Digitalisation and Finance in Asia

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Preface

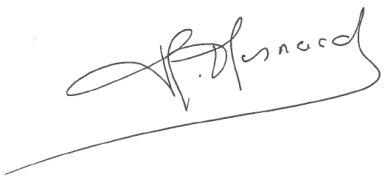
Financial markets—like our societies—are undergoing a digital transformation. We are seeing the emergence of new and innovative financial products or other types of assets; new types of trading venues and innovative technologies for financial market infrastructures, as well as new forms of financial intermediation or even dis-intermediation.

The COVID-19 pandemic has accelerated this trend of digitalisation of financial markets and of our economies. Digitally-enabled financial services helped economies avoid a complete standstill during the COVID-19 pandemic, and they have the potential to support a digitally-enabled recovery.

But, as this report warns, such innovative technologies deployed in finance also pose important risks and challenges. These include challenges around data privacy and governance; investor and consumer protection risks; increased cyber security and fraud risks, but also the built-up of vulnerabilities that could have implications for financial stability.

Policy makers must strike a balance. Innovations like artificial intelligence in finance, tokenisation and the use of distributed ledger technologies (DLTs) for the provision of financial services could act as enablers for more efficient, inclusive and competitive financial markets. The regulatory response should, however, ensure that we maintain financial stability, the protection of financial consumers, and the promotion of market integrity and competition.

This report is an important part of the OECD's efforts to support policy makers in striking this balance. It offers the evidence and analysis that should inform efforts to ensure digital financial innovation continues to grow in a safe and compliant manner.



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Foreword

The Asian region is home to the highest number of online internet users, who are the demographic most keen to adapt new technologies and most comfortable with using cashless payments, crypto-assets, and digital financial services. At the same time, parts of the Asian region remain unbanked or underbanked. The rapidly growing digital innovation in finance has allowed citizens of all countries to enjoy greater accessibility to financial products and services, unlocked, for example, through smartphone applications. This underlines the significant potential that the digitalisation of financial services could have with respect to financial development and financial inclusion in such parts of Asia, and beyond.

This publication examines FinTech applications and use cases in the Asian region and provides an overview of the most recent and prominent digital innovations in finance. It reviews policy tools used by jurisdictions in the region, and suggests policy responses intended to support financial innovation while ensuring that the use of such mechanisms is consistent with promoting financial stability, market integrity and competition, while protecting financial consumers.

The report can help policy makers to assess the implications of these new technologies and to identify the benefits and risks related to their use in finance in the Asian region and beyond. The exponential growth of digitally-enabled financial services and products, and the global nature of many of these applications, call for international collaboration and dialogue to promote coordinated action and policy responses to prevent regulatory arbitrage and address emerging risks.

The report builds on the work of the Committee on Financial Markets' Experts Group on Finance and Digitalisation and has been greatly enriched by the high-level discussions at the 2021 OECD Asian Symposium on Digitalisation and Finance. Both this publication and the 2021 Symposium on Digitalisation and Finance in Asia were supported by the Government of Japan.

Acknowledgements

A preliminary version of this report served as background to the discussions at the 2021 OECD Symposium on Digitalisation and Finance in Asia (www.oecd.org/finance/2021-symposium-digitalisation-finance-asia.htm). The final version has benefited from views and input from high-level officials, market participants and academics during the Symposium. The report also incorporates comments by delegates from the OECD Committee on Financial Markets and its Experts Group on Finance and Digitalisation.

This report has been prepared by Iota Kaousar Nassr, Ana Teresa Alvarez Hernandez, Yasuaki Inada, Nikki Kaur, Christophe Debonneuil and Ana Sasi-Brodesky under the supervision of Robert Patalano and Mamiko Yokoi-Arai from the Division of Financial Markets of the OECD Directorate for Financial and Enterprise Affairs. Pamela Duffin and Tobias Leber provided editorial and communication support.

This report contributes to the horizontal OECD Going Digital project which provides policy makers with tools to help economies and societies prosper in an increasingly digital and data-driven world. For more information, visit www.oecd.org/going-digital.

Table of contents

Executive summary

The emergence of distributed ledger technologies (DLTs), such as the blockchain, alongside innovations such as artificial intelligence (AI), machine learning (ML) and the growing availability of large volumes of big data are playing a central role in driving the recent developments in the digitalisation of financial services. Most recently, the use of digital financial services has played an important part in maintaining a high level of economic activity during the COVID-19 pandemic despite repeated closures, and has demonstrated the potential of FinTech to support a digitally-enabled recovery, improve economic resilience in future times of stress and promote financial inclusion.

The tokenisation of assets, involving the representation of assets in a digital form on distributed ledgers, is a core part of blockchain technology's potential. The use of DLT-based tokens in financial markets was introduced during the 2017-18 period with the appearance of initial coin offerings (ICOs). Some ICO activity has been recorded in almost all ASEAN Member States (with the exception of Brunei Darussalam and Myanmar). Though the technology and practice of tokenisation are nascent, its potential benefits include efficiency gains driven by automation and disintermediation; transparency; improved liquidity potential and tradability of assets with low liquidity; and faster and potentially more efficient clearing and settlement, and activities such as repo and securities lending. Recent private initiatives in Asia include several issuances of tokenised bonds and the creation of exchanges for digital assets.

The emergence of stablecoins and BigTech-based financial services initiatives, potentially challenging the effectiveness of monetary policy transmission carried out by central banks, alongside growing demand by consumers for faster and secure digital payments, have led to increased interest in Central Bank Digital Currencies (CBDC); As of July 2021, 51 central banks have published their CBDC research or pilots, with more central banks in the process of development. The Asian region accounts for 36% of the retail CBDC projects under development and more than half of the wholesale CBDC projects.

The stage of development across CBDC projects varies widely. Some countries have already launched their CBDCs or have live, or near-live pilots, while others are at research stages, including technical experimentation. One of the key considerations around the issuance of CBDCs is associated with design characteristics and choices that must be aligned with the intended goals. In countries where large part of the population is banked and able to access digital payments, the main motivation of central banks to explore the idea of CBDC is to prevent payment system fragmentation and support further financial innovation. In contrast, for countries with less developed financial infrastructure, where large part of the population is un-banked or under-banked, CBDC might offer greater digitalisation of P2P payments, higher payment efficiency, increase the trust in the domestic currency and promote financial inclusion. In addition, CBDCs may increase the efficiency and speed of international payments (i.e. remittances), while lowering their cost, which has significant relevance for lower income families in the region.

The concept of Decentralised Finance (DeFi) has been discussed since the advent of the Bitcoin and DLT. In the past year and a half this theory has matured into several real-life DeFi applications and protocols that have been gaining traction. DeFi claims to provide traditional centralised financial (CeFi) services involving crypto-assets in an open, decentralised, permissionless way, built (mainly) on the Ethereum blockchain network. The total value of crypto-assets locked in DeFi applications as of 22 November 2021

reached USD 104.2 billion up from USD 1.9 billion on 2 July 2020 (50-fold increase in less than a year). The DeFi space is growing rapidly, attracting an increasing number of retail and institutional investors alike. Increased interest and adoption of cryptoassets by institutional investors and other traditional financial service providers could lead to increased interconnections between CeFi and the parallel DeFi system and creates channels of risk transmission to the traditional markets and potentially the real economy. The Blockchain Governance Initiative Network (BGIN) was created as an open and neutral sphere for all stakeholders of the decentralised finance ecosystem with the aim to deepen common understanding and promote collaboration within the ecosystem.

Underling the emergence of new forms of DLT-based financial services is the growing integration of AI and ML in financial services provision as decision-supporting tools. AI techniques are being deployed in asset management to improve asset allocation as well as to reduce back-office costs and improve risk management through their ability to derive insights from large and alternative data sets. When used in trading, AI helps identify and execute trades without or with little human intervention, while AI-based models and big data are increasingly being used by banks and FinTech lenders to assess the creditworthiness of prospective borrowers and make underwriting decisions. Such models could reduce the cost of underwriting while at the same time facilitating the extension of credit to thin credit file clients, without collateral or historic financials. Also, AI in DLT-based finance has the potential to augment the capacity of smart contracts, while such innovation has been leveraged by authorities for facilitating regulatory compliance (RegTech) and for supervision (SupTech) in a more efficient and effective manner.

Although there are many potential gains from AI in terms of efficiency, financial inclusion, SME financing and cost reduction, this report also highlights the challenges with respect to consumer protection, safeguarding financial stability, avoiding regulatory arbitrage and non-compliance, and reviews policy reactions taken by countries in Asia. There is a growing debate on how regulators and supervisors can foster innovation while ensuring that risks stemming from the use of AI in financial services can be mitigated, and a number of Asian countries have introduced national strategies for the use of AI in finance and beyond.

1 Tokenisation of Assets

1.1. Introduction[1]

The tokenisation of assets, involving the representation of assets in a digital form on distributed ledgers, is a core part of the DLT's potential. Asset tokenisation has potential cross-cutting implications for financial market practices and participants, market infrastructure and regulation, across a large range of financial instruments and asset classes (OECD, 2020b).Though the technology and practice of tokenisation are nascent, its theoretical benefits include efficiency gains driven by automation and disintermediation; transparency; improved liquidity potential and tradability of assets with near-absent liquidity; and faster and potentially more efficient clearing and settlement, and activities such as repo and securities lending (OECD, 2020a).

This chapter analyses the impact that widespread adoption of tokenisation could have in countries across Asia, discussing emerging opportunities and risks for financial markets and their participants, illustrated with case studies from the region. It also touches upon the potential impact of tokenisation on the post-trade and the need for a tokenised form of central bank currency (CBDC) or stablecoin for the payment leg of settlements on DLT-based trading venues. The chapter concludes with a discussion of regulatory approaches to tokenisation being implemented in Asian economies and policy considerations.

The emergence of blockchain and other DLTs and their use in financial markets can facilitate the exchange of value without the need for a trusted central authority or intermediary (e.g. government, bank) and can potentially allow for efficiency gains driven by disintermediation (OECD, 2020b). The use of DLT-based tokens in financial markets was introduced during the 2017-18 period with the debate around initial coin offerings (ICOs), and has since kept growing, with tokenisation becoming one of the most prominent use-cases of DLT in financial markets.

Policy makers have a role in ensuring that tokenised markets are functioning in a consistent manner with regulatory aims of promoting financial stability, protecting consumers, and ensuring market integrity. For some jurisdictions with a technology-neutral approach to regulation, existing regulation may need to apply to new actors and new products, and new requirements may need to be designed to address emerging risks, stemming from the novel nature of some of the business models and processes involved in tokenisation. Potential gaps in existing regulatory frameworks need to be identified, and regulatory and legal ambiguity around asset tokenisation should be addressed, as a stepping stone to the safe development and use of tokenisation in Asian markets. Further, cross-border transactions of tokenised assets require international cooperation to limit regulatory arbitrage and to foster the safe development of tokenised markets.

[1] This chapter is based on OECD, 2019; OECD, 2020; OECD, 2021.

1.2. Defining tokenised assets and the benefits of tokenisation

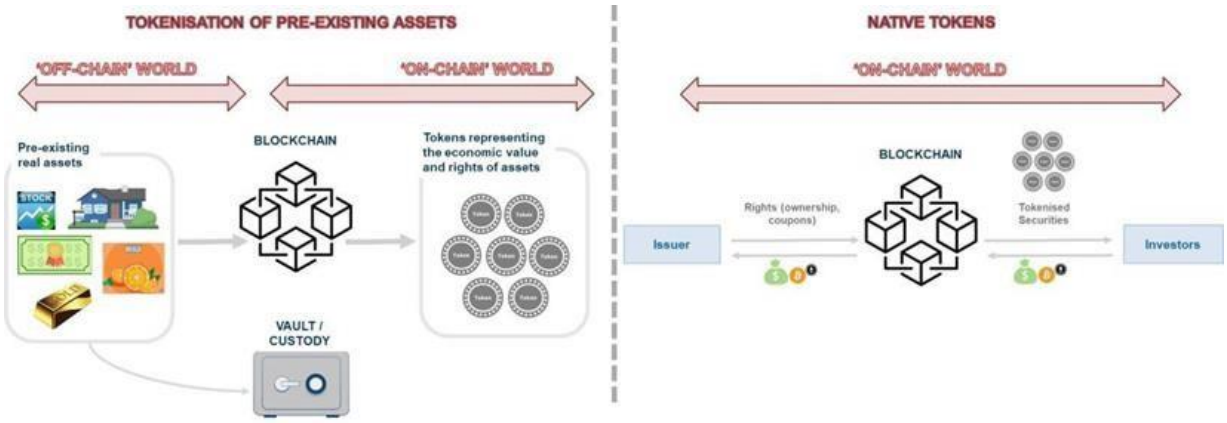
The tokenisation of assets involves the creation of digital tokens representing real-world assets (otherwise called digital twins), or the issuance of tokens native to the blockchain (OECD, 2020b) (Figure 1.1). Important distinctions need to be made between tokenised assets that exist off--chain and tokens that are native to the blockchain. Tokens issued on the back of real-world assets, otherwise called digital twins, exist on the chain and carry the rights of the assets they represent, acting as store of value. The real assets on the back of which the tokens are issued continue to exist in the "off-chain" world and, in the case of physical real assets, those would typically need to be placed in custody to ensure that tokens are constantly backed by these assets. Communication between the "off-chain" (traditional financial market infrastructures) and "on-chain" environments is crucial for assets that continue to exist off chain. In theory, any real asset can be tokenised and rights to such asset be represented on a distributed ledger (e.g. stablecoins, real estate assets (see Box 1.3), commodities such as gold, art through the recently emerged non-fungible tokens (NFTs)). Intangible assets (e.g. IP) could also be tokenised, creating new innovative digital assets.

Native tokens are built directly on-chain and live exclusively on the distributed ledger (OECD, 2020b). Bitcoin and other crypto-assets and payment tokens are examples of native tokens. Native tokens derive their value in and of themselves and are defined by their existence on the blockchain. Tokens issued in Initial Coin Offerings (ICOs) are another example of native tokens, and consist of the creation of digital tokens by start-up companies and their distribution to investors in exchange for funds for the purposes of fundraising (OECD, 2019). Tokens issued in ICOs are generated within the blockchain and are not backed by an off-chain security or other asset (see Section 1.3.1).

Examples of tokenisation of financial assets can include the tokenisation of equities of non-listed companies and of private debt placements (OECD, 2020b). Investment funds and alternatives such as private equity and venture capital funds, as well as real estate investment vehicles and other fund units, are also thought to be suitable for tokenisation given the near-total absence of liquidity of such funds/vehicles. Tokenisation of financial securities (equity and/or debt) is seen by the market as the sector with the most imminent potential for growth. 'Security Token Offerings'[2] or STOs, marketed as a more 'regulatory-compliant' successor of ICOs aiming to raise capital, as well as 'Security Tokens' representing existing securities in secondary DLT markets are prime examples of such issuances. Direct issuance on DLTs is more straightforward for bonds, given that these are bearer assets on which no ownership information is recorded and whose possession accords ownership, but this will ultimately depend on the jurisdiction (OECD, 2020b). Direct issuance of equities, as registered securities, is more cumbersome; the majority of the current applications of equity tokenisation involve the digital representation of the rights to a share.

[2] There is no formally agreed classification for STOs, except for some jurisdictions where specific regulation has been introduced (e.g. Japan, see Section 3.2).

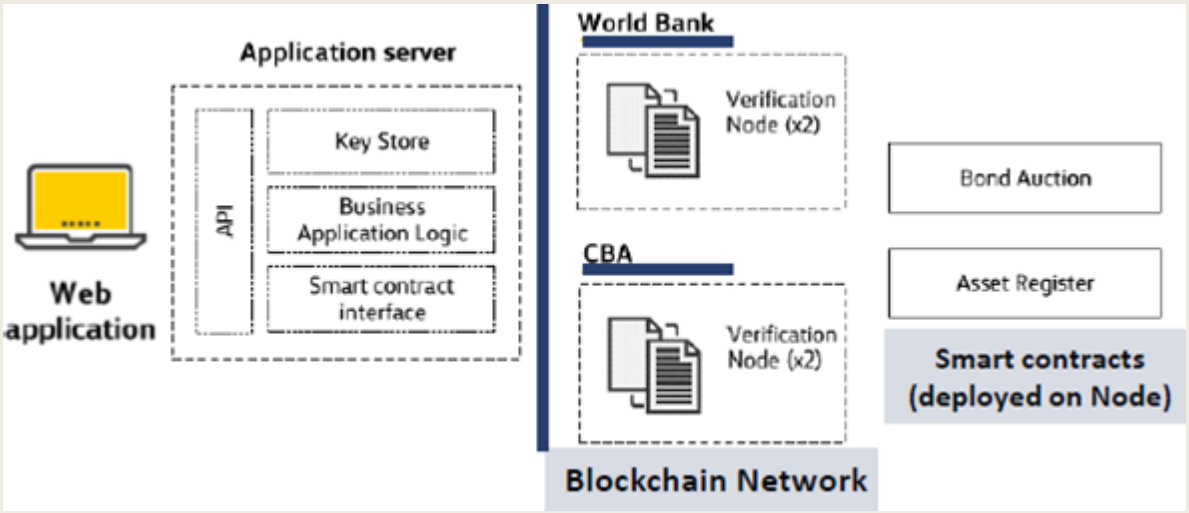
Figure 1.1. Representation of tokenisation forms



Box 1.1. World Bank 'Bond-I' Blockchain-based Debt Instrument

In 2018, the World Bank launched bond-I, a new blockchain-operated debt instrument, and the first legally binding bond to be created, allocated, transferred, and managed through its life cycle using DLTs. The 2-year bond raised AUD 110 million, and the World Bank mandated the Commonwealth Bank of Australia (CBA) as arranger for the bond. The CBA Blockchain Centre of Excellence developed and built the bond-I blockchain platform, housed in the Sydney Innovation Lab (World Bank, 2018a).

Figure 1.2. Schematic representation of the World Bank 'Bond-I' platform



Source: World Bank.

The bond-I platform runs on a private, permissioned blockchain, where only the World Bank and the CBA are authorised to access and validate transactions. The register is based on the blockchain ledger and is held by CBA in Sydney. Settlement is managed by CBA as issuing, paying and calculating agent. The cash settlement is performed off-chain (World Bank, 2018a). Investors wishing to participate have to get pre-authorisation. They then use their authentication key to enter bids onto the platform through

a web interface. The World Bank observes the book-building in real-time. Following the finalisation of pricing, investors can see their bids and allocations in real-time (only their own bids and allocations). The platform provider has real-time access to all bids and allocations. Cash settlement performed off-the-chain leads to a transfer of the legal title in the registry of the register (CBA). Smart contracts allow for the automation of payments (e.g. coupons) based on pre-defined rules (World Bank, 2018a).

Source: (OECD, 2020b).

The application of DLT in asset tokenisation may deliver efficiency gains through the transfer of value without the need for trusted centralised intermediaries and/or through the efficient automation of processes, resulting in faster, potentially cheaper, and frictionless transactions, driven by disintermediation and automation (OECD, 2020b). The use of smart contracts may reduce the cost of issuing and administering securities, further reducing the cost of transactions, increasing the speed of execution and streamlining transactions. Smart contracts may facilitate corporate actions (e.g. coupon or dividend payments, voting), escrow arrangements (e.g. release of funds) and collateral management (e.g. exchange of ownership interest). Custody chains typically involved in holding traditional securities may be shortened and their transparency increased, avoiding potential liquidity problems for market participants in case of operational issues or financial distress of sub-custodians (Financial Stability Board FSB, 2019).

The distributed nature of the network with no single 'point of failure', the immutability of the ledger and the application of cryptography may add to the resilience and safety of the infrastructure (OECD, 2020b). This depends on the applicable consensus mechanism and the governance model of each DLT, which may give rise to other vulnerabilities (e.g. risk of forks). Asset tokenisation may bring benefits of increased transparency regarding transaction data and information on the issuer and the asset characteristics, through enhanced information recording and sharing. DLT-based security registries may provide increased transparency and a clear record of beneficial ownership with certainty at any point in time. The role of register agents/registrars/transfer agents may thus be rendered redundant and corporate/shareholder registries replaced by the decentralised ledger itself.

Box 1.2. The European Investment Bank (EIB) tokenised bond

EIB announced on 27 April 2021 the issuance of a two-year €100 million digital bond on a blockchain platform, led by underwriters Goldman Sachs, Banco Santander, and Société General using central bank digital currency (CBDC) issued by Banque de France (EIB, 2021). The three underwriting banks paid the EIB with CBDC but other investors paid the underwriters in conventional fiat money (LedgerInsights, 2021a). The EIB stated that this digitalisation project allows to reduce intermediaries and fixed costs, increase market transparency through an increased capacity to see trading flows and identity of asset owners, and a faster settlement speed (EIB, 2021). This bond represents the first multi-dealer-led, primary issuance of digitally native token using public blockchain technology.

Similar capital market innovations have taken place in Asia, with Thailand's Central Bank blockchain-powered platform for government bond savings, launched in September 2020 with the aim to improve investor's buying experience, enhance operational efficiency, and reduce the overall cost of operations (Blockchain News, 2021). In November 2020, the China Construction Bank (CCB) worked with Labuan-based digital asset exchange Fusang for the issuance of USD 3 billion worth of debt securities on blockchain (CoinDesk, 2021b). In December 2020, the Union Bank of the Philippines and Standard Charter created a proof-of-concept for the issuance of a blockchain-powered retail bond worth USD 187 million involving 3 and 5.25-year dual issuances (Blockchain News, 2021).

Tokenisation may allow for the slicing up of ownership of assets (or interest in funds), dividing it into smaller claims than typically observed in stocks/bonds, similar to structured products and securitisation (OECD, 2020b). Retail investors in particular, get an entry point at a lower initial minimum investment for investment classes that may have been otherwise beyond their capacity (e.g. participation in private equity funds) and participate in capital markets with lower minimum tickets or portfolio sizes. In order to support fractional ownership of securities, the underlying payment system that executes the settlement of payments these securities pay to their owners, has to allow for larger amount of transactions and micro payments to be processed in an efficient, fast and cheap manner.

Private placements of equity or debt of small and medium-sized companies (SMEs) are examples of security transactions that are traditionally restricted to large institutional investors and funds. By using tokenisation, the borrowing firms get to have a closer unmediated relationship with their creditors being able to cater to their demand and allowing for wider financial opportunities to raise capital.

Box 1.3. Tokenisation of real estate assets

Tokenisation is gaining traction in the real estate sector, and traditional real estate companies are partnering with technology providers to explore the tokenisation of debt or equity (Liquefy, Sidley, KPMG, Colliers, 2020). Real estate is known to be one of the least fungible asset classes since it is not standardised, deployable nor exchangeable, and only a small percentage of the population can participate in its funding given the large amounts of investment required (Savills PLC, 2017).

Tokenising real estate assets through blockchain technology can allow for the creation of completely new markets and exchanges for tokenised real estate asset-backed securities that can provide liquidity to create an efficient market for a previously un-fungible asset (Fudan University, 2019). Tokenised assets may carry lower illiquidity premia allowing for the asset to trade closer to its fair value. This, however, may be a difficult proposition to test as illiquidity premia are difficult to isolate, quantify and dissociate from systemic or market risk (OECD, 2020b). According to some market participants, the benefit described above may be greater for the most illiquid asset classes (e.g. privately held SME equity, real estate, etc.), given that these carry the highest illiquidity premia.

The first sale of a building through blockchain technology in Europe took place in June 2019, involving the tokenised sale of AnnA Villa, a luxury property located in Bologne-Billancourt, France. The transaction, facilitated by Equisafe investment platform and partnered by Ethereum, was valued at EUR6.5 million (Equisafe, 2019). The AnnA property first followed a classic sale process with a notarial deed validating the value of the building and marking its transfer to a simplified joint stock company (SAPEB AnnA) (OECD, 2020b). Equisafe, an investment platform operating via blockchain technology, then registered this company as an issuer in its system, before dividing it into 100 digitised shares/tokens, which were then transferred via the blockchain to the promoter. The real estate developer could therefore exercise his ownership rights over an entire building via the blockchain. Tokens issued complied with the requirements applying to financial securities as per Article L.211-1, II of the French Monetary and Financial Code. The tokens were divisible, and a 10,000 factor of divisibility was applied, resulting in investment with a minimum ticket entry of EUR 6.5, with a one-year vesting period applied to initial token holders. The ownership rights of the company owning the building were thus fully coded on the blockchain: each token issued on the back of this transaction contained the conditions of purchase, sale and exchange of the securities, as well as the rights to which it gives access, such as dividends and voting rights.

All documents traditionally exchanged on the sale chain of a real estate property transaction were recorded and encrypted on the blockchain (notarial deed, certificate of ownership, identification data of buyers and sellers). Registration of the title deeds on a blockchain register, in which the information is certified by notaries, digitised, unfalsifiable and permanently accessible, can allow for a faster exchange and tracking of information from the creation of the asset to its sale (OECD, 2020b). In addition to benefits related to transparency and information sharing, the expected benefits of the transaction include faster and more efficient process and structure, greater liquidity, financial inclusion, and the democratisation of an investment allowed by proposing an accessible minimum investment amount.

Increased efficiencies in clearing and settlement processes could be the biggest breakthrough of asset tokenisation which has wider disruptive implications for financial markets and may result in reduced counterparty and operational risks in permissioned blockchains (OECD, 2021). The ability to conduct ‘atomic swaps’ may significantly reduce, if not eliminate, counterparty risk. Atomic swaps are defined as the wallet-to-wallet exchange of two digital assets simultaneously in a single operation across different blockchains without going through any centralised intermediary such as an exchange. However, these types of transactions are not widespread as the underlying technology is still quite nascent.

1.3. Tokens issuance for the financing of SMEs and corporates: the Asian landscape

The important role of SMEs in the real economy is well recognised and is derived from their contribution to employment, value added and innovation. Financing sources allow SMEs to fulfil their role, and it is therefore important for SMEs to have access to multiple financing sources both under normal market conditions and in periods of financial distress (OECD, 2019). Due to the importance of this economic segment and at the same time, the worldwide consensus on the difficulty of SMEs in accessing funding sources, it is important to discuss policy implications of Initial Coin Offerings (ICOs) as one specific application of tokenisation and its potential to constitute a potential alternative mechanism of inclusive SME financing.

1.3.1. ICOs: structure and characteristics

ICOs consist of the creation of digital tokens by start-up companies (i.e. young micro-SMEs) and their distribution to investors in exchange for fiat currency or, in most cases, mainstream crypto-assets (Bitcoin or Ether) (OECD, 2019). Tokens created in ICOs either offer utility in using the product or service the issuing company is developing, or represent a stake in such a project. ICOs are enabled by the use of DLTs which facilitate the exchange of value without the need for a trusted central authority or intermediary, allowing for efficiency gains driven by such dis-intermediation and by automation. Tokens issued in ICOs are cryptographically secured and benefit from the inherent characteristics of DLTs on which they are built, such as transparency, security and immutability of the ledger, given its distributed nature.

ICOs have the potential to be a financing mechanism for start-ups and SMEs if delivered in a compliant and safe manner (OECD, 2019). Network effects allow for potential value creation by the network that is being formed automatically in every ICO with the mere participation of token holders in the offering. Potential network effects, together with efficiency gains driven by the uses of DLTs, are arguably the two most important sources of value creation of ICOs and are central to the success of ICO-funded ventures (OECD, 2019).

Structuring of ICO offerings varies across projects in regard to the number of tokens issued; the proportion maintained as compared to the one distributed to investors; the allocation mechanisms; the future supply of tokens; and the sale model used. ICOs may place caps on individual contributions, and conversely, minimum contributions can be imposed in case the issuer wishes to restrict participation to institutional investors. A portion of the tokens issued is, in many cases, set aside for the founding team of the project. Extra tokens are allocated to those undertaking the mining process through which nodes validate transactions. The issuance can be contingent to the achievement of a minimum threshold, the “soft cap”. If the pre-defined target of proceeds set by the imposition of the soft cap is not met, investors’ contributions are returned and the platform is not launched. When it comes to sales models, sales at a fixed price, auctions, reverse auctions and hybrid forms of the above or other innovative mechanisms are being used. To date, no single structure or sale model has proved to combine all the desired properties that would render it an industry standard in ICOs.

1.3.2. The Case of Japan: Security Token Offerings (STOs)

STOs are often analogised to IPOs due to similar sounding acronyms, but the largest STOs have been debt offerings (Deloitte, 2020). Once tokenised, the security can have streamlined settlement and automated administrative functions coded into smart contracts. The benefits of STOs are not limited to public issuance of debt or equity as private placements; STOs can take advantage of increased efficiency and transparency of tokenising a security (e.g. issuers don’t have to incur high costs of public offerings).

The Financial Services Agency of Japan introduced a number of changes in policies related to crypto-assets (Okamoto and Takeuchi, 2020). As part of the reform, it was clarified that tokens issued to investors in exchange of funds (fiat or crypto) through STOs, and which offer the possibility to receive dividends, will be regulated under the Financial Instruments and Exchange Act. The reform also introduced regulations on conduct of business, targeting brokering of security tokens, including solicitation and management of tokens.

Table 1.1. Categorisation of STO-issued tokenised securities in Japan

	Type Ⅰ Securities			Type Ⅱ Securities	
	(1)Shares, public and corporate bonds, etc.	Tokenised securities			(5)Collective investments schemes, etc.
		(2) Shares, public and corporate bonds, etc.	(3)Electronically Recorded Transferable Rights (ERTRs) such as Collective investments schemes, etc.	(4)Tokenized Type Ⅱ securities excluded from ERTRs	
Disclosure of issuers	When soliciting 50 or more general investors and issuing securities exceeding 100 million yen	When soliciting 50 or more general investors and issuing tokens exceeding 100 million yen		When soliciting 500 or more investors, issuing tokens exceeding 100 million yen, and investing 50% or more of capital contributions in securities	When soliciting 500 or more investors, issuing securities exceeding 100 million yen, and investing 50% or more of capital contributions in securities
Service providers	Type Ⅰ financial instruments business (Stated capital not less than 50 million yen)			Type Ⅱ financial instruments business (Stated capital not less than 10 million yen)	

Source: JFSA, OECD (2021).

According to the tiered regulation in Japan, corporate bonds, or other securities considered as highly liquid, are referred to as 'Type I Securities'. When tokenised, these securities continue to be subject to the corresponding regulations. Low liquidity securities and collective schemes are referred to as 'Type II Securities', and are defined as electronically recorded transferable rights (ERTRs). As their liquidity increases through tokenisation, these become subject to the regulations applying to Type I Securities.

Tokenised Type II Securities that are considered to have relatively low liquidity when held by a limited number of investors (accredited investor category), are excluded from ERTRs and continue to be subject to regulations applying to Type II Securities, while giving due consideration to balance between user protection and innovation. Under the Financial Instruments and Exchange Act, Type II Securities are subject to a less strict framework than Type I Securities with regard to the duty of disclosure on issuers and regulations on businesses engaging in transactions.

Similar to other forms of tokenisation, STOs enable smaller investment units, expanding corporate bond and real estate investment to a wider range of investors (Nomura Institute, 2020). Moreover, STOs could appeal to investors with diverse values through non-pecuniary returns. Both channels could contribute to the expansion of the Japanese capital market.

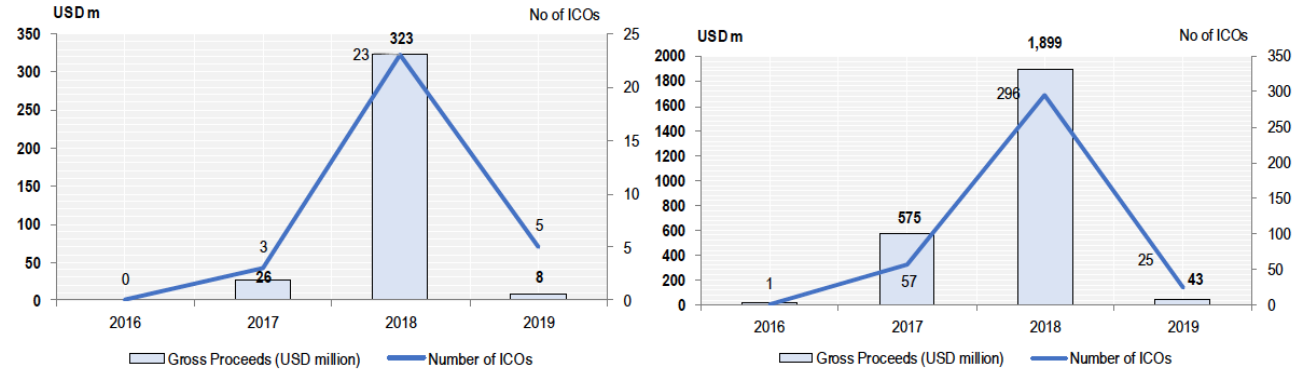
1.3.3. Spotlight on ASEAN ICO activity

Some ICO activity has been recorded in all ASEAN Member States (AMS) with the exception of Brunei Darussalam and Myanmar (for the period 2016-19, before the ICO hype collapsed) (OECD, 2020a). The vast majority of ICO issuance has been observed in Singapore, partly explained by the position of the country as a global financial centre, as well as the timely provision of regulatory guidance on token offerings. The development of ICOs in Singapore points also to the importance and value of the ecosystem for SME financing instruments (OECD, 2020a). The existence of infrastructure, entrepreneurial culture, investor concentration and skilled workforce, coupled with clarity on the regulatory framework, provided fertile ground for such an SME financing mechanism to flourish.

Four AMS, namely Malaysia, the Philippines, Singapore and Thailand, have chosen to provide specific, tailor-made regulation for ICOs (OECD, 2020a). The Securities Commission Malaysia, The Securities and Exchange Commission of Thailand, the Monetary Authority of Singapore, and the Securities and Exchange Commission of the Philippines actively promoted a safer and supervised use of ICOs by proposing holistic, 'tailor-made' regulation, applicable to token offerings issued in their respective jurisdictions. In that way, issuers had appropriate clarity around the requirements related to such offerings, and subscribers benefited from investor and consumer protection frameworks that safeguarded their rights when participating in token offerings. Therefore, the use of ICOs as alternative financing mechanism was encouraged through a safe regulated form, responding to the funding needs of SMEs, while protecting investors and maintaining the necessary ingredients of fair and orderly markets.

Figure 1.3. ICO Issuance in ASEAN, 2016 – H1 2019

Excluding Singapore (LHS) and all ASEAN Member States (RHS), in USD million and in number of issuances



Note: The quality of data on ICO offerings and crypto-assets varies and might not always be satisfactory, while market-related figures (prices, trading volumes, and volatility) may be manipulated or may not necessarily fit all types of crypto-assets equally (Financial Stability Board (FSB), 2018). To that end, this chapter is only reporting data on issuance sourced from public sources and should be treated with caution. Data from the official sector are scarce or completely unavailable (OECD, 2020a).
Source: OECD calculations, based on publicly available information, OECD (2020a).

In AMS where ICO activity remains unregulated, the ambiguity around the legal and regulatory framework applying to ICOs did not prevent issuers from offering tokens through such structures (OECD, 2020a). Indeed, there has been evidence of unregulated ICO activity in AMS that did not provide clarity around ICO regulation, exposing participants and issuers to a number of important risks. In Cambodia, the relevant authorities (the National Bank of Cambodia, the Securities and Exchange Commission of Cambodia and the General Commissariat of National Police) issued a joint statement to inform the public that any unregulated crypto-related activity is illegal (National Bank of Cambodia and Cambodia and General Commissariat of National Police, 2018).

In addition, given the inherent global nature of ICO issuance, investors have participated in ICOs performed in foreign jurisdictions despite bans or investor warnings issued by the home authorities, exposing themselves to significant risks in the absence of any consumer protection safeguards (OECD, 2020a).

Box 1.4. Market-led tokenisation initiatives in the ASEAN region

Some of the largest companies innovating in the tokenisation of assets sphere operate in the ASEAN region (e.g. Harbor, Tokeny Solutions, Templum, Masterworks, Bitmark, Mattereum, Parallel Markets, FinFabrik, AlphaPoint, and PO8) (VentureRadar, 2019). For example, FinFabrik is a Hong Kong (China)-based FinTech company that transforms traditionally alternative, illiquid assets into Digital Asset-Backed Securities (DABS) (VentureRadar, 2019).

SIX Digital Exchange (SDX) and SBI Digital Asset Holdings Co. announced their plan of a joint venture to establish a Singapore-based digital issuance platform, exchange and central securities depository (CSD), set to go live by 2022, subject to regulatory approval from the Monetary Authority of Singapore (SIX Group, 2020). The joint venture is aimed at catering to the demand of institutional investors for liquidity in digital assets trading (SIX Group, 2020).

The DBS Group Holdings, Southeast Asia's largest bank, is setting up an exchange for digital assets, including crypto-assets that will provide tokenisation, trading, and custody services to institutional and accredited investors (Reuters, 2020). The DBS Digital Exchange will use DLT to provide a platform for fundraising through asset tokenisation and secondary trading of digital assets where DBS and the Singapore Exchange will take a 10% stake in the project (Reuters, 2020).

ICO issuance in ASEAN was partly driven by tailor-made regulatory frameworks explicitly covering ICOs in countries such as Thailand, Malaysia, the Philippines, and Singapore (OECD, 2020a). The paragraphs below look at the specific case of each of these AMS to understand the underlying drivers of such activity and the policy approach taken.

Thailand

Financial market participants in Thailand demonstrated an interest in blockchain technology early on, with banks looking to integrate DLTs in their operations, for example Bank of Ayudhya's pilot blockchain programme with IBM, or the plans of the Stock Exchange of Thailand for a blockchain-based market (Bangkok Post, 2017). According to publicly sourced information, USD 99 million was successfully raised through ICO issuances in Thailand in 2019 (OECD, 2020a).

In May 2018, SEC Thailand presented a holistic regulatory framework applicable to Digital Assets covering both crypto-assets and digital tokens, as well as digital asset exchanges, brokers and dealers for secondary markets, and portal service providers (Emergency Decree on the Digital Asset Business B.E. 2561 A.D. 2018) (Linklaters Thailand Ltd, 2018). Under the Thai framework, ICO issuance is considered a regulated activity with strict rules are requirements: issuers are required to obtain approval from SEC Thailand by submitting a filing data form (registration statement), a draft prospectus and a draft whitepaper before launching an offering; ICO has to be launched using a pre-approved portal. Issuers are required to specify the rights attached to the tokens and disclose the source code. Periodic reporting is also required, pertaining to the progress of the project in regular intervals. All digital asset business operators are covered by the same regulation, and these must obtain a license from the Ministry of Finance, issued following a recommendation by SEC Thailand.

Thailand's finance ministry remains very restrictive with the digital asset business licences it grants. A licence was denied to Cash2Coin and Southeast Asia Digital Exchange (SEADEX) because of insufficient KYC processes and inadequate IT infrastructure (Securities.io, 2021). Moreover, in May 2021, the Anti-

Money Laundering Office (AMLO) announced that the opening of new crypto-asset accounts in the second half of 2021 will require the physical presence of its clients (Bangkok Post, 2021).

Box 1.5. Project Inthanon by Hong Kong Monetary Authority and Bank of Thailand

In 2018, the Hong Kong Monetary Authority and the Bank of Thailand launched Project Inthanon, which explores DLT solutions for cross-border transfers (BoT and HKMA, 2020). The proof-of-concept is designed and developed to offer a cross-border corridor network where fund transfers can occur instantaneously on a peer-to-peer basis.

This design allows on-demand foreign exchange price discovery on the corridor network and enables on-demand foreign exchange conversion and settlement, which is done in an atomic payment-vs-payment (PvP) manner (BoT and HKMA, 2020). This project puts forward insights and ideas that could improve the use of digital currencies for cross-border financial transactions while preserving global financial stability.

Malaysia

Malaysian-based companies raised USD 15.8 million in 2017 and USD 159.2 million in 2018 before the regulatory framework for ICOs was put forth by the Securities Commission of Malaysia (OECD, 2020a). In 2019, the Securities Commission Malaysia issued a proposed regulatory framework explicitly covering ICOs (Securities Commission Malaysia, 2019). The regulation requires issuers to seek authorisation from the Securities Commission for any offering or issuance of tokens, as well as submitting a disclosure document or whitepaper, compliant with prescribed requirements set by the Securities Commission. These include fitness and proprietary checks for issuers, managers and board of director members of the issuing company; an assessment of the project that is the target of the financing; safeguards to protect existing shareholders and prospective token holders; AML monitoring; as well as an evaluation of the protocol, code and cyber risk management framework of the issuer.

The Philippines

In 2018, USD 9.6 million was raised through ICOs in the Philippines (OECD, 2020a). Based on estimates by the World Bank, USD 65 billion of remittances were sent to AMS, out of which USD 33 billion to the Philippines (World Bank, 2018b). According to World Bank estimates, the global average cost of remittance in Q2 2018 stood at 7.0%, which is more than double the 3.0% goal set under the UN Sustainable Development Goals (SDG). The high cost associated with international remittances is potentially one of the reasons for the increased crypto-asset activity seen in the Philippines, despite the lack of regulatory framework in the early days of adoption. This is because the use of money in digital form offers lower transaction costs and shorter transaction times.

In January 2021, the Bangko Sentral ng Pilipinas (BSP), central bank of the Philippines, published new rules concerning virtual asset service providers. Accordingly, exchange between one or more forms of virtual assets, their transfer, and the safekeeping or administration of virtual assets or instruments enabling control over them, shall be subject to the BSP's licensing requirements, regulatory expectations for money service businesses, as well as AML rules (INQUIRER.NET, 2021).

The BSP regulation does not address virtual assets companies operating as trading platforms or performing ICOs. In 2018, the Philippines SEC published a consultation for a proposed regulatory framework specifically covering ICOs (Securities and Exchange Commission of the Philippines, 2018). The proposed framework applies to ICOs by entities incorporated in the Philippines or subscribed by residents of the country. The new regulation requires an initial filing to the SEC at least 90 days before any pre-sale

period, which will allow the SEC to determine whether the token qualifies as a security. If the offered token is declared a security, the issuer is required to follow all regulatory requirements applicable to security issuances including registration of the security (OECD, 2020a). This proposed regulation remains pending (Doing Business in the Philippines, 2019).

In parallel, the Philippines introduced a new self-regulation to govern crypto-assets through the Cagayan Economic Zone Authority (CEZA), a government-owned corporation responsible for the Cagayan Special Economic Zone and Freeport. This approved the Digital Asset Token Offering (DATO) regulations in February 2019 (ABACA, 2019). Under the new framework, CEZA is the principal regulating authority, and the Asia Blockchain and Crypto Association (ABACA) is designed as a self-regulatory organisation to help implement and enforce the new rules.

Singapore

Singapore has been among the top five markets for ICO issuance globally, as measured by the amount of funds raised (USD 0.5 billion raised in ICOs in 2017 and over USD 1.5 billion raised by 273 token offerings in 2018) (OECD, 2020a). The regulatory guidance that the Monetary Authority of Singapore (MAS) has provided to issuers and investors early on in the evolution of digital tokens has possibly assisted the development of the local ICO market. It could also be argued that the regulatory responses of other countries in the region - the ban imposed by China's People's Bank of China (PBOC) and the Financial Services Commission of Korea on ICOs – may have displaced some prospective issuers to nearby markets such as the one in Singapore (Reuters, 2017a, 2017b).

In 2017, the Monetary Authority of Singapore (MAS) issued a clarification on its regulatory position around the offering of digital tokens in Singapore (MAS, 2017). It then published a comprehensive guide on digital token offerings from a regulatory standpoint, clarifying the application of existing laws with regard to tokens (MAS, 2018). According to the guide, digital tokens may represent ownership or a security interest over an issuer's assets or property, and MAS will examine the structure and characteristics of, including the rights attached to a digital token in determining if the digital token is a type of capital markets product under the Securities and Futures Act (SFA). Digital tokens may also represent a debt owed by an issuer and be considered a debenture under the SFA, or a securities-based derivative contract in case any derivatives are included. Where digital tokens fall within the definition of securities in the SFA, issuers of such tokens would be required to lodge and register a prospectus with MAS prior to the offer of such tokens, unless exempted. Similarly, the issuer and any intermediaries participating in the offering, will be subject to licensing requirements under the SFA as holders of capital markets services license and/or a financial advisor's license. The guide also makes it clear that MAS's Money Laundering and Countering the Financing of Terrorism requirements apply with regard to certain token-related activities. MAS has continued to update this guide from time to time.

In July 2020, the MAS published the Omnibus Act (OA), introducing changes to Singapore's financial sector regulation. In particular, the proposal will affect service providers in the sector of crypto-assets. For example, virtual asset service providers created in Singapore but offering services outside the country will be regulated and will be subject to AML/CFT requirements (Lexology, 2021).

Hong Kong (China)

The Securities and Futures Commission Hong Kong (China) (SFC HK) reported an increase in the use of ICOs to raise funds in Hong Kong (China) recognising that digital tokens that are offered or sold may be 'securities' as defined in the Securities and Futures Commission and subject to the laws of Hong Kong (China) (SFC HK, 2017). SFC observed investors' growing interest in virtual assets which requires existing regulatory requirements for guidance on expected standards and practices in relation to distribution of virtual asset funds (SFC HK, 2018).

In November 2018, the SFK HK announced a framework for potential regulation of virtual asset trading platforms and will consider whether it is appropriate to grant licenses to platform operators and regulate them under existing powers (SFC HK, 2019). The authority has adopted robust regulatory standards for virtual asset trading platforms which are comparable to ones applicable to licensed securities brokers and automated trading venues (SFC HK, 2019).

In July 2021, the SFK HK issued a warning on unregulated crypto-asset trading platforms, such as Binance. In particular, "stock tokens", defined as tokens representing stocks, and should not be traded on these platforms considering that they are, as securities, regulated financial instruments (Bitcoin.com, 2021).

Cambodia, Lao PDR, Indonesia, Viet Nam and South Korea

ICOs have been banned in three of the AMS: Cambodia, Lao PDR, and Viet Nam, either through specific bans on ICOs or through bans on any crypto-related activity. For example, in Cambodia, any activity involving crypto-assets is illegal.

The State Bank of Viet Nam has declared virtual currencies as illegal means of payment in 2017 (Ngan Hang Nha, 2017). Further, the State Securities Commission has issued a ban on any crypto-asset activity for public companies, securities firms, fund managers and securities investment funds (Viet Nam News, 2018). Nonetheless, USD 9.0 million were successfully raised by ICO issuances in Viet Nam in 2018 and another USD 7.7 million in H1 2019 (OECD, 2020a).

Indonesia has a very developed digital landscape and is currently one of the world's largest e-commerce markets. USD 41 million were successfully raised through ICOs in Indonesia in 2018 (OECD, 2020a). However, Indonesia has not issued guidance on ICOs thus far. In January 2018, Bank Indonesia, the central bank of the country, issued a warning against virtual currencies, such as the Bitcoin, and warned all market participants not to buy, sell or trade crypto-assets (Bank Indonesia, 2018). In June 2018, the Commodity Futures Trading Supervisory Agency (Badan Pengawas Perdagangan Berjankgka Komoditi (BAPPEBTI)) issued a guidance explaining that it considers crypto-assets as commodities that may be traded on futures exchanges (Indonesian Commodity Futures Trading Supervisory Agency, 2018). In January 2021, Indonesia's Commodity Futures Trading Supervisory Body (BAPPEBTI) made public a list of crypto-assets that can be traded in Indonesia (SSEK, 2020) (Mondaq, 2021).

The Bank of Laos issued a warning against crypto-currencies such as Bitcoin in 2018 (The Laotian Times, 2018) and proceeded to declare a full ban in 2019 (Vientiane Times, 2019). USD 5 million were successfully raised by a single unregulated ICO offering in Lao PDR in 2018 (OECD, 2020a).

Legislation has been drafted for the National Assembly in Korea to consider as part of the Korean government's response for promoting regulatory clarity in the industry. In May 2021, bills such as the 'Virtual Assets Act' and 'Act for Fostering the Virtual Asset Industry and Protecting Investors' were submitted by democratic party members in the National Assembly (CoinDesk, 2021d). This is the Korean parliament's first effort toward establishing legal mechanisms to protect investors and the domestic industry in order to remain at pace with the rest of the world. The Korea Financial Services Commission (FSC) announced that it will impose a fine of 100 million won, or USD 89,844, for exchange employees caught trading on the platforms for which they work (CoinDesk, 2021c). There was previously no law that prohibited executives and employees of exchanges from trading crypto-assets on their own platforms. Officials from the Korea Financial Intelligence Unit (FIU) which operates under the FSC met with heads of Korea's major crypto-asset exchanges in June 2021 to inform them of this updated ruling (CoinDesk, 2021d). South Korea's updated Financial Transactions Reports Act (FTRA) requires all crypto-asset exchanges to register with the FIU by 24 September 2021, after meeting registration criteria (CoinDesk, 2021d). These conditions include acquiring partnerships with commercial banks and having their AML and KYC systems approved.

Box 1.6. South Korean City of Seoul's 'S-Coin' crypto

Despite restrictions on trading crypto-assets, Seoul is developing its own crypto-asset called 'S-coin', to be used in city-funded social benefits programs and support advancement of blockchain technology and related start-ups (CoinDesk, 2018). The early signs of Seoul launching its own digital currency were indicated by the government's efforts to supress illegitimate crypto-asset businesses in the region (Seoulz, 2021a). The Korea Financial Services Commission has full authority to monitor all inflows and outflows of crypto-asset in Korea where any suspicious transactions related to money laundering can be prosecuted.

The 'S-coin' project is proposed to be led by the Korean government with the help of Samsung SDS and ICONLOOP (Seoulz, 2021a). The ICON Foundation runs ICONLOOP, which is the country's most successful ICO project where the start-up is looking to create the largest decentralized network through their blockchain protocol, much like Ethereum and EOS (Seoulz, 2021b).

Brunei Darussalam, Myanmar and Cambodia

Autoriti Monetori Brunei Darussalam's (AMBD) has issued a press release on 22 December 2017 advising the public to exercise extreme caution with crypto-assets, such as Bitcoin, as crypto-assets are not legal tender in Brunei Darussalam and are not regulated by AMBD. In April 2018, AMBD issued another press release reiterating AMBD's position on crypto-assets. The activities surrounding crypto-assets could be regulated if they fall under any of the activities regulated in the relevant legislations under AMBD's purview (Autoriti Monetori Brunei Darussalam, 2018).

In Myanmar, at this stage, neither the Central Bank of Myanmar nor any other authority of the country has taken a formal position on ICOs. The Central Bank of Myanmar has, however, issued warning statements against crypto-assets such as Bitcoin (Liwin, 2019).

Crypto-asset activity is prohibited also in Cambodia. The National Bank of Cambodia has reaffirmed in 2017 that the purchase or sale and circulation of any form of crypto-assets is prohibited, in the context of the false information around the National Bank's involvement in the issuance of 'K-coin' (National Bank of Cambodia, 2017). In 2018, the National Bank of Cambodia, the Securities and Exchange Commission of Cambodia and the General Commissariat of National Police issued a joint statement stating that any unregulated crypto-related activity is illegal and warning investors of risks related to the issuance of crypto-assets (National Bank of Cambodia and Cambodia and General Commissariat of National Police, 2018). These included the increased volatility and risk of loss; risks of cybercrime and hacking; risks of money laundering and financing of terrorism; and the lack of customer protection mechanisms for users of such assets. Given such prohibition, only one ICO of a Cambodian-incorporated issuer was recorded in Cambodia in 2017, raising USD 10 million via an unregulated issuance (OECD, 2020a). As mentioned above, unregulated token offerings carry significant risks for participants, given the complete lack of investor and consumer protection safeguards but also taking into account the numerous conflicts of interest that may rise; operational risks; lack of transparency and accountability, among other risks (OECD, 2020a).

China

In 2017, China imposed a comprehensive ban on ICOs and similar token offerings, characterising these activities as illegal fundraising or illegal securities offering (Clifford Chance, 2020). This was confirmed during a forum in 2021 by Huo Xuenwen, a Chinese financial official who maintained that STOs were illegal (Tokenist, 2021a). Though, in May 2021, during a summit, Guo Weimin, the Chief Scientist of Bank of China, said China was preparing to provide a legal framework for STOs. The framework will be issued only after the roll out of the digital yuan (Tokenist, 2021b).

1.4. Policy implications of tokenisation for the financing of SMEs

Unregulated ICO activity and token offerings under uncertain and ambiguous regulatory frameworks, coupled with limitations in the structuring of ICOs and operational risks related to DLT-based networks, expose investors subscribing to ICOs to significant risks given primarily the absence of consumer protection safeguards (OECD, 2020a). Such risks involve market manipulation, pump and dump schemes, AML/CFT risks, limited recourse and consumer protection rights, cyber risks and hacking, as well as operational risks related to the use of DLTs. As market confidence in the underlying DLT technology grows, the potential to create a safer environment for ICO activity in the future is strong. In addition to regulation, best practices that are increasingly driven by the industry could also support a robust and safe ICO market. A delicate balance will need to be achieved in the development or application of regulatory and supervisory requirements that will not deprive the ICO mechanism of its speed and cost benefits, particularly when it comes to smaller size offerings (OECD, 2019).

Clarity in the regulatory and supervisory framework applying to ICOs is arguably a stepping stone to the safer and wider use of token issuance for financing purposes (OECD, 2019). Standardised disclosure requirements are indispensable so as to overcome information asymmetries that are present in the financing of SMEs. Enhanced investor protection for retail investors, coupled with efforts for the financial education of retail investors, can safeguard their informed participation in such offerings. AML/CFT requirements on all ICO issuances are equally important, especially given the wide range of issues observed in the crypto-asset space.

Risk of regulatory arbitrage has indeed been identified by research, while the disproportionate distribution of ICO offerings in a small number of jurisdictions, and may be evidence of such regulatory arbitrage being exploited by issuers (OECD, 2020a). Taxation is another motivation of participants of ICO markets trying to take advantage of regulatory arbitrage opportunities. Given the global nature of ICO issuing and trading across borders, cooperation at the international and regional levels would warrant a coordinated approach that will prevent regulatory arbitrage and allow ICOs to deliver their potential for the financing of blockchain-based SMEs, while also protecting investors (OECD, 2019).

In terms of specific content of the regulation proposed by Malaysia, the Philippines, Singapore, and Thailand, proportionality is applied in the requirements to some ICOs, similar to the ones that certain OECD and some AMS jurisdictions apply to small-sized public equity offerings or placement to a limited number of investors or to accredited investors only (OECD, 2020a). These consist mainly of exemptions from full prospectus requirements based on limitations in the offering value or in the number and type of investors allowed (e.g. similar to the threshold applying in the U.S. equity markets under the JOBS Act). Similar to public equity markets, proportionate, adapted legislation designed for small companies, rather than a simple relaxation of certain listing and reporting requirements for SMEs, has the potential to alleviate cost and other impediments for small issuers, while preserving investor protection and confidence in such instruments (Nassr and Wehinger, 2016).

Any ICO regulatory framework should provide enhanced investor protection for retail investors in particular, coupled with financial education initiatives, so as to safeguard their informed participation in such financing (OECD, 2020a). Policy tools, such as the policy guidance provided by the G20/OECD Task Force on Financial Consumer Protection on Financial Consumer Protection Approaches in the Digital Age, can be useful in ensuring that adequate consumer protection safeguards are in place in jurisdictions with active ICO markets.

Box 1.7. Asian Development Bank's Green Finance Potential

The Paris Agreement emphasised the importance of making financial flows consistent with a pathway toward low greenhouse gas emissions and climate-resilient development with the contribution of nearly 200 signatory members. The World Bank IFC estimates investment of USD 23 trillion are required for climate-smart investments in emerging markets (Asian Development Bank, 2020). It is an ideal time to invest in climate solutions and Asia requires a climate change investment of USD 22.6 trillion between 2016 and 2030 (Asian Development Bank, 2020). Thus far, only 35% of the estimated USD 4 trillion needed annually is available, leaving a USD 2.5 trillion investment gap (Asian Development Bank, 2020). Limited public budgets require innovative financial instruments to accelerate private financing to close this gap.

High transaction costs and minimum investment size are key barriers to implementing green bonds in development countries (Asian Development Bank, 2020). With a volume of over USD 100 million in 2017, the bond market could provide the finance required to close the investment gap. However, green bonds amount to 1.5% of the bond market of climate-aligned bonds (Asian Development Bank, 2020). Blockchain technology has the potential to address the barriers to green finance through the automation of data collection and the Internet of Things (IoT) sensors (Asian Development Bank, 2020). Transaction costs for issuing green assets are significantly higher than traditional assets, which means that the potential of green assets to benefit from blockchain application is high. This can be applied to the creation of green infrastructure in developing economies. Infrastructure is essential to alleviate poverty and generate long-term growth in emerging markets and developing countries (Tian et al., 2020). The potential of tokenisation to improve public finance efficiency and mobilise broader private sources to bridge the widening gap, could improve the development of green infrastructure in developing countries (Tian et al., 2020).

1.5. Tokenisation and the Post-Trade: impact on clearing and settlement

DLT-enabled systems and the use of smart contracts for clearing and settlement of tokenised assets can verify ownership, confirm trade matching and record transactions in an automated, immutable, transparent, and near-immediate way (OECD, 2020b). Part of the inefficiencies in post-trade processes derives from the need of transacting sides of the trade to maintain records of the information around the transaction and reconcile each party's data with the data of the counterparty at each step of the contract execution (Swift Institute, 2016). The use of the blockchain in post-trade allows for the maintenance of a single, shared, immutable ledger of transaction information that is updated at each step of the process and can be instantly accessed by all involved parties.

Blockchain technology can also enhance efficiency in the settlement process, reducing complexity and shortening the settlement cycle to near real-time (T+0) compared to T+3 or T+2 settlement periods currently applying (OECD, 2020b). The use of DLTs could reduce back-office costs and data discrepancies, facilitating the faster reconciliation of data (BIS, 2017). Enhanced efficiency could also be driven by the fact that legal and beneficial ownership in DLT-based clearing and settlement systems is not to be split between investors and nominees (OECD, 2020b). In a typical case of traditional security settlement, the investor will be recorded as beneficial owner while the nominees/brokers will be listed as the legal owner in the ownership records of the CSD (Allen & Overy, 2018). The use of DLTs for clearing and settlement reduces the number of intermediaries involved and streamlines the process of paying or delivering securities to the ultimate beneficial owners.

If tokenisation of assets were to take off, a potential disruption in the market structure could involve the replacement of CSDs by the distributed ledger as a decentralised version of depositories (OECD, 2020b). Similarly, central clearing houses could, in theory, ultimately be made redundant by the use of the blockchain platform itself as the clearing entity, given that transactions would only be executed if both sides of the trade are in place. Trades could effectively be settled through the validation of transactions by participants of the network. A shorter settlement cycle could enhance investor protection by reducing counterparty and principal risks. In addition to lower counterparty risks, investors benefit from a release of capital otherwise held in the form of risk-based margin requirements for central clearing purposes. Such collateral margin requirements could, in theory, be completely eradicated, reducing asset encumbrance for assets pledged, indirectly affecting financial market liquidity (OECD, 2020b). Liquidity would also be directly improved by the faster settlement cycles through the reduced delays in change of ownership of assets.

Both the technical feasibility and the operational savings and cost efficiencies derived from disintermediation in post-trade remain to be fully assessed and quantified through real-life applications (OECD, 2020b). Impediments to the full realisation of the theoretical potential cost efficiencies of DLT-based clearing and settlement may include, for instance, the fact that the application of DLTs in post-trade processes may not be full and comprehensive throughout the process: aspects of the post-trade clearing and settlement may still require back-office reconciliation. In case that other activities that affect securities positions and the payment or delivery of securities, such as securities lending or derivatives, are not based on the same technology, the full scale of efficiencies cannot be realised.

Proof-of-concept projects and experimental application of DLTs on clearing and settlement have produced mixed results in the delivery of efficiency gains. Important hurdles in the development of the technology need to be overcome for the application to arrive at a stage where it can provide better performance than systems currently in use. It should be noted, however, that conventional clearing provides anonymity that is valuable to trading parties and which will have to be given up in near real-time settlement of the blockchain, or replaced by pseudonymity.

1.5.1. The Role of Wholesale CBDCs and Stablecoins

For transaction settlement to be achieved at near real-time and for delivery to be certain in securities transactions (DvP), the securities transacted, and the corresponding payments need to switch simultaneously in what is called ‘atomic settlement’ of tokenised assets (OECD, 2020b). For the payment to be exchanged without potentially lengthy processing times or costly fees involving intermediaries off-the-chain, pilot clearing, and settlement systems, market participants use tokenised forms of central bank money on the blockchain, or stablecoins, for the payment leg of the transaction (OECD, 2020b). This highlights the importance of wholesale CBDCs or stablecoins for the atomic settlement of tokenised assets.

The use of wholesale CBDCs for the payment leg of tokenised asset clearing and settlement may present some perceived advantages compared to stablecoins, as access to the central bank payment infrastructure would reduce credit risk as well as liquidity risk related to the funds required to be held with the commercial bank that would act as the intermediary in a different case (OECD, 2021). The use of private sector stablecoins could introduce risks to the network, and in particular counterparty risk related to the issuer of the stablecoin (OECD, 2021). Private initiatives may lack proper audit and assurance over the availability of the funds backing the stablecoin, and users are exposed to all kinds of operational or other risks derived from the counterparty. The regulatory treatment of stablecoins also differs, affecting the willingness of bank participants to hold the stablecoin overnight and thus book it into their balance sheet.

1.5.2. Pilots for the settlement of tokenised assets with tokenised forms of central bank money

Project Helvetia (BIS)

Project Helvetia is a joint experiment by the BIS Innovation Hub (BISIH) Swiss Centre, SIX Group AG (SIX), and the Swiss National Bank (SNB), exploring the integration of tokenised assets and central bank money on SIX SDX platform (BIS, SIX Group AG and Swiss National Bank, 2020). Two proof-of-concepts (PoCs) for settling tokenised assets were conducted: (i) issuing a novel wholesale central bank digital currency (w-CBDC) and (ii) building a link between the new securities settlement platform of SDX and the existing central bank payment system. Project Helvetia published the results of the first two proof of concepts in December 2020, announcing that the experiments confirmed both PoCs as realistically as possible. Specifically, both PoCs used the testing environment of live or near-live systems, and transfers were shown to be legally robust. In particular, the experiment consisted of the SNB issuing a Swiss franc w-CBDC onto a near-live DLT test platform and, together with SIX, building a link from the Swiss RTGS test system to the same platform. Detailed analysis showed that settlement in both approaches is legally feasible and robust. Project Helvetia's next steps will be to seek a deeper understanding of the practical complexities and policy implications of issuing w-CBDC, by introducing even more realism into the project and exploring in more detail the different trade-offs that different design choices yield.

Wholesale CBDCs are intended for the settlement of interbank transfers and related wholesale transactions where they serve the same purpose as reserves held at the central bank with additional functionality (BIS, 2021a). One example is the conditionality of payments, whereby a payment only settles if certain conditions are met. This could encompass a broad variety of conditional payment instructions which goes beyond today's delivery-versus-payment mechanism in real-time gross settlement (RTGS) systems (BIS, 2021a). In effect, wholesale CBDCs could make central bank money more programmable, support automation and mitigate risks. Further, they would be implemented on new technology stacks where this clean-slate approach would let wholesale CBDC systems be designed with international standards in mind to support interoperability (BIS, 2021a). These state-of-the-art approaches are exemplified in Project Helvetia which demonstrates the feasibility of settling digital assets in central bank money (BIS, 2021a). Compared to wholesale CBDCs, however, a more far-reaching innovation is the introduction of retail CBDCs. This instrument modifies the conventional two-tier monetary system in that it makes central bank digital money available to the general public, just as cash is available to the general public as a direct claim on the central bank (BIS, 2021a).

Project Stella: Bank of Japan and European Central Bank

The use of DLT for financial market infrastructures is analysed in joint research Project Stella between the Bank of Japan (BoJ) and the European Central Bank (ECB). The joint work is being conducted at conceptual level and through practical experimentation with the technology as the project aims to contribute to the ongoing broader debate around the potential usability of DLT (ECB and BoJ, 2019). The project does not aim to explore legal aspects or replace existing central bank services with DLT-based solutions. In September 2017, the first findings of Project Stella were published where the analysis focused on efficiency and safety aspects of the operation of payment system functionalities in a DLT environment. Although there were promising results and valuable insights into the DLT functioning, the technology was noted as unviable for large-scale payment services such as BOJ-NET and TARGET2.

The second phase of Project Stella explored the delivery of securities against cash and how they could be conceptually designed and operated in a DLT environment (ECB and BoJ 2018). The experiment draws on existing delivery-versus-payment (DvP) approaches and innovative solutions currently being discussed for DLT. In order to gain a practical understanding of DvP functioning on DLT, prototypes were developed using three DLT platforms: Corda, Elements, and Hyperledger Fabric. The second phase of the project

concluded that DvP can run in a DLT environment subject to the specificities of the different DLT platforms. Moreover, DLT offers a new approach for achieving DvP between ledgers, which does not require any connection between ledgers. Lastly, the design of cross-ledger DvP arrangements on DLT may entail and their complexity could give rise to additional challenges that would need to be addressed such as transaction speed.

The third phase of Project Stella examines how cross-border payments could potentially be improved by new technologies, especially in terms of safety (ECB and BoJ, 2019). The report considers the credit risk if one of the parties to the payment fails before the cross-border transfer is complete. After experimenting with several types of payment method, the report concludes that only payment methods with an enforcement mechanism, either through the ledger itself or through a third party, can ensure the safety of the principal amount of money being transferred. This is in contrast to the two previous phases which focused on large-value payments processing using DLT and securities delivery-versus-payment in a DLT environment.

The fourth and last phase of Project Stella explores innovative solutions to cross-border payments between currency areas and expands discussion on balancing confidentiality and auditability of transactions for practical application (ECB and BoJ, 2020). The results of this stage can be used as a starting point for choosing privacy enhancing technologies or techniques (PETs) and designing auditing processes for transactions. PETs can be divided into three categories based on the underlying concept for making transaction information confidential to third parties, including: segregating PETs ensure that each participant can only view a subset of all transactions conducted on the network, hiding PETs make use of cryptographic techniques to prevent third parties from interpreting transaction details, and unlinking PETs makes it difficult for third parties to determine transacting relationships from the sender/receiver information recorded on the ledger. Stella stage four proposes three key perspectives for assessing the auditability of each PET setup, including: accessibility to the necessary information to determine whether the auditor can obtain, with certainty, the information it needs to conduct auditing activities; reliability of the obtained information to determine whether the auditor can interpret confidential transaction information with certainty using the obtained information; and efficiency of the auditing process to determine whether the auditing process could be conducted in a manner efficient enough for it to be feasible. Lastly, phase four of Project Stella raises points for further consideration when expanding the discussion on balancing confidentiality and auditability of transactions for practical application such as relying on a trusted source point, single point of failure risks for the network, coordination of different standards between systems, and managing the confidentiality of end-user information (Moody's Analytics, 2020).

Projects Ubin and Jasper

Project Ubin in Singapore is an example of the use of tokenised currency for DvP in securities settlement. A group of banks, supported by the Monetary Authority of Singapore (MAS) has deployed a payment system prototype using DLT in which bank users can exchange currency on the blockchain, placing a tokenised form of the Singapore Dollar (SGD) on a DLT (MAS and Deloitte, 2017). The resulting digital representation of the SGD or 'SGD-on-ledger' is a specific limited-use coupon issued on a one-to-one basis in exchange for money, with the only purpose of serving in the settlement of interbank debts and with no value outside of this purpose. Each token represents a binding claim on central bank's currency and is fully backed by an equivalent amount of SGDs held in custody, while ledger holdings do not receive interest, unlike money in bank accounts.

MAS announced Project Ubin on 16 November 2016 stating that it will be partnering with R3, a DLT company, and a consortium of financial institutions, on a proof-of-concept project to conduct inter-bank payments using Blockchain technology (MAS, 2020). The consortium included the following institutions: Bank of America Merrill Lynch, Credit Suisse, DBS Bank, Hong Kong and Shanghai Banking Corporation (HSBC) Limited, JPMorgan, Mitsubishi UFJ Financial Group, OCDB, R3, Singapore Exchange (SGX), and

United Overseas Bank (UOB). Phase one successfully concluded on 9 March 2017 where Deloitte was commissioned to produce a report that covers the aspects of DLT found to be most suited to settlement systems and details the design principles used for the prototype (MAS, 2020).

MAS and the Association of Banks in Singapore (ABS) announced on 5 October 2017 that the consortium which they are leading had successfully developed software prototype of three different models for decentralised inter-bank payment and settlements system with liquidity savings mechanisms (MAS, 2020). MAS and Singapore Exchange (SGX) announced phase three of the project on 24 August 2018 stating the two organisations are collaborating to develop DvP capabilities for settlement of tokenised assets across different blockchain platforms (Monetary Authority of Singapore, 2020). This will allow financial institutions and corporate investors to carry out simultaneous exchange and final settlement of tokenised digital currencies and securities, improving operational efficiency, and reducing settlements risks (MAS, 2020). Three companies including Anquan, Deloitte, and NASDAQ were appointed as technology partners for this project where they leveraged the open-source software developed and made publicly in Project Ubin phase two.

Project Ubin was inspired by another project for inter-bank payments developed by the Bank of Canada, Project Jasper. The third phase of Project Jasper demonstrated that a DLT-based system can functionally address the steps required to execute an irrevocable settlement of equities against central bank cash (Bank of Canada, 2018). This included the successful implementation of a DvP settlement flow of cash and equities between counterparties on a shared ledger. In the context of this project, both cash and equity were tokenised according to a digital depository receipt (DDR) model, and the ensuing tokens represented secure digital claims for the underlying assets on deposit at the token issuer. The cash tokens represented a claim on Canadian dollar deposits held in accounts at the Bank of Canada, while the equity tokens represented a claim issued by Canadian Depository for Securities (CDS) for the underlying equity held at CDS.

On 15 November 2018 the Bank of Canada (BoC), Bank of England (BoE), and MAS jointly published a report assessing alternative models that could enhance cross-border payments and settlements, improving the speed, cost, and transparency for users (MAS, 2020). MAS and BoC linked their experimental domestic payment networks, Project Ubin and Project Jasper, respectively, and announced on 2 May 2019 that a successful experiment on cross-border and cross-currency payments using central bank digital currencies was established, marking the completion of stage four of project Ubin.

In the example of the Jasper proof-of-concept, participants are required to be members of the Payment Canada Large Value Transfer System (LVTS) in order to tokenise cash, and members of the Canadian Depository for Securities (CDS) to be able to tokenise equity. Members of the LVTS can obtain cash tokens from the Bank of Canada by pledging cash from their existing account at the Bank, which the Bank of Canada transfers to a pool account. Similarly, CDS members can obtain equity tokens from CDS by pledging the given equity in their CDS account and redeeming these tokens at CDS in exchange for receiving the underlying equity in their account. This approach ensures that the amount of cash and equity on-chain equals, and is backed by, the same amount in the corresponding off-chain pool at all times.

What Project Jasper has proven is that a shared ledger for cash and securities performs better than CDS and LVTS systems and requires lower liquidity to settle positions. In particular, the pilot demonstrated that the tokenisation of both cash and equities on a shared ledger resulted in better asset interactions during DvP settlement relative to the siloed CDS and LVTS systems. Immediate finality of settlement resulted in the ability to instantly reuse cash and equity tokens, which in theory supports liquidity efficiency, in that the system only required the minimum amount of liquidity necessary to settle each net position with true finality (Bank of Canada, 2018).

On 13 July 2020, MAS and Temasek jointly released a report to mark the successful completion of the fifth and final phase of Project Ubin (Monetary Authority of Singapore, 2020). Phase five continued the work from the previous phase, which was focused on cross-border payments, and explored the development of

a multi-currency, broad-ecosystem payments model, providing connectivity interfaces for other blockchain networks to connect and integrate seamlessly. It also allowed for additional features to support use-cases such as DvP with private exchanges, conditional payments and escrow for trade, and payment commitments for trade finance (MAS, 2020). Beyond the technical experimentation, phase five also aimed to explore and prove the business value of a blockchain-based payments network such as in enabling business opportunities that would benefit from or be made viable through greater cost efficiencies as compared to existing systems (MAS, 2020).

Box 1.8. Project Partior

Following experience gained during project Ubin, several of the former participants in the project teamed up to create a real world Blockchain-based payment platform. On April 2021, JP Morgan Chase, Temasek, Singapore's wealth fund, and DBS, a Singapore based bank, announced the establishing of Partior, a market based initiative that will digitize M1 commercial bank money for the purpose of processing cross-border payments (Bloomberg, 2021). The platform is designed as a global shared ledger. Its aim is "to disrupt the traditional cross-border payment" by offering near instantaneous and compliant settlement and clearing (Partior, 2021). Partior will be recording transfers on "permissioned" blockchain ledgers, where only members can validate transactions. The payment will be transparent and "programmable" (Economist, 2021). Recently, Partior has announced its first pilot where Bahrain's ABC Bank, Partior's first external partner, will be connecting to the network. During the announcement on the pilot, Partior's CEO gave a three to five-year timeframe for mass adoption of the network (LedgerInsights, 2021b).

MAS has continued to form partnership with central banks. In July 2021, MAS partnered with the French central bank and succeeded in a wholesale cross-border payment and settlement experiment using CBDCs. It relied on JP Morgan's Onyx blockchain. This is the first multi-CBDC experiment that applied automated market making and liquidity management capabilities (BusinessTimes, 2021).

Project Dunbar

Project Dunbar explores different governance and connectivity models for cross-border transactions using multi-CBDCs that could form the basis of a future international payment and settlement network. This is a joint project by the BIS Innovation Hub and MAS which aims to work with central banks, financial institutions, and technology partners (BIS, 2021b).

The work builds on Project Ubin and will focus initially on the development of a common platform for multi-CBDC settlement that fulfils the needs and requirements of central banks and financial institutions. Whereas Project Ubin demonstrated the possibility of a domestic multi-currency settlement platform managed by commercial banks, Project Dunbar will aim to explore how multi-CBDC platforms can be designed and developed as international settlement platforms, cooperatively managed by the global central banking community as a public good (MAS, 2021). The model of a multi-CBDC on a common platform may be useful for regions where requirements and payment policies are already similar, and a common application may be more cost-effective (MAS, 2021). In this scenario, there will still be fragmentation with multiple regional platforms in addition to single-jurisdiction single-currency platforms.

The project will work with ecosystem partners, including those that have implemented, or are implementing, live technology solutions for digital currencies, to develop platform prototypes that enable the purchase, exchange, transfer, and redemption of CBDCs in a shared test environment (BIS, 2021b). The intermediate goal of the project is to design, build, and test the architecture as applied to a regional

multi-CBDCs network with multiple banks (MAS, 2021). New opportunities will be explored in this project, made possible through smart contracts and multi-CBDCs such as mechanisms and algorithms that enable more efficient matching and settlement of foreign exchange transactions (BIS, 2021b).

If countries were to issue CBDCs, interoperating CBDC and multi-CBDC would mean improving the cross-border payment opportunities, which is especially relevant for emerging economies poorly served by the existing correspondent banking arrangements (BIS, 2021c).

Globally, coordinated policy action is required for CBDCs in order to establish common technical standards such as message formats, cryptographic techniques, data requirements, and user interface (BIS, 2021c). This can reduce the operational burden of participating in multiple systems and experience shows that it takes years to coordinate participants in complex markets to move towards common standards or legal frameworks (BIS, 2021c). Legal and regulatory compatibility for multi-CBDC is cited as the greatest challenge for cross-border payments by banks and payment service providers and efforts are underway to reduce unintentional barriers.

Project Aber (Saudi Central Bank and Central Bank of the U.A.E.)

Project Aber was an initiative launched by the central banks of Saudi Arabia and United Arab Emirates to explore the viability of a single dual-issued digital currency as an instrument of domestic and cross-border settlement between the two countries (Central Bank of the U.A.E. and Saudi Central bank, 2021). The project was structured into three distinct phases or use cases: (i) to explore cross-border settlement between the two central banks, (ii) to explore domestic settlement between three commercial banks in each country and (iii) to explore cross-border transactions between the commercial banks using the digital currency. The project confirmed that a cross-border dual issued currency was technically viable and that it was possible to design a distributed payment system that offers the two countries significant improvement over centralised payment systems in terms of architectural resilience. The project has confirmed the viability of DLT as a mechanism for both domestic and cross-border settlement and confirmed the technical viability of a single digital currency issued by both central banks (Central Bank of the U.A.E. and Saudi Central bank, 2021).

1.6. Case studies of tokenisation in Asia

The crypto-asset and tokenisation space has experienced the emergence of a business ecosystem across the world. This section presents business cases across Asia that demonstrate the emergence of exchanges and digital bonds through the collaboration of private and public actors.

Singapore issues first digital corporate bond pilot in Asia

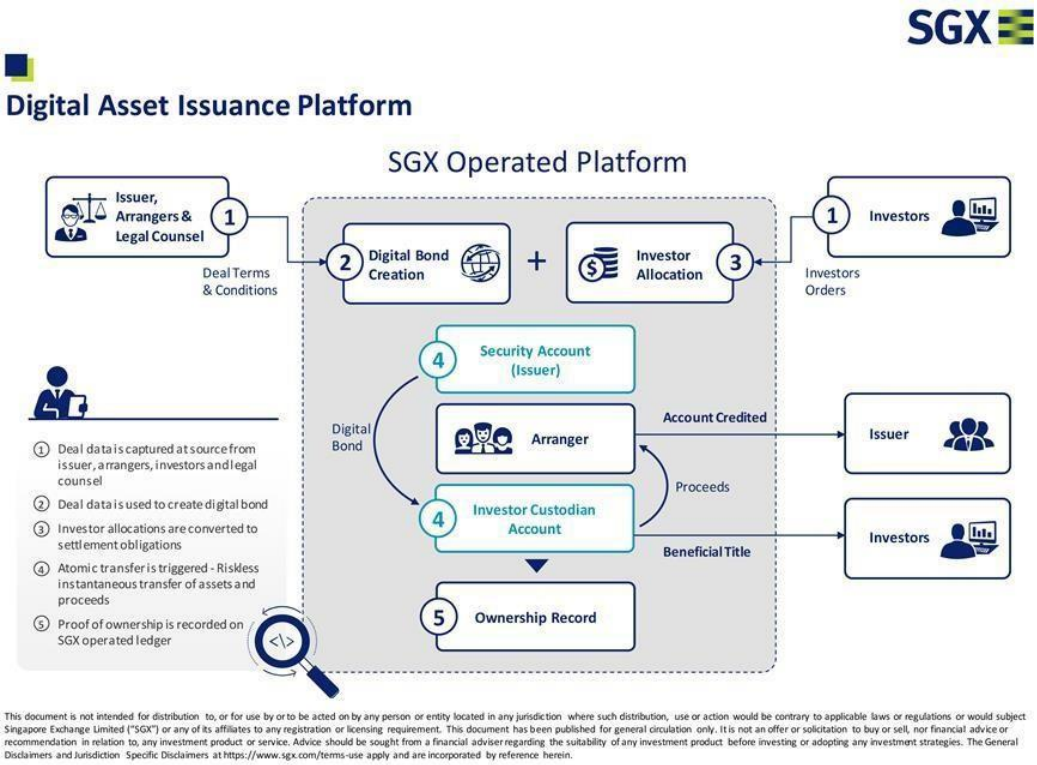
In September 2020, SGX in collaboration with HSBC and Temasek, completed the first pilot of issuing a digital syndicated corporate bond in Asia (SDX, 2020). SGX's digital asset issuance, depository and servicing platform was used to launch and settle in parallel a SDG (Singapore Dollar) 400 million 5.5-year public bond issue and a follow-on SGD100 million tap of the same issue by Olam International.

SGX utilised DAML, the smart contract language created by Digital Asset, to model the bond and its distributed workflows for issuance and asset servicing over the bond's lifecycle. SGX's solution used smart contracts to capture the rights and obligations of parties involved in issuance and asset servicing, such as arrangers, depository agents, legal counsel and custodians. The digital bond used HSBC's on-chain payments solution, which reportedly allowed for seamless settlement in multiple currencies to facilitate transfer of proceeds between the issuer, arranger, and investor custodian.

Key efficiencies that were observed within the pilot include timely ISIN (identifier) generation, elimination of settlement risk (for issuer, arranger, and investors), reduction in primary issuance settlement (from 5 days to 2 days) as well as automation of coupon and redemption payments, and registrar functionality.

In response to the first digital corporate bond pilot launched by SGX, other banks followed with their own projects. In December 2020, 1-Singapore DBS Group Holdings, Southeast Asia's largest bank, launched a digital exchange that will provide tokenisation, trading, and custody services to institutional and accredited investors (Reuters, 2020). The DBS Digital Exchange will use blockchain technology to provide a platform for fundraising through asset tokenisation and secondary trading of digital assets.

Figure 1.4: SGX Digital Asset Issuance Platform



Source: SGX.

China Construction Bank Issues USD 3 billion in bonds tradable for Bitcoin

In November 2020, the China Construction Bank (CCB) tapped Labuan-based digital asset exchange Fusang for the issuance of USD 3 billion worth of debt securities over a blockchain (CoinDesk, 2020). Tokenised bond certificates were issued through the state-owned bank Lauban's Malaysia branch over a period of three months (CoinDesk, 2020). Notably, the digital securities are exchangeable for Bitcoin on the Fusang exchange, as well as U.S. dollars. Trading of the financial instrument began in November 2020. If the project is successful, Fusang intends to work with the 'Big Four' Chinese banks on the issuance of certificates in other currencies, including the yuan (CoinDesk, 2020).

CCB is the second-largest bank globally measured by market capitalisation and the blockchain issuance allows it to reduce the costs associated with financial intermediaries (CoinDesk, 2020). It will also offer the debt instruments at lower amounts to make them accessible to retail investors. Chinese bonds usually trade for tens of thousands of yuan, meaning they are mainly accessible to institutional and professional investors. These bonds are defined as tradable debt securities issued by a government or company to

support spending obligations. The bank aims to reduce the investment barrier to entry by making certificates available for a minimum of USD 100 (CoinDesk, 2020). They will offer approximately 0.75 percent yield at maturity, higher than the average 0.25 percent annum at other banks (CoinDesk, 2020).

Japan's SBI Group Broadens Investor Access

Japanese financial services provider SBI aims to be the regional entry point to crypto-assets, and has acquired London-headquartered B2C2, a dealer in the crypto-asset class (Nikkei Asia, 2020). SBI Group is the largest internet financial group in Japan, allowing it to bring together a large customer base with the expertise of B2C2 in order to mature the crypto-asset market (Nikkei Asia, 2020). Since the partnership emerged, SBI has seen daily volumes increased tenfold on its digital exchange, while B2C2 has observed a quadrupling of OTC volumes (Nikkei Asia, 2020). For growth, both are looking to expand services into crypto-asset options and derivatives and allow SBI clients to borrow and lend crypto-assets on B2C2's electronic funding platform (Nikkei Asia, 2020).

In March 2021, Sumitomo Mitsui Trust Bank has completed its first security token issuance pilot. The operation was rated "a-1" by the Japan's leading credit service Rating and Investment Information. The security tokens are compliant with Japan's Financial Instruments and Exchange Act (FIEA). The trial is conducted on the platform Securitize Japan, a unit of the Californian based company Securitize Inc. (Nasdaq, 2021)

Thailand's Kasikorn Bank (KBank) Furthering Intermediary Bypass

Thailand's fourth-largest bank by assets - Kasikorn Bank - is furthering the exploration of a project that seeks to bypass financial intermediaries using decentralised finance in an effort to grow business (CoinDesk, 2021e). In collaboration with the Stock Exchange of Thailand, the project, known as Kubix, has been set up to run as an ICO portal for digital tokens (CoinDesk, 2021e). The project uses smart contracts built on blockchain technology to allow users to lend and borrow funds without relying on brokerages, exchanges, or banks to provide traditional services.

Malaysia's proof of concept for Tokenised Bonds

In July 2020, the Bursa Malaysia announced a proof-of-concept for tokenising bonds at its subsidiary Labuan International Financial Exchange (LFX), an existing bond market where most of the listings are denominated in US dollars. The trial was made in partnership with Singapore-based Hashstacs, who participated in the Singapore's project Ubin (LedgerInsights, 2020)

1.7. Emerging policies and regulatory approaches to tokenisation in Asia

1.7.1. Regulatory approaches to tokenisation

Policy makers in different jurisdictions have approached tokenisation in different ways, either by applying existing rules to tokenised assets, or by introducing new, tailor-made, regulatory frameworks to accommodate the application of DLTs in financial services and provide regulatory clarity for specific processes/products or actors involved in asset tokenisation (OECD, 2021). The difference amongst policy responses could be explained by the different development stage of the market for tokenised assets and its pace of evolution, and corresponding risks identified in the market; the financial architecture and the structure of the financial regulation; and the overall strategy vis-à-vis FinTechs adopted in each jurisdiction. For example, some blockchain-based products that are positioned at the intersection of payments, regulated securities markets and FMIs may require coordination by authorities involved at the national level. Similarly, competition issues are not necessarily included in the mandate of the financial regulator in

many jurisdictions, so cooperation at the national level is required. Importantly, given the global nature of markets for tokenised assets, collaboration at the international level is of essence.

It should be highlighted that the approaches taken by different jurisdictions, some of which are presented in this section, are not mutually exclusive; regulators may combine various elements of different policy approaches in the way they address asset tokenisation, participants of tokenised markets and risks arising in these markets. Therefore, the following sub-sections do not intend to classify approaches into categories, but rather to describe elements and characteristics of jurisdictional approaches to asset tokenisation and which can co-exist in a number of cases.

Most jurisdictions with active tokenised markets adopted thus far a technology-neutral approach to regulation for financial services, which they also applied to tokenised assets and their markets (e.g. European Commission, UK FCA, U.S. Regulators) (OECD, 2021). Under a technology-neutral principle, the regulatory perimeter and the subsequent treatment of financial products/services and activities are not influenced by the technological medium through which the product/service or activity is provided (OECD, 2021). As such, the use of DLTs or other technology does not affect the way these regulators assess whether or not the ensuing financial product/service or activity falls within the regulatory perimeter or not, and by consequence, whether it is regulated or unregulated (OECD, 2021).

DLT allows the creation of native tokenised securities and the tokenisation of existing securities. In some jurisdictions, tokenised securities could be described as a form of cryptography-enabled dematerialised securities that are based and recorded on decentralised ledger powered by DLTs, instead of electronic book-entries in securities registries of central securities depositories (OECD, 2020b). Tokenisation in these jurisdictions could therefore be seen as merely replacing one digital technology with another where requirements are set without having any specific technology in mind (OECD, 2021).

Industry participants, investors and financial consumers have argued that outdated regulation or even taking a technology-neutral regulatory approach might be hampering the expansion and development of tokenisation (Symposium on Digitalisation and Finance in Asia, 2021). Greater clarity around the regulatory and supervisory frameworks applied to tokenised assets and markets would assist the development of fair and sound markets for such instruments (OECD, 2021). Market participants may not fully and correctly understand whether and how tokenised assets fall within the regulatory perimeter, or have intentionally attempted to avoid compliance with existing laws, thereby exposing themselves to risks, potentially engaging in illegal activities, and undermining the smooth functioning of such marketplaces (OECD, 2021). In some jurisdictions, the existence of a requirement to use a central depository for security trading is unsuitable for DeFi (Symposium on Digitalisation and Finance in Asia, 2021). As with all financial instruments, guidance and clarifications on the regulatory perimeter and applicable regulations can help protect financial consumers and other market participants, while promoting market integrity. This was particularly the case at the early stages of development of tokenisation activity through ICOs, when guidance, positions, warnings and clarifications were issued by a vast number of jurisdictions, and in many cases reminding participants that their activities were (or could potentially be) subject to the pre-existing regulatory regime.

The demand from retail investors to have access to tokenised products raises the question of the appropriate definition of “accredited investors”. Often, regulators restrict investment in exotic or non-traditional vehicles to individuals with minimal personal wealth or to financial institutions. This approach assumes that this type of investors are more informed and thus less in need for consumer protection defences from the government. Regulators also assume that such investors have the financial capacity to absorb high losses. When it comes to digital finance, many of the times demand for participation comes not from wealthy investors but rather from digitally informed and educated investors that do not meet the definition of “accredited investors” in the traditional approach. Thus, further expansion of tokenisation also depends on regulators’ willingness to consider alternative definitions for accredited investors” (Symposium on Digitalisation and Finance in Asia, 2021).

1.7.2. Potential of tokenisation to enhance financial inclusion in Asia

Tokenisation could enhance access to finance for SMEs by potentially allowing any type of investor, including retail ones, to indirectly, or directly, fund SME projects (OECD, 2020b). The flow of private financing from capital owners to small corporates could be facilitated, allowing for a more efficient allocation of capital within the economy and increasing inclusiveness not just for the investor side but also for seekers of capital unable to access capital markets otherwise (OECD, 2020b).

Tokenisation has the potential to allow for wider inclusion because of lower transaction costs and initial minimum investment sizes, unlocking access to a wide range of assets for a new demographic of investors; Asia is an ideal springboard to test such projects. Tokenising assets has the potential to open up new investment opportunities to a wider audience (e.g. through fractionalisation of investment) and provide additional alternative channels of financing for the underbanked or unbanked parts of the population. The Asia Pacific region will be responsible for the majority of the 2.3 billion new members of the middle class entering the global economy (HSBC Bank, 2020). The bulk of this growth will come from the developing markets of China, India, and throughout South-East Asia.

Moreover, the region is home to the highest number of internet users which is the demographic most comfortable with using crypto-assets, and cashless payments (HSBC Bank, 2020). This growing, young, middle-class group is the ideal target for projects related to tokenisation and inclusive investment opportunities. At the same time, the Asian region has also experienced rising income inequality as the Gini coefficient for Asia is higher than the average for the rest of the world. The rapidly growing digital accessibility, primarily through smartphone ownership, allows this region to have significant investment potential that can be unlocked through DLT applications.

Given the potential of tokenisation to enhance financial inclusion in Asia, it important for policy makers in the Asian region to support the development of such innovative mechanisms in a safe manner. As decentralised finance and markets for tokenised and crypto-assets develop and grow in size and importance, policy makers have a role in ensuring that the safeguards present in traditional financial markets will equally apply in DLT-based systems and networks, with a view to protecting investors and financial consumers, safeguarding financial stability, while promoting market integrity (OECD, 2020b). Given the global, cross-border nature of DLT-based transactions and products, further policy dialogue and international collaboration efforts are warranted.

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2 Artificial intelligence in Finance

2.1. Introduction[3]

Artificial intelligence (AI) is defined as machine-based systems with varying levels of autonomy that can, for a given set of human-defined objectives, make predictions, recommendations or decisions using massive amounts of alternative data sources and data analytics referred to as 'big data' (OECD, 2021a). Machine learning (ML) models can learn from big data to 'self-improve' without being explicitly programmed by humans.

First academic studies on AI date back to the 1950s; however, the innovation has recently gained popularity due to three main factors: the growing volume of digital data available; availability of data storage and computational processing capacity and a lower cost; and progress made on algorithms used (Laney, 2001). ML models use massive amounts of alternative data sources and data analytics, referred to as 'big data'. Big data analytics refers to the process of collecting, organising, and analysing large amounts of raw data to discover trends and patterns that can help make data-informed decisions (ADB, 2021). Key characteristics of big data include the '4Vs': volume (scale of data); velocity (high-speed processing and analysis of streaming data); variety (heterogeneous data), and veracity (certainty of data, source reliability, truthfulness), as well as other qualities including exhaustivity, extensionality, and complexity (OECD, 2019c; IBM, 2020).

Greater data availability allows ML models to perform better because of their ability to learn from the data fed into the models in an iterative process referred to as training the model. The collection and storage of big data has been facilitated by cloud computing, which allows larger storage capacity, faster computing power, and flexible scaling of resources without the need for on-premises hardware. In addition, the process of analysing big data requires new data analysis methods such as data mining, predictive analytics, and deep learning.

In the financial sector, AI adoption has deepened in areas such as asset management, algorithmic trading, credit underwriting or blockchain-based financial services (OECD, 2021a). This includes embedding AI tools in products/services within retail and corporate banking (tailored products, chat boxes for client service, credit underwriting and scoring, credit loss forecasting, AML and fraud monitoring and detection, customer service); asset management (robo-advice, management of portfolio strategies, risk management); trading (algorithmic trading); and insurance (robo-advice, claims management). AI models are currently being used in financial services as decision-supporting tools rather than fully automated functions with execution permissions.

AI has been leveraged by authorities for RegTech and SupTech applications (e.g. natural language processing or NLP, compliance processes) (OECD, 2021a). FinTech, RegTech, and Suptech are strategic concepts in the financial sector, each one with its own perspective and approach to support the development of sound policies (Zeranski & Sancak, 2020). RegTech is often regarded as a subset of FinTech that focuses on facilitating regulatory compliance more efficiently and effectively than existing

[3] This chapter is based on (OECD, 2021a).

capabilities (Financial Stability Board, 2020b). By making compliance less complex, RegTech solutions could free capital to put to more productive uses, increase competition by removing barriers to entry, improve the quality and efficiency of supervision, and reduce potential risks (Zeranski & Sancak, 2020). Lastly, SupTech refers to the use of new technologies for authorities' internal supervisory purposes (BIS, 2018). The ability of AI to recognize behavioural patterns can increase the efficiency of regulation; while individuals can often refrain from bluntly violating regulatory thresholds, AI models are theoretically able to identify irregular behaviour indicative of non-compliance.

Given the potentially transformative effect of AI on certain markets, as well as the new types of risks stemming from its use, AI has become a policy priority for the past few years (OECD, 2021a). There is growing debate on how regulators and supervisors can foster innovation while ensuring that risks stemming from the use of AI in financial services can be mitigated (OECD, 2021a). In this context, on May 2019, the OECD adopted its Principles on Artificial Intelligence, the first international standard for the responsible stewardship of trustworthy AI, with guidance from a multi-stakeholders expert group (OECD, 2021a).

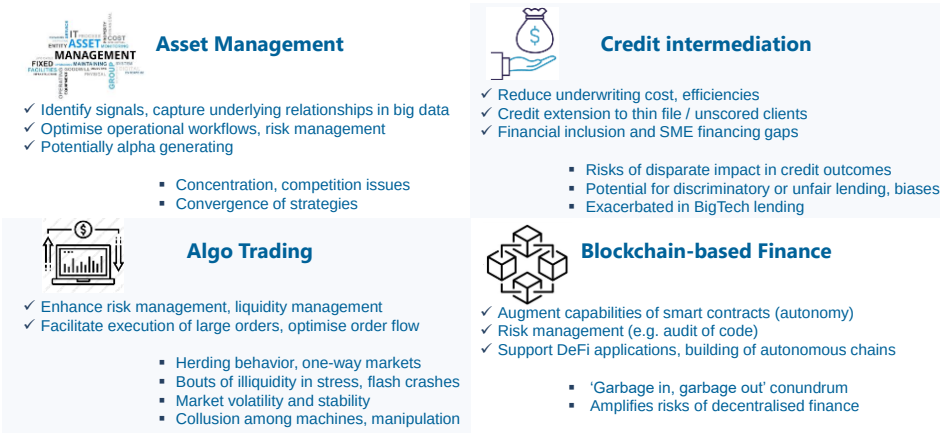
This chapter examines the ways AI/ML and big data could affect certain financial sector areas and how innovative mechanisms are transforming business models. It analyses benefits and associated risks from the deployment of such innovative technologies in finance in the Asian region in particular; and provides insights into regulatory and other policy activity in the Asian region and beyond.

2.2. AI in finance: use cases and business models

The adoption of AI/ML and big data by financial sector companies is expected to drive firms' competitive advantage, through improving firms' efficiency by reducing costs, and enhancing the quality of financial services products demanded by customers. Notably, when analysing the adoption of AI in finance, there is a 'flywheel' effect that rewards early movers with the potential to establish barriers to entry (Cambridge Judge Business School, WEF, 2019). This effect will redefine the establishment of successful business models in the financial sector, increasing the likelihood of 'winner-takes-all' dynamics (Cambridge Judge Business School, WEF, 2019).

This section provides an overview of the possible impact that the increasing deployment of AI in finance could have on specific lines of activity and the respective business models. Namely, the chapter looks into asset management, trading and blockchain-based financing.

Figure 2.1. Impact of AI on business models and activity in the financial markets



Source: OECD (2021a).

2.2.1. Portfolio allocation by asset managers and the broader investment community (buy-side)

The use of AI and ML in asset management has the potential to increase the efficiency and accuracy of operational workflows, enhance performance, strengthen risk management, and improve the customer experience (Blackrock, 2019; Deloitte, 2019). Natural Language Generation (NLG), a subset of AI, can be used by financial advisors to 'humanise' and simplify data analysis and reporting to clients (Gould, 2016). In terms of operational benefits, the use of AI can reduce back-office costs of investment managers, replace manually intensive reconciliations with automated ones, and potentially reduce costs while increasing speed (OECD, 2021a). The most common area for firms to use AI is risk management, followed by the generation of revenue potential (Cambridge Judge Business School, WEF, 2019).

AI allows asset managers to digest vast amounts of data from multiple sources and unlock insights to inform their strategies in very short timeframes, as well as to dynamically adjust such strategies. Feeding ML models with big data can provide asset managers with recommendations that can influence portfolio allocation and/or stock selection (OECD, 2021a). While traditionally, structured data was at the core of every strategy, now vast amounts of raw or unstructured/semi-structured data are promising to provide a new informational edge to investors deploying AI in the implementation of their strategies (OECD, 2021a).

AI use by hedge funds

The use of AI/ML and big data may be reserved to larger asset managers or institutional investors who have the capacity and resources to invest in AI technologies, possibly introducing a barrier for the adoption of such techniques by smaller actors (OECD, 2021a). This could potentially reinforce the trend of concentration in a small number of larger players in the hedge fund industry (Financial Times, 2020a). Restricted participation by smaller players would persevere until the industry reaches a point where such tools become ubiquitous or provided as a service by third party vendors (OECD, 2021a).

Nevertheless, the use of the same AI models by many asset managers could lead to herding behaviour and one-way markets, which may raise potential risks for liquidity and the stability of the system particularly in times of stress (OECD, 2021a). Market volatility could increase through large sales or purchases executed simultaneously, giving rise to new sources of vulnerabilities. In fact, a class of 'AI pure play' hedge funds has emerged in recent years, whose operation is entirely based on AI and ML (e.g. Aidiyia Holdings, Cerebellum Capital, Taaffeite Capital Management, and Numerai) (BNY Mellon, 2019).

2.2.2. Algorithmic trading

Algorithmic trading is the use of computer algorithms to decide on trades automatically, submit orders, and manage those orders after submission (OECD, 2019b). The popularity of algorithmic trading has grown dramatically over the past decade, and it now accounts for most trades put through exchanges globally (OECD, 2019b). In 2017, JPMorgan estimated that just 10% of trading volume in stocks was regular stock picking (OECD, 2019b). Given today's interconnectedness between asset classes and geographies, the use of AI allows for predictive capacity that is fast outpacing the power of even conventional algorithms in finance and trading (OECD, 2021a). AI-enabled systems in trading can also assist traders in their risk management and in the management of the flow of their orders. For example, AI-based applications can track the risk exposure and adjust or exit the position depending on the needs of the user, in a fully automated manner without the need for reprogramming, as they train on their own and adapt to changing market circumstances without (or with minimal) human intervention (OECD, 2021a).

In practice, AI is currently used to extract signal from noise in data and convert this information into decisions about trades (OECD, 2021a). At this stage, ML-based models are therefore not aiming at front-running trades and profit from speed of action, such as High Frequency Trading (HFT) strategies (OECD, 2021a). Instead, they are mostly confined to being used offline, for example for the calibration of algorithm

parameters and for improving algorithms' decision logic, rather than for execution purposes (BIS Markets Committee, 2020). In the future, however, as AI technology advances, it could amplify the capabilities of traditional algorithmic trading, with implications for financial markets (OECD, 2021a). This is expected to occur when AI techniques become part of the execution phase of trades, offering increased capabilities for automated execution of trades, and serving the entire chain of action from picking up signal, to devising strategies, and executing them (OECD, 2021a).

2.2.3. Integration of AI in blockchain-based financial products

Applications of DLT, such as the blockchain, have proliferated in recent years across industries and primarily in finance. The rapid growth of blockchain-based applications is supported by the purported benefits of speed, efficiency, and transparency, driven by automation and disintermediation (OECD, 2020). The most important use-cases of DLTs in finance have focused on securities markets (i.e. issuance, and post-trade, clearing and settlement); payments (i.e. central bank digital currencies and fiat-backed stablecoins); and tokenisation of assets more broadly (OECD, 2020).

The largest contribution of AI in DLT-based finance is augmenting and automating the capacity of smart contracts. Several applications of AI can be identified in specific use-cases applied within DLT networks, such as compliance and risk management (e.g. anti-fraud, introduction of automated restrictions to a network); and data inference and management (e.g. enhancing the function of Oracles) (OECD, 2021a). Most of these applications are still in the development phase. AI can particularly be used in blockchain networks to reduce, but not eliminate, security susceptibilities and help protect against compromising of the network (OECD, 2021a). This primarily occurs in payment applications. Leveraging the power of AI can assist users of blockchain networks to identify irregular activities that could be associated with theft or scams as these evens do occur despite the need of both private and public keys to compromise the security of a user (OECD, 2021a).

The integration of AI-based solutions in DLT-based systems at the protocol level could help authorities achieve their regulatory objectives in an efficient manner. However, challenges around operational risks as well as the computability and interoperability of conventional infrastructure with a DLT-based one and AI technologies remain to be examined (OECD, 2021a). AI techniques such as deep learning require significant amounts of computational resources, which may pose an obstacle to performing well on the Blockchain (Hackermoon, 2020).

AI for smart contracts

The most significant impact from the integration of AI techniques in blockchain-based systems is expected to come from their application in smart contracts, with a practical impact on the governance and risk management of such contracts (OECD, 2021a). Theoretically, the use of AI can allow for self-regulated DLT chains that will be operating on a fully autonomous basis (OECD, 2021a). AI use cases are helpful in augmenting smart contract capabilities, particularly when it comes to risk management and the identification of flaws in the code of the smart contract (OECD, 2021a). Importantly, AI can perform testing of the code in a way that a human code reviewer cannot, in terms of both speed and level of detail/scenario analysis (OECD, 2021a). This code is the underlying basis for the automation of smart contracts and flawless coding is at the heart of the robustness of such contracts (OECD, 2021a). It should be noted that applications of AI for smart contracts are purely theoretical at this stage and remain to be tested in real-life examples (OECD, 2021a).

Box 2.1. Self-Learning smart contracts and governance of DLTs: self-regulated chains and Decentralised Finance (DeFi)

Theoretically, AI can be used to extract and process information of real-time systems and feed information into smart contracts. Research suggests that in the future, AI could also be integrated for forecasting and automating 'self-learned' smart contracts, like models applying reinforcement of learning AI techniques (Almasoud et al., 2020). This means that code of smart contracts would be adjusted automatically, and the governance of the chain would not require any human intervention, resulting in fully autonomous, self-regulated decentralised chains (OECD, 2021a). As in other blockchain-based financial applications, the deployment of AI in DeFi augments the capabilities of the DLT use-case by providing additional functionalities. However, it is not expected to radically affect any of the business models involved in DeFi applications.

The use of AI to build fully autonomous chains raises important challenges and risks to its users and the wider ecosystem. In these environments, AI contracts rather than human executive decisions operate the systems where human intervention in the decision-making or operation of the systems is not applied (OECD, 2021a). Important ethical considerations arise from this phenomenon. The introduction of automated mechanisms that switch off the model instantaneously (so-called 'kill switches') is very difficult in these networks, not least because of the decentralised nature of the network (OECD, 2021a). This is one of the major issues that is also encountered in the DeFi space.

Source: (OECD, 2021a).

2.3. Trends in investment and deployment of AI in Asia

AI offers opportunities for Asian economies to transition to a knowledge-intensive, high-productivity growth model. The global leaders in AI adoption, research, and development include China, Singapore and Japan. In fact, Asia is expected to emerge as a major market for AI-led initiatives given the creation of national AI strategies and their deployment over the next few years (Analytics Insight, 2021).

The level of development in AI differs between regions[4], and Asia is experiencing significant AI growth with the large volume and broad range of data generated by hundreds of millions of users of the mobile internet and various applications, coupled with a rapid increase in investments targeted toward AI development (Asia Business Council, 2017). The AI investments in the ASEAN region, however, are unequal: in 2019, Singapore recorded an AI investment per capita of USD 68, whereas Thailand, Malaysia, Indonesia, Vietnam and the Philippines all reached less than USD 1 (Financial Times, 2020b).

The Asia-Pacific region already has the data to build AI/ML models to be better and faster (Refinitiv, 2021). Most companies in the region use commodities, supply chain, and shipping data to support their business models (Refinitiv, 2021).

Financial institutions are considering the use of AI for the provision of services such as deposit-taking, lending, asset management, and insurance brokerage (Inoue, S. and M. Une, 2020). AI also has a role to play in the automation of KYC enabling opening an account to be a fluid customer experience – AI powered eKYC (The FinTech Times, 2021). The International Data Corporation (IDC) expects big data technology and service-related revenues to grow 15.6 percent over the period of 2019-2024, approximately USD 25

[4] According to the European Commission, private investment in AI exceeded EUR 6.5 billion in Asia, EUR 3.5 billion in Europe and EUR 12 billion in North America in 2018 (Banco de España, 2019).

billion (Infotech Lead, 2021). China continues to be the largest market for Big Data and Analytics solutions where banking, state, and local governments are the leading consumers of these products (Infotech Llead, 2021).

The rapid growth of financial technologies in emerging and developing economies across Asia can be attributed to various supply and demand factors. On the demand side, users' appetite for financial services has become increasingly diversified and more sophisticated reflecting their desire to pursue diversified lifestyles against the background of globalisation and digitisation of the economy (Bank of Japan, 2018). For example, the demand for faster and less-costly cross-border remittances is increasingly for those in emerging and developing economies. On the supply side, a range of new IT has made a significant impact on financial services which has emerged at the same time as increasing consumer demands. Smartphones have rapidly spread across the borders since the launch of the iPhone in 2007 (Bank of Japan, 2018). They have become new vehicles to provide financial services instead of relying on traditional brick and mortar branch networks and ATMs (Bank of Japan, 2018).

In the Asian region, typical AI/ML use cases include enhancing the efficiency of business operators, improving the quality of financial services, assisting decision-making and prediction, and managing or reducing risks (Inoue, S. and M. Une, 2020). Several financial institutions have already introduced chatbot-based services to improve the quality of customer-related operations and propose financial products (Inoue, S. and M. Une, 2020). Further, assisting decision making and predictions in the realm of credit scoring for loan applicant screening is another main application of ML systems (Inoue, S. and M. Une, 2020). Financial institutions are developing ML-based anomaly detection systems as tools to reduce operational risks where typical uses include detection of anomalies in financial markets and fraudulent credit card transactions (Inoue, S. and M. Une, 2020).

2.3.1. Credit intermediation and assessment of creditworthiness: the most critical AI use-case in Asia

AI-based models and big data are increasingly being used by banks and FinTech lenders to assess the creditworthiness of prospective borrowers and make underwriting decisions, both functions at the core of finance (OECD, 2021a). Credit scoring models powered by AI combine the use of conventional credit information, where available, with big data not intuitively related to creditworthiness (e.g. social media data, digital footprints, and transactional data accessible through Open Banking initiatives) (OECD, 2021a). These technologies allow calculating credit risk more precisely, and there is a possibility that borrowers whose credit risk is lower than that of existing financial institutions will be able to lend at lower interest rates (Ministry of Finance Japan, 2020).

Moreover, alternative scoring methods could better serve segments of the population that has historically been left behind, such as near-prime clients or underbanked parts of the population (OECD, 2021a). Notwithstanding, AI-based credit scoring models remain untested over longer credit cycles or in case of a market downturn, and there is limited conclusive empirical support as to the benefits of ML-driven techniques for financial inclusion (OECD, 2021a).

AI/ML-based credit scoring, transparency, and fairness in lending

Despite their vast potential for speed, efficiency and risk scoring of the 'unscored', AI/ML-based credit scoring models raise risks of disparate impact in credit outcomes and the potential for discriminatory or unfair lending (US Treasury, 2016). Similar to other applications of AI in finance, such models also raise important challenges related to the quality of data used and the lack of transparency/explainability around the model (OECD, 2021a). Well-intentioned models may inadvertently generate biased conclusions, discriminated against protected classes of people (e.g. race, gender, ethnicity, religion) (White & Case, 2017). For example, while some analysis suggests that the use of ML models for credit risk assessment results in cheaper access to credit only for majority ethnic groups (Fuster et al., 2017), others find that

lending-decision rules based on ML predictions help reduce racial bias in the consumer loan market (Dobbie et al., 2018).

As with any model used in financial services, the risk of 'garbage in, garbage out' exists in AI/ML-based models for risk assessment and beyond (OECD, 2021a). A neutral ML model that is trained with inadequate data may produce inaccurate results even when fed with 'good' data (OECD, 2021a). Alternatively, a neural network trained on high-quality data, which is fed inadequate data, will produce a questionable output, despite the well-trained underlying algorithm (OECD, 2021a). The use of poor quality or inadequate/unsuitable data may result in wrong or biased decision-making (OECD, 2021a). This, combined with the lack of explainability in ML models, makes it harder to detect inappropriate use of data or use of unsuitable data in AI-based applications (OECD, 2021a). Biases may also be inherent in the data used as variables and, given that the model trains itself on data from external sources that may have already incorporated certain biases, perpetuates historical biases (OECD, 2021a).

Issues related to lack of explainability in ML-based models are particularly pertinent in lending decisions, as lenders are accountable for their decisions and must be able to explain the basis for denials of credit extension (OECD, 2021a). This also means that consumers have limited ability to identify and contest unfair credit decisions, and little chance to understand what steps they should take to improve their credit rating (OECD, 2021a). Potential mitigants against such risks are the existence of auditing mechanisms that sense check the results of the model against baseline datasets; and testing of such scoring systems to ensure their fairness and accuracy (Citron and Pasquale, 2014).

The role of BigTech

As BigTechs increasingly leverage their free access to vast amounts of customer data that feed their AI-driven models, there are increasing concerns around data privacy and the ways in which the collection, storage, and use of personal data may be exploited for commercial gain (OECD, 2021a). Access to customer data by BigTechs gives them a clear competitive advantage over conventional financial service providers. The dominance of BigTech in certain areas of the market could lead to excessive market concentration and increase the dependence of the market to few large BigTech players, with possible systemic implications depending on their scale and scope (Financial Stability Board, 2020a). Consequently, this could give rise to concerns over potential risks to financial consumers, who may not be receiving the same range of products options, pricing, or advice that would be provided through traditional financial service providers (OECD, 2021a). It could also lead to difficulties for supervisors in accessing and auditing the financial activities provided by such firms.

Anti-competitive behaviours and market concentration in the technology aspect of the service provision presents another related risk. There is the possibility of a small number of key players in the markets for AI solutions and/or services incorporating AI technologies emerging (e.g. cloud computing service providers who provide AI services), evidence of which is already observed in some parts of the world (ACPR, 2018). Challenges for the competitive environment are also present given the privileged position BigTech players have with regards to customer data (OECD, 2021a). Firms can use their big data advantage to build monopolistic positions, both in relation to client acquisition (e.g. through effective price discrimination) and through the introduction of high barriers to entry for small players (OECD, 2021a).

Box 2.2. China's smartphone payments

In China, the market for payment and settlement services using smartphones such as Alipay and WeChatPay has been rapidly increasing (Bank of Japan, 2018). One of the characteristics of Chinese mobile payments is that the parent companies of the service providers (i.e. Alibaba for Alipay and Tencent for WeChatPay) are not financial institutions in origin (Bank of Japan, 2018). These parent companies provide services such as e-commerce, games and SNS, and then used their networks as an expanded vehicle for financial services including payments and settlement (Bank of Japan, 2018). For these companies, offering both financial services and non-financial services on the same platform has been operated according to a basic business model since their inception (Bank of Japan, 2018). They do not depend on the payment fees for their earnings. Instead, their aim is to earn through customer retention and collection, including the accumulation and wide use of big data (Bank of Japan, 2018). Ultimately, this is an inexpensive mechanism for financial services in return for users to provide data about themselves.

Financial inclusion in Asia

Nearly half the world's adult population or 3.5 billion adults are unbanked or underbanked (i.e. limited or non-transactional access to finance) (Mhlanga, 2020). Most of the unbanked population is in developing countries across Asia, Africa, and Latin America (Kshetri, 2021). Although the dominance of BigTech firms has resulted in the dependence of customers on a few large industry players, these firms have also presented several benefits for the hard-to-reach populations of Asia. The existence of ICT and AI made it possible for financial inclusion to change to digital has allowed to increasingly include those at the bottom of the wealth pyramid (Mhlanga, 2020). Smartphones have rapidly spread even among emerging and developing economies where the networks of branches and ATMs of traditional commercial banks were not fully developed. Handheld devices have enabled financial services to be performed instantaneously without building vast networks of infrastructure through software applications in the form of mobile banking and mobile payments (Bank of Japan, 2018).

Digital financial inclusion is different from traditional methods such as microcredit and microfinance since digital financial services reduce transaction costs in rural areas due to lower marginal costs (Mhlanga, 2020). Although the creation of new digital technologies faces high start-up costs to establish the technological infrastructure, the marginal costs will move toward zero when business volume increases (Mhlanga, 2020). Further, the use of AI/ML tools helps overcome a major challenge for traditional financial inclusion which is information asymmetry.

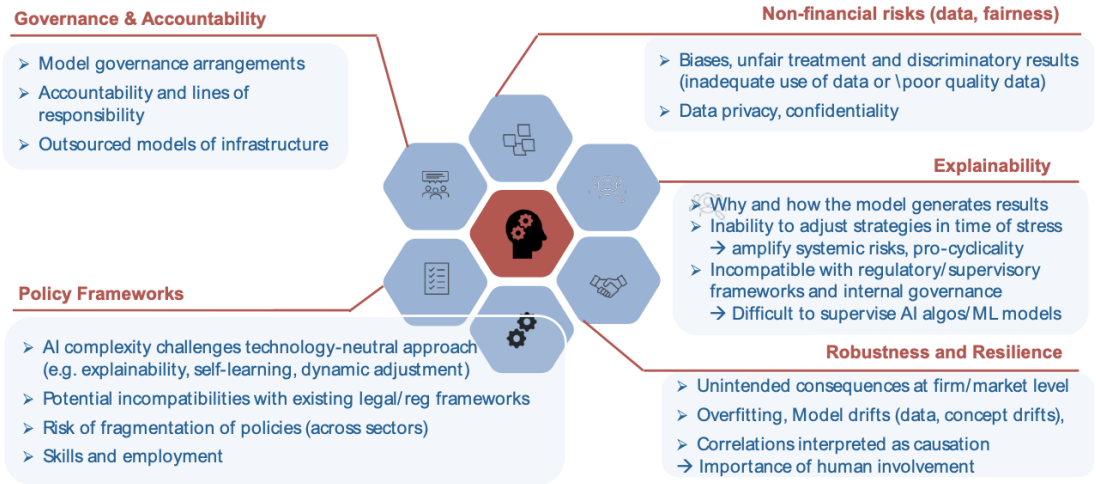
Financial inclusion has been particularly accelerated due to the effects of the COVID-19 pandemic. Lockdowns and social distancing are increasing the digitalisation of many sectors, including financial services. Just as the SARS epidemic of 2003 expedited China's path in launching digital payments and e-commerce, some countries are taking steps to facilitate the massive use of digital financial services especially in the payments sector (Singapore Management University, 2020). Digital payments are now a backbone to China's vibrant digital economy and its development influences data-driven initiatives (Singapore Management University, 2020). Contactless payment to taxi drivers, vendors, and even temples are possible through scanning a QR code (Singapore Management University, 2020). Governments at all levels in the country accept mobile payments as a payment method where the system in China has almost become a public good and a factor in data-driven finance (Singapore Management University, 2020). Many other countries are replicating China's model in similar ways and supporting this shift with measures such as lowering fees and increasing limits on mobile money transactions (Singapore Management University, 2020).

Data-driven finance, if adequately deployed, can contribute to inclusive post-pandemic recovery across the world to avoid damaging the economy through job losses and higher inequality (Singapore Management University, 2020). For instance, financial institutions could build a dynamic credit decisioning framework and credit scores that incorporate potential impact of the pandemic to reduce inequality. However, reaching the most vulnerable can be challenging in developing economies where nearly 70 percent of employment is informal (Singapore Management University, 2020).

2.4. Risks and challenges from the use of AI in finance

The use of AI/ML technology can raise challenges related to data management and concentration; risk of bias and discrimination; explainability; robustness and resilience of models; governance and accountability; regulatory considerations; and employment risks (OECD, 2021a). The main risks stem from the potential bias in the results obtained using AI tools, and the difficulties involved in understanding the reasoning process followed by the algorithms to reach a specific conclusion.

Figure 2.2. Relevant issues and risks stemming from the deployment of AI in finance



Source: (OECD, 2021a).

The use of the same or similar models by a large number of traders could have unintended consequences for competition, and could also contribute to the amplification of stress in markets (OECD, 2021a). This would potentially result in convergence, herding behaviour and one-way markets, with possible implications for the stability of the market and for liquidity conditions particularly during periods of acute stress (OECD, 2021a). Such convergence could also increase the risk of cyber-attacks, as it becomes easier for cyber-criminals to influence agents acting in the same way rather than autonomous agents with distinct behaviour (ACPR, 2018).

In terms of potential unintended effects in the market, it could be argued that the application of AI technologies in trading and high frequency trading (HFT) could increase market volatility through large sales or purchases executed simultaneously, giving rise to new sources of vulnerabilities (Financial Stability Board, 2017). As HFT are a major source of liquidity provision under normal market conditions, improving market efficiency, any disruption in the operation of their models in times of crisis results in liquidity being pulled out of the market, with potential impact on market resilience (OECD, 2021a).

The deployment of AI in trading may also increase the interconnectedness of financial markets and institutions in unexpected ways, and potentially increase correlations and dependencies of previously unrelated variables (Financial Stability Board, 2017). It can also amplify network effects, such as unexpected changes in the scale and direction of market moves (OECD, 2021a). To mitigate risks from the deployment of AI in trading, defences need to be put in place for AI-driven algorithmic trading (OECD, 2021a). Automated control mechanisms that instantly switch off the model are the ultimate lines of defence of market practitioners, when the algorithm goes beyond the risk system, and consist of 'pulling the plug' and replacing any technology with human handling (OECD, 2021a). Such mechanisms could be considered suboptimal from a policy perspective, as they switch off the operation of the systems when it is most needed in times of stress, and give rise to operational vulnerabilities (OECD, 2021a).

2.4.1. Data management

Data is at the core of any AI application, and as such, it is important to analyse the use of big data as it could become an important source of non-financial risk. The importance of data in testing, training, the validation of ML models along with the capacity of models to retain their predictive powers in tail event situations are characteristics that must be defined by policy makers. Additional data, not used by AI model for training or predicting, might in fact be necessary, and thus should be collected, for addressing concerns of bias in the model output. For example – gender should not be used as a input for model training with regard to credit authorization, but it is still important to verify that the model output does not demonstrate gender bias.

Appropriate data management is a fundamental issue for every algorithm, as both performance and regulatory compliance are conditional upon it. Ethical considerations such as fairness of processing and the absence of discriminatory bias must be considered in this regard. Evaluation of an ML-based system also need to account for operations performed on input data prior to the machine learning phase itself. Pre-processing of data may have an impact on the resulting model's performance (for example by over- or under-sampling training data) as well as on its ethical acceptability (for example by excluding protected variables from training data). Moreover, evaluation should also include operations performed on the output (i.e. predictions or decisions). This post-processing may have a significant impact as well, such as in the case of methods aiming to remove or reduce discriminatory biases from already trained models. Data management is one of four criteria Banque de France relies on when evaluating AI algorithms and tools in finance. Performance of an ML algorithm is the second criterion, using two types of metrics: predictive performance metrics and business performance metrics. Predictive performance metrics includes AUC (Area Under the Curve) or an F1 score which can be applied to algorithms predicting credit default risk of a person and can be categorized as Key Risk Indicators (KRI). Business performance metrics which can be categorized as Key Performance Indicators (KPI) which must be consistent with the algorithm's objectives and their compatibility with its compliance requirements. Importantly, algorithmic importance of an AI is not a standalone objective and must be weighed against the explainability principle (Banque de France, 2020).

Stability is the third of four criteria, which ensures that an ML algorithm's performance and its main operational characteristics are consistent over time (Banque de France, 2020). Expectations in terms of stability are more important in the case of ML, as the dimension of data tends to be larger than in traditional predictive or decisional algorithms (Banque de France, 2020).In addition to financial consumer protection considerations, there are potential competition issues arising from the use of big data and ML models, relating to potential high concentration amongst market providers (OECD, 2021a). It should be noted that the challenges of data use and management identified and discussed in this section are not specific to big data/alternative data but apply to data more broadly.

Data privacy and confidentiality

The volume, ubiquitous and continuous flowing nature of data used in AI systems can raise various data protection and privacy concerns. Data privacy relates to the use and governance of individual data while security is concerned with protecting data from potential risk of data privacy infringements and unethical usage (ADB, 2021). Date privacy also means that data should be used only upon explicit consent of the individuals to whom this information relates. There are questions around data connectivity in financial services and the ability to aggregate, store, process, and transmit data across borders for financial sector development (Hardoon, 2020b). The fusion of multiple datasets can present big data users with new opportunities to aggregate data, while at the same time give rise to analytical challenges, including confounding, sampling selection, and cross-population biases (Bareinboim and Pearla, 2016).

Cyber incidents, risk of hacking and other operational risks have direct implications on data privacy and confidentiality (OECD, 2021a). While the deployment of AI does not open possibilities of new cyber breaches, it could exacerbate pre-existing ones by, inter alia, linking falsified data and cyber breaches, creating new attacks which can alter the functioning of the algorithm through the introduction of falsified data into models or the alternation of existing ones (ACPR, 2018). Consumers' financial and non-financial data are increasingly being shared and used, sometimes without their understanding and informed consent (US Treasury, 2018). Observed data not provided by the customer, such as geolocation data or credit card transaction data are prime examples of datasets at risk of possible violations of privacy policy and data protection laws (OECD, 2021a).

The use of big data by AI-powered models could expand the universe of data that is considered sensitive, as such models can become highly proficient in identifying users individually (US Treasury, 2018). The higher dimensionality of ML data sets is the possibility to consider an unlimited number of variables compared to conventional statistical techniques, which in turn increases the likelihood of sensitive information being included in the analysis (OECD, 2021a). AI models could achieve the re-identification of anonymised databases by cross-referencing publicly available databases and narrowing down matches to ultimately attribute sensitive information to individuals (Luminovo.ai, 2020).

> Regulators have renewed their focus on data privacy and protection by reinforcing consumer protection across markets, rebalancing the power relationship of corporates and individuals, shifting power back to the consumer, and ultimately increasing transparency to improve the trust in how companies use consumer data (OECD, 2021a). 'Protection of Consumer Data and Privacy' is one of the Principles of the G20/OECD High-Level Principles on Financial Consumer Protection (OECD, 2021a). Protection of individuals' personal data in the use of AI in finance is at the core of the Monetary Authority of Singapore's principles to promote fairness, ethics, accountability, and transparency (MAS, 2019).

Data concentration and competition in AI-enabled financial services

Advances in AI could potentially harm the operations of efficient and competitive markets if consumers' ability to make informed decisions is constrained by high concentrations amongst market providers (US Treasury, 2018). To the extent that the deployment of AI and proprietary models provide a performance edge against competition, this may, in turn, result in restricted participation by smaller service providers who may not have the financial resources to adopt in-house AI/ML techniques or use big data information sources (OECD, 2021a). The potential for network effects further amplifies the risks of concentration and dependencies, which could in turn result in the emergence of new systematically important players. BigTech are the prime example of potential risk, and the fact that they fall outside regulatory perimeter adds to the challenges involved.

Healthy competition in the market for AI-based financial products and services is vital for providers to be able to fully unleash the benefits of technology, particularly when it comes to trading and investing (OECD, 2021a). The use of outsourced and third-party vendor models could 'arbitrage away' the benefits of such

tools for firms adopting them and could result in one-way markets and herding behaviour by financial consumers or convergence of trading/investment strategies by finance practitioners (OECD, 2021a).

Box 2.3. Risk of bias and discrimination

Depending on how they are used, AI methods have the potential to help avoid discrimination based on human interactions. Delegating the human-driven part of the decision-making to the algorithm allows the user of AI-powered model to avoid biases attached to human judgement. However, the use of AI applications may risk bias or discrimination through the potential to compound existing biases found in the data; by training models with such biased data or through the identification of spurious correlations (US Treasury, 2018). Regulators and courts in the U.S., for example, face heightened hurdles to identify which Big Data variables can give rise to a successful claim of illegal discrimination under U.S. fair-lending laws (NBER, 2019).

Biases may also be inherent in the data used as variables and given that the model trains itself on data from external sources that may have already incorporated certain biases, perpetuates historical biases (OECD, 2021a). Proper data management of input data is sometimes governed by sector-specific regulation. The design of a ML model and its audit can further strengthen the degree of assurances about the robustness of the model when it comes to avoiding potential biases. Auditing mechanisms of the model and the algorithm that check the results of the model against baseline datasets can help ensure there is no unfair treatment or discrimination by the technology (OECD, 2021a). Tests can also be run based on whether protected classes can be inferred from other attributes in the data, and a number of techniques can be applied to identify and/or rectify discrimination in ML models (Feldman et al., 2015).

2.4.2. Explainability

The most widely acknowledged challenge of ML models is the difficulty in decomposing the output of a ML model into the underlying drivers of its decision. This difficulty in justifying or rationalising model decisions and outputs is generally described by the term ‘explainability’ (OECD, 2021a). The possible intentional concealment by market players of the mechanics of AI models to protect their intellectual property reinforces the lack of explainability (OECD, 2021a). While several approaches to solve this issue have been explored, ranging from game-theory based solutions to local model approximations, a widely applicable, scalable approach which is independent of model complexity is yet to be found (Cambridge Judge Business School, WEF, 2019).

The lack of explainability in ML-based models used by financial market participants could become a macro-level risk if not appropriately supervised by micro prudential supervisors, as it becomes difficult for both firms and supervisors to predict how models will affect markets (Financial Stability Board, 2017). AI could introduce or amplify systemic risks related to pro-cyclicality given the increased risk of herding and convergence of strategies by users of ‘off-the-shelf’ third party provider models (OECD, 2021a). Risks of market manipulation such as spoofing or tacit collusions are also present in the absence of understanding the underlying mechanics to the model (OECD, 2021a).

To manage associated risks, market participants are working to improve the explainability of models to better comprehend their behaviour in normal market conditions and in times of stress (OECD, 2021a). Contrary to post-hoc explainability of a single decision, explainability by design (e.g. incorporated into the AI mechanism) is more difficult to achieve given that (i) the audience may be unable to grasp the logic of the model; (ii) some models are by definition impossible to fully comprehend (e.g. some neutral networks); and (iii) the full revealing of the mechanism is equivalent to giving away IP (OECD, 2021a).

There is a debate on the question of whether and how AI explainability should be any different to that required in the application of other complex mathematical models in finance (OECD, 2021a). There is a risk that AI applications are held to a higher standard and thus subjected to a more onerous explainability requirement as compared to other technologies, with negative repercussions for innovation (Hardoon, 2020a). Ensuring the explainability of the model does not in itself guarantee the model is reliable (Brainard Lael, 2020).

Auditability of AI algorithms and models

The underlying complexity of 'black box' models raises regulatory challenges in the transparency and auditing process in financial services use cases (US Treasury, 2018). It is difficult, if not impossible, to perform an audit on a ML model if one cannot decompose the outcome of the model into its underlying drivers (OECD, 2021a). Numerous laws or regulations in some jurisdictions have been designed around a baseline expectation of auditability and transparency, which may not be easily achievable when AI-enabled models are used (OECD, 2021a). Audit trails can only be followed if one can provide evidence of the sequence of activities or processes, and this capacity is curtailed by the lack of interpretability of some AI models (OECD, 2021a). As decisions made by such models no longer follow a linear process, the models themselves are characterised by limited interpretability. Improvement in the explainability of AI outcomes is needed while ensuring accountability and robust governance dynamics in AI-based systems (OECD, 2021a). Research efforts that aim at improving the interpretability of AI-driven applications and rendering ML models more amenable to ex-ante and ex-post inspection are underway both in academia and the industry (Vellido, Martin-Guerrero and Lisboa, 2012).

2.4.3. Robustness and resilience of AI models: training and testing performance

The robustness of AI systems can be reinforced by the careful training of models, as well as testing of the performance of models based on their intended purpose (OECD, 2021a). The datasets used for training must be large enough to capture non-linear relationships and tail events in the data. This is hard to achieve in practice as tail events are rare and the dataset may not be robust enough for optimal outcomes (OECD, 2021a). The inability to train models on datasets that include tail events is creating a significant vulnerability for the financial system, weakening the reliability of such models in times of unpredicted crisis and rendering AI a tool that can be used only when market conditions are stable (OECD, 2021a).

ML models carry a risk of over-fitting which happens when a trained model performs extremely well on the samples used for training but performs poorly on new unknown samples (i.e. the model does not generalise well) (Xu and Goodacre, 2018). To mitigate this risk, modellers split the data into training and test/validation set and use the training set to build the supervised model with multiple model parameter settings; and the test/validation set to challenge the trained model, assess the accuracy of the model and optimise its parameters (OECD, 2021a). Based on the errors of the validation set, the optimal model parameters set is determined using the one with the lowest validation error (Xu and Goodacre, 2018).

The measured performance of validation models was previously considered by scientists as an unbiased estimation of the performance of such models, however, multiple recent studies have demonstrated that this assumption does not always hold (Westerhuis et al., 2018; Harrington, 2018). Synthetic datasets are being artificially generated to serve as test sets for validation and provide an interesting alternative given that they can provide inexhaustible amounts of simulated data, and a potentially cheaper way of improving the predictive power and enhancing the robustness of ML models (OECD, 2021a). This is especially pronounced when real data is scarce and expensive. Some regulators require, in some instances, the evaluation of the results produced by AI models in test scenarios set by the supervisory authorities (IOSCO, 2020).

Ongoing monitoring and validation of models through their life is fundamental for the risk management of any type of model (Federal Reserve, 2011). Some regulators have imposed the existence of 'kill switches'

or automatic control mechanisms that trigger alerts under high risk circumstances in addition to ongoing monitoring and review of the code/model (OECD, 2021a). Kill switches are an example of control mechanisms that can quickly shut down an AI-based system in case it ceases to function according to the intended purpose. Kill switches need to be tested and monitored themselves to ensure firms can rely on them in case of need.

Box 2.4. AI and tail risk: the example of the COVID19 crisis

Although AI models are adaptive in nature, they may not be able to perform under idiosyncratic one-time events that have not been experienced before, such as the COVID-19 crisis (OECD, 2021a). As AI-managed trading systems are based on dynamic models trained on long time series, they are expected to be effective in as long as the market environment has some consistency with the past (OECD, 2021a). Evidence based on a survey conducted of UK banks suggests that around 35% of banks experienced a negative impact on ML model performance during the pandemic (Bhloat, Gharbawi, and Thew, 2020). This is likely because the pandemic has created major movements in macroeconomic variables, such as rising unemployment and mortgage forbearance, which required ML models and traditional models to be recalibrated (OECD, 2021a).

Tail and unforeseen events are giving rise to discontinuity in the datasets, which in turn creates model drifts that undermine the models' predictive capacity. Ongoing testing of models with validation datasets that incorporate extreme scenarios and continuous monitoring for model drifts is therefore of paramount importance to mitigate risks encountered in times of stress. It should be noted that models based on reinforcement learning, where the model is trained in simulated conditions are expected to perform better in times of one-off tail risk events, as they are easier to train based on scenarios of extreme unexpected market conditions that may not have been observed in the past (OECD, 2021a).

2.4.4. Governance of AI systems and accountability

Solid governance arrangements and clear accountability mechanisms are fundamentally important as AI models are deployed in high-value decision-making use cases (OECD, 2021a). Organisations and individuals developing, deploying or operating AI systems should be held accountable for their proper functioning (OECD, 2019a). In addition, human oversight from the product design and throughout the lifecycle of AI products and systems may be needed as a safeguard (European Commission, 2020).

Currently, financial market participants using AI rely on existing governance and oversight arrangements for the use of such technologies, as AI-based algorithms are not considered to be fundamentally different from conventional ones (IOSCO, 2020). Explicit governance frameworks that designate clear lines of responsibility for the development and overseeing of AI-based systems throughout their lifecycle, from development to deployment, could further strengthen existing arrangements for operations related to AI (OECD, 2021a).

Model governance frameworks do not necessarily fully address the specific characteristics of AI models, which exist only ephemerally, and change frequently. The challenge of using existing model governance processes for ML models is associated with more advanced AI models that rebuild themselves at relatively short time intervals (OECD, 2021a). One possible mitigating approach would be to retain data and code so replications of the inputs and outputs can be produced based on a past date (OECD, 2021a). However, since many ML models are non-deterministic, there is no guarantee that even with the same input data the same model will be produced.

Outsourcing and third-party providers

Risks arise when it comes to outsourcing of AI techniques to third parties, both in terms of competitive dynamics (concentration risks) and in terms of giving rise to systemic vulnerabilities related to increased risk of convergence (OECD, 2021a). Possible risks of concentrating third-party providers may rise either in terms of data collection and management (e.g. dataset providers), in the area of technology (e.g. third party model providers), and infrastructure (e.g. cloud providers) provision (OECD, 2021a). The use of third-party models could also give rise to risks of convergence at the firm level and systemic level, especially if there is a lack of heterogeneity of third-party models in the market (OECD, 2021a). This could translate into herding and bouts of illiquidity in times of stress when liquidity is most needed.

The outsourcing of AI techniques or enabling technologies and infrastructure raises challenges in terms of accountability in addition to concentration risks (OECD, 2021a). Over-reliance on outsourcing may also give rise to increased risk of disruption of service with potential systemic impact in the markets (OECD, 2021a). Contingency and security plans need to be in place to allow business to function as usual if any vulnerability materialises (OECD, 2021a). Attacks on security measures for ML systems may occur through third-party entities. Therefore, the security framework for ML and IT systems must ensure confidentiality, integrity, and availability (Inoue, S. and M. Une, 2020).

2.4.5. Regulatory considerations, fragmentation, and potential incompatibility with existing regulatory requirements

Although many countries have developed AI strategies; in most cases, regulation and supervision of ML applications are based on overarching requirements for systems and controls (IOSCO, 2020). The technology-neutral approach that is being applied by most jurisdictions to regulate financial market products (in relation to risk management, governance, and controls over the use of algorithms) may fall short in addressing the systemic risk posed by a potential broad adoption of AI in finance (Gensler and Bailey, 2020). Advanced AI techniques may not be compatible with existing legal or regulatory requirements. The opaqueness of AI systems makes it difficult to identify and prove possible breaches of laws, including legal provisions that protect fundamental rights, attribute liability, and meet the conditions to claim compensation (OECD, 2021a).

In addition to existing regulation that is applicable to AI models and systems, a multitude of published AI principles, guidance, and best practices have been developed in recent years (OECD, 2021a). While these are all seen by the industry as valuable in addressing potential risks, views differ over their practical value and the difficulty of translating such principles into effective practical guidance (e.g. through real-life examples) (Bank of England and FCA, 2020). Further, industry participants note a potential risk of fragmentation of the regulatory landscape with respect to AI at the national, international, and sectoral level, and the need for more consistency to ensure these techniques can function across border (Bank of England and FCA, 2020).

AI and disclosure

Based on OECD AI Principles ‘there should be transparency and responsible disclosure around AI systems to ensure that people understand AI-based outcomes and can challenge them (OECD, 2021a). The opacity of algorithm-based systems could be addressed through transparency requirements and ensuring that clear information is provided to the AI system’s capabilities and limitations (European Commission, 2020). Separate disclosure should inform consumers about the use of AI system in the delivery of a product and their interaction with an AI system instead of a human (e.g. robo-advisors) (OECD, 2021a).

Currently, there is no commonly accepted practice to the level of disclosure that should be provided to investors, financial consumers, and proportionality in such information (OECD, 2021a). According to market regulators, there should be a differentiation regarding the level of transparency depending on the

type of investor (retail vs. institutional), as well as the area of implementation (front vs. back office) (IOSCO, 2020).

Requirements for financial firms to document in writing operational details and design characteristics of models used in finance were already in place before the advent of AI (OECD, 2021a). Documentation of the logic behind the algorithm, to the extent feasible, is being used by some regulators to ensure the outcomes produced by the model are explainable, traceable, and repeatable (Financial Services Regulatory Authority (Abu Dhabi), 2019). An auditor will need to consider the precise context in which the algorithm was developed, and particularly the business processes into which it is integrated, or which are impacted by it in one way or another (Banque de France, 2020).

Some jurisdictions have proposed a two-pronged approach to AI model supervision: (i) analytical: combining analysis of the source code and of the data with methods for documenting AI algorithms, predictive models, and datasets; and (ii) empirical: leveraging methods providing explanations for an individual decision or for the overall algorithm's behaviour (OECD, 2021a). The latter of these supervision models relies on two techniques for testing an algorithm as a black box: challenger models which compare against the model under test, and benchmarking datasets, which are both curated by the auditor (ACPR, 2020).

2.5. Regulatory Frameworks and National Strategies on AI in Asia

A number of Asian countries have introduced national strategies for the use of AI in finance and beyond. This section provides details around some of these national strategies in the Asian region.

2.5.1. Japan's framework for AI

In April 2016, Prime Minister Abe issued Japan's national AI strategy (Medium, 2018). The Government of Japan is implementing AI projects through the Integrated Innovation Strategy Promotion Council with the aim to develop research goals and a roadmap for the industrialisation of AI.

In March 2017, Japan released the 'Artificial Intelligence Technology Strategy and its Industrialisation Roadmap' which envisions AI as a service and organises the development of AI into three phases: (1) the utilisation and application of data-driven AI developed in various domains, (2) the public use of AI and data developed across various domains, and (3) the creation of ecosystems built by connecting multiplying domains (Medium, 2018). This strategy applies the framework to three priority areas of Japan's 'Society 5.0' initiative including: productivity, health, and mobility.

In April 2016, the Bank of Japan established the FinTech Centre within its Payment and Settlement Systems Department which aims to play an active role as a catalyst to link financial practices with advanced technologies and research to meet the demand of society in the digitised world (Bank of Japan, 2018). The Bank of Japan will also continue to work on Project Stella with the European Central Bank (ECB) to promote in-depth analysis and experiments of applying DLT to several financial infrastructures (Bank of Japan, 2018).

From a legislative perspective, the amending of the Banking Act in June 2017 allowed Japan to require Fintech companies to register as 'electronic payment service providers' (Bank of Japan, 2018). Financial institutions, in return, are required to disclose their APIs based on the agreement between the two and disclose their policy for coordination/collaboration with the payment service providers (Bank of Japan, 2018). The government's growth strategy titled the 'Investment for the Future Strategy 2017' set a numerical target to facilitate the engagement of open APIs, while the Review Committee on Open APIs of the Japanese Bankers Association, in which the Bank of Japan participates as an observer, published guidelines for user protection and security with respect to open APIs (Bank of Japan, 2018).

In terms of private sector efforts in developing AI, companies in Japan are building on their skills in high-tech manufacturing to focus on robotics and IoT (Asia Business Council, 2017). Japanese conglomerates Toyota and Hitachi have both set up R&D facilities in the U.S. (Asia Business Council, 2017). In 2016, Toyota formed Toyota Research Institute (TRI) in several locations in the U.S. and plans to invest USD 1 billion focusing on robotics for home and business use, and on AI for improved safety in both traditional and autonomous vehicles (Asia Business Council, 2017). In 2016, Hitachi located the Hitachi Insight Group, a team of 6,000 in Silicon Valley, California where the group will focus on Lumada, Hitachi's IoT platform that collects information from sensor-embedded products Hitachi manufactures and sells to key end-markets (Asia Business Council, 2017). Fanus, the Japanese computer company is the world's largest maker of industrial robots, invested in the project as well, with the goal that its robots can learn skills independently much like Google's DeepMind teaching itself how to walk, run, and jump (Asia Business Council, 2017).

2.5.2. Singapore's national AI strategy

The Government of Singapore has proposed a 'National AI Strategy' as a key step in the nation's journey. The plan articulates the country's plans to deepen the use of AI technologies to transform the economy, going beyond just adopting technology to fundamentally rethinking business models and making deep changes to reap productivity gains and ultimately create new areas of growth (Government of Singapore, 2021). The strategy identifies 5 national AI projects in the following sectors: transport and logistics; smart cities and estates; healthcare; education; and safety and security where AI technologies will be used to address key challenges and deliver strong social and/or economic impact for Singaporeans (Government of Singapore, 2021). Singapore is also gaining research attention from international companies. American software firm Salesforce opened its first overseas AI research centre in Singapore last year, joining the ranks of YITU Technology, Alibaba, Dyson, and DataRobot (Kearney, 2020).

> From a financial regulatory perspective, the Monetary Authority of Singapore has established a set of 'Principles to Promote Fairness, Ethics, Accountability, and Transparency' (FEAT) in the use of AI and Data Analytics in the country's financial sector (MAS, 2019). The objective of the principles is to provide firms with a set of foundational principles to consider when using AI and data analytics; to assist firms in contextualising and operationalising governance of using AI and data analytics in their own business models and structures; and to promote public confidence and trust in the use of AI and data analytics (MAS, 2019).

Singapore's commitment to a progressive and conducive approach to AI is embodied by 'AI Singapore' a five-year national program devoted to enhancing AI capabilities through investment and adoption. It is a SGD 50 million (USD 36 m) government-wide partnership to enhance Singapore's capabilities in AI (IICOM, 2020). AI Singapore consists of four key pillars: fundamental AI research; support multi-disciplinary teams that provide innovative solutions to major challenges (i.e. health, mobility, finance, etc.); 100 experiments which funds scalable AI-based solutions to industry-identified problems; and AI apprenticeship which is a nine-month structured program to foster a new cohort of AI talent in the country (IICOM, 2020). Singapore is also focusing on raising awareness on AI capabilities: in 2019, DBS Bank collaborated with AWS DeepRacer League to educate 3,000 staff about AI and machine learning (Kearney, 2020). In 2021, MAS has launched the Global Veritas Challenge, supported by Government of Singapore, to promote the adoption of artificial intelligence (AI) solutions in the financial sector (Business Times, 2021).

The most significant obstacle the country will face is on the topic of cybersecurity lapses. The cyberattack on SingHealth in 2018 saw the personal information of 1.5 million victims stolen (IICOM, 2020). Investigators revealed SingHealth had not received the necessary security software updates for 14 months since the last update on the spread of the WannaCry ransomware (IICOM, 2020). Despite nationwide calls to increase cybersecurity, another unauthorised access attempt was reported to have taken place involving 70 HealthHub accounts (IICOM, 2020).

2.5.3. Indonesia's shift from resource-based to innovation-based economy through AI

The Ministry of Research and Technology published the Indonesia National Strategy with a timeframe from 2020 to 2045 with the principled objectives for AI development (OECD, 2021c). The objectives for the national strategy include transforming Indonesia into an innovation-based country, encouraging AI research and industrial innovation, improving data and data-related infrastructure, establishing ethical and relevant policies, and developing AI-related talents in the population (OECD, 2021c). Within this strategy, the Indonesian government has outlined five sectors of focus: AI, Internet of Things (IoT), robotics, augmented reality, and 3D printing (OECD, 2021c). The strategy also aims to support five national priorities: health services, bureaucratic reform, education and research, food security, and mobility and smart cities (OECD, 2021c). To achieve objectives in these areas, the country will focus on the following four areas of development: ethics and policy, talent development, infrastructure and data, and industrial research and innovation (OECD, 2021c).

The Indonesian government is driving the country's AI readiness where agencies are launching AI-driven initiatives in a range of sectors including: the Central Bank and Tax Department's goal to use AI to analyse their own data and improve their policy-making decisions; the Agency for Climatology, Meteorology, and Geophysics to leverage weather and earthquake data (IICOM, 2020).

There are also innovative public-private partnerships emerging. E-commerce platform Bukalapak partnered with the Bandung Institute of Technology in February 2019 to inaugurate the country's first AI and cloud computing innovation centre (IICOM, 2020). In March 2019, another e-commerce giant Tokopedia partnered with Universitas Indonesia to create the country's first AI Centre of Excellence with support from Nvidia (IICOM, 2020). Leveraging Nvidia's deep learning supercomputer technology allows researchers to develop and test a wide range of AI solutions tailored for different industries such as logistics, transport, and financial services (IICOM, 2020). In July 2019, BLOCK71 Jakarta which is a notable private sector initiative between the Salim Group and the National University of Singapore's NUS Enterprise (the entrepreneurial arm of the university) provided an ecosystem for disruptive technology start-up companies through an incubation facility located in Kuningan (Asia Business Council, 2017).

The biggest challenge the country must address is the small pool of AI talent, and the relatively small proportion of students studying STEM subjects (IICOM, 2020). Moreover, fixed and mobile broadband speeds in Indonesia are one of the lowest in the ASEAN behind Laos, Philippines, and Vietnam where many rural parts of the country are unable to access high-speed mobile networks (IICOM, 2020).

2.5.4. China's strategy to become AI leader

China has a national AI policy that outlines the country's strategy to become a world's leading AI power by 2030 (IICOM, 2020). The government has published the 'Three-Year Action Plan to Promote the Development of New-Generation AI Industry' which advances four major tasks: developing intelligent and networked products such as vehicles, service robots, and identification systems; enable AI support systems including intelligent sensors and neutral network chips; support the growth of intelligent manufacturing systems and mechanisms; and create a conducive environment by investing in industry training resources, standard testing, and cybersecurity (IICOM, 2020).

China's AI industry was valued at CNY23.7 billion (USD 3.5 billion) in 2017 (IICOM, 2020). Unlike other economies, the population is more willing to adopt technology first rather than waiting for related regulations. This unparalleled access to large quantities of consumer data generated from a large population actively using mobile devices and digital platforms has given Chinese AI companies a distinct comparative advantage in research and development which involves the testing for algorithms and ML (IICOM, 2020). China has emerged as an AI global leader, accelerated by a powerful technology industry, a 'mobile first' society, and an open approach to data collection (IICOM, 2020). Based on some estimates, with a 45% share of the total Asia Pacific excluding Japan AI spending, China was the largest market in

the region in 2019, with the banking industry being the largest spender on AI (The International Data Corporation (IDC), 2020). As an example, in 2019, China's WeBank, the world largest digital bank, generated USD 570 million in profit, leveraging AI mostly in the back office to optimize efficiencies and scale-up (TechWire Asia, 2021).

One of the primary challenges China will grapple with is a domestic talent shortage. According to a an assessment performed in Tshingua University, China had the world's second largest AI talent pool following the United States (China Institute for Science and Technology Policy at Tsinghua University, 2018). Municipal governments, research institutes and IT companies alike have been relying on short-term strategies such as scholarships and competitive remuneration packages to attract talent from overseas and retain local talent (IICOM, 2020). To bridge the talent gap, the government needs to devote more resources to universities and boost the number of undergraduate and graduate students taking not only core STEM subjects, but various creatively challenging subjects that will be necessarily for holistic AI development (IICOM, 2020).

2.5.5. Malaysian plans for an AI framework

Malaysia's former Prime Minister Najib Razak announced in October 2017 the plan to develop a National AI Framework for the country (Medium, 2018The country's new government has yet to release an update on the national AI proposal which is required to ensure the country is on the right track to develop a robust AI ecosystem. The existing AI strategy in the country is based on fostering enhanced cooperation mechanisms between government, academia, and industry as demonstrated by several strategic partnerships launched in the smart city and e-commerce sectors (IICOM, 2020). For example, the Malaysia City Brain project is a partnership between MDEC, Kuala Lumpur city Hall, and Alibaba where the initiative combines 5G, IoT, and AI technologies to optimise traffic, parking, and energy management (IICOM, 2020). A digital free trade zone (DFTZ) was set up by Alibaba and MDEC as an eFulfillment and eServices hub designed to facilitate cross-border trade and enable local online businesses to export their goods (IICOM, 2020).

Malaysia's start-up and technology ecosystem has experience transformation within the past few years where the community has attracted approximately USD 1.45 billion in investments (IICOM, 2020). The country's start-ups have incubated several deep-learning start-ups that are using AI for e-commerce activities, human sentiment analysis, and automated customer support (IICOM, 2020). Malaysia's private sector has been very active in developing innovative uses of AI primarily led by international organisations in sectors such as transport, logistics, and energy (IICOM, 2020).

The most significant obstacle for Malaysia remains the lack of open discussions with stakeholders and the absence of a National AI Framework. Since the framework was announced by the previous Najib government, there was uncertainty on the continuity of the proposal. Without a transparent process involving multi-stakeholders including local industry players, there will likely be an implementation gap of any future AI frameworks by the country (IICOM, 2020).

Box 2.5. Malaysian Securities Commission (SC Malaysia) AI/ML in corporate governance

SC Malaysia uses AI – including machine learning and natural language processing – to monitor the adoption of corporate governance best practices and quality of disclosures by listed companies on the Malaysia Stock Exchange (Bursa Malaysia; Denis, 2021).

Since the revision of the Malaysian Code on Corporate Governance (MCCG) in 2017, listed companies are required to report on their adoption of the MCCG using a prescribed template for corporate governance reports, introduced to improve readability and comparability of information, and designed to be system-friendly (e.g. use of drop-down options to ensure standardisation of entry) to enable data extraction, evaluation, and analysis of AI, which considers among others the type of information disclosed, depth of explanation, and in relation to departures, the strength of alternative practices (Denis, 2021). There is an evaluation parameter for all 36 best practices in the MCCG. Prior to these enhancements, including the use of AI, monitoring the adoption of the Malaysian Code on Corporate Governance and the quality of disclosures by either regulators or investors required extensive resources to undertake heavily manual activities, posting some challenges, including to obtain current data and observations on the adoption of best practices (Denis, 2021). The data also supports evidence-based regulatory measures to improve corporate governance practices or address areas of concern including practices with low score of disclosure (Denis, 2021).

2.5.6. South Korean corporations the key drivers of AI in the country

Corporations such as Samsung, Hyundai, and LG dominate Korea's manufacturing base and remain key drivers of the country's private R&D technology spending, including fast-growing areas such as AI (Asia Business Council, 2017). Samsung Electronics alone invested 14 trillion won (USD 12 billion) in R&D in 2016, much of it devoted for AI, IoT, and autonomous driving (Asia Business Council, 2017). In 2016, Hyundai Motors spent 2.4 trillion won on R&D for conventional vehicles and exploring dimensions of autonomous driving (Asia Business Council, 2017). LG Electronics spent 2.2 trillion won on R&D in 2016 showcasing its SmartThingQtechnology which is an IoT for the home allowing devices such as stoves, refrigerators, washing machine, robot vacuum cleaners to be linked together (Asia Business Council, 2017).

In May 2018, as part of the national I-Korea 4.0 plan, the Ministry of Science and ICT (MSIT) announced a new AI R&D Strategy, which is comprised of three main components: securing AI talent in six graduate schools with the goal of training 5,000 AI specialists; developing AI technology by funding large-scale projects in national defence, medicine, and public safety through an AI R&D challenge; and supporting the development of AI start-ups and SMEs by creating an AI-oriented start-up incubator (IICOM, 2020).

2.5.7. Thailand requires capacity building for AI

Thailand has yet to formulate a national AI policy and is instead focusing on capacity building, re-skilling, and up-skilling manpower to prepare society for the wide impact of AI (IICOM, 2020). Most of the country's AI initiatives are embedded within policies developed by ministries and agencies (IICOM, 2020).

AI start-ups are relatively new in Thailand and the main AI trend is in NLP which includes sentiment analysis and machine translation (IICOM, 2020). Government is also adopting AI across various industries. The Thai Ministry of Public Health has started leveraging ML and computer visualisation systems to help government agencies identify public health risks, disease hotspots, and ultimately mitigate the risk of epidemics (IICOM, 2020). The Ministry of Digital Economy and Society (MDES) is setting up a 'big data sandbox' or an experimental regulatory safe space that allows organisations to test digital products and

services without putting data or systems at risk (IICOM, 2020). The banking sector in Thailand plans to use facial recognition for electronic KYC, blockchain, and ML for fraud detection (IICOM, 2020).

Further, the Thai government has engaged in public-private partnerships to improve the skillset of its economy to meet AI ambitions (IICOM, 2020). Thailand is working with Google and the United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP) on a joint 'AI for Social Good' initiative to discuss uses of AI for sustainable development (IICOM, 2020). Similarly, Google, Microsoft, Cisco, and Huawei are collaborating with the Digital Economy Promotion Agency (DEPA) to create a learning curriculum that will produce 40,000 digital and high-tech workers by 2022 (IICOM, 2020).

Although the Thai government is aiming to make better use of AI and prioritise the adoption of AI, it has yet to develop clear strategies and guidelines at the national level. There is limited strategic coordination between the country's existing national plans to promote AI and limited success metrics to evaluate where gaps exist (IICOM, 2020).

2.5.8. Hong Kong, China's emphasis on academia for AI development

Hong Kong, China is home to a relatively high number of top computer scientists as it ranks just after Singapore in terms of number of academic papers published (Asia Business Council, 2017). The emphasis on academia is the impetus behind one of Hong Kong, China's notable AI start-ups called Snapask, a program which allows students to connect with Snapask tutors for help with their homework (Asia Business Council, 2017). From a simple service of ask and answer, Snapask now uses AI cloud-based technology to aid students in need where the website promises tutorial expertise in a broad range of subjects (Asia Business Council, 2017). CompareAsiaGroup, a Hong Kong, China-based start-up that operates in five ASEAN countries uses ML to match customers with financial, telecom, and utility services across Asia (McKinsey Global Institute, 2017).

2.5.9. Chinese Taipei's manufacturing advantage for AI platforms

Chinese Taipei's former Premier Willian Lai announced the four-year 'AI Action Plan' in January 2018 with an annual budget of New Taiwan Dollar 10 billion over four years as part of Executive Yuan's larger strategy to use Chinese Taipei's information technology and semiconductor industries to develop new smart technologies (IICOM, 2020).

Technology companies in Chinese Taipei are competing on AI through building on their manufacturing capabilities to develop hardware and tools that make AI faster and more powerful (Asia Business Council, 2017). Chinese Taipei also has a burgeoning start-up sector that is gaining investor interest. The start-up Appier helps increase the effectiveness of digital ad campaigns by tracking target buyers' usage behaviour across their devices, including the iPhone, iPad, and laptop (Asia Business Council, 2017). Appier then combines this with AI analysis of purchasing behaviour for a given product to serve ads to the target of users' suite of devices more efficiently (Asia Business Council, 2017).

2.5.10. Vietnam

Vietnam's Ministry of Science and Technology is taking measures to support the country to best use AI for economic growth during the period of 2018 to 2025 (OECD, 2021b). The objectives of the country's plans are to research and monitor AI technology to develop AI products made in Vietnam, and to develop a skilful labour force in the technical sector and AI industry in particular (OECD, 2021b). The National Forum in AI has been the primary activity to implement the country's plan where it attracted more than 2,000 participants with events on AI start-ups (OECD, 2021b). The country's National Program 'Supporting the national Innovation Initiative to 2025' aims to create favourable environments to promote and support the formation and develop of start-up enterprises (OECD, 2021b). This will be achieved through the

improvement of legal frameworks for supporting start-ups to catalyse business innovation and entrepreneurship (OECD, 2021b).

Hochiminh City used AI technology to develop a smart city model, particularly in the transportation and health services sectors (OECD, 2021b). The centre is being transformed into a smart city and will develop blockchain infrastructure to minimise potential risks (OECD, 2021b). The objective of the project is to help the city deal with problems such as rapid population growth, inadequate healthcare, education, and transport services (OECD, 2021b). This will be achieved through developing a regulatory framework and policies associated with blockchain that will improve public administration and enhance its capability to forecast and make long-term plans (OECD, 2021b).

In November 2017, Vietnam and Australia announced the creation of the Australia-Vietnam Innovation Partnership (OECD, 2021b). The Aus4Innovation program is an AUD 11 million development assistance program with the objective to strengthen Vietnam's innovation system, prepare for opportunities associated with Industry 4.0, and help shape Vietnam's innovation agenda in science and technology (OECD, 2021b).

2.5.11. Philippines plan to establish an AI research centre in 2021

In 2021, the government designed a plan to build a national centre for artificial intelligence (AI) research that will help the private sector develop new technologies. Though, the "digital divide" in Philippines between those with and without the internet leads to unequal access to social services and life-changing economic opportunities (OpenGov, 2021).

2.6. AI Policy Implications and considerations

2.6.1. Recent Policy Activity around AI and Finance

Given the potentially transformative effect of AI on certain markets and the new types of risk stemming from its use, AI has been a growing policy priority for the past few years. In May 2019, the OECD adopted its 'Principles on Artificial Intelligence' which are the first international standards agreed by governments for the responsible stewardship of trustworthy AI, with guidance from a multi-stakeholder expert group (OECD, 2021a). In 2020, the European Commission issued a white paper with policy and regulatory options for an 'AI ecosystem for excellence and trust' with a proposed future regulatory framework on AI and a discussion on safety and liability aspects (European Commission, 2020). Action at the European level is also directed at the practical implementation level, with initiatives such as the ''Infinitech consortium's pilot project''[5] financed by the European Commission.

In 2020, IOSCO published a consultation report on the use of AI by market intermediaries and asset managers, and proposed six measures to create appropriate regulatory frameworks to supervise market intermediaries and asset managers that use such technologies (OECD, 2021a). Efforts are also being made at the national level. In 2018, the French ACPR established a taskforce bringing together the financial industry (i.e. business associations, banks, insurers, FinTechs) and public authorities to discuss current and potential uses of AI along with opportunities and risks (ACPR, 2018). In 2019, the Bank of England and Financial Conduct Authority launched the AI Public Private Forum. The Russian Federation enacted a National Strategy for the development of AI in 2019[6], and a concept for the development of regulating AI

[5] A joint private initiative bringing together financial and ICT corporations in creating an experimental environment for testing Big Data, AI and IoT innovations. The project "aims at lowering the barriers for AI-driven innovation, boosting regulatory compliance, and stimulating investments in the sector" (Infinitech, 2020).

[6] Decree of the President of the Russian Federation of 10.10.2019 No. 490 • President of Russia (kremlin.ru)

technologies and robotics in 2020[7]. In 2021, a Federal law on Experimental Digital Innovation Regimes[8] came into force empowering the Bank of Russia to approve the launch of regulatory sandboxes, including for projects deploying AI solutions in finance.

On 31 March 2021, the Comptroller of the Currency, the Federal Reserve System, the Federal Deposit Insurance Corporation, the Consumer Financial Protection Bureau, and the National Credit Union Administration issued a Request for Information and comment on financial institutions' use of AI, including ML (Federal Register, 2021). The consultation notes the benefits and main risks of AI in finance (around explainability, data usage, and dynamic updating) seeks input on questions related to explainability, the broader or more intensive data processing and usage, risk of overfitting, cybersecurity risks, fair lending considerations, and oversight of third parties and considerations (Federal Register, 2021).

On 21 April 2021, the European Commission published a proposal for a regulation that aims to address the risks of AI and lay down harmonised rules on the uses of AI across sectors of activity, while also proposing the establishment of a European AI Board (European Commission, 2021). While the proposal's overall scope is wide, the strongest requirements apply to the high-risk applications of AI, which includes assessment of creditworthiness. The proposed rules also introduce a requirement for human oversight by suitably trained individuals; the use of kill switches and/or explicit human confirmation of decision making; ensure the accuracy, robustness, and security of the system; conduct post-market monitoring and notify the regulatory about serious incidents; and register the system of a public register (OECD, 2021a).

2.6.2. Policy considerations

The increased deployment of AI in financial services can provide important benefits to financial consumers and market participants by improving the quality of services offered, and producing efficiencies to financial service providers (OECD, 2021a). At the same time, AI-based applications in finance can give rise to new challenges (e.g. related to lack of explainability) or amplify risks that already exist in financial markets (e.g. related to data management and use). Policy makers and regulators have a role in ensuring the use of AI in finance is consistent with promoting financial stability, protecting financial consumers, and promoting market integrity and competition.

The application of regulatory and supervisory requirements on AI techniques could be considered under a contextual and proportionality framework, depending on the criticality of the application and potential impact on consumers (OECD, 2021a). This will likely encourage the use of AI without unnecessarily stifling innovation. Policy makers could consider the introduction of specific requirements or best practices for data management in AI-based techniques. These could touch upon data quality, adequacy of the dataset used depending on the intended use of the AI model, and safeguards that provide assurance about the robustness of the model when it comes to avoiding potential biases. Requirements for additional transparency over the use of personal data and opt-out options for the use of personal data could be considered by authorities.

Disclosure requirements around the use of AI techniques in the provision of financial services must also be considered by policy makers. Clear information around the AI system's capabilities and limitations should be included in such disclosure. The introduction of suitability requirements for AI-driven financial services, similar to the ones applicable to the sale of investment products, would help financial service providers better assess whether prospective clients have a solid understanding of how the use of AI affects the delivery of the product (OECD, 2021a).

[7] The Ministry of Economic Development of Russia has prepared a draft concept for the regulation of artificial intelligence and robotics | Ministry of Economic Development of the Russian Federation (economy.gov.ru)

[8] Federal Law of July 31, 2020 No. 258-FZ "On Experimental Legal Regimes in the Field of Digital Innovations in the Russian Federation" — Rossiyskaya Gazeta (rg.ru)

The limited transparency and explainability of many advanced AI-based ML models is a key policy question that remains to be solved. Lack of explainability limits the ability of users to understand how their models affect markets to contribute to market shocks. Importantly, the inability of users to adjust their strategies in times of stress may lead to exacerbated market volatility and bouts of illiquidity during periods of acute stress, aggravating flash crash type of events (OECD, 2021a). At current stage of development, it is important to retain human oversight and re-examination of decisions made by automated functions, especially when the risk of mistake is high, both in terms of systemic loss but also in terms of individual loos.

Regulatory rules should be broken down into components, such that each entity participating in the chain of production and use of an AI based model will be subject to the appropriate set of guidelines.

Regulators should consider how to overcome the perceived incompatibility of the lack of explainability in AI with existing laws and regulations. The supervisory focus may need to be shifted from documentation of the development process and the process by which the model arrives to its prediction to model behaviour and outcomes (OECD, 2021a). Supervisors may wish to investigate more technical ways of managing risk such as adversarial model stress testing or outcome-based metrics (Gensler and Bailey, 2020). Overall, explainability remains at the core of the perceived lack of trust of users and supervisors around AI applications. However, while current discussions tend to focus on improving explainability, other checks and balances need to be introduced to ensure ML model-based decisioning is operating as intended.

Policy makers could consider requiring clear model governance frameworks and attribution of accountability to the human to help build trust in AI-driven systems. Explicit governance frameworks that designate clear lines of responsibility for the development and overseeing of AI-based systems, may need to be put in place. Adequate documentation and audit trails of the above processes can assist the oversight of such activity by supervisors (OECD, 2021a).

The performance of models needs to be tested in extreme market conditions, to prevent systemic risks and vulnerabilities that may arise in times of stress (OECD, 2021a). The introduction of automatic control mechanisms (such as kill switches) that trigger alerts or switch off models in times of stress could assist in mitigating risks, although they expose the firm to new operational risks. Back-up plans, models and processes should be in place to ensure business continuity in case the models fail or act in unexpected ways.

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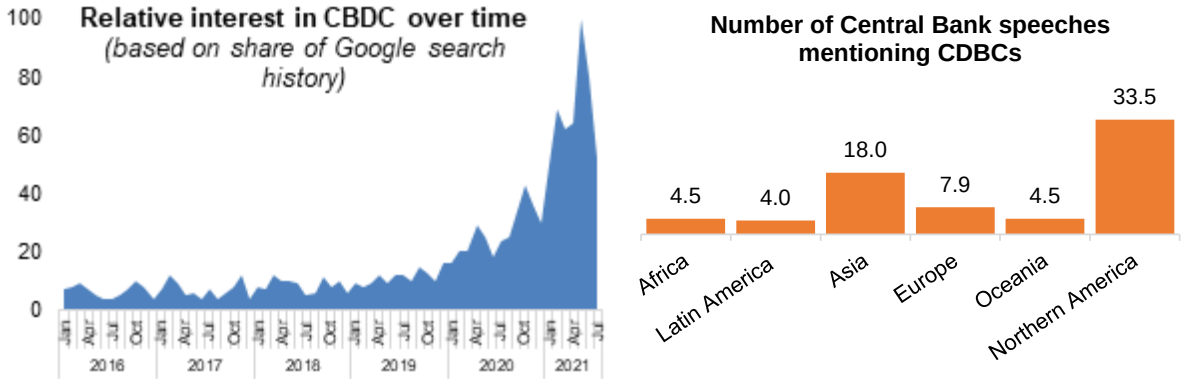
3 Central Bank Digital Currencies (CBDCs)

3.1. Introduction

Over the past five years, public interest in central bank digital currencies (CBDCs) has grown, and the topic has received increasing attention from central banks (Figure 3.1). Google search engine statistics show that the relative interest has spiked in the last year, particularly in Asia (South Korea, China, Hong Kong (China), Singapore) North America and Europe (Switzerland, United Kingdom, Netherlands). As of July 2021, 51 central banks have published their involvement in CBDC research or pilots.

Figure 3.1. Growing interest in CBDCs

Google statistics on CBDCs searches [LHS] and number of central bank speeches mentioning CBDCs (RHS)



Note: LHS Values are calculated on a scale from 0 to 100, where 100 is the location with the most popularity as a fraction of total searches in that location, a value of 50 indicates a location which is half as popular. 2021 Speeches included considered until July 2021
Source: (BIS, 2021), Google Trends (accessed on 7 July, 2021).

According to the Bank for International Settlements (BIS), a CBDC refers to a digital payment instrument, denominated in the national unit of account, which is a direct liability of the central bank, like cash (BIS, 2020b). The discussion on whether to allow any individual to hold central bank reserves began decades ago; In the 1980s, it was proposed that central banks make available to the public a medium of exchange/payment with the convenience of deposits and the safety of currency (essentially currency on deposit), transferable in any amount by check or other order (Tobin 1985, 1987).

Many central banks are currently researching the potential of CBDCs. The objectives are diverse and are linked to the underlying degree of financial infrastructure development in each jurisdiction. Access to payment system and banking services varies a great deal among countries in Asia. In countries where a

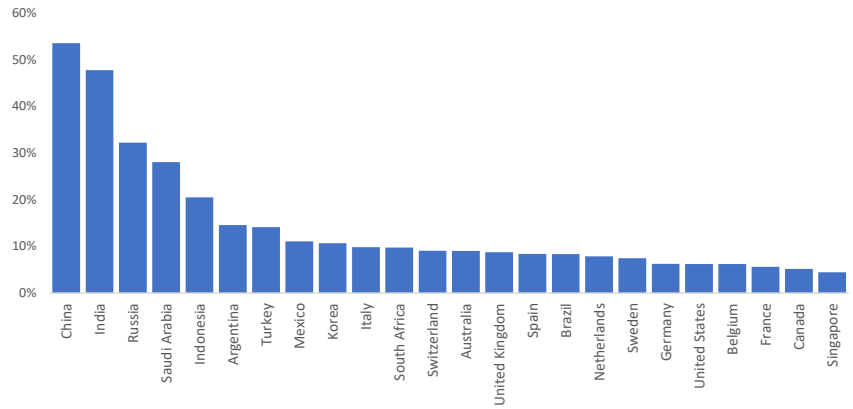
large part of the population is banked and able to access digital payments, the main motivation of central banks to explore the idea of CBDC is to prevent payment system fragmentation between cash-based and digital-based systems but even more so within the digital-based payment systems, especially given the increasing adoption of, and interest in, crypto-assets. At the same time, CBDCs could support further financial development and innovation by providing an advanced and efficient payment infrastructure on which more private sector innovations can be built. The digitalisation of the economy, particularly post COVID-19, has accelerated the adoption of digital payments and lowered the use of cash in some areas around the world (Figures 3.2 and 3.3). CBDCs could offer governments a digital version of money to safeguard public trust in central bank money while addressing the demand of consumers for digital means of payment. The introduction of CBDC could encourage greater competition and innovation by allowing for equal access to a more efficient, consumer-friendly, convenient and safe payment option on the basis of which financial service innovation can flourish.

In contrast, for countries with less developed financial infrastructure, where a large part of the population is un-banked or under-banked, CBDC might offer greater digitalisation of P2P payments and higher payment efficiency, increase the trust in the domestic currency relative to non-fiat private constructs, by making the currency more widespread and accepted while also promoting financial inclusion.

Another aspect of CBDC is international payments (i.e. remittances); cross-border payments are continuously perceived as being slower, costlier, and more opaque than domestic payments. Marked differences are observed in the cost of sending remittances across different payment instruments and across countries. Countries exploring some type of CBDC – retail, wholesale or both – present a higher average total cost of cross-border payments from their jurisdiction than countries that have not declared an intention to do so (see Section 3.2.3). CBDCs may increase the efficiency and speed of international payments, while lowering their cost, which has significant relevance for lower income families.

Figure 3.2. Growth in volume of cashless payments by country

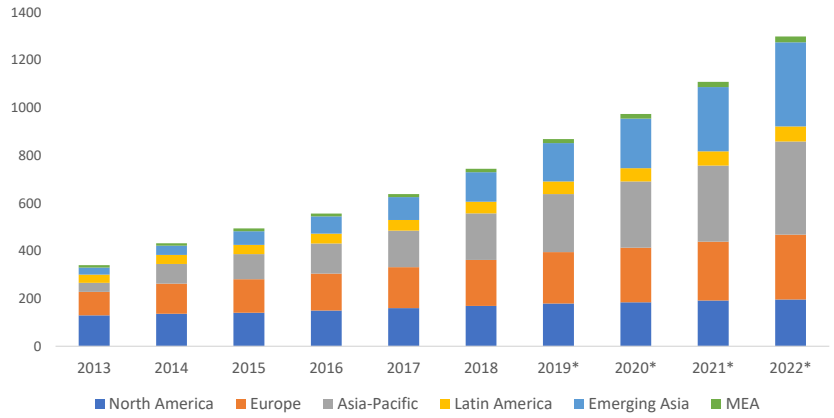
Average Year-on-Year Growth during 2014-2019



Source: BIS Statistics Explorer (accessed on 7 July, 2021).

Figure 3.3. Cashless transactions by region

2014-2018, with forecasts up until 2023



Note: MEA: Middle East and Africa (includes Saudi Arabia, UAE, Israel, South Africa, and other GCC as well as African countries); Asia Pacific includes India, China, Japan, Singapore, South Korea, Hong Kong (China), Australia, and other South East Asian markets.

In addition, CBDCs could, in concept, work towards improving efficiency of monetary policy transmission if changes to the policy rate are directly passing through to CBDC remuneration, and preserve monetary sovereignty. This is particularly important given the emergence of stablecoins or BigTech-based financial services. At the same time, issuance of CBDCs would undermine bank funding and raise the risk of structural disintermediation of banks and centralisation of credit allocation within the central bank, which is why a two-tier remuneration CBDC design and other safeguard measures have been proposed (Bindseil, 2020).

The declining use of cash may be driven, to a large degree, by the demand for digital payments and by the greater use of digitalised financial services. In 2018, USD 195 billion non-cash transactions were carried out in the Asia-Pacific, higher than any other region. Europe and North America followed, with USD 192 billion and USD 170 billion in transactions, respectively (Capgemini, 2020b). The growth in volume of cashless transactions has been driven by several trends. Although the major non-cash payment methods remain credit and debit cards, direct debits, and credit transfers, the trend in three alternative payment solutions stand out: the rise (and fall) of Bitcoin and related mainstream crypto-assets (BIS, 2018); Facebook's proposal to develop Libra – a private global stablecoin (G7, 2019); and the entrance of BigTech and FinTech firms into financial services (BIS, 2019). Some of these have failed to gain much traction; others are perceived as a threat to jurisdictions' monetary sovereignty; while many have yet to address a host of regulatory and competition issues (BIS, 2020a). Nonetheless, all these have highlighted the need to analyse CBDCs and their recognition in policy makers' agendas.

The stage of development across CBDC projects varies widely. Some countries have already launched their CBDCs or have live or near-live pilots (the Bahamas, China, Eastern Caribbean), while others are at research stages including technical experimentation (Euro Area, Japan, South Korea, Thailand). Many jurisdictions are undertaking initial cost-benefit assessments (Australia, Brazil, Hong Kong (China)) to determine whether to pursue further research.

At the regional level, Asia accounts for 36% of the retail CBDC projects under development, followed by Europe, Latin America and the Caribbean, which have 21% and 19%, respectively (Figure 3.17). Regarding wholesale CBDCs, more than half of the countries that have officially announced their involvement in wholesale CBDC projects are in Asia, followed by Europe.

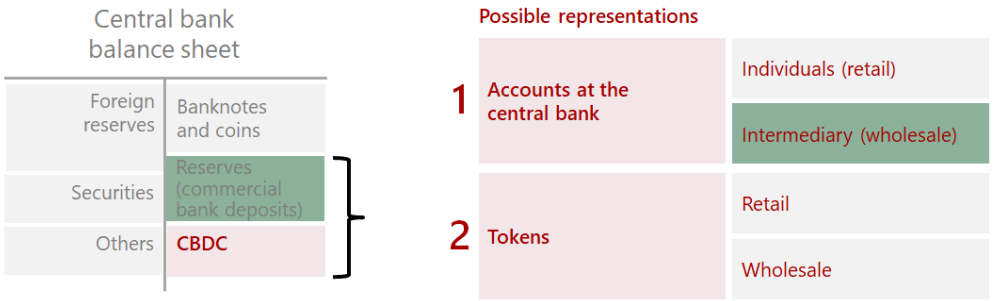
Key considerations regarding the issuance of CBDCs include design characteristics and choices. Prior to launching a CBDC, the monetary authority must decide on key technical features that determine the CBDC scope and reach, aligned with the intended goals (e.g. financial inclusion, reduction of cross-border payments' cost, payment security, among others). By looking at goals and motivations shaping CBDC research, this chapter aims to consolidate research on CBDCs and shed some light on the rationale behind authorities' decision to issue a CBDC, the potential technical considerations that are taken in the design and development of CBDCs, and implications for the impact on their respective financial systems.

This chapter is divided in two sections. The first section gives a brief review of the definition of retail and wholesale CBDCs, as well as an overview of the major technical decisions that authorities must make when developing a CBDC. Privacy, interoperability, neutrality, and a range of macro-financial implications and macroeconomic considerations surface as CBDC projects mature. International cooperation will be crucial to address these issues, and to ensure that central banks can continue to learn from one another and grasp the opportunities of CDBCs for more efficient cross-border payments (BIS, 2021b). The second section provides a stock-take of retail and wholesale CBDC projects across the world and analyses potential underlying motivation for the technical choices made by each authority. This section also focuses on CBDC considerations in Asian countries, given the concentration of CBDC projects in the region.

3.2. CBDC definition and technical features

CBDCs are considered a digital form of claims to a central bank. A CBDC could be used by individuals to pay businesses, shops or each other (a "retail CBDC"), or between financial institutions to settle trades in financial markets (a "wholesale CBDC") (BIS Innovations Hub). They are a digital payment instrument, denominated in the national unit of account that is a direct liability of the central bank (BIS, 2020b). Looking at a generic central bank balance sheet, at present, the central bank's liabilities include cash and central bank deposits from commercial banks, also known as reserves. These reserves can be considered a type of wholesale CBDC - available for exclusive use by commercial banks (BIS, 2021b).

Figure 3.4. CBDCs as a new type of central bank money



Source: BIS (2021).

CBDCs can be reserved for the sole use of financial institutions (wholesale CBDCs), or they can be used by the general public to make day-to-day payments transactions (retail CBDCs). So-called 'synthetic CBDCs' allow consumers and households to hold commercial bank-issued deposits that are backed by

deposits stored at the central bank instead of stored at a commercial bank, but are not considered as CBDCs as they are not issued by the monetary authority (Adrian and Mancini-Griffoli, 2019).[9]

Table 3.1. Comparison of CBDC types

Key retail CBDC Criteria	Retail CBDC	Wholesale CBDC	Synthetic CBDC[1]
Denominated in jurisdiction's unit of account	X	X	X
Issued by and direct liability of jurisdictions' monetary authority	X	X	
Backed by jurisdiction's monetary authority	X	X	X[1]
Broadly accessible to the public for general-purpose usage	X		?

Note: 1. Backed by monetary authority deposits or wholesale CBDC, and not considered a CBDC. For more detail on sCBDC see Adrian and Mancini-Griffoli (2019a).
Source: Kiff (2021).

3.2.1. Retail CBDCs

There are several technological, financial, and regulatory decisions that domestic authorities make as part of the design process of a CBDC. These decisions are based on the specific goals of a CBDC. In the case of retail CBDCs, the BIS provides the "CBDC pyramid" which maps consumer needs to CBDC design choices (BIS, 2020d). CBDCs in the proof-of-concept stage are currently testing which design option works best for their needs. Moreover, no design selection is made independent of other design characteristics, as some choices can preclude the opportunity to use another design option.

Architecture

A CBDC must be issued and redeemed by a central bank, and its architecture depends on the structure of legal claims and the record kept by the central bank (BIS, 2020d). The three standard architecture designs and their corresponding characteristics are presented in Figure 3.5. In the Indirect CBDC design, also called a two-tier model, the central bank only manages wholesale payment, while intermediaries handle retail payment and application of required checks such as Know-Your-Customer (KYC) requirements. In the Direct CBDC design, the central bank oversees all transactions and application of financial regulatory requirements. The Hybrid CBDC design refers to a combination of Direct and Indirect CBDC architectures.

There are several trade-offs to consider when deciding on the type of architecture. The direct CBDC simplicity eliminates dependence on intermediaries, making deposits of consumers entirely risk- free, but at the same time it increases the operational burden on central banks – responsibility for KYC, customer due diligence and requirement to sustain payments when one intermediary is under technical stress – which could compromise the payments' system reliability, speed, and efficiency. On the other hand, whereas the indirect model enables credit formation in the economy, since retail payments are managed

[9] According to Adrian and Mancini-Griffoli (2019), a synthetic CBDC or sCBDC allows consumers and households to hold commercial bank-issued deposits that are backed by deposits stored at the central bank instead of stored at a commercial bank. This proposal is similar to a narrow banking system, and could involve commercial banks and third parties helping central banks build front-end consumer facing interfaces, as well as manage the accounts and provide customer service & compliance, among other things. An argument can be made that this type of synthetic CBDC already exists by way of China's Alipay, which is required to be fully reserved with deposits maintained at central bank, the People's Bank of China (PBOC).

by financial institutions, in this model the central bank cannot honour claims from consumers without receiving information from the intermediary.

Figure 3.5. Retail CBDC architecture: roles of the involved parties

	Legal claim relies on….	Manages wholesale payment	Manages retail payment	Handles regulation
Indirect CBDC *(Two-tier model)*	Intermediaries *(e.g. banks, non-banks financial institutions)*	Central Bank	Intermediaries *(e.g. banks, non-banks financial institutions)*	Intermediaries *(e.g. banks, non-banks financial institutions)*
Direct CBDC *(Single-tier model)*	Central Bank	Central Bank	Central Bank	Central Bank
Hybrid CBDC *(Direct + Indirect)*	Central Bank	Central Bank	Intermediaries *(e.g. banks, non-banks financial institutions)*	Intermediaries *(e.g. banks, non-banks financial institutions)*

Source: OECD based on (BIS, 2020).

Infrastructure

At the infrastructure level, central banks must decide between a centralised or decentralised infrastructure. Decentralised ledger technologies (DLT) can provide potential benefits such as censorship resistance, resilience (given the absence of single point of failure) and potential efficiencies driven by automation and disintermediation (OECD, 2020b). It is worth noting that the decision around the underlying infrastructure technology can only be made once the CBDC architecture design has been chosen, as some models may be incompatible with DLTs. For instance, under certain conditions, DLTs may not support a direct CBDC as it would require massive technological capabilities for the central bank to process all transactions itself (BIS, 2020d). It is unclear at this stage whether DLTs have, in practice, the scalability that would be required for such transaction volumes.

Access technology and privacy

Data privacy is one of the most critical considerations in CBDC design and has been widely discussed across CBDC initiatives, particularly with regards to financial inclusion. The degree of privacy or inclusion that can be achieved is to a large extent dependent on whether the CBDC is token-based or account-based. Token-based CBDCs would represent a cash-like instrument, in which tokens are not linked to the identity of their holders, as would be the case for a bank account, thereby allowing for anonymity and privacy but undermining compliance. Account-based CBDCs, on the other hand, will result in a centralised system and create a bank-account-like instrument, making it easier for authorities to fulfil KYC and AML/CFT checks (FATF, 2020). At the same time, the centralisation of the system will increase its one-point vulnerability and might increase the motivation of hackers to attack the central bank's infrastructure.

Interlinkages

Efficiencies and reduction of the costs related to cross-border payments is one of the most cited motivations behind jurisdictions' interest in CBDCs. It has been argued that CBDCs would represent a unique opportunity to facilitate cross-border payments (Cœuré, 2019). Coordination will be key for reducing costs and inefficiencies, harmonising regulatory frameworks across jurisdictions, and fostering competitive foreign exchange markets. CBDCs could present potential new retail interlinkages if, for example, they were to allow consumers to hold multiple currencies. Those new retail interlinkages and their design would

depend on the national access technology chosen (i.e. token or account-based). If a national system is based on digital tokens, it will - by default - be accessible to foreign residents. On the contrary, account-based systems would be linking ownership to identity and transactions need to be authorised via identification (BIS, 2020d). This gives rise to data privacy considerations and interoperability, coordinated at the international level, would need to be included in the initial design of the system for cross-border payments.

Remuneration

Monetary policy considerations play an important consideration for CBDC design. Central banks can decide whether retail CBDCs are interest-bearing (like commercial banking deposits) or not (like cash). The implications of both models should be carefully examined, including the impact on monetary policy efficiency, potential cash replacement, and incentives to hoard CBDCs. As discussed in Section 4, central banks could maintain a lower interest rate on CBDCs than the one offered by bank deposits in order to mitigate risk of disintermediation in the banking sector.

3.2.2. Wholesale CBDCs

A wholesale CBDC enables payments and settlement of transactions between authorised financial institutions. Although this concept already exists in the current payment system as banks can access central bank deposits (i.e. reserves), a wholesale CBDC could improve the efficiency and resilience of the settlement process, as well as facilitate cross-border payments. Furthermore, it could provide access to market participants who currently cannot hold accounts at the central bank, such as non-banking financial institutions. For settlement to be achieved at near real-time and for delivery to be certain in securities transactions, the securities transacted, and the corresponding payments need to switch simultaneously in what is called ‘atomic settlement’ of tokenised assets (OECD, 2020b) (see Chapter 1). Wholesale CBDCs would allow for atomic settlement of transactions, by offering a tokenised form of central bank money for the payment leg of delivery versus payment (DvP) settlement of tokenised transactions (OECD, 2020b). Overall, wholesale CBDCs can be categorised in two use cases: domestic or cross-border payment CBDCs.

Wholesale CBDCs for domestic payments

Wholesale domestic payments are not a novel concept, as large-value payments are currently executed through real time gross settlement (RTGS) systems, usually controlled and operated by central banks due to their systemic importance, such as CHAPS system in the UK and Fedwire Funds Service in the US. RTGS systems emerged in the 1980s and were adopted globally within a span of 30 years (Bech et al, 2017b). The Euro zone provides two examples: TARGET2, which is owned and operated by the Eurosystem, and EURO1, which is operated privately under strict supervision by the European Central bank (ECB).

Fast Payments Systems (FPS) emerged in the early 2000s and have been increasingly adopted ever since. FPS offer instant payments on a 24-hour, seven-day basis by requiring immediate clearing between the payment service providers (PSPs) of the payer and payee[10]. Funds settlements between the PSPs, however, can be either coupled (i.e. real-time settlement) or decoupled (i.e. deferred settlement) (Bech et al, 2017b). Some examples of FPS include SPEI in Mexico, BiR/Swish in Sweden, IMPS in India, and FPS in the United Kingdom.

[10] CPMI (2012) defines clearing as the process of transmitting, reconciling and, in some cases, confirming transactions prior to settlement, potentially including the netting of transactions and the establishment of final positions for settlement.

Given these developments, some jurisdictions are researching whether the advantages of implementing a domestic wholesale payments system counterbalance the required investment to build a new CBDC-based system. The use case is more relevant for jurisdictions that have not already implemented a RTGS system, and are struggling to provide faster, more reliable, and secure high-value domestic payments.

Wholesale CBDCs for cross-border payments

In terms of cross-border payments, wholesale CBDCs could streamline the settlement process that today involves several intermediaries, a high level of complexity and significant costs and lengthy processes. What is more, the current processes involve payments routed through different countries with different regulations, following different operational standards and with their own technical infrastructures.

According to the Banque de France, some considerations of consequences associated with the implementation of a wholesale CBDC from the central bank perspective are as follows (Banque de France, 2021):

- Choice of the technology: DLTs must continue to be tested for large-scale applications to ensure interoperability, with both conventional systems and other DLT systems;
- Technological neutrality: when designing a wholesale CBDC, central banks should guarantee technological neutrality
- Governance: make sure that the DLT-based solution is underpinned by strong governance and includes adequate processes conducive to the proper production of information data through the consensus mechanism;
- Access: a wholesale CBDC could trigger a demand from other financial actors that do not currently have access to central bank money to become eligible to settle in CBDC. This could have positive implications for the market, insofar as these actors are subject to similar regulatory and supervisory requirements.

Other challenges in the implementation of wholesale CBDCs include operational resilience, cybersecurity, and protection of data confidentiality and privacy, as mentioned above.

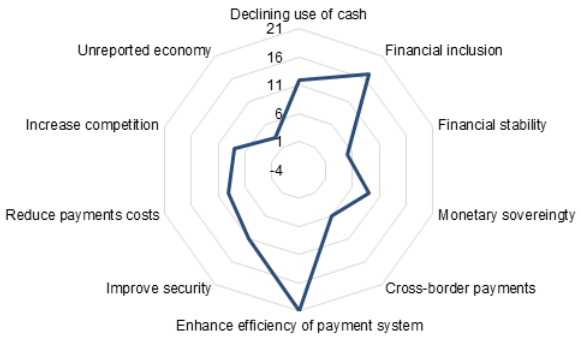
In order to better understand the design choices of central banks around the world when it comes to CBDC pilots or other research, it is important to take stock of the activity undertaken in recent months and map out the projects and corresponding models. The next section provides a stock-take of retail and wholesale CBDC projects across the globe, their stage of development and analyses the underlying reasons for the technical choices made by each authority.

3.2.3. Motivations and implications for CBDC design choices

According to analysis of official statements of central banks, the main drivers for issuing retail CBDCs are enhancing the efficiency of the local payments system and financial inclusion, both of which are consistent with the BIS 2021 Survey findings. Other relevant reasons include maintaining financial stability, reducing payments' costs and increasing competition. Monetary sovereignty and addressing the declining use of cash have become increasingly common in central bank speeches in the face of "digital dollarization" and to prevent a widespread adoption of private digital currencies denominated in major foreign currencies (BIS, 2021c).

One motivation that weights more for wholesale CBDCs is in cross-border payments efficiency. According to the BIS 2021 Survey, other important motivations for issuing a wholesale CBDC include the development of capital markets, enhancement of cyber resilience, and improvements in securities trading and settlement (BIS, 2021c).

Figure 3.6. Motivations for considering retail CBDCs



Source: OECD staff based on Central banks' official publications.

Enhanced efficiency of the payments system

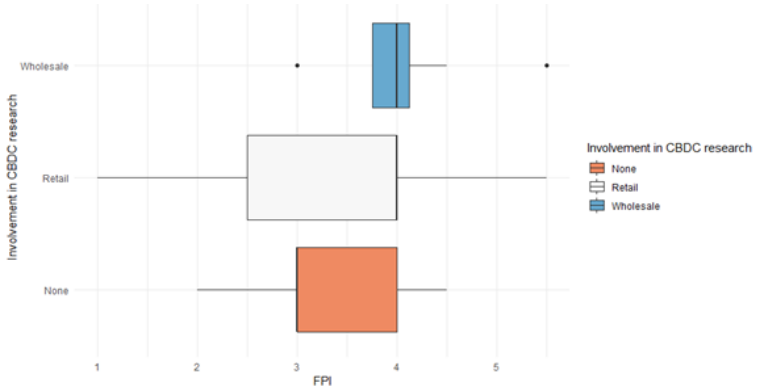
Enhancing the efficiency of payments systems is a constant priority for central banks, both at the wholesale and retail levels. RTGS, traditionally reserved only for domestic banks, have been opening-up access to non-banks (Bech et al, 2020), creating areas of opportunity. In addition to producing efficiencies for the domestic payment system and promoting financial inclusion at the national level, CBDCs have strong potential to improve interoperability for cross-border payments. Multi-CBDC (mCBDC) arrangements have gained importance, especially for emerging market economies poorly served by the existing correspondent banking arrangements (Auer et al, 2021).

In terms of retail payments, much of the private sector's innovations have been focusing on improving the consumer experience with their front-end interfaces (such as mobile and contactless payments) (Bech et al, 2020). Some examples include ApplePay, PayPal, SamsungPay and GooglePay. However, there are a growing number of initiatives that focus on back-end arrangements and are gaining systemic importance. In China, Alipay and WeChat Pay together account for 92% of mobile payments (Klein, 2019), and M-Pesa in Kenya processes payments equivalent to just under half of Kenya's GDP (McGath, 2018). Although these back-end solutions can be near real-time and available 24/7, they are closed-loop systems, which means that an individual must become a client to access its network.

FPS, on the other hand, can facilitate payments between account holders at multiple payment service providers near real-time and available 24/7. FPS have been increasingly developed across jurisdictions; According to the BIS, 55 jurisdictions have FPSs, and this number is projected to rise to 65 in the near future (Bech et al, 2020). The Faster Payments Innovation Index (FPII) is a comparative rating system where diverse payment schemes around the globe could be contrasted (FIS, 2020)[11], and jurisdictions considering retail CBDCs present lower levels of FPII, and countries involved in wholesale CBDCs are skewed to higher levels of FPII and present less variance (Figure 3.7). This could suggest that countries aiming at improving their payments infrastructure – due to a lower development of their current FPS – have identified retail CBDCs as a potential solution.

[11] While inclusion in the FPII demands only basic requirements (e.g. interbank account to account in less than one minute), a higher FPII score requires meeting more criteria, and ideally, opens the road to innovation, open banking and API-driven services on top of a faster payment service. Thus, the FPII measures not only the speed with which transferred funds become available, but how the scheme in question is applied in its local market (FIS, 2019).

Figure 3.7. Relationship between the existence of Fast Payment Systems and CBDC development



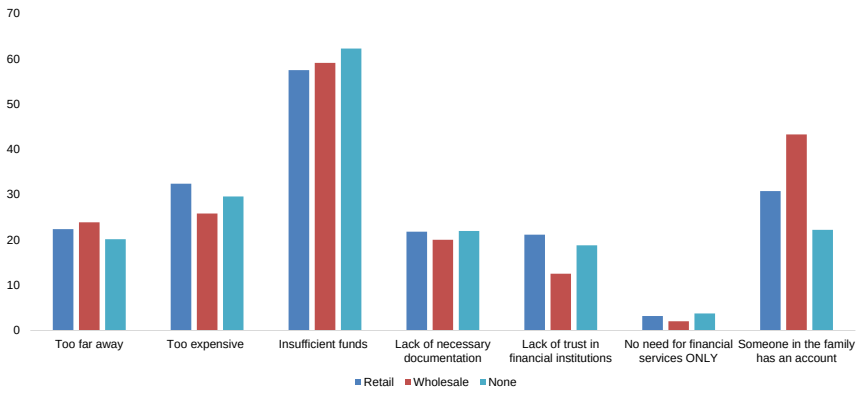
Source: OECD Staff based on FIS Report 2019 index.

Financial inclusion

A key motivation for experimenting with CBDCs in many emerging market economies is the opportunity to improve financial inclusion (Boar et al. 2020). Close to one-third of adults around the globe – 1.7 billion – are still unbanked (Findex, 2017, Figure 3.8). Furthermore, financial inclusion has been identified as an enabler for seven of the 17 Sustainable Development Goals (OECD, 2020a). Despite the increasing digitalisation of the economy in developed and emerging markets and widespread use of smartphones, some sections of the population remain behind due to barriers around trust vis-à-vis traditional financial institutions, low levels of digital literacy, access to IT (which nevertheless remains an issue when it comes to CBDCs) and data privacy concerns, all of which create a digital divide (BIS, 2020b). This highlights a potential opportunity of retail CBDCs to promote financial inclusion. In some cases, traditional financial institutions may find it unprofitable to offer services to users in certain geographies or at lower income levels, or may offer such services at costs that are uneconomical for the consumer. Rural areas that are becoming less inhabited in developed countries are subject to the same problem. Given the challenge of reaching remote areas where cash remains prevalent due to the lack of access points to the traditional financial system, or during natural disasters, a CBDC system might provide a better means to distribute and use funds depending on the interface (BIS, 2020b).

Figure 3.8. Barriers to greater inclusion

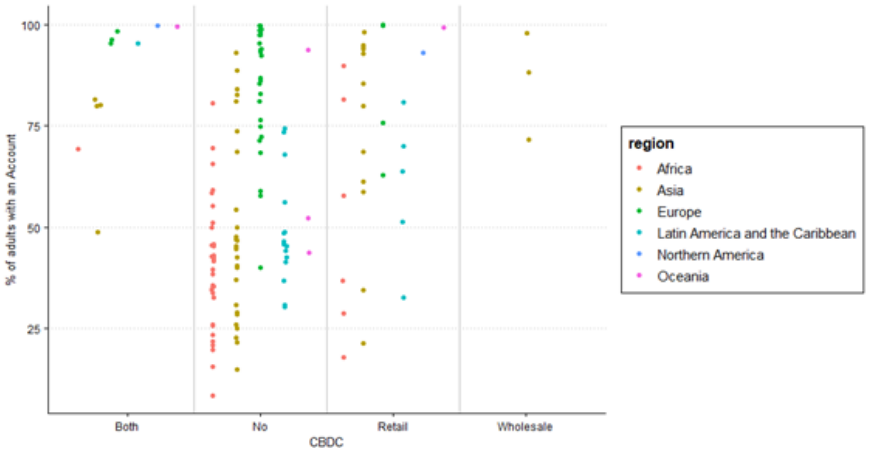
% of respondents without a financial account, aged>15, for countries with retail/wholesale/no CBDC project



Source: Global Findex 2017.

There is no specific pattern observable in the level of financial inclusion and a country's involvement in CBDC activity at this stage (Figure 3.9). However, it stands out that countries that are involved in either wholesale or both (retail and wholesale) CBDC initiatives have higher levels of financial inclusion already achieved in their economies, and therefore may have less of a driver to improve financial inclusion levels through the issuance of a retail CBDC. Countries involved in retail CBDC initiatives span from 12% up to almost complete financial inclusion level, in other words retail CBDCs are being experimented both by countries with low levels of financial inclusion and with an explicit motivation to improve such levels, but also by advanced economies with very good levels of financial inclusion.

Figure 3.9. Financial inclusion level per country grouped by type of CBDC activity



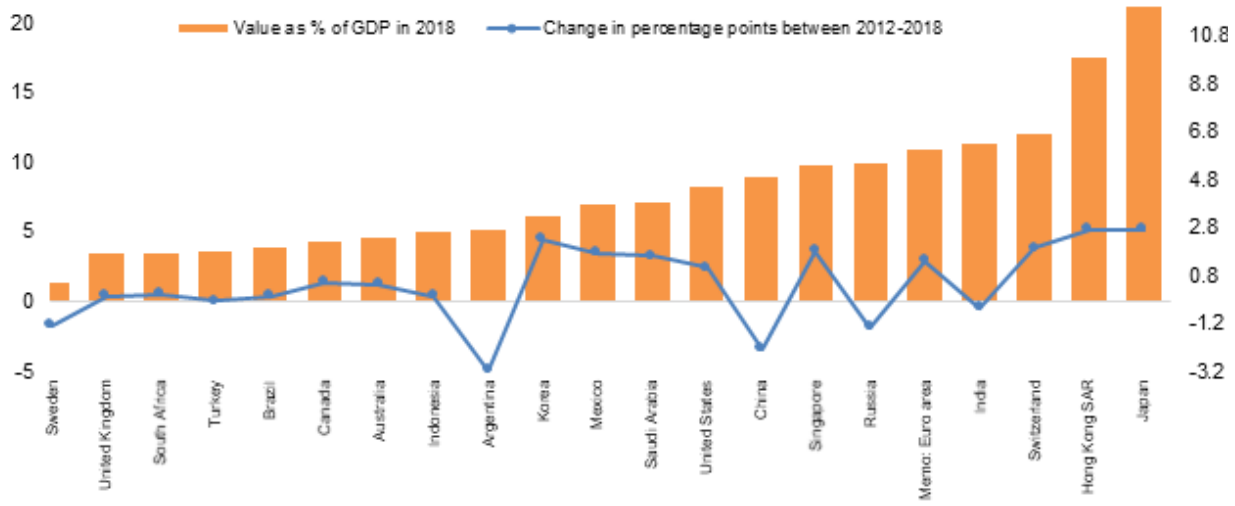
Source: OECD Calculations based on Global Findex 2017.

Nevertheless, the new digital payment alternatives as well as CBDCs may not include some segments of the population, such as the elderly, minorities, or less tech-savvy individuals, which could exacerbate the barriers for financial inclusion. When launching a CBDC, authorities must ensure that alternative, non-digital means of payments remain available to such parts of the population.

Declining use of cash

The third most relevant reason quoted by central banks for issuing a retail CBDC is the declining use of cash in the economy. However, according to the BIS Red Book, the global demand for cash does not appear to have weakened despite the increasing emergence of digital payments. The trends across countries do not seem to converge with different levels of cash use (see Figures 3.2 and 3.3). From the available sample, only Sweden, Argentina, China, Russia and India have seen a decline in cash in circulation between 2012 and 2018. On the contrary, there are still countries that are highly dependent on cash such as Japan, Hong Kong (China), Switzerland, and India.

Figure 3.10. Amount of cash in circulation relative to GDP



Source: OECD based on CPMI Red Book (2021).

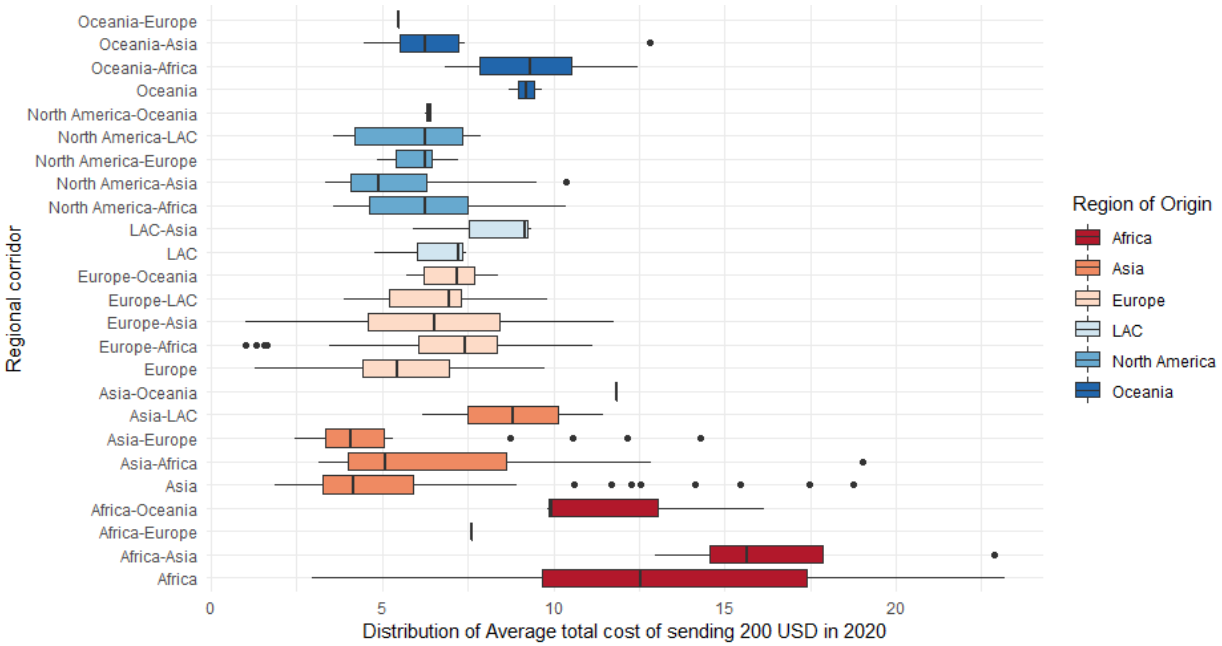
Nevertheless, there are estimates suggesting that the use of cash could further decline in many regions due to younger generations' embracement of digital payments, for example. According to those estimates, countries are expected to see on average a 1.4% annual decrease in the use of cash as a means of payment, although there are significant differences across countries' estimated trends (Khiaonarong and Humphrey, 2019). Issuance of CBDC might prevent the fragmentation of the local payment system into a cash-based and a digital-based components, by making central bank money a continuous means of payment, available and exchangeable across both ecosystems.

Overall, there are two main benefits of digital cash, which include the reduction in cost for supplying cash to the public – seigniorage and other expenses for printing currency – and the cost of distributing cash. As the difference between these costs and the value of the currency represent seigniorage revenues, these revenues would be retained if digital cash replaces currency (Khiaonarong and Humphrey, 2019).

Cross-border payments

A significant number of people and businesses depend on the ability to readily send or receive cross-border payments, such as migrants who send remittances to their families or firms that rely on international trade and commerce. Despite their wide use, cross-border payments are continuously perceived as being slower, costlier, and more opaque than domestic payments (CPMI, 2018). For instance, in 4Q 2020, the global average cost for sending USD 200 between different jurisdictions was 6.51% of this amount (World Bank, 2021). However, there remain significant differences across and within regions, as observed in the wide range of prices reported by remittance service providers (RSPs) in each regional corridor. For instance, while in Africa one can find a RSP that charges less than 3%, most RSPs charge fees ranging between 9% and 17.5%, and there are RSPs charging over 22% of the amount sent. This has important implications as the average USD 200 that migrants send to their families represent around 60% of their monthly income, and therefore high remittances' fees affect mostly the poorest migrants who remit small amounts and pay proportionally more (IFAD, 2021).

Figure 3.11. Regional comparison of average total cost of sending USD 200 in 2020



Source: OECD staff based on the World Bank, Remittance Prices Worldwide, available at http://remittanceprices.worldbank.org.

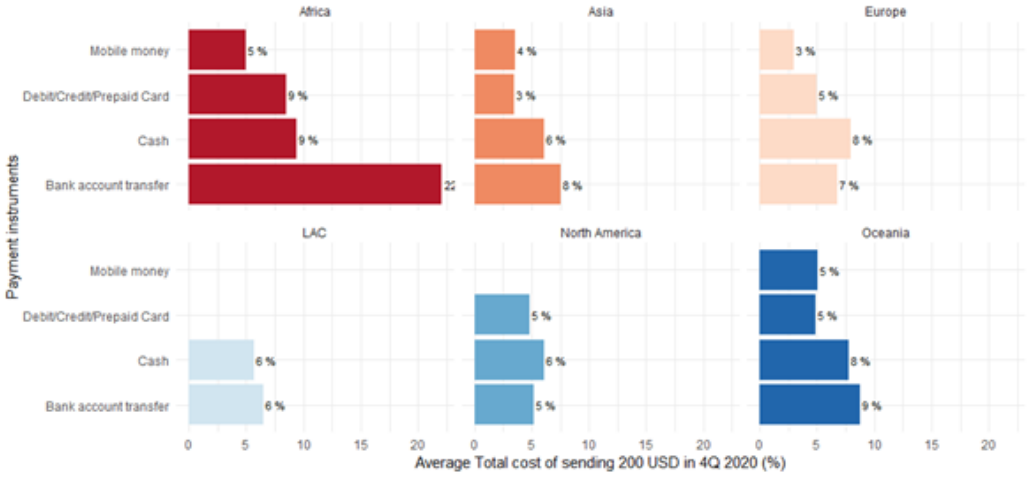
Cross-border retail payments are associated with higher funding costs given more complexity and more risks than domestic payments stemming from fragmented and truncated data formats, complex processing of compliance checks, limited operating hours, legacy technology platforms and long transaction chains (BIS, 2021a). They also portray weak competition. To address this, in 2020, the G20 endorsed a roadmap to enhance cross-border payments. The roadmap was developed by the Financial Stability Board (FSB), together with the Committee on Payments and Market Infrastructures (CPMI) and other relevant stakeholders. (FSB, 2020a, b, c; CPMI, 2020a, b).

These efforts, combined with technological innovation, are advancing retail cross-border payments in terms of speed and convenience in many jurisdictions. The evolution is further supported by the participation of non-banks, such as BigTechs, in payments, and by the increasing emergence of mobile money providers and privately-issued crypto-assets and stablecoins (see Chapter 1 on Tokenisation for more). Digitalisation, both online and mobile, is proving to be a catalyst and an enabler of remittance flows. For instance, mobile remittances increased by 65%, to USD 1.2 billion, in the course of 2020 (GSMA, 2021).

Marked differences are observed in the cost of sending remittances across different payment instruments. While transferring funds through bank accounts and cash continues to be charged the highest fees in all regions, mobile money is charging the lowest fees, standing at 2-5% (Figure 3.12).

Figure 3.12. Average total cost of sending USD 200 per payment instrument and region

As of Q4 2020

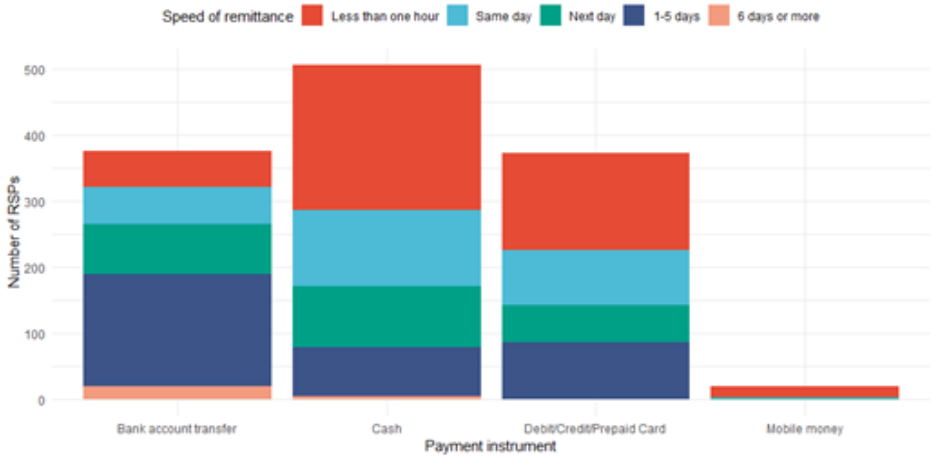


Source: OECD staff based on the World Bank, Remittance Prices Worldwide, available at http://remittanceprices.worldbank.org.

On the other hand, the number of RSPs that remit through mobile money is still low (Figure 3.13), the speed of transfer is less than an hour for an important share of all payment instruments. Bank account transfers are the exception, as most RSPs still take between one to five days to deliver the funds.

Figure 3.13. Supply of RSPs services per payment instrument and speed

As of Q4 2020



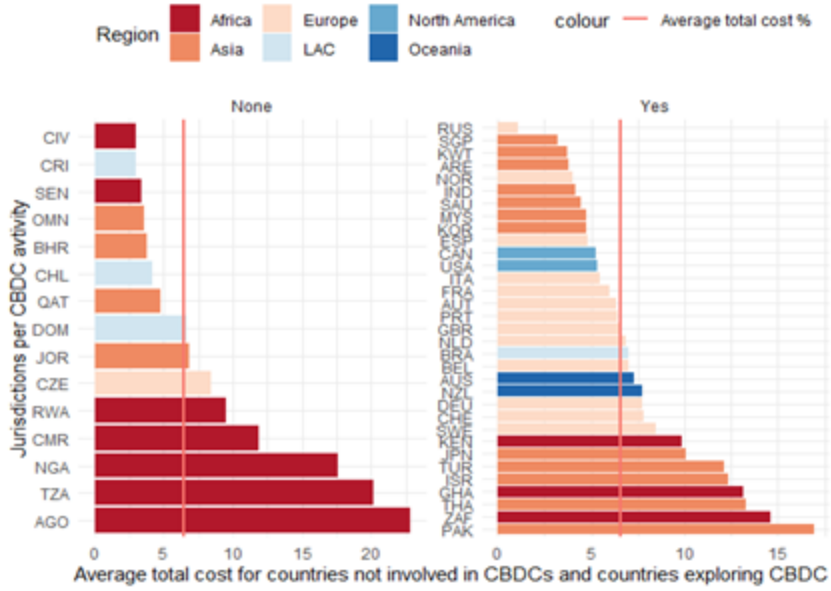
Source: OECD staff based on the World Bank, Remittance Prices Worldwide, available at http://remittanceprices.worldbank.org.

In this context, CBDCs are being explored as a tool to enhance cross-border payments and reduce costs. Many central banks that have published work on their wholesale CBDC projects, mention cross-border payments as one of their strongest motivations for exploring them. To enhance cross-border payment, wholesale CBDCs would enable expanding direct access to digital central bank money to more financial intermediaries, and would likely be accessible 24/7, thus eliminating operating hour mismatches. Furthermore, they could serve as a secure settlement asset for payment versus payment (PvP) systems

or PvP could be built into CBDC designs, therefore mitigating credit and liquidity risk of cross-currency payments (BIS, 2021a).[12]

To some extent, central banks are also considering retail CBDCs as a potential tool for enhancing cross-border payments (Figure 3.14). The extent to which retail CBDCs could facilitate cross-border payments is less clear as it will depend on the CBDC's infrastructure, regional and/or international cooperation of central banks to achieve standardisation, as well as the macro-financial dynamics that will result from the use of CBDCs. These include a potential increase in cross-border flows, possible financial stability risks and currency substitution, and reserve currency configurations and backstops (BIS, 2021a). However, in theory, cross-border payments via retail CBDCs have the potential to save on the costs charged by financial intermediaries.

Figure 3.14. Average total cost of cross-border payments per region and CBDC activity



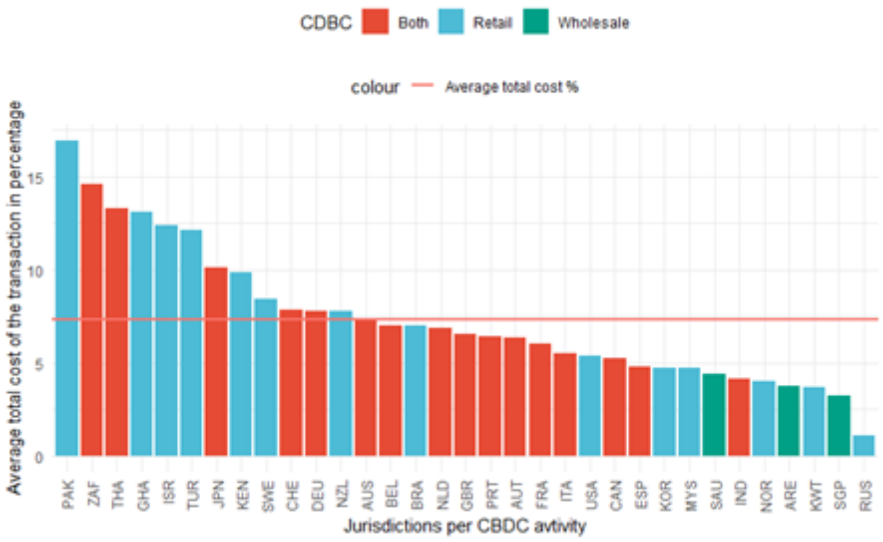
Source: OECD staff based on the World Bank, Remittance Prices Worldwide, available at http://remittanceprices.worldbank.org.

Among jurisdictions included in the World Bank Remittances database, countries exploring some type of CBDC – retail, wholesale or both – present a higher average total cost of sending USD 200 (as of 4Q 2020) than countries that have not declared an intention to do so. While this comparison lacks data from all jurisdictions, this analysis provides three main observations. First, among jurisdictions not involved in CBDC activity, African countries seem to be pulling up the average cost, and the same can be observed for the group of countries involved in CBDCs (Kenya, Ghana and South Africa are above the average cost). Second, all European countries in the database, except Czech Republic, are involved in CBDCs, which could be attributed to the efforts of the European Central bank (ECB) to develop the digital euro among euro area countries. Third, the countries pursuing only wholesale CBDCs have costs below average, with all other countries pursuing either retail CBDCs or have initiatives in both types of CBCDs (Figure 3.15). This could imply that authorities are considering retail CBDCs as a tool to address challenges in cross-border payments.

[12] According to the CPMI, Payment versus payment (PvP) refers to a settlement mechanism that ensures that the final transfer of a payment in one currency occurs if and only if the final transfer of a payment in another currency or currencies takes place (CPMI, 2012)

Figure 3.15. Average total cost of cross-border payments for countries exploring CBDCs

As of Q4 2020



Source: OECD staff based on the World Bank, Remittance Prices Worldwide, available at http://remittanceprices.worldbank.org.

The BIS proposed two different models through which CBDCs could enable cross-border payments. In the first, a retail CBDC of a given jurisdiction becomes available to anyone inside and outside of that country, with no specific coordination between the central banks. In the second one, access and settlement arrangements are established among different retail and/or wholesale CBDCs, built on strong cooperation among central banks (BIS, 2021a). In this context, the macro-financial implications of cross-border CBDC use will ultimately depend on the level of adoption, the design of the CBDC, and on the degree of collaboration among issuing and recipient countries (BIS, 2021a).

Given the early stage of development, CBDCs offer the opportunity to start with a “clean slate” by coordinating regulatory frameworks as well as fostering common data and market practices to address current challenges in cross-border payment systems (BIS, 2021a) (see Box 3.1 for ongoing efforts on international coordination and best practices).

Monetary sovereignty

Another relevant motivation for central banks to issue CBDCs is maintaining effective control of monetary policy transmission. As mobile payments, crypto-assets and private issued forms of money emerge, the share of public money or central bank liabilities (i.e. cash and central bank reserves) over which central banks have direct control and use as a tool of monetary policy, could decrease over time. If that were to happen, CBDCs could be used to achieve the objective of maintaining a public currency as well as financial and monetary stability.

There is some literature on the implications of private issued currencies on the transmission of monetary policy and macroeconomic stability. For instance, a model of competition among privately issued forms of money show that while the system could ensure some level of price stability, it could still face self-fulfilling inflationary pressures that would not lead to a socially efficient allocation of money (Villaverde and Sanches, 2018). Nevertheless, some research argues that the coexistence of both public and private forms of money could impose market discipline on governments.

Literature also focuses on the argument that a CBDC could be desirable as a way for monetary authorities to avoid the ubiquitous adoption of private substitutes of cash (e.g. stablecoins or private issued crypto-assets), which could hamper payment instrument competition, or exacerbate risks in the event of operational problems with privately supplied payment methods (Khiaonarong and Humphrey, 2019). Competition between private digital currencies, each defining a Digital Currency Area (DCA)[13] could risk smaller countries with higher inflation rates facing risks of digital dollarisation, as the digital currency would be a way to protect oneself from currency devaluation, even if the user would still face currency volatility at the moment of conversion back to national currency. Alternatively, if several private digital networks emerge, the international monetary system could become more fragmented. In this sense, CBDCs could emerge as solutions to address these risks (Brunnermeier, James and Landau; 2019).

3.3. Global outlook

As of July 2021, 51 central banks were involved in CBDC projects, either through the development of retail CBDCs (regions coloured in green), wholesale CBDCs (regions coloured in coral), or both models (regions coloured in dark red).[14]

Interest for retail CBDCs is more pronounced than for wholesale CBDCs, as 47 central banks have published work related to retail CBDCs, while 16 central banks have done so for wholesale CBDCs. Further, 12 central banks have expanded their research and they are assessing both retail and wholesale models.[15]

The Asian region accounts for a large share of CBDC pilot activity: 36% of retail projects and 55% of wholesale CDBCs under development are taking place in Asia. Europe, on the other hand, concentrates 30% of wholesale projects and 21% of the retail CDBCs. Although there was no wholesale use case identified in Latin America and the Caribbean, the region has 19% of the retail CDBCs projects, the more advanced being the Sand Dollar in the Bahamas, which was launched in October 2020 (CBB, 2020). Africa[16] follows with 15% of the retail projects, and 5% of the wholesale CBDC – the latter representing South Africa's wholesale Project Khokha (South African Reserve Bank, 2018). North America (including the United States and Canada) and Oceania have two retail CBDCs projects each, representing 4% of the total retail CBDCs. Similarly, by Canada in North America and South Africa in Africa have one wholesale CBDC project each.

[13] The authors define a Digital Currency Area as a network where payments and transactions are made digitally by using a currency that is specific to this network (Brunnermeier, James and Landau; 2019).

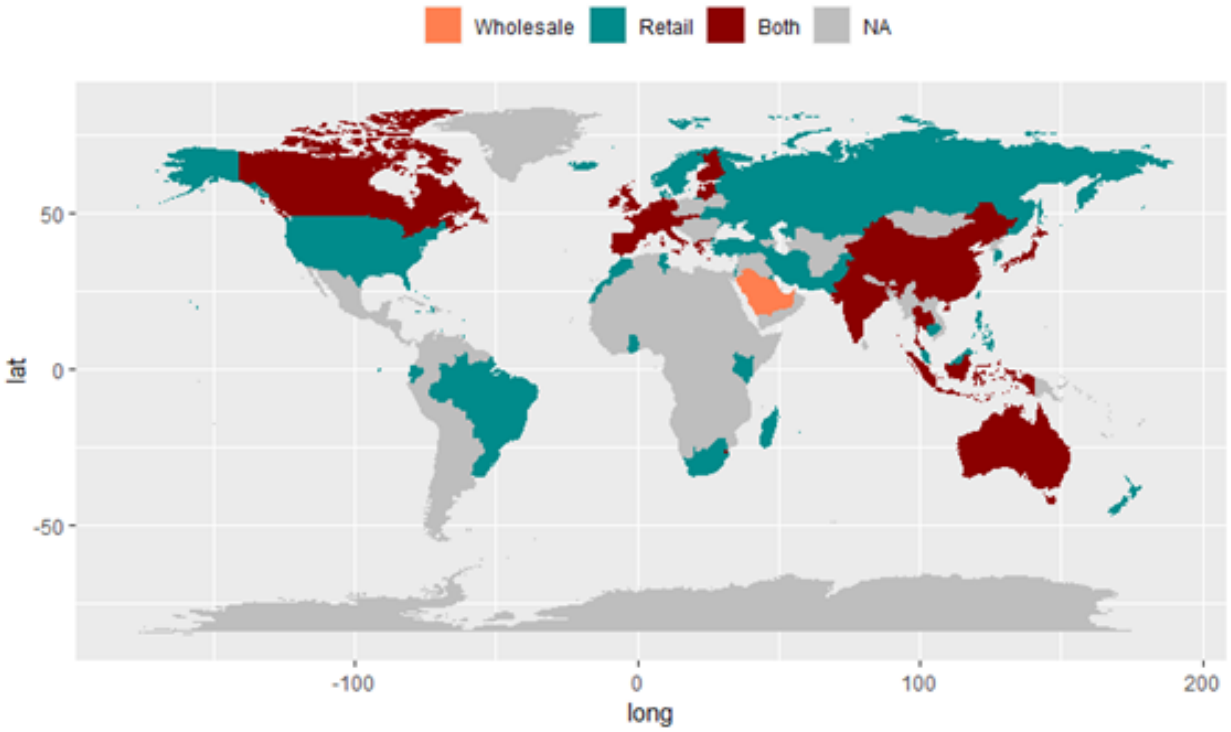
[14] The stock-take was done based on central banks' speeches and press releases, the Bank for International Settlements CBDC database (BIS, 2021), CBDCTracker.org (CBDCTracker, 2021) and Kiffmeister Fintech Daily Digest (Kiff, 2021).To avoid duplication, this count considers the Euro Zone as one instead of individual jurisdictions although the analysis of this section recognises that some Euro Zone countries are doing CBDC research in addition to the ECB CBDC research (e.g. France, Netherlands and Spain). Cambodia is considered in this count as the country was indeed researching CBDCs, nevertheless the analysis recognises that Bakong is not a CBDC as defined by the BIS. See more detail in Box 3.2.

[15] For purposes of this analysis, jurisdictions under the initial research stage include countries that have officially declared interest and have started research related to CBDCs. Stepping up CBDC work does not prejudice the policy decision of whether or not to actually launch a CBDC, but it does demonstrate a strong interest (BIS, 2021).

[16] As of July 2021; the eNaira, Nigerian CBDC, was made available to the public in October 2021 (CoinDesk, 2021).

Figure 3.16. CBDC retail and wholesale projects

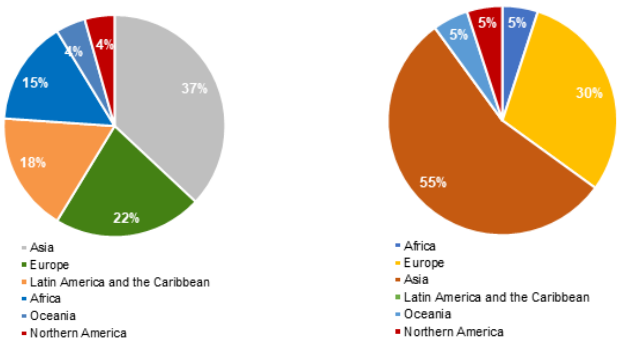
As of July 2021



Source: CB's speeches and press releases, BIS CBDC database (BIS, 2021), CBDCTracker.org (CBDCTracker, 2021) and Kiffmeister Fintech Daily Digest (Kiff, 2021).

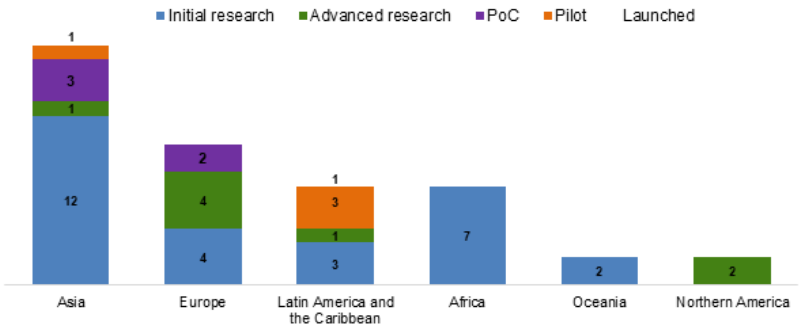
Figure 3.17. Retail and wholesale CBDC initiatives by region

Breakdown of CBDC projects by region in % of total projects. Retail CBDC (LHS) and wholesale CBDC (RHS)



At the aggregate level, central banks have been moving into more advanced stages of CBDC development in recent months. Regarding retail CBDCs, initiatives across the globe have been progressing from conceptual research to proof-of-concepts and launching of pilots; Forty percent of the projects are either in advanced stages of research and developing proof-of-concepts or have launched pilots, while 60% of the initiatives remain at initial stages of research.

Figure 3.18. Status of retail CBDC initiatives by region (by number of projects)



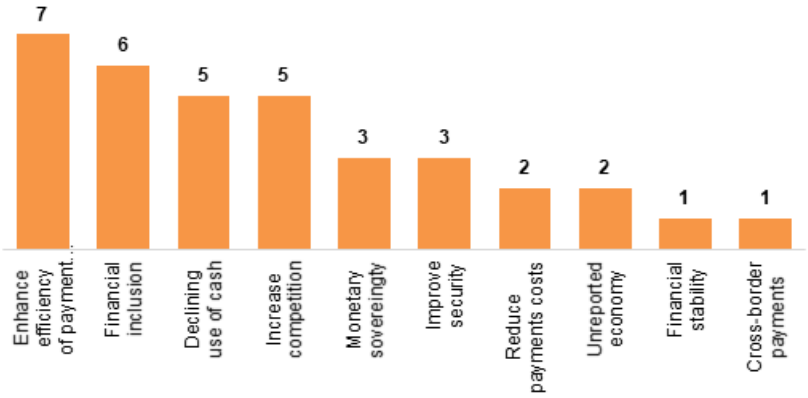
3.3.1. Trends in Asia

The Asian region accounts for a large share of CBDC activity: 36% of retail projects and 55% of wholesale CDBCs under development are taking place in Asia (Figures 3.17 and 3.18). From the 17 retail projects, China's e-CNY is already at the pilot stage, and it is the most advanced in the region. Japan, Thailand, and South Korea are already developing their proof-of-concepts, and four other jurisdictions are potentially entering this stage in the very near future. There are nine more initiatives in the region which are at early stages of research, as they are assessing the viability of implementing a CBDC in their jurisdictions.

According to the official statements and publications of central banks in the Asian region, 41% of the jurisdictions exploring CBDCs are looking to enhance the efficiency of their payment systems, 35% are interested in promoting financial inclusion through CBDCs, and 30% are considering CBDC as a way to address the declining use of cash and promoting competition across payment services providers.

Figure 3.19. Motivations of CBDC initiatives in Asia

No of jurisdictions mentioning each motivation



Source: OECD Staff based on CB's official publications.

In terms of design features, most central banks have not yet taken a firm position in terms of architecture, infrastructure, or access, as evidenced by the high share of "unspecified" allocations. However, the most advanced projects can shed some light on the direction that countries are taking (i.e. China, Japan, Thailand and Kazakhstan).

Table 3.2. Description of design features in most advanced CBDC projects in the region

CBDC	Country	Architecture	Infrastructure	Access	International	Interest bearing
e-CNY	China	Hybrid or intermediate	DLT & Centralized	Account-based	National	No
Digital yen	Japan	Hybrid or intermediate	Unspecified	Unspecified	Unspecified	Unspecified
Digital Tenge	Kazakhstan	Hybrid or intermediate	DLT & Centralized	Token-based	International	No
Thai Baht retail CBDC	Thailand	Hybrid or intermediate	DLT & Centralized	Unspecified	Unspecified	Unspecified
E-won	Korea	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified

Source: OECD Staff based on CB's official publications, as of July 2021.

China: e-CNY

The People's Bank of China (PBOC) has been working on a digital yuan within the Digital Currency/Electronic Payment (DC/EP) project since 2014, currently called e-CNY. The design features have already been decided for the e-CNY, its architecture will be hybrid or intermediate, meaning that the PBOC will not directly handle the accounts of the users. It will use both types of infrastructure, decentralised and centralised. In terms of access, the e-CNY will be account-based, which means that it will be a bank-account-like instrument.

The primary aim of e-CNY is for domestic retail usage, while foreign tourists and business travellers could register for use of an entry-level e-CNY wallet with a foreign cell phone number during their stay in mainland China. Nonetheless, if an understanding can be reached with foreign jurisdictions to avoid spill over effects, interoperability could be enabled between e-CNY and other retail systems and the conversion of e-CNY and other fiat currencies would be processed at virtual borders between digital wallets (BIS, 2021a). So far, there is no plan for making the e-CNY interest bearing.

The Hong Kong Monetary Authority (HKMA) has stated that they are working with the Digital Currency Institute of the PBOC on the technical preparations for making cross-border payments using the e-CNY (Yue, 2020).

Japan: Digital Yen

The Bank of Japan (BoJ) started its Proof of Concept (PoC) Phase I in April 2021 to test the technical feasibility of the core functions and features required for CBDC. During the Phase I, BoJ is verifying basic functions of CBDC as a means of payment – issuance, delivery, transfer, reception and redemption (BoJ, 2021). In addition, according to central bank officials, the PoC is testing three design models in terms of ledger structure and data structure (account-based or token-based). Phase I of the PoC is expected to terminate in March 2022, after which phase II will immediately begin. Phase II will evaluate additional functions that could include safeguards to mitigate the impact of CBDC on the financial system and based on the results of the PoC, the BoJ will consider, if necessary, the need for a Pilot that includes intermediaries and end users (Symposium on Digitalisation and Finance in Asia, 2021).

Cash is widely used in Japan with no observable trend of declining amount outstanding. Thus, the BoJ currently has not plan to issue CBDC, according to central bank officials. Experimenting with CBDC has nonetheless three objectives; the first is potential difficulty in accessing cash in some geographical areas due to uneven distribution of the population and immigration to metropolitans in the future. The second challenge is fragmentation in the payment system, as discrepancies in services available in stores and incapacity to execute person-to-person transfers across payment platforms are observed. A third objective

is to further develop payment systems suitable for digital innovations (Symposium on Digitalisation and Finance in Asia, 2021).

The BoJ has acknowledged some important features that the CBDC would need to fulfil, such as universal access, security, resilience, instant payment capability and interoperability (BoJ, 2020). In addition, the CBDC must not hamper the effectiveness of monetary policy and financial stability, and it should foster innovation by carefully considering the role of payment service providers (e.g. banks and non-bank PSPs). The BoJ is working on a solution to the problem of using CBDC without having access to the internet due to the frequency of natural disasters and possible interruptions from them in Japan. The BoJ is thinking about introducing certain safeguards (e.g. caps for CBDC holdings and/or transactions, tiered interest rates paid to CBDC holders, in order to moderate the demand for CBDC deposits (Symposium on Digitalisation and Finance in Asia, 2021).

Regarding wholesale CBDCs, the BoJ has been involved in the Stella Project together with the European Central Bank since 2016. The Project, which intended to analyse the potential gains in efficiency and safety offered by using DLT in financial markets infrastructure, involved four phases until 2020 (for more detail on Project Stella see Chapter 1 on Tokenisation).

Thailand: Thai Baht retail CBDC

Beginning in 2018, the Bank of Thailand (BoT) completed three phases of Project Inthanon in which DLT was tested in enhancing payment efficiency, bond tokenisation, streamlining workflows and cross-border interbank settlements via a wholesale CBDC. In the third phase of the Project, BoT partnered with the Hong Kong Monetary Authority (HKMA) to undertake Project Inthanon-LionRock to assess functional benefits of using DLT to eliminate correspondent banks in cross-border transactions and settling currencies through payment-versus-payment (PvP) method (BoT, 2021).

Currently, Thailand is exploring the capabilities of DLT in a multi-jurisdictional context with the Central Bank of the United Arab Emirates, the People's Bank of China, and supported by the BIS Innovation Hub in Hong Kong (China) (for more details on the pilot, see the Chapter 1 on Tokenisation).

While Project Inthanon had primarily focused on wholesale CBDCs, in August 2020, BoT expanded the scope of this project to explore potential benefits for the business sector of using retail CBDCs (BoT, 2020). By collaborating with the private sector, BoT undertook a first Proof-of-Concept (PoC) to explore how CBDCs could be used for payment and settlement with the corporate sector[17]. In this PoC, the BoT developed a prototype in a blockchain-based digital form based on a two-tier system in which the central bank distributes CBDC through intermediaries, which included commercial banks and PSPs. Intermediaries then distributed CBDCs to the corporates in the second tier, who were allowed to make payments on a peer-to-peer and real-time basis (BoT, 2020). The project tested basic payment functionalities such as issuing, destroying, distributing and transferring CBDC, to more complex features, namely invoice tokenisation and programmable money with smart contracts.

A second PoC began in April 2021, to assess BoT's three primary concerns associated with a retail CBDC: (i) disintermediation of financial intermediaries, (ii) potential bank runs especially in times of stress, and (iii) maintenance of high security standards and public trust in the CBDC system (BoT, 2021). The BoT concluded that those concerns could be mitigated through design decisions and other measures. For instance, the two-tier distribution model would preserve the role of financial intermediaries and PSPs. To mitigate bank runs during times of crisis, the CBDC could be initially designed as non-interest bearing, same as cash, with specified limits for holding, transacting and conversion. In addition, according to BoT officials, to preserve the characteristics of a cash like product, the CBDC will allow a certain degree of

[17] Participants from the private sector include Siam Cement Group (SCG) and Digital Ventures Company Limited (DV), with technical support from ConsenSys.

anonymity, on the basis of turnover and volume of transactions and balance. Financial intermediaries (banks) will only be exposed to partial user data (Symposium on Digitalisation and Finance in Asia, 2021). The Thai baht CBDC will harness the strengths of both centralised and decentralised technologies. While centralised technology offers advantages in terms of scalability and performance, decentralised technology offers greater resiliency, and its cryptographic techniques can help enhance security (BoT, 2021). Nevertheless, according to the BoT, there is no immediate need to issue a retail CBDC, although its issuance may be appropriate if private digital currencies become widely adopted or systematically important in the future. In this context, the next step for Thailand would be to launch a pilot in 2022. The objectives of BoT for future experimentation are to expand the number and nature of participants including commercial banks, service providers and real-world users. In addition, the BoT has yet to resolve how the CBDC ecosystem will synthesise with the existing payment system consisting of cash and e-payments. Another target for future research and experimentation for Thailand is cross-border CBDC cooperation (Symposium on Digitalisation and Finance in Asia, 2021).

Box 3.1. A Proposal for Asia Digital Common Currency (ADCC)

Recently, a digital common currency in Asia[18] has been proposed as a first step to develop a common financial market infrastructure in the region[19]. The ADCC would be managed by an ASEAN+3[20] international organisation (IO) (such as AMRO[21]) in the region. The proposal considers developing a wholesale digital currency using a token-based scheme (Inui, Takahashi & Ishida, 2020). Although an early-stage proposal, it is an example of initiatives that are coming together to address the challenges involved in cross-border transactions (payments and remittances in particular).

Potential benefits include: (i) providing an infrastructure which enables convenient payment and stable settlement by a common digital currency in the region; (ii) reducing foreign exchange risks and foreign policy impact resulting from use of a currency outside the region; (iii) reduce the room for large (political or commercial) powers to dominate international currencies and allow smaller countries in the region to have more influence.

According to the proposal, the process of issuing this ADCC would start with monetary authorities in ASEAN+3, which would provide their own government bonds or currencies to the chosen ASEAN+3 IO that would issue the ADCC. Then, the IO would issue “Bonds to issue ADCC” – in an Asian Currency Unit denominated bond – equivalent to the assets provided by countries. Therefore, monetary authorities will have “Bond to issue ADCC” on their asset side of balance sheet and will be able to issue the currency up to that amount. Creating the ADCC itself will be done by the chosen coin issuing body centrally, to secure interoperability of the digital coin in the region.

[18] This concept is not new – in fact, about 500 years ago, within the territory occupied by the ASEAN+3 jurisdictions there was a common currency named the “Yongle coin” (Inui, Takahashi & Ishida, 2020).

[19] In this context, financial market integration involves having a regional payment and settlement infrastructures as well as legal and accounting system.

[20] ASEAN+3 comprises the Association of Southeast Asian Nations (ASEAN) plus the People’s Republic of China, Japan, and the Republic of Korea. ASEAN consists of Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

[21] ASEAN+3 Macroeconomic Research Office. AMRO is a regional macroeconomic surveillance organisation that aims to contribute to securing macroeconomic and financial stability in the ASEAN+3 region.

A CBDC must be issued by a CB as a legal tender and backed by the creditworthiness of the lender of last resort. With respect to the creditworthiness of the ADCC that will be issued without such legal status, it needs to be guaranteed as a safe asset just as the official currency. The proposal puts forward AMRO's safety-net named "Chiang Mai Initiative Multi (CMIM)" to support a country in case of a short-term shortage of liquidity.

An important part of the proposal is seigniorage. Since the equivalent value of safe assets provided by ASEAN+3 countries will be shown on the asset side of the balance sheet of the issuing authority, the profit obtained from the management of those assets will be distributed to the ASEAN+3 jurisdictions as seigniorage, after deducting operational costs.

Kazakhstan: Digital Tenge

In November 2020, the National Bank of the Republic of Kazakhstan (NBK) announced a research project on digital currency implementation. The NBK will test various scenarios for the use of digital Tenge as part of its pilot project. The NBK plans to implement a hybrid approach to the architecture of the digital Tenge. This approach does not change the functions of the central bank and second-tier banks, where the former provides the infrastructure, and financial market participants provide payment services (NBK, 2021).

The digital Tenge is not intended to replace cash or non-cash money, and will coexist as an additional form of money. In terms of access design, the pilot project will use a social wallet – a token-based CBDC – and based on the results, the NBK will determine whether the use of tokens is the best approach for developing its CBDC. In addition, when designing the pilot project, the NBK chose an infrastructure based on both a decentralised system and a centralised system.

Box 3.2. Cambodia: Project Bakong

In July 2019, the National Bank of Cambodia (NBC) partnered with Soramitsu to modernise the country's retail payments using Hyperledger Iroha blockchain technology. In October 2020, the National Bank of Cambodia (NBC) launched this initiative under the name of Bakong, a payment and money transfer service that enables interoperability between banks and financial institutions. Bakong allows Cambodian citizens to pay at stores or send money through its mobile app, supporting settlements and remittances in riel or U.S. dollar (NBC, 2021). Banks can use it to make interbank transfers at much lower cost (Kiff, 2020).

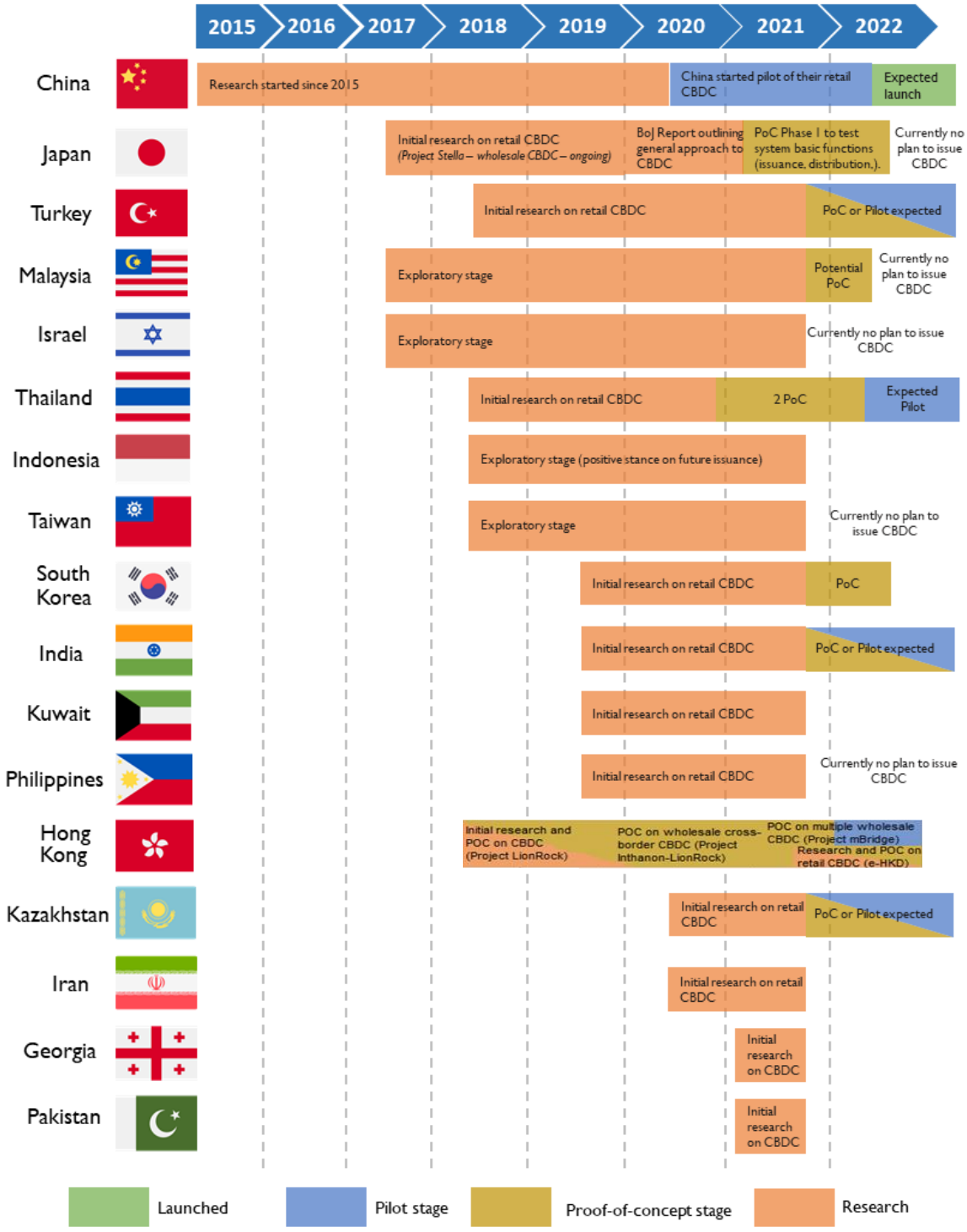
The Cambodian Bakong does not represent an entry on the central bank balance sheet intended for use as legal tender – as established on the CBDC standard definition (Kiff, 2020). Therefore, the Cambodian Bakong is not a form of CBDC, and it is rather a DLT-based retail payment system.

The main thrust of Bakong is to promote P2P digital payments carried out in domestic currency and operating on DLT. Most of the population in Cambodia is unbanked and cash constitute the main means of payment. At the same time, there is high mobile penetration. The Bakong project was launched with the objective to increase the use of digital payments and to address concerns over payment system fragmentation due to the adoption of several digital platforms without them being able to interoperate. In addition, requiring payment providers to open an account at the NBC in order to be able to connect to the national clearing and settlement system will considerably increase their costs and result in less financial inclusion. Thus, the DLT-based P2P system of Bakong is preferable to this alternative (Symposium on Digitalisation and Finance in Asia, 2021).

The Cambodian economy is also heavy dollarised, and according to surveys, people do not switch to domestic currency because of convenience, despite the currency showing low and steady inflation patterns. The introduction of Bakong is expected to contribute to wider use of the local currency (Symposium on Digitalisation and Finance in Asia, 2021).

KYC in the Bakong is delegated to commercial banks who can participate in the Bakong project by exchanging their fiat money reserves for the digital form of Bakong. NBC allows banks to keep certain information of customers' payment history with the objective that it might benefit the users in receiving better credit and other services offers from banks, as an alternative to having credit history. The digital money safeguarded on the Bakong network carries no interest but transferring money to a saving account at a bank is instantaneous (Symposium on Digitalisation and Finance in Asia, 2021).

Figure 3.20. Timeline of CBDC activity across jurisdictions



Source: OECD Staff based on BIS CBDC dataset (July 2021), CBDCTracker, Kiffmeister's FinTech Daily Digest and official CB Connuniques.

3.4. Conclusions

In recent years, overall interest in CBDCs has drawn significant attention from financial authorities, policy makers and the general public. More than 50 central banks have allocated resources to CBDC research to understand the opportunities and challenges it presents, with an important share being developed in the Asian region. The development of research and pilot projects has been rapid, with several jurisdictions having passed from the exploratory phase to developing proofs-of-concept and even launching pilots.

Although the majority of central banks that have published work on their wholesale CBDC projects mention cross-border payments as one of their strongest motivations, authorities are also considering retail CBDCs as a potential tool for enhancing cross-border payments. Financial inclusion stands out as an often cited reason by countries considering retail CBDC. Other important drivers for CBDC exploration include maintaining financial stability and increasing competition.

The motivations for considering CBDCs depend on each jurisdiction's specific context, varying widely across regions, size, and maturity of the country's financial markets. Those motivations justify the decision of countries to either pursue a wholesale, a retail or even both types of CBDCs, and could are linked to the design choice of the CBDC being studied. For instance, countries with a low development of FPS have identified CBDCs as a potential solution aiming at improving their payments infrastructure.

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4 Decentralised Finance (DeFi)

4.1. Introduction

Decentralised Finance (DeFi) claims to provide traditional centralised financial services involving cryptoassets (i.e. mimicking the 'CeFi' or centralised finance market) in an open, decentralised, permissionless way. Decentralised finance as a high-level concept has been discussed since the advent of the Bitcoin and DLTs at national and international level. Indeed, decentralised finance was discussed at the G20 Finance Ministers and Central Bank Governors in their meeting in Fukuoka on 8-9 June 2019 under the Japanese presidency of the G20 (FSB, 2019).

The DeFi market is the practical application of decentralised finance and embodies this high level concept by providing financial products and services built as decentralised applications (mainly) on the Ethereum blockchain network (OECD, forthcoming). The DeFi market started making headlines in the summer of 2020 (referred to as 'the DeFi summer'), when a number of DeFi apps appeared to gain traction with users, and has grown to a multiple of its initial size ever since. The total value of crypto-assets locked in DeFi applications as of 31 March 2021 reached USD 42.9 billion, up from USD 1.9 billion on 2 July 2020 (close to 150% increase in less than a year, albeit from a very low base).

Although the size of the DeFi market itself is not large enough to be considered a risk to the stability of the markets, the DeFi space is still worth delving into as it is growing rapidly, attracting an increasing number of retail and institutional investors alike. Increased interest and adoption of crypto-assets by institutional investors and other traditional financial service providers in particular, is leading to increased interconnections between CeFi and the parallel DeFi system and creates channels of risk transmission to the traditional markets and potentially the real economy (OECD, forthcoming).

This chapter gives an overview of the DeFi market's evolution, touches upon the governance of decentralised systems, shedding light on the Blockchain Governance Initiative Network (BGIN) as a way to promote a multi-stakeholder dialogue in this field. It analyses privacy and traceability aspects of decentralised networks and discusses related regulatory and supervisory challenges. The Chapter concludes with considerations around the future direction of decentralised finance.

4.2. DeFi: Definitions and evolution

Decentralised Finance, or 'DeFi', is the latest development in the crypto-asset space, and claims to replicate the traditional financial system in an open, decentralised, permission-less and autonomous way. Rather than relying on centralised parties for trust or liquidity provision, DeFi markets are community-based networks relying on 'automated' trust and operating on a global, borderless way. DeFi is offered through applications built mainly on the Ethereum protocol, which was launched in 2009 and allows for the creation of smart contracts through its ERC-20 standard.

DeFi applications replicate most of the main CeFi financial products and services in a decentralised manner relying on smart contracts. Lending is the fastest growing DeFi product, driven by yield farming. Yield farming, or liquidity mining, is a process allowing DeFi market participants to lock up their crypto-asset

holdings in applications and generate rewards in exchange for the provision of liquidity to the system (either interest on their locked up crypto-assets or new tokens of the platform, issued as rewards). Other products offered include decentralised exchanges (DEX); derivatives and synthetics; stablecoins; asset management; insurance; payments; and prediction markets.

Figure 4.1. The DeFi universe: selected applications by activity

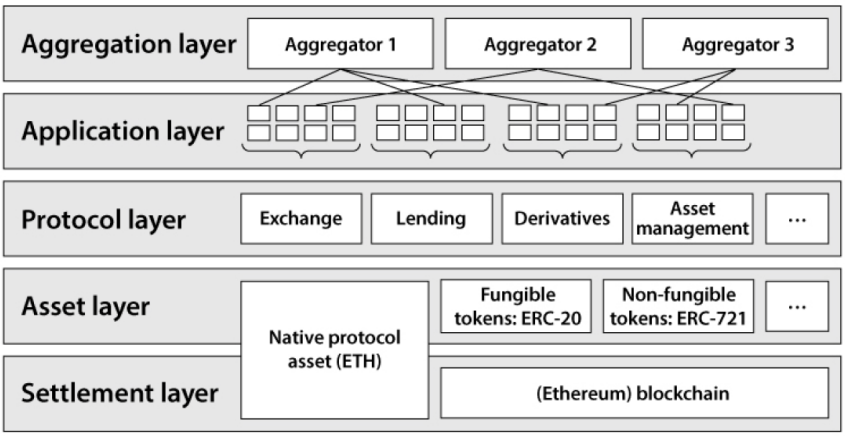
Source: theblockcrypto.com.

In terms of architecture, the DeFi market is composed of different layers, each built on top of the other and where each layer has a distinct purpose. Layers are interoperable, and the basis of the structure is the settlement layer, such as the Bitcoin blockchain or the Ethereum blockchain, serves as the foundation of the system and allows for transaction execution. The asset layer is built on top of the settlement layer and consists of the native assets and tokens created on the basis of such settlement layer in DeFi. The protocol layer is provides the standards that are required for DeFi applications to be built on the application layer, which is, in turn, built on top of the protocol layer. Finally, the aggregation layer brings together different applications in a composable manner for the development of new products and services which combine different applications and protocols (Schär, 2021).

There are several key defining features of DeFi that differentiate it from traditional financial markets (OECD, forthcoming). DeFi applications are non-custodial in nature, and no central authority or other intermediary gets access or control over participants' digital assets; instead, participants manage their private keys and therefore their digital assets directly. Protocols in DeFi markets are self-governed and community-driven, and most DeFi protocols are open-source and allow the community to review and further develop the code underlying the protocols. In terms of governance, the distribution of governance tokens in many, if not most DeFi apps allows users to participate in any decision-making related to the application. DeFi is also characterised by its composability, which constitutes one of the most important innovations brought by this market. Existing components of DeFi networks (i.e. digital assets, smart contracts, protocols and apps built on top of the protocol layer) can be combined to create new applications. Composability gives ample room for the creation of innovative products and structures, and has the potential to further amplify network effects, increasing the value of DeFi products and services as participation in the network grows. At the

same time, the recycling of assets and funds on different applications adds to the complexity of an already complicated market, and to the risks underlying its applications.

Figure 4.2. The architecture structure of DeFi



Source: (Schär, 2021).

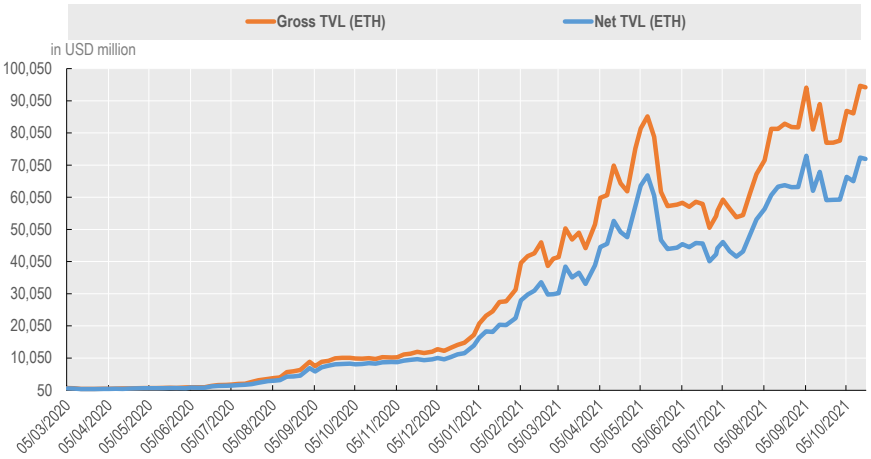
4.2.1. Market evolution

The DeFi market started making headlines in the summer of 2020, when a number of DeFi apps appeared to gain traction with users, and has since grown to a multiple of its initial size. The total value of crypto-assets locked in DeFi applications as of 22 November 2021 exceeded USD 100 billion up from USD 1.9 billion on 2 July 2020 (more than 50x increase in less than a year, albeit from a very low base).

Total value locked (TVL) is currently the best available proxy to assess the growth of this market, albeit with a lot of flaws (OECD, forthcoming). The price volatility of crypto-assets impacts the TVL and an adjustment for the price effect would be necessary to have a clear picture of the adoption growth in this market. Also, the use of leverage and the composable nature of DeFi applications is likely to lead to double counting and miscalculations of the total amount of funds in the DeFi market (e.g. yield farming; lending by platforms to users that is then recycled in the platform leading to double counting of funds). The credibility of industry metrics such as TVL in DeFi remains to be tested.

The overall market value of DeFi tokens exceeded USD 175 billion as of 22 November 2021, and is experiencing wide volatility (30% single day drops for example). There are no fundamental drivers of the surge in crypto-asset prices in what is clearly a market driven by speculation. Investors have diverse motivations to participate in DeFi; retail investors based in developed markets are drawn by the high returns offered by some of the products and by fear of missing out. Investors based in developing markets might be looking to safeguard their savings from inflation and exchange rate fluctuations. Recycling of profits from other crypto-asset activity (e.g. Bitcoin) is another driver for participation. Some spill overs from accommodative monetary policy and a search for yield by retail and institutional investors may also have contributed to this trend. For some retail investors, crypto-assets, such as the Bitcoin, are perceived as inflation hedges, perhaps because of them having some similar characteristics to gold. However, the relative short time crypto-assets have been around does not allow to make a definitive judgment on the long-term co-movement of inflation of national currencies and crypto-assets' prices. The exponential growth of the DeFi market has a lot of the characteristics of the 2017-18 ICO boom in terms of its drivers. Similarities exist also in terms of associated complexities and risks for participants.

Figure 4.3. Total value locked in DeFi



Note: TVL (USD) is calculated by taking these balances and multiplying them by their price in USD.
Source: Defipulse.com, as of 19 October 2021, includes only DeFi apps built on the Ethereum blockchain.

DeFi applications' native tokens are issued through mining and are distributed to participants as incentives (e.g. COMP tokens by COMPOUND, MKR tokens by MakerDao). Such issuance has allowed for the development of yield farming or liquidity mining, a practice whereby participants lock their crypto-assets in a lending of market-making protocol (so called 'staking' of holdings) in order to earn rewards (e.g. fees, new tokens). Native tokens are also used in the decentralised governance model developed by such applications. It should be highlighted, however, that these tokens have intrinsic value and are traded.

4.3. DeFi activities

The range of services and products offered in the DeFi world is diverse and varied, and many of the services available in DeFi claim to replicate a CeFi activity in a decentralised manner.

Peer-to-peer lending and borrowing protocols are some of the most widely used applications in the DeFi. They enable to borrow or lend money on a large scale between unknown participants and without any intermediaries. Some of these protocols are described as algorithmic, autonomous interest rate protocols that integrate with and underlie other DeFi platforms, given the composable nature of DeFi applications (Consensys, 2021). Such applications allow users to earn interest on crypto-assets that they supply to the lending pools. The smart contracts of the protocols automatically match borrowers and lenders and calculate interest rate based on the ratio of borrowed to supplied assets.

Decentralised exchanges (DEXs) are cryptocurrency exchanges that operate without a central authority, allowing users to transact peer-to-peer. An exchange can have inherent incentives for users to act as liquidity providers eliminating the need for market making. Some exchanges incorporate centralised servers that host order books and other features. As of July 2021, DEX activity was the second largest in DeFi, with lending protocols accounting for the lion's share of DeFi activity.

Other applications such as Synthetix offer derivative issuance and trade, and even asset management. Crypto-asset wallets exist to safeguard individuals' crypto assets and can directly interact with decentralised applications allowing to buy, sell and transfer crypto assets. DLT-based prediction markets such as Augur are another interesting innovation in DeFi, and such platforms claim to be able to harness the wisdom of the crowd so as to enable users to vote and trade value on the outcome of events

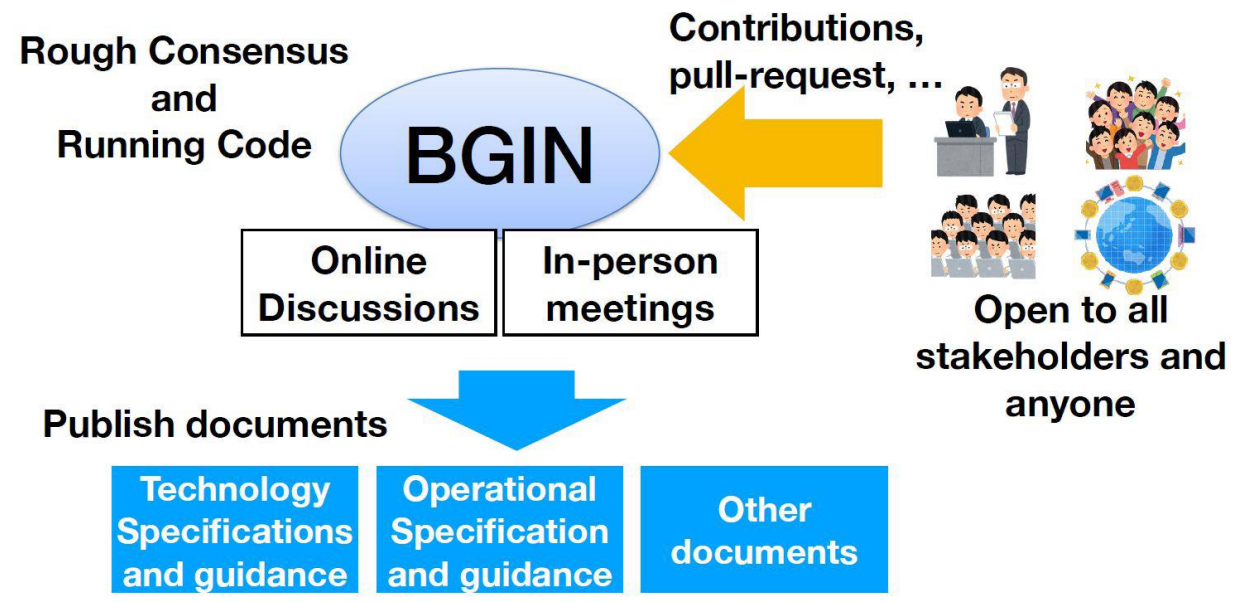
(Consensys, 2021). Market prices then become crowd-sourced indicators of the likelihood of an event. Such events could include election results, sports games, economic events, and more.

Box 4.1. Governance of decentralised finance: the Blockchain Governance Initiative Network (BGIN)

BGIN was created as an open and neutral sphere for all stakeholders of the decentralised finance ecosystem that aims to deepen common understanding and promote collaboration within the ecosystem (BGIN Declaration, 2020). Its ultimate aim is to address issues that stakeholders face in order to attain sustainable development of the blockchain community. It brings together creators and users of decentralised finance, traditional financial market participants, open source code engineers and software developers, exchange Interface operators (crypto-asset exchanges and custodians), academics, regulators, users and civil society and other stakeholders of the DeFi ecosystem.

The network aims to develop a common language and understanding among stakeholders with diverse perspectives and build academic anchors through continuous provision of trustable documents and codes based on open source-style approach. The network hosts meetings and events in diverse locations, convening a variety of stakeholders and works together with affiliated organisations to promote dialogue and a common understanding of the decentralised finance space.

Figure 4.4. The BGIN initiative



Source: Matsuo, 2021 and https://bgin-global.org/.

Ultimately, the objective of BGIN is to take a leading role in the development of a healthy governance system for decentralised finance. The main components of such multi-stakeholder governance include common language, enhanced transparency, and multilateral stewardship, harmonisation of technology, business and law. The network's stakeholders cultivate common understanding, enhance dialogue, and work together to make a significant positive impact on the decentralised finance ecosystem and to the society more broadly (BGIN Terms of Reference, 2020). The network aims to contributes to public policy

design and implementation through such constructive communication with global standard-setters and jurisdictional regulatory, supervisory and enforcement authorities (BGIN Terms of Reference, 2020).

As outlined in the Genesis document of BGIN, the core values of the initiative are as follows:

- BGIN focuses on real world tangible impact to serve social good in order to advance society rather than just becoming a discussion forum;
- BGIN is an open and inclusive network where anyone can join and contribute to the discussions and the outcomes;
- BGIN values diversity. The network actively seeks participation from under-represented groups;
- BGIN makes its discussion and decision making process transparent through proactive public communications;
- BGIN takes a fully bottom-up process in which any single party cannot dictate discussion and has no top-down decision making;
- BGIN values fairness and neutrality among participants. The network strictly avoids serving any particular interest of any particular stakeholder group.

The BGIN network was established in March 2020 in the Blockchain Global Governance Conference (BG2C) in Tokyo ("Genesis block"). Since then, there have been three BGIN meetings (spring 2020, autumn 2020, and early 2021). In addition to the regular meetings, the network is hosting ad hoc meetings and events to foster dialogue and cultivate common understanding on the issues that need to be addressed in decentralised finance, actively reaching out to a variety of stakeholders and affiliated organisations to foster a well-balanced and diverse dialogue (BGIN Terms of Reference, 2020). For example, in March 2021, BGIN hosted a workshop on Coordination of Decentralised Finance (CoDecFin) at the Financial Cryptography 2021 academic conference, to discuss recent regulatory actions and technology advancements on AML/KYC and privacy (Codecfin, 2021). The discussions outcomes of BGIN-hosted events aim to influence the way people design, use, and manage DLT-based applications based on fair, academic and technology-driven analysis discussed in special thematic Working Groups, including the Governance Working Group and the IAM, Privacy and Key Management Study Group. Such working groups focus on well-defined problems, such as peer-to-peer or machine-to-machine communications and impact of AI; ways to improve technologies and operations to fit regulatory goals; ways to transform rules to become more workable, effective and scalable (Matsuo, 2021). The working groups develop documents that are published on an open-source basis (see for example BGIN, 2021a, BGIN, 2021b, BGIN SR1, 2021).

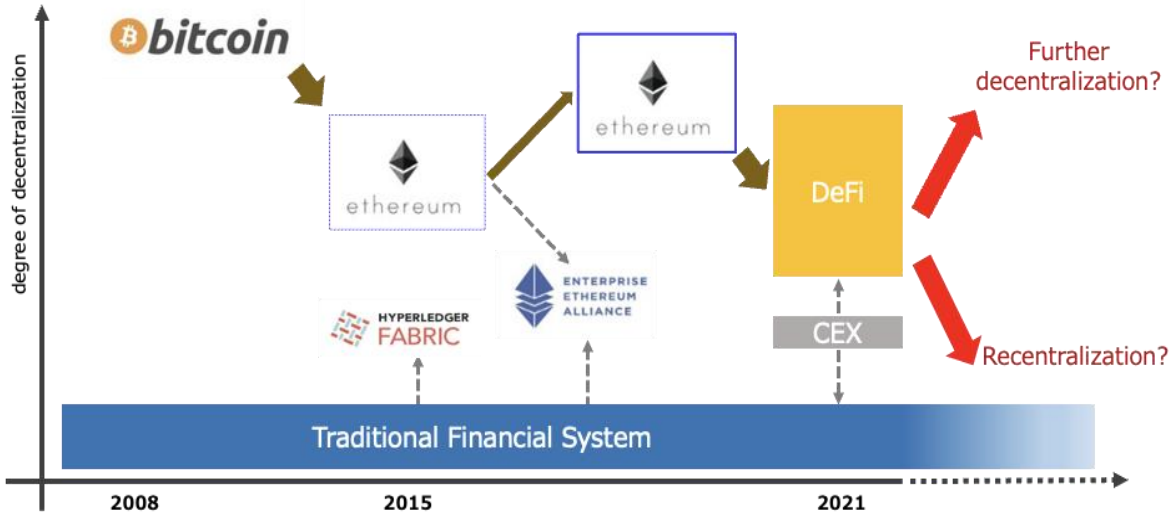
Several policy makers are actively participating in the network, although all participating members act in their individual capacity and not as representatives of their organisations. It should be noted that the Japanese Financial Services Authority (JFSA) is an active supporter of BGIN, although not its initiator. JFSA hosted a global conference where the establishment of BGIN was announced in March 2020 (JFSA, 2020).

4.4. Future direction of decentralised finance: further decentralisation or recentralisation? The views of BGIN

Currently, DLT technology inevitably poses tensions with the existing order and ways of doing things (BGIN Genesis, 2020). The Internet can be used as an example of the power of decentralised community-building which was made possible through the gradual development and adoption of a multi-stakeholder governance approach to cyberspace (BGIN Genesis, 2020).

The decentralised finance ecosystem is rapidly developing and evolving with additional innovation. The BGIN initiative has analysed the potential future direction of decentralised systems towards further decentralisation or recentralisation, and the way such evolution could affect regulatory enforceability (BGIN SR1, 2021).

Figure 4.5. Advancement of DeFi ecosystem to date and future direction



Source: (BGIN SR1, 2021)

BGIN analysis argues that one of the differentiating factors may be the willingness of the community to comply or circumvent the existing legal framework applied to financial services in each jurisdiction (BGIN SR1, 2021). For example, currently, the absence of KYC/AML in many of the DeFi applications constitutes one of the value propositions of these apps. Given growing regulatory scrutiny, BGIN analysis suggests that some DeFi projects might choose to further decentralize the project by, for example, dispersing the governance token ownership, anonymizing the developer and community members, or avoiding administrative functions to lessen the control points that could be captured by regulators (BGIN SR1, 2021). On the contrary, other decentralised finance networks may choose to work closely with regulators and other stakeholders to ensure legal certainty, mainly by increasing the centralised aspects of the DeFi project so as to meet regulatory requirements in an effective manner (BGIN SR1, 2021).

BGIN analysis argues that the DeFi construct eliminates the single-point of failure risk existing in traditional finance where large systemically important institutions, such as banks, run the risk of default, potentially leading to contagion and market crises (BGIN SR1, 2021). Given the decentralised nature of DeFi, BGIN analysis argues that all default and liquidity risks are born by participants, so there are no systemically important institutions that need to be regulated and monitored. However, code errors and market crashes can equally happen in DeFi applications, exacerbated by operational risks related to the underlying technology.

In addition, BGIN analysis argues that the current form of DeFi is based on collateral so the risk for losses due to default is lower than in non-collateralised mechanisms (BGIN SR1, 2021). At the same time, although currently DeFi apps have high levels of over-collateralisation, it could be expected that further growth of the DeFi market would bring down collateralisation levels to allow for better capital efficiency, as competition would put pressure on the tokenomics involved in DeFi protocols (OECD, forthcoming). This would translate into thinner protection threshold for automatic liquidations of users (the equivalent of margin calls for DeFi protocols). The volatility of crypto-asset prices intensifies the fragility of the DeFi market, and volatility spikes in the price of main crypto-assets (Bitcoin, Ether) pledged as collateral for

borrowing and leverage or provided as liquidity for yield farming can induce massive automatic liquidations in DeFi protocols. Such liquidations can have a domino effect on investor holdings across the board, and may even have spill over effects in traditional markets (OECD, forthcoming).

In addition, BGIN analysis points to the lack of identifiable mediator is a challenge for regulators, because no entity can be made the target of compliance. In addition, once regulation on activity goes into effect in one jurisdiction, the DeFi operation can very quickly be moved to a different jurisdiction. Regulators might be forced to come up with new ways to carry out regulation, for example, by becoming themselves participants in the DeFi network and influencing the application's governance exploiting its the democratic nature (BGIN SR1, 2021).

According to BGIN analysis, it is critical for policy makers to keep up with the significant changes and rapid development of the decentralised financial system and build the foundational knowledge necessary so as to have a constructive dialogue with the decentralised ecosystem. Efforts such as the BGIN initiative can constitute an effective avenue for such learning and knowledge sharing between the different stakeholders involved in the decentralised finance ecosystem (BGIN SR1, 2021).

According to BGIN analysis, currently, further expansion of DeFi is bounded by the size of the crypto space. The only way this dependence can be lifted is if DeFi applications will start to accept non-crypto/non-tokenised assets as collateral (BGIN SR1, 2021).

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