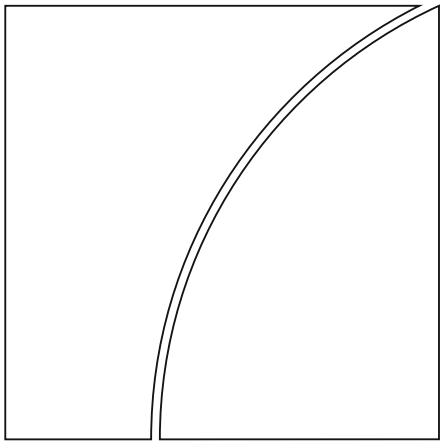
BANK FOR INTERNATIONAL SETTLEMENTS



BIS Papers

No 120

Virtual banking and beyond

by Sally Chen, Derryl D'Silva, Frank Packer and Siddharth Tiwari

Monetary and Economic Department

January 2022

JEL classification: G28, H41, L15, L17, O33.

Keywords: incumbent banks, virtual banks, banking business models, financial inclusion, technology stack, information capital, data governance, big tech, regulatory framework.

The views expressed are those of the authors and not necessarily the views of the BIS.

This publication is available on the BIS website (www.bis.org).

ISSN 1682-7651 (online)
ISBN 978-92-9259-538-8 (online)

Virtual banking and beyond

Abstract

The integration of technology, finance and services is rapidly changing Asia's banking landscape, as ownership stakes in banks are taken by big techs and fintech firms and non-bank financial institutions as well as by incumbent banks. Many new entrants are leveraging social media platforms and applying advanced data analytics. The changed landscape opens up opportunities to leapfrog traditional evolutionary processes and thus advance financial inclusion. It also presents regulatory and competition challenges that need to be tackled.

The use of the banking system to borrow lags the increase in bank accounts worldwide. One key reason is the requirement for collateral in conventional bank business loan models in developing, emerging and advanced economies alike. New technology-driven business models exploit the expanding data footprints of individuals and firms to generate information capital and reduce the reliance on collateral when offering loans and other financial services. Data and entities that manage data – in an unbundled banking stack within the regulated banking system – will be at the heart of this transformation.

The growing variety of new entrants to the banking industry that employ data collection techniques poses two challenges for regulators and competition authorities. First, financial regulators need to ensure that regulatory oversight delivers on the inclusion and intermediation-enhancing benefits of digital finance without compromising traditional regulatory goals such as financial stability, adequate competition, consumer protection and market integrity. Second, there is a pressing need for a system of data governance that allows consumers and business to exercise control over their data through the granting and withholding of consent to the use and transfer of their data. Developing a user-friendly granular consent-based data governance system with low transaction costs is a challenge that, when successfully addressed, will promote the development of virtual banking worldwide.

Hong Kong SAR offers one example of an integrated regulatory framework for virtual banks. The licensing and regulatory regime – also applicable to incumbent banks – aims to manage the full spectrum of risks arising from any source, including the ownership structure, without compromising development objectives that often rest on technological innovation. How the framework deals with data is in the early stages of development.

Keywords: incumbent banks, virtual banks, banking business models, financial inclusion, technology stack, information capital, data governance, big tech, regulatory framework.

JEL classification: G28, H41, L15, L17, O33.

Acknowledgements: We are grateful to Agustín Carstens, Nandan Nilekani, Arthur Yuen, Chen Lin and Tanuj Bhojwani for their imprint on our thinking. We wish to thank Alan Au and many others at the HKMA for extensive discussions over the course of the project. We are also grateful to Sharad Sharma and the team at iSPIRT, as well as Stefan Ingves and the team at Sveriges Riksbank, for providing valuable advice. Codruta Boar, Benoît Cœuré, Gong Cheng, Leora Clapper, Stijn Claessens, Wenzhi Deng, Jon Frost, Fernando Restoy, Carolyn Rogers, Hyun Song Shin, and Raihan Zamil provided helpful comments on earlier drafts. Amanda Liu, Jenny Hung, Taejin Park and Murphy Pan provided excellent support.

Contents

Virtual banking and beyond

1. Introduction

In June 2021, the Hong Kong Monetary Authority (HKMA) unveiled its Fintech 2025 Strategy[1] based on the understanding that the future of banking is based on technology. HKMA's vision for fintech focuses on three areas: (i) facilitating banks' adoption of technology; (ii) an enhanced data infrastructure; and (iii) supporting a growing digital ecosystem. A key part of this journey is the *Guideline on Authorization of Virtual Banks* unveiled in 2018, under which eight new banking licenses have been granted to date.[2]

What is distinctive about the Hong Kong virtual banking initiative is the combination of criteria for licensing,[3] namely: (i) mandating the virtual distribution of all banking services ie no physical (brick-and-mortar) branches; (ii) maintaining the explicit objective of promoting financial inclusion; (iii) an ownership structure that includes the participation of big techs and fintechs; and (iv) maintaining a risk-based and technology-neutral regulatory framework. In this paper, we examine the opportunities and challenges presented by such a framework.

First, how widespread is the challenge of financial inclusion? According to the World Bank Findex database, significant gains were made between 2011 and 2017, with the percentage of individuals aged 15 years or over with an account increasing from 51.3% to 68.5% – the equivalent of around 1.2 billion individuals being brought into the formal financial system.[4] One key advantage of being in the financial system is access to the payments system. In this area, spurred by technological advances, considerable progress has been made over the last two decades – today 55 jurisdictions have fast payment systems and this total is expected to rise to 64 in the near future.[5] According to the Findex survey, more than three quarters of those surveyed by Findex with a financial account have used it to make a digital payment over the last year.

Another key advantage of being in the financial system is access to financial intermediation. Here, not only do many account holders globally not save funds in them, but the proportion who borrow funds from their financial institutions without collateral in the past year is small, at around 11% on average; over three times that number borrow outside the system. The gap between those with bank accounts and those who use financial services more broadly is large, and it does not narrow significantly with the growth of per capita income. For example, in international financial centres such as Hong Kong and Singapore, there are relatively low levels of

[1] www.hkma.gov.hk/eng/news-and-media/press-releases/2021/06/20210608-4/.

[2] www.hkma.gov.hk/eng/news-and-media/press-releases/2018/05/20180530-3/ ; www.hkma.gov.hk/eng/news-and-media/press-releases/2019/05/20190509-3/.

[3] www.hkma.gov.hk/eng/regulatory-resources/regulatory-guides/guide-to-authorisation/.

[4] This estimate assumes that in 2011, 0.8% of those using mobile phone to pay bills, send or receive money did so without access to a formal bank account (the same percentage as in 2014). It also assumes that the growth of the population 15 years or older between 2011 and 2014 was at around the same rate as that recorded in the Findex survey between 2014 and 2017 (an annual rate of 1.7%).

[5] www.bis.org/publ/qtrpdf/r_qt2003x.htm.

borrowing from the formal financial system, despite near universal bank accounts, high levels of income, mobile penetration, education and, importantly, financial literacy. While societal attitudes towards borrowing differ, data show that the need exists – particularly among small and medium-sized enterprises (SMEs) and low-income households – and is often satisfied through costly borrowing from the non-bank sector.

Why does this gap still exist? One key reason appears to be that tangible collateral is still key to lending: it represents a common solution to the problem of asymmetric information between creditors and borrowers in a system where property rights are well established. This reliance on collateral leaves many underserved by the financial system: the young do not accumulate tangible capital that can be used as collateral until later in life and the poor never do. A second reason is that the cost of traditional brick-and-mortar banking operations makes reaching out to low-margin customers uneconomical. This phenomenon, common across countries irrespective of their level of income, also obstructs the smoothing of lifetime consumption and investment, so that in many cases a large swathe of the population remains in the informal sector.

These challenges – information asymmetry and high operating expenses – that preclude service provision to low-margin, high-risk borrowers argue for efforts to leverage technology to expand banking services to this segment of the population. The exponential increases in the volume and granularity of data (big data), and the advent of the Internet of Things (IoT), cloud computing, artificial intelligence (AI) and machine learning (ML) have all made data collection and analyses based on that data much cheaper and more efficient. Information captured from the everyday online activities of individuals creates "information capital" that reduces transaction costs, information asymmetry between borrowers and lenders, and the reliance on physical collateral. Cost reductions have also come from the evolution of the bank technology stack – ie the set of modular platforms on which the bank's digital financial activities now generally take place – and its associated unbundling of banking activities.

These developments also help to improve risk assessment and monitoring, with the promise of cost savings to expand the pool of "bankable" borrowers. In this manner, new banking models can increasingly provide more services and serve individuals who were not able to meet the requirements of the conventional banking model before. Data and firms that can manage data – including banks as well as fintech and big tech firms[6] – will be at the heart of this transformation. The benefits of this new landscape can be effectively secured only through data governance arrangements where consumers have agency over the data they create. A consent-based, granular, open, interoperable, revocable, auditable and secure data governance system will ensure that the dual objectives of consumer privacy and market integrity are respected. As this new banking model matures, the development of credit intermediation could again leapfrog evolutionary processes.[7]

Activity within the new banking model can include both new digital-only entrants and incumbent banks expanding into digital finance. While incumbent banks generally have the scale to undertake large investments, virtual banks do not have the legacy IT systems and the operating costs of brick-and-mortar operations. At the

[6] Large companies whose primary activity is digital services rather than financial services. See Cornelli et al (2020).

[7] For an early discussion of how technological innovation in e-finance could provide opportunities for countries to leapfrog ahead in financial development, see Claessens et al (2002).

same time, new entrants can be a source of competitive pressure and a catalyst for innovation. The HKMA survey of banks indicates that virtual banks aim to take advantage of technology to cut transaction costs in every phase of the provision of financial services, allowing them to service a more diverse range of borrowers. The same survey also indicates that incumbent banks plan to close the gap.

Virtual banks in Hong Kong and the rest of Asia usually offer a suite of products in different areas – consistent with the unbundling of activities through the technology stack. Based on measured download activity, virtual bank platforms are growing, evidencing a more inclusive usage based on gender and age distribution.

In this new landscape, where technology, finance and services interact, technology companies are playing an important role because of their capabilities in managing modular platforms, data analytics and risk mitigation. They are also some of the largest shareholders in new entrants to the sector. Here lies the challenge for regulators: the greater the variety of firms that enter the banking industry, the more pressing the need for the authorities to achieve a balance between promoting innovation and inclusion, while at the same time safeguarding financial stability, adequate competition, consumer protection and market integrity. A greater reliance on data as opposed to collateral generates its own unknowns, given that new data-based lending models have less of a track record through credit cycles. And while information capital has the potential to reduce the reliance on tangible collateral for lending purposes, it is no substitute for tangible collateral in the event of default. The new banking model must employ other safeguards to take this consideration into account.

The rest of the paper proceeds as follows. First, we discuss the challenges of inclusion in financial services, and present evidence that suggests that these are not limited to developing economies; even financial centres such as Hong Kong face issues with financial inclusion. Second, we examine how technological innovation and the emergence of information capital as well as the evolution of the banking technology stack promise to allow the more tailored provision of credit and to broaden financial inclusion. Third, we outline the building blocks of a data governance system that will give consumers agency over their data. Fourth, we sketch some features of the emerging landscape for virtual banks in Hong Kong as well as in other Asian jurisdictions, and document how they are contributing to the evolution of banking towards a life-style business, serving a diverse and inclusive clientele. But these advantages do not come without risks: in the final section, we describe the risk-based technology-neutral regulatory system that Hong Kong has adopted to address the challenges posed by virtual banking.

2. Financial inclusion challenges not limited to developing countries

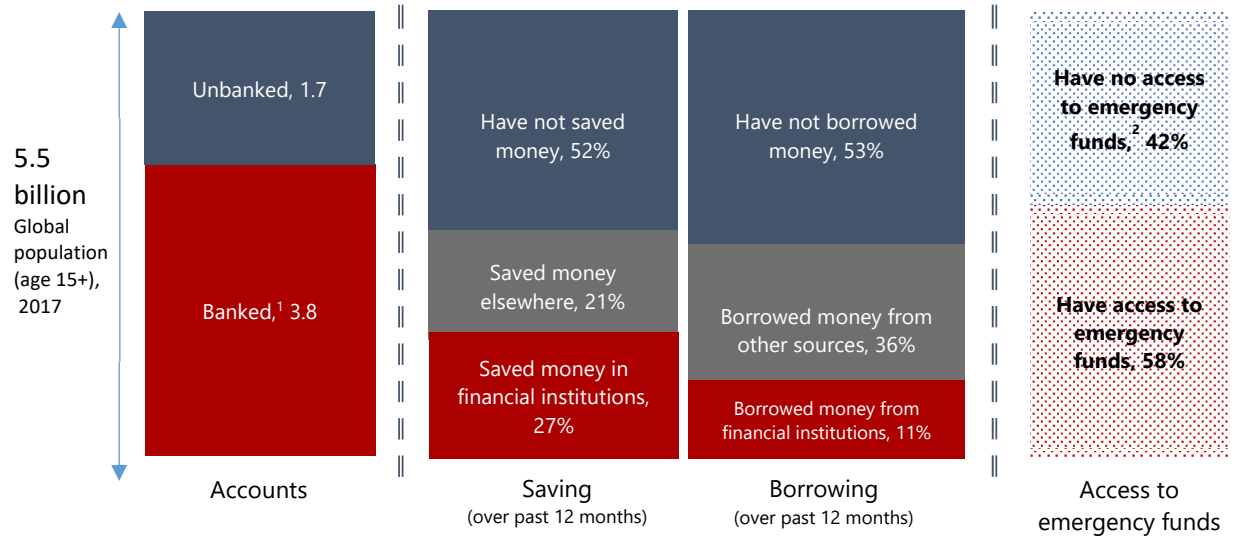
a. Many households still not utilising the formal financial system to save or borrow

Despite the progress made globally in bringing individuals into the formal financial system, as discussed in the introduction, more remains to be done. Two thirds of the global population have an account at a financial institution, according to the Global Findex 2017 survey, but only around a quarter, or 1.5 billion, report saving or setting aside money in those accounts over the past 12 months. Further, just over one tenth, or just 0.6 billion, report borrowing money from a financial institution over the past 12 months (Graph 1).[8] In contrast, over one fifth report saving money outside a financial institution over the past year, while 36% report recent borrowing outside financial institutions from other sources such as family and moneylenders.

While it may be argued that not all households want to be in debt, the same World Bank survey indicates that a large proportion of the adult population, 42%, find themselves unable in times of emergency to access sufficient funds – defined as 5% of per capita gross national income in the jurisdiction (Graph 1, right-hand column). This share is far greater than the proportion of unbanked.

The global population is not fully utilising the services of financial institutions

Graph 1



[1] Banked population includes those with mobile money accounts, which adds 0.1 billion to the (rounded) total. [2] The percentage of respondents who report that, in case of an emergency, they cannot come up with 1/20 of gross national income (GNI) per capita in local currency within the next month.

Source: Demirgüç-Kunt et al (2018).

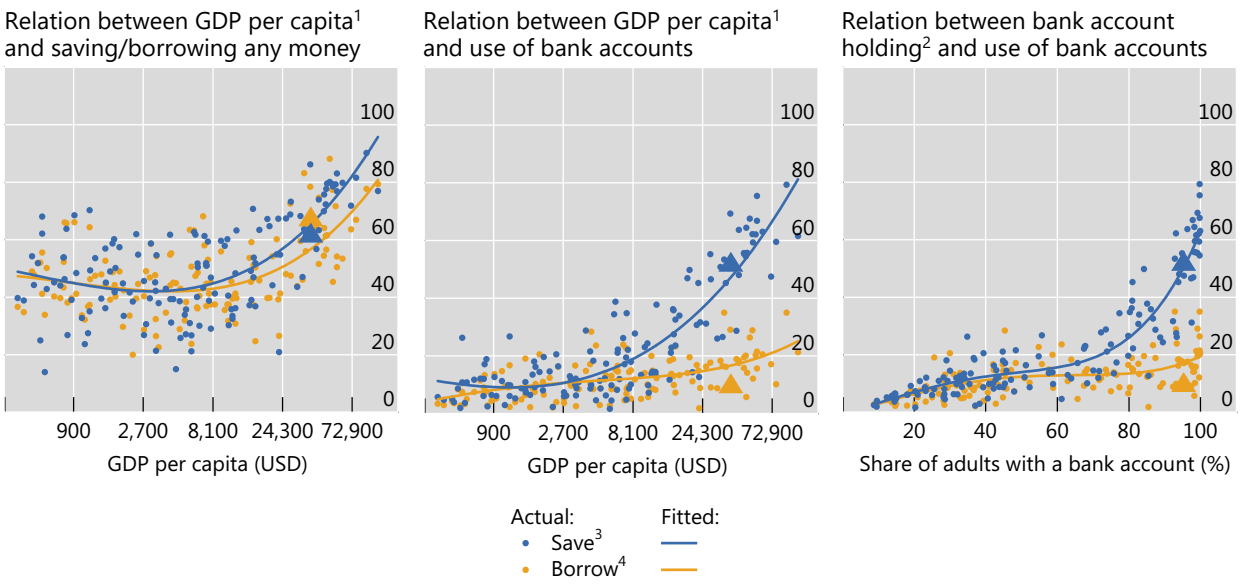
[8] The indicators in the 2017 Global Findex database are draw from nationally representative surveys of more than 150,000 adults in 144 economies. These economies represent more than 97% of the world's population. For a full discussion of the survey methodology, see Demirgüç-Kunt et al (2018).

b. There is limited usage at all levels of economic development

To be sure, increases in national income lead to an increase in overall savings and borrowings. The left-hand panel of Graph 2 documents the degree to which all savings and borrowings over the past 12 months rise with income per capita over $8,100 (the scatter plots reflect the values of the proportions of the population saving and borrowing in each surveyed jurisdiction). These activities become noticeably more pronounced at higher per capita income levels (Graph 2). However, when the same estimates are made for saving and borrowing using an account at a financial institution, marked increases in saving are evident with rises in the level of income, although not in borrowing (Graph 2, centre panel). For borrowing at a financial institution, the estimated proportion of population engaged in the activity rises only from 15% to 20% for increases in income from $8,100 to $72,900. And the estimated proportion of the population borrowing from a financial institution is virtually flat even when the share of the population with bank accounts rises from 50% to 80% (Graph 2, right-hand panel).

Saving and borrowing in past 12 months

As percentage of adults (age 15+) Graph 2



Fitted lines estimated with fourth degree polynomial. The scatter plots show the actual values used to generate fitted lines from 139 economies in the sample. The triangles represent Hong Kong SAR.

[1] In constant 2010 US dollars. The scatter plot uses logarithm of GDP per capita. [2] The share of adults who have a financial institution account. [3] The share of adults (age 15+) who saved or set money aside in the last 12 months. [4] The share of adults (age 15+) who borrowed money in the last 12 months.

Source: Demirgüç-Kunt et al (2018); World Bank national account data and OECD National Account data files; authors' calculations.

In terms of access to emergency funds discussed above, while the proportion of the population in advanced economies that has insufficient access is lower than in emerging and developing economies (38% vs 63%), it still is nearly two fifths, which again suggests there is considerable room for greater use of the financial system at all levels of economic development (See Annex Table 1).

The conventional wisdom is that developed countries with high levels of education[9] and near universal mobile penetration and bank account ownership should not have constraints on the use of the financial system. This would appear to apply even more strongly in international financial centres such as Hong Kong, where over 20% of GDP originates in the financial sector.[10] However, according to data from the Findex survey, Hong Kong also lags in its use of the financial system. The share of adults in Hong Kong who borrow from banks is, in fact, below that in other advanced economies (Graph 2), largely driven by the small proportion of the lower-income population that uses the financial system to save and borrow (Table 1). As in other jurisdictions, personal borrowing in Hong Kong is secured largely by tangible collateral, above all in mortgage lending.[11]

Limited use of financial institutions: Hong Kong

In per cent of population (age 15+) Table 1

	Entire population			Poorest 40% of the population		
	2011	2014	2017	2011	2014	2017
Saved any money in the past year	n.a	67	61	n.a	53	43
Saved any money at a financial institution in the past year	43	50	51	n.a	32	32
Borrowed any money in the past year	n.a	68	66	n.a	53	49
Borrowed any money from a financial institution in the past year	8	8	9	n.a	5	4
Coming up with emergency funds not possible	n.a	24	26	n.a	38	45

Source: Demirgüç-Kunt et al (2018).

c. Firm loan markets also have room to develop

Similarly, SME firm loan markets have room to develop, even though small firms have gained more access to the financial system. Of the 164,000 firms surveyed by the World Bank in their enterprise surveys database, some 89% of the firms have a checking or savings account at a financial institution, but fewer than one third have a bank loan or line of credit. Among the firms surveyed in emerging market and developing economies, on average only 21% of the firms have a bank loan or line of credit compared with 30% in advanced economies. About 28% of the firms in emerging market and developing economies self-identify as constrained in their access to finance compared with 12% in advanced economies (see Annex Table 2).

[9] OECD, PISA 2018 insights and interpretations, PISA 2018 Insights and Interpretations FINAL PDF.pdf (oecd.org).

[10] See paragraph 3.2 and Table 1, "The Four Key Industries in the Hong Kong Economy", January 2021, www.censtatd.gov.hk/en/data/stat_report/product/FA100099/att/B72101FB2021XXXXB0100.pdf.

[11] Bank loans to the household sector were valued at HK$ 2.4 trillion in 2020, accounting for 22% of total lending. They consist of residential mortgage loans (68%), credit card advances (5%) and other personal loans (27%). This final category consists mainly of loans to private banking and wealth management customers (over 65%), secured by financial assets such as stocks and bonds. About half the rest are unsecured personal loans. Unsecured lending, including personal loans and credit card advances, thus accounts for a little less than 10% of household debt.

d. What explains the inability of individuals and firms to borrow?

There are two reasons why individuals and firms do not use formal loan markets more. The first is the frequent need to post collateral for borrowing. It is well established in the academic literature that collateral represents one solution to the problem of asymmetric information between creditors and borrowers, including both the ex ante problems of adverse selection as well as the ex post problems of borrower moral hazard and difficulties in the verification and enforcement of contracts. In particular, collateral is noted to be quite important in enabling SMEs, whose financial information is more opaque and/or poorly rated, to obtain funds (Menkhoff et al (2006), Bahaj et al (2020), FSB (2019)). For individuals, tangible collateral is accumulated either later in life or never in the case of the poor. The lack of tangible collateral in turn forces borrowers to use the informal sector and obstructs the smoothing of life-time consumption and investment choices (Beaumont et al (2021), Erel and Liebersohn (2020), Fenwick et al (2017)).

Indeed, the latest evidence from the World Bank Enterprise Surveys global database shows that the provision of collateral is still crucial for SMEs. Namely, most SMEs need collateral in order to borrow from the formal financial system: more than 70% of the surveyed firms reported that collateral was required to receive a loan.[12] The value of the collateral posted was on average nearly twice the loan amount. Although Hong Kong is not included in this survey, as in other jurisdictions, a feature of SME financing is that banks with insufficient business data may well require collateral before making a loan.[13]

The second reason for the underdevelopment of formal loan markets is that, for brick and mortar banks, low-margin customers are uneconomical. As later documented in Section 6 and in the box on a leading virtual bank, online lending can offer significant cost savings in the servicing of small, low-margin clients. Not least, far fewer staff are needed to handle the customer interface and risk assessment.

3. Technological innovation and the banking technology stack

Over time, innovations have transformed core business models in several industries. The banking industry is no exception and technological innovation holds the promise of alleviating the underdevelopment of financial activity within the financial system.

Technological developments over the past two decades have made the increased use and analysis of ever-expanding data resources much cheaper and more efficient, for several reasons (Tam (2021), Chen et al (2019)). First, the consumer's digital footprint has expanded as the number of touchpoints have increased dramatically, aided by high-speed internet networks, high network connectivity and smart phones (Graph 3).[14] Second, the larger footprint has led to an explosion in the availability of high-

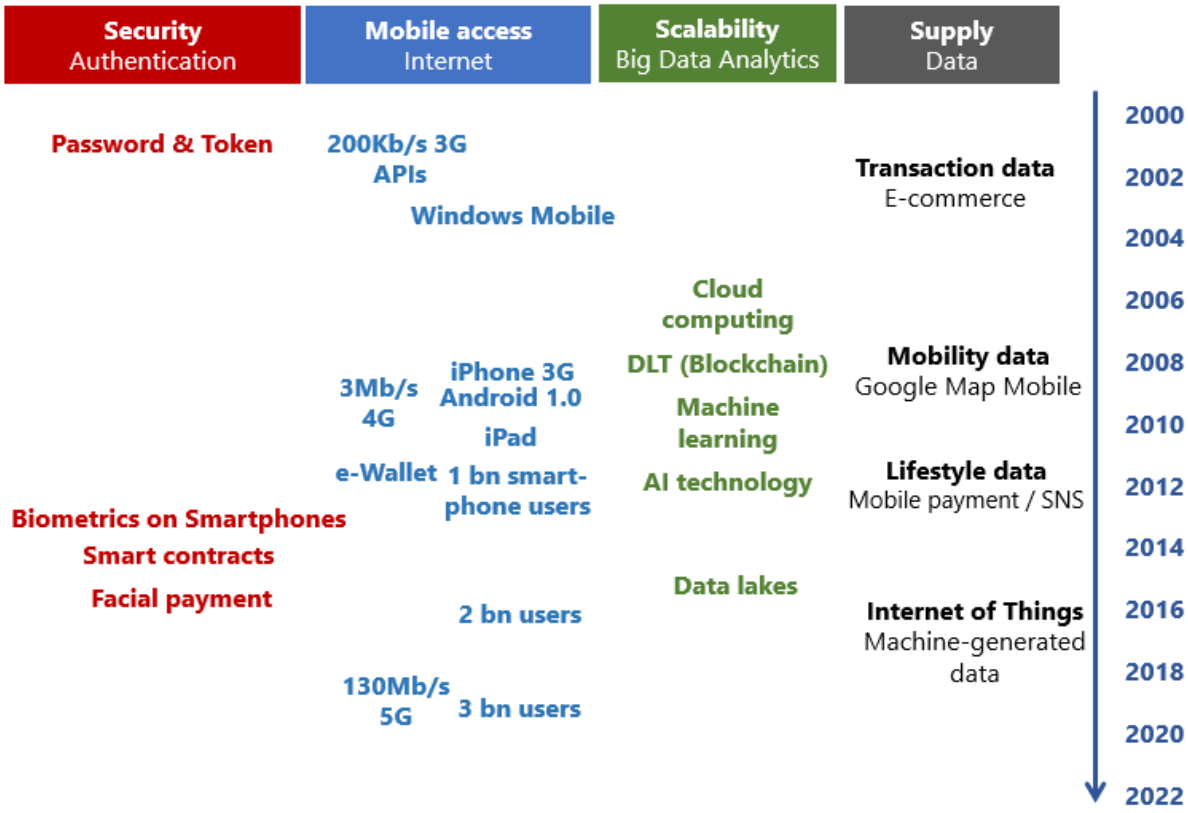
[12] For additional evidence that enlarging the range of collateralisable assets makes SMEs and other firms better off, see Ayyagari et al (2016), and Campello and Larrain (2016).

[13] See Yue (2020).

[14] For example, a typical mobile device has sensors relating to GPS, accelerometer, Bluetooth, cell tower identity, call logs, SMS log, proximity, running apps, installed apps, screen state, battery status, browsing history, contacts and light density, to name but a few.

quality unstructured data (texts, images, videos) which has outpaced the structured data (names, addresses, date of birth) that was traditionally used in analysis.[15] Third, as the volume of data has increased, technological innovations such as cloud computing have led to a large drop in the cost of permanent storage with real-time global accessibility. Fourth, the combination of the expanding consumer footprint, the increased availability of data and cheaper storage has provided the foundation for high-performance computation. Moore's Law – ie the doubling of computational power every 18–24 months – continues to hold (Tam (2021)).

Timeline of technology and digital bank development Graph 3



Source: Authors' elaboration.

Real-time computation and communication between humans and machines and among machines, combined with intelligent human interfaces (voice, facial and text), have provided the groundwork for algorithms based on artificial intelligence, statistically based artificial intelligence (machine learning) and neural networks (deep learning), which are all outperforming previous learning algorithms.[16]

These computing innovations have reshaped the entire banking business. Remote know-your-customer (eKYC) verification and chatbots are integrated into

[15] Unstructured data have no fixed format, often appearing as a large volume of continuous stream of events with a lesser degree of consistency.

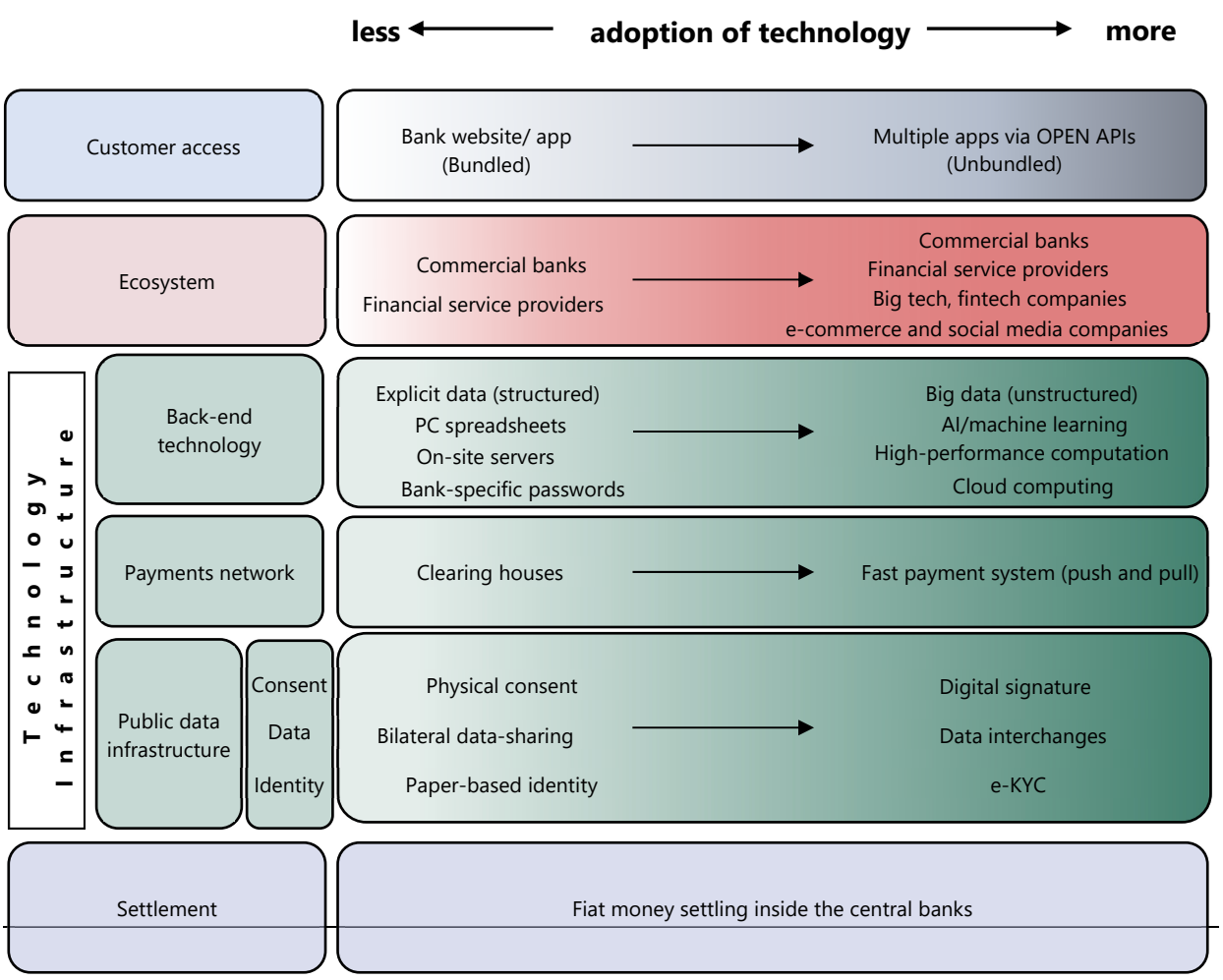
[16] At the same time, AI based on models, algorithms and autonomous controls poses several challenges. These challenges include data risks (biased/contaminated data), algorithm risks (bias, hidden errors), and privacy issues.

retail interfaces. Banking operations are also characterised by strengthened credit assessment, risk management and anti-fraud measures, more targeted marketing, and enhanced enforcement and recovery measures, all of which cut transaction costs and help banks to serve low-margin customers. Incumbent banks with sufficient resources to invest in technology can adopt digital channels and models, while others, to reduce upfront technological costs, can consider forming partnerships with big tech and fintech firms. On the other hand, virtual banks leverage technological capabilities across their entire business to improve the quality of their banking services.

The impact of these developments on banking activities can also be traced through the evolution of the bank technology stack, which can accommodate a variety of banking business models (Graph 4). In all of them, greater use of mobile devices and connectivity – combined with digital identification, electronic KYC verification and digital signatures – has vastly improved access to the banking system.

Evolution of the bank technology stack

Graph 4



Greater adoption of technology – including by virtual banks – has brought two significant changes.[17] First, banks have unbundled what they offer and are collaborating with other firms to improve the customer interface. Second, all participants on the platforms intensively use data from an ever-expanding consumer digital footprint and adapt their offerings, thereby attracting new customers. In unbundling the products offered and through the use of application programming interfaces (APIs), the bank provides customers with more choices from financial services and other third-party firms accessing the platform (BCBS (2019)). For instance, customers can access payment-processing platforms (eg Stripe, Venmo) to send and receive payments online, mobile wallets (eg Alipay, Payme) to load money and pay for services by scanning QR codes, and retail platforms (eg Robinhood) for securities and FX trading. In this way, technology is empowering financial firms to open previously untapped markets. For traditional banks – mostly confined to operations on their own premises or networks between branches in a city – adaptation of the stack approach offers customers a bundle of financial services from payments and lending to insurance and wealth management. Such efforts to reach customers online are creating new opportunities for reaching low-margin or excluded customers with more tailored and affordable services.

Greater adoption of technology focuses the heart of new banking business models on the use of all available data.[18] As more consumers go online, the more popular applications attract more traffic and generate more data. Advances in technology, including real-time computation and artificial intelligence, have enabled enhanced monitoring of user interests, spending patterns and payments behaviour. This allows banks to offer more tailored products to their customers, both individuals and firms alike, which in turn attracts new customers and generates more data, creating a virtuous circle. In the realm of credit, these valuable data can be used for the purpose of credit assessment, monitoring and enforcement, thus lessening the need of lending banks to depend on tangible collateral.

All in all, the provision of financial services is becoming more widely spread across different platforms, and a variety of financial products are being offered to an increasingly large share of the population. Payments still settle in fiat money within the central bank, further demonstrating the transformational impact of public-private partnerships. The model could be further enhanced by the introduction of central bank digital currencies, which when properly designed are consistent with open payment platforms and a level playing field that enhances competition and innovation in financial service provision (BIS (2021)).

[17] In practice, existing banks, depending on their customer base, can combine practices of both the incumbent bank and the virtual bank models as described in this section. Further, how unbundling occurs is of vital importance. In economies where big tech has been dominant, such as China, these firms and their arms have all the data and thus can extract all of the value, leaving little for banks to exploit independently. That said, in some jurisdictions, regulators have sought to force big tech to make their data more widely available (Zhai (2021)).

[18] Academic research on these models is also progressing rapidly; see Berg et al (2020) for an empirical examination of how digital footprints can predict consumer defaults; Ghosh et al (2021) for a theoretical and empirical uncovering of the synergy between fintech lending and cashless payments that produces transferrable and verifiable information; He et al (2020) for focus on competition in lending between traditional banks and fintech lenders when borrowers share their bank data with fintech lenders; and Parlour et al (2020) for when fintech firms compete for payments flows.

4. Information capital lessens the dependence on collateral

Holmstrom and Tirole (1997) analysed how information created by the monitoring of financial intermediaries, or "monitoring capital", could allow firms with low collateral (low net worth) to finance their investments. As described in Section 3, technological developments have allowed data previously scattered across various locations – and that had previously tended to move along lender-borrower or vendor-purchaser bilateral channels – to be consolidated for resolving asymmetric information challenges in credit markets (Yue (2020), Frost et al (2019), Gambacorta et al (2020)).

One related focus of attention in recent years has been on the ability of big tech firms and their subsidiaries to make use of advanced computational techniques – machine learning and other analytical techniques – on the data they possess to better screen and monitor borrowers. This is made possible by their access to a large stock of comprehensive real-time transactional and locational data on potential borrowers gathered from borrower activities online. In other words, the measure of the borrower's ability to pay has the potential to shift from a reliance only on tangible collateral to the inclusion of metrics derived from information generated from the borrower's everyday activities and cash flows. Research at the BIS shows that information is beginning to partially replace the role of collateral for an increasing number of borrowers, as an effective means of facilitating financial intermediation (BIS (2019), Gambacorta et al (2020), Carstens (2020)).

Lending based on information capital, combined with the cost efficiencies from a digital model, improves financial inclusion. In the early stage, available data – including cash flow information – support access to small-size loans and the building of creditworthiness. Over time, as businesses mature and creditworthiness is established, individuals can access more credit, rather than being excluded from larger – and more profitable – loans despite the lack of collateral. Indeed, the evidence suggests that in many parts of the world, including China and Argentina, big techs have improved access to credit for many firms who would have otherwise been denied access in the absence of collateral (Frost et al (2019), see also Box A on WeBank's lending platforms)). This is despite the known risks to competition implied by the walled garden of a big tech firm.[19]

Distributional implications arise from the increasing ability of information and data to lessen the need for collateral in overcoming the problems of asymmetric information in credit markets as well as from the reductions in transaction costs. The young and the poor have neither the time nor the means to build up the net worth that can serve as collateral, thus remaining underserved. But more intensive use of big data, artificial intelligence and computational power has enabled digital banking models to cut transaction costs and raise efficiency. In sum, access to a broader range of information about borrowers and savers, as well as firms, from their online and other activities will facilitate credit assessments based on information capital, also for individuals who do not meet the requirements for physical collateral.

[19] The downside to the use of big data within big tech firms is that competition in offerings based on the user's data is less likely when the ownership of the customer data footprint belongs to a single firm. As an alternative paradigm, in some jurisdictions, such as Hong Kong, India and Singapore, financial authorities have created (or are planning to create) data-sharing infrastructure platforms as a public good, whereby customers can consent to share their digital footprint and thus provide banks with a substantial body of credit-relevant information, so as to enhance their access to financial services, while maintaining the principles of consent and data security (D'Silva et al (2019), Yue (2020)).

There are significant gains – in both efficiency and inclusion – to be made by greater use of technology in banking. Data extraction and computing capabilities now allow for the full exploitation of a data-rich environment. And the largest changes are likely to emerge in the assessment, provision, monitoring and enforcement of credit.

A data-rich environment will let information capital complement the provision of tangible collateral to help resolve informational asymmetries. In doing so, AI-based automation and machine learning will increasingly supplement – and in some tasks replace – human decision-making. And whereas it may previously have taken months or weeks to make a credit decision based on the collection and analysis of paper-based documentation, near instantaneous and paperless credit decisions are now feasible and in some banks the norm. No longer constrained by a scarcity of borrower data, and with machine-readable capabilities, verification costs have been reduced dramatically.

Financing can be increasingly tailored to the recipients' needs, enabling the provision of small loans to individuals who may not be able to provide information in the formats specified for traditional credit origination requirements. At the core of these new products are data-driven models that estimate the incomes of loan applicants based on their attributes, such as the sector in which they are employed and other demographical information. As regards the terms of financing, loans with a fixed schedule of repayment terms stretching over years are giving way to bespoke loans that have flexible terms and repayment schedules.

Monitoring of loan performance will be recast as well. Technology will allow monitoring activity to move to much higher frequencies including daily. And, big data can help estimate and update the probability of future delinquencies based on data and events as they unfold. More timely recognition will reduce the lags in NPL recognition and fraud.

Similarly, the costs of enforcing loan contracts should be reduced. First, while the cost of locating delinquent borrowers or defaulters was traditionally high, modern technology in many cases allows instant location. Second, the high costs of enforcement through the legal system can be lowered through readily available comprehensive documented evidence of loan agreements. And reduced enforcement costs will also boost default recovery rates. Importantly, in the event of a default, the lender has no tangible collateral to acquire in settlement, but the bespoke nature of lending means that lenders' underwriting standards will reflect this risk.

This new environment is not without risks. Data analytics, the backbone of artificial intelligence, is dependent on the underlying data used to train algorithms. Evidence suggests that human and societal biases can be embedded in AI, and be deployed at scale, undermining the goal of financial inclusion (McKinsey (2019), Angwin et al (2016)). And, because no AI algorithm can satisfy all definitions of "fairness" (Kleinberg et al (2017)), different metrics and standards that reflect the nuance of interactions – depending on the circumstances and analytical objectives – as defined by humans, will still be necessary. In a similar vein, analytics are very much backward-looking, limiting the ability to predict turning points in economic cycles or user behaviour. There are also fundamental issues concerning data governance that are highlighted in Section 6 below.

Box A

Reducing tangible collateral and costs: the case of WeBank①

WeBank – China's first virtual as well as privately owned bank – received its banking license in 2014.② It started initially with unsecured personal loans and later expanded to SME lending. At end-2020, WeBank served 270 million consumers and 1.88 million SMEs. The focus of WeBank is to serve the underserved. To date, WeBank customers have included over 19 million individuals, who had little to no credit history at the time of their loan application. In 2020, about 100,000 new SME customers had never received credit from a bank. Some 80% of its Weilidai retail customers do not have a college degree and are in non-white-collar service sectors. Also, a typical SME borrower has a smaller operation compared with clients of incumbent banks: on average, SME borrowers have 10 employees and over 60% of these customers have an annual revenue of less than RMB 5 million (or about $0.7 million).

Technology is at the heart of WeBank's model and can be summarised as "ABCD", which stands for AI, Blockchain, Cloud Computing, and (Big) Data. This "ABCD" strategy helps WeBank achieve two goals – harnessing information capital to bypass the need for tangible collateral and significantly reducing operating costs.

A key part of WeBank's lending operation lies in leveraging data from a wide range of sources, such as credit, judicial and business registration bureaus, access to which requires borrower consent. These data are used as inputs into a quantitative risk assessment model that offers a broader view of borrowers' credit worthiness, allowing for more effective risk management. Loan lines, capped at RMB 200,000 for individuals and RMB 3 million for SMEs, are set dynamically based on risk assessment. The NPL ratio at end-2020 was 1.2%, lower than the average for China's commercial banks of about 1.9%, despite the fact that most of the loans at incumbent banks were collateralised. Insights from these data also help identify new users. WeBank delivers tailored promotions to SMEs whose characteristics suggest a potential need for credit; this approach reduced customer acquisition costs by 93%. The success rate of SME customer acquisition from these promotions is more than twice the industry average in China.

AI biometric authentication is used to onboard customers remotely, and virtually all customer enquiries – 98% to be exact – are handled by WeBank's chatbot using AI. Credit evaluation is nearly instantaneous as WeBank leverages the information provided by the user. The core banking system can process over 750 million transactions per day. The cost savings from technology let WeBank operate with an average revenue of RMB 73.6 (or about $10) per customer in 2020, a level no incumbent banks with brick-and-mortar operations can match.

Meanwhile, cost reduction through technology helps WeBank to broaden its customer reach to those with modest loan demands and limited credit history. For example, the average loan size for retail borrowers is small – at around RMB 8,000 (or about $1,200); interest income from its loan portfolio is also small – 70% of Weilidai customers made interest payments of less than RMB 100 (or about $15) in 2020. The picture is similar for SMEs: the average loan size was RMB 265,000 (about $40,000), far smaller than those at incumbent banks; interest income is also smaller – 60% of these borrowers paid interest payments of less than RMB 1,000 (about $150) in 2020.

WeBank's lending platform has provided formerly underserved segments with access to low-cost loans; however, such digital finance also highlights two general issues for policymakers in the age of virtual banking. One is data privacy: access to data is crucial for information capital accumulation and data analysis, as the bedrock for all virtual bank operations. In order to gain access to data while meeting strict data privacy standards, WeBank has begun developing federated learning technologies. This approach to collaborative model development builds machine learning algorithms without the need to aggregate data, ensuring that the data are kept private. It is not clear if other firms have this capability. Moreover, the broader issue of data privacy requires a holistic approach from supervisors and regulators (see Section 6).

A second issue relates to the challenges posed by a digital divide, amplified by the growth of digital finance globally, in that big techs maintain walled gardens as a core part of their business models. Access to WeBank's personal loan products – Weilidai – is extended only to those on partner platforms with a sufficient transaction history. Whitelisting potential borrowers reduces the risks of fraud such as identity theft, a common challenge for virtual banks; it also highlights the possibility that those not in the digital ecosystem and without digital footprints risk being excluded from this new financial system.

① This box draws extensively upon WeBank's 2019 and 2020 Annual Reports and on correspondence and discussions with WeBank. The authors are solely responsible for any policy opinions expressed. ② WeBank's largest shareholders are Tencent 30% (capped according to regulatory requirement), Shenzhen Baiyeyuan Investment 20% and Shenzhen Liye Group 20%. WeBank was launched by Tencent and partners with Tencent's WeChat ecosystem on certain products.

5. Features of the new landscape

The evolution of banking suggests a new landscape where multiple providers coexist to provide an array of services. In this new landscape, technology plays an increasingly integral role – not only in data analytics, risk mitigation, but increasingly in managing modular platforms and coordinating service provision. Investments in technology are not only crucial in expanding banking services, but the attendant cost savings help expand the reach of these services to include previously underbanked populations. In this section, we examine the features and activities of virtual banks for a cross section of jurisdictions in Asia.

Main features of selected Asian virtual banks[20] Table 2

		Payment	Deposit	Loan	Wealth	Insurance	Other key platform features
CN	WeBank	√	√	√	√	√	Social media, utilities, dining, entertainment, e-commerce
	MyBank	√	√	√	√		Social media, transportation, utilities, education, entertainment, e-commerce
	XW Bank	√	√	√	√		Lifestyle, consumption
	AiBank	√	√	√	√	√	n/a
	Suning Bank	√	√	√	√	√	Retail chains
HK	ZA Bank	√	√	√		√	Lifestyle, consumption
	Mox Bank	√	√				Lifestyle, consumption
	Livi Bank	√	√				Lifestyle, consumption
	Ant Bank	√	√				Mobile payment platform
	WeLab Bank	√	√				Lifestyle, consumption
	Airstar Bank	√	√	√			n/a
	Fusion Bank	√	√				Mobile payment
	PAObank	√	√	√			n/a
KR	Kakao Bank	√	√	√	√		Social media
	K-Bank	√	√	√		√	Lifestyle, consumption
JP	Rakuten Bank	√	√	√	√	√	E-commerce
	Jibun	√	√	√	√		Diversified financial services
IN	YONO	√	√	√	√	√	E-commerce, investments
	Digibank	√	√	√	√	√	End-to-end travel solution
ID	Digibank	√	√	√	√		Lifestyle, consumption
	Jenius	√	√	√			Lifestyle, consumption

Source: Company websites; data as of Q2 2021. Singapore virtual banks are not expected to be operational until 2022.

While all virtual banks surveyed offer payments and deposit services and most have extended into loan provision, the service and products offered by virtual banks in Asia generally go further, tapping into the concept of banking as a way of life, with operations integrated into lifestyle portals (Table 2).

[20] Data as of Q2 2021; data on Singapore virtual banks are not available as banks have yet to be launched.

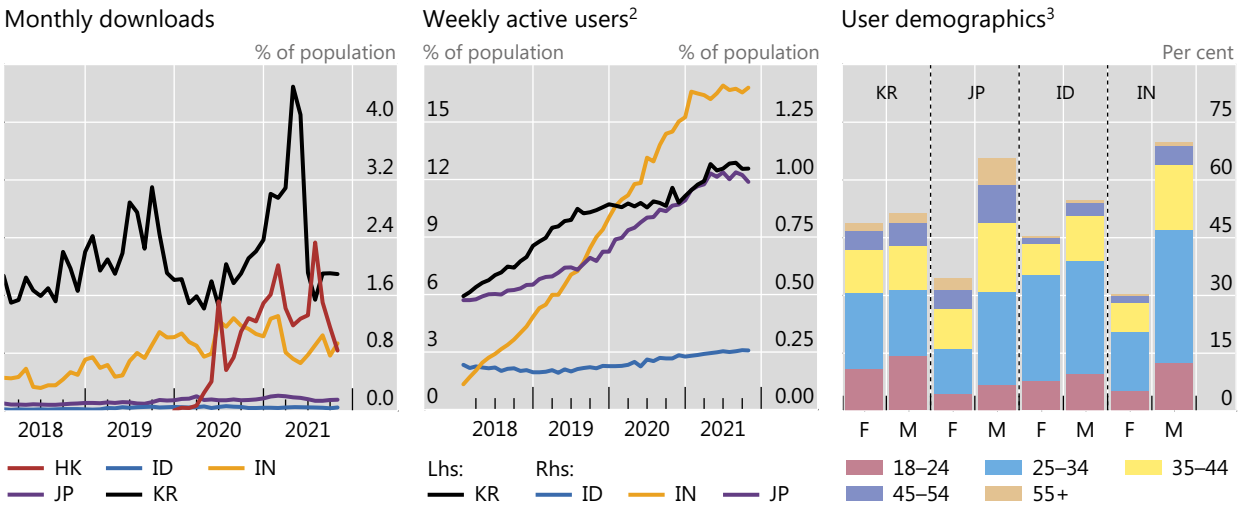
Most of these digital banks offer an enhanced digital experience that encompasses other parts of the consumer's lifestyle, including social media and consumption; these are services that are typically not yet available at traditional brick-and-mortar banks. This approach is seen as crucial for creating a digital ecosystem that builds up the user base over social networks and helps create a large volume of data points for analytics. Measures of access to and demand for digital banking services – as proxied by banking app downloads and the number of users – suggest that there is a growing interest in and greater access to virtual banks. Monthly downloads of major virtual banking apps are accelerating rapidly in Korea and Hong Kong, although measured growth in other jurisdictions has been more muted (Graph 5, left-hand panel). A virtual bank in Korea, Kakao Bank, is linked to Kakao Talk, a popular messaging app in Korea, underscoring the network effect of – and the corresponding boost from – being attached to lifestyle apps. By contrast, in Hong Kong, where virtual bank downloads have also accelerated, these banking apps were only recently introduced and have remained mostly as standalone features, making the growing interest in these apps all the more striking (for an overview of the development of virtual banking in Hong Kong, see Box B).

Another notable feature of virtual banks is the reliance on technology for cost reduction. Technology affects not only the customer interface such as onboarding arrangements, but also key operations such as transaction speeds, risk analytics and risk mitigation. In particular, brick-and-mortar service models find it uneconomical to offset the costs of servicing individual and SMEs with small loan borrowings, particularly as switching from legacy technology infrastructures can be difficult in the short term. Virtual banks, without a legacy technology system, have emerged to meet these immediate market needs. Data from virtual banks suggest sizeable reductions in operating costs, including a dramatic reduction in the number of staff needed for client interfacing as well as risk assessment and mitigation. This cost reduction – and the ability to operate with a low revenue-to-user ratio – is crucial to reaching underserved borrowers. Digitalisation enables banks to incorporate a range of technologies, including artificial intelligence, blockchain, cloud computing and big data – to reduce cost and scale up operations (for more examples of cost reduction, see the case of WeBank (Box A) and virtual banking in Hong Kong (Box B)).

Usage data indicate that the number of regular, active users of digital banking apps is rising (Graph 5, centre panel). The largest population of active digital app users is in Korea, where about 17% of the population uses virtual banking apps on a weekly basis, doubling the share of users over three years. Elsewhere, other jurisdictions are also seeing rapid increases in usage, with growth in Indonesia particularly striking.

Digital banking platforms show evidence of expanded financial inclusion, reaching out to women and younger users, two traditionally underserved groups. Across countries surveyed, those in the 25–34 and 35–44 age cohorts made up the largest group of users. And, notably, women comprise a larger share of users in countries that have an established history of virtual banks (Graph 5, right-hand panel). In Korea, women made up 49% of virtual bank app users on average and as many as 57% of all users for Kakao Bank in the Apple App Store. In Japan, where the first digital bank in Asia, Jibun Bank, was launched in 2008, women accounted for more than a third of all virtual bank users, averaging 34% across Apple and Google platforms. Meanwhile, in Indonesia, although men made up a larger share of virtual bank users, the share of female users in the 18–34 age cohorts were nearly equal to that of men, underscoring the strong appeal of digital apps to younger users.

Select virtual bank app downloads, usage and user demographics[1] Graph 5



The number of apps included in the country aggregates varies by country and is determined by the number of apps and data availability. The apps included in the country aggregates are consistent across the three panels. For Hong Kong SAR, weekly active users and user demographics data are unavailable due to an insufficient sample size.

[1] Data on China not included due to incomplete coverage with only traffic on the Apple platforms captured. Data for Singapore are not yet available (as of October 2021). [2] An active user is defined as a user who has at least one or more sessions within a week; each session is defined as an app brought to the foreground for more than two seconds. [3] Average across virtual bank apps and app stores. Demographics data cover the period from October 2015 to October 2021.

Sources: Sensor Tower; national data; authors' calculations.

The unique blend of technology, finance and service company ownership structure for digital banks further underscores the transformation under way in banking business models (Table 3). Big tech/fintech firms are some of the largest shareholders of virtual banks across Asian markets. These technology companies rely on their technical capabilities including advanced data analytics. At the same time, even in markets that have a well developed banking sector such as Hong Kong, Korea and Singapore, non-bank financial institutions such as insurance, securities or investment companies have stepped in, suggesting unmet credit demand from SMEs and consumers. For example, ZhongAn, a Chinese insurer, co-owns Hong Kong's ZA Bank, while investment firm Korea Investment & Securities has a stake in South Korea's Kakao Bank.

Notably, incumbent banks also often take significant ownership stakes in virtual bank ventures. Banks enter these ventures with the experience and insight that new entrants such as tech companies often lack.

These partnerships allow incumbent banks to leverage technology to revamp legacy IT infrastructure, reduce capital costs and capture new customer segments: for example, China's CITIC has a 70% stake in AiBank; Standard Chartered Bank owns 65% of Mox; and Bank of China has a 44% stake in Hong Kong's Livi Bank. Incumbent banks also rely on these ventures to further capitalise on their strengths. For example, the State Bank of India launched Yono, its digital banking application, with a focus on convenience for its customers, based on the idea that the mobile application can meet all of a consumer's transaction needs, including banking, shopping, lifestyle and investments (McKinsey Global Institute (2021)). Another point of interest is that the nationalities of the main/ultimate shareholder point towards cross-border linkages, with, for example, Ant Financial taking controlling stakes in one of the approved

virtual banks in Singapore, and Singapore's DBS doing the same in India and Indonesia.

Ownership structure of selected virtual banks[1] Table 3

	Virtual banks	Main/ultimate shareholder	Incumbent bank	Other financial services, investments[2]	Big tech / fintech[3]	Telecom	Other
China	WeBank	Tencent		Secondary	Largest		Secondary
	MyBank	Ant Group			Largest		Secondary
	XW Bank	New Hope Group					Largest
	AiBank	CITIC	Largest		Secondary		
	Suning Bank	Suning.com					Largest
Hong Kong SAR	ZA Bank	ZhongAn		Largest			Secondary
	Mox Bank	Standard Chartered	Largest			Secondary	
	Livi Bank	Bank of China	Largest		Secondary		Secondary
	Ant Bank	Ant Group			Largest		
	WeLab Bank	Welab Holdings			Largest		
	Airstar Bank	Xiaomi		Secondary	Largest		
	Fusion Bank	Tencent Holdings	Unknown	Unknown	Largest		
	PAObank	OneConnect			Largest		
Korea	Kakao Bank	Kakao		Secondary	Largest		
	K-Bank	BC Card	Secondary	Largest			
	Toss Bank	Viva Republica	Secondary	Secondary	Largest		Secondary
Japan	Rakuten Bank	Rakuten			Largest		
	Jibun	KDDI	Secondary			Largest	
India	Yono	State Bank of India	Largest				
	Digibank	DBS	Largest				
Indonesia	Digibank	DBS	Largest				
	Jenius	BTPN	Largest				
Singapore	Grab/Singtel[4]	Grab			Largest	Secondary	
	Sea	Sea Group			Largest		
	Ant	Ant Group			Largest		
	Greenland Financial[4]	Greenland Financial		Largest	Unknown		

Largest shareholder; Secondary shareholders (≥10%); Secondary shareholders with stake unknown

[1] Top three largest shareholders with stake of 10% or more. [2] For example, insurance, securities or investment holding companies. [3] Large internet-based companies and conglomerates with core businesses in e-commerce, online gaming, social media, internet search etc, and their financial services subsidiaries. [4] Tentative name of consortiums.

Sources: McKinsey (2021); company websites.

These developments – the participation of incumbents as well as big techs, the proliferation of lifestyle portals that connect multiple facets of consumers' lives, and a growing presence across borders and outside their traditional lending base – echo a drive to achieve network effects in digital banking through scale similar to those that have boosted the growth of big tech in other spheres such as WeChat in China.

Box B

A case study of Hong Kong banks①

Hong Kong's virtual banking structure was designed with an eye on inclusion. The HKMA survey of virtual banks in May 2020 indicated that virtual banks expect that advances in technology will lower transaction costs in every phase of the provision of financial services (See Annex Tables 3–5). This bodes well for making financial services more accessible to lower-income individuals. Notable progress to date includes the following developments.

Onboarding arrangements through remote channels, such as mobile applications or digital platforms, have provided new and additional choices to prospective customers. Aided by eKYC solutions, enhanced by supervised machine learning, remote onboarding can allow customers to open accounts 24 hours a day and in as little as a few minutes without physically visiting bank branches or being subject to their opening hour restrictions.

Virtual banks adopt technological solutions to perform identity authentication and matching, such as biometric solutions (eg facial recognition and liveness detection) for opening and transacting through bank accounts. These can deliver enhanced customer due diligence processes as well as improved customer experiences, while at the same time removing the barrier of access to banking services resulting from the requirement for a customer to visit a bank branch to verify their identity, which may be expensive, difficult or inconvenient to arrange. This is helpful to SMEs, including new start-ups, whose principals cannot readily furnish the information/documents required for opening traditional accounts but do not initially require a full range of banking services.

Hong Kong's virtual banking licensing requirements do not allow these banks to charge low-balance fees or maintain minimum balance requirements.② This has resulted in positive spillover effects, with 80% of the major incumbent retail banks in Hong Kong, as of October 2020, having removed their minimum account balance requirements or low-balance fees for various categories of their retail banking accounts and products. This has made bank accounts even more accessible, as a gateway to a wider range of financial services.

As many banks – particularly the new virtual banks – are still accumulating customer data, the models are constantly being recalibrated and improved. In the meantime, banks are using risk mitigation methods such as taking the lower of declared and model-estimated income when assessing credit applications or setting prudent portfolio limits. As the models become more accurate and predictive, these personal lending portfolios should also increase in size as well as include more customers.

As noted earlier, several virtual banks are in the process of developing loan products for SMEs or retail customers that use alternative data in credit underwriting instead of relying on traditional financial statements/management accounts or tangible collateral. In trade finance, a virtual bank is applying machine-learning techniques to electronic records of custom declarations and cargo manifests – indicators of current and past business activities for import and export firms – to gauge the creditworthiness of the firms and, ultimately, make credit decisions. Other banks are exploring the use of sales statistics, such as sales turnover and product return rates, in underwriting supply chain financing for SME suppliers that sell through e-commerce platforms.

A survey of virtual banks in Hong Kong indicates that the time period for credit assessment of individual borrowers is now almost instantaneous, as compared with the (previous) norm of several weeks for incumbent banks. For SME borrowers, virtual banks report taking less than a week to complete their credit assessment, whereas similar credit assessments took at least several weeks at incumbent banks, even for existing borrowers.

Financing can now be provided to more borrowers, and with greater timeliness and flexibility. Whereas the average SME loan size from incumbent banks could often be higher than HK$ 10 million (or $1.3 million) depending on the loan purpose and financial strength of borrowers, the average size of loans from virtual banks is around HK$ 1 million. Virtual banks are reportedly targeting small businesses with an annual turnover of less than HK$ 100 million, and often without financial statements. As for individual borrowers, the average loan size of incumbent bank loans was around HK$ 250,000, whereas the average credit limits offered by virtual banks using credit assessment models are in the range of HK$ 40,000 to HK$ 110,000. The tenors of virtual bank loans to SMEs are less than two years, whereas loans from incumbent banks often have maturities of more than two years. On the deposit side, flexible time deposit tenors have been introduced with no early withdrawal penalty.

In addition to offering basic services, many Hong Kong banks with retail businesses, including some virtual banks, have introduced personal lending products that make use of new credit management tools underpinned by financial technology.③ As the models and methods applied to alternative data mature, two trends are likely to

emerge. First, banks should be able to offer the products to a wider array of SMEs, relying more on the accuracy of the credit assessment from the models and less on other forms of risk mitigation. Second, products other than trade finance or supply chain finance should begin to emerge, leveraging these new alternative data techniques.

① Unless otherwise noted, this box has drawn upon extensive communications with the HKMA as well as many of the virtual banks operating in Hong Kong. The authors take full responsibility for any errors. ② Typically, the minimum fixed fees and minimum balance conditions of banking are regressive, weighing disproportionately on lower-income customers. ③ Other examples of innovative and customer-centric experiences provided by Hong Kong's virtual banks include (a) numberless debit cards to enhance privacy and security; (b) card management via mobile app (eg suspending the card if the physical card is lost or stolen, managing the spending limit, and resetting the ATM PIN); (c) customised debit card numbers; and (d) budgeting tools and personal spending pattern analysis.

Social media marketing that pulls in users – and these users' friends – as well as the interoperability of apps across phones, service providers and borders could dramatically alter the provision of banking services and expand their adoption. Indeed, the evidence suggests that many virtual banks have leveraged their social media platforms and are offering a suite of products across different ecosystems. Moreover, the provision of these lifestyle services relies on the integration of banking, technology and services. Not surprisingly, in addition to traditional banks, the main shareholders of the banks are often big tech or fintech firms, as well as non-bank financial institutions. Many virtual banks show signs of growing rapidly and serving a diverse and inclusive demographic, with benefits seen in advanced, emerging market and developing economies alike.

6. Data governance considerations

As noted above, the digital footprint of consumers has increased dramatically as more and more activity moves online. Advanced computing techniques have enabled this ever-expanding data footprint to provide benefits from access to a large stock of comprehensive transactional and locational data on an individual – the individual's "information capital". Traditionally, economic systems have ensured that individuals and businesses have ownership rights over the assets they create but this is not the case with data. The cost to individuals and businesses of the lack of ownership is the absence of benefits that this ownership would bring.

Globally, most countries have privacy laws that recognise the rights of individuals over their data. These laws give data subjects – consumers and businesses in this case – the opportunity to exercise control over their data through the granting or withholding of consent to the use and transfer of these data. However, consumers find it difficult to manage this consent effectively for two reasons. First, a service provider usually seeks consent to use and transfer data at the point when a consumer signs up to use the provider's services. Since this consent is sought ex ante for a wide range of possibilities, it is broad and sweeping in nature. Second, newly created data are often gathered and retained in proprietary silos, and stored in various institutions in incompatible formats. Consumers can find it difficult to share their data as they have only limited options for combining data requests across institutions. Thus, service providers who are custodians of data effectively act as de facto owners of data. Inaccessible data, including data isolated in silos, represent a significant cost to consumers and to society.

To correct this would require a granular consent-based data governance system that is user-friendly with low transaction costs. Such a system would also obviate the

need for consumers to provide the broad, sweeping consent described earlier. Various jurisdictions are developing consent-based data governance systems so that data subjects can derive the full value from their data while maintaining control over them. Given the amount of data involved, as well as the need to keep it secure, this consent-based system needs to be digital. It is key that consent request – every time data is shared – be granular, specifying what data have been requested, how long they will be retained, and who will process them. In this manner, purpose limitation,[21] data minimisation,[22] retention[23] and use limitation[24] are achieved, as is the avoidance of ex ante broad, sweeping consent as now. The consent framework should be open, revocable, secure and subject to audit.[25]

For a consent system to be adopted widely within a jurisdiction, it should be data subject- and data user-friendly, and operate with low transaction costs. In systems where data subjects are presently at a significant handicap, trust in the system as well as widespread adoption of the consent architecture will be significantly enhanced by the participation of specialised data fiduciaries whose primary task – as the advocate of data subjects – is to ensure that the rules are being followed.

Even in the best designed systems, ensuring use limitation is a challenge because – with currently available technology – it is difficult to enforce. However, advances in technology provide scope for a solution to guarantee use limitation. The use of a confidential computing environment will enable the data user to process the data, as well as to extract the results of the analysis, but not to access the personally identifiable information data.

7. The integrated regulatory framework

As we have seen, the information capital generated by real-time transactional and locational data on potential borrowers is an essential feature of the new banking model – one that allows it to enhance financial inclusion and intermediation. But the greater the variety of firms that enter the banking industry amid changing customer preferences, the more pressing the need for central banks and financial regulators to ensure that the regulatory oversight of the new financial architecture delivers on the inclusion and intermediation-enhancing benefits of digital finance without compromising essential regulatory goals.[26] At the same time, as discussed earlier, a data governance system where the data subjects have agency over the data they create is essential.

[21] The obligation to ensure that the purpose for which data are being collected is described in clear and specific terms.

[22] The obligation to collect only as much data as are strictly necessary to achieve the stated purpose.

[23] The obligation to ensure that data are not retained for longer than required to achieve the stated purpose.

[24] The obligation to ensure that data are only used for the purpose it was collected.

[25] In India, the governance of such a system needs to be anchored by specialised data fiduciaries whose primary task is to manage the consent-based sharing of data, known as Account Aggregators. For a description of their recent activities, see sahamati.org.in/faq/.

[26] For an overview of the challenges for central banks and financial regulators in their oversight of the activity of big tech and fintech firms more generally in financial services, see Carstens et al (2021), Restoy (2021), Feyen et al (2021) and Croxson et al (2022).

Hong Kong has established a licensing and regulatory regime – applicable equally to incumbent and new banks – with the aim of managing the full spectrum of risks arising from any source, including the ownership structure or technology bias, but without compromising either development objectives that often rest on technological innovation or the regulatory goal of financial stability. This has called for an integrated regulatory framework that aims to maintain the above-mentioned balance. How the framework deals with data is in the early stages of development and the nascent consent-based data-sharing platform is limited to commercial transactions. This section describes how the regulatory framework tackles these challenges.

a. Overall approach

The HKMA has adopted a risk-based and technology-neutral approach in its regulation and supervision, with an eye towards promoting financial inclusion and innovation and providing an enhanced customer experience. Thus, when implementing the regulatory framework, the HKMA focuses on the intrinsic characteristics of the financial activities or transactions, and the risks arising from them. Undue exemptions or requirements are not introduced simply because of novel technological applications. This helps maintain an environment conducive to innovation and a competitive market while ensuring that end users will not have to bear undue risk.

The HKMA granted banking licences to eight virtual banks in the first half of 2019. All of them officially launched services to the public in 2020. In their short operating period, the general public has been quite receptive to virtual banks, particularly on the deposit side; their customer base and growth rate could increase further as they roll out a wider range of products and customer experiences. As of end-September 2021, the virtual banks had signed up a total of about 1.1 million customers, equivalent to around 17.5% of the adult population (20+ years old), and had attracted over HK$ 24 billion (or about $3 billion) in deposits. The aggregate amount of loans extended by virtual banks remained small, at approximately HK$ 4 billion. The loans remain on the banks' balance sheets and are funded by their customer deposits as well as their capital base.

Virtual banks in Hong Kong engage primarily in retail banking activities, with a focus on serving individuals and SMEs – the segments of the population that need to be better served by the credit intermediation process.[27] Thus, in the licensing phase, all virtual bank applicants submit a detailed and credible business plan explaining how the virtual bank intends to comply with the HKMA's objectives for the introduction of virtual banking into Hong Kong, including the promotion of financial inclusion, as well as enhancing the customer interface. Once the licence is granted, the HKMA closely follows the operation of each virtual bank, including relative to their submitted plans. As part of this exercise, it assesses the development of new products and services in relation to financial inclusion for both individuals and corporates, especially SMEs. Where customers might not be as familiar with the new products,

[27] Details of the licensing criteria of banks (both traditional and virtual banks) are set out in Chapters 4 and 9 of the *Guide to Authorization* issued by the HKMA, www.hkma.gov.hk/media/eng/doc/key-functions/banking-stability/guide-authorization/Chapter-4.pdf; www.hkma.gov.hk/media/eng/doc/key-functions/banking-stability/guide-authorization/Chapter-9.pdf.

virtual banks are required to enhance their disclosures to ensure adequate consumer protection.[28]

The basic licensing requirements for incumbent banks are retained when evaluating the applications – the adequacy of financial resources including capital, risk management, control systems and fitness of senior management among other factors. This applies also to big tech applicants, who may be new to the risk management and internal control expectations imposed on regulated banks. Irrespective of the ownership structure, the board of directors and senior management of virtual banks should have members with the right mix of expertise and experience to ensure that the risks of virtual banks are properly monitored and controlled.

The presentation of relevant financial and other information to the HKMA also becomes an ongoing obligation, as with incumbent banks. Thus, the principle of activity-based regulation applies ("same activity, same regulation"). In this way, it is ensured that the virtual banking licence is not an avenue for shadow banking activities and thus regulatory arbitrage.

At the same time, in keeping with the integrated regulatory approach, the process for the selection of virtual banks further includes the presentation and examination of evidence of technological expertise and experience in the board and senior management. A further requirement is the demonstrated capability of an applicant to formulate a proper framework for risk management and to establish board and senior management committees to oversee the firm's IT governance. After granting the banking licences, and before business commences, independent assessment reports on the bank's technology risk management are reviewed. After the start of business operations, the HKMA places its ongoing supervisory focus on the virtual bank's IT governance, system resilience and stability, and cyber security, and carries out onsite exams and desktop reviews to that end.

Virtual banks are thought to pose two additional unique risks: – (i) the diversity of firms that own and control the banks; and (ii) a data and technology-based business model – that require the regulatory framework in Hong Kong to be extended for incumbent banks. As discussed in more detail below, safeguards have been put in place to contain the risks arising from the ownership structure of the virtual banks since a number of controlling firms have no previous financial experience, and include both standalone institutions as well as joint ventures between banks, non-bank financial institutions and technology companies. This type of regulation is clearly entity- rather than activity-based.

b. Whom to regulate and why?

The virtual banks operating in Hong Kong fall under the same regulations as incumbent banks. They must operate as a locally incorporated bank. The majority shareholder should be either a bank or a financial institution in good standing and supervised by a recognised authority in Hong Kong or elsewhere, or additional requirements will apply.

[28] An array of new banking products – including deposit-linked and salary-linked personal loan products and a new mode of instalment payment for card spending – was brought to market by the virtual banks in the second and third quarters of 2021 (see HKMA *inSight*, 12 July 2021).

As noted earlier, virtual banks may be owned by entities operating non-banking activities, and it is therefore possible for the majority owner to be incorporated outside Hong Kong or to be a locally incorporated company that is neither a financial holding company nor a subsidiary of a financial holding company. In such instances, the virtual bank within the group must be majority-owned by a holding company incorporated in Hong Kong. In implementing this requirement, the HKMA imposes regulatory and supervisory conditions on the holding company so that the HKMA's primary concern is allayed – that risks may be posed to the virtual bank in Hong Kong by its majority owner or any related parties of the group of which the majority owner is a part.

The immediate holding company is subject to regulatory and supervisory conditions that are akin to the key prudential requirements that the virtual bank is normally subject to (eg observing prudential limits on capital adequacy, liquidity, large exposures, intra-group exposures and charges over assets, ensuring the fitness and propriety of its chief executive and directors, and exercising effective corporate governance).[29]

The owners of virtual banks include diversified conglomerates with other significant group entities engaged in non-financial activities, and hence, there could be instances where the majority owner is either the ultimate holding company or an intermediate holding company, within the diversified conglomerate. In such instances, HKMA imposes regulatory and supervisory conditions on the ultimate/intermediate holding company. These focus mainly on enabling the HKMA to obtain relevant information (in addition to audited accounts, notification of any significant capital impairments or increases in leverage, and any changes in the board and chief executive) to assess any potential risks posed to the virtual bank by activities elsewhere in the group and to contain them. In particular, the ultimate holding company must submit an annual independent review report on its financial conditions, its ability to provide timely capital and liquidity support to the virtual bank in case of need, and any inherent business risks (including non-financial activities) that could adversely impact the virtual bank's safety and soundness. The report's findings are considered in the annual supervisory review process for determining the bank's capital requirements.

c. Technology-based business model risks

While virtual banks are subject to the same set of regulatory and supervisory requirements that are applicable to incumbent banks, the HKMA has, where appropriate, adapted its requirements in a manner proportionate and relevant to the risk profile and business model of the virtual bank activity. For example, in the area of personal lending, the HKMA has observed that conventional supervisory requirements for banks such as the collection of borrowers' income statements might make it difficult for banks to develop new loan products relying on alternative data. In view of this, in 2018, they allowed banks to lend up to 10% of a bank's capital base

[29] For virtual banks whose majority owners are subject to regulatory and supervisory conditions imposed by the HKMA, the holding company of the virtual bank is required to observe a prudential limit on its exposures (ie including the virtual bank) to the ultimate parent of the group. If a virtual bank is not majority-owned by a regulated bank or financial institution in Hong Kong or overseas, the immediate holding company of the virtual bank will submit financial information to the HKMA information on a quarterly basis. The primary purpose of the immediate holding company is to hold the shares of the virtual bank, and should the holding company conduct any other business, these would be only for the purpose of providing support to the activities of its virtual bank.

for new personal lending. In this case, a departure from conventional lending practices was permitted. Subsequently in 2019, recognising that even these caps could be binding on virtual banks in their initial growth phase, the HKMA removed the 10% limit altogether, allowing banks to set their own limits for such new personal lending products.[30] That said, banks are expected to discuss their plan with the HKMA before launching such new products.

The use of technology-based financial architecture often involves the rapid scale-up of operations. In its supervision of virtual banks, the HKMA regularly monitors the pace of business expansion, and focuses on ensuring that it is not so rapid as to put undue strains on the bank's systems and risk management capabilities. Particular attention is paid to the adequacy of the virtual banks' risk management and internal controls to manage the associated risks, including the banks' staff resourcing as well as its operational capacity to cope with a surge in account opening applications and customer transactions. Where necessary, the HKMA requires the virtual banks to engage an independent party to assess their risk management systems and internal controls before giving the green light to the launch of a major or novel business initiative.

The HKMA also requires that virtual bank applicants develop an exit plan so that, if necessary, the virtual bank can unwind its business operations in an orderly manner without causing disruption to the customers and the financial system. For example, the plan sets out the triggers for activating the exit plan, the process and procedures to be taken, the strategy for communicating with customers and other stakeholders (including the regulators), and the sources of funding and channels to be used for repaying depositors. The virtual banks must keep their exit plans under review.

The HKMA is aware that the introduction of virtual banks could create competitive pressures in the banking sector, which might cause banks to increase risk-taking, with an adverse effect on the stability of individual banks or even that of the entire banking sector. As the virtual banks are still in the early stages of operation, their impact on competition remains to be seen. That said, not long after banking licences were granted to the virtual banks, they introduced fee-less account opening, and accounts with no monthly fees or minimum balances. In response, a number of incumbent banks have also removed monthly or minimum balance fees for basic bank accounts. Thus far, the virtual banks are proving to be a source of competitive pressure, forcing incumbent banks to speed up their adoption of technologies and broaden their digital offerings.

Competition in the digital age can also reflect incentives to capture data and scale up rapidly to take advantage of network effects. The HKMA monitors whether virtual banks engage in predatory tactics (ie aggressively building market share at the expense of substantial losses in the early years of operation). In particular, the HKMA considers the preferential pricing offered by virtual banks in promotion campaigns, and also whether the bank's overall business strategy is sustainable, and if it has a credible plan to achieve profitability in the medium term.[31]

Generally speaking, the HKMA does not interfere in the commercial decisions of individual banks. Its focus is rather on whether the pricing and sales practices adopted by banks might cause them to loosen their risk management standards, thus

[30] See www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2019/20190829e1.pdf.

[31] As an example, promotional schemes that are continued for only a brief period and offer an unsustainably high interest rate on initial deposits.

adversely affecting the soundness of the individual bank or the banking system as a whole. Examples of actions that the HKMA might consider in response include requiring the virtual bank to slow or suspend its promotional campaigns, requiring the bank to commission an independent party to review its governance and internal controls, imposing a more stringent capital requirement, or restricting or suspending its business activities.

d. Data governance

As discussed in Section 6, data provided on digital platforms can be invaluable for credit assessment, increasing access to credit and lowering the cost of existing credit lines for borrowers. Innovations such as machine learning and big data analytics, combined with cloud computing, facilitate the use of large, previously untapped data repositories. However, in the absence of an effective data governance framework, borrowers will be unable to derive many of the benefits outlined earlier as they are unable to exercise control over their data.

To make data-sharing more efficient and enable SMEs to efficiently use data generated by their digital activity for their own benefit, in 2020, the HKMA announced the Commercial Data Interchange (CDI), which is an integral part of HKMA's Fintech 2025 strategy. As the name suggests, the CDI focuses on commercial transactions. The first phase of the HKMA's proof-of-concept study focused on using trade-related data to facilitate trade finance and was completed by end-2020. The second phase, which focused on using payment data to facilitate alternative credit scoring, was completed in October 2021. The participants included financial institutions and data providers from the e-commerce, payment and telecommunications industries.

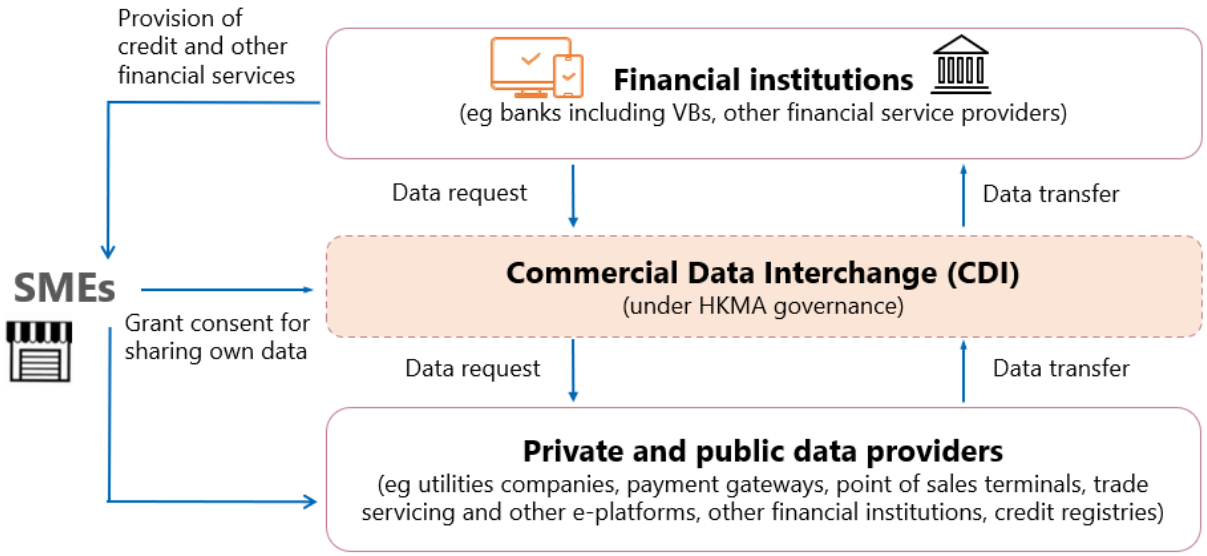
With CDI, instead of multiple one-to-one connections between data users (banks) and data providers, each bank and data provider will have a single connection to an interoperable platform, making data-sharing more efficient. As a secure system based on consent-to-share, the CDI, when operational, should follow the principles of purpose limitation, data minimisation and restrictions on storage in data-sharing. The CDI will enable a prospective SME borrower to authenticate their identity and consent, allowing the SME to provide relevant data – such as historical turnover, types of trade counterparty and credit performance – to lenders through the CDI platform. By improving credit analysis across a wide range of lenders, it should permit SMEs to benefit more from the data they generate (Graph 6). The CDI will be unveiled in full during the second half of 2022. At this stage, the CDI does not extend to individual consumers.

A key risk area identified by the HKMA with the advent of virtual banking is customer protection, including data privacy. The efficiencies in the collection and use of data can result not only in increased risk of consumer fraud and mis-selling, but also in potential privacy violations. To contain these risks, the CDI incorporates end-to-end data encryption, among other safeguards. A governance framework will be announced when the CDI is officially launched to ensure that CDI users comply with the rules on cyber security and data protection. The HKMA has put in place measures to increase consumer protection in banks' open API initiatives, as well as in banks' use of data analytics and artificial intelligence.[32] These measures are designed to protect

[32] See www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2019/20191029e1.pdf; www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2019/20191105e1.pdf. Enhanced retrieval of e-statements, enhanced disclosure on digital

customer interests irrespective of whether the bank provides the service directly or in partnership with third-party service providers.

Commercial Data Interchange (CDI) design – a digital data-sharing platform Graph 6



Source: HKMA.

To the extent that the introduction of the CDI makes up-to-date borrower data more readily available to lenders, some firms that might have been excluded due to a lack of collateral may still be in a position to access credit markets. The establishment of the CDI shows that the public sector can contribute to infrastructure that enhances the availability of data. At the same time, under the regulatory umbrella provided by the central bank, the CDI is designed to respect the principles of consent and data security.

Data governance platforms are being developed in several jurisdictions worldwide, with important differences in design. The recently launched Account Aggregator model in India has a consent-based data governance system – to collect, process and share data – that is open and interoperable and where consent is granular, revocable, auditable and secure. The system is anchored by consent managers, licensed by the Reserve Bank of India, who ensure that data subjects – in this case consumers and businesses – benefit from the data they create. This system offers important pointers for the CDI and other consent-based data-sharing systems for future adaptations. Other jurisdictions such as Singapore have also introduced platforms under central bank supervision to mitigate the trade-offs between privacy

platforms to reduce impulsive overborrowing, as well as procedures for following up on the mistransfer of funds have also been introduced.

See www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2019/20190912e1.pdf; www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2020/20200904e1.pdf; www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2019/20190125e1.pdf.

and financial innovation in the sharing of data, with important differences in their design.[33]

e. Systems, model and algorithm governance

To strike a balance between technological innovation and the interests of consumers, the HKMA advises banks to implement consumer protection measures that are commensurate with the risks involved. For instance, with regard to banks' open API initiatives, the HKMA issued a circular that banks should uphold the consumer protection principles set out in the Code of Banking Practice and comply with other regulatory requirements for their banking products and services. Banks must address all relevant consumer protection aspects such as fair treatment of customers, disclosure and transparency, protection against fraud, redress mechanisms, liability and settlement arrangement and the potential risk of misrepresentation.[34]

Furthermore, the HKMA has established some guiding principles for banks' big data analytics and artificial intelligence (BDAI) applications so that consumer protection and risk management aspects are addressed.[35] These cover:

- (i) for governance purposes, the board and senior management of banks remain accountable for all BDAI-driven decisions and processes. Accordingly, they should ensure that the BDAI models can be readily explained including any algorithms (ie no "black box" excuses). As part of the HKMA's supervisory work, banks have to demonstrate that their BDAI initiatives are consistent with the guiding principles, as well as that the relevant risks are managed.
- (ii) Banks should ensure that BDAI models produce objective, ethical and fair outcomes for customers, which includes, among others, allowing for the possibility of manual intervention to mitigate irresponsible lending decisions where necessary (eg in cases involving higher risks or impacts from automated decisions).

In addition, artificial intelligence (AI) models should be rigorously validated and continuously monitored to confirm their accuracy and appropriateness and to ensure that they continue to perform as intended. This is all the more important given the biases embedded in AI and data analytics that could work against financial inclusion. As described, the principles are deliberately high-level in nature as the HKMA is mindful that overly prescriptive or rigid requirements may inhibit the further

[33] In 2020, the Monetary Authority of Singapore, together with other government bodies, introduced the Singapore Financial Data Exchange (SGFinDex), a managed online data-sharing consent system. India started sooner: the RBI established a framework for regulated data fiduciary entities called account aggregators as early as 2016. The architecture of the Indian model is common for credit to both businesses and consumers. Further, it has multiple licensed consent managers, and the data flowing through them are fully encrypted so that no one can gain access unless approved by the customer (see D'Silva et al (2019)). More generally, open banking initiatives that mandate data-sharing among financial institutions and accredited third parties upon the customer request in jurisdictions such as the United Kingdom and European Union also give users more choice, enable new entrants, and drive the adoption of platforms. That said, individual jurisdictions may define open banking differently: see Report on open banking and application programming interfaces (APIs) (bis.org).

[34] See www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2019/20191029e1.pdf.

[35] See www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2019/20191101e1.pdf and www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2019/20191105e1.pdf.

development of AI-related technologies. For this reason, banks apply the principles in a manner that reflects the nature of their AI applications and the level of risks involved. Further, banks are expected to conduct model assessments at varied frequencies, in proportion to the nature of their AI models and the risk level.

8. Conclusions

While significant progress has been made over the last decade in increasing access to bank accounts, use of the financial system to save and borrow remains low. This is a problem not only for developing countries but for jurisdictions with high levels of education and income.

Technology holds the promise of closing this gap. Although individuals and small firms seeking credit have traditionally needed to post collateral or are uneconomical to pursue for many banks, the ever-expanding digital footprint of consumers and firms online and elsewhere creates data that can be used by banks as information capital to provide loans, lessening the dependence on collateral. At the same time, banks will be better able to serve low-margin, high-risk customers as the use of technology lowers transaction costs. More generally, the banking technology stack will enable different service providers to enter at various layers of the stack to use and reap the benefits of data. Our examination of the breadth of activity, diversity of customer demographics, and innovative mixture of ownership structure in virtual banks in Asia suggests that financial inclusion could take an important step forward.

In the past, individuals and firms often used only one bank for all their financial needs, although competition in the provision of financial services has increased over time. Increased digitalisation of banking has taken this competition one step further. By means of an unbundled banking stack, financial services can be provided across more platforms, offering a wider variety of financial products to an increasing share of the population, but also settling in fiat money inside the regulated system.

The transformational impact of public initiatives is evident in developments in Asia, including Hong Kong. The HKMA has defined a regulatory framework for virtual banks that seeks the benefits – of fostering innovation and inclusion – from allowing diverse ownership structures in which big tech/fintech companies as well as non-bank financial institutions can take controlling stakes. At the same time, in addition to maintaining activity-based regulatory objectives, the HKMA also considers the risks posed by technology to individual banks and the financial system that come with the participation of large technological companies with no previous financial sector experience.

The indispensability of data in the new banking model raises the importance of data privacy standards that mitigate any risks to the customer's security and privacy. While this is work in progress for most jurisdictions, it is key that open, non-discriminatory and interoperable systems are put in place. One solution to the problem – seen in India and Singapore, as well as under development in Hong Kong – is to create a platform under central bank supervision that facilitates the sharing of personal data with financial service providers, but only with the consent of the customers. At present, the system under development in Hong Kong will apply only to commercial transactions. Supervision of the consent-sharing platforms by the central bank is intended to ensure that the principles of consumer protection and content are maintained, together with data security.

The transition to and growing reliance on information capital underscore several key challenges for virtual banks: the validity of data and the attendant stringent monitoring and assessment of borrowers necessary for unsecured lending. For debt resolution regimes that subject virtual and brick-and-mortar banks to the same regulations, unsecured lending, particularly for non-recourse loans, puts lenders at a higher risk of loss than those extending collateralised lending. To keep potential losses to a minimum, virtual banks have relied on strong monitoring, including more frequent and multi-dimensional inputs for credit assessment, and the provision of bespoke loans that better meet borrower repayment abilities. The net result from this transition from tangible collateral to information capital is thus greater reliance on information-gathering and a more continuous and vigorous assessment of users' credit profiles.

The complete array of side effects on the financial system from the new model of banking has not been covered in this report.[36] How these might work over the full business cycle, and whether the reduced term of loans combined with the reduced reliance on physical collateral will mitigate or amplify financial system procyclicality, is an open question. Data-based credit allocation might diminish the value of relationships between borrowers and their bankers, which in other contexts have been shown to increase banks' capacity to handle crises and the financial restructuring of borrower obligations ex post. New entrants to the financial ecosystem will be in both competitive and complementary relationships with incumbent banks. While virtual banks are likely to lead the way in this technological transformation, incumbent banks will seek to manage the burden of their IT legacy systems and complex organisational structures to close the gap. Ideally, when granted control of their own data, consumers will be able to choose from the best of both worlds.

[36] For an early example of in-depth analysis, see Basel Committee on Banking Supervision (2018).

9. References

Angwin, J, J Larson, S Mattur and L Kirchner (2016): "Machine bias", *ProPublica*, 23 May, www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing.

Armantier, O, S Doerr, J Frost, F Andreas and K Shue (2021): "Whom do consumers trust with their data? US survey evidence", *BIS Bulletin*, no 42, May 2021.

Ayyagari, M, P Juarros, M Martinez Peria and S Singh (2016): "Access to finance and job growth: firm-level evidence across developing countries", *Policy Research Working Papers*, no 7604, World Bank.

Bahaj, S, A Foulis and G Pinter (2020): "Home values and firm behavior", *American Economic Review*, vol 110, no 7, pp 2225–70.

Bank for International Settlements (BIS) (2019): *Annual Economic Report*, Chapter 3: "Big tech in finance: opportunities and risks".

——— (2020): *Annual Economic Report*, Chapter 3: "Central banks and payments in the digital era".

——— (2021): *Annual Economic Report*, Chapter 3: "CBDCs: an opportunity for the monetary system".

Basel Committee on Banking Supervision (2019): "Report on open banking and application programming interfaces", November.

——— (2018): "Sound Practices: Implications of fintech developments for banks and bank supervisors", February.

Beaumont, P, H Tang and E Vansteenberghe (2021): "The role of fintech in small business lending: evidence from France", *Bank of France Working Paper*.

Berg, T, V Burg, A Gombović and M Puri (2020): "On the rise of fintechs: credit scoring using digital footprints", *Review of Financial Studies*, vol 33, pp 2845–97.

Campello, M and M Larrain (2016): "Enlarging the contracting space: collateral menus, access to credit, and economic activity", *Review of Financial Studies*, vol 29, pp 349-83.

Carrière-Swallow, Y, V Haksar and M Patnam (2021): "India's approach to open banking: some implications for financial inclusion", *IMF Working Papers*, no 2021/052, February.

Carstens, A (2019): "Data and technology: embracing innovation", keynote speech, 55th SEACEN Governors' Conference and High-level Seminar, Singapore, November 2019.

Carstens, A, S Claessens, F Restoy and H S Shin (2021): "Regulating big techs in finance", *BIS Bulletin*, no 45, August.

Chen, M, Q Wu and B Yang (2019): "How valuable Is fintech innovation?", *Review of Financial Studies*, vol 32, pp 2062–106.

Claessens, S, T Glaessner and D Klingebiel (2002): "Electronic finance: reshaping the financial landscape around the world", *Journal of Financial Services Research*, vol 22, pp 29–61.

Cornelli G, J Frost, L Gambacorta, R Rau, R Wardrop and T Ziegler (2020): "Fintech and big tech credit: a new database", *BIS Working Papers*, no 887, September.

Croxson K, J Frost, L Gambacorta, T Valletti (2022): "Platform-based business models and financial inclusion", *BIS Working Papers*, no 986, January.

Demirgüç-Kunt, A, S Ansar, J Hess, L Klapper and D Singer (2018): *The Global Findex Database 2017: Measuring financial inclusion and the fintech revolution*, World Bank.

——— (2018): *The little data book on financial inclusion*, World Bank.

D'Silva, D, Z Filková, F Packer and S Tiwari (2019): "The design of digital financial infrastructure: lessons from India", *BIS Papers*, no 106, December.

Duflos, E and L Klapper (2015): "New accounts in China drive global financial inclusion figures", *World Bank Blogs*, June, https://blogs.worldbank.org/eastasiapacific/new-accounts-china-drive-global-financial-inclusion-figures.

Erel, I and J Liebersohn (2020): "Does fintech substitute for banks? Evidence from the Paycheck Protection Program", *NBER Working Papers*, no 27659, December.

Fenwick, M, J McCahery and E Vermeulen (2017): "Fintech and the financing of entrepreneurs: from crowdfunding to marketplace lending", *TILEC Discussion Papers*, no 2017-25.

Feyen, E, J Frost, L Gambacorta, H Natarajan and M Saal (2021): "Fintech and the digital transformation of financial services: implications for market structure and public policy", *BIS Papers*, no 117, July.

Financial Stability Board (FSB) (2019): *Evaluation of the effects of financial regulatory reforms on small and medium-sized enterprise (SME) financing*, consultative document, June.

Frost J, L Gambacorta, Y Huang, H S Shin and P Zbinden (2019): "Big tech and the changing structure of financial intermediation", *Economic Policy*, vol 34, no 100, pp 761–99.

Gambacorta L, Y Huang, Z Li, H Qiu and S Chen (2020): "Data vs collateral", *BIS Working Papers*, no 881.

Ghosh, P, B Vallee and Y Zeng (2021): "Fintech lending and cashless payments", *Harvard Business School Working Papers*, February.

He, Z, J Huang and J Zhou (2020): "Open banking: credit market competition when borrowers own the data", *NBER Working Papers*, no 28118, November.

Holmstrom, B and J Tirole (1997): "Financial intermediation, loanable funds, and the real sector", *Quarterly Journal of Economics*, vol 112, no 3, pp 663–91.

Hong Kong Institute of Monetary and Financial Research (HKIMR) (2020): "Adoption and innovation in the Hong Kong Banking industry", May.

Kleinberg, J, S Mullainathan and M Raghavan (2017): "Inherent trade-offs in the fair determination of risk scores", *Computer Science*, vol 67.

Moenjak, T and V Santiprabhob (2021): "Regulating big tech and non-bank financial services in the digital era", *Central Banking*, April.

McKinsey & Company (2021): "Joining the next generation of digital banks in Asia".

——— (2019): "Tackling bias in artificial intelligence (and in humans)".

McKinsey Global Institute (2021): "Disrupting the disruptors: Business building for banks".

Menkhoff, L, D Neuberger and O Rungruxsirivorn (2021): "Collateral and its substitutes in emerging markets' lending", *Journal of Banking & Finance*, vol 36, no 3, pages 817–34.

Parlour, C, U Rajan and H Zhu (2020): "When FinTech competes for payment flows", working paper, https://ssrn.com/abstract=3544981.

Phadke, S (2021): "Can digital currencies and crypto investors help close India's SME financing gap", ProductNation blog, iSPIRT, April, https://pn.ispirt.in/can-digital-currencies-and-crypto-investors-help-close-indias-sme-financing-gap/.

Restoy, F (2021): "Fintech regulation: how to achieve a level playing field", Financial Stability Institute, *Occasional Papers*, no 17, February.

Stulz, R (2019): "Fintech, bigtech, and the future of banks", *Journal of Applied Corporate Finance*, vol 31, no 4, November.

Tam, K Y (2021): "Fintech, Artificial Intelligence and Machine Learning", lecture at the Hong Kong Academy of Finance (AoF), April.

Yue, E (2020): "What's next in our fintech journey", keynote speech at the Hong Kong FinTech Week 2020, November.

Zhai, K (2021): "China orders tech giants to unbundle financial services", *Wall Street Journal*, 30 April.

10. Annex

Utilisation of the financial system (per cent)[1] Annex Table 1

	2011	2014	2017
G20 (20 economies)	**20**	**25**	**26**
Argentina	5	6	7
Brazil	8	12	12
Canada	37	45	47
Germany	34	38	37
Euro area	26	32	33
France	34	34	33
United Kingdom	28	37	41
Italy	10	24	31
Mexico	7	12	8
Russia	9	13	14
Saudi Arabia	10	14	13
Turkey	4	15	18
United States	35	39	46
South Africa	15	22	16
Australia[2]	39	42	41
China[2]	20	25	22
India[2]	10	10	13
Japan[2]	29	34	35
Korea[2]	32	35	36
Indonesia[2,3]	12	20	19
ACC (12 economies)	**26**	**29**	**29**
Hong Kong SAR[3]	25	29	30
New Zealand[3]	44	52	49
Malaysia[3]	23	27	25
Philippines[3]	13	13	11
Singapore[3]	34	30	41
Thailand[3]	31	28	27
ASEAN[4] (9 economies)	**26**	**29**	**29**
Cambodia	10	16	16
Lao PDR	19		13
Myanmar		14	14
Vietnam	12	17	18

[1] Simple average of the share of adults that saved money in a financial institution and the shares of adults that borrowed money from a financial institution. [2] ACC countries. [3] ASEAN countries. [4] Data for Brunei are not available.

Firm loan markets are also underdeveloped, with outsized dependence on collateral

In per cent of adults (age 15+) Annex Table 2

.	Percent of firms with bank account	Percent of firms with bank loan /line of credit	Percent of firms using banks to finance investments	Percent of loans requiring collateral	Value of collateral needed for a loan (percent of the loan amount)	Percent of firms identifying access to finance as major constraint
Global aggregate[2]	89	29	25	71	191	13
Advanced economies[3]	97	30	39	59	111	12
Emerging economies[3]	90	29	24	72	203	11
Developing economies[4]	76	21	16	88	235	28

[1] The numbers are averages of the latest available survey results from all economies in each group weighted by economies' GDP (constant 2010 US dollar) at year-end 2017. GDP numbers are from the World Bank. [2] All countries include 130 countries with latest available records on or after 2010 in the Survey database. [3] Refer to BIS classification (https://stats.bis.org/statx/srs/table/f1.2) for Advanced economies and Emerging market economies. [4] Developing economies refers to "low-income developing countries" according to IMF classification in Fiscal Monitor Reports: www.imf.org/en/Publications/FM/Issues/2021/03/29/fiscal-monitor-april-2021.

Sources: The World Bank Enterprise Survey under Finance Topic, www.enterprisesurveys.org/en/data/exploretopics/finance.

HKIMR Survey: Adoption of Technology/Innovations

(applied or plan to apply to a limited or full extent) Annex Table 3

	Retail	Foreign	Virtual
Big data/AL			
ML	89	68	100
Robo	83	53	88
RegTech	67	74	88
Mobile			
Digital Wallets	44	21	75
Mobile Bank	100	68	100
Distributed computing			
DLT	72	63	88
Cryptography			
Digital currencies	11	32	25
ID/authentication	94	68	88
Smart Contracts	72	47	88
Cloud, open API			
Cloud	94	63	100
Open APIs	100	53	100
Marketplace platforms			
Crowdfunding	11	0	38
Lending marketplaces	22	5	50
Savings/deposit marketplaces	33	16	50

Source: HKIMR, *Adoption and Innovation in the Hong Kong Banking Industry*, May 2020.

HKIMR Survey: Motivation for adoption of technology

Annex Table 4

Share of respondents (%)[1]	Retail	Foreign	Virtual Bank
Customer-related			
Increase customer base	100	63	100
Improve retention	100	79	100
Cost-related			
Reduce staff costs	56	58	75
Reduce overhead & rentals	39	32	75
Reduce compliance costs	56	58	88
Reduce credit costs	72	42	100
Improve efficiency	94	79	100
Revenue-related			
Expand product	94	53	100
Improve opportunities	89	58	100
Others			
Respond to increased competition	94	58	88
Cyber/IT security	94	68	100
Mitigate fraud	78	63	100
Revamp legacy	72	68	25

[1] Share of respondents reported "Important" or "Very important".

Source: HKIMR, *Adoption and Innovation in the Hong Kong Banking Industry*, May 2020.

HKIMR Survey: Banks' adoption status of fintech applications in specific financial services and operations[1]

Annex Table 5

	Retail	Foreign	Virtual
Financial services			
Savings/deposit account	100	73	100
Payment fund	94	75	100
FX transfer/remit	94	75	100
Personal finance	100	0	100
Mortgage loans	82	0	100
Corporate lending	81	57	100
Trade finance	94	81	100
Investment/wealth management	100	92	100
Brokerage	93	90	100
Cash & liquidity	88	57	50
Risk management	92	88	100
Custodian	79	73	50
Others			
Back office	94	89	100
Compliance	82	84	100
IT security	100	84	100

[1] Applied or plan to apply to a broad range or a limited number of financial technologies.

Source: HKIMR, *Adoption and Innovation in the Hong Kong Banking Industry*, May 2020.

Previous volumes in this series

No	Title	Issue date
BIS Papers No 119	Non-bank financial institutions and the functioning of government bond markets	November 2021
BIS Papers No 118	A taxonomy of sustainable finance taxonomies	October 2021
BIS Papers No 117	Fintech and the digital transformation of financial services: implications for market structure and public policy	July 2021
BIS Papers No 116	CBDCs beyond borders: results from a survey of central banks	June 2021
BIS Papers No 115	Multi-CBDC arrangements and the future of cross-border payments	March 2021
BIS Papers No 114	Ready, steady, go? – Results of the third BIS survey on central bank digital currency	January 2021
BIS Papers No 113	Financial market development, monetary policy and financial stability in emerging market economies	December 2020
BIS Papers No 112	The dawn of fintech in Latin America: landscape, prospects and challenges	November 2020
BIS Papers No 111	Inflation dynamics in Asia and the Pacific	March 2020
BIS Papers No 110	Measuring the effectiveness of macroprudential policies using supervisory bank-level data	February 2020
BIS Papers No 109	The digital economy and financial innovation	February 2020
BIS Papers No 108	Stress testing in Latin America: A comparison of approaches and methodologies	February 2020
BIS Papers No 107	Impending arrival – a sequel to the survey on central bank digital currency	January 2020
BIS Papers No 106	The design of digital financial infrastructure: lessons from India	December 2019
BIS Papers No 105	Foreign exchange reserves in Africa: benefits, costs and political economy considerations	October 2019
BIS Papers No 104	Reserve management and FX intervention	October 2019

All volumes are available on the BIS website (www.bis.org).