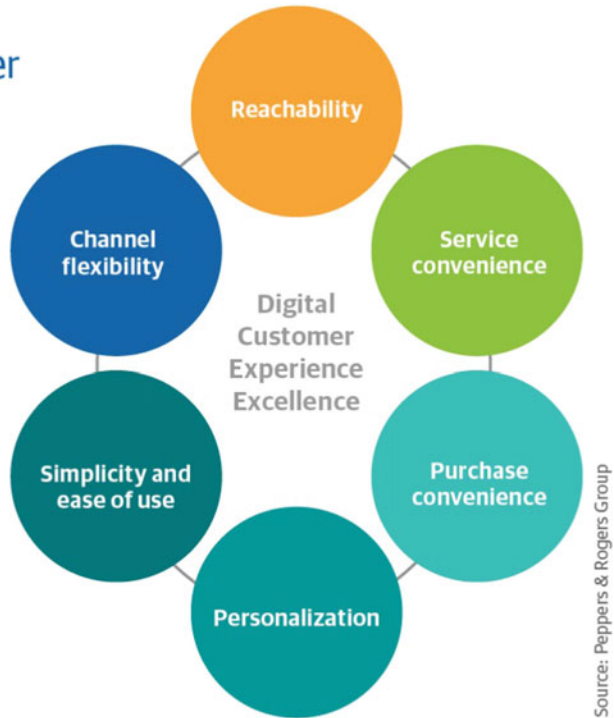
“Our experience shows that digital customer experience excellence, from a customer perspective, is directly linked to the extent to which companies excel in six key areas—channel flexibility, reachability, service convenience, purchase convenience, simplicity, and personalization” [24] (Fig. 21.6).

In-depth study of each of the six areas, “the DX maturity spectrum will show the actual positioning of the company’s digital customer experience strategy. Before reaching its goal, companies need to go through multiple stages of maturity: a frictionless and competitive digital customer experience. Based on six key areas, a specific digital experience maturity assessment framework helps corporates better position actual DX performance delivered to customers through digital channels. Companies have shifted from being digitally provided to consumers to caring, engaging, and ultimately driving people’s preferred digital lifestyle” [25].

Companies can choose many ways to measure a company’s DX maturity. “Reachability is assessed by measuring the existence and reliability of a customer’s preferred channel, plus consumer awareness and attractiveness. Service convenience measures how easy it serves customers digitally. Purchase convenience matches the service convenience metrics, along with how seamless the digital transaction process is. Personalization is measured based on the recognition of customers as individuals. Simplicity assesses digital navigation and timeliness. And channel flexibility tracks how seamless it is for customers to switch channels” [23].

## Digital Customer Experience (DX) areas

The DX a company delivers to its customers is highly dependent on the maturity of its digital channels in six key areas, assessed from the customer's perspective.



**Fig. 21.6** Digital customer experience (DX) (*Source* Peppers & Rogers Group)

“Knowing where you are on the DX maturity ladder is essential for customer experience strategies” [23]. Digital campaigns must be optimized and integrated with other channels to create a truly omnichannel environment for customers. Not only can it provide better digital customer experience, but it can also optimize your operations to increase efficiency and save costs.

There are several ways companies can improve the DX maturity ladder. From a strategic perspective, senior management must prioritize the digital customer experience and align it with a broader corporate strategy to drive real improvement. Here, senior management must define clear channel roles and responsibilities. They define how to transform existing processes from traditional to digital channels.

In an organizational structure, it is recommended to establish a dedicated digital team that defines consistency and synergy with other relevant business units (marketing, sales, customer service, and other channels). Organizations must develop KPIs to drive organizational and cultural ideas toward digital experiences and streamline operational processes to increase efficiency and eliminate redundancy. It is a top priority to automate current processes and design new processes with a customer focus.

Data analytics tools can measure the performance of digital customer experience. They include digital and social analytics, right-time analytics, search engine optimization (SEO), search engine marketing (SEM), etc.

“Effective omnichannel solutions must include a 360-degree view of customer interactions across all channels (digital and traditional) to monitor channel preference, usage, and customer journeys from the customer perspective. And the design of any new DX program must be customer-centric and fit into the current customer journey” [23].

An effective omnichannel solution must include a 360-degree view of customer interactions across all channels (digital and traditional) to monitor channel preferences, usage, and customer journeys from a customer perspective. And any new DX program design must be customer-centric and adapt to the current customer journey.

In conclusion, the concept of “digital” is the mindset of most business leaders and executives. When they decide their future investment direction, they must consider the DX strategy from the perspective of the customer experience. Digital experiences have become the primary type of experience for most customers. Companies that can determine organizational maturity and develop long-term strategies will have an advantage over competitors.

### 21.3.3 *Customer Care*

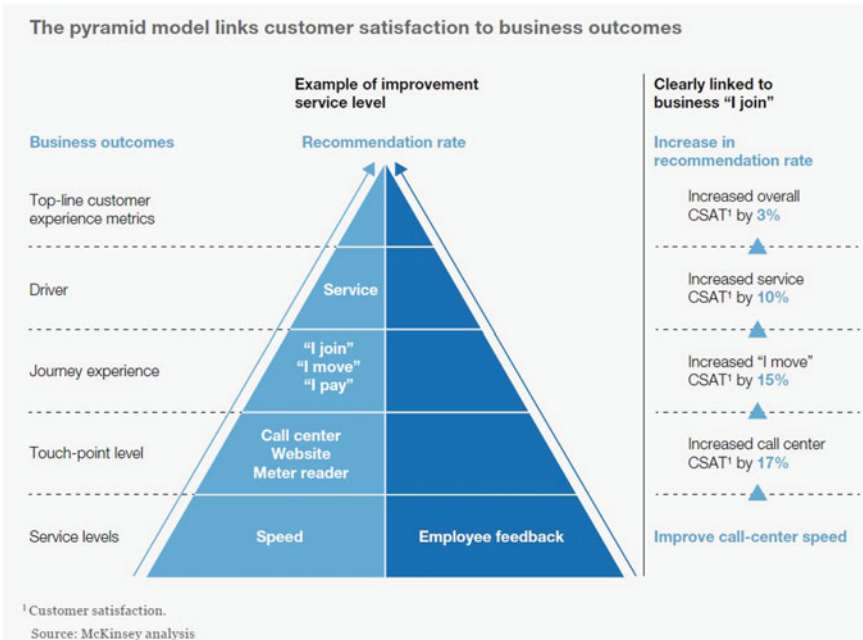
Customer care is always important for all kinds of industries, mainly traditional retail business and eCommerce. A recent article, “The Role of Customer Care in a Customer Experience,” has presented the pyramid model linking customer satisfaction to business outcomes by categorizing the importance of customer care in the customer journey (Fig. 21.7).

Large corporations are using data analytics as “a digital transformation tool to correlate the customer journey and customer satisfaction to the overall strategy and top-line metrics on growth and operational performance” [23].

“By understanding how operational factors such as speed and first-call resolution translate into customer satisfaction, contact centers can ensure they focus their energy and resources on areas that have the most significant impact on the customer experience” [20]. These consolidated efforts enhance customer experience contributing a higher recommendation rate (a core metric) for the company and achieve the organization’s overall goals.

Customer service plays an important role in digital transformation. For more and more organizations, customer service plays an essential natural role in mapping the customer journey. There are usually several obstacles that must be overcome during digital transformation. The function started in the call center, was responsible for only one touchpoint, and was mostly “transactional. In an omnichannel world, customer care is increasingly becoming a significant factor” [20] affecting customer satisfaction, and its scope of influence is becoming wider and wider, thereby increasing the number of entities that interact with customers in the organization. While customer care is always





**Fig. 21.7** The Pyramid Model of customer satisfaction, the role of customer care in a customer experience (Source McKinsey & Company)

at the center of the customer experience, features like sales and marketing are thought to understand the customer better. Finally, obstacles to information sharing and collaboration can sometimes reduce the impact of customer care on developing customer experience strategies.

The fact is that customer care should be intimately involved in the design of the customer journey: this feature includes all touchpoints and organizational units with precise service components such as branches, field services, contact centers, email, etc.

Many organizations have adopted an integrated approach, bundling responsibilities for “different channels into one unit, and the rise of omnichannel has accelerated this development” [20] Due to the responsibility of the customer care department, its front-line agents enable the feature to hear “customer’s voice” every day, monitor trends and overall mood, identify pain points, improve means and success factors.

**Cross-functional collaboration in customer journeys**

An omnichannel approach emphasizes all formats of communication and interaction, which are essential to the customer journey. “A customer can leap from touchpoint to touchpoint across channels” [20], whereas it drives the need for cross-functional collaboration (Fig. 21.8).



**Fig. 21.8** Omnichannel-customer-experience-platform (Source Reve Chat Blog “What is an Omni Channel Customer Experience?”)

The above-mentioned omnichannel approach includes chat and social media to mobile apps, etc. “In some organizations, the function is still perceived as executional rather than strategic, focused primarily on handling low-value requests” [20]

#### 21.3.4 *Customer-Centricity*

Digital transformation cannot drive customer experience success. Corporates need to focus on customer-centric with a combination of talent and technology.

Digital transformation is composed of business activities, processes, and competencies to leverage emerging digital technology fully. Customer centricity is an engagement and implementation strategy derived from an understanding of customers’ needs, and to provide a total tailor-made solution.

In “CX and Technology” Summit 2019—here are the top ten tips for building a genuinely Customer-Centric Organization in the digital business era.

### **Continuously listen to your customers**

In today’s era, customers provide businesses with personal data at almost every online and offline touchpoint. Due to the status quo, it is expected that this insight will be leveraged in delivering personalized and attractive customer-centric communications.

### **Ensure you follow-up on customer feedback**

Good customer relationships are based on reciprocal value. Being customer-centric means showing your customers that you value their input and take action. When companies stop listening to their customers, their customers stop talking, which is a deadlock unfavorable to profitability.

### **Proactively anticipate customer needs**

Think about the customer user journey—offline and online. Whether the customer is just near the store or waiting in line, ordering through the app or browsing product review videos, you can draw a journey and surprise customers with unique, useful, and relevant communication.

### **Respect customer privacy**

Use data and don’t abuse it. Customers expect transparency in how their data is collected, stored, processed, and used. Make sure your communication is contextual and, most importantly, legal. With GDPR at work, the slogan “Use it, don’t abuse it” is essential.

### **Build customer empathy into processes and policies**

Truly customer-focused organization dedicated to providing customers with timely and convenient channels. Through an in-depth understanding of the problems of the customer experience, they can take the proactive initiative to solve the problem. On this basis, helpful, fair, and friendly staff can provide outstanding customer support for them at the right time through the right channel.

### **Deliver value and convenience for customers**

Businesses need to believe in self-service capabilities that not only simplify the customer journey but also help anticipate service delays. Although front-end solutions need to be highly automated, they don’t need to be overly complicated. Building a self-service system requires minimal interaction, but for maximum access to ancillary channels, it can provide excellent CX.

### **Motivate employees to stay engaged**

Happy employees make for more satisfied customers: they work harder and are more committed to the success of the company. By investing in your employees and getting them engaged and excited about the brand, your operational performance and overall customer experience will soar.

**Act systematically to improve customer experience**

Have a strategic vision for your CX and carry it through. Ensuring that all teams are aligned in their working and that they're passionate about the job at hand, is the crux behind the success of your CX vision.

**Create accountability for CX improvements**

Inspiring accountability for delivering CX goals across the business is fundamental. From Marketing, Sales, Customer Services, and IT to Management, Strategy, and Supply Chain teams, delegating clear responsibility for delivering on CX KPIs better aligns all business units for success.

**Adapt and evolve with the customer**

Customer centricity is about putting customers at the center of your decision-making. Increasing your business capabilities to provide an event-driven, real-time situational awareness of customer actions is crucial. From there, you can automate and act to achieve a unified customer experience with consistent and timely messaging across all inbound and outbound channels.

*21.3.5 Customer Satisfaction*

Gartner's research shows organizations how to discover innovative customer experiences that build stronger relationships.

"Eighty-one percent of customer experience (CX) leaders reported that they would compete mostly or entirely on CX. Less than half have established the rationale for why CX would drive business outcomes, according to Gartner, Inc. The goal of CX is to meet and exceed customer expectations. Still, while 48 percent say their CX efforts exceed management's expectations, just 22 percent of customer experience leaders report their CX efforts to exceed customers' expectations" [20]

"To address this challenge, Gartner unveiled the CX Pyramid, a new methodology to test organizations' customer journeys and forge more powerful experiences that deliver higher customer loyalty and brand advocacy" [26].

"The fact that so many organizations understand the importance of CX to the brand, but are unable to deliver outcomes that meet or exceed customer expectations is indicative of the growing need for fresh approaches to delivering more positive outcomes for customers," [21] said Augie Ray, research director at Gartner. "Leading brands in CX start with a strong foundation in customer satisfaction. Getting this right and understanding how to build upon it to drive positive financial and business outcomes is what sets the best brands apart from the rest" [26].

The Gartner CX Pyramid (see Fig. 21.9) is a "framework to understand what separates the most powerful customer experiences from the rest. Each level, from bottom to top, defines an incrementally stronger way to forge relationships between an organization's brand and its customers based on the way CX leaders listen for, understand, act on and solve customer needs" [26].



**Fig. 21.9** The CX Pyramid (*Source* Gartner, July 2018)

“The pyramid helps to identify the most powerful CX based on criteria including (a) how the experiences are triggered, (b) the amount of effort required of the customer, (c) the completeness of the solution, and (d) the emotion and change in perception created by the experience” [27].

Gartner pointed out that the customer experience pyramid drives loyalty. “By analyzing the five levels: communication, responsive, commitment, proactive, and evolution, the corporation can position itself at which level it is in the pyramid now. They study how to drive innovative solutions to reach a higher level in the pyramid to increase its competitiveness” [26] (Fig. 21.9).

## 21.4 THE WAY FORWARD

The era of disruptive innovation has come due to the following facts:

- Revenue generated from digital services is growing up tremendously and is significant to the corporates;
- The corporate executives often encounter business dilemma on how to manage disruptive technologies and innovation management;
- Many executives start to learn about innovation management. Large corporates are going to re-structure to build a new dynamic culture to fit for agile development, to recruit more talents. The corporates adopt innovation management and disruptive technologies quickly to foster competitive advantages.

According to recent trends, most promising disruptive technologies have been developed rapidly and come to maturity. These disruptive technologies contribute to the following development:

- 5G, Blockchain and Crypto-currencies, emerging BaaS, AI, and Machine Learning, Cloud, Big Data and Faster WiFi (according to Accenture, Gartner, McKinsey, etc.);
- These disruptive technologies will be applied for FinTech, smart cities, IoT, analytics, and cloud computing;
- These disruptive technologies kick-off the digital transformation era;
- Corporates want to compete with competitors for the survival in 2025. ING transformation project “Think Forward” is a good example of changing traditional finance business into an “ING as platform” business.

Transformation is not an easy task. Without top management commitment, intensive investment, the right direction, and good pilot project, transformation always does not deliver to the expected outcome, according to the Gartner report. The right choice of minimum viable product (MVP) is very crucial. Recruitment of a good agile team and building an innovative culture will let the digital transformation be implemented with a higher chance of success.

Based on ten guiding principles of a digital transformation advocated by McKinsey, the top management can implement new digital services by three phases—defining value, launch, and acceleration, and scaling up. If the corporation implements the new digital services successfully, it can accelerate its corporate digital transformation goals by the last phase scaling up subsequently. Just like ING strategic transformation project “Think Forward” speeds up the transformation after a few years by positioning ING as a platform for partners and stakeholders in numerous target services.

When a lot of executives and management are focusing on touchpoints experience, it is proved that touchpoint can only improve customer experience a little bit. A few types of research concluded that good customer journeys are generating business results better than touchpoints. The corporates must focus on the end-to-end customer journey satisfaction. Empowered by disruptive technologies like 5G, big data, the corporates can shorten and improve existing business procedures into a meaningful single customer journey, which can improve customer experience, customer satisfaction, increase productivity, and reduce costs.

However, a good customer journey is not easily designed. The customer journey mapping is a useful tool for designing a remarkable customer journey. “Customer journey mapping is the center of all consumer-focused organizations and can transform business.” The whole mapping involves multi-layer

studying on the existing process and solicits constructive insights and suggestions from various stakeholders. The executives always learn lessons from customer journey map exercise.

Finally, every corporation is looking for the best return on investment by delivering excellent products and services to enhance customer satisfaction. There are mainly three focal points to achieve better customer satisfaction. They are customer care, customer experience, and customer-centricity.

Most corporates design their customer experience strategies. Typically, seamless omnichannel customer journeys are often chosen by them. A good customer experience strategy will consider channel flexibility, reachability, convenience, ease of use, and personalization. Know Your Customer (KYC) will give us meaningful inputs on designing personalized customer journeys according to customers positioning in the digital customer experience ladder.

The corporates understand that they can increase customer satisfaction easily for the three basic business outcomes—services level, touchpoint level, and journey experience, according to the Pyramid Model from Gartner. For example, if a corporation improves the existing call center by launching a good touchpoint, it may increase by 17% in customer satisfaction. However, if the corporation improves existing products and services, it may increase by 10% in customer satisfaction.

To maintain good company cultures, the corporates should focus on customer-centricity which is an engagement and implementation strategy derived from customers' needs. In a customer-centric organization, the corporates must decide the company's services level including continuous listening to customers, proactive attitude, follow-up, and follow-through manner, staff motivation and talent development strategies, and accountability.

Gartner pointed out that the customer experience pyramid drives loyalty. By analyzing the five levels: communication, responsive, commitment, proactive, and evolution, the corporation can position itself at which level it is in the pyramid now. They study how to drive innovative solutions to reach a higher level in the pyramid to increase its competitiveness.

This chapter has explained how digital transformation improves customer satisfaction. I expect that new disruptive technologies come to the market rapidly; they will also change the ways of doing business mostly. I recommend the corporates to transform themselves into an innovative and digital culture to nurture more young talents. A good digital transformation strategy and effective implementation ways will be critical success factors. I expect some large traditional corporates moving fast pace in digital transformation like ING, and others remain unchanged to be fated out soon.

I am sure that most businesses will adopt new digital services to improve the customer journey. It is an exciting era of Digital Transformation, and customers will feel excited about enjoying their products and services.

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Part V

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## Fintech in the New Order



# From Disruption to Post-pandemic Scenario

*Maurizio Pompella and Lorenzo Costantino*

## 22.1 WHY CORONAVIRUS EMERGENCY DOES MATTER

While researching the realm of similarities between the sharing economy models in traditional sectors—i.e. mobility and lodging—and finance and banking, the COVID-19 pandemic struck, revolutionising social and economic paradigms. While we conclude (from part 1, Ch. 18) that sharing economy models have the potential of affecting but not disrupting the finance and banking sectors, the advent of COVID-19 led us to dare into another comparison and use the term “pandemisation of economy” rather than limiting our scope to gauging the “Uberisation of banking”. The COVID-19 virus is leaving its mark with 112 million infections and two and a half million deaths (at the time of writing—February 2021). While everybody is vulnerable, the virus is particularly dangerous for the elderly and those affected by pre-existing chronic conditions.

The pandemic has also badly hit economic actors: not only individuals but also legal entities (i.e. companies) are impacted. No sector is immune and no market is shielded by the economic impact of the pandemic: companies in retail, transportation, energy, travel and leisure have either closed or significantly reduced their business. Leaving aside the social implications and costs

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(loss in employment, GDP contribution and value creation), the “pandemisation of the economy” is a process by which only the healthiest companies sail through the crisis and survive, while those with “chronic conditions” succumb. The health of a company may lie in its business model, value proposition, management structure, human resource management strategy and cash flow. In the domain of banking and finance, the actors that are best poised to survive the pandemisation of the economy are those with robust business models, credibility (*vis a vis* consumers, regulators, industry peers, etc.), secure technology stronghold and the ability to respond to fast-changing operational settings.

Still running the health analogy, pandemisation of the economy requires strong and credible authorities (regulators and policymakers) that can provide reliable information and guidance while commanding credibility by setting rules. The availability of common and reliable diagnostic mechanisms is imperative to monitor the evolution of the disease: in the case of banking and finance, stress-test methodologies are used to gauge the robustness of market actors. Moreover, therapies are being experimented with the COVID-19; similarly, remedy measures are available in the financial sector to deal with inefficiencies in the system (at both individual intermediary and systemic levels).

The concept of pandemisation of the economy may lead to the concept of developing a vaccine for those market operators in the domains of fintech and blockchain: in this case, not a vaccine to avoid harm to self, but a remedy to prevent harm to others and the systems as a whole; a vaccine to halt the contagion.

The COVID-19 pandemic triggered social and economic consequences that do not leave the blockchain and fintech ecosystems untouched. What started as a health emergency morphed into an economic shock on a global scale, affecting all sectors and abating gains of the last five years. The IMF dubbed the “Great Lockdown” as the worst economic downturn since the Great Depression, generating shockwaves that impact all economic sectors.

COVID-19 has dramatically affected traditional sectors (transportation, air travel, tourism, just to mention a few) and revolutionised social interactions as well as changed the way people live (from shopping to socialising) and work (telecommuting is now the norm). The pandemic is having implications for the blockchain and fintech ecosystem as well. A most immediate impact has been on a more realistic attitude of investors towards innovative ventures, resulting in slowing trends in Venture Capital funding for blockchain initiatives.

While many blockchain projects raise capital through Initial Coin Offering, Venture Capital and other forms of equity financing represent the most important source of funding for blockchain-related initiatives. The trend of VC investment in blockchain-related ventures saw a considerable decrease from \$4.2 billion in 2018 to \$2.8 billion in 2019,<sup>1</sup> most probably due to the hype of cryptocurrency-related investment that spiked in 2018.

COVID-19 was dubbed as the “2020 Black Swan” by Sequoia Capital, a leading global VC Fund with a proven track record in investments in technology and innovative business models. The current contractions in the financial system due to the COVID-19 pandemic will inevitably affect investments in the blockchain space.

COVID-19 impact on Venture Capital may slow down investment in blockchain initiatives. A comparison of completed cross-border investment between Q1 of 2020 and 2019 shows a considerable drop in deals. While it is too early to assess the overall impact of COVID-19 on investment deals and flows, it appears that investors are holding the closure of pre-pandemic deals, primarily due to uncertainty around valuations and future investment dynamics.<sup>2</sup>

Conversely, shocks also lead to opportunities: the decrease in investment rounds and deals may also lead to more realistic valuation and more scrutiny of new blockchain ventures.

As such, the COVID-19 pandemic is poised to becoming the shock that arrests the hyperbole of the blockchain and fintech hype to bring the sector as a whole back to more realistic terms. From a market perspective, COVID-19 may be compared and associated with the two symbolic shocks that re-booted the information technology and financial sectors, respectively, the “dot.com” bubble of 1999–2001 and the Great Financial Crisis of 2008.

### **The Dot-Com Bubble**

In the late 1990s, the growth of Internet-based services and applications, coupled with the wider adoption of ICTs from US households and consumers, generated expectations among investors and the general public about limitless opportunities of the so-called “new economy” or “dot-com economy”. The novelty of the Internet led to fantasy valuations of start-up companies: any new venture that was even remotely related to the Internet attracted investors.

The hype inflated the Dot-Com bubble, with impressive growth in the equity markets: the Nasdaq index rose from 1,000 in 1995 to 5000 in 2000. The turning point was in the 1997-1999 period in which Internet-related companies attracted almost 40% of Venture Capital investments and raised funds through IPOs: in 1999, 295 IPOs out of 457 were of “new economy”-related companies.<sup>3</sup>

The Internet-mania attracted investors lured more by the fear of missing out than robustness of business models. Time to market and the urge to move fast were more important than testing products, services and market dynamics. The failure of many Internet-related companies to provide sustainability and profitability led to a sudden burst of the Dot-Com Bubble: the Nasdaq index crashed more than 75% from the March 10, 2000 peak of 5,048.62 to 1,139.90 on October 4, 2002. It took the market more than a decade to fully recover from the Dot-Com bubble, with the Nasdaq Index crossing the 5,000 threshold in 2015.

By 2002, most of the start-ups that promised to change the world folded; even technology giants suffered greatly from the burst. Among the so-called “Four Horsemen” of the Nasdaq Index (Microsoft, Intel, Cisco Systems and Dell Computer), only Microsoft’s stock price recovered from the burst.<sup>4</sup>

### **The Great Financial Crisis**

In the period between 2007 and 2009, the excesses in financial innovation led to the so-called global financial crisis (GFC) that hit the international financial markets and banking systems. Inefficiencies in the housing market in the USA were the spark that ignited a chain reaction leaving no financial market untouched nor economy immune from considerable negative spill-overs with increasing unemployment rates and significant economic downturn.

While there is still no full consensus on the specific causes of the GFC (Merrouche and Nier 2010),<sup>5</sup> a series of contributing factors led to a gradual deterioration of financial stability and the sudden capitulation of financial markets. The decline in short-term interest rates, growth in capital flows to the USA and increased demand for mortgages<sup>6</sup> all contributed to the development of “innovative” financial products to accommodate the appetite of global investors for low-risk and relatively high-return assets. The abuse of securitisation and the increasing deterioration of underlying assets generated a vicious circle in the financial markets. The complacency of rating agencies and regulators not only did not prevent the crisis but at times even exacerbated its long-term impact. Regulatory and supervisory agencies were blamed for sharing the responsibility of the crisis due to lax oversight.

Initial public policy response from some governments affected by the GFC included measures such as ownership stakes in financial firms to rebuild confidence in the financial system, deposit insurance and guarantees and increased public spending to support demand and employment. Nonetheless, the depth of the shockwaves of the financial crisis led to the bankruptcy in September of 2008 of Lehman Brothers, a US financial services firm established in 1847 and an iconic name in finance and banking.

Lehman’s bankruptcy was a demarcation point that deteriorated confidence in the financial markets and triggered panic and uncertainty. Global investors pulled out of their positions; credit dried up and spending halted: the only outcome possible from such a scenario was a global recession.

While the real cost and final impact of the crisis are difficult to capture, economists agree on the fact that the scars of the GFC are still visible. In 2018, ten years after the crisis, many studies tried to capture the impact of the GFC using various metrics: an OECD study estimates a 6% output loss in the 19 OECD countries that experienced a banking crisis; IMF calculations suggest that the stimulus packages face the GFC led to an increase of public debt in advanced economies by more than 30% of GDP; research from the Federal Reserve (Barnichon and Ziegenbein 2018)<sup>7</sup> identifies in 70,000 USD per American citizen the cost of the GFC.

Irrespective of the methods used to assess the GFC, the impact on the real economy led to job and output losses that took a decade to recover from. Moreover, recent research (Cerra and Saxena 2017)<sup>8</sup> suggests that recessions lead to permanent losses in output and welfare, dismissing the conventional

wisdom that considers recessions as short-term periods of negative economic growth after which recovery leads to pre-recession trends and figures.

In both instances, the sparkle that ignited the burst was an “internal” cause, with similarities related to reckless investors’ behaviour, development of exotic products under the disguise of innovation, and fantasy valuations. The distance between innovation and reality reached a level that was no longer sustainable and the systems collapsed. Both phenomena led to a virtuous restructuring of the sectors, accompanied by more realistic investors’ attitude and better equipped regulatory and supervisory bodies.

The dot.com bubble and Great Financial Crisis took a considerable toll on industry operators, investors and regulators: a plethora of start-ups, as well as established companies, disappeared; institutional and retail investors and Venture Capitalists suffered considerable losses that took years to recover; regulators’ inadequacies were revealed.

In a sense it appears that COVID-19 is deflating the bubble of blockchain and fintech before it bursts: the pandemic is accelerating the process and anticipating some of the adverse effects of a bubble burst, enacting a process of natural selection that is due not to an internal process but an external factor. The COVID-19 can hence be considered a “reset” in the industry as it is revealing the extremely positive potential of blockchain and fintech solutions while exposing the vulnerabilities of the hype-related complacency of some blockchain and fintech ventures.

The social and economic impact of the COVID-19 has pushed investors and industry to a “back to basics” approach in business, by which more robust and realistic bottom-lines are required, such as product relevance, addressable market, competition, willingness to pay of potential customers and most importantly cash-flow robustness and path to profitability.

In the wave of innovations, there is often a phenomenon of overcrowding of the market from participants who seize the opportunity to free-ride or take advantage of possible openings for speculative opportunities. This generates a sense of elation, at times backed and ignited by media that may fog investors’ acumen and attitude as well as generate opportunities for misconduct and reckless behaviour. Moreover, such situations may also overwhelm regulators who may not be fully empowered and equipped to adequately police the market and carry out their oversight functions.

In those instances, regulators have constantly to catch up with innovations (both at product and technology levels) that can prove difficult to oversee with regulatory tools and approaches that were designed for more traditional settings. Regulatory agencies have to follow the lead of the market: at times regulators are not able to keep the pace, other times regulators remain on the alert to monitor evolutions and intervene only when necessary in an effort not to limit innovation.<sup>9</sup>

## 22.2 A FEW DIRECTIONS FOR POLICYMAKERS AND REGULATORS IN THE NEW NORMALITY

As far as the current emergency, COVID-19 is disrupting the same technologies that were expected to disrupt banking and finance. Such deceleration should not be deemed necessary as negative: the pandemic is working as a “reset”, allowing industry and sector participants to take advantage of a new scenario rid of imaginative and potentially speculative approaches.

Besides, COVID-19 may be providing opportunities for governments to advance the implementation of public blockchain and fintech initiatives: most governments are rolling out economic packages to support the most affected groups of society and economy, from consumer grants to sustain spending to direct help for enterprises and companies to cope with market and economic uncertainty. This could provide the ground to test innovative initiatives to issue electronically backed currencies (or tokens) that can be traded on specific platforms for a set of transactions.

For instance, some governments are defining subsidy and grant schemes to promote the tourism sector, by which consumers can obtain subsidies to be spent on domestic touristic destinations. This could prove to be an interesting opportunity to test a virtual currency that is traded on a specific portal in which tour operators can provide their services, tourists can access and select specific products and transact using the specific token/digital currency issued as a grant. Such a mechanism could prove useful in promoting the adoption of blockchain and fintech applications from consumers and operators of a specific industry. Moreover, this system would also allow to further enhance transparency in specific markets and segments (i.e. tourism).

Policymakers and regulatory agencies could reassert their leading role in the space of blockchain and fintech by proactively acting rather than merely reacting. The COVID-19 pandemic confirmed that uncertainty is the main source of distress: regulators should take the lead in clearing the ground from uncertainty, for instance by:

1. Delimiting the domain: regulators could provide elements to define the boundaries of the blockchain and fintech space by providing a clear definition of the domain according to the technology and/or the activity: for instance specifying the technology parameters or whether the blockchain and fintech domain is “technology neutral”; type of activities that fall within the domain, i.e. describing the type of financial transaction, whether there is an interest or a payment; intermediation of economic relevance and value; nature of investment and classification of activities; etc.
2. Defining the actors: regulators could provide guidance for the profiling of market participants in any intermediation, clarifying the demand and supply side, widening the spectrum of the actors to include all the



- cohorts eventually involved and potentially interested in and by the application/solution/product;
3. Describing options and issues: once the domain and participants are identified, regulators could provide the set of issues that constitute the priority concern from a policy and regulatory perspective in terms of investors' protection, consumer protection and financial market stability;
  4. Providing guidance: the above elements should be the inspiration for a blockchain and fintech decalogue that could serve as guiding principles for industry. The decalogue would also serve the purpose of identifying ex-ante the triggers for regulatory red-flags for market participants.

COVID-19 is such an unprecedented event that will change the way people live, study and work as well as revolutionise business models and market dynamics. While pandemics are not new to the world, this is the first pandemic affecting a globalised world with accelerated rates of technology developments. COVID-19 will also disrupt academic research and analysis. Any analytical model will need to take into account the pandemic: there will be a “before” and “after” in any facet of social sciences. The year 2020 will destabilise the robustness of variables and models.

The pandemic will also change the way governments will collect evidence, interpret data and promote responsive policymaking. Coping with the social and economic challenges of the pandemic requires brave policymaking to balance different priorities and interests, at times even conflicting due to the economic impact of restrictive measures. In some economies the conundrum is to decide between fighting poverty and safeguarding public health: the impact of a lockdown is the immediate closure of some economic sectors, directly affecting income and spending.

In the context of blockchain and fintech and from a policymaking perspective, COVID-19 appears to offer more opportunities than challenges. Safety and health concerns do not burden regulation and policymaking in the field of blockchain and fintech: besides, the potential of blockchain and fintech applications in the context of the pandemic (from health to payment mechanisms) would further legitimise a strong intervention.

In sum, COVID-19 represents a unique opportunity for regulators and policymakers to

1. Stepping in the most pressing issues pertaining to financial markets' stability and protection of investors' rights, in areas such as Tokenomics and Initial Coin Offering. Regulators could step in and while recognising that the regulatory framework needs to be upgraded and aligned with the advancements of information, communication and financial technology, operators still need to comply with the safeguards provided for in the applicable financial regulation and supervision. While limiting market-driven innovation, such an intervention—some observers would even

- label it “interference”—would at the very least produce two positive effects: on the one hand provide clarity on the relevant and applicable regulatory framework; on the other, pressure regulators to upgrade the relevant regulation;
2. Establishing blockchain and fintech units within regulatory agencies: experience has shown that establishing units working on fintech within regulatory agencies is proving useful in advancing innovation while safeguarding market’s supervision and participants’ protection.<sup>10</sup> A “one size fits all” approach would not be suitable, as “Innovation Offices” would need to be tailored (in function, role and structure) within each countries’ regulatory and institutional frameworks. Nevertheless, regulators—or even international fora, such as the IFIs or OECD—could develop a prototype of “Innovation Office” describing the tasks, composition, functions and working of such units. The depth of an Innovation Office would vary depending on the needs of a specific jurisdiction/market: the type of functions could be expanded up to encompassing also the role of registry for blockchain and fintech companies;
  3. Developing support programmes for the development of COVID-19 related applications for the blockchain and fintech domains: such programmes would disburse financial support (in form of co-financing grants and/or soft loans) and/or grant “regulatory exceptions” to operators as long as they abide by a specific Code of Conduct and comply with clearly elaborated guiding principles. Such programmes would serve the dual purpose of promoting innovation while bringing operators closer to regulatory compliance, as the set of guidelines for eligibility would provide clear definitions of the requirements (i.e. transparency, investors’ protection, cyber-security, data-management, reporting, etc.);
  4. Launching government-supported cryptocurrency initiatives within the context of COVID-19 related relief measures: most governments globally are launching relief measures to cope with the impact and effect of the pandemic. Relief packages include a wide array of options ranging from fiscal measures and monetary policies to social protection and direct enterprise support. This provides a unique and unprecedented opportunity for governments to experiment with new measures to promote financial innovation through the adoption of blockchain and fintech solutions under a “controlled environment”. A government-supported cryptocurrency for the disbursement and distribution of relief (grants, for instance) to a defined target group (social and/or business recipients) in a well-defined domain of society and/or economy (by sector, for instance).
  5. Promoting the development of voluntary industry standards and “controlled self-regulation” of the sector. In such a system, the “controlled” feature would be represented by the direct involvement of the regulators that would set the boundaries of the self-regulation and identifies

red-flag situations that would trigger control measures from the regulators. Governments and regulators have a crucial role in promoting self-regulation and voluntary industry standards by providing guidance on the ultimate objective and vision of any self-regulatory approach. Moreover, governments and regulators typically serve as the broker to bring various actors together and break the silos approach that often undermines collaboration in specific fields. Regulators could also promote—and steer—a consultative process with industry and market participants;

6. Reversing the burden of proof in the space of blockchain and fintech: rather than being the regulator to demonstrate that potential innovations (at product and process levels) may pose a threat to investors, participants and the financial system, the company putting forward a new solution into the market will have to prove that the solution is “safe”. The regulators would still need to produce clear guidelines and criteria to assess the viability of new ventures, and those could be consolidated in the “blockchain decalogue” mentioned in the sections above.

The above options would provide a concrete and immediate opportunity for regulators to gain the central role in the space of blockchain and fintech in a very complex historical moment. COVID-19 has accelerated the market selection process that would have probably taken years and generated yet another asset bubble. The “blockchain and fintech” bubble most probably was already in the making with features (such as fantasy valuations, investors’ euphoria and fantasy valuations) similar to those that preceded the Dot-Com Bubble and the Great Financial Crisis in the late 1990s and 2000s, respectively.

Crypto-assets, Tokenomics and ICOs provide for similar features to the excesses of the last two asset bubbles, such as Internet-mania and securitisation: in sum, new tools for old tricks perpetrated under the name of “innovation”. The pandemic has triggered investors’ prudence and a generalised repositioning of priorities from innovation to survival. A context in which regulators and policymakers should reinstate their leading role in safeguarding markets’ stability while promoting robust and safe innovation.

## NOTES

1. According to latest data available from specialized web resources; interestingly, the number of deals is almost unchanged, with 807 deals in 2019 and 822 in 2018. [www.coindesk.com/vc-deals-in-crypto-remain-steady-while-volume-drops-in-2019-report](http://www.coindesk.com/vc-deals-in-crypto-remain-steady-while-volume-drops-in-2019-report), accessed September 21, 2020.
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3. The Wall Street Journal, “Lessons From the Dot-Com Bust”, By M. Hulbert, March 8, 2020 [www.wsj.com/articles/lessons-from-the-dot-com-bust-11583192099](http://www.wsj.com/articles/lessons-from-the-dot-com-bust-11583192099). accessed September 21, 2020.

4. NASDAQ, “20 Years After Dot-com Peak, Tech Dominance Keeps Investors on Edge”, Contributors: N. Randewich and L. Krauskopf (Reuters), Published February 18, 2020, [www.nasdaq.com/articles/graphic-20-years-after-dot-com-peak-tech-dominance-keeps-investors-on-edge-2020-02-18](http://www.nasdaq.com/articles/graphic-20-years-after-dot-com-peak-tech-dominance-keeps-investors-on-edge-2020-02-18), accessed September 21, 2020. The “Four Horsemen” of the Nasdaq are a memory of the early 2000s, and currently the equity market for technology stocks is dominated by the so called “FAANG” referring to the five technology companies Facebook, Amazon, Apple, Netflix and Google (Alphabet).
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10. A good taxonomy of “Innovation Offices” and their roles in various countries is provided in UNSGSA FinTech Working Group and CCAF. 2019. Early Lessons on Regulatory Innovations to Enable Inclusive FinTech: Innovation Offices, Regulatory Sandboxes, and RegTech. Office of the UNSGSA and CCAF: New York, NY and Cambridge, UK.

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