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Disruptions and Digital Banking Trends

Luigi Wewege[1], Jeo Lee[2] and Michael C. Thomsett[3]

Abstract

Technology in financial services, or 'fintech', entrants and technology-media-telecommunication companies have rapidly evolved into the traditional banking industry, offering customer-centric, faster-easier-convenient-free, financial services. Digital-only-neo-banks focus on payment, money transfer, lending for small-medium-businesses, and microfinancing, facilitating technological innovation such as digital wallet and messaging peer-to-peer transactions. Fintech banks generally lack scale and trust, unregulated in some cases with credit or liquidity risk exposure, from the customers perspective. Fintechs are increasingly perceived as a partner for a source of value creation through technological advances and innovations to large, traditional, and incumbent banks moving to accelerated digital transformation. All innovative technologies which have laid the groundwork for major disruption in the current digital banking revolution, set forth unimagined trajectory of collaboration and consolidation as fintech industry matures. This paper updates the digital banking transformation in fintechs and incumbent banking institutions to show that access to future fintech trends will grow significantly in coming years. The combined findings suggest that digitalised-mobile-banking transitions emphasize the capabilities of banking infrastructure for data sharing, connectivity, stability and cybersecurity and standardisation of internal and external APIs as progress continues within the regulatory framework of data protection as part of the privacy act and open-banking directives.

JEL classification numbers: G18, G21, G24, G28
Keywords: Retail Banking, FinTech, Artificial Intelligence (AI), Data Sharing, Application Programming Interface (API), Data Protection Regulation.

[1] Corresponding author. Co-author of 'The Digital Banking Revolution' 2020 and co-author of Pilot Study 2 on the Processes for Determining the Accuracy of Credit Bureau Information.
[2] School of Finance and Management, SOAS University of London.
[3] Co-author of 'The Digital Banking Revolution', 2020, widely published with international and national book publishers and peer-reviewed press.

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1. Introduction

Financial technology, where finances meet technological innovation, or 'FinTech,' is perceptibly matured beyond the early stage, creating a threat reached on a global scale to emerging digital transformation of the banking market. Since 2008, global fintech financing activity has increased primarily in the USA, and from 2014, in European fintech. An era of cloud and mobile banking with personalised banking experiences and security, predicts that digital banking will continue to develop and be fine-tuned to be more secure and to satisfy the customers. A majority of traditional and digitally advanced banks have formed four partnerships on average in 2018, reflected in a survey by PwC (2017), showing that most (88%) global financial institutions are concerned they will lose revenue without incorporating emerging innovations without partnerships with fintechs (Galvin et al., 2018).

The estimated size of the digital banking market was over US$7 trillion in 2017 and the anticipated growth was over US$9 trillion by 2024 (Bhutani, Wadhwani, 2018). Financial technology companies (fintechs) are set to disrupt revenue worth $4.7 trillion of global financial services (Schmith, Vincent, & Perera, 2018). In 2019, global fintech investment was pulling $137.5 billion, a slight drop from 2018 results, remaining more than double every year prior to 2018 (Frankel, 2020)[4]. The significant proportion of 2019's deal value of fintech investment was driven by acquisition of Worldpay by Fidelity National Information Services (FIS) for $42.5 billion and the $22 billion acquisition of First Data by Fiserv. Evidently, some of the largest and oldest banks in the U.S., such as JP Morgan and Goldman Sachs, started to actively collaborate with fintech start-ups by heavily investing (e.g. venture capital, M&A, private equity) for investment banking and customer retail banking, while the traditional banks like Barclays, Citi banks and other high-street banks have digitalized their retail-commercial banking with fully integrated automation for their legacy financial services to be cheaper, faster, more convenient and more secure than ever before. This is from the banking customer's perspective of financial institutions, intended to bring down costs and risks, and explore ways to provide banking services and more customer-centric and personalised banking experience.

Some of distinctive fintechs emerged within fintech-banking and financial industry such as 'cybersecurity,' 'cloud-banking-platform providers' for automating regulatory and compliance processes,' and they have entered IPO (initial public offering) and listed in the major stock exchanges (see below, Section 2.2). The traditional banks and fintechs envision collaboration beyond the threat of fintech-disruption. Their scale, trust, and the continued increase in technological advancements to leverage technology and innovation, make financial services more efficient, and more accessible to create better financial lives and customer-experience.

Fintech trends show that fintech start-ups entered the incumbent retail banking

[4] The estimated fintech-investment will continue to proliferate, exceeding $30 billion in 2020 compared to $1.8 billion in 2011 (McKinsey & Co., 2019).

market involving mainly payment and banking (e.g. fund transfer, lending, loans). According to the survey by PwC (2020), 88% of financial institutions feared fintech start-ups for digital-only banks and global payment solutions in 2019. The survey also revealed that 82% of banks, insurers, and investment managers plan to increase FinTech partnership (PwC, 2020). Fintech is propelling FS (financial services) companies and TMT (technology, media, and telecommunications) companies to digital-transform banking industry for enhancing the quality of customer experience of financial services and products with lower costs and operational efficiency. Mobile only-banks with digital wallets are offering lending and payment services to underbanked population in Asia, Middle East, and sub-Saharan regions. Traditional banks in the national and global finance system have scale and credibility that rooted from regulatory supervision and policy, so for fintechs, a variety of value-added collaboration and partnerships are in the future (Wharton, 2019).

The domination of retail banking in the digital banking revolution results from increased deployment of online and mobile banking platforms and online and mobile payment solutions among the users of smartphones and on the Internet. Asia Pacific leads the market with over 60% revenue share owing to rapid adoption of digital payment services in China and India. This is because of growing population of younger generation, existence of telecommunication infrastructure, growth of e-commerce industry and the governments support towards digital transactions. For example, the percentage of digitally active consumers using fintech in 2019 showed the global average (33%), Europe (38%), UK (42%), India (52%) and China (69%) (Business Insider Intelligence, 2019). Similarly, consumer fintech adoption rates showed that China and India (87%) posit higher than other countries, i.e. UK (71%) (EY, 2019). These two results indicate that countries' demographic with large proportion of the younger generation (aged between 16 to 34) are shifting toward digital payment methods. Digital banking market demand is credited with the high-volume non-cash and digital transactions in India and China. Besides, the supportive government policies and initiatives in the emerging economies, China and India would foster growing market value.[5]

The traditional banking models are changing due to overflow of new competitors, digital challenger neo-banks, or digital-only-virtual-banks, from financial technology start-ups in the market after remaining in a comfortable position for decades with a low customer turnover and almost no regional competition. Large banks are investing in digitalizing their services to distinguish from the financial technology start-ups with innovation and technology, while the fintech-digital banks are catering to a niche segment of the market.

The methodology of this study adopts a systematic review across fintech investment data and analytics including global financing data from venture capital and private equity firms, corporate venture capital division, hedge funds and government-

[5] In Europe, the Netherlands is an exceptional case with more than 90% of the smartphone users adopting mobile banking services.

backed funds for the period between 2010 through 1st quarter of 2020. We focus on fintech companies, those offering technologies for banking (e.g. savings, loans), payments (e.g. transfer), corporate finance (e.g. lending to SMEs) and personal financial management although fintechs provide technologies and innovations for capital markets infrastructure, financial data analytics and cloud platforms, insurance, portfolio management, and cybersecurity, legal and compliance, and accounting. The consolidated data are assessed and evaluated from four different perspectives of interests of each group of

i. fintech start-ups, technology-media-telecommunication companies,
ii. large, traditional and incumbent banks,
iii. banking customers or users, and
iv. fintech-investors of listed fintech companies.

This review updates the development in fintechs space and how traditional firms retain the banking industry and the TMT posit them into the coming years. In section 2, the changes in retail banking models are described with critical assessment. Section 3 compares and updates the leaders between 2008-2015 and 2016-2020 to oversee the evolution of fintechs on offering the services and products. The summary of distinguished fintech trends into the future is shown in Section 4, followed by discussion, and concluding remarks.

2. Preliminary Notes

2.1 Literature Review

An unmistakable trend is underway, involving rapid deployment of digital banking. This is evolving not only as new technology, but also as a measurable level of enthusiastic support among customers. In one study of 400 customers in 4 major banks in Brunei Darussalam, 31% of respondents were using Internal banking, and 46% reported being satisfied with it. (Seval & Rahim, 2011).

It is not merely customer satisfaction that defines this trend. Innovative digital banking channels also reduce costs compared to traditional channels. Terminal-based banking reduces transactional costs to 58% and mobile-based channels to 15% of traditional cost levels. (Haas, 2014)

Another study, of 170 branches of a large bank, pointed out the key role played by customer-centric banking organisations, and that digital technical plays a key role. This relies on two service capabilities, customer orientation and customer response capabilities. (Setia *et al*, 2013)

As this rapidly expanding and new approach to banking grows, core assumptions must be re-examined and so must public policy. (Sheth, 2011)

What makes this digital revolution so appealing even too many traditional banks? Business strategy must adapt or become obsolete, and the digital strategic posture of banking has a growing influence on overall digital business strategy. This was according to a study based on 400 U.S.-based firms between 1999 and 2006. (Mithas *et al*, 2013).

It may be ironic to observe that as this revolution is underway, large numbers of

managers and IT professionals are unaware of how and why digital infrastructure evolves over time and how this affects their operations and customer response. A study involved 41 cases of digital infrastructure and paths to successful outcomes. (Henfridsson & Bygstad, 2013)

These studies and outcomes demonstrate a point observed time and again: The digital revolution is happening, and it is a fast-moving change in banking and other industries. At the same time, many managers and professionals are not fully aware of the profound implications of this revolution to their organisations or their functions within those organizations.

2.2 Digital Transformaton of Incumbent Banks

Disruptive technology in financial services, fintechs have digitally transformed the banking industry with focus on customer-centric financial services, expanding for SMEs. Overwhelmed by fintechs and technology firms' innovations and advances, the traditional investment banks are remodelling their operations by extending their core platform to retail and commercial banking, while incumbent retail banks rapidly shift their business models toward digital mobilisation for a faster, more secure and more personalised customer banking experience. Almost all traditional banks, leveraging their strength in a regulatory and existing customer base, have collaborated with fintech market entrants incorporating emerging innovative technologies for the last few years. As we enter a new decade, the banking and fintech industries will grow further in a form of joint venture, merger, and acquisition, toward consolidation among banks, fintechs and technology firms, and social media network providers. Digital tools such as AI and blockchain, data platforms, regtech of cybersecurity and strategic partnerships will be essentially be well positioned to be retained in the banking market of fully digital transformed financial ecosystem. (Khanna & Martins, 2018)

Traditional banking has been largely unchanged and unchallenged until digital banking began with the branch-based banking model in the early 1990s (see Figure 1 below). The first Internet bank was Stanford Federal Credit Union in the USA in 1994. At the dawn of online banking, the number of bank local branches has been significantly reduced worldwide. At the same time, there has been a steady increase in the number of digital banks worldwide. ING Direct was the original digital disruptor, starting as an exclusively online bank in 1996 and attracting more than 20 million customers in 9 countries over a little more than a decade without the need to invest in physical infrastructure. The fintech-bank 'N26' was first approved for a banking licence in 2013. Facebook will launch in 2020 a social network-based banking facility while Amazon will offer an e-commerce-based checking account feature in 2021. As of 2020, mobile banking apps, direct deposit to P2P payment and AI-powered-cloud-based banking platforms become a norm to banking customers. The timeline below of the development of digital retail banking indicates there was a significant implication of a change for a next stage of fintech-banking from around 2019 when fintech APIs called across large banks. All types of these collaborations and partnerships such as M&A, Venture Capital (VC) and Private

Equity (PV) has reached a historical deal value in 2018 and 2019, reflecting the fintech industry entering a matured market.

Digital-only banks or challenger banks are competing with traditional banking institutions. Generally, these neo-digital mobile banks show features of user-friendly interfaces, competitive pricing, commission-free stock trading, cryptocurrencies for premium accounts, and virtual identity verification, Apple Pay and Google Pay and P2P transfers by phone or email to the same bank users only.

These customer-centric fintech companies raised over $2.5 billion in 2019. These upstart digital banks are the fastest-growing sector among fintech start-ups as they offer convenience and ease in banking, for instance, nearly a 40% drop in bank visits. According to time survey (2016), consumers prefer to interact with their financial institution online (67%); in-person at a branch (57%); smartphone (55%), ATM (52%); and phone (26%) (Pilcher, 2020). Digital-only banks are growing in numbers and revenue all over the world (Bhutani & Wadhwani, 2018). They're the major reason the numbers of bank branches are set to drop 36% (approximately four visits per year) from 2017-2022 with mobile transactions rising 121% in the same period so that banking interactions on laptop and desktop devices will decrease by 63% between 2017 and 2022. (Pilcher, 2020). In the next five years, 88% of all interactions with retail financial institutions will be mobile. A shift towards mobile banking from desktop banking is not happening at the same rate across every demographic.

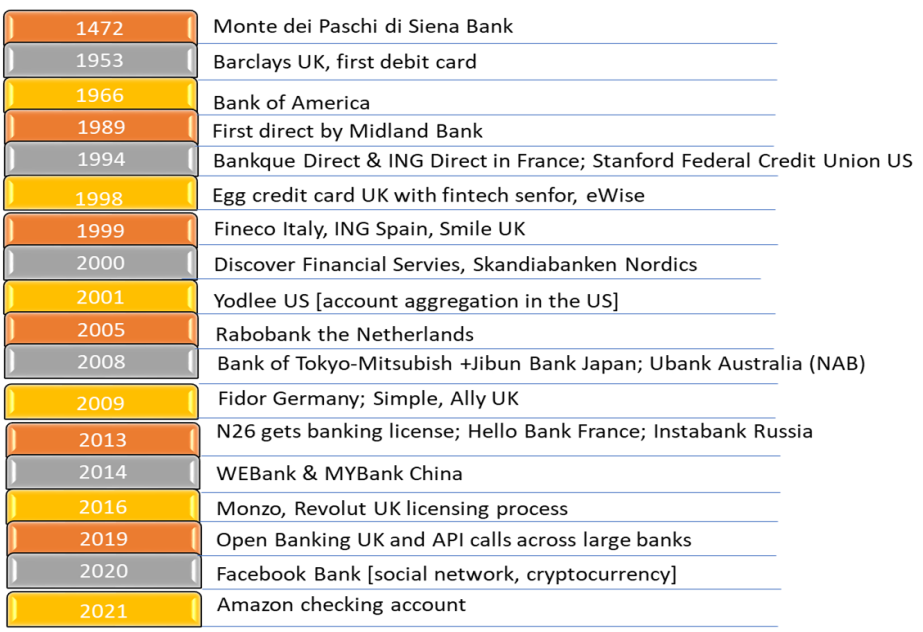

Figure 1: Timeline of Digital Retail Banking (1472 – 2021)

Source: History of digital banking by Verdict (2020) .

As Figure 2 below shows, payment-fintechs share 84 % of fintech banking, followed by fund transfer (68%); personal finance (60%); personal loans (56%); traditional deposits/savings accounts (49%); insurance (38%); and wealth management (38%) (KPMG, 2018). Mobile payment innovations by large technology companies, such as Amazon, Google, and Apple, have their own payment platforms and continue to roll out new features such as biometric access control in order to meet the customers' needs, payments to be instant, safe and fee-free. Often, mobile payment platforms are building programs and offers based on the user's purchase history. Payment innovations in fintech-banks and banking apps handle mobile payments, contactless payments, mobile wallets, blockchain technologies, smart speaker systems, identity verification technologies, and AI for security. These are already well on their way toward boosting cashless transactions. According to Statista digital market outlook (2016), estimated mobile payment volume will increase from $8.5 billion in 2015 to tenfold by 2020 for $274.4 billion in the United States. The annual average growth rate 2016 - 2021 was +62%.[6] Digital banking market value is estimated for over $9 trillion in 2024 from $7 trillion in 2017, an average growth rate over 4% for the period 2018-24. Digital retail banking sector share posits over 75% by 2024; investment digital banking segment growth rate posits 8% for 2018 – 24; and transaction services sector share was over 90% in 2017 (Global Market Insights, 2017).[7] The increased mobile payments resulted from exponentially increased mobile and Internet users worldwide (World Bank 2018)[8] and also the growth of mobile e-commerce sales worldwide, which was increased from 52.4% in 2016 to 67.2% by 2019, according to 'eMarketer' s estimation (2018). The share will increase 72.9% and the total mobile e-commerce sales will be $3.56 trillion in 2021.[9]

Financial technology covers a broader range of applications from simple to complex include online and mobile banking platforms and apps; person-to-person (P2P) payment apps for individuals; peer-to-peer lending for small or medium enterprises (SMEs); budgeting apps; robo-advisers; mobile payments; digital wallets; cryptocurrencies; international transfer; foreign exchanges; savings; mobile brokerage and trading apps; personal financial management; automation of accounting/tax support for SMEs; cloud-banking; fraud protection and cybersecurity. Figure 2 below exhibits the financial transactions within fintech banks. Fintechs include, broadly, 84% of payments; fund transfer (68%); personal finance (60%); personal loans (56%); traditional deposits/savings accounts (49%); insurance (38%); and wealth management (38%) (KPMG, 2018). With these potential applications of fintechs and digital ecosystems, how banks' core competencies can leverage for innovation strategy with fintech start-ups through B2B partnerships would affect the fintech trends over coming years.

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[6] Statista estimates as of November 2016.
[7] Source: Statista (2017) Digital banking market, by Global Market Insights.
[8] Source: World Bank, individual using the internet (% of population), 49.72% in 2017, and mobile cellular subscriptions (7.858 billion 2018) 1960-2018.
[9] Source: eMarketer (2018)

The fintech with consumer-centric start-ups or infrastructure providers may huddle coping with customer acquisition costs or regulatory challenges while incumbent banks may lack a speedy execution of new technology at the space of fintech's.

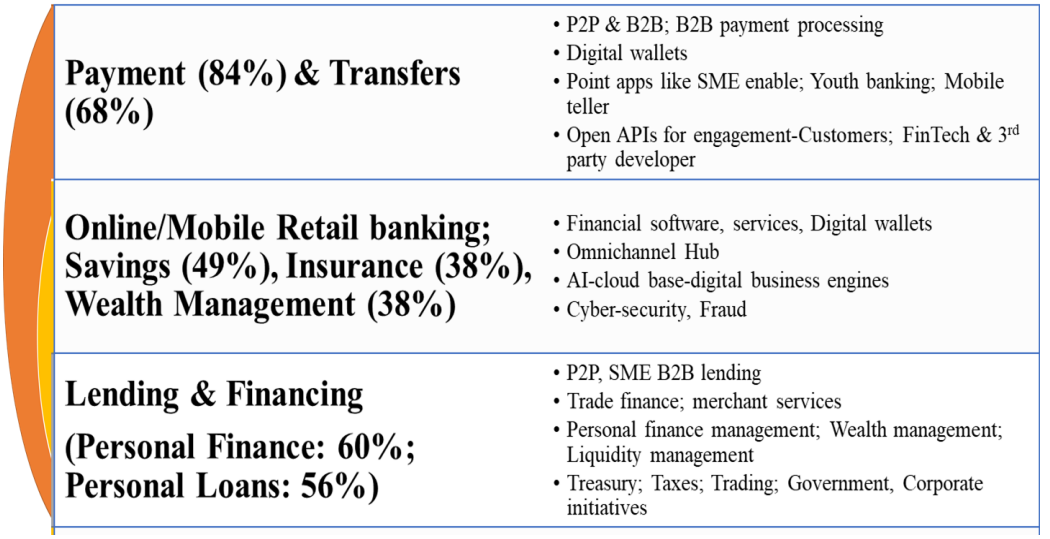


Figure 1: The FinTech Ecosystem

Digital-only banks might be cheaper because they do not open branches and just maintain the website and no administrative employees due to automation of process of the applications, and more convenience. But at times customers run into problems and can't settle everything online. Fintech disruptors might not have banking licences or not hold a deposit insurance, moreover, they bound to be prime targets of the financial fraudsters, cybercriminals, or hackers. The solution is to partner with traditional banks. The first stage of fintech challengers between 1996 and 2015 was coming disruption and threat with new technologies to large banks, after the transition period of 2016-2017, and since 2018, the collaboration between large banks and fintechs came both disruption and synergies.

Table 1 below (Galvin et al, 2018) categorised fintechs with four shapes:

1. Fintechs as new entrants, start-ups, and attackers looking to enter financial services with customer-centric financial technologies. The key challenge for this group is the cost of customer acquisition.
2. Fintechs as traditional banks or incumbent financial institutions that are investing significantly in technology to improve better customer experience and respond to competitive threats and partnership opportunities. Some examples are JPMorgan & Chase, Goldman Sachs, BNP Paribus, ABN AMRO bank, Citibank, BBVA and other large banks.
3. Fintechs as fintech-ecosystem-networks by technology companies like 'Apply-Pay' and 'Mastercard networks' which offer financial services to facilitating existing platforms with materialising user data or relationships. 2020-2021,

Facebook and Amazon will enter fintech industry to utilizing their platforms, user data, AI, and cloud platform.

4. Fintechs as infrastructure providers selling services to financial institutions for providing digital channels in real time (e.g. H2 Holding), for automating legal and compliance of accounting systems (e.g. Blackline), for a portfolio management platform (e.g. SS&C Technologies), and for a core-insurance-operation platform (e.g. Guidewire) (see below Table 1) (Galvin, et al., 2018).

As the fintech industry matures, incumbent financial institutions and large banks should strategically engage with fintech disruption, whether by building their own capabilities or by investing in a form of JV or M&A. The four categories of fintechs would further consolidate for scale and regulatory provisions, at the same time new fintech entrants (e.g. on cybersecurity) would unstoppably enter the fintech market.

Table 1: Types of FinTech Banking Examples from Listed Companies

[1] Fintechs as new entrants, start-ups	'Square': The credit card reader offering payment processing services to smaller businesses that could not traditionally afford card acceptance services. Hold 'Square Capital;, a microloan platform for small businesses, deploys a specific point-of-sale (POS) platform Square for Restaurants, 'Caviar', Square's food delivery and Cash App is a digital wallet P2P payments. (See above Figure 2)
[2] Fintechs as incumbent financial institutions	'JPMorgan Chase': Acquired WePay, a platforms to integrate payment solutions, new all-mobile bank, Finn
[3] Fintechs as fintech-ecosystem-networks	'PayPal': The world's first digital wallet showing growth and innovation in the area of mobile commerce. Mobile payments, 'One Touch' had more than 120 million consumers and 10 million merchants registered on the platform. 'Mastercard': Exhibits acquisitions 'APT', which stands for Applied Predictive Technologies, is a cloud-based analytical tool; 'NuData Security' creates digital identities for consumers based on passive biometrics; 'Brighterion' is an AI-powered platform that helps detect fraudulent transactions; 'Oltio' is a South African mobile payments start-up; and 'Vocalink' provides Fast ACH transactions in a number of different geographical markets.
[4] Fintechs as infrastructure providers selling services to financial institutions	'Guidewire': Provides property and casualty insurers with software platforms that enable insurance core services, from data analytics and digital engagement to underwriting and claims management. 'SS&C 'Technologies': Provides software platforms for trading and portfolio management, with back-office functions, to financial institutions, asset managers, and trusts. 'Blackline': A cloud-based software platform to automate regulatory compliance in accounting practices, reconciling financial data, in real time. 'Q2 Holdings': Offer cloud-based platforms for smaller banks and credit unions to apply digital channels.

Note: Authors own compiling of the examples, the second column.

Traditional banks are shifting toward digital channels and collaborating with fintech companies for increasing Internet and smartphone users by adopting online and mobile banking platforms to deliver more customer-centric products, provide better banking experiences – faster, safer, and convenient payment -- as well as to reduce operational costs. Fending off cyber-attacks is one of the major challenges in digital banking. Retail banking sector shared over 75% in the total digital banking market in 2017 with transactional services (over 90% share) toward banks developing new business models to cope up with the changes in customers' requirements through integrating or connecting distribution channels. The digital banking market are highly competitive due to the presence of both multinational companies and fintech start-ups. Some of the digital banking fintechs focus on collaboration with banking institutes to gain market share. The multinational TMTs and banking institutes are acquiring fintech start-ups to develop their own omni-channel digital banking products to meet their customers' requirements and reduce the fee rate.

McKinsey (2019) expects that US banking will continue to consolidate via bank-to-bank and fintechs M&A a decade after the 2008 financial crisis. The market reaction to bank-to-bank and fintech mergers has generally been positive and banks have a better capital position to execute M&A as the average return-on-equity raised from 8.6 % in 2013 to 10.8% in 2018. More than 60 US banks with assets of $10 billion to $25 billion might be attractive acquisition targets for regional banks (with a high cost-income ratio and a low loans-to-deposits ratio).[10] Interestingly, both old and large investment banks and incumbent retail banks have evolved toward digitalisation for their extensive-banking models.

Digital transformation can offer opportunities for banks to build on core strengths to create sustainable outcomes by improving their existing customer base and operational capabilities, strengthen engagement, and use of big data to reflect customers' needs. Banks can grow beyond their core checking account, credit card, mortgage, auto finance and insurance into relevant financial ecosystems. Extending beyond the core can allow banks to form a network of value across industries and create their own "ecosystems" providing the services that customers want at lower cost and with greater convenience.

The evidence below indicates all banks are not ignored digital growth strategies. For instance, the large investment bank, Goldman Sachs' is in the middle of extension their investment banking to retail banking through HR transformation. By early 2017, about one-third of Goldman's approximately 9,000 employees were computer engineers, and most trades were replaced with complex computer algorithms. Followed by the change in HR for trading automation, the new platform Marcus Goldman offered to US customers consumer banking for personal loans, savings accounts, a personal finance app and issued the 'Apple's credit card' (2019). The bank's business is built on a tech-focus with no branches approach that reflecting the organizational approaches innovate from within existing businesses, and by expanding for unconventional growth opportunities in consumer banking

[10] The consolidation has steadily reduced the number of US banks from roughly 15,000 in 1985 to about 5,000 in 2018.

that represents a good fit with competitive position in investment banking. Goldman Sachs' Marcus entered into consumer finance-lending franchise in 2016 which recently surpassed $3 billion in US consumer lending volume appears to be an error – removed Goldman used established digital sales and marketing techniques to become a leading provider of consumer finance in a short period of time which evidences while technical innovation is important, the Marcus' success in the US led new digital capabilities that delivered the most value quickly, as it hit $1 billion in loans in just eight months while competitors took over a year, launched in the UK in September 2018 offering its savings product, seized 100,000 customers in the first month to hold onto a legacy position (Brodsky et al 2018). Other large investment banks have focused on robot-advisory services for their wealth management platforms as their digital transformation effort. In 2017, Morgan Stanley launched 'Access Investing', Merrill Lynch offered 'Merrill Edge Guided Investing' and Deutsche Bank, 'Robin'.

An example of retail banking digitalisation can be seen in Wells Fargo. The bank upgraded digital experiences in its core banking products by adding a predictive banking feature to provide tailored financial guidance to existing customers. Barclays took a data-driven approach to rolling out new features and updates for customers and small to medium sized businesses to view personalised experience of faster and more efficient ways to visualise bank statements.

Ideabank and ING have extended into banking adjacencies by providing services like accounts-receivable management, factoring, and cash-flow analysis to small and medium enterprise customers. Post Bank, for example, has become the largest provider of mobile phone services in Italy.

Large and traditional banks can create significant value by rapidly executing a novel business model to deliver a service-as-infrastructure, or entering new market segments via digital channels based on back-end-infrastructure of banking platforms, capital assets, banking licenses, core banking products, renting their balance sheet to small fintechs, and providing credit-card processing to retailers, instead of competing with non-financial techs on the customer-facing front end of platforms or apps (Cleary, et al., 2018).

3. Main Results

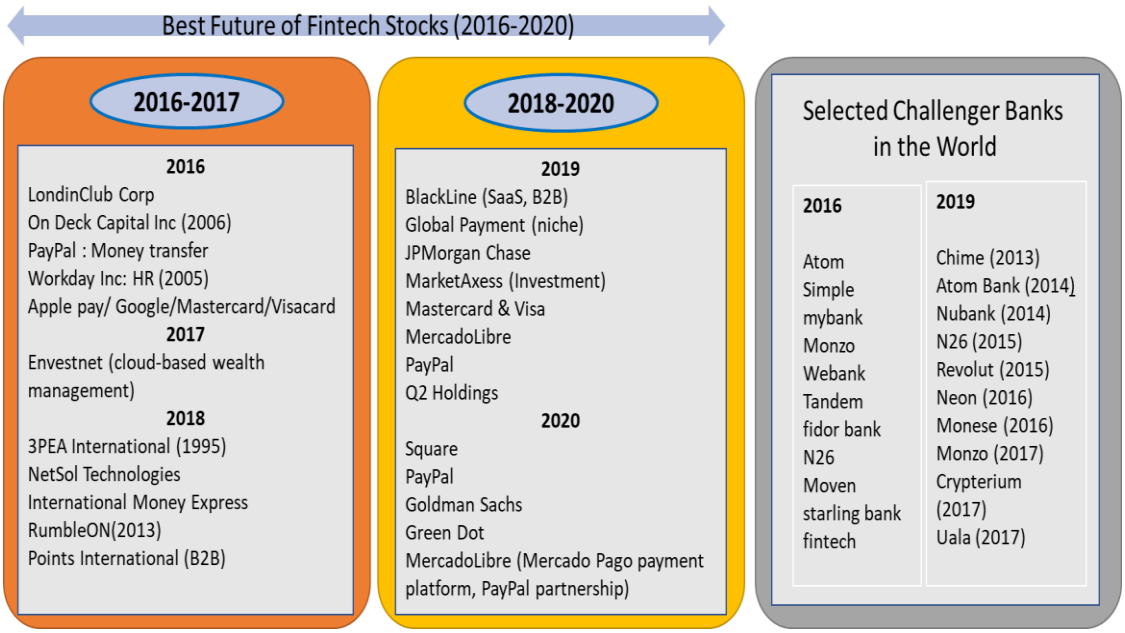
3.1 The rise of invisible digital-fintech banks

Investments into digital-only- banks more than tripled in 2019 to US$5.2 billion from US$1.6 billion in 2018. Foundering into the category of payments (28%) and lending (25%) start-ups took over half of global fintech investment while insurtechs ranked 13%. A maturing fintech industry shows that the number of fintech deals globally rose to record level to 6.8% in 2019. However, the numbers of fintechs start-up decreased to 3,472 in 2019, reflecting a mature fintech-market, from around 6,000 fintech start-ups in 2017, and stood at 13,000 in 2014. The trend indicates that fintechs easily persuaded customers by offering a user-focused designed mobile apps for money transfer and payment. This is gone as nowadays, great user-

experience is the norm that most financial institutions have transformed, offering full mobile functionality with best-in-class design. Customers, as a result, require more reasons to switch to new fintech offerings. Fintechs and large technology companies (e.g. Apple, Google, Microsoft, and Amazon) will focus on data-sharing analytics with AI and prioritisation on cybersecurity in coming years.

Digital-only-virtual banks offer global payments, peer to peer (P2P) transfers, contactless MasterCard with free transaction fees on checking and current accounts or the equivalent, which a transactional account t intended for day-to-day consumptions and payments. Some of looming digital-only banks are Revolut, Moven, Monese, HelloBank, FirstDirect and Digibank, among dozens of others in 2018 (Pilcher, 2020).

Figure 2: Competitive Landscape[11]



Note: Above show compiled highly ranked fintech-banks in the market (Crypterium, 2020).

Figure 3 shows selected and highly ranked (in value, growth, and investment analysts' recognition) recommended fintech stocks (left two boxes) in 2016-2020, and on the right-hand-side box, showing, digital-only-fintech-banks in 2016 and 2019. The digital banks that top-ranked in 2016 were Atom, Simple, Maybank,

[11]Source:
https://www.nasdaq.com/articles/5-great-stocks-for-the-future-of-fintech-2016-03-14
https://www.fool.com/investing/2017/09/21/the-best-fintech-stock-to-buy-in-2017.aspx
https://investingnews.com/daily/tech-investing/fintech-investing/5-top-fintech-stocks-2018/
https://www.fool.com/investing/best-fintech-stocks-buy-2019-financial-technology.aspx
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Monzo, Webank, Tandem, Fidor bank, N26, Moven, and starling bank. Atom, N26 and Monzo were highly ranked in both 2016 and 2019. Monzo, founded in 2015, is one of the UK's first 'digital only' banks that offers conventional banking services via a mobile app with instant predictive overspending notifications and auto budgeting features. The weak features of digital-only-banks compared to traditional banks are often not available outside a certain country or region, low fee-free ATM withdrawal limit, fee for sending money, a fee for (international) ATM withdrawal, international purchases fee 4%, no debit card or limited banking services, monthly maintenance for premium account, slow customer service, no loans, and system interruptions for updates/maintenance (Miklos Dietz, 2016). Non-bank owned highly ranked digital-only banks are Chime (US), which offers Visa debit card with no fee; Fidor (Germany), which offers an interest-bearing current account**;** and GoBank (US), which offers prepaid debit card; Koho (Canada); Loot (UK); Monese (UK); Moven (US); N26 (Germany); Neat (Hong Kong); Revolut (UK); starling (UK); and USAA (US) (2020). The top fintech-banks include Atom; simple; Maybank; Monzo; Webank; Tandem; Fidor bank; N26; Moven; and Starling bank in 2016 (Figure 3 above). In 2016, Simple offered ease of use-interfaces; Moven provided a pioneering mobile money-management app and is now partnering with financial institutions to provide this service to retail customers. In 2017, Envestnet was ranked as a top fintec company, providing unified wealth management technology and products to financial advisors and institutions. This sort of wealthtech will continue to disrupt both financial institutions and individuals' asset management in coming years.

In Figure 3, highly ranked challenger banks in 2019 included: BlackLine (SaaS, automation); Global Payments (payment processing for niche industries); Mastercard (global payment network with more than 2.5 billion credit and debit cards, supplementary services to its fintechs clients); MarketAxess (electronic fixed income investment trading platform); PayPal (digital wallet platform, 267 million users including 21 mil. Merchants); and Q2 (digital and mobile banking platform provider).

Figure 3 shows top ranked digital-banking service providers in 2020, including Square, PayPal, and Green Dot'. Square enables small merchants accept credit and debit card payments with a simple dongle that plugs into smartphones and tablets. It processes card payments at an annualized rate of over $100 billion, and has a thriving small-business lending platform, Square Capital with 24 million monthly active users. Square offers point-of-sale payment-processing that accumulated over 7 million monthly users as of December 2018. PayPal is undisputed leader in online payments, its Venmo person-to-person payment platform has emerged as an industry leader. PayPal has acquired complementary e-commerce tool Honey and built partnerships with over 300 million active accounts at the end of 2019. Green Dot, one of the fintech banking-as-a-service (BaaS) platform companies, offered prepaid debit card two decades ago but is losing market share to companies like Square and PayPal.

The distinct element of virtual banks is generally owned by traditional banks and a digital bank named 'B', for instance. The parent company of 'B' is Clydesdale and Yorkshire Bank incorporating Apple and Google Pay. Similarly, Bank Mobile is owned by Customers Bank and offers P2P mobile payments; CBD Now is owned by Commercial Bank of Dubai; Singapore based DBS Bank owns Digibank (headquartered in India) and currently offers eWallets and mobile investments in India and Indonesia; Finn is owned by JPMorgan Chase; First Direct is owned by HSBC and was the first true direct bank on earth (1989); BNP Paribas owns HelloBank and is one of the largest and most sophisticated digital-banks in Europe. Mashreq Neo' is owned by Mashreq banking group in UAE; Pepper is owned by Bank Leumi in Israel; Simple is owned by a Spanish banking group, BBVA; Simplii Financial and Tangerine are owned by Canadian banks CIBC and Scotiabank, respectively.

Fintech-banks' key innovations focused money transfer which has been traditionally dominated by large incumbents such as Western Union and TransferWise. Fintech's payment innovations such as mobile wallets and digital-only banks break the money-transfer borders financially and enable users to make global payments., no start-ups have gained scale of the two payment incumbents. As fintechs mature, at some point they must decide whether to go public. Many fintech founders have preferred to stay in the private market to avoid the burdens of public listing in the IPO (Initial Public Offering) market. Many peer-to-peer (P2P) lending fintechs, such as Adyen, the Dutch payments fintech, listed in June 2018, and has seen its share price double. Funding Circle, the UK P2P lender, listed in October 2018, growing over 50% a year since its 2017 IPO.

Some challenger digital banks have raised significant sums of capital, but still struggle to monetize their products effectively; others have not yet delivered a current account product due to complications around banking licenses and regulations. Fintechs have revolutionized the financial sector in many ways, from increasing the use of payment gateways (e.g. WePay owned by Chase, Braintree owned by PayPal, Amazon pay, PayPal) to providing credits, boosting e-commerce with easier account setups and transactions.

The fintech sector has undergone a great deal of growth and disruption and is being funded more from venture capital (VC) investment than initial public offerings (IPOs). In 2018, according to CB Insights, VC-backed fintech companies raised a record $39.75 billion over 1,707 deals, more than twice the amount in 2017. Among public fintech companies, in 2019, Fiserv acquired First Data for approximately $21.8 billion. Fidelity National Information Services (FIS), acquired Worldpay for $35.3 billion. These were two of three biggest deals in fintech history. Fiserv and FIS, targeting some of the largest merchant processors, suggesting that the competitors keep an eye on each other.

3.2 Competitors to collaborators

Despite digital disruption in the financial services industry, fintech start-ups and large technology companies have so far shared only a tiny portion of global financial

services revenues, (valued at $120 billion in the US) that have grown 4 percent annually over the past ten years. From the banking customers' perspective, the demand for fintech services and products is rising however, and the survey report by PYMNTS (2019) found that 90.6% of consumers in the US respondents stated that their primary banks fit their needs, Trust was still the most-cited answer (63%) from respondents. It was followed by other answers such as easy-to-use online banking services from the 57.5% of consumers who would be interested in banking with non-financial institutions (i.e. digital-only-banks), and easy-to-use mobile apps at 44.4%. The five most popular brands for banking for respondent were the big tech and fintechs: 30.5% PayPal; 24.8% Amazon.com; 17.5% Walmart; 14.9% Google; 13% Apple; Mastercard; and Square. Recognizing the need and benefit of combining strengths in partnership models between fintechs, start-ups and incumbent financial and technology institutions for the relatively flat years from 2009 to 2017, fintech start-ups and incumbent banks and card companies partnered with fintechs and have redefined the financial industry from 2018 through all sorts of strategic leveraged collaboration among them. A majority of global financial institutions fear they will lose revenue without incorporating all the emerging innovations through partnerships with fintechs.

Clearly, banks are moving to collaborate with fintechs rather than develop their own in-house solutions, taking advantage of technological innovations while often saving costs and time through partnerships, venture capital, private equity or merger and acquisition. Banks perceived collaborating with fintechs would create value at the core of the bank's financial-innovation activities through agile digital transformations while overseeing their internal capabilities and competitors' partnering strategies.

Banks move to digitize further in high-margin areas such as lending, financing, and investing and to partner with artificial-intelligence companies (AI-techs) to improve customer service (see below 5.2) so that they share embedded analytics and AI that entails digital engines of big-data, omnichannel hub, and digital experiences. Digital experiences include online and mobile banking, digital wallets, point apps like SME enable, youth banking, mobile teller; open APIs for engagement-customers; fintech and third-party providers (TPPs). Digital business engines include core, liquidity management, wealth management, payments, trade finance and treasury. Banks can offer a mix of internal and TTPs (e.g. fintechs) offerings to provide customers with easy, one-stop access to financial products and the ability to address multiple financial needs through integrated channels. (Barreto, de Freitas, & Volin, 2020)

Most incumbent banks, insurers and investment companies have partnered with at least one fintech company since 2018 from 55 percent in 2016, either as investors or through strategic partnerships for value creation, and they intend to invest in their fintech partnerships over the next few years. According to McKinsey (2019), global venture capital (VC) fintech investment in 2018 reached $30.8 billion, up from $1.8 billion in 2011. PwC sees 82% of current financial service providers increasing partnerships, investment and acquisition, and international development

within the next five years (PwC survey, 2017, McKinsey, 2018, 2019).[12]
From the fintech start-ups prospective, they reach a saturation point in digital marketing channels, and many are actively looking for partnerships to grow their business and combine higher speed and risk tolerance with and flexibility in reacting to market changes with larger ecosystem firms like ApplyPay, Mastercard, Visa, Facebook and Amazon, with their broad customer networks from their core internet businesses. For fintechs, the incumbent banks' large customer data sets in their core current account mortgage products, and the capacity and capability of compliance and regulatory competencies are highly valuable for newer and smaller fintech entrants. Large banks perceive that fintech companies are potent sources of innovation and insights from an externally developed technology, providing advances for banks to disrupt themselves.
Some examples of recent cases are

i. Goldman Sachs' collaboration with Elinvar [13] and acquisition of United Capital and its FinLife CX digital customer-service platform to add an advisor-led tech-enabled platform. Goldman Sachs' acquisition of Final is an augments strategy. Final impacts Goldman Sachs' partnership with Apple Card by adding digital features for fraud and theft protection, including those which allow consumers to monitor their spending in real time.
ii. JPMorgan Chase earmarked $11.5 billion in 2019 alone for technology investments, an example is the bank's recent acquisition of InstaMed to support its position in payments. the bank's other strategic partnerships with fintechs including OnDeck, a small business lender; Roostify, a mortgage fintech; and Symphony, a secure messaging app. JPMorgan Chase's recent acquisition of WePay for $400 million supports its payments platform.
iii. Citi bank partnered with Demyst Data for credit scoring for lending division and plug and play financial capability. Citi Ventures invested in Betterment, Blue Vine, C2FO, Chain along with big data and analytics startups. Citi bank developed Citicoin which is in pre-production as a digital currency.
iv. In 2015, ING launched what it called FinTech Village, an accelerator for start-ups in Belgium, and ING Ventures, launched in 2017, is a €300 million fund focused on fintech investing a total of 115 start-ups over the last three years, of which ING has built strategic partnerships with Kabbage, the automated online lending platform provider for full back-to-front platform integration for lending.
v. Santander bank partnered with Socure biometrics fintech, and SigFig, and Santander InnoVentures invested a $100 million for fintech fund. Santander develops OpenBank in Spain, a digital bank which operates outside of the bank. In lending, referral programs with FundingCircle adopted for both Royal Bank of Scotland and Santander while Santander

[12] PwC, 2017 Fintech Report.
[13] 15/05/2019.

and Royal Bank of Canada are working with Ripple to develop cross-border blockchain-based transactions for payment.

vi. Banco Bilbao Vizcaya Argentaria (BBVA) is the second largest bank in Spain with digital innovation. BBVA is using OnDeck scores to assess small businesses looking for loans. BBVA has partnered with Dwolla in real-time payments.

vii. HSBC is partnering with Ayasdi to combat money laundering, while Erste Group Bank has introduced video-based identification with the aid of IDnow. In investments and account-management services,

viii. ABN AMRO Bank has collaborated with Tink to launch a personal financial-management app.

ix. Barclays has partnered with Flux Systems to give customers itemized receipts on their smartphones, allowing them to see in detail how they spend their money. Barac is working with Barclays to provide real-time analytics that can predict fraud and computer outages.

x. Betterment Holdings has partnered with BlackRock and Goldman Sachs to expand portfolio options for increased personalization. Risk and customer service, while less active, are picking up the pace. For example,

xi. BNP Paribas has integrated the SPIXII chatbot for customer service, and

xii. TD Bank has integrated the Kasisto conversational artificial-intelligence platform into its mobile app.

xiii. In 2018, PayPal made four acquisitions for a combined total close to $3 billion. Mastercard acquired VocaLink, a company specializing in instant bank account transfers. Visa acquired Earthport, a cross-border payments specialist.

Recent merger cases reflect their focus on increasing geographic footprints, scale efficiencies and capability-building. McKinsey's 2019 report showed the share of capability and fintech in total strategic collaboration and partnerships was 14% in 2009-11 and 34% in 2018-20 while the shares of scale (from 51% in 2009-11 to 36% in 2018-20) and geographic expansion (from 20% to 13%) in total collaboration/partnerships were reduced, indicating an intertemporal saturation in investing fintechs industry after the fintech-bang for the market (Pollari & Ruddenklau, 2019). Generally, US regional banks face intense pressure to build new capabilities in advanced technology and analytics to transform a digital banking. To them, M&A is one of the ways to benefit regional banks to strengthen their competitive position for greater size and scale to challenge larger banks. The examples of merger case in 2019 include TCF with Chemical Financial and BB&T with SunTrust. BB&T and SunTrust, on the day of the merger announcement, saw share value of both companies increase by 4 percent and 10 percent, respectively. BB&T, in acquiring SunTrust, and announced a cost-savings target of $1.6 billion and plans to invest a substantial portion into digital banking.

McKinsey's report stated that M&A's by US banks and fintechs showed upward in 2018 and for 2019 and that M&A strategy and integration will prove critical to next-generation transformation in US banking, although less than expected performance

was realised in the total shareholder return (TsR). M&A transactions by US banks between 2010-19 showed new product (-6.9%), capability/fintech (-4.2), scale (-3.1%), and geographic expansion (-2.9%). The potencies of the full spectrum of opportunities of integration to improve cost productivity and new talent pools through bank-to-bank and fintechs could be assessed as these are missed in the TsR performance categories. US regulatory reform is supportive for mid-sized and regional banks with lifting the requirement. Relating to liquidity and contingent capital, counterparty credit risk and short-term debt limits, stress testing of Dodd-Frank. in section 165 Enhanced Prudential Standards (EPS) in 2018 for Bank Holding Companies (BHCs) with consolidated assets between $50 billion and $250 billion. The changes imply lower liquidity and contingent capital that would lead lower systemic risk and stress testing compliance costs. Many regional banks need to assess the full range of partnership opportunities to banking advances further into digitization and advanced analytics. (Seth et al, 2019).

4. Advantages

4.1 Banking-tech infrastructure, regtech frontier

4.1.1 Core Banking System and Capital Market Infrastructure Fintechs

Hundreds of fintechs are focusing development on their core banking system (CBS) and capital market infrastructure (CMI) to support banks and financial institutions, increasing productivity and lowering costs while generating new sources of revenue. Core banking system (CBS) fintechs have emerged, but CBS do not seek to disrupt incumbent banks, but rather to build a profitable business by helping banks upgrade their technology capabilities in a modular, open-API. Thus, changing banks' CBS is less costly, risky, or complicated within the banks' planned timeframe. One of leading CBS fintechs is Mambu, an infrastructure provider offering CBS products for larger customers such as New10, the digital bank launched in the Netherlands by ABN Amro in 2017. Other banks such as TBC-Bank adopted the Mambu system for banking, and for the Mambu cloud banking platform, Asto, Cheers, ZestMoney and Monedo; N26, the first pan-European mobile-only bank with 5 million and P.F.C. adopted Mambu as a core banking platform. CBS fintechs are likely to continue to target smaller banks or focus on non-core areas such as Ferratum, Folkefinans, Mynt, OakNorth, and Wenance, adopted Mambu as the platform for their lending business.

The role and importance of CMI techs have been growing in the past decade as changes in the regulatory environment in the markets have been enacted, such as a mandatory central counterparty clearing of over-the-counter derivatives or reporting requirements in buy-side firms. In coming years, CMI applications will grow although the numbers of fintech new entrants across the broader financial services sector have declined since 2015 due to the fintech industry's maturing and being saturated around 2017 toward clearly entering collaborations and the partnerships stage. CMI applications incorporate advanced analytics and artificial intelligence as available and aggregated data volumes through capital markets and financial and

economic data. The CMI applications also seek to use of the Distributed Ledger Technology (DLT) of blockchain to a range of CMI operations of clearing and settlement, and as alternatives to initial coin offerings (ICO). CMI fintechs enrich efficiency through matching technologies based on cloud and quantum computing while expanding new asset classes in traded markets.

CMI applications will gain in productivity for post-trade services utilising automation and robotics. For instance, regulatory tech firms (regtechs) will bring efficiency and standardisation to regulatory and risk management reporting. To date, most CMI fintechs are smaller start-ups developing products as components within the CMI industry and appear to be mainly integrated in working with existing providers. Given CMI fintechs' great capital resources, deep data pools, and analytic capabilities, their entry could disturb the CMI industry at scare. According to the McKinsey survey (2018) of the members of the World Federation of Exchanges (WFE), respondents report perception largely positive about the potential of CMI fintechs, expecting enhanced productivity or new revenues or revenue growth from incorporating their technologies in development of their internal capabilities by collaboration (40%) and joint ventures (25%) because for internal development, limits in needing resources storages and rapid speed of innovations to develop own solution, and securing diverse talents. Just 9 percent of survey participants of the 46 WFE members surveyed cited acquisition of fintechs as the most effective approach.

The CMI providers can transform with weltech and insurtech companies.

Wealth management technology companies (welthtechs) start-ups estimated funding reaches $4.6 billion include micro-investing, digital brokerage, and robo-retirement. For example, the weltech micro-investing apps in 2020 include Acorns, Robinhood, ETFMatic, Chip, Nutmeg,Stash, Clink, WiseAlpha, Wealthsimple and Moneyfarm. Weltech will continue to reinvent managed personal finances and micro-investment, digital brokerage platforms and apps for novice investors to invest in stock markets.

4.2 AI personalisation and integration for banking platforms

Artificial Intelligence (AI) has been integrated into the financial industry and experts predict a stronger relationship between AI and fintech as one of most popular trends as the transition to the big-data cloud and data-sharing accelerates. According to the annual Internet Trends Report by Meeker (2019), there will be more than 200 zettabytes of original and duplicated data or structured and unstructured data by the year 2025, indicating meaningful insights from vast data and AI algorithm will enable consumers to satisfy their personal financial needs and increase the accuracy and quality of decisions at a reduced cost. For example, they might use big data for predictive analysis to manage risk by creating risk profiles to identify how risky a certain investment is. Big data based predictive analysis for creditors can be used to detect financial fraudsters from analysed big data to identify the buying habits and behaviour of customers. The large and traditional banks can

provide personalised user experience as so do fintechs using the machine learning and AI tools. AI has a critical role to personalise delivery of core banking services to leverage across a range of commercial functions from virtual AI assistants, robo-adviser and intelligent chatbots or other smart systems and to predict consumer behaviour patterns.

AI helps process, store, and drive insights from big data, facilitates real-time omnichannel integration of business intelligence to deliver a personalized marketing experience for their customers with more relevant and useful information. For example, chatbots are adopted to 85% of banks to interact with the customers with improving productivity for personal banking conversational interface that can provide 24/7 service, instant responses to queries, and quick complaint resolution to significantly improve customer experience in the financial sector. For the age of digital banking, chatbots will need to become more human-like to meet the demands of younger generations (Hinds, 2018). AI and predictive analytics technologies also helps real-time decision making to directly influence business practice (e.g. lending) and brings higher returns by reducing operational costs and speed the time. From a mobile-banking perspective, AI and personalisation have a critical role to engage a better banking experience for self-sufficient banking customers. For example, AI-powered systems gather data and analyse it with the intention of recommending the best investment choice to the mobile banking users. AI providing a full justification of the choice.[14]

AI-powered systems being implemented can help reduce bank processing and operating costs by 22%, and that could mean $1 trillion savings by fine-tuning AI automation strategies.

Some banks use AI to help make credit underwriting decisions and lending decision using a credit scorer powered by AI to determine the financial health of the loan applicant, for instance. Consumer lending platforms are increasingly incorporating iterative machine-learning (AI) approaches to steadily improve current performance by the capability to combine advanced analytics and distinctive random data records. Banks and other financial institutions will increasingly rely on AI to handle risk management, security to deal with the incidence of cybercrimes and financial fraud. Fintech start-ups are using AI algorithms to improve and expand financial services credit offerings, insurance options, personal finance services, and regulatory software. Funding to AI start-ups reached record highs in 2016. According to CB Insights, core offering includes the application of AI to serve the financial services industry, including commercial banking and credit offerings, insurance, asset management, accounting, and personal finance, as well as regulatory and compliance services.

[14] Most popular customer service software: Freshdesk; Zendesk; Freshservice; LiveAgent; and Vision Helpdesk.

CB Insights (2017) categories 9 main segments:

i. Credit scoring/direct Lending (Affirm , ZestFinance);
ii. assistant/personal finance (Digit , Kasisto, Cleo);
iii. quantitative and asset management (Sentient Technologies , Numerai);
iv. insurance (Lemonade , Cape Analytics);
v. market research (Dataminr, Alphasense);
vi. debt collection (TrueAccord, CollectAI);
vii. business finance & expense reporting (AppZen, Zeitgold);
viii. predictive analytics (Opera Solutions , Kensho Technologies); and
ix. regulatory, compliance, & fraud Detection (Trifacta, Digital Reasoning Systems).

Other notable AI fintech start-ups using deep learning in fintech services are Element (segment: enterprise), Orbital Insight (Satellite image analysis), Cape Analytics (real estate insurance), Captricity (digitizing paper trail), and Descartes Labs (satellite image analysis) (CBNSIGHTS, 2017). Axyon AI provides deep learning solutions for capital markets and asset management, partnerships with Refinitiv/Thomson Reuters and IBM. Axyon AI completed a EUR 1.3 million funding round led by ING Ventures. Capital.com provides a mobile trading app, which allows investors to trade financial products, raised US$25 million by VP Capital (Fintechnews, 2018).

Financial institutions and large tech companies around the world are adopting AI for task automation, customer services, behaviour analysis, and detecting financial fraud. They are making large-scale investments in related technologies and estimates the number to reach US$10 billion by 2020 (Fintechnews, 2018). Amazon, Apple, and Google are pushing the boundaries of deep learning (DL) research and may soon bring their AI tools to financial services. For instance, Amazon uses machine learning (ML) tools for lending. Amazon India unveiled a seller lending network using machine learning to facilitate loans. Large banks like Goldman Sachs and JPMorgan are building dedicated AI teams and partnering with DL start-ups, increasing adoption in the near term. Applications for AI technologies exist across nearly the entire spectrum of financial services, from algorithmic stock trading, detecting credit card fraud, investment advisors and market research and sentiment analysis (Fintechnews, 2018).

4.3 Blockchain & dlt in global fintech ecosystem

Nakamoto[15] first introduced the concept of cryptocurrency and the blockchain, an undisputable computer file that is decentralized and distributed, in 2008 and 2009. Due to the developments and contributions for the last decade since Nakamoto's concept was released, blockchain is disrupting the financial industry by enabling the requirements of fintech to be effective in performance in terms of privacy of transactions involved, security of transactions conducted, and significantly faster speed of transactions between banks. Financial institutions will use blockchain for

[15] Source: Journal article and letter by Satoshi Nakamoto (2008, blockchain, 2009, Bitcoin).

smart contracts, digital payments, identity management, and trading shares (Marr, 2019). Blockchain can speed the transaction time of issuance stage up to settlement phase that may take at least a day in implementation. Banks and other financial institutions can build smart contracts based on blockchain involved business or transaction. To fully implement the cryptocurrency blockchain for fintechs and the financial industry at large, R&D is in progress as of 2020.

For example, blockchain fintech remains on the path of financial transactions with low processing fees and global reach. Using blockchain wallets, blockchain innovation will be used for payments, funds transfer and digital identity management (Vermeulen & McDermott, 2017). [16] Funding in blockchain companies increased to $450 million globally in 2016 (Szmigiera, 2020).

Customer adoption of truly innovative business models takes time, and smaller-scale attackers may require heavy infrastructure investments over a long period before revenues start coming in. Blockchain start-ups, for example, are attracting a significant amount of venture capital with radically new infrastructure for payments and other sectors. However, incumbents remain cautious, with blockchain remaining in prototype mode, and the leap to revenue-generation yet to take place. Payments continue to dominate partnerships, due mainly to aggressive low-cost strategies by fintech companies but also due to the immense opportunities that new technologies, such as blockchain, might offer.

The technology offered by blockchain offers multiple potential benefits, including a higher level of authentication and improved resiliency. Blockchain technology could allow organisations to use distributed public key infrastructure to authorise users by their devices, which is a stronger method of authentication than passwords. The certificate data is managed on the blockchain, making it harder for cyber criminals to attack the system and falsify certificates. Financial services firms may adopt this technology in cases where increased levels of access controls and authentication are required.

4.4 Open banking APIs, payment directive (psd2) and data sharing

The fintech regulations will be intensified with increasing cybersecurity threats and blockchain hackings although countries will address fintech regulations at their own pace and standards. In the age of digital banking, regulators would also scrutinize data breaches, based on the General Data Protection Regulation (GDPR) 2002; the Payment Card Industry Data Security Standard (PCI DSS) 2018; Europe's GDPR, which took effect in 2018; and the California Consumer Privacy Act (CCPA) of 2018, impacting the financial services industry for issues such as stolen customers' confidential and sensitive data.

The banking sector is one of the most regulated industries in the world with the supervision of the financial conducting authority and the central bank together with

[16] Opinions around use cases for blockchain vary by country, for example the countries that have adopted cryptocurrencies are Turkey, Brazil, Colombia, Argentina, South Africa, Mexico, Chile, China, and Indonesia. The US dollar is substituted with cryptocurrencies in these countries for the business (e.g. oil trade) or other purposes (e.g. drugs and arms trades), against using US dollars (Buchholz, 2019).

legislations at a regional and global levels. For example, money transfer and global payment transactions should promote transparency and anti-money laundering based on the US Foreign Account Tax Compliance Act (FATCA) and Sarbanes-Oxley Act of 2002 (SOX).

Fintech digital banking delivers customer value propositions with a better customer experience. The large banks pose advantage over trust based on the regulatory approval of holding bank license with deposit insurance schemes and banking regulatory supervision. Digital-only-banks or fintech-banks should meet the national and regional compliance and the regulatory requirements for their banking services. For example, the mobile-based brokerage app provider, Robinhood planned to offer checking and savings accounts with 3% interest rates to account holders, however, the plan was interrupted by federal regulators, who stated that the money would not be insured by either the Federal Deposit Insurance Corporation (FDIC) or the Securities Investor Protection Corporation (SIPC). With consideration of regulatory variation, WorldRemit and TransferWise in the UK, plan to expand into neighbouring European countries before moving across the Atlantic, which requires additional regulatory compliance. Each state in the US requires its own licenses for money transfer, which makes US expansion more cumbersome than for European operators.

The consideration of both regulatory requirements would cause a next generation of banking applications relating to personal data protection and sharing data among B2B operations that will influence the customers' banking experience (PulkiewiczKrzysztof, 2020). Financial services need to become increasingly digital, automated, and data driven. Banks, fintechs, and regulators will work together to deliver the best possible financial services products to consumers. Banking APIs are at the core of digital transformation. Regulation can provide structure to data sharing, and consumers will demand greater control, transparency, and trust over the process. In the European Union and the United Kingdom, the Second Payments Directive (PSD2) and the Open Banking Initiative are giving more control to the customer over payment data. In Europe, a third-party to connect to banking APIs is possible to obtain history of clients' accounts, making payment or checking availability of funds due to PSD2 effective on 14 September 2019.[17] With regards to Open Banking, a new third parties emerge and existing third parties being reduced as banks and merchants transact directly for cost reduction with efficient transactions. Open Banking Directive that came into force in January 2018 in the UK lead the regtech banking Application Programming Interfaces (APIs) solutions that were available in the UK. Digital banks such as N26, Fidor and Klarna are reinventing open banking. In the United States, large banks are striking data-sharing deals with individual partners in a departure from the aggregator model, e.g. the Chase partnership with Intuit and Wells Fargo's partnerships with Xero and Finicity. The advent of Open Banking means banking data is shared between two

[17] On 14 September 2019, the Second Payments Directive (PSD2) went into full effect all over Europe. See Krzysztof Pulkiewicz, 2020 on 'Open banking wave is coming, but are banking Application Programming Interface (API) ready for fintech?'.

or more unaffiliated parties to deliver enhanced capabilities to the marketplace that data and integration options allow for constructing a fintech ecosystem that helps banks provide differentiated and customer centric products and services. Data sharing is depending on market structures, regulatory environments, and consumer attitudes toward privacy and security. Open banking notions will result in implementing new APIs for financial data, alternative underwriting, and lending, facilitating new payment streams, and opening of data AI ecosystems (McKinsey, 2017). Open banking and data sharing are commonly associated with APIs although there are no truly open APIs in financial services dur to security, regulatory, and privacy concerns.

Account Servicing Payment Service (ASPS) providers are typically banks (i.e. current accounts) and non-bank payment companies (i.e. payment accounts) that offer accounts to customers subject to the scope of its authorisation. ASPS to the access interfaces establish through which TPPs can access the customers' payment accounts in a secure manner, and to ensure that these comply with the applicable requirements in the PSD2 and the regulatory technical standards. Under PSD2 an 'account information service' is an online service which provides consolidated information to a payment service user on payment accounts held by that payment service user with other payment service providers. An Account Information Service (AIS) provider is a company authorised to access an individual or SME's account data from their financial institutions with their explicit consent. The UK's nine largest banks are required by law to comply with these requests from the AISPs.

To fintech API providers to banks' internal banking architecture, optimisation should focus either on maximising the quality of security, connectivity, and stability of the APIs or minimising the effort of implementation. However, the development of banking APIs solutions is inconvenient situation of the scale of differences in API standards. The APIs provided by banks are different across different API standards, and each bank has a different approach to how it complies with PSD2 directive. There are notable banking API platforms include Revolut, a UK-based fintech, BanqUP, a Belgium-based platform that works similarly to what the Plaid platform does for the US Market, they already connected to over 50 banks from eight countries in their aggregator platform. The case of BanqUP, a Belgium-based open banking platform and its cloud-based Sandbox, encountered different standards across different national and multinational APIs and their implementations in Europe. Furthermore, often APIs provided by banks are observed significantly differ from the final API that third-party providers (TPPs) find not easy to design the functionalities of the production APIs to connect to access data and also allow any entity without a TPP licence to build its solution. Standards are treated as guidelines by banks together with Representational State Transfer (REST), a set of rules their APIs originally possess. Frequently tool APIs require stability and reliability issues that changes to a production API may cause failure to connected application. Another issue of banking APIs is the differences within a standard of a single API so that some banks support additional features and functionalities of the API standard but ignore some elements of the API standard.

For example, a standard payment is allowed but a ignore scheduled payment if the latter are not useful. With PSD2, that begins to change, and user consent and the right to be forgotten is creating a better market balance.
Besides, blockchain based smart contracts are a digital contract that will be widely used for fintechs. Smart contracts are robust in terms of trust and execution as the devices named a public blockchain would prevent breaching the authenticity of the contract to see the execution of the contract.

4.5 Cybersecurity, regulatory compliance, and regtechs

The cybersecurity industry is growing fast with an increasing e-commerce and a number of Internet-broadband and mobile network subscriptions. This digital transformation is global. Consequently, cybersecurity will become a high priority in financial services in coming years. The rapid speed of digital transformation in the financial services sector will continue to be susceptible to cyber-attacks and cyber risk exposure due to the concentration of financial and digital assets. Digital and mobile platforms to deliver services and products face challenges in their cyber security (Tantrigama, 2019). Financial cybercrime continues to be one of the biggest challenges facing banks and financial institutions, and with some estimates putting the cost to the global economy at over $2 trillion each year, it's critical that all parties come together to mitigate the impact and protect their customers. An increasing number of consumers are interested in mobile apps on their smartphone to accomplish basic financial tasks. According to the survey of U.S. Consumer Payment by Total System Services (Tsys, 2017), the highest percentage of the respondents are interested in is stopping fraudulent transactions (80%).[18] Since 2017, more than 80 percent of financial institutions are on average partnered with at least one fintech company or a technology provider that creates a vulnerability of exponential rise in cyber-attacks through partners, customers and third party vendors (e.g. software tools and software-as-a-service products).
There are two key legislations relating to protect personal data online:

1. The GDPR-2016/679 (General Data Protection Regulation) is an EU law on data protection and privacy for all individual citizens of the European Union and the European Economic Area and the transfer of personal data outside the EU and EEA areas. The GDPR came into force on 25 May 2018.[19]
2. The CCPA (California Consumer Privacy Act) is a data privacy law that took effect on January 1, 2020 in the State of California. The CCPA applies to businesses that collect California residents' personal information, and its privacy requirements are like those of the EU's GDPR (General Data Protection Regulation).

[18] Source: Report by **Total System Services on** U.S. Consumer Payment Study. Findings: Instantly view credit and debit card transactions for reviewing recent card transactions (72%); Turn a card on or off based on merchant, time, and location (64%); Receive instant offers from a store they are visiting (59%); Keep loyalty and reward points on a phone (56%); 56% for transferring money to family and friends; 51% for making payments for purchases at the checkout's point-of-sale . A sizable majority (63%) are now using banking apps, up from 46% in 2015. Two-thirds of consumers are familiar with in-app payments, and that percentage jumps to more than 80% for the respondents under the age of 34.
[19] See the effects of the EU GDPR by Mike Chapple.

For consistency, the federal law will follow the CCPA with a consistent privacy policy across the states in the USA. Fintech cyber security start-ups, cloud-platform, core banking providers and fintech banks will fine-tune their products and services to meet the requirements of the GDPR and CCPA. I Incumbent banks will update these and other regulatory requirements in their inhouse legal and compliance units. Increased regulatory scrutiny and enhanced privacy laws based on the GDPR-EU and the CCPA-USA mean that threats may will leverage the data breaches and regulatory fines. According to Cybersecurity benchmark study (Tantrigama, 2019), firms use multi-factor authentication (90%); Internet-of-Things (IoT) (62%) and AI (44%). According to the study, 68% use blockchain as cybersecurity measures are expected to increase.[20] 56% responding to the survey said AI offers potential benefits including the ability to automate complex processes for detecting attacks and reacting to breaches. However, AI and Internet-of-Things (IoT) can be used by threat actors to carry out sophisticated attacks. Out of cyber threats, malicious code seeks to steal computing resources to generate revenue via mining of cryptocurrencies. Once the malware is deployed, usually through standard attack methods (e.g. malicious links, script injecting), the malware goes to work in the background, usually without triggering any warnings.

The digitalization of financial institutions concerns sensitive personal information about the fintech business model. The cyberthreats that people are concerned about were identity theft, money laundering, cyberattack and hacking. Digital banking customers and smaller fintech banks are vulnerable to manipulation by cyberterrorists and cybercriminals who often target the digital banks with less investment in security due to budget constraints. Updating security systems and security software should be fintechs' and their customers' priority.

Generally, incumbent banks have comparative advantages over digital-only neo banks. Trust from banking customers due to the banks' dedicated in-house regulatory compliance and risk management divisions relies on the mandatory banking supervisions such as Basel II and III, and the deposit guarantee scheme in the banks' home state. In an era of digital-mobile banking, there is evidence of cybercriminal attacks or fraud in banking and mobile payment transactions. Recent trends in cyber security and global anti-money laundering (AML) uses sophisticated machine learning (ML) and AI to fight financial fraud and abnormal financial behaviour.

A key question is:

Which technologies will fight against financial crime in digital banking?

The cybersecurity-fintechs on anti-fraud, cyber security, and global anti-money laundering (AML) in digital and mobile banking use AI, incorporating other new

[20] There are emerging cybercrimes relating to digital-currency hacking. Money transfer using cryptocurrencies are unregulated that makes cryptocurrency a target for hackers the main targets are crypto exchanges. The first major hack was Mt.Gox , the exchange handling about 70 percent of all Bitcoin transactions worldwide by 2014. In 2011, at least $8.75 million was hacked, with losses of $350 million (850,000 BTCs) in 2014 though recovered 200,000 BTCs. The largest hack was Coincheck in 2018 for losses of $500 million worth of NEM tokens to hackers in 2018. In 2019, Binance was hacked for $40 million worth BTCs due to data breach. The exchange security should be improved and use own wallet rather than in an exchange to secure money transfer worldwide using cryptocurrency wallets (CryptoPro, 2019).

tech with biometrics technology on authentication to prevent user manipulation or user impersonation, verification of legitimate or suspicious behaviour access, anomalies or malware, and behavioural biometrics, often used for the investigation. McKinsey (2019) estimated that the cybersecurity industry will grow an average of 12% per year and reach $300 billion by 2024, including identity, authentication, and access management (IAAM), security information and event management (SIEM), and privileged access management (PAM).[21] Cloud-security start-ups offering Internet security and website performance services often act as cloud-based software web gateways or cloud-native-platforms, and identity protection.

Goldman Sachs backed iboss plays in sandbox. which defends networks against malware, cyber threats, and data loss with an innovative direct-to-cloud approach. (Columbus, 2020). Fintechs in this category of regulatory-compliance-fraud detection from cybercriminals to hack systems are growing and enabling AI and robotic process intelligence to distinguish unauthorised access for data breach. Notable companies include Trifacta and Digital Reasoning System, NetGuardians, Fraugster and Risk Ident. Examples of two of the fintechs are: NetGuardians, helping over 50 Tier 1 to Tier 3 banks worldwide to fight financial crime using augmented intelligence combined with other security solutions for fraud investigation. Fraugster's technology prevents fraud for online retailers and handles risk management for payment service providers such as Ingenico ePayments and Six Payments, and hedges payments with an annual volume of EUR 35 billion. Risk Ident developed two anti-fraud products, DEVICE IDEN and FRID to prevent payment fraud, account takeovers, and identity theft, securing more than EUR 50 billion in transaction volume. An example of payments fraud prevention solution providers is Kount. Its web-based platform provides a tool to reduce fraud for small and mid-size merchants. Fiserv financial crime risk management solutions fit large enterprises. Fiserv's platform supports cloud, iPhone app and Android app with the largest network of trust and risk data, linked by adaptive AI for real-time fraud prevention and account takeover protection. Fiserv is innovating for both issuers (e.g. False Decline Defence) and merchants (e.g. Authorization Optimization), ensuring legitimate transaction approval. Google, Microsoft, Amazon, and Facebook all have consumer identity services which provide common standards for identity and enable interoperability. One notable identity fintech is Okta, which focuses on IAM (identity access management), and other IAM providers, an identity as a service (IDaaS) models on data breaches and authentication, including: Microsoft Azure Active Directory, IBM, Oracle, Centrify, and RSA SecurID Access as of 2019.

[21] Lots of cloud-security start-ups issued IPO and listed on major stock exchanges in the USA, namely, Cloudflare**;** Zscaler; Symantec**;** Palo Alto Networks; Fortinet; Splunk; Zscaler; CrowdStrike; CyberArk; Veeva; Okta; Arista Networks.

5. Discussion and concluding remarks

To some extent, fintech start-ups and challenger banks gained competitive advantage over traditional banks by adopting a mobile-centric user experience. Incumbent banks and financial services companies provided slow and simple function apps to retain their loyal existing customers (Waracle, 2020). As of 2020, even after the growth of the cashless payments space in recent years, the majority of payment transactions around the world are still done in cash and consumers still use branch-based traditional banks though digital-only-banks offer better interest rates and fee structures. (Frankel, 2020).

Large and incumbent banks accelerate digital transformation by combining experimentation and prototyping into new initiatives in the fintech ecosystem, incorporating multidisciplinary approaches together with partnerships with fintechs' technological innovations to provide a cheaper, more secure and convenient customer experience in their banking services. Fintech will continue to provide technological advances and an agile execution while experimenting with the new technology, focusing on user experience and customer value proposition in testing processes in the shortest possible timescale. This improves digital applications, accessing core banking services via digital channels (Waracle, 2019).

The fundamental growth drivers of digital banking transformation depend on leveraging data-driven AI-powered insights that meet changing customer behaviour and their financial and banking needs online. They may provide AI-driven personalised self-service for 24/7 response, increasing investment in fintechs, supportive government policies, growth of e-commerce industry, and rising adoption of electronic mobile payment solutions. This challenges fintechs' lack of regulatory framework to cope with threat of cyber-attacks (Bhutani & Wadhwani, 2018). Furthermore, fintech's future within digital banking may address the challenges and opportunities faced by insurance, regulatory and investment centres via the insuretech and regtech worlds. This will be an important consideration in coming years. AI will get more prominence in integrating consumer data, financial data, and relevant information. Blockchain cloud computing services and digital bond offering are another fintech future trend (Verdict, 2020). The transition to the cloud platforms is accelerating with growing use of data sharing and data volume. Equipped with the integration of machine learning and AI in financial services, large and traditional banks can provide hyper-personalised user experience as do fintechs. Part of digital banking transformation, robotic process-automation will continue to improve, enabling financial institutions to be more efficient and effective in repetitive administrative requirements as well as to ensure meeting regulatory and accounting compliance requirements. Investment in fintech-automation of financial services is expected to exceed $30 billion by 2020 (Waracle, 2020).

The development of the digital banking revolution is no longer a question whether or not fintechs will transform traditional banking services, but which emerging fintechs will provide for the challenges of creating value and capability, how they will be funded through collaborating of merging or acquiring, joint venture,

private equity or IPO; and how financial institutes and technology-media-telecommunications (TMT) companies will interact and respond with others. Disruption and innovation change fast, and large banks can offer mobile apps with P2P payment and investing capabilities, while fintech-banking upstarts can offer personal loans and mortgages. The key areas of investing into financial technologies are:

i. creating digital capability (28%),
ii. modernize legacy systems (23%),
iii. managing cybersecurity, identity and privacy (18%), and
iv. building modern workplaces (15%) (Deloitte, 2019).

As of 2020, the trends of technology that shape and leverage in fintechs' financial services are consolidating into

1. digital-only-banking ;
2. blockchain in financial make-over;
3. a wider integration of AI in financial services and products;
4. increasing fintech regulation (e.g. data breach, credit exposure and liquidity risk in lending-saving-fintech ;
5. enriching payment innovations;
6. collaboration between fintechs, tech-companies and incumbent financial institutions; and
7. use of smart contracts for fintechs.

Besides, 'financial inclusion' for the use of mobile money services, payment cards, and other financial services applications would have potential development benefits (World Bank, 2018) through deploying a geographic coverage model to enable 1 billion adults to gain access to a transaction account. There were 1.7 billion unbanked adults across the globe in 2017, revealing far less than the 2.7 billion unbanked population in 2011 (World Bank, 2018). Fintech has potential to benefit for social and financial development for financial inclusion according to the Alliance for Financial Inclusion (Afi, 2008). This is a step towards ensuring that fintech should attribute for many currently underbanked or unbanked poor populations of no less than 1.1 billion people to gain access and availability to financial services in Africa and South Asia. In India, fintechs redesign the established micro-financing business model for SME. In 2017, the initiative by Accenture and Microsoft sought to provide a blockchain-based ID network for illegal aliens, refugees, and people who do not possess any government-issued documents. Fintech is partly credited for the shrinking number of unbanked or underbanked population who lack access to basic banking services such as bank accounts. Other development of philanthropic charitable fintechs' apps have evolved since 2012.

Shadow banking by non-banking-financial institutions (NBFIs, including mobile-only-banking companies, and banking by technology, media and telecommunication companies, funds and asset management companies, among money market funds), typically do not have full banking licenses; deposit insurance facility is not available; and this has been a growing concern in two ways: First,

they are outside of regulatory controls governing commercial banking activity, and second, the rapid increase of the inter-dependency between banks and NBFC, via digital banking transformations, on underwriting personal and commercial loans for small and medium-size businesses at microfinance scale, evidently exposes credit and liquidity risk from both lenders and borrowers. Mobile-based-shadow banking has expanded to surpass conventional banking in importance. Non-Banking Financial Institution (NBFI), Non-Banking Financial Company (NBFC), Micro Financial Company (MFC) and non-bank financial sectors such as insurance, mutual funds, and investment funds are linked with banking. In India, the Reserve Bank of India recognised the NBFCs (NBFCs, housing finance companies, and micro-finance institutions)' funding and liquidity will continue to face pressure (Fitch, 2020). NBFIs' in India have a significant role of India's development by offering loans to individuals and SMEs. The NBFIs' shadow banking has a role in developing countries. However, fast-growing shadow banking in China to $766 billion faces defaults (Bloomberg, 2020), so that the governments should set measures for unregulated banking activities that can recreate financial vulnerability. Extending regulations and the financial safety net to cover these NBFIs and NFIs (e.g. fintechs, TMTs), those providing banking services and products, should be regulated like a bank. In foreseeable coming years, regulators and central banks should pay attention to the repercussion of social and financial crises situations from aggregated microfinance (e.g. lending) to lower-credit scored individuals and small (Bloomberg, 2020)-medium business owners via mobile-only-banking by NBFIs and NFTIs. This can avoid the vulnerability resulted from combined liquidity risk, credit risk and reputational risk as they are not protected by regulation and often are the target of cybercriminals.

To sum up, in coming years, there will be a rapid digital-mobile banking transformation on cloud-based platforms by the strategic partnerships, joint venture, merger and acquisition among fintechs and large technology companies, banks and other financial institutions for value creation and scale synergy. Banks will need to address the potential loss of revenue in the payments or money transfer division where the fintechs technology innovations' initial target entry with customer-centric services. Banks should capitalize on their incumbent advantage in regulatory compliance provisions and their scale of customer accounts to explore data-sharing agreements with API fintechs and other third-party providers of banks' aggregate APIs development in order to extend and expand the banks' AI-powered service model. Fintech cybersecurity will become a significant priority as digital-only banks or banking apps are the norm. The use of big data with fintech AI and blockchain technology will proliferate for technological advances in preventing cybercrimes, cyber-attacks and data breach in all banking services and products. The use of fintech blockchain in capital market infrastructure and fintech contracts will continue to grow. The old and large investment banking will extend their business model to retail and commercial banking via AI-powered digital channels while retail banks will extend their core boundaries to leverage regtech, insurtech and wealthtech-investment technological innovations and advances to improve the

pittance revenue. Large network-based technology firms such as Facebook or Amazon will deploy financial inclusion for more than one billion underbanked or unbanked adults, utilizing mobile-cloud-based platforms for essential financial services such as money-transfer, remittance, payment, and microfinance.

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6. APPENDIX – Labels of figures and tables

Notes:
Case DataSet–Tables below are the summarised datasets that obtained from 'FinTechFutures' for the technology of fintech-banks in the UK, Germany, France, Spain, the United States of America, Canada, Austrailia, the Middle East (Barain, UAE, Saudi Arabia and Israle), India and Hong Kong. Tables are based on the data obatinaed from 'fintech futures'

Table 1: Banking-Technology in the UK

Technology	Name
Sungard Ambit Quantum; AmbitFocus Treasury Management, DPR consulting, Phoebus, Iress' MSO Wolters Kluwer's OneSumX, IE, CSC's ConfidentID WDS Virtual Agent, Grasp, TruNarrative, Temenos Infinity Temenos T24 Transact, Omnichannel Banking Platform	AlbaCo; Aldermore Bank; Allicia Bank; Amicus; Hampshire Trust Bank; Metro Bank ; OneSavigns Bank; PCF Bank ; Redwood Bank]
Mambu's core banking system, Finastra's Fusion banking Essence	Bank of Dave; Revverbank; OakNorth; N26; Recognise; Sumo
Infosys' Finacle core banking system	Axis Bank UK; Baroda UK Operations; ICICI Bank UK (India); Marcus; Soldo; Starling Bank
GPS and Wirecard, STEP2 and Target 2, FMS (core banking operations). Dovetail (Fiserv), Sphonic, Aquilla – accounting system	Soldo; Starling Bank
Oracle FSS's Flexcube, ACI Worldwide	Soldo
Sopra Banking Mortgage and Savings Suite	SVB
Cloud Base (Amazon Web Services, Microsoft Azura, Google Cloud)	Holvi; Monzo; Tandem; Starling Bank; Bung Redwood Bank; Revverbank; Atom Bank; CSBA; B-North; Gatehouse Bank]
Blockchain-Digital Currency	Bobb (>Contis Group); Chip (a e-wallet); Diaspora (blockchain); Fiinu (Cryptocurrency trading, Fiinuscore, PSD2); Founders Bank (Cripto exchange Binance); LHV Bank (cript-wallet)

Table 2: Digital Banking and Tech-Banks in Germany

Digital Banking for personal, business, marketplace	*SME/ Community focused banking*	*Speciality Banking*
Check24 (online banking in 2020) *Bitwala (B2C trade bitcoin out of a current account)* *Consorsbank (part of BNP Paribas)* *Fidor (digital only)* *Insha (Albaraka Turk Participation Bank, Islamic banking, SolarisBank tech, Mastercard)* *Openbank (Santander group subsidiary, full business in 2020)*	Fyrst (offshoot of Deutsche Bank, self-employed workers) Holvi (business Mastercard, SumUp) Kontist (partner of solaris Bank) Penta Silicon Valley Bank (venture capital, M&A)	solarisBank (B2B2C, a banking-as-a-platform service) Tomorrow (finance renewable energies, organic agriculture, microcredits)

Technology	Name
Temenos Infinity Temenos T24 Transact core banking system Oracle (Flexcube core banking system, business process management, content management and ERP software), ACI Worldwide's software for online banking.	Openbank Silicon Valley Bank
Mambu's core banking system (back office processing)	N26
SolarisBank, Fido banking-as-a-platform	Penta; Insha; Kontist; Tomorrow
AxiomSL for regtech ClauseMatch/BearingPoint	Openbank Revolut
Vaamo customised investment management Robo-advisor for micro investing	N26 Openbank
Accounting systems (FastBill, Debitdoor)	Kontist
Cloud Base (Amazon Web Services, Microsoft Azura, Google Cloud)	Holvi; Monzo; Openbank;
Blockchain-Digital Currency	Bitwala (trade bitcoin, solarisBank, Sony Financial Ventures, NKB Group, B2C

Table 3: Digital Banking and Tech-Banks in France

Digital Banking for personal, business, marketplace	*SME/ Community focused banking*	*Speciality Banking*
Boursorama Bank (Societe Generale, Visacard, Kador (12-17 year old) *Bunq (Maestro, Mastercards, Apple Pay, TransferWise, Monzo* *Ditto* *Eko (Credit Agricole)* *Fortuneo (subsidiary of Credit Mutuel Arkea)* *N26 (TransferWise)* *Orange Bank (Wirecard)* *Zelf (instant messenger apps, no-card, June 2020 launch)*	Anytime (business account, SumUp) Hello Bank (SME by 2022, BNP Paribas, acquired Compte Nickel) Morning (B2B API) Qonto	Compte Nickel (customers banned from banks, 1.2 mil customers) Kard (young adult for personal money management) Ma French Bank (subsidiary of La Bankque Postale, mobile with calls support) Moneyway (young audience for personal money management, payment service agent of Treezor by Societe Generale) Pixpay; Xaalys (Children 10-18 year old) Revolut (travellers)

Technology	Name
FMS.next core system (Profile Software) for processing, payments, treasury operations	Ditto
Mambu's core banking system (back office processing)	N26
Digital payments platform, Wirecard; TransferWise	Orange Bank; N26
Mobile payments via Apple Pay or Google Pay (Viewport Meta, iPhone/Mobile Compatible, SPF)	Pixpay
Treezor (Soiete Generale) infrastructure	Xaalys; Zelf; Moneyway
Off-the-shelf back office solution, Forest	Qonto
Blockchain-Digital Currency	Revolut (Cripto-currencies exchange platform)

Table 4: Technology of FinTech-Banks in Spain

Digital Banking for personal, business, marketplace	*SME/ Community focused banking*	*Speciality Banking*
Boursorama Bank (Societe Generale, Visacard, Kador (12-17 year old) *Bunq (Maestro, Mastercards, Apple Pay, TransferWise, Monzo* *Ditto* *Eko (Credit Agricole)* *Fortuneo (subsidiary of Credit Mutuel Arkea)* *N26 (TransferWise)* *Orange Bank (Wirecard)* *Zelf (instant messenger apps, no-card, June 2020 launch)*	Anytime (business account, SumUp) Hello Bank (SME by 2022, BNP Paribas, acquired Compte Nickel) Morning (B2B API) Qonto	Compte Nickel (customers banned from banks, 1.2 mil customers) Kard (young adult for personal money management) Ma French Bank (subsidiary of La Bankque Postale, mobile with calls support) Moneyway (young audience for personal money management, payment service agent of Treezor by Societe Generale) Pixpay; Xaalys (Children 10-18 year old) Revolut (travellers)

Technology	Name
FMS.next core system (Profile Software) for processing, payments, treasury operations	Ditto
Mambu's core banking system (back office processing)	N26
Digital payments platform, Wirecard; TransferWise	Orange Bank; N26
Mobile payments via Apple Pay or Google Pay (Viewport Meta, iPhone/Mobile Compatible, SPF)	Pixpay
Treezor (Soiete Generale) infrastructure	Xaalys; Zelf; Moneyway
Off-the-shelf back office solution, Forest	Qonto
Blockchain-Digital Currency	Revolut (Cripto-currencies exchange platform)

Table 5: Technology of FinTech-Banks in the USA

Digital Banking for personal, business, marketplace	*SME/ Community/Corporate Banking*	*Speciality Banking*
Booyah! (mobile/online banking); Branch; CBW Bank (Yantra digital platform); Chime;Citizens Access; Community Bank of the Carolinas; GoBank; HMBradley (early 2020); Karat; Lakeside Bank M1 Finance (spend/borrow/invest); Marcus; Medici Bank; Meed Banking Club; Monzo (P2P); Moven; N26;Newbridge Bank; Pangea (money transfer); Point (point card);Poppy Bank; PurePoint Financial; Quontic Bank; Rellevate (2020); Revolut; Rising Bank (2019); Sesame Cash (March 2020, credit/loan finder); simple; SoFi (personal loans); Stash Tennessee Bank & Trust; T-mobile money (2019) Upgrade (2019); Unifimoney; Varo Money Zenus Bank (global clients); Zero Financial	Alpha Business Bank; American Bank & Trust Azlo; Bank of Austin; Beacon Community Bank; BlueVine (Bancorp bank debit card); Core Commercial Bank; Denizen;Endeavor Bank; Gainey Business Bank; Grasshopper Bank; Infinity Bank ; Joust;MiBank ; New Valley Bank & Trust; Nexos National Bank (2020); Novo; Oxygen (AI based, freelancers, 2019); Piermont Bank (commercial banking, 2019); Primary Bank (community banking); Spirit Community Bank ; Studio Bank; TAB Bank (digital only); VisionBank (2019); Watermark Bank (2019)	Aspiration (socially-conscious banking/investment) AWSM (13-18 based) Bambu (underbanked populations); BankMobile (students) Bask Bank (American Airlines miles instead of interest) Cogni (P2P millennial); Current (teenagers) Envel (millennials money management) Gateway First Bank (mortgage) Iam Money (millennials); Kard (under age 21) LikeBank(millennials/Gen Z SME messenger service) Level Bank (millennials) Marathon International Bank (Ethiopian in the USA) One (middle class, Summer 2020) Rebtel (imigrants, 2019); Step (under 21s, Evolve Bank)

Technology	Name
Temenos' T24 core banking system; IBS core banking system (deposit) from FIS (datacentre); Infosys' Finacle core banking system for lending; Fiserv, DNA core banking system; Mambu's core banking system	Grasshopper Bank; BankMobile; Citizens Access; Gateway First Bank; Marcus; Mi Bank; N26 ; PurePoint Financial; SoFi; Varo Money
JHA LutLink Processing Services, Beacon for Silverlake core banking system ; CSI's NuPoint core/mobile banking; BankMobile	Beacon Community Bank; Primary Bank ; Rising Bank; Studio Bank; T-mobile money
Nymbus' banking-as-a-service platforms – Smartlaunch, Smartcore, Smartpayments and Smartdigital	Booyah!
Mobile payments via Apple Pay, Samsung Pay, or Google Pay (Viewport Meta, iPhone/Mobile Compatible, SPF) ; messengers (facebook, Viber, telegram)	Iam Money ; LikeBank; T-mobile money; Unifimoney
SAP; Axxiome	Meed Banking Club
Q2 Open's CorePro digital processing platform	Joust
Blockchain-Digital Currency; AI; AWS, Cloud basis	Newbridge; Medici Bank; Monzo; Varo Money

Table 6: Technology of FinTech-Banks in Canada

Digital Banking for personal, business, marketplace	*SME/ Community/Corporate Banking*	*Speciality Banking*
ATB Brightside (March 2020); Koho (alternative banking platform, 2020); Mogo (crypto trading app); Motusbank (2019); Neo Financial; Quest Bank (brokerage to invest); Revolut	NorthOne Business Banking	*Impak Finance (Impak coin, ethical bank (2017); Stack (millennial)*

Technology	Name
Temenos' T24 core banking system, Temenos Connect/Infinity; IBS core banking system (deposit) from FIS (datacentre); Infosys' Finacle core banking system for lending; Fiserv, DNA core banking system; Mambu's core banking system	EQ BAnk
FIS' Profile/ PortfolioPlusMeniga personal finance management solution	Tangerinee
SAP Cyberbank Core, Cyberbank Digital solution	ATB Brightside;
ClauseMatch regtech	Revolut
Blockchain-Digital Currency; AI; AWS, Cloud basis, BI	ATB Brightside; EQ Bank

Table 7: Technology of FinTech-Banks in Australia

Digital Banking for personal, business, marketplace	*SME/ Community/Corporate Banking*	*Speciality Banking*
86 400 (2018, payment); Volt Bank (2019/2020) Archa (2016, criptocurrency); Xinja (2017); Up Alex (2019/2020, loan); Goldfields Money (+B2B) Hay; iSignthis (2019, +B2B); Revolut (2019); Ubank	Judo Bank (2018/2019) Tyro	Pelikin (digital natives, travel money); QPay (, Students, payment)

Technology	Name
Temenos' T24 core banking system, Temenos Connect/Infinity; IBS core banking system (deposit) from FIS (datacentre); Infosys' Finacle core banking system for lending; Fiserv, DNA core banking system; Mambu's core banking system	Goldfields Money; Judo Bank; Volt Bank
Oracle Banking Platform (OBP) from Oracle FSS	Ubank; Xinja
Probankx information systems	iSignthis
ClauseMatch regtech	Revolut
Blockchain-Digital Currency Newworks; AI; AWS, Cloud basis, BI	Archa ; Hay; Judo Bank; Tyro; Ubank (IBM Watson); Up
Mobile payments via Apple Pay, Samsung Pay, or Google Pay (Viewport Meta, iPhone/Mobile Compatible, SPF) ; messengers (facebook, Viber, telegram)	86 400;

Table 8: Technology of FinTech-Banks in South Africa

Digital Banking for personal, business, marketplace	*SME/ Community/Corporate Banking*	*Speciality Banking*
BankZero (2018/2019) *Bettr Finance* *Discovery Bank (2016/2019)* *Postbank* *TymeBank (2019)*		*Barko Financial Services (microfinance)*

Technology	Name
Temenos' T24 core banking system, Temenos Connect/Infinity; IBS core banking system (deposit) from FIS (datacentre); Infosys' Finacle core banking system for lending; Fiserv, DNA core banking system; Mambu's core banking system	Barko Financial Serices; Discovery BAnk
SAP Cyberbank Core, Cyberbank Digital solution; Oracle FSS	Discovery Bank
Blockchain-Digital Currency; AI; AWS, Cloud basis, BI	Barko Financial Services; TymeBank (Finn AI)

Table 9: Technology of FinTech-Banks in the Middle East

Digital Banking for personal, business, marketplace	*SME/ Community/Corporate Banking*	*Speciality Banking*
Bank ABC (2018/2019Bahrain); Meem (2018, Baharain))- murabaha; Pepper (2017, Israel); Meem (Saudi Arabia, OnePack, 2015); Halalah (2019, Saudi Arabia, UAE , ADGM); Clearly (2016, UAE); Liv Bank (UAE); Mashreg Neo (UAE); OG Bank/OG Pay (UAE 2020)	E20 (2019); Xpence (2017)	Pepper (Israel, 2017, 2019, young people target) CBD Now (2017/2018 UAE)

Technology	Name
Temenos' T24 core banking system, Temenos Connect/Infinity; IBS core banking system (deposit) from FIS (datacentre); Infosys' Finacle core banking system for lending; Fiserv, DNA core banking system; Mambu's core banking system	Pepper (Israel, 2017, 2019)
Backbase's Omnichannel Banking Platform	Bank ABC (Bahrain)
Blockchain-Digital Currency Newworks; AI; AWS, Cloud basis, BI	Liv Bank (UAE, AI); Mashreq Neo (UAE, AI)

Table 10: Technology of FinTech-Banks in India

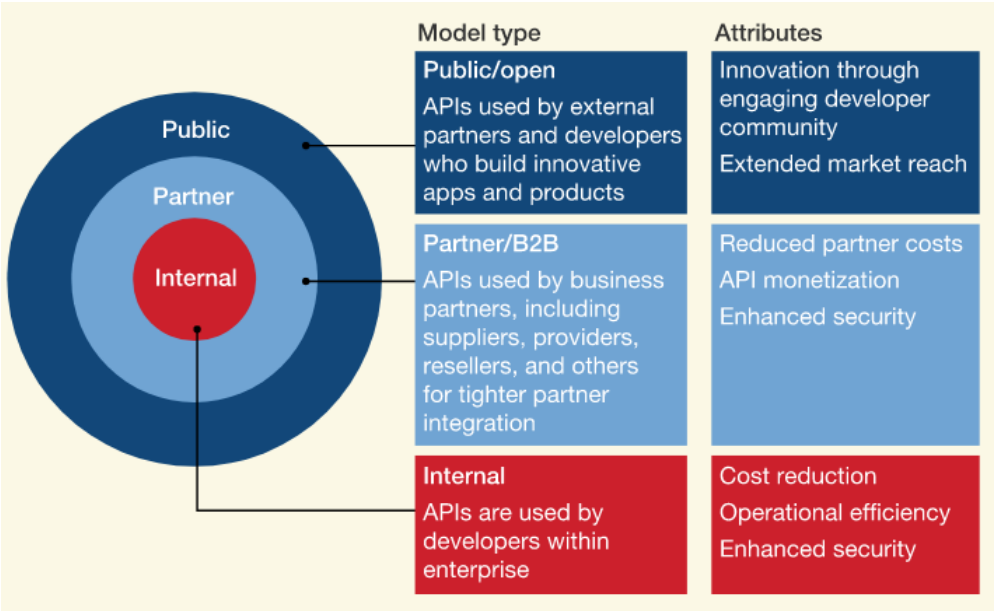
Digital Banking for personal, business, marketplace	*SME/Micro-finance/Corporate Banking*	*Speciality Banking*
811 (2017/2019); Digibank (2016); Payzello (2017); Walrus (2019); Yelo (2019) Yono (2017); Payment banks (2019); Fino Payments Bank (2017); India Post Payment Bank (2018); Lio Payments Bank (2018); Paytm Payments Bank (2017)	InstantPay (2019); Namaste Credit (2019); NiYO; Open (2017, 2020); Airtel Payments Bank (2017); AU Small Finance Bank (2017, micro-finance); Capitak Small Finance Bank (2016, micro-finance); Equitas Small Finance Bank (2016, micro-finance); ESAF Small Finance Bank (2017); Fincare Small Finance Bank (2017); North East Small Finance Bank (2017); Ujjivan Small Finance Bank (2017);	Amica (millennials, 2020)

Technology	Name
Temenos' T24 core banking system, Temenos Connect/Infinity; IBS core banking system (deposit) from FIS (datacentre); Infosys' Finacle core banking system for lending; Fiserv, DNA core banking system; Intellect Design Arena's LaserPanacea core banking processing, ACI Worldwide's UP Retail Payment solution	Fino Payments Bank (2017); Equitas Small Finance Bank (2016); Utkarsh Small Finance Bank (2017); ESAF Small Finance Bank (2017); Capital Small Finance Bank (2016)
Oracle FSS products, Flexcube core banking sysem	Airtel Payments Bank
Blockchain-Digital Currency; AI; AWS, Cloud basis, BI	811 (Active.AI); Digibank (2019, AI)

Table 11: Technology of FinTech-Banks in Hong Kong

Digital Banking for personal, business, marketplace	*SME/ Community/Corporate Banking*	*Speciality Banking*
Ant Financial (2019, Alibaba); Fusion Bank (2019, ICBC/Tencent, investment); Livi Virtual Bank (2019); Mox (2019/2020); Ping An OneConnect (2019); Revolut (2015); Tandem Bank (HI in 2019); WeLab (B2B, 2019)	Neat (2018)	Insight Virtual Bank (2019, Xiomi, investment); XhongAn Bank (2017, insurance)

Technology	Name
Oracle Banking Platform (OBP) from Oracle FSS, FICO (credit)	Mox (launching 2019/testing 2020)
Mobile payments via Apple Pay, Samsung Pay, or Google Pay (Viewport Meta, iPhone/Mobile Compatible, SPF) ; messengers (facebook, Viber, telegram)	Ant Financial (Alipay); Neat (2018)
ClauseMatch regtech	Revolut
Blockchain-Digital Currency Newworks; AI; AWS, Cloud basis, BI	Ping An OneConnect (2019, AI/Cloud); Tandem Bank (AWS, AI)



Source: BrodskyLaura & OakesLiz (2017)

Figure 3: API models by McKinsey & Company McKinsey Payments Practice