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RESEARCH REPORT

FINANCIAL TECHNOLOGY APPLICATIONS AND RELATED REGULATORY FRAMEWORK

CONTENTS

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SUMMARY

Financial technology, or Fintech, refers to financial innovations driven by technological advancement in the forms of new business models, new financial services, and new software and applications that have a great impact on the provision of financial services and the development of the financial industry. In the new era of Fintech, stock exchanges around the globe are actively exploring ways to perform system upgrades and service enhancements with Fintech. However, most of the existing Fintech applications are deployed in the industries of banking, Internet finance and digital currencies rather than the securities industry, in which only very few could come up with feasible plans based on specific securities business models. It is generally believed that blockchain and Artificial Intelligence (AI) technologies such as intelligent investment advisor (robo-advisor) would be the most applicable in the exchange market.

This report focuses on blockchain and AI applications in the securities industry and explores how these new technologies could be integrated in the areas of investment, trading, clearing and settlement, as well as regulation, with a view to find specific feasible applications of Fintech in the capital market. Practical examples are presented to illustrate the impacts and significance of Fintech in the capital market and securities trading. This report introduces examples of blockchain technology deployed in trading and clearing and settlement businesses, asset rehypothecation business and private equity market as well as the use of AI technology in intelligent/robo-investment research and advisory services. Each example compares the pros and cons of the new technology and the traditional business model, and the difficulties and challenges arising from the use of blockchain and AI technologies. Noteworthily, AI technologies in intelligent investment advisor and investment research are currently a key testing item in the "supervisory sandbox", and securities regulators in certain countries (e.g. Korea) have already established a dedicated testing environment. These international experience could be made reference to for considering the next step in the Hong Kong market.

This report also discusses the principles and tools in the establishment of the regulatory framework for the development of Fintech. As an emerging industry, Fintech-based business models have been evolving and becoming increasingly complicated. To a certain extent, the use of Fintech may not help reduce the inherent risks in the financial system but rather, may magnify or expose new forms of financial risk. Therefore, regulators should consider how to enable the application of Fintech innovations in the securities industry under an appropriate regulatory framework.

"Supervisory sandbox" is an effective tool for testing new financial technologies. A number of countries have been conducting "sandbox" testing on Fintech elements to different degrees. To minimize, in a controllable way, the potential negative impacts of new technology applications under uncertain regulations regulators could provide a regulatory sandbox testing environment with relatively loose regulations for pilot trials of Fintech applications. Once the risks and issues encountered in the trial have been eliminated or resolved, and that the protection of customers' interests and the smooth operation of the financial system are ensured, the Fintech could then be extended to a larger scope.

This report also discusses the consistency principle in financial regulation. The consistency principle means that financial businesses of the same nature should be subject to the same regulation. Financial services, be they offered in a virtual or real environment, should be governed by the same legal framework. This will ensure fair competition and prevent regulatory arbitrage. At the same time, the regulatory framework should also be continuously upgraded to keep in pace with Fintech developments, to avoid any possible regulatory loopholes.

Lastly, the report discusses the feasibility of using big data, deep learning and knowledge-graph to establish effective regulatory technology systems. It is essential for regulators to build an effective regulatory technology (Regtech) system, using big data and AI analysis to strengthen their ability to do macro-analysis of financial institutions and track systematic risks, in order to better monitor and prevent systemic financial risks.

1. CHARACTERISTICS OF TODAY'S FINTECH

1.1 Fintech's substitution of traditional financial institutions and its increasing impact

Financial technology, or Fintech, refers to financial innovations driven by technological advancement in the forms of new business models, new financial services, and new software and applications that have a great impact on the provision of financial services and the development of the financial industry.

Starting from the end of the 20th Century, Fintech has been thriving as an emerging industry, thanks to the in-depth development and application of information technology (IT) in financial services, the government and regulatory support for innovation, and the extensive involvement of non-traditional financial institutions and technology companies. Representative examples of Fintech applications include blockchain, big data, cloud computing, AI, robo advisors, smart contracts, e-money and online lending. These have profound impacts on the financial industry and people's life style. Theoretically, Fintech can substantially reduce transaction costs and asymmetric information, and is critical in the transformation of financial structures. Technological advancement addresses information asymmetry, improves intermediaries' matching of financers and financees and increases financial market liquidity. It also reduces transaction costs and expands market capacity. These two fundamental forces act together to drive more efficient financial resources allocation, resulting in drastic implications on the financial system.

The integration of technology and finance has undergone three stages:

Phase 1 is the financial IT stage. This was the stage of information digitalisation in the financial industry. Traditional IT was deployed to increase computer usage in offices and businesses. IT support, services and solutions (software and hardware) were usually provided by specialised vendors in IT terminals or services, or by financial IT integrated service providers. At this stage, IT companies did not participate in a financial company's businesses. The IT team was more a cost unit in the financial company. The application of technology was mainly in the areas of automated teller machines (ATM), point-of-sales (POS), and the core systems of banks for trading, credit and loans, and clearing. Technology was mainly used to improve business efficiency and to increase computerisation in the industry.

Phase 2 is the Internet finance stage. At this stage, discretionary combination and connectivity of different segments of financial businesses — asset management, transactions, payment and funding — have been achieved on the basis of the Internet or mobile devices. Internet finance is characterised by the pooling of users on online business platforms constructed by technology companies. It provides new and efficient channels outside traditional banks and the securities market to facilitate information sharing and business matching between financers and financees. This reduces transaction cost and expands the scope of financial services, thereby extending the benefits of advanced technology and financial services to small and micro-sized companies and the public. Internet finance can therefore be considered a beneficial complement to the traditional financial system.

Internet finance is developing rapidly in China, with the application mainly in fund sales on the Internet, online lending, Internet insurance and mobile payment. Fintech is seen to be gaining a foothold in the traditional financial areas of payment, insurance and financing, having both a competitive and a cooperative relationship with traditional financial institutions. Take for example peer-to-peer (P2P) online lending. In 2016, P2P transactions in China amounted to RMB 1,495.51 billion[1]. As for China's third-party payment, China's third-party mobile payment amounted to RMB 37.8 trillion in 2017Q4, up 195% year-on-year and 27.91% from the

[1] Source: iResearch. 《中國網路借貸行業研究報告》 (*Research report on online lending in China*), December 2017.

previous quarter[2]. In 2016, China's Internet insurance premium amounted to RMB 234.7 billion, with 117 Mainland Chinese insurers having introduced Internet insurance business[3].

Phase 3 is de facto integration of finance and technology. At this stage, Fintech focuses on the use of technologies like big data, cloud computing, AI and blockchain to change the traditional ways of collecting financial information, risk-pricing models, investment decision-making process and the traditional role of credit intermediaries. The result is a substantial improvement in the efficiency of finance and the resolution of problems of traditional finance.

Since 2014, the application of AI, big data and Distributed Ledger Technologies (DLT), especially blockchain, in the financial industry has been widely discussed. These technologies are quietly being adopted and explored across different sectors. For example, in Internet businesses, e-commerce can make precise product recommendations based on information related to clients' potential needs; tailor-made web pages with recommended news stories are being introduced by news applications; navigation software accurately predicts road conditions ahead and the estimated arrival time based on information from Global Positioning System (GPS) with a large user base.

However, the feasibility of Fintech application in certain detailed areas is still under technical debate, with few practical examples observed. Both the technology sector and the finance sector believe that along with the development of AI and big data, Fintech will move, in the next stage, from payment convenience and security towards human-machine interaction and automated and intelligence-based investment and financing. It may support or even substitute the work of financial practitioners.

The following sections will introduce how these technologies can be applied in the finance sector under different scenarios.

1.2 Traditional financial institutions' influence and bargaining power in Phase 3 of Fintech development

While Fintech's development is driven by technology in the financial IT and Internet finance phases led by technology companies, the momentum in Phase 3 may come from the traditional financial sector.

Internet or technology companies do not have a monopoly in technology in Phase 3. Traditional financial institutions can acquire or develop their own technology, which will no longer be exclusively possessed by Internet or technology companies. Moreover, Fintech innovation cannot demonstrate its value if it is not integrated with financial businesses. Fintech companies must therefore be well-versed with financial businesses for promoting financial innovation. In this phase, traditional financial institutions may have advantages over Internet finance companies in the implementation of Fintech, repositioning themselves with a change in business model and re-establishing new supremacy in the area.

Take the US as an example. The centre of Fintech development in the US began to shift from Silicon Valley to New York since 2016. The Wall Street grasps the most critical financial models required for Fintech revolution. Fintech must be backed by financial business models to manifest its value. In 2016, venture capital investment in Fintech was concentrated in New York, not Silicon Valley; major blockchain companies and similar organisations were established in New York, not Silicon Valley — more than 40 banks globally are members of

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[2] Source: Analysys.《中國第三方支付移動支付市場季度監測報告 2017 年第 4 季度》 *(Quarterly monitoring report of China's third-party mobile payment market 2017Q4)*, April 2018.

[3] Source: The Insurance Association of China.《2017 中國互聯網保險行業發展報告》*(Research report on Internet insurance in China 2017).*

the blockchain network, R3, in New York; and major leading Fintech companies were founded by Wall Street financial practitioners[4]. These reflect the greater role of traditional financial institutions in Fintech development at this stage in that they will turn from a defensive role to a more proactive role in the new financial system of an informational society in the future.

1.3 The key to maintain international Fintech competitiveness — R&D

In Phase 3 of Fintech development, i.e. the phase of intelligence finance, China is a world leader on par with the US and other developed countries in terms of Fintech application scenarios and number of users. According to the Fintech 100 Report 2016 by KPMG and H2 Ventures, five of the top 10 Fintech companies came from China, with Ant Financial at the top. Zhejiang University's Academy of Internet Finance recently published the Financial Technology Centre Index 2017, for which they analysed the Fintech industry and Fintech ecosystem of key Mainland cities. In a regional perspective three world-class Fintech hubs have emerged in China — the Pearl River Delta region (Hong Kong, Shenzhen and Guangdong), the Yangtze River Delta region (Shanghai, Hangzhou and Ningpo) and the region comprising Beijing, Tianjin and Hebei[5].

Having said that, R&D in Fintech still lags behind the application side in China. The IT framework basic modules, system combinations and other hardware and underlying technologies are still dominated in the hands of international companies in the US, Europe and Japan. China lacks core competitiveness in R&D and intellectual property of fundamental technologies. Fintech's future development in China will therefore focus on the use and mastery of digital currencies, blockchain, cloud computing, cloud storage, big data and robo investment. Deep mastery and research in technical models and their applications are not only the response to international competition, but also the pre-requisite for financial deepening. This is the only way to maintain the leading position of China in Fintech.

2. Current scenarios of Fintech application and business models

The core value of Fintech lies in its applicability to financial scenarios. The flourishing research in Fintech implies that Fintech will have drastic impact on traditional finance and will change the global financial landscape. The critical factor for financial institutions to fulfil the value of Fintech is whether or not they can integrate Fintech with their financial businesses, explore the application of new technologies and create business value under the new application scenarios.

In the new era of Fintech, stock exchanges around the globe are actively exploring ways to perform system upgrades and service enhancements with Fintech. However, most of the existing Fintech applications are deployed in the industries of banking, Internet finance and digital currencies rather than in the securities industry, in which only very few could come up with feasible plans based on specific securities business models. It is believed that among the various financial technologies, blockchain and AI technologies such as intelligent investment advisor would be the most applicable in the exchange market.

The following sections mainly discuss the current leading Fintech areas of blockchain and AI, investigate how these can be integrated with securities investment, trading, clearing and settlement, and identify specific application models for Fintech in the capital market. Practical examples are presented to illustrate the impacts and significance of Fintech in the capital market and securities trading.

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[4] Source: Xiao Feng.〈區塊鏈，讓價值互聯網露出曙光（國際視野）〉(“Blockchain shows value of Internet (international perspective) ”), *People's Daily*, 10 January 2017.

[5] Source:〈2017 金融科技中心指數發佈，中國金融科技呈現新格局〉 (“Financial Technology Center Index 2017 announced, showing a new development pattern of China's financial technology”), 中國金融信息網 (http://www.xinhua08.com/), 29 September 2017.

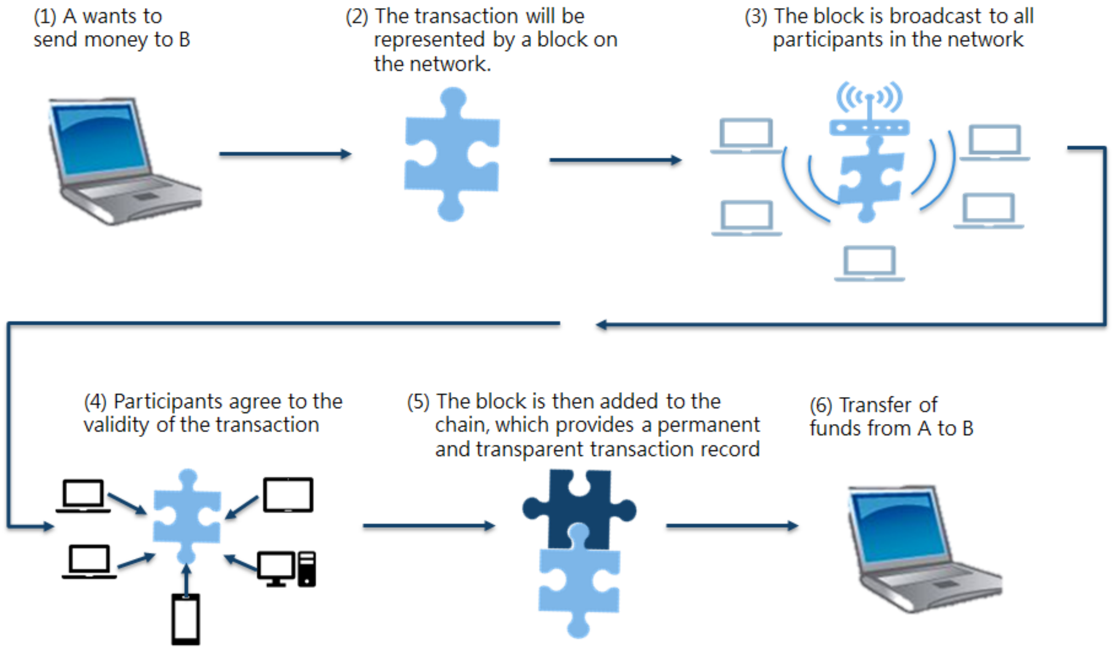
2.1 Application of blockchain in trading, clearing and settlement and the challenges

2.1.1 Basic principles of blockchain

Blockchain technology is a kind of DLT. Through network construction, distributed data storage, time sequence, irrevocable encrypted ledgers and a distributed consensus mechanism, blockchain can achieve network-wide record entry, joint verification, peer-to-peer transmission of values and decentralisation. Blockchain may be considered as a group-maintained shared ledger system, which holds a reliable record of transactions between any two participants. The transaction forms a block which is distributed to all nodes of the whole network, and all participating nodes jointly determine the authenticity of a record. Blockchain is an innovative Internet application of distributed storage, cryptography and consensus mechanism. It is distributed, irrevocable and extensible.

As shown in Figure 1, if A wants to send B a sum of money, the encryption algorithm will turn the transaction into a hash value in the form of a data code. It will become a data block after adding a time stamp, and will then be broadcast to participants in the network such as A's and B's common friends, colleagues, etc. Once these participants confirm the validity of the transaction, the data block will be added to the chain and permanently recorded. Both A and B cannot deny the transaction afterwards.

Figure 1. The basic process of blockchain



The existing business and social structures dictate that value creation and transfers require the credibility of a centralised system (e.g. government credit endorsement) and organisations (e.g. banks and payment entities). In blockchain, the digital signature by asymmetric cryptography safeguards the validity of a trading account, while "proof of work" ensures the integrity of record entry rights. With a digital signature, trade participants can activate a corresponding unique blockchain account to conduct transactions. Their transaction data is permanently stored on blockchain by a random third party of integrity. The chain of sequential records related to the transaction ensures that the transactions is traceable and no alteration can be made. Blockchain basically substitutes technological endorsement for centralised credibility and enables transactions to be completed point-to-point between any two nodes without a central platform. This significantly reduces data transmission error and improves transmission efficiency.

2.1.2 Three forms of blockchain

Blockchains can take the form of “public chains”, “private chains” and “consortium chains”. Private and consortium chains are also known as “generalised private chains”. The most famous public chain applications are Bitcoin and Ethereum.

Public chains are truly decentralised and distributed blockchains. Their participants are often anonymous, and each can write, read, and verify a transaction. The security of public chains is guaranteed by “proof of work” or “proof of stake”. Deployment of its applications is easy, allowing global access and no reliance on a single company or jurisdiction. As anyone can become a node in a public chain, every participant has a complete ledger and may review a transaction as necessary. As transaction data grows as time goes by, there is increasing demand for better system performance at each node. The larger the volume of data, the longer the time it takes to confirm a trade and the higher the maintenance costs to be borne by an individual, not being able to attain the required service level. For example, bitcoin transactions are now constrained by network transmission — the completion of a bitcoin transaction is subject to notification to the majority of nodes and their confirmation in the next record entry cycle (e.g. about 10 minutes for bitcoin).

Consortium chains are blockchains with characteristics between public and private chains. They are initiated by institutions and practise some form of decentralisation. Consortium chains have multiple centres. Participants are predetermined based on certain criteria, and the nodes to confirm a transaction are assigned in advance. Transactions are confirmed by consensus. Depending on the degree of trust within a consortium chain and the demand, a participant in a virtual digital currency transaction may choose to be anonymous or not. Consortium chains allow easy permission control setting. They are highly extensible and have a higher application value in clearing, settlement and auditing across industries and countries. Consortium chains lower the cost and time spent on trade settlement in another jurisdiction, and are therefore simpler and more efficient than existing systems. Monopolisation is also minimised due to decentralisation. Consortium chains, as an intermediate form of blockchain, reduce the cost of an individual’s participation as a node and facilitate the establishment and maintenance of the entire system. It has been, therefore, the key research focus of major financial institutions and technology companies. Examples of consortium chains include ChinaLedger in April 2016, and the alliance of 42 prominent banks formed by the Internet Fintech company, R3 CEV, at the end of 2015.

Private chains are featured with distributed ledgers without decentralisation. The controller of the centre determines who is eligible to participate and to confirm transactions (usually the internal units of a company). Members within a private chain are not rewarded with virtual currencies. The highest authority of a private chain lies at its centre. Private chains are of great value in auditing tests within a company or the government, and in transactions and settlement between banks within a consortium.

The networks in public chains is open and accessible to all and is not constrained by any participant. Data are stored in encrypted form in the public network and can be read by all participants. If exchanges adopt a public chain, participant A can know all trades to which B is a participant as long as A knows B’s identity code. This is not conducive to financial transactions which require anonymity. Furthermore, the huge amount of daily transactions and data at an exchange implies that an individual will need very powerful computing and storage facilities, and therefore will incur high costs, to perform the role of a node. This, together with the limited storage space for a single block, will increase the time lag in transaction recording and therefore affect transactions. Hence, public chains are not suitable for exchanges.

Generalised private chains employ proprietary networks and have greater control over participants. Although there is no complete decentralisation, they retain the features of distributed ledgers. Consortium chains, in particular, are jointly set up by several institutions. They have the characteristics in between public chains and private chains, and practise a certain degree of decentralisation. Consortium chains have multiple centres, pre-determining participants and transaction nodes which are confirmed by consensus. Permission is set according to a participant's characteristics and roles. A consortium chain with multiple centres is more applicable and extensible in financial businesses in practice. For example, members can easily change rules without having to consult the whole network provided that they have obtained the approval from the management team. As transactions are confirmed only among members, not involving other network users, costs can be kept at a lower level. Regulators also prefer private chains and consortium chains because of their non-anonymity. Therefore, generalised private chains are more suitable for applications in exchanges, especially for post-trade clearing and settlement.

2.1.3 Features of blockchain and their implications in business operations

First, blockchain is distributed and decentralised. Encrypted data is stored in a distributed manner in the server of each node of a blockchain. Each node stores a complete set of the general ledger, and can view all transaction data. Concurrent data update at all nodes is the most important "distributed mode" feature of blockchain. While traditional securities business models are often centralised with transactions conducted based on trust between the intermediaries, a distributed structure can perform peer-to-peer transactions, so that securities issuance, trading, clearing and settlement can proceed without an intermediary. Trade transparency and efficiency is therefore improved with reduced costs. **This characteristic is reflected in post-trade clearing and settlement, asset rehypothecation, and private equity issuance that are discussed in detail in Section 2.2 below.**

Second, blockchain is encrypted and tamper-proof. With cryptography and timestamp, each block proceeds strictly in chronological order. Such irreversibility in time ensures that any attempt to tamper with blockchain data will be easily traceable. The consensus mechanism safeguards the data codes and verifies their authenticity. Even if there are errors or tampering with an individual node, the authenticity of the entire blockchain ledger can be guaranteed given that the majority of nodes carry the same information. This feature resolves the traditional model's reliance on the trustworthiness of intermediaries, and prevents fake transactions. This feature has extensive applications in the financial market, as illustrated by examples in Section 2.2.

Third, blockchain is extensible and programmable. blockchain is an open source bottom-level technology based on which various kinds of extension, decentralisation and de-trust can be achieved. New entities may easily be added to a blockchain in the form of a node without affecting existing nodes. Preconditions of a transaction can be set through code programming, so that the transaction will be blocked automatically if it does not meet the preconditions. Programmable codes of blockchain, as known as smart contracts, can satisfy the complex demands in the financial market. In a traditional model, control mechanisms often could not detect and address risks in a timely manner. Smart contracts, on the other hand, can ensure early risk detection and risk control. Such feature is fully exemplified in the case of asset rehypothecation.

2.2 Examples of blockchain application

Technology applications should be able to resolve problems in the context of practical scenarios. The following discussion attempts to address the problems under the current securities business model and provide feasible solutions, utilising technical features of blockchain, in order to improve financial market efficiency.

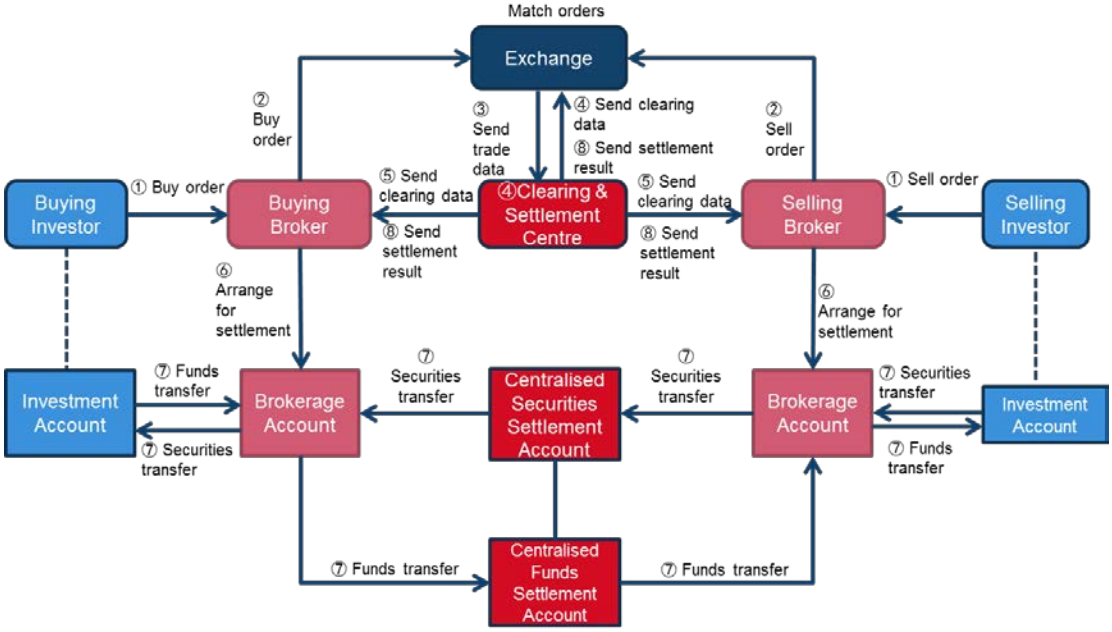
2.2.1 Case 1: Blockchain application in post-trade clearing and settlement

Clearing and settlement take place after a securities transaction in accordance with predetermined rules. The process includes the calculation of the amount of money and securities to be settled, and the transfer of these amounts between money accounts and securities accounts of the trade parties. Such process usually takes place after market close on the transaction day. Major participants in the process are the exchange, the central counterparty, the securities custodians and the central depository.

(1) Current-state issues in post-trade clearing and settlement

Firstly, given the relatively large number of participants and the relatively long cycle, clearing and settlement cannot be completed within a short time. In the traditional model, securities are traded through banks or securities companies and the exchange. Post-trade clearing and settlement is centralised at the clearing house and involve multiple layers of participants and accounts. Particularly if a securities market crosses regional boundaries, the communication and trade clearing and settlement processes will become even more complex. Secondly, data discrepancies, if any, in the clearing process at the clearing house will have to be resolved manually. Manual intervention has low efficiency and is subject to errors, given the high frequency of transactions and the huge volume of data. Thirdly, there are operational risk and default risk. System breakdown or potential manual errors would seriously affect normal clearing and settlement. Fourthly, the process incurs high costs as it involves third parties such as clearing houses and banks.

Figure 2. Current business model in trading, clearing and settlement



Notes:

① Investor places buy or sell order through a securities company.

② The securities company sends client's trade order to the exchange; the exchange does timely matching of orders and delivery of trade result to the securities company; Clearing is conducted after market close between clearing house and clearing participants (i.e. the securities companies) .

③ The exchange sends trade data to the clearing house which acts as the central counterparty (CCP).

④ All trades due for clearing on the day by each clearing participant (usually securities company) are netted by the clearing house (the CCP), resulting in a single net amount in cash and securities due to or from the participant. Taxes, commissions, dividends and interest are also included in netting. The CCP sends clearing data to the exchange which receives and verifies the data.

⑤ After clearing, the clearing house will send clearing results to the respective clearing participants (securities companies).

⑥ After reconciliation, clearing participants prepare securities or funds for settlement based on the clearing results. Cash payables are deposited into cash clearing accounts. Securities payables are deposited into securities accounts at the central securities depository (CSD). The CCP is informed accordingly.

⑦ Settlement takes place at the CCP. For a participant due to deliver securities, securities are transferred by the CCP from the participant's securities settlement account to the central securities settlement account at the CSD. For a participant due to receive securities, securities are transferred by the CCP from the central securities settlement account at the CSD to the participant's securities settlement account. For a participant due to deliver or receive funds, funds are transferred correspondingly.

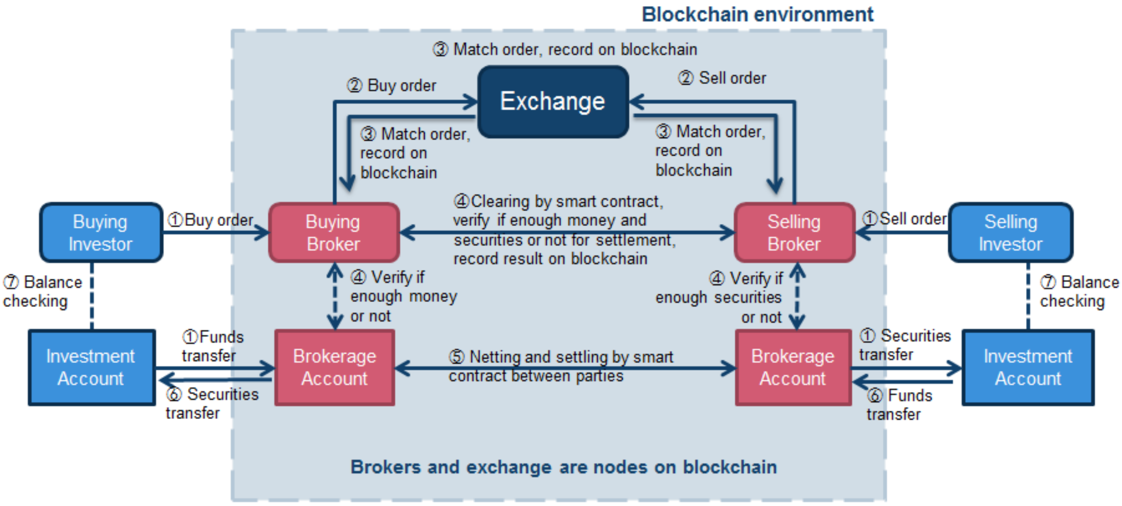
⑧ Settlement results are sent by the clearing house to participants and the exchange for participants' reconciliation.

⑨ Participants provide clients with account balance enquiry service and cash withdrawal service based on reconciliation results. The exchange can perform pre-trade monitoring based on the settlement results.

(2) Benefits of blockchain application in post-trade clearing and settlement

Firstly, blockchain technology enables clearing and settlement to be conducted upon the conclusion of a transaction, significantly reducing settlement time. Secondly, participants' consensus on the data on the blockchain enables rapid data processing and greatly improves settlement efficiency. Thirdly, automatic verification by smart contracts lowers default risk due to insufficient funds or securities. Smart contracts' automatic completion of funds and securities transfers also reduces manual errors. Fourthly, trade confirmation stored on blockchain enables investors to receive trade, clearing and settlement notifications in real time. Fifthly, under blockchain DLT model, all participants share and maintain the same ledger. Data encryption, timestamping, and data isolation ensures the tamper-proof quality of blockchain records (vis-à-vis the general ledger under a centralised model), lowering the maintenance cost to be borne by exchanges.

Figure 3. Blockchain-based model for securities trading, clearing and settlement



Notes:

The exchange and all settlement participants (securities companies) are nodes on the blockchain and form a consortium chain. As with traditional model, the exchange matches and confirms trades in real time and the clearing and settlement process then commences.

① Through the securities company, investor deposits funds and places buy order (funds will be locked in broker account) or sell order (securities held by the investor will be locked by the securities company).

② The securities company sends client's trade order to the exchange.

③ The exchange matches trade orders and uploads successful trade data (time, counterparty, securities name, volume, amount, etc.) within a period to blockchain which is disseminated to all nodes. Clearing and settlement starts after data uploading.

④ Smart contract calculates taxes, commissions, dividends and interest, and verifies the sufficiency of funds or securities in real time based on the trader's account records on the chain. If verification is successful, the trade will proceed and trade data will be written on the blockchain. Otherwise, the trade will fail.

⑤ Upon successful verification, smart contract nets all trades between the nodes, performs real-time transfer of securities and funds between the participants, and stores the records on the blockchain for verification of subsequent trades.

⑥ The securities company performs second-level settlement by transferring funds or securities due to an individual investor from the broker account to the individual's account.

⑦ Clearing participants provide clients with account balance enquiry service. Investors can withdraw the cash balance.

(3) Technical, business and regulatory challenges of blockchain application in securities clearing and settlement

First are the technical issues. One issue is that trade confirmation on the blockchain may take a long time as a transaction has to be transmitted to other nodes for verification. The bitcoin system targets to generate a data block in 10 minutes, but confirmation of a bitcoin transaction takes 60 minutes (the time for generating 6 blocks). An ethereum platform, in contrast, targets to confirm a transaction in 12 seconds. The second issue is trade throughput. Each bitcoin transaction, for example, has on average 250 bytes, and each bitcoin block has a size of 1 megabyte (MB). That means one bitcoin block can hold 4,000 bitcoin transactions. If one block is generated every 10 minutes, 24,000 transactions are stored in an hour. Such a speed cannot satisfy the centralised and high-volume trades executed at an exchange, particularly high-frequency trades. These two technical issues must be carefully considered when securities transactions are to be cleared and settled in real time using blockchain.

Although the “consensus mechanism” newly emerged can shorten trade confirmation time to seconds, and “flash network” technology can process a million trades per second, further innovation is still required for practical application.

Second are the business considerations. Securities exchanges often have controlling ownership in clearing houses, with their main source of income and profit from securities clearing and settlement. Once blockchain is used to clear and settle securities transactions, the income model of exchanges will change accordingly. In addition, trading data is stored in nodes of the blockchain and no longer owned by a single party. This may require the regulators to adopt different ways to regulate the business.

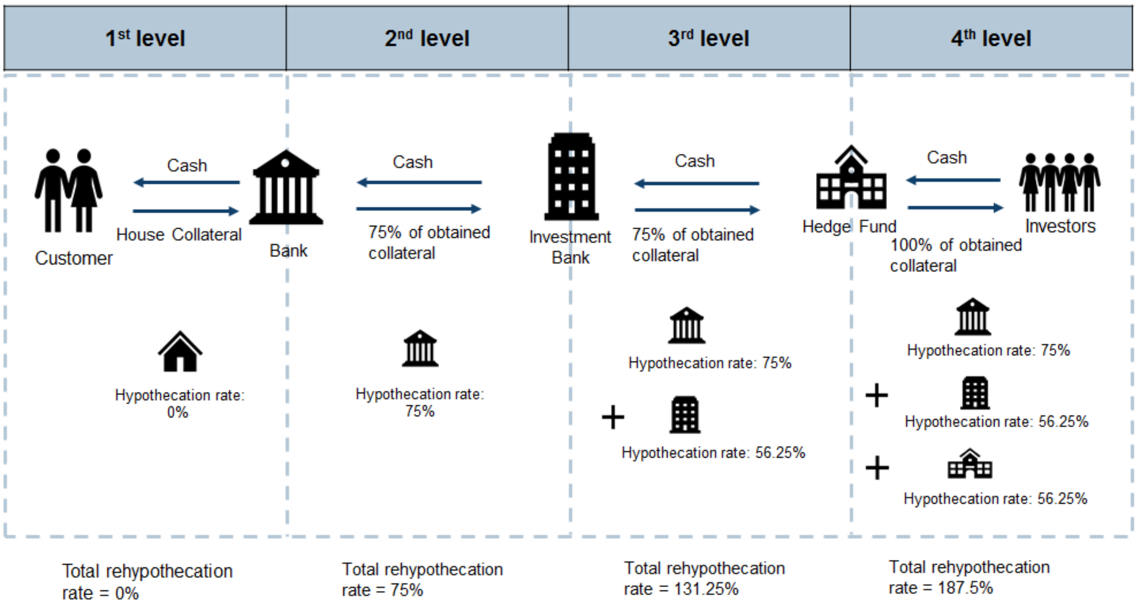
Third are the regulatory issues. Related laws and regulatory mechanisms governing blockchain are not kept in pace with the technology. This leads to inadequate regulation and legal protection for blockchain-related economic activities and increases risks for participation. In terms of data protection, financial transactions and account data are considered sensitive information by all countries. Under a blockchain-based clearing system, each securities company is a node. If bitcoin’s transparent model is adopted, there may be regulatory concerns about privacy protection and data leakage. Technological advancement such as the emergence of “quantum computing” will set off an explosive growth in computing power which may trigger some forceful attacks on blockchain-encrypted data and result in the collapse of blockchain systems. The potential financial risks arising from such data security issues would arouse special concerns of market regulators.

2.2.2 Case 2: Blockchain application in asset rehypothecation

The rehypothecation of repackaged mortgage claims by financial institutions is a common market practice. Securitisation of mortgage claims for re-sale reduces the financial costs and risks of financial institutions. As securitised packaged mortgage claims are abundant and their historical transaction records are often incomplete, tracking of the ownership of the underlying assets by traditional methods as well as accurate credit assessment are difficult. This increases the uncertainties in counterparty risk assessment and asset valuation. In addition, without a transaction trail for securitised assets, it is almost impossible for regulators to control the leverage ratio of the underlying assets or implement other risk control and regulatory measures. This may eventually lead to crises and financial turbulence.

The 2008 financial crisis broken out in the US is a typical example. Subprime mortgage loans were prevalent in the US before 2007. The emergence of various rehypothecated asset securitisation products on such loans further and further increased the leverage ratio of the underlying assets. As the underlying assets were repeatedly rehypothecated, restructured and repackaged, it was difficult for financial institutions to price them reasonably, and regulatory authorities could not keep track of the actual leverage ratios and control the risks. In the end, borrowers defaulted on their loans and the bubble burst. A subprime mortgage crisis erupted resulting in widespread financial crisis.

Figure 4. Traditional process of asset rehypothecation



Notes:

① Housing buyer applies to Bank A for mortgage loan. To be eligible for the prime rate, Bank A is authorised to rehypothecate the house collateral.

② Bank A packages 75% of the house collateral together with other similar collateral for securitisation, and sells the securitised assets to Investment Bank B.

③ Investment Bank B repackages 75% of the purchased collateral into a new asset pack and sells it to Hedge Fund C.

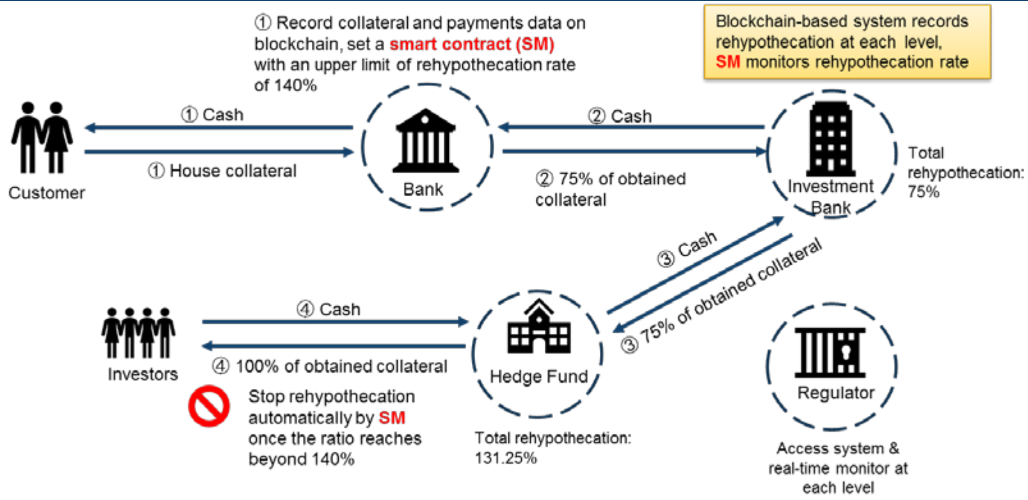
④ Hedge Fund C repackages the collateral and sells it to investors over the counter.

Remark: Total rehypothecation rate increases upon each repackaging and sale of the underlying collateral. In this example, the total rehypothecation rate increases by 187.5% after repeated rehypothecation.

(1) Current-state issues in asset rehypothecation

First is the lack of regulatory reporting. In the example illustrated in Figure 4, after layers of repackaging and re-sale, the regulatory report submitted by the hedge fund often includes only the preceding layer of asset transaction. Historical transaction details such as purchase prices, dates, original owners of the claims are difficult to trace. Second are the counterparty risks. Investors lack the knowledge about additional counterparties with ownership claims to the asset. If a default on the asset results in a lawsuit, the claims on the asset's ownership will give rise to new problems. Third is the lack of transparency. Regulators can neither trace the rights to the underlying assets nor know the leverage ratio of the underlying assets so that it might impose controls when the ratio reaches an alert level. It is also impossible for investors to know in time whether the underlying debts are being repaid normally or a default has taken place. Fourthly, valuation and pricing are difficult. As historical transaction details of the underlying assets are not available, it is difficult to reasonably assess the true values and risks of the assets after several times of rehypothecation, repackaging and restructuring. Fifth are the systemic risks. Default by one party in the whole process will affect subsequent participants and may lead to unexpected outcomes that have impacts on the whole financial system. The US subprime mortgage crisis in 2008 has, for example, caused turbulences in the whole financial system.

Figure 5. Blockchain application in asset rehypothecation



Notes:

Key participants of asset securitisation and rehypothecation will become nodes of the blockchain. In this example, they are Bank A, Investment Bank B, Hedge Fund C And Regulator. Data about the first-time pledging, subsequent transactions, repackaging and restructuring and are all uploaded onto the chain.

① Housing buyer applies to Bank A for mortgage loan. To be eligible for the prime rate, Bank A is authorised to rehypothecate the house collateral. Bank A records the mortgage on blockchain and generates a smart contract as required by Regulator. The rehypothecation rate is set at a maximum of 140%.

② Bank A packages 75% of the house collateral together with other similar collateral for securitisation, and sells the securitised assets to Investment Bank B. To do so, Bank A has to upload the transaction details to blockchain for smart contract approval. The rehypothecation rate calculated by the smart contract is 75%. As the rate is lower than the preset rehypothecation ceiling, the transaction is approved.

③ Investment Bank B repackages 75% of the purchased collateral into a new asset pack and sells it to Hedge Fund C. To do so, Investment Bank B has to upload the transaction details to blockchain for smart contract approval. Total rehypothecation rate calculated by the smart contract as a result of the transaction will rise to 131.25%. Since conditions are satisfied, the transaction is approved.

④ Hedge Fund C repackages the collateral and sells it to investors over the counter. Hedge Fund C has to upload details to blockchain for smart contract approval. Total rehypothecation rate calculated by the smart contract as a result of the transaction will rise to 187.5%. The transaction is automatically terminated.

(2) Benefits of blockchain application in asset rehypothecation

Firstly, the use of blockchain will increase the transparency of asset rehypothecation. Investors can review an underlying asset's value as collateral, risk rating, and ownership history, etc., and make investment decisions accordingly. If there is any default on an asset, investors will know it quickly and can re-evaluate the asset. Secondly, automated regulation is made possible. Regulators can maintain better tamper-proof historical transactions and rehypothecation records. Smart contracts ensure asset rehypothecation does not exceed the regulatory ceiling, satisfying to the fullest extent see-through audit and regulatory requirements, and lowering the costs in processing and supervision. Thirdly, when regulators enforce rules and increase trade transparency by using blockchain technology, the impact of default risks on the financial market will be greatly reduced and financial stability will be enhanced. Fourthly, smart contracts significantly reduce the time and cost of due diligence investigation of the underlying assets.

(3) Challenges of blockchain application in asset rehypothecation

The application of blockchain in asset rehypothecation faces no challenges technically. However, the acceptance of blockchain by financial institutions and regulators for use in asset rehypothecation and the market regulatory regime may face some adaptation difficulties. For example, the methods used by financial insititutions to measure mortgage loans are currently not standardised. Different risk measurement methods and standards are being used. Standardised rules and regulations are yet to be developed by financial insititutions and regulators together. Consortiums of financial institutions and participants also need to be established.

From a regulatory respective, how to establish such a blockchain ecosystem, what financial insititutions should be involved and the admission criteria and thresholds are all required to be formulated. Legal ownership and other legal issues involved in the use of blockchain in asset rehypothecation must also be sorted out.

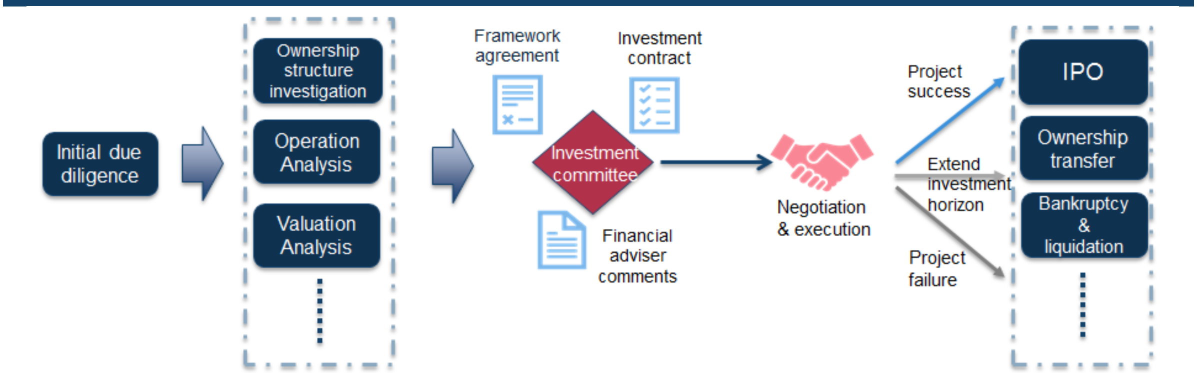
2.2.3 Case 3: Blockchain application in the private equity market

Blockchain's biggest merit is its ability to provide a tamper-proof record and a permanent data chain to users. These characteristics precisely address market concerns in private equity investment.

(1) Current state issues in the private equity market

Under the current business model, a target start-up company is first subject to due diligence investigation and valuation analysis before it is reviewed by the investment committee for finalisation of the private equity investment plan. Upon conclusion of the transaction, the private equity firm has to manage the investment and consider the exit plan. Due to their uniqueness, there is no credit intermediary to register private equity transactions. Equity changes and shareholder information are therefore not fully recorded or confirmed through authoritative and simple e-certificates on equity ownership. Each transaction entails lengthy documentation review to trace the validity and authenticity.

Figure 6 Current-state process in the private equity market



During the process of private equity investment or transaction, the lack of transparency in equity ownership information and the strictly confidential valuation adjustment provisions in the financing contract often give rise to information asymmetry and potential frauds. This makes it difficult for investors to fully understand the risks involved based on which to make rational valuation and pricing. These provisions also create asymmetry between the financer and the financee in execution. In the end, when the enterprise finally goes for an initial public offer (IPO) which requires due diligence checks on all the historical equity ownership transfer records, the current administration model would delay the auditing and reviewing process and ultimately affect the IPO progress.

(2) Benefits of blockchain application in private equity registration

Decentralisation, encryption and confirmation by consensus are features of blockchain that can link up the private equity market (which has no credit intermediary), facilitate the issuance of private equity e-certificates by startup companies and increase the transparency of equity transaction information. The use of blockchain-based smart contracts to compile valuation adjustment provisions also helps the implementation of such provisions. Within the blockchain-based system, when a startup meets additional financing conditions, the smart contract will automatically transfer extra investment funding from the investor's account to the financee's account. Otherwise, if a startup fails to meet additional financing conditions, the smart contract will automatically transfer some of the founder's shares to the investor.

Nasdaq Linq, a private equity platform launched jointly by the US exchange, Nasdaq, and blockchain startup, Chain, in 2015 is one example based on blockchain technology. Startups selling private equities can inquire on the system about the issuance of share certificates to investors, the validity of the certificates and other information (e.g. asset serial number and price per share). They can also search for certificates interactively and view the most recent certificates or find out who are the investors holding the most shares in the company. Startups can also assess shares held by a single investor in the company. Blockchain technology can improve the efficiency of private equity transaction, with immediate pose-trade clearing and settlement. It can also increase private equity market transparency and boosts the vibrancy and liquidity of the primary market.

(3) Legal and technical challenges of blockchain application in private equity market

Technically, blockchain can achieve decentralisation in private equity issuance and trading. However,from a legal compliance perspective, e-certificates of ownership generated by equity transactions on blockchain need to be approved by regulators as well as legal departments. To recognise equity rights and other corporate operations, regulators may need the help of multiple centres to enable related authoritative entities to participate in the blockchain for exercising their respective responsibilities and at the same time to enable information transparency and timely sharing.

If blockchain is to be deployed right away in the securities industry on a large scale, there are yet significant risk concerns. As each node has a ledger of the whole chain, any successful hacking will not only expose data of the hacked node to theft but also expose all data in the full ledger to potential replication. The one-way hash encryption technology being used is also at risk of being cracked as technology advances. Moreover, blockchain technology is still in a developing stage and would have technical defects. A typical example is the previous case of bitcoins being stolen on a bitcoin trading platform, which exposed the technical defects of blockchain, including smart contract programming vulnerabilities, trading system vulnerabilities, and record system vulnerabilities.

2.3 Main scenarios of AI application in the capital market

Although robo-advisors and robo-investment research are mainly deployed in securities investment and currently have no direct business implications on the exchange businesses, they are the major testing products in supervisory sandboxes of various countries. Some securities regulatory institutions (e.g. in Korea) have specifically designed a testing environment for AI applications. Such overseas practices may be of reference to Hong Kong for its next steps. This section discusses the principles and development of the AI technologies of robo-advisors and robo-investment research, so as to provide the technical background for associated regulatory policy changes in the securities market.

2.3.1 Application of AI technologies in robo-investment research

(1) Scenarios of application and specific models

Robo-investment research technology utilises machine learning and big data mining system to analyse massive historical data and natural language processing technologies to perform rapid real-time market analysis of specific events, and present the results in the form of knowledge graphs. For example, valuation of a listed company can be done by AI technology — models built by major sell-side analysts are analysed to find out the logics behind data relationships and establish its own model automatically.

The robo-investment research system, Warren, developed by Kensho in the US was the earliest AI application in robo-investment research using relatively mature AI technology. Warren can analyse the impacts of economic reports, monetary policies and political events, etc. on financial assets. It can search 90,000 pieces of behavioural data and provide answers to more than 65 million combo questions in real time [6]。

Warren performs its role as a robo-investment researcher in the following way: Direct questions may be raised to Warren, like “Which infrastructure company will see the biggest gain in share price when a category 3 hurricane hits Florida?” or “Which supplier will see the biggest gain in share price when Apple releases a new iPad?”. Keywords are extracted from the question using natural-language processing technologies for the computer to identify and recognise information from oral, unstructured text in a logical way. The program will then use big-data technologies to search in the global event database established from big data and market information collected. MapReduce, for example, can distribute massive data to cloud server clusters for analysis. BigTable, another example, can store large amounts of data in distributed databases and perform quick searches to find out the correlation between the inquired event and the price trend of related products. In the end, a model on the market impact of the event will be presented in real time using knowledge graphs. Users can enhance the impact model through adjusting the time range, the target company and other variables, and get an answer to the question “which stock will see the biggest gain in share price”.

(2) Competitive edge and constraints of robo-investment research relative to traditional technologies

By using robo-investment research, financial companies can save much manpower costs in data collection and analysis, and can focus their team efforts on identifying new investment strategies and their execution. To the market, robo-investment research can theoretically enable asset prices to reflect all available information and decisions more quickly and to a larger extent, i.e. more rapid price response to new information. The result would be a significant change in investment behaviour in modern finance.

While robo-investment research can perform more comprehensive and detailed data collection, and provide graphical presentations, it cannot generate an advanced thinking model for, say, a deep understanding of the cause-and-effect logic between

[6] Source: “Can Kensho Bring Google Style Search To Stock Picking?”, *Forbes*. 7 May 2014.

incidents and assets and the correlation between variables. Therefore, it cannot provide fully automated financial analysis. For a long time to come, it will still be unable to replace a human analyst.

Hence, **in the long-run, robo-investment research and human financial analysts will be complementary and not competitors to each other.** From the prespective of the integration of business and technology, the use of robo-investment research can substantially release the productivity of financial analysts. With model-based training, robo-investment research systems can be tuned to extract information accurately and quickly, thereby improving the efficiency of investment research with AI technologies.

2.3.2 Application of AI in the field of robo-advice

Robo-advisors build data models and back-end algorithms by using AI technology based on algorithms from asset portfolio theories. By providing intelligent and automated asset allocation recommendations to investors, they are able to offer wealth management services that are offered traditionally by human advisers. Unlike traditional quantitative trading, robo-advisors are machine-assisted to provide investment models. At present, robo-advisors mainly target ETFs for investment. Through dynamic allocation of different ETFs, more diversified allocation of assets can be achieved in investment portfolios.

(1) Applications of robo-advisor

Robo-advisors first came into being in the US. Wealthfront is one of the earliest and more well-established robo-advisors. It provides the general public with wealth management advisory service comparable to those offered by traditional consultants but at lower admission requirements and lower cost. Supported mainly by computing models, AI and big-data technology, the company provides robo-advisor service, with tailor-made investment recommendations at reduced operating costs, to clients who have completed risk assessment questionnaires.

(2) Current bottlenecks in the development of robo-advisors

Machine-based models are often used by robo-advisors to increase diversification and provide passive and undifferentiated asset allocation strategies. The benefits are low entry requirements and low costs. The entry point for traditional private wealth management is generally US$1 million, at a fee rate of 1% or above. The entry point for a membership at Wealthfront is only US$5,000, at a fee rate of only 0.25%[7]. The downside is that, while robo-advisors lower the entry requirements for ordinary investors, their investment targets and strategies are similar to each other's, and investment returns are not outstanding.

In the light of this, an integrated human-machines model is on the rise. Betterment, for example, launched "Betterment Plus" and "Betterment Premium" in January 2017, which use the human-machine model to offer wealth management services. The robo-advisor product BiRobot3.0 released by Hundsun Electronics in June 2017 put emphasis on stand-by human advisers ("automated wealth management + robo-advisors + human advisers + fund management strategies").

[7] Source: "How much does Wealthfront charge for its service?", Wealthfront website.

(3) National features of the robo-advisor industry

In the US, individuals' demand for assistance in investment decision-making is the biggest driver of the robo-advisor industry. US people are highly receptive to passive investment, and the US ETF market is well established, providing a rich variety of investment targets for robo-advisors. Robo-advisors' low management fees and tax liabilities help increase investors' expected returns. Given this, traditional leading financial houses launched their own robo-advisors. Examples are Charles Schwab's Robo Intelligent Portfolios, Fidelity's Robo Fidelity Go and securities broker TD Ameritrade's Robo Essential Portfolios. ETrade's robo-advisor has also incorporated a decision-making mechanism of professionals. The statistics company, Statista, projected that assets under management by US robo-advisors would reach US$266.1 billion in 2018 and US$576.5 billion in 2022[8].

In Mainland China, the robo-advisor industry needs to develop its own business model based on local circumstances. Unlike the US, Mainland people do not have personal pension accounts. Their social security funds cannot be invested as they wish and are not operated under market demands and a legal framework as those in the US. However, a considerable amount of wealth has been accumulated in the hands of the Mainland people ever since China's economic reform and market opening up. At the end of 2016, assets investible by Mainland individuals reached RMB118 trillion[9]. Middle-class and affluent Mainland people now invest more for the sake of financial security, younger generations, children's education and personal development than for obtaining investment returns. Mainland robo-advisors therefore have to develop more diversified and detailed services to satisfy various asset management needs.

Mainland robo-advisors are currently in their infancy. As the different classes of financial instruments are not yet well established in the Mainland, it is unable to form investment portfolios in the Mainland financial market based on modern investment portfolio theories. Besides, Mainland investors are predominantly retail-type and do not have the mindset to invest in the long term and diversify their asset allocation as their overseas counterparts in developed markets. The Mainland is still exploring how to make good use of robo-advisors.

Insurers, banks, securities companies and funds with client resources could be the primary driver of robo-advisors in the Mainland. For example, China Merchants Bank launched the Mainland's first robo-advisor product, "Machine Gene Investment", at the end of 2016 to recommend investment portfolios of public funds; GF Securities launched "Beta Niu" to recommend customised A-share investment plans based on fund size and risk appetite, and execution strategies based on market information; Minsheng Securities and Pintec's subsidiary, Xuanji, have announced a joint plan to develop a digital asset allocation system. Statista data shows that assets under management by Mainland robo-advisors reached US$28.8 billion in 2017 and would reach US$665 billion in 2022[10]. The room for development is substantial.

3. DEVELOPMENT OF FINTECH REGULATORY FRAMEWORK AND TOOLS

With the rapid development in Fintech technologies of AI, blockchain, big data, and cloud computing, Fintech is undoubtedly fast changing the ecosystem of the financial industry, and financial innovation is now an irreversible trend. However, Fintech business application

8 Source: Statista website.

9 Source: Wind database.

10 Source: Statista website.

models are very diverse and have become more and more sophisticated. Along with enhanced operational efficiency, they also bring along many uncertainties and risks. Issues like financial risks and mis-matched regulations have gradually emerged. The use of Fintech may not help reduce the inherent risks in the financial system but rather, may magnify or expose new forms of financial risk. Therefore, regulators and participants need to have a deep understanding of the nature of Fintech and to take consideration, in multiple dimensions, of the application scope of Fintech.

To a certain extent, Fintech may amplify the inherent risks of the financial sector, mainly in the following areas:

Firstly, Fintech may amplify the high-leverage characteristic of finance. Take third-party payment as an example. Online payment institutions generally have a higher leverage than traditional banks. Therefore, capital adequacy will be a tough issue for Fintech companies, particularly for those actually undertaking financial risks. Secondly, Fintech innovations are prone to incur compliance risks and operational risks. Fintech companies often race to launch products earlier than peers to achieve the critical mass required for network effect. Their trial-and-error mode of innovation pushes immature products to the market. Network effects tend to turn small risks into bigger risks, causing substantial financial losses and resulting in operational risks and compliance issues. Thirdly, the externalities of Fintech can be a "black swan" causing systemic financial risks. Once a Fintech company achieves a critical mass, the leading company will rapidly become "systemically-important" institution or even monopolise the market. These "too-big-to fall" companies would threaten financial stability.

How to strike a balance between innovation and risk prevention and control is the biggest issue faced by Fintech. Exchanges, as one of the securities regulators, have to consider how to apply technology and business model innovations to the securities industry in a controllable manner. With reference to international regulatory experience, regulators and exchanges may consider the principles and tools set out in Sections 3.1 to 3.3 below in constructing their Fintech regulatory framework.

3.1 Deploying "supervisory sandbox" to encourage Fintech innovations with effective risk prevention and control

As stated above, the progress of Fintech regulation varies across countries. The primary consideration focuses currently on regulating Fintech in financing and third-party payment. The implications of digital currencies and blockchain technologies, and their application in different financial sectors are still being explored. Due to the openness and high-tech characteristics of Fintech, financial risks, in particular IT system risks and operational risks, are more difficult to detect, and potential systemic and cyclical risks have become more complex. "Supervisory sandbox" is an effective tool to facilitate the application of Fintech.

3.1.1 Testing various Fintech projects in "sandboxes"[11]

A "Fintech Supervisory Sandbox" (FSS) refers to the flexible supervisory arrangement adopted by financial regulators to allow authorised financial institutions or technology start-ups to conduct live tests of new financial products, financial models and business procedures for a given period of time within a confined scope to promote financial innovation and Fintech development. Admission requirements are lowered and regulatory restrictions are relaxed for pilot trials in the sandbox.

[11] Information on the practices of FSS in various countries described in this section was obtained from the official websites of the relevant authorities, including the UK Financial Conduct Authority and the Hong Kong Monetary Authority.

The Financial Conduct Authority of the United Kingdom has been at the forefront in promoting blockchain development. It was the first regulator in the world to introduce FSS in the regulation of blockchain technology. In 2015, 18 companies participated in the first pilot trial, covering the areas of blockchain technology, electronic payment and investment platforms. In July 2016, the participant base was extended to 31 companies, including traditional financial institutions such as HSBC and start-ups like BitX which mainly deal with cross-border payment via blockchain. Blockchain tests conducted in the UK's FSS include: the effectiveness of using decentralised digital currencies for remittance; the remittance of funds from a developed market to an emerging market through licensed remittance companies; monitoring the price, speed and transparency of bitcoin transactions, etc.

The FSS initiated in the UK provides regulatory testing ground for new business models of the financial industry. Since its initiation, FSS has been adopted and developed to different degrees in Singapore, Australia, the US, Hong Kong, Malaysia, Switzerland, Thailand and United Arab Emirates. So far, various tests have been conducted in different countries/regions on products of different scopes and objectives. These include tests on blockchain applications under different scenarios, risk management for P2P online lending, robo-advisor designs, the security and stability of algorithmic trading, "investor suitability" in wealth management platforms, and the security of biometric identity etc. For example, Hong Kong's FSS tests covered biometric identification technology, identity authentication, securities trading, Application Programming Interface (API) services, blockchain, chatbots and other financial solutions. Korea's FSS focuses on robo-advisors — in the first batch of FSS tests launched between September 2016 and April 2017, 35 robo-advisors of financial institutions and Fintech companies were tested. In Australia, stock trading applications were tested in FSS.

3.1.2 Accelerating the extension of supervisory sandboxes to non-banking sector and facilitating technology innovations among securities industry

Currently, most market regulators around the globe are accommodating in regulating financial innovations. Given that FSS is timely and flexible in making regulatory response to market innovations, it can encourage Fintech innovations and minimize the negative impact of regulatory uncertainties with effective risk prevention and control. It is therefore the most suitable regulatory tool for Fintech.

Although sandbox has an extensive scope of application, global market practices show that sandbox tests are still taken up mainly in the banking industry where risk control is the strongest. Regulators may allow sandbox trials firstly in the banking industry, providing a simulated live market with an easy regulatory environment. They may also narrow the scope of the eligible testing entities to further reduce potential risks and problems. When the financial regulatory framework and coordination mechanism are further enhanced, the use of FSS could be extended to a larger scope, covering more the securities and insurance industries and other financial institutions to promote Fintech development, provided that the interests of customers and the steady operation of the financial system are ensured.

3.2 Emphasizing regulatory consistency and integrally evaluating Fintech's systemic risks

3.2.1 Incorporating Fintech innovations into existing regulatory frameworks according to the characteristics of different Fintech areas[12]

Fintech is commonly seen as the integration of traditional finance with technology. The key value of technology lies in the upgrade of delivery channels rather than the nature and content of the financial products. Hence, Fintech does not alter the nature of financial risks. The current regulatory principles and philosophies governing financial payments, financial product marketing and sales, financing and the investment sector remain applicable to Fintech. **The common international practice is therefore to incorporate Fintech into existing regulatory frameworks without changing the basic regulatory principles.**

P2P is viewed as a kind of securities business in the US, and, along with crowdfunding, is governed under the same regulatory framework for the securities market, which assesses and controls its process of credit registration and quota enforcement. The European Union (EU) and the UK have formulated specific regulations on both crowdfunding and P2P with clear definitions and regulatory requirements for the institutions involved — P2P and crowdfunding are regulated by the Financial Conduct Authority in the UK; Germany and France treat P2P lending as banking business to be governed by the same banking regulations, and require the Internet financial institutions that provide credit services to obtain a traditional lender licence. The EU and the UK emphasize more on micro-prudential management in regulating the business entities than the US. For example, the UK has specified the prudential regulatory benchmarks like minimum capital requirements for P2P online lending and crowdfunding, and requires investment-related crowdfunding to join its Financial Services Compensation Scheme which is similar to the financial safety net for commercial banks.

Third-party payment is considered similar to bill payment service and saving cards from the perspective of internal audit in the US. By depositing money in a third-party payment agency, a user can pay another party with the money deposited or withdraw the money by request. Therefore, third-party payment satisfies the definition of “receiving money or a monetary value for the purpose of providing transfer services”, and is defined in the scope of money transfer services and subject to the same regulations on other non-banking payment instrument issuers. The EU applies the same regulations on quasi financial institutions to third-party payment. The EU states clearly that electronic payment providers must be banks, and if not, they must obtain relevant banking licenses in order to offer third-party payment services. The EU also requires that prepayments in third-party payment platforms must be held in their special accounts opened with the central banks and must not be used for other purposes.

In respect of digital currencies, each country sets out different regulatory targets and methods based on their different interpretation of digital currencies. For example, the New York State Department of Financial Services in the US tends to treat digital currencies as assets and regulates the commercial activities based on digital currencies similar to regulating financial institutions — financial institutions operating digital currencies are required to fulfill consumer protection, anti-money laundering and other obligations. The EU and the UK focus on regulating the issuers of digital currencies. In its Electronic Money Directive and Payment Service Directive, the EU treats issuers of digital currencies as one kind of payment service providers and includes them into the same regulatory framework as for other payment service providers. Overall speaking, digital currencies are subject to

[12] Information on the regulatory practices in various countries described in this section was obtained from the official websites of the relevant authorities and working papers from Bank for International Settlements, including “FinTech credit: Market structure, business models and financial stability implications”, May 2017.

anti-money laundering regulations in most countries in order to reduce the negative impacts of digital currencies on the existing financial system.

3.2.2 Applying the same principles onto both real and virtual financial services to prevent regulatory arbitrage

As the innovation level and maturity of service differs among Fintech applications, each country decides on the applicable laws and regulatory bodies based on the nature of the Fintech products and services. Despite the difference in Fintech regulations among countries, the principle of consistency generally applies, i.e. financial services with the same nature are subject to the same regulations under the existing legal framework, so as to maintain fair competition, ensure regulatory effectiveness and prevent regulatory arbitrage. Meanwhile, innovative regulatory philosophies are being put forward worldwide in response to the latest developments. To address regulatory loopholes arisen from Internet finance, countries are expanding their regulatory structures through new legislations and supplementary provisions.

In China, Fintech has made crowdfunding, Internet IPO, blockchain securities trading and other new ways of securities issuance and transaction possible. The principle of consistency requires that robo-advisors and the issuance of digital currencies and digital funds must be governed under the existing securities regulatory framework. The legitimacy of crowdfunding has yet to be recognised by regulators. The public fund-raising activities of shares issuance by issuers — which do so with merely a prospectus published on the Internet but without any underwriter nor compliance with the IPO registration procedures or strict disclosure requirements — must be rectified by subjecting them to the governance by the Securities Law.

3.3 Establishing effective regulatory technology system by more use of big data and AI

From the regulatory perspective, new Fintech applications may, in certain aspects, aggravate the inherent risks of the financial market and increase the risks of financial intermediaries. Since regulatory standards have been elevated after the global financial crisis in 2008, regulators have to rely on technology to process and analyze the large volumes of data provided by financial institutions in order to achieve precise regulatory judgement and policy-making. As the market continues to expand and cross-border financial activities continues to develop, big data, AI and other similar technologies have become essential tools to help build effective intelligent regulatory technology (Regtech) systems. This would improve financial regulators' capabilities to do macro-analysis and track systemic risks so as to better monitor and prevent systemic financial risks.

Given the current features of technological development, Regtech can be further explored in the following areas:

(1) Application of deep learning in Know-Your-Client (KYC) operations

For example, face-recognition technology can be used in remote account opening. A unique template of features can be established for each investor through collecting, testing, preprocessing, extracting, matching and identifying their facial features. Remote identity authentication can be completed with the help of cameras, network and recognition algorithm when investor identity verification is required. This will reduce costs and fraud in the KYC process, and provide investors with convenience and security.

(2) Application in public sentiment monitoring and sentiment indices using big data and natural-language processing

Through collecting and analyzing media information and user information generated continuously in the Internet, semantic processing and sentiment analysis using natural-language processing technology, and inputting the results into a sentiment model, the prevailing market sentiment and the trends can be obtained for reference by regulators and investors. Through analyzing and monitoring specific keywords, regulators may better understand about a company or an area and accordingly problems can be identified quickly and addressed promptly.

(3) Identification of corporate relationships based on big data and knowledge graphs

For example, a knowledge graph can be created based on a company's business registration information, annual reports, notices/announcements and information on its shareholders/legal persons and connected companies, while business intelligence (BI) software can provide searching, screening and enquiry functions. This will allow more direct and transparent understanding of a company's details and development, particularly sensitive information such as connected persons and companies, helping improve regulatory efficiency and effectiveness. There are now some business search engines (e.g. "Handshakes") in the market which can help regulators analyse the nexus of commercial transactions and relationships in the financial market. These business search engines can analyse public information of listed issuers faster and in greater depth with the help of technologies, providing the accurate connections between companies and discovering possible insider dealing. This would be the primary application of big data in Regtech.

4. CONCLUSION

Financial business model innovation brought about by technology innovation, with the aim of financial services upgrade, can satisfy financial needs in a wide range of new scenarios and can contribute to enhanced allocation of financial resources. Technology innovation is conducive to the further development of the financial industry but cannot replace its basic functions. Whether the core technologies of Fintech can promote healthy development of the financial industry would depend largely on innovation in the regulatory model. Exploring through sandbox regulatory requirements, the technology industry and financial institutions are on and on with their innovative attempts. Alongside are regulatory innovations to ensure the autonomy in Fintech innovations for the benefit of the public and to promote an open financial ecosystem, Internet finance and other forms of financial innovation.

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