CHAPTER 6

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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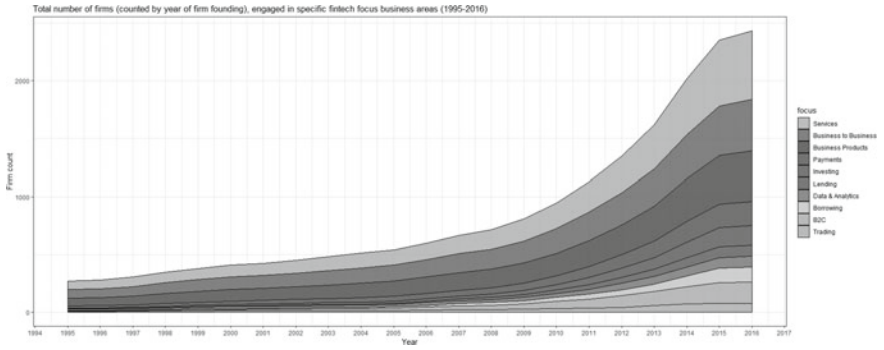


Fig. 6.1 The evolution of fintech and the business area focus of fintech firms through time

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

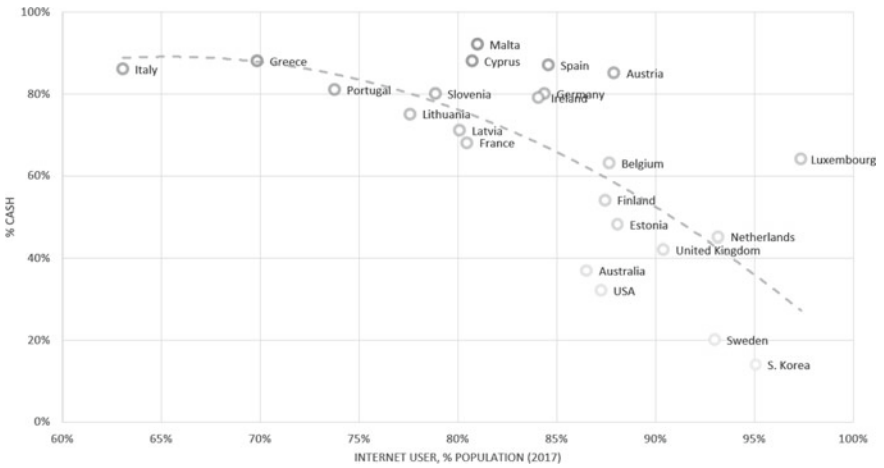


Fig. 6.2 Cash use vs internet penetration (August 3, 2019, *The Economist*)

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[a]

Increasing roles in workforce from 2018 to 2022	*Declining roles in workforce from 2018 to 2022*
• Data analysts and scientists • AI and machine learning specialists • User experience and human-machine interaction designers • Digital transformation specialists • Sales and marketing professionals • Client information and customer service workers • Innovation professionals • Information technology services • Information security analysts • General and operation managers	• Data entry clerks • Administration and executive secretaries • Accounting, bookkeeping and payroll clerks • Business services and administration managers • Bank tellers and related clerks • Management and organization analysts • Financial analysts • Postal service clerks • Credit and loan officers • Accountants and auditors

[a]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.

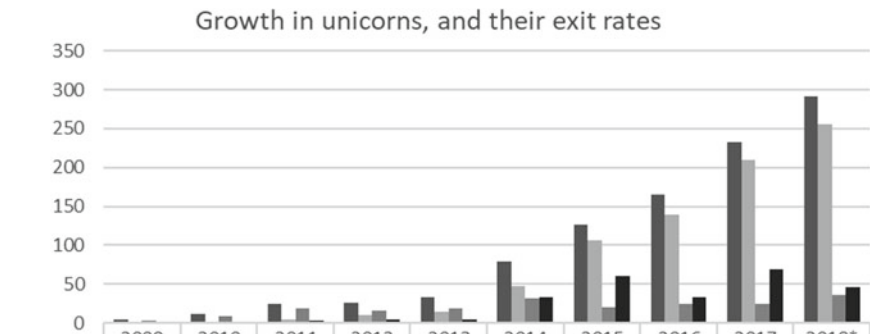
Table 6.2 adds further definition to the trends contained in Fig. 6.4 giving an overview of the distribution of industries that unicorns are positioning themselves into, based on the non-exiting startups for 2018. The vast majority fall inside under 'technology, media and telecommunication' classification (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. 6.3 One-line focus areas of fintech startups

under the 'others' category might engage with fintech activities to a lesser or greater degree.

In 2018 the fintech unicorn industry carried a valuation of US$85.8 billion, see Table 6.2. This valuation, though largest, can be accumulated within very modest time frames as can be observed from the information in Table 6.3. Seven of the top 10 fastest growing unicorns achieved their unicorn status within 12 months of their company inception, with the fastest being shopping website Jet.com, who reached a US$1 billion valuation in just 4 months from their launch, while online loan provider Apus Group achieved unicorn status in just 7 months. The majority of unicorns take a little longer achieve their status, and according to data on fleximize.com, the average fintech unicorn takes 6 years to make a billion-dollar valuation.

The brief facts presented so far stand testament to the excitement which the fintech industry offers to the business and investment community. From



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*
Total	4	11	24	26	33	79	127	165	233	291
Non-exit	1	2	5	10	14	47	107	140	209	255
Exit	3	9	19	16	19	32	20	25	24	36
Minted	1	1	3	5	4	33	60	33	69	46

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

Industry	*No. of unicorns*	*Percentage*	*Valuation ($B)*	*Valuation (%)*	*Average value ($Bn)*
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[a]	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

[a]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

Company	*Transformation speed*	*Business*
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 be 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 experiment. 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.[1] 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.[2] 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.

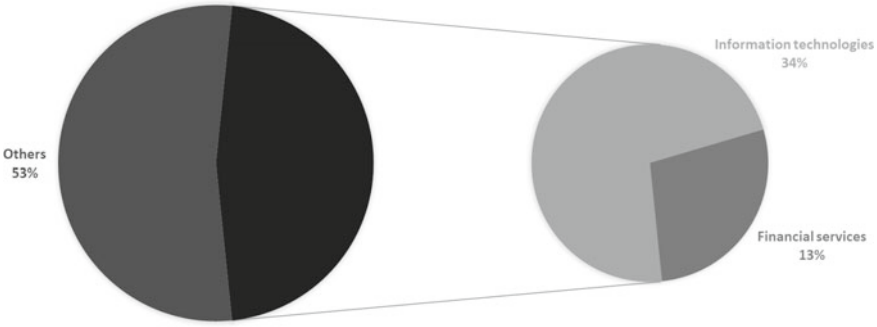


Fig. 6.5 DJIA companies by market capitalization of major industries (total market capitalization: USD 7.6 Trillion, July 17, 2019)

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

Company	*Industry*	*Market capitalization (USD billions)*
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

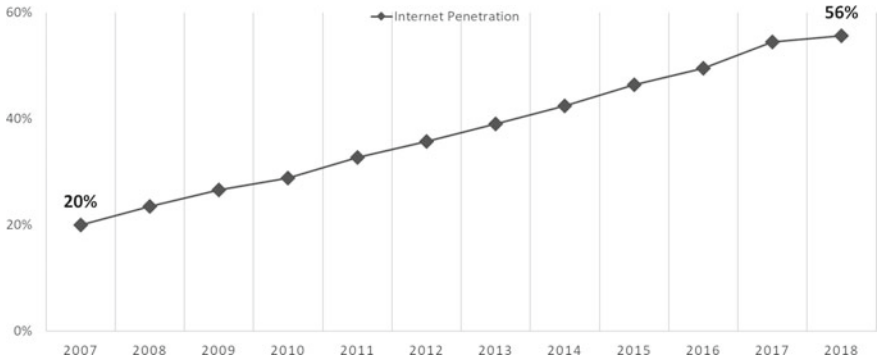


Fig. 6.6 Internet penetration (2007–2018)—sourced from www.internetworldstats.com

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

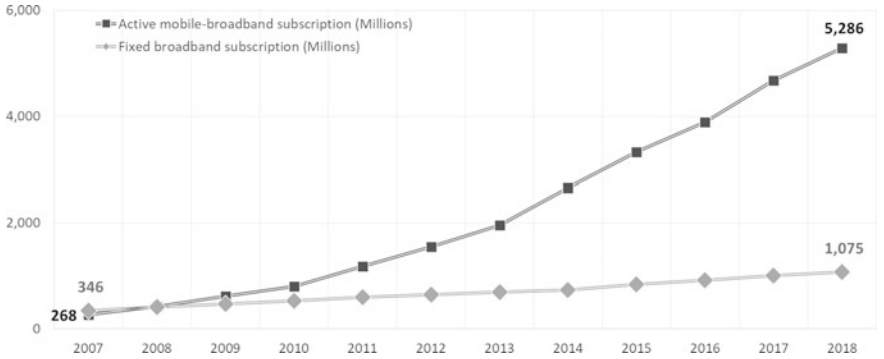


Fig. 6.7 Fixed and mobile broadband subscription worldwide (2007–2018)—data obtained from ITU 2018 statistics

second. However, the speed of GRPS still remains too slow for any meaningful mobile application and business models to strive. 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.[3] 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.

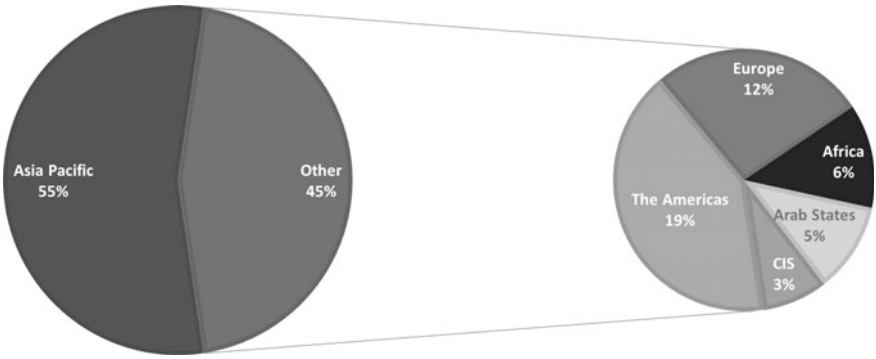


Fig. 6.8 Worldwide share of active mobile broadband subscription (2018), ITU

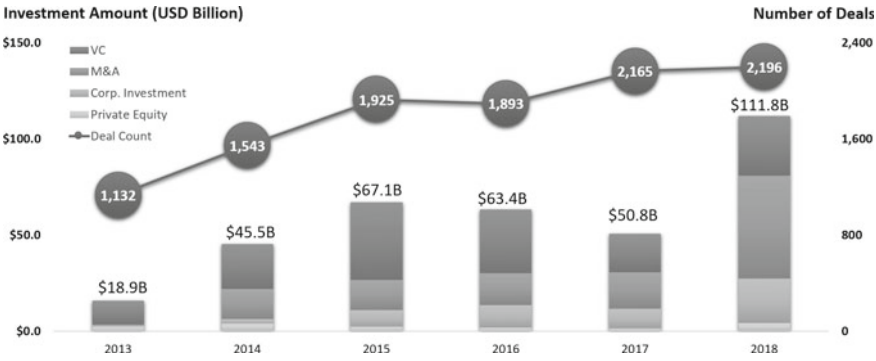


Fig. 6.9 Fintech investment activities worldwide (venture capital, private equity, and merger & acquisition) between 2013 and 2018

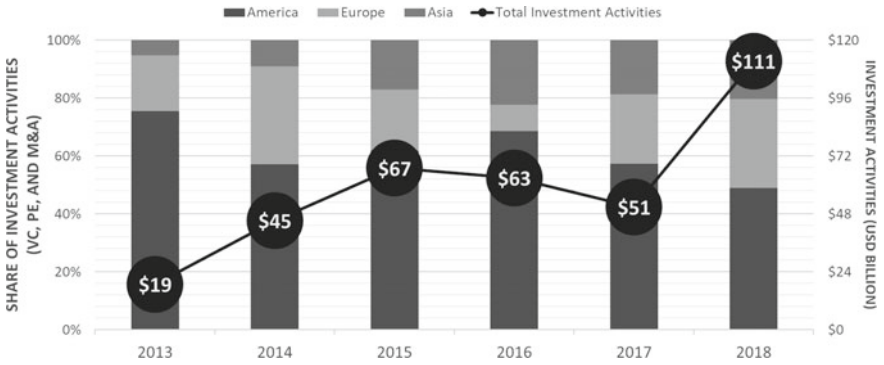


Fig. 6.10 Fintech investment activity by regions (2013–2018)

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.[4] 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.[5]

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

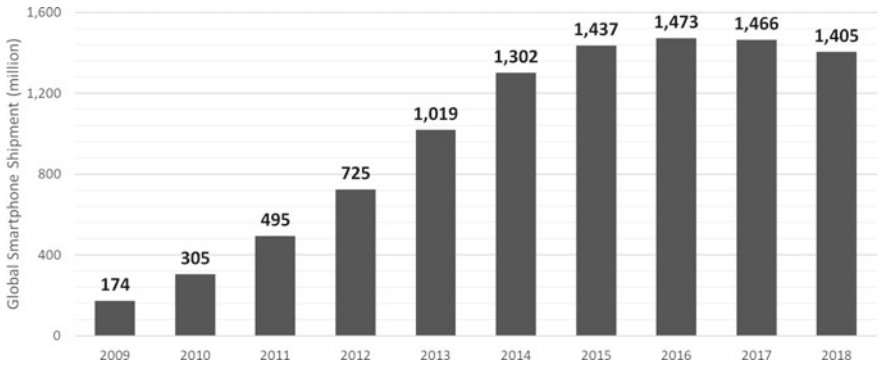


Fig. 6.11 Global smartphone shipments 2009–2018 (*Source* IDC 2018)

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 datacenters 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.[6] 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 datacenter 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

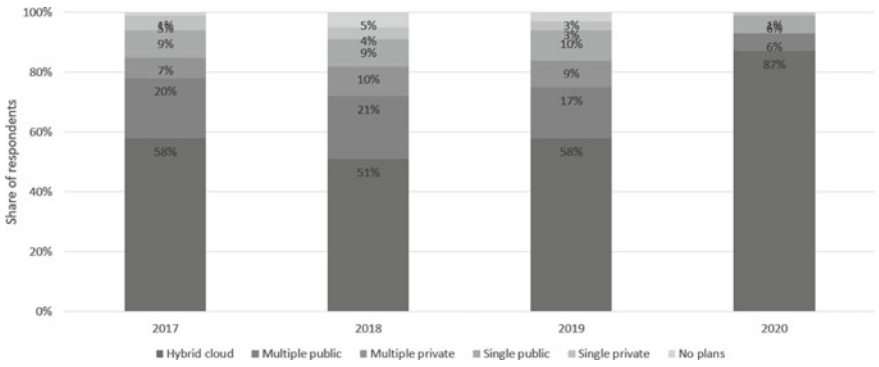


Fig. 6.12 Percentage of application workloads shifting to public cloud (*Source* Morgan Stanley. https://www.morganstanley.com/ideas/cloud-cybersecurity)

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.[7] 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.[8] 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.[9] 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

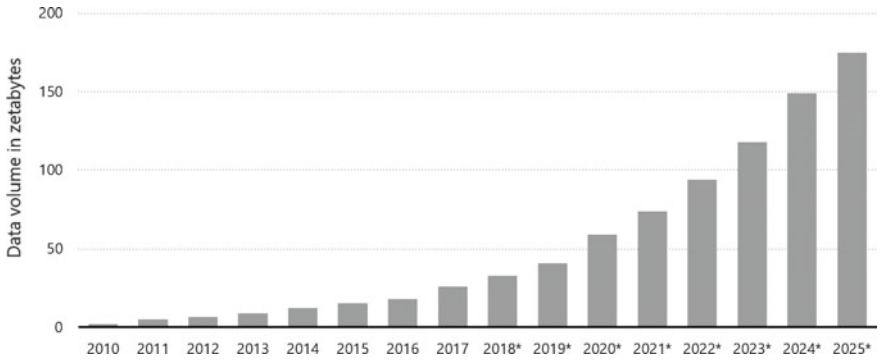


Fig. 6.13 Annual size of the global datasphere (*Source* Data Age 2025, IDC, November 2018)

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 global by 2025, and that over 30% of the data stored are generated real-time from these devices.[10] 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.[11]

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

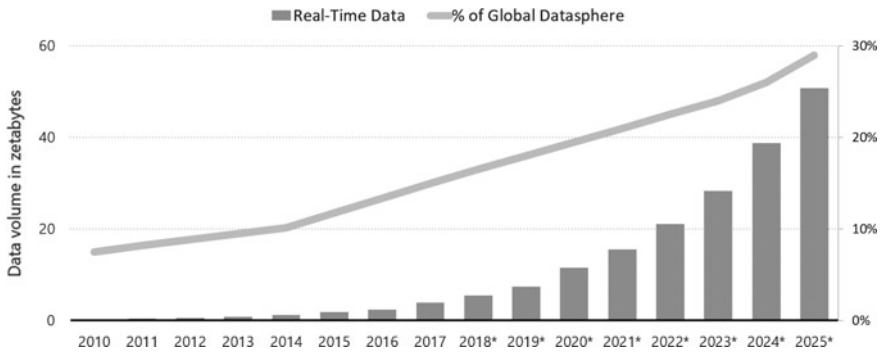


Fig. 6.14 Annual real-time data generation (*Source* IDC, November 2018)

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 effectives. 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 cyber-security. 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.[12] 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.[13] 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 80×10^{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.[14] Even with the availability of cloud computing resources, the cost to launch such attacks out-weight 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.[15] 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 heave 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

Key attributes	*Enterprise ethereum alliance*	*Hyperledger*	*Corda*
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.[16] 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

Company name	*Business areas*
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)

Company name	*Business areas*
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

Company name	*Assigned attributes*
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)

Company name	*Assigned attributes*
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

Customer type attributes	*China*	*USA*
B2B	35	25
B2C	25	24
B2B2C	10	11

Table 6.9 The most innovative fintech companies in 2019

Non-customer type attributes	*China*	*USA*
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[17]

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

Year	*Total no. of unicorns (excluding exits)*[a]	*Total no. of unicorns (including exits)*	*New unicorns minted*	*Unicorn exits*[b]
2019[a]	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

[a]as of 12 September 2019
[b]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[a]. 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

Industry	*# of unicorns*	*%*	*Valuation ($B)*	*Valuation %*	*Average value ($B)*
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

[a]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[a]. 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

Industry	*# of unicorns*	*%*	*Valuation ($B)*	*Valuation %*	*Average value ($B)*
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

[a]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

Description	*Angel/seed investor*	*Venture capital*	*Private equity*
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[a]. 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

Investors	*# of Unicorns in Portfolio*	*Investor 'group' includes:*
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	

[a]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)[a]. 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

Industry	*Exit method*	*# of unicorns*	*%*	*Exit value ($B)*	*Average exit value ($B)*
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

[a]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)[a]. 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

Industry	*# of Unicorns*	*%*	*Exit value ($B)*	*Exit value (%)*	*Average exit value ($B)*
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

[a]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[a]. 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

Industry	*# of unicorns*	*%*	*Valuation ($B)*	*Valuation (%)*	*Average value ($B)*
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

[a]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[a]. 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

Industry	*# of Unicorns*	*%*	*Valuation ($B)*	*Valuation (%)*	*Average value ($B)*
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

[a]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)[a]. 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[b]

Country	*Industry*	*Exit Method*	*# of Unicorns*	*%*	*Exit Value ($B)*	*Average exit value ($B)*
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
	Total	**M&A**	**7**	**23%**	**24.1**	**3.4**
		Public Listing	**23**	**77%**	**341.7**	**14.9**
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)

Country	*Industry*	*Exit Method*	*# of Unicorns*	*%*	*Exit Value ($B)*	*Average exit value ($B)*
	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
	Total	**M&A**	**60**	**45%**	**137.3**	**2.3**
		Public Listing	**74**	**55%**	**314.4**	**4.2**

[a]as of 12 September 2018
[b]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)[a]. 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[b]. Company with foreign revenue means the % of revenue from foreign source is larger than 0 according to Bloomberg[c]

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

[a]as of 12 September 2018
[b]Technology is further divided into Software & Technology Services and Hardware; Others included Industrials, Energy and Utilities
[c]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

Industry	*Country*	*No. of unicorns (CB insight)*	*No. of unicorns in Hurun*	*Total no. of unicorns*	*Valuation in CB ($B)*	*Valuation in Hurun ($B)*	*Total valuation ($B)*	*Average value ($B)*
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

[a]as of 12 September 2019
[b]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[a]

Country	*No. of unicorns*	*Valuation ($B)*	*Average value($B)*
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

[a]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.[18] 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 position 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, Chinese 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/programmatic 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.
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 x 10^{18} hashes/ 20 x 10^{6} hashes per second/ (10 minutes * 60 seconds per minute). Bitcoin is designed to generate one block in approximately 10 miniutes.
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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