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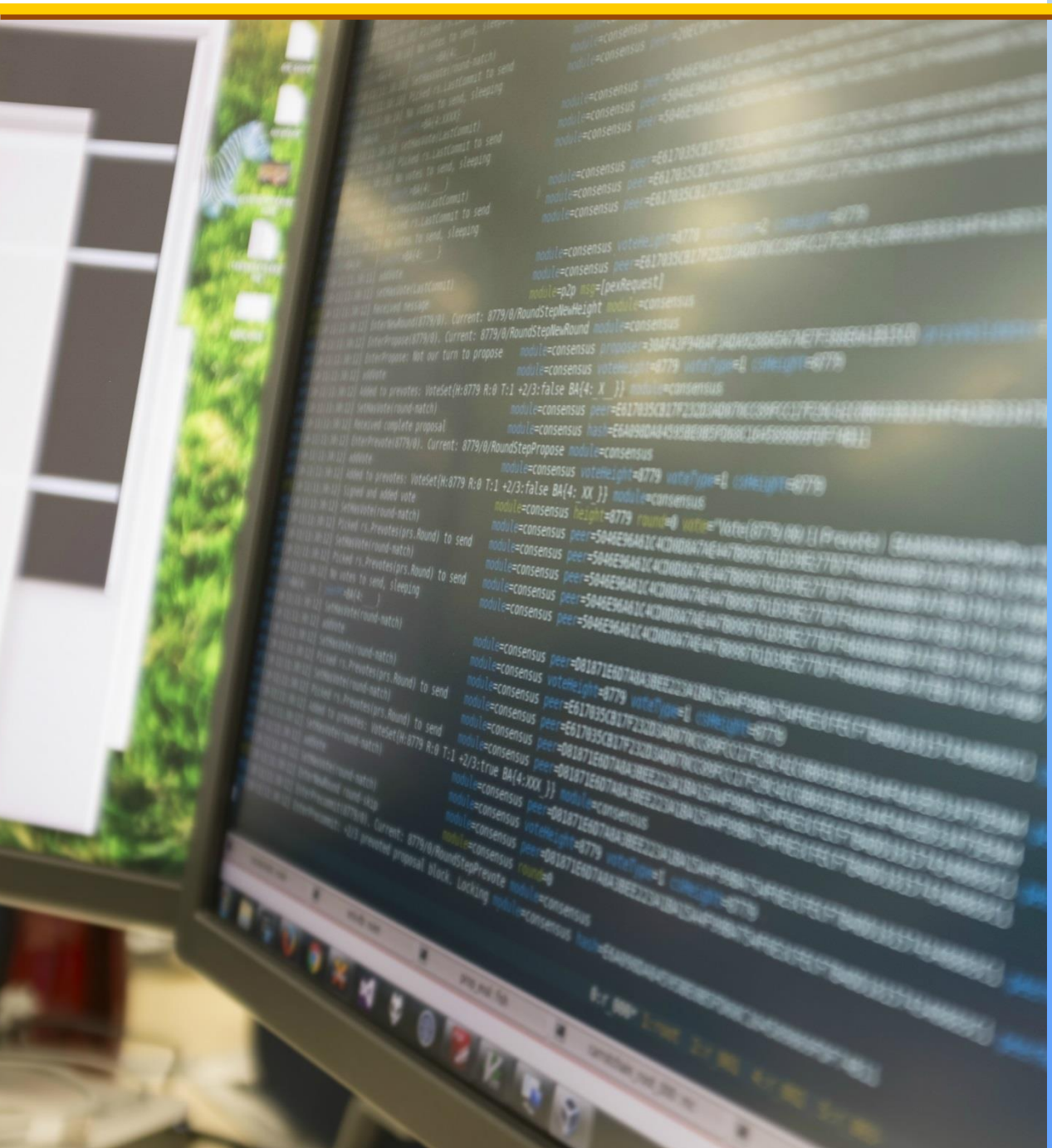
Hong Kong – Building Trust Using Distributed Ledger Technology



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Executive Summary

Blockchain's proposition is of a ledger which is distributed rather than centralised. This simple-sounding innovation has fundamental implications, including the potential to transform financial services as well as many other areas of activity. Distributed ledger technology (DLT) is still at a nascent stage; nonetheless, its proposition is so compelling that a number of other jurisdictions are investing in it now in order to carve out a role for themselves in a future DLT-enabled world. Hong Kong, with its large financial sector and its strategic role vis-à-vis Mainland China and the world, has the potential to take on an important role in DLT.

While the US overall has the most blockchain activities, other jurisdictions are taking a proactive approach. London is probably the global leader in terms of government initiatives. Dubai, aiming to be the blockchain hub of the Middle East, has a US$275 million fund for blockchain proofs of concept (PoCs), and is putting government records on blockchain, Singapore is establishing a blockchain innovation centre and is eyeing a role as the Southeast Asia hub. Mainland China is focusing on blockchain for finance; the central bank has formed a team to consider blockchain as a possible technology to develop digital renminbi (RMB).

In Hong Kong, exploration of DLT has begun. The Cyberport and Science Park are providing support for technology start-ups; work has commenced on DLT PoCs. However, there are shortfalls in innovation and technological capability, and the all-important ecosystem is not yet functioning. Hong Kong needs to act decisively to secure a role for itself in a DLT-enabled future.

What is so special about DLT? The technology allows the ledger (transaction record) to be distributed – meaning that each participant has a copy – rather than centralised, and the ability to write to the ledger is distributed as well. This is a striking innovation. Ledgers are crucial to many activities – banking, securities trading, recording ownership of homes and other assets – and hitherto the ledger always had to be maintained by a trusted authority such as a bank or central depository or government department. Now using DLT, the ledger can be maintained by the transacting parties directly on the network. The truly remarkable thing is that such distributed ledger, written up by random participants and maintained on servers anywhere, is generally perceived as trustworthy. This is because in DLT the process of

writing to and maintaining the ledger is secured through encryption and the ingenious block structure.

DLT adds a layer of trust to the Internet. It reduces the opportunity for fraud by preserving a full transaction history; it speeds up clearing and settlement by eliminating the need for intermediaries; it reduces counterparty risk; it provides regulators with an unprecedentedly clear view of the transaction process; it reduces the need for capital. DLT could transform finance; it could contribute at many levels to the 'smart city' concept; it could eventually open the way to a disintermediated world where people enjoy targeted services directly from business and government, and from one another. Existing businesses may have to restructure; new businesses – even new industries – may arise.

DLT, which originated as the platform for Bitcoin but can be applied independently of the cryptocurrency, has many issues to overcome before this prospect can be realised. The issues include scalability, latency and data privacy; fraud and hacking of e-wallets are also concerns; regulators, governments and users need to be comfortable with the technology's implications. Nonetheless, financial institutions (particularly banks), businesses, academics, regulators and public bodies around the world are experimenting with the technology. The targeted uses fall into two main groups – those that focus on digital currencies, and (mainly) those that focus on the broader record-keeping properties of DLT.

Why is DLT important for Hong Kong? The technology is potentially important everywhere, but Hong Kong with its large financial sector would be especially affected. DLT opportunity is that of transformation – not only of Hong Kong's financial sector but of its economic and even social and governmental activities. Hong Kong has the opportunity to build on its existing strengths with DLT, and secure its future in a DLT-enabled world.

While the main initiative must come from the private sector, there is a crucial role for government to galvanise the DLT ecosystem into life. Government can facilitate and support, undertake selected projects itself to demonstrate the technology's potential, and signal to the world that Hong Kong is open for blockchain business. Local and overseas firms would respond by congregating in Hong Kong, forming consortia, and otherwise collaborating to reap the efficiencies and ultimately the transformative benefits of the technology.

A four-pronged approach is suggested:

(1) ***Government lead function.*** Create a DLT lead function within government, supported by an advisory group from industry and academia. This lead function would help coordinate public sector efforts on blockchain, engage regulatory support, build DLT capability within the public sector, and promote the technology.

(2) ***DLT Hub.*** Develop a DLT Hub as focal point for the technology ecosystem, a centre of knowledge, education and advocacy, and a go-to place for ideas and contacts. The hub should incorporate a DLT Laboratory to reduce the cost of testing and support the emergence of common standards. The hub could be funded by the public sector (including the regulators), industry bodies and/or other sources where appropriate.

(3) ***Digital currencies***. Ensure that the Hong Kong financial system and legislative and regulatory framework are positioned to capitalise on the likely issuance of digital RMB by the Mainland Chinese authorities.

(4) ***Demonstration projects***. Initial work in developing blockchain-based PoCs for certain specific activities in Hong Kong has already begun, including projects conducted by Hong Kong Applied Science and Technology Research Institute (ASTRI) as commissioned by the Fintech Facilitation Office of the Hong Kong Monetary Authority (HKMA). To provide effective demonstration of DLT's capabilities and benefits, this work should be given higher priority, backed by more substantial funding, and extended under 'Finance', 'Smart City', and 'Trade and Logistics' themes.

As Hong Kong gains experience with DLT broader and deeper programmes should be launched. Legal support may be needed. For example, for the recognition of digital assets, and regulatory waivers ('sandboxes') for the exploration of new digital models; government services could be digitised; and a range of blockchain use-cases implemented for greater efficiency. Potential efficiency enhancements could include providing digital identity for all Hong Kong residents and Hong Kong-registered companies on which DLT applications could be built, digistalising the Land Registry, Hong Kong's intellectual property register and the Companies Registry, and supporting the Belt and Road Initiative.

Hong Kong needs to commit to DLT now in order to reserve a place for itself in a potentially very different world. Investment in DLT would be a crucial step towards preparing Hong Kong across a broader front for a more technology-intense future.

1. Introduction

Blockchain, the distributed ledger technology (DLT) which underpins Bitcoin, has the potential to transform financial services as well as many other areas of activity. (The terms 'blockchain' and 'distributed ledger technology/DLT' are used interchangeably in this paper.). DLT, which can be applied independently of Bitcoin, is particularly relevant to Hong Kong because of its large financial sector (18% of GDP and 6% of employment). DLT has the potential to disintermediate financial institutions and eliminate traditional reconciliation and settlement procedures which take up much current investment and employment. It is important for Hong Kong to engage with the technology to work out a new positioning for itself in a DLT-enabled world.

Globally, the application of DLT is still at a nascent stage. Nonetheless, a multitude of banks, other financial institutions, governments, central banks, private enterprises and academics are exploring the technology's potential. A Global Blockchain Business Council of 25 nations' representatives was inaugurated at Davos in January 2017.

In Hong Kong, multiple parties are looking at blockchain. So far, the effort has been modest, and the initiatives scattered. Yet this is a technology that could improve the efficiency of the financial sector, business and government, with potentially transformative effects on society as a whole. Hong Kong needs to engage more deeply with DLT.

This paper aims to,

- Explain briefly what DLT is, and indicate the technology's transformative potential.
- Describe what selected overseas jurisdictions have been doing to explore DLT.
- Describe the present state of DLT exploration in Hong Kong.
- Suggest an initial framework for Hong Kong to build up a DLT ecosystem.
- Suggest potential DLT use-cases in Hong Kong for medium-term consideration.

The paper takes its lead from the financial services implications of DLT – from which perspective DLT is a dimension of FinTech[1] and also a digital currency. In that sense, blockchain strategy is one element of FinTech strategy. However, DLT has implications far beyond financial services, which the present paper also seeks to address.

[1] Reference can be made to a companion FSDC paper, *The Future of FinTech in Hong Kong*, May 2017.

2. The DLT Proposition

2.1 A distributed ledger…

The fundamental proposition of DLT is that it creates a ledger that is distributed rather than centralised.

A ledger is a summary record of transactions and/or of assets and liabilities. The 'ledger' – a dry-sounding term with associations of accounting records – is fundamental to finance, indeed to civilisation itself. The first primitive ledgers appear in Mesopotamia some 7,000 years ago recording crops and herds. By the fourth century BC, the Egyptians and Babylonians had methods of assuring the ledger though an audit process. In the vastly more complex society of modern times, ledgers have proliferated, been computerised, and subjected not only to audit but to an array of regulatory and governance procedures. Yet the essential structure has remained the same. The ledger is kept in a central place by an authority – be it a government department, a bank or a shared utility such as a clearing house – and only that authority has the power to write to the ledger.

This centralised arrangement works most of the time, but fraud and collusion on the part of employees of the authority are possible, as are shortfalls in the audit and oversight process, and the authority itself may collapse – as banks did in the Global Financial Crisis and its aftermath. Moreover, the frictions associated with the authority, not to mention the layers of checking, audit and oversight, are costly and time-consuming.

DLT changes all this. With DLT, the ledger is distributed, meaning that each participant in the network has a copy. And each participant has the ability to write to the ledger. It is no longer necessary to rely on central authorities such as banks, clearing houses, and government departments – parties can transact with one another over the internet directly, avoiding the frictions associated with a middleman.

This opens up a vision of a 'flatter' world without hierarchies of authority. The traditional 'hub-and-spokes' transaction model where many customers are served by a single bank, and many banks by a single clearing house, is replaced by a 'point-to-point' model in which customers transact with one another directly, and banks and other service-providers – even the regulator – are nodes in the network rather than restrictive channels. This model is operating today, and has done so since the creation of DLT in 2009. Individuals and businesses are

successfully transacting among themselves via Bitcoin without the services of a bank or a clearing house or a regulator.

DLT is a twenty-first century approach to existing centralised processes which have their origins in the nineteenth century if not earlier. Commentators talk excitedly about the coming 'disruption' of finance – even of government itself. Fired by DLT's potential, many parties are exploring the technology, either individually or in consortia. Some US$1.5 billion of venture capital funding has been invested globally in Bitcoin ventures.[2]

2.2 …which is trustworthy

How can a ledger which is maintained and updated by random parties over the internet be reliable?

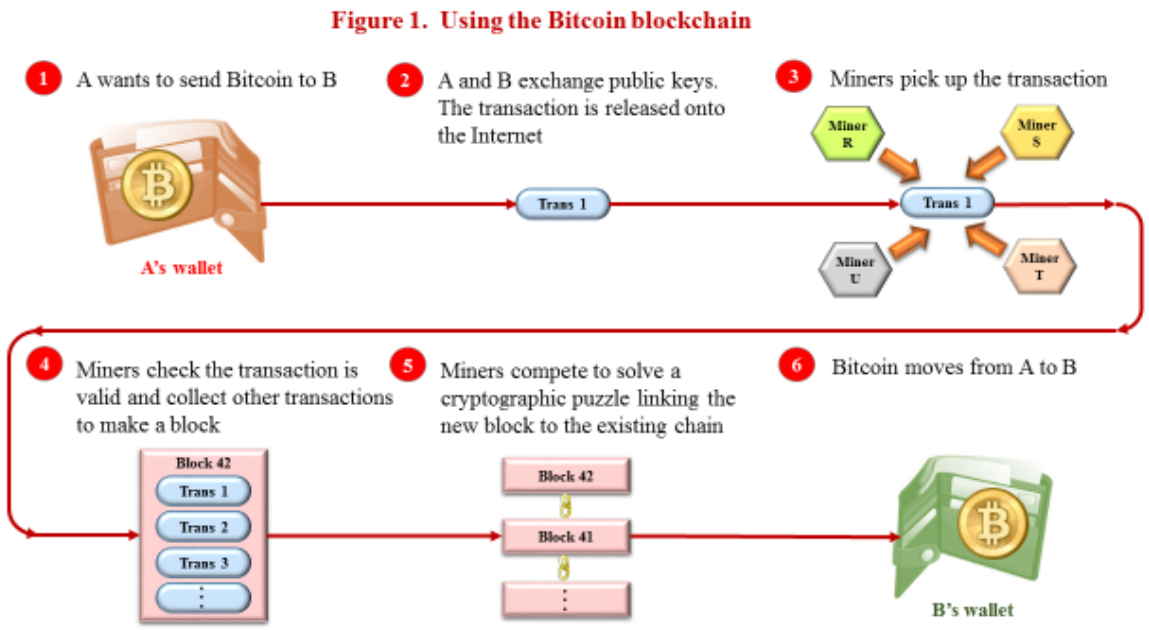
Reliability is provided through an ingenious two-step process relying on cryptography:

- First, each transaction is unique and verifiable. Each party to the transaction holds a public and a private key, which are related to one another via a cryptographic process and can be verified. The parties exchange public keys, so that they know the person they are transacting with is who he/she claims to be; and send their confirmed transaction record out onto the internet.
- Second, these matched transaction records are collected by specialised computing companies (called 'miners') which compile them into a 'block' (effectively, a ledger page) sealed by a cryptographic puzzle. When confirmed, the new block is linked to the 'chain' of existing blocks via the puzzle solution. Thereafter the transaction record in a particular block cannot be changed (say, by a would-be forger) without re-solving the puzzle solutions of all the subsequent blocks *before* the next block is added in accordance with the cycle (currently around 10 minutes) – which would be virtually impossible and if achieved would immediately be visible and so self-defeating. As a result, the ledger is trustworthy, despite having no trusted authority behind it.

The key steps in the workflow for the Bitcoin blockchain are shown in **Figure 1** below. See **Appendix 1** for a more detailed description of blockchain concepts and workflows.

[2] http://www.coindesk.com/bitcoin-venture-capital/, viewed on 27 February 2017.

Figure 1. Using the Bitcoin blockchain



Source: FSDC analysis

2.3 DLT and finance

The implications of blockchain are profound for many areas of activity, especially financial services. DLT's core proposition is trust – which is also the core proposition of financial institutions. DLT is transparent – while financial institutions rely on the lack of transparency resulting from an asymmetry of information between themselves and their clients. Hence, financial institutions are concerned that certain applications of blockchain technology may disintermediate them. Nonetheless, they are also keen to take advantage of any efficiencies available through the technology.

So far, the main impact on banks has been collaborative rather than disruptive. Some remittance business, marginal to banks, has been taken by Bitcoin-based ventures. Otherwise, banks themselves are investigating DLT, either individually or in consortia like R3, a group of more than 70 financial institutions worldwide and including Hong Kong's Securities and Futures Commission.[3]

[3] *The Weekend Read: Feb 19*, www.r3cev.com, 19 February 2017.

The World Economic Forum (WEF) has conducted a detailed study and identified six value drivers of DLT in financial services[4]:

- *Operational simplification*: reconciliation is not required; disputes do not arise.
- *Counterparty risk reduction*: obligations are 'hard-coded' and execute automatically.
- *Clearing and settlement*: intermediaries are not required; settlement is accelerated.
- *Liquidity and capital*: locked-in capital is reduced; sources of liquidity are transparent.
- *Fraud minimisation*: an asset's full transaction history and provenance are available.
- *Regulatory efficiency*: regulators can monitor their charges in real time.

Accordingly, the WEF identifies nine specific use-cases for blockchain in finance. These are, global payments, property and casualty claims processing, syndicated loans, trade finance, contingent convertible bonds, automated compliance, proxy voting, asset re-hypothecation, and equity post-trade.[5] There are doubtless more – indeed, every financial process that requires record-keeping and involves multiple parties could potentially benefit from blockchain.

The Bitcoin blockchain is a public chain – anyone with a computer may participate. However, financial services firms are required to know their clients; accordingly financial institutions would normally prefer a private chain.

Private blockchains operate under similar principles to public blockchains, with the crucial difference that participation and the ability to write to the ledger are restricted to identified parties (such as banks) and are granted by a permissioning process. Given that banks are already trusted parties, the safeguards protecting the integrity of the ledger need not be as stringent as on a public blockchain. Private chains may still run on the Internet; they need not be confined to Intranet or private networks. And in due course the intersection of private and public blockchains via federated and/or hybrid models may prove interesting.

Numerous incumbent exchanges and clearing houses including Japan Exchange, ASX, DTCC and NASDAQ are exploring blockchain; newcomer SETL is trying to position itself as

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4 *The future of financial infrastructure – An ambitious look at how blockchain can reshape financial services*, World Economic Forum, August 2016 ('*WEF*'), page 19.

5 *WEF* ibid.

blockchain-based clearing house; and a flurry of blockchain-based gold trading initiatives were announced at the end of 2016.[6]

2.4 Digital currencies

Blockchain began with the digital currency Bitcoin. A digital currency is an Internet-based medium of exchange which can be used to buy things in a manner similar to central bank-issued (fiat) currency but instantaneously on a cross-border basis. Bitcoin is a cryptocurrency, where issuance and transactions are secured by cryptography; however, digital currency can be issued by a trusted party or parties without encryption. A digital currency may be recorded on a distributed ledger (as Bitcoin is).

The problem with digital currency is that of ensuring that it has been validly issued (no fraudulent minting) and validly used in transactions (no 'double-spending'). In Bitcoin, the problem is solved via encryption and the distributed ledger – issuance is to the 'miners' in payment for their solving the cryptographic puzzles that link the blocks in the blockchain.

Numerous digital currencies have been issued, although Bitcoin remains the largest. Central banks are showing interest. The Bank for International Settlements (BIS) has published a report on digital currencies.[7] In June 2016, a gathering of global central bank representatives incorporated detailed private discussions about blockchain technology.[8] The Central Bank of Canada, working with other Canadian banks, is developing its own blockchain-based version of the Canadian dollar – CAD-coin. Participants would post cash to be held by the bank that would be converted into CAD-coin. Verified parties would then process transactions, with the central bank maintaining the ability to destroy CAD-coins if needed.[9] Numerous other central banks have expressed interest in, or are actively working on, issuance of digital currency, including the Monetary Authority of Singapore (see **Appendix 3.6**), and Carribean cenral banks.[10]

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6 *Royal Mint And CME Make A Mint On The Blockchain?*, zerohedge.com, 22 December 2017.

7 *Digital currencies*, BIS, November 2016.

8 *90 Central Banks Seek Blockchain Answers at Federal Reserve Event*, Coindesk.com, 6 June 2016. See, https://medium.com/chain-inc/why-central-banks-will-issue-digital-currency-5fd9c1d3d8a2#.s710lpifr, for one of the presentations at that event.

9 *Bank of Canada to Reveal Results of its Digital Currency Experiment While Bitcoin Stands Dismissed, cryptocoinsnews.com, 3 November 2016*.

10 *Blockchain and Central banks: a Tour de Table Part II*, Finextra, 9 January 2017.

In early 2016, People's Bank of China (PBC) indicated that it is working on a digital version of the RMB. A distributed ledger with a trusted third party is one possible model. If the initiative goes ahead, the PBC is likely to introduce the digital currency in phases with initial issuance to commercial banks in Mainland China. However they have not ruled out the possibility that digital RMB might also be issued to China-interested banks outside Mainland China.

The Bank of England (BoE) suggests numerous benefits to central bank-issued digital currency. Issuance of digital currency backed by government bonds in the amount of 30% of GDP could boost GDP by 3% as a result of reductions in real interest rates, distortionary taxes, and monetary transaction costs, and would provide an additional countercyclical policy tool.[11] Central bank-issued digital currencies would improve financial inclusion, and would help address the monetary impact of peer-to-peer lending (which, unlike bank lending, does not add to the monetary stock).[12] Digital currency would also provide comprehensive data on transactions in real time, improving inputs to policy-making. It would lessen the impact of bank failure, although transition to a digital currency regime would bring risks of its own such as the possibility of a run on existing banks.

The BoE envisages central bank-issued digital currency implemented via distributed ledgers (to ensure resilience). However, the digital currency would not be protected cryptographically; rather the ledgers would be maintained by approved institutions (such as banks) which would be subject to audit and regulatory supervision. The digital currency would be issued alongside the existing fiat currency rather than supplanting it.

A group of leading commercial banks has announced a blockchain-based digital currency, Utility Settlement Coin (USC), which they hope to launch within two or three years. USC would be used by major clients to settle trades, so improving efficiency and releasing capital.[13]

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11 *The macroeconomics of central bank issued digital currencies*, Staff Working Paper No. 605, Bank of England, July 2016.

12 *Digital Cash: Why Central Banks Should Start Issuing Electronic Money*, Positive Money, January 2016.

13 *Four top banks join forces on new digital currency*, Cnbc.com, 24 August 2016.

3. Benefits and Challenges

3.1 Benefits

The blockchain proposition – in general a trustworthy ledger without a central authority behind it – is a truly fundamental innovation. It has prompted visionary speculations on a transformed future. One commentator (typical of many) suggests three possible blockchain-powered scenarios:

- Disruption of finance – superseding large financial institutions and enabling peer-to-peer financial transactions, by expanding use of Bitcoin or developing new public blockchains.
- Distributed data and identity – returning ownership of data and identity to the individual by providing a secure and reliable source defining the individual in terms of profile, health, activity records, tastes, etc., so enabling a multitude of tailored services, as well as superseding today's tech giants which gather personal data for their own commercial ends.
- Distributed everything – a 'decentralisation singularity' arrives, in which existing companies, institutions and governments dissolve and are replaced by distributed autonomous organisations (DAO) and crowd-sourced services.[14]

At present, these scenarios are just dreams. Solutions to the technological constraints need to be found and meaningful services developed. Even if the technology matures, there will be resistance from incumbent corporations, regulators and governments – and even consumers. The 'disruption' of finance, given its systemic implications, would hardly be tolerated.

The WEF cautions[15] that blockchain is not a panacea but rather one of many technologies that will contribute to next-generation financial services infrastructure. Digital identity and digital fiat (linking blockchain-based tokens or digital currencies with central bank-issued fiat currencies) will be critical enablers. Implementation will require deep cooperation among incumbents, new entrants and regulators, and will take time.

For reference, five predictions for blockchain's future development are set out in **Appendix 2**.

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[14] *How Bitcoin's blockchain could power an alternate Internet*, Rosenberg, Backchannel.com, 13 January 2015.

[15] *WEF*, page 18, ibid.

3.2 Challenges

Although many parties globally are exploring DLT, the outcomes of these initiatives are presently uncertain. Technological, political or regulatory barriers may impede progress; there is also a global shortage of developer talent. Nonetheless within 2017, outcomes from the present round of experiments should provide a more definite view of DLT's potential.

One commentator, although bullish overall on the prospects for Blockchain, sees eight challenges that the technology must overcome for widespread propagation. These include, the difficulty of getting diverse interests to agree on a common set of requirements for an application, the larger hackable 'surface area' of a distributed ledger as compared with a centralised one, the vulnerability of new software to bugs and design flaws (as evident for example in the hacking of the Ethereum DAO, the vulnerability of digital assets (being bearer instruments) to theft.[16] See **Box 1** for one view of obstacles to blockchain financial sector implementations.

Box 1. Reasons to be cautious about blockchain

US central securities depository DTCC warns[17] that existing practices in the financial markets derive from incremental improvements over decades, and that it will be difficult for a new technology such as blockchain to replace them. 'The state of distributed ledger technology today is that of development experiments. … As of today, there are different implementations, different rules and different data and security models. Furthermore, there are no commonly accepted standards, and with multiple efforts being undertaken in the space, resolution will take time ….'

Blockchain technology lacks built-in integration with existing systems and infrastructure, does not include supporting workflows and exception-processing, does not allow cancellation or reversal of a transaction (e.g. in the event of error), and does not support analytics and data-searching on a par with existing systems. Other problems include the slowness of decentralised processing, data privacy, and regulatory approval.[18]

Other possible impediments include, incumbents raising barriers to entry (e.g. high prices for real-time immutable data), investor readiness to take-up on crypto-assets, liquidity, and the viability of new business models. The market image of Bitcoin has been tarnished by the scandals besetting certain Bitcoin exchanges, the largest being a US$350 million theft from Mt. Gox, and by the use of Bitcoin for drug purchases and criminal activities. Hong Kong has

16 *Blockchain, The Trust Disrupter*, Credit Suisse, 3 August 2016.

17 *Embracing disruption*, DTCC, January 2016. ('DTCC')

18 *DTCC*, page 8, ibid.

already seen a high profile case of theft from a Bitcoin exchange.[19] These negative associations may impede wider use of DLT technology.

[19] *The Bitfinex Bitcoin Hack: What We Know (And Don't Know)*, Coindesk.com, 3 August 2016.

4. Other Jurisdictions' Exploration of Blockchain

Some key jurisdictions are actively engaged with DLT, and are seeking leadership in blockchain-related roles.

The US, with its world-leading technological endowment, is the most advanced in terms of DLT research, business initiatives, and start-ups. Activity has surged without much overt support from the US authorities. However, in September 2016 the House of Representatives passed a resolution calling on the US government to formulae a national policy for technology, with specific mentions for digital currencies and blockchain.[20]

The UK is the leader in articulating the potential for DLT to transform the relationship between citizen and government. As discussed in Section 2.4 above, the BoE has looked deeply into the issuance of digital currency. London is a major centre for blockchain related companies, and UK regulators have been facilitative of new enterprises and new business models.

Elsewhere, various governments have proactively tried to stimulate their budding blockchain ecosystems and win positioning in the nascent blockchain world. Dubai, Singapore, Australia, Mainland China and other governments are making significant investments, while even small jurisdictions are targeting specialised roles. The Isle of Man, already a centre for Bitcoin exchanges, is building a cluster of DLT technology and software companies serving the European Union.

The Dubai authorities have created a US$275 million fund to support the development of blockchain PoCs. They are seeking to become the blockchain hub for the Middle East, put all government documents on blockchain by 2020, and open the database to other cities around the world. Singapore is pursuing a 'Smart Nation' goal, funding PoCs and a blockchain Innovation Centre while aiming at blockchain leadership for Southeast Asia.

Mainland China authorities have given the technology national recognition to blockchain. The authorities have allocated responsibility for developing a national blockchain industry plan to the electronics standardisation institute, and assumed leadership of private sector blockchain consortia, while the PBC is exploring the potential of digital currency.

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[20] *Blockchain Support Bill Passes Vote in US Congress*, Coindesk.com, 12 September 2016.

More information on the main blockchain initiatives of the UK, the Isle of Man, Estonia, Dubai, Mainland China, Singapore, and Australia is provided in **Appendix 3**.

5. Hong Kong's Present DLT-Readiness

How does Hong Kong compare with the burgeoning activity and strong leadership in the foregoing jurisdictions?

Overall, Hong Kong can be said to be starting out in DLT. In November 2016, ASTRI (as commissioned by the Fintech Facilitation Office of the HKMA) published a *Whitepaper on Distributed Ledger Technology*, setting out three areas of PoC work in DLT, namely (i) mortgage loan application (already a live application as of March 2017), (ii) trade finance, and (iii) digital identity management. ASTRI plans to issue a second whitepaper in the latter half of 2017 which will cover more in-depth findings from the PoCs, regulatory implications and general control principles of DLT for the banking and payment industries.

Albeit with lower profile than in other centres, certain PoCs are also under development at other Government-backed research institutions such as the Hong Kong R&D Centre for Logistics and Supply Chain Management Enabling Technologies (LSCM) – see **Box 2**. A range of financial institutions[21], academics and private businesses are looking into the DLT technology. There are active Bitcoin exchanges, and services providers for facilitating streamlined workflow and more cost-effective operation. However, these overall efforts are still small and uncoordinated, and may not be well-publicised.

More fundamentally, Hong Kong has traditionally been a buyer of technology. This worked well in the age of proprietary systems, but in today's world of open technology and open innovation, it is necessary to select and adapt – which require technical understanding and innovation. It is also difficult to attract and retain developer talent in the territory. As technology becomes more and more important for all aspects of business and social interaction, Hong Kong needs to build a stronger capacity for technological innovation.[22] One positive is that the Electronic Transactions Ordinance is in place, recognising electronic records and signatures, including digital certificates. See **Appendix 4** for a summary of Hong Kong Government efforts to build technological capability and support innovation.

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[21] Including HKEX – see, *HKEX Next Generation Post-Trade Platform*, HKEX, 12 July 2016.

[22] See, *The Ecosystem of Innovation and Technology in Hong Kong*, December 2015, Our Hong Kong Foundation, for a full discussion and numerous action suggestions.

Box 2. Initial DLT proofs of concept

The HKMA has engaged ASTRI, working initially with Bank of China Hong Kong, to develop DLT-based prototypes for mortgage loan applications, starting with the property valuation process. Where a customer applies to multiple banks for a mortgage, at present each bank has to approach the property valuer itself. To make the process more efficient, the application will store key property valuation information and the digitised property valuation report hash key for file transfer validation. The aim is to build up the DLT infrastructure in order to facilitate the transformation of the mortgage business. Once launched, other banks and property surveyors will be able to join this DLT network, and it can be extended to other mortgage-related parties like solicitors and the Land Registry. A Whitepaper was published on 11 November 2016.

Similar initiatives are in progress in trade finance and identity management, with white papers expected in 2017. All three prototypes will be developed and demonstrated in the HKMA-ASTRI Innovation Hub in ASTRI's premises. The Innovation Hub will enable the regulator, bankers and ASTRI R&D engineers to collaborate, experiment, and formulate DLT technological systems and business models.

Collaborating with the HKMA, LSCM has developed a proof of concept for a blockchain-based version of e-cheque tracking. Launched by the HKMA and an initial nine banks in December 2015, the e-cheque is a secure electronic version of a normal paper cheque. A person can issue an e-cheque using mobile or desktop devices through his/her internet banking account, secured by two-factor authentication and Public Key Infrastructure (PKI) technology in the digital signature, and send the e-cheque PDF file to the receiver, who can then present it to a participating bank to collect the money. As for normal cheques, e-cheques are cleared by HKICL, and payment is made to the receiver the following day; banks in Guangzhou and Shenzhen can also clear e-cheques.

LSCM has implemented an e-cheque wallet. e-cheques can be stored in the wallet and transferred to other wallets by e.g. Gmail or Dropbox, in case the recipient is offline when the e-cheque is sent. To prevent possible 'double-spend' of e-cheques, each e-cheque transfer will be recorded in a similar manner to a Bitcoin payment (but without involving Bitcoin); blockchain records the transaction source, time, and destination uniquely and immutably so that the e-cheque cannot be reused. e-cheques, although presently in an initial launch stage, may have significant potential – e.g. for cross-border remittances, for escrow accounts, and more.

6. DLT Strategy for Hong Kong

6.1 Fostering the ecosystem

DLT is a technology; how can Hong Kong develop and exploit a new technology?

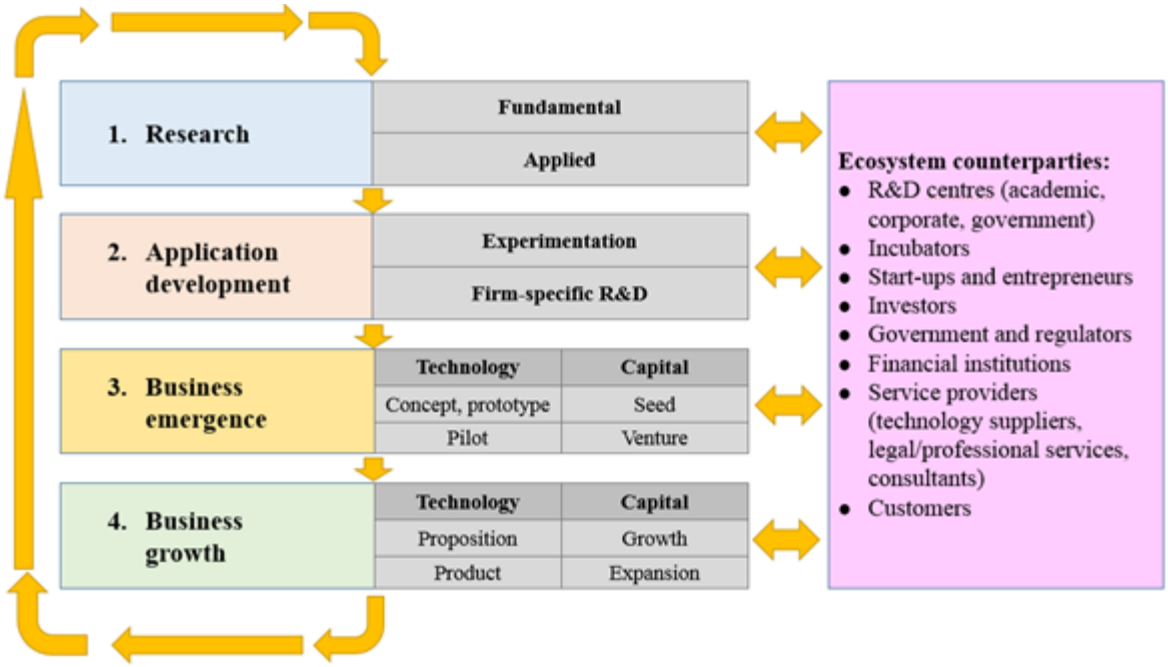
The key is to promote the development of an ecosystem. An ecosystem model for technology business in general is suggested in **Figure 2** below – Research flows through to Application Development to Business Emergence to Business Growth, with funding and support needed at each stage. The model can apply to a start-up or an existing enterprise. The enterprise and its suppliers and counterparties form an ecosystem attracting talent and money through its success.

For Research, Hong Kong has universities and R&D centres; for Applications, a DLT laboratory would help; Business Emergence is provided for by co-working spaces, accelerators and incubators; for Business Growth there are capital-raising markets. Innovation centres allow incumbent institutions to meet emerging enterprises, providing them with data and defining requirements, so reducing the sales cycle. Nonetheless, the ecosystem as a whole is not yet fully functional. The start-up environment in Hong Kong generally is only moderately favourable – among other things it is hard for a fledgling enterprise to open a bank account[23], and the process for obtaining regulatory reliefs is not transparent.[24] There is also a shortage of tech talent and tech firms, particularly with DLT-relevant skills.

[23] See, *De-risking and Financial Inclusion*, HKMA, 8 September 2016.

[24] Although see, *Fintech Supervisory Sandbox*, HKMA, 6 September 2016, and the HKMA's establishment of a Fintech Facilitation Office. The Office of the Commissioner of Insurance and the Securities and Futures Commission have also established FinTech contact points to explain current regulations to the industry.

Figure 2. Technology business development ecosystem



Source: FSDC analysis

Appropriate parties need to take responsibility for monitoring and curating Hong Kong's emerging DLT ecosystem, addressing shortfalls, promoting and communicating and holding events, and identifying and broadcasting opportunities as they arise. There should be a focal point of leadership in government. And there should be a DLT Hub, funded by government, with resources to carry out this role.

A flow of projects is critical to provide 'nourishment' for the ecosystem. This flow will attract overseas players to Hong Kong, stimulate existing players, and encourage start-ups. The public sector can help by providing some initial project flow, setting the agenda, and raising awareness. Reference points here include Dubai's US$275 million (HK$2,145 billion) fund for blockchain-related development, and a similar sized fund (albeit for FinTech as a whole) in Singapore.

Initial work in developing DLT-based PoCs for certain specific activities in Hong Kong has already begun (see Section 4 above). This work should be stepped up, adequately funded (whether through existing funding schemes or new ones), and extended under the 'Finance', 'Smart City', and 'Trade and Logistics' themes. Although given the shortage of IT talent some of the work on these might be done outside the territory, the PoCs should catalyse the

formation of local expertise and resources, galvanising the ecosystem – as well as adding value themselves.

DLT is about 'distributed' business models that operate 'horizontally' across enterprises and across industries (as well as 'vertically' within the enterprise or industry silo). Horizontal models may raise regulatory issues, in that key functions are no longer controlled 'in-house'. Given that DLT applications would generally span geographies, regulatory issues may be multijurisdictional. Regulation and laws may need revamping to accommodate digital models.

6.2 Hong Kong's strengths

In blockchain as in other fields, Hong Kong should leverage its strengths:

- International business links and acumen;
- The rule of law, and an independent and respected legal system;
- A large financial sector serving the Mainland, the region, and the world;
- An established role as bridge between the Mainland and the world, between East and West.

Additionally, Hong Kong has good physical and telecommunications infrastructure, high quality professional services, a dedicated and educated workforce, and a population of demanding customers. It has large-scale capital-raising ability, and has low personal and corporate tax rates. Hong Kong's proximity to Shenzhen, a leading innovation and technology centre, is a plus, and can help make up for local shortfalls in tech resources.

Given Hong Kong's large financial sector, the territory may suit DLT propositions aimed at business enterprises (B2B). Hong Kong's small population offers less scope for consumer (B2C) propositions, although it may make a convenient testing ground. In either case, propositions developed in Hong Kong will need to be exported.

6.3 Hong Kong-specific themes

Hong Kong cannot aim at all areas of potential blockchain activity, but should focus on areas relevant to its unique nature and position.

- ***Smart city***. DLT technology has the potential to contribute at many levels to Hong Kong's development as a 'smart city'. As noted in Section 4 above, Dubai and Singapore

are already commissioning blockchain-based PoCs around possible smart city applications. Blockchain can support digital ID for citizens – an enabler for government e-services as well as tailored services from the private sector including financial services where identity is a foundational utility. DLT can help with dissemination of validated government data. It can support the issuance of digital currency. DLT can potentially also make taxation efficient (for example, tax at source for stamp duty), and similarly for rent and other types of income.

- ***Certification***. Although assets and information within the blockchain are more or less impervious to fraud and alteration, this is not the case with referenced assets and information in the real world or adjacent chains. Yet to provide useful services, the blockchain will need to reference such external sources. To enable this, there will be a need for 'certification' of the relevant blockchain entry by a trusted authority to bring the external item within the trust envelope. Hong Kong is a good base for such certification services. Even the participation of Hong Kong institutions in a DLT initiative would likely increase the latter's credibility. This would be one way to leverage Hong Kong's trusted brand, and realise the vision, 'Made in China, trusted in Hong Kong'.

Mainland China's activities potentially provide enormous scope for blockchain solutions:

- ***Digital manufacturing***, part of China's latest Five Year Plan, could make use of digital ledger technology. Digital manufacturing – the integration of all the various automated tools, processes, software and other resources in a manufacturing plant or set of plants – involves controlling, monitoring and coordinating a large number of digital entities, particularly in the Internet of Things (IoT) context, which may be a good use-case for digital ledger technology.
- ***The Belt and Road Initiative***. The Belt and Road countries are generally less developed; much of the trade being among smaller enterprises that lack the resources to engage reputable banks or to fly personnel to meet business counterparts, hence trust is a key issue. A DLT-based platform established in Hong Kong could facilitate trust and accountability particularly in trade and trade finance, although it might take years to implement fully. There would be arbitration and quality assurance aspects to build into the platform.

- ***Supply-chain management***. Trade finance, monitoring and controlling the movement of goods and payments, are all activities for which DLT solutions are actively being explored by financial institutions and others.

The Mainland may well introduce its own blockchain or chains, based on its own standards rather than emerging international standards. If so, there may be scope for Hong Kong to act to bridge the two blockchain worlds.

6.4 Digital currencies

Although digital currency firms operate in Hong Kong today, such business should ideally be put on a more solid regulatory footing. At present, digital currency is treated as a virtual commodity and is not regulated[25]; trading is permitted if no existent regulations are breached. It would be desirable to recognise digital currencies, define the rights and obligations attaching to digital assets and liabilities, and establish an appropriate oversight regime.

As discussed in section 4 above, the PBC is actively considering the issuance of digital RMB. If it goes ahead, and makes digital RMB available to banks overseas to support RMB internationalisation, it would be important for the Hong Kong financial system to be capable of handling transactions involving digital currencies issued by other central banks, with regard particularly to cross-border payments and correspondent banking. The Society for Worldwide Interbank Financial Telecommunication (SWIFT), a network that enables financial institutions to conduct financial transactions, may also need to include an additional field for digital currencies in their Message Type (MT) payment messages system. Indeed, SWIFT itself is working on a blockchain-based PoC for global payments reconciliation.[26]

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25 *The HKMA reminds the public to be aware of the risks associated with Bitcoin*, HKMA, 11 February 2015.

26 S*WIFT launches Blockchain Proof of Concept In Hyperledger*, the-blockchain.com, 12 January 2017.

7. Recommended Actions

7.1 Actionable items

While the main initiative must come from the private sector, there is an important role for government in facilitation and support, and also in undertaking selected projects itself to demonstrate the technology's potential and stimulate the emergence of a DLT ecosystem. A four-pronged approach is suggested.

(1) ***Government lead function***. Create a lead function within government. Such function should be supported by an advisory group of DLT experts from industry and academia, and should have the following responsibilities:

- To coordinate public sector efforts on blockchain.
- To develop DLT capability within the public sector with reference to validated use-cases.
- To engage the support of the regulators for DLT-related experimentation.
- To partner with the proposed DLT Hub (see (2) below) to support private sector initiatives on blockchain.
- To seek public funding and resources (mainly or wholly from existing programmes) for DLT-related research, development and PoCs.
- To identify any legal issues with DLT applications which may need specific regulatory or legislative support, and seek to progress the same.

(2) ***DLT Hub.*** Develop a DLT Hub funded by the public sector (including the regulators), industry bodies and/or other sources where appropirate. The DLT Hub would have the following functions[27]:

- To act as repository of knowledge on blockchain activity in the territory.
- To act as a focal point for education and advocacy, and as a go-to centre for tools, ideas and contacts.
- To conduct research into potential DLT use-cases.

[27] Reference can be made to the Muskoka Group Findings Report, http://www.muskokagroup.org/the-muskoka-group, viewed on 3 March 2017.

- To establish a Distributed Ledger Technology Laboratory to reduce cost of testing, help synchronise community discussion and facilitate the emergence of common standards.

The first step for the hub would be to inventorise, categorise and analyse the blockchain ecosystem in terms of organisations, networks and individuals, and monitor this ecosystem going forward. Key gaps vis-à-vis major jurisdictions should be identified, and bridging strategies suggested. The hub should create a set of tools to help local DLT ecosystem players self-organise. It should also build links with other centres and horizontal organisations in Hong Kong and the Mainland, creating a 'network of networks'. Government would provide funding for the core functions, while for expansion and addition the hub would look to the private sector for support.

(3) ***Digital currencies***. With businesses, financial institutions and central banks worldwide experimenting with digital currencies, it is important that Hong Kong's financial system is ready.

- Regulatory and legislative change is needed to recognise digital currencies, define the rights and obligations attaching to digital assets and liabilities, and establish an appropriate oversight regime.

- Hong Kong needs in particular to be positioned to capitalise on the possible issuance of digital RMB overseas by the Mainland Chinese authorities in the context of RMB internationalisation. If such issuance takes place, there will be an opportunity for Hong Kong to establish itself as the digital RMB payments rail in and out of Mainland China.

- Hong Kong may also consider the issuance of digital currency via the appropriate authority in its own right on an experimental basis. For example, the HKMA might issue digital Hong Kong dollars (backed by US dollars), enabling individuals and businesses to settle obligations in real time in 'central bank' money. Such issuance would put individuals and businesses on a par with banks, potentially opening the way to new services, and in the longer run possibly adding a new tool for monetary management.

(4) ***Demonstration projects***. Initial work in developing -based PoCs for certain specific activities in Hong Kong has already begun. As part of the marketing and coordination efforts, to provide effective demonstration of blockchain's capabilities and benefits, and to attract talent to the territory, this work should be given higher priority, backed with more funding (whether through existing funding schemes or new ones), and extended under 'Finance', 'Smart City', and 'Trade and Logistics' themes.

As these initiatives progress and experience is gained in the application of DLT to Hong Kong problems, broader and deeper initiatives should be considered. Legislative changes may be needed to support DLT-related applications. Waivers from existing regulation (under a regulatory 'sandbox' concept) would help support new business applications and business models at the experimental stage. (The HKMA has announced the creation of a FinTech Supervisory Scheme Sandbox, albeit only for banks.[28]) Another likely theme in the coming years is the digital delivery of government services. The capability will need to be developed within government departments, public institutions and regulators to support digital operations and service delivery, including via DLT-related applications.

7.2 Efficiency enhancement opportunities

If DLT technology fulfils its promise, consideration should be given to a wider range of efficiency enhancement opportunities. Although at present the most DLT effort is being made in financial services, applications may be easier to implement in areas that are not as heavily regulated as finance.

Finance-related opportunities

(1) ***RegTech***. Within Finance, RegTech may be a particularly suitable use-case for DLT technology that does not involve regulatory licensing. It is recommended that Hong Kong regulators consider commissioning blockchain-based RegTech solutions – with the side-benefits of familiarising themselves and their regulatory charges with the technology, and demonstrating the benefits to the wider community.

(2) The ***e-cheque initiative*** introduced in 2015. Consideration should be given to implementing the current DLT PoC (see Section 5 above) as appropriate and perhaps extending it.

[28] *What does it take to build a "Hong Kong Brand" for financial services?* HKMA, 6 September 2016.

(3) ***Insurance claims processing and repository***, so as to avoid claims on multiple providers for a single event.

(4) ***Mandatory Provident Fund (MPF) trustee collaboration***, with extension of the participant base to the regulator and to employers (and perhaps eventually to employees) for greater transparency, in line with the Mandatory Provident Fund Schemes Authority's SSA (Streamline, Standardise and Automate) initiative to enforce more collaboration among trustees.

(5) ***Decentralised credit check platform***. In line with plans in Australia and elsewhere, consideration should be given to banks sharing SME/individual credit data.

Other opportunities

(6) ***Digital identity*** for all Hong Kong residents. Provided by one or more trusted authority(ies), digital identity would enable better access to services/provision of improved services, including permission-based services operating on DLT. Data privacy concerns would need to be addressed, possibly via role-based ID – compartmentalising the elements of the identity used for different purposes. Digital identity for taxpayers would enable DLT-based services, including for example a facility for managing customer reporting by financial institutions to the Inland Revenue Department under the Common Reporting Standard. The plan should be coordinated with the forthcoming enhancement of the Hong Kong ID card.

(7) ***'Smart city – smart citizens'***. Smart contracts on a DLT platform could underpin many initiatives or applications that support the 'smart city' concept.

(8) ***A blockchain-based portal for the Belt and Road Initiative***. The Belt and Road countries are less developed, much trade being among SMEs without the resources to fly to meet one another or to engage reputable banks, hence trust is a key issue. A DLT-based platform could help build trust and accountability along supply chains. The portal could cover, identity of players, trade finance, tracking movement of goods, geolocation, among others. Arbitration and quality assurance aspects could be built into the platform.

(9) The Customs and Excise Department's ***Single Trade Window***: this could incorporate a -based facility incorporating some or all of the 50 forms involved.

(10) ***Companies registry***, i.e. digital identity for companies – again, to enable the provision of improved services, including services operated via DLT technology.

(11) ***Government procurement***. The procurement processes should be DLT-aware.

(12) ***Land registry***. The registry could be moved onto a DLT platform.

(13) ***Trade in intangibles***. Hong Kong's intellectual property register could be moved onto a blockchain platform, to enable the provision of new and improved services.

(14) ***Public data verification***. Government-provided data could be digitally signed and verified via blockchain.

(15) ***University certification***. As an example, US universities already provide digitally-signed transcripts.

(16) ***Civil procedure.*** Some elements of civil procedure could potentially be expressed algorithmically and executed via smart contracts.

8. Conclusion

Distributed ledger technology with its ability to create trust via code has the potential to make many financial, commercial, governmental, and individual activities more efficient by simplifying processes and eliminating intermediaries. Blockchain may ultimately have transformative effects, reshaping economic structures and empowering individuals and institutions in new ways. Finance and related services, which rely on trust and have many frictions, provide a rich field for potential blockchain applications by both incumbents and new entrants.

Hong Kong with its large financial services sector has much to gain and also much to lose from DLT. At present, the territory's exploration of blockchain is modest and uncoordinated, in fact with plenty of room to catch up with that of Singapore, the Mainland and other jurisdictions.

To guard against this risk, and to reap the benefits of blockchain, Hong Kong should leverage its strengths in a four-pronged approach – establishing a leadership function within government, establishing a hub or focal point for the DLT community, embacing digital currency development, and stepping up the commissioning of DLT-based PoCs. As DLT technology matures and experience is gained, consideration should be given to legal underpinning, and to digitisation of government services. A wider range of DLT-based efficiency enhancement opportunities can be explored. These steps should help establish a substantial role for Hong Kong in a DLT-enabled world, indeed prepare Hong Kong for a technology-driven future.

Appendix 1 – Summary of Blockchain's Attributes

Concepts and workflow

A distributed ledger is a database of assets that is maintained across a network of multiple sites. All participants to a blockchain may have their own copy of the ledger, and all copies are identical; changes to all copies being effected across the network in near-real time. The security and accuracy of the records in the ledger are ensured by the use of cryptographic keys and electronic signatures which identify the participants in the network and establish their rights to transact and to update the ledger. See **Figure 3** below for the Bitcoin blockchain workflow.

Blockchain itself performs a limited set of functions around recording assets, transactions, values and information; it is a relatively 'dumb' piece of software. The functionality of blockchain is enhanced by smart contracts – computer programmes that operate autonomously to put pre-defined arrangements into effect when given conditions are met. Other technology, such as a calculation engine, is usually needed to make the application complete.

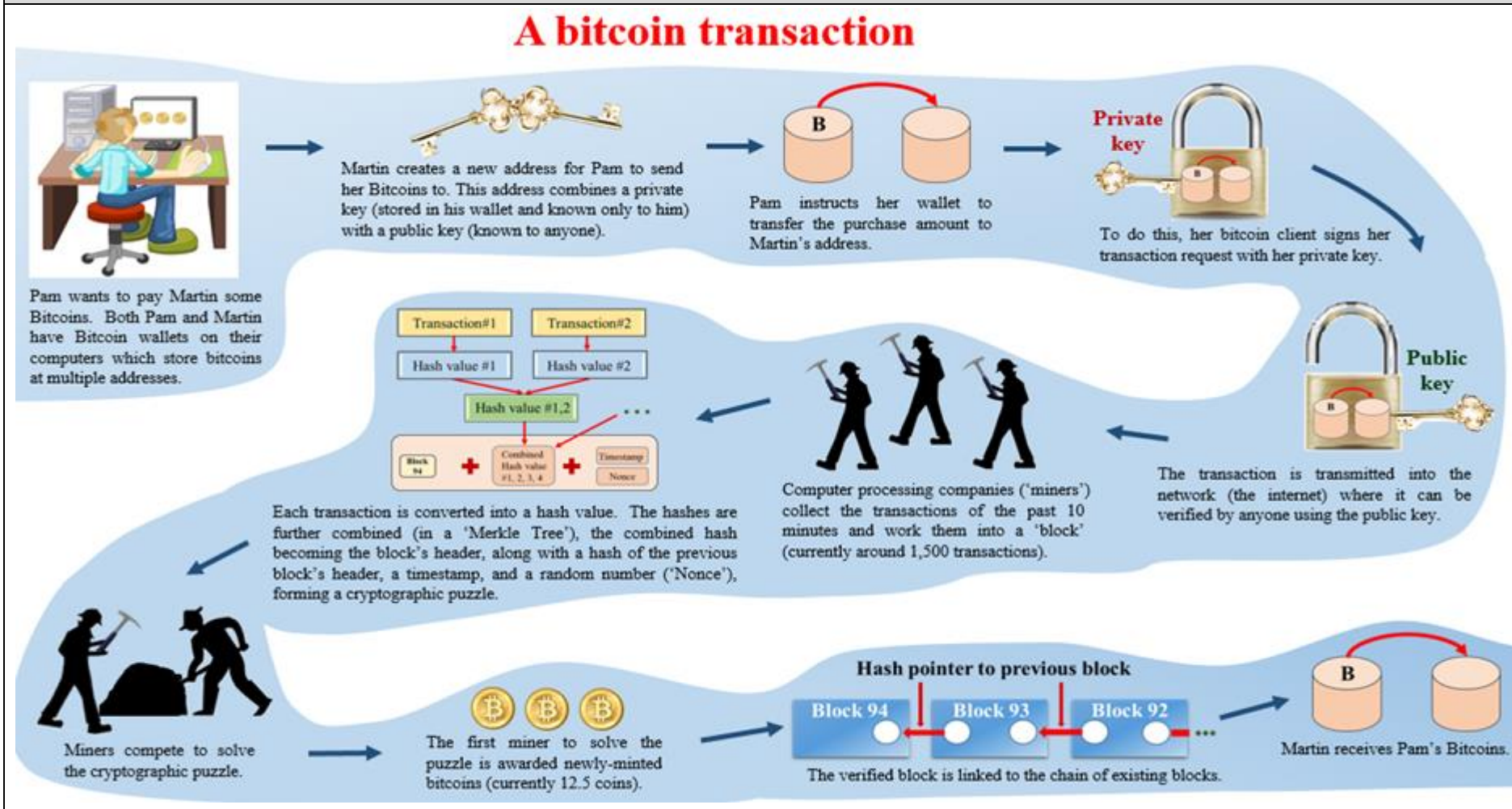
Blockchains are being used to record changes in ownership of digital assets (such as Bitcoin), or to provide a secure timestamped record of other kinds of data. In order to write to the ledger, depending on the blockchain design a participant must either solve a cryptographic puzzle by computer (so-called 'mining' or 'proof-of-work') or be granted write-permission by the controller of the blockchain ('proof-of-stake'). Blockchains may be public or private (see below); private chains usually operate under a proof-of-stake approach.

The distributed ledger has some or all of the following key attributes.

- ***Consensus.*** Participants in the network see and agree upon the records in the ledger. In some applications all participants may see the entire ledger; in others participants may see only the entries that relate to them.
- ***Authentication and validity***. The process of entry into the ledger is secured by the use of matching keys by the participants. There is always a private key associated with a ledger entry; all participants know that a given entry is valid. In public blockchains there is no master key or 'administrator key' with special powers, although in private chains there may be such central authority.

- ***Provenance***. Where ownership changes are recorded in the blockchain, the transaction history of each asset in the ledger is visible.
- ***Uniqueness/Finality***. The assets recorded in the ledger are protected against 'double-spend'; trading is settlement.
- ***Immutability***. The ledger cannot be changed or overwritten. Any attempt to change an entry in the ledger would be non-trivial because of the digital signature, and would immediately be visible to other participants in the network. Depending on the chain design, the dynamic process of ledger compilation would add a further barrier.
- ***Resilience***. The distributed nature of the ledger – multiple copies across the network – means there is greater resistance to denial-of-service attacks (no single point of failure). The ledger will survive as long as the last participating computer in the network.

Figure 3. Bitcoin blockchain workflow



Source: FSDC analysis

These attributes are very powerful and have far-reaching implications. At present, many kinds of transaction can only be conducted under the auspices of a trusted institution. Now DLT enables individuals and enterprises to transact among themselves directly, saving cost and time and avoiding possible institutional error, fraud or sanction. The ability to trace provenance enables entirely new functions, such as tracing valuable assets like diamonds or art[29], and protecting digital intellectual property from unauthorised copying. Regulatory compliance and monitoring can be built into technical code as well – so-called 'RegTech'. Trade and supply chain management are further target areas for DLT application.[30]

DLT may complement and be complemented by concurrent technological developments, such as big data analytics and IoT – Internet-connected smart devices that can regulate and operate themselves. All three developments may feed into digital manufacturing, as well as into complex activities such as trade finance, supply chain management, and health care administration. Altogether, blockchain reaches far beyond financial services, promising a transformed and disintermediated world; government delivering services that are more personal, immediate and efficient; and citizens and enterprises empowered with more control and choice.

Public versus private chains

DLT can be applied in private as well as public networks. The Bitcoin blockchain, currently by far the largest, is a public network, open to anyone with an Internet connection. There are numerous other public blockchains, but mostly with very small followings. Public blockchains have strict capacity and latency (speed) limitations.[31] They are open to anyone, and so may not suit institutions that are subject to know-your-customer (KYC) regulation. Data on the blockchain are transparent, which is not appropriate for uses requiring confidentiality. So public blockchains may not be suitable for many important purposes.

In the Bitcoin blockchain, the ability to 'write' on the ledger is secured by a proof-of-work mechanism. Transaction messages (records) transmitted over the Internet by users are bundled into blocks over a ten-minute cycle by specialised computing nodes (called 'miners')

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29 *Everledger Plans Blockchain Database to Combat Art Fraud*, Coindesk.com, 2 May 2016.

30 *The World's Largest Shipping Firm Now Tracks Cargo on Blockchain* (on Maersk's blockchain trial), Coindesk.com, 5 March 2017.

31 Although the Lightning Network promises to expand Bitcoin to accommodate millions of transactions per second using hashed timelock contracts that don't require any extra trust in intermediaries, see, *What's Left Before Bitcoin's Lightning Network Goes Live*, Coindesk, 12 November 2016.

who compete to solve a cryptographic puzzle which requires massive computing power and win a reward (currently 12.5 newly minted Bitcoins, worth around US$15,000). The resultant block, once validated by other network participants, is linked via the solved puzzle to the chain of existing blocks. No block can be amended without changing the solutions to the puzzles linking each subsequent block in the chain. This arrangement is very secure, but it is costly in (computer) energy consumption, slow, and of low capacity.

In private blockchains, the ability to write on the ledger is secured by proof-of-stake rules (e.g. nomination by the chain owner), or by having the blocks signed round-robin-style by a limited known list of signatories. Signatures reveal which entity signed which block; any attempted falsification would be visible. Private blockchains can have arbitrarily low latency (high speed) and high capacity, with no 'wasted' spend on electricity. However, users have to trust the chain's nodes (participants with write-permission).

Financial institutions are required to know their customers, have confidentiality concerns, and in some use-cases need low latency. Accordingly, financial institutions and groups such as R3 are exploring private chains or other private arrangements using blockchain technology.

The attributes of a particular DLT application will depend on design choices made, and will not necessarily be those listed above. In a private chain, consensus might be limited to the transacting parties, only; immutability will be less strong than on the public blockchain given the greater possibility of collusion given the smaller number of participants, although illegitimate attempts to change the ledger will be non-trivial (due to cryptographically-sealed links between blocks), and will be transparent to participants (and so self-defeating).

Reflecting the above, trust in private chains may need to be reinforced by audit and regulatory supervision. Regulatory oversight may itself be wholly or partly automated via Regtech and/or the regulator having full view of all transactions by virtue of being itself a node on the network.

Blockchains are being used to record activity securely. The parties to a commercially-sensitive arrangement may record key data in a hash (computerised reference), and submit the hash to a blockchain where it is cryptographically signed and timestamped. The chain may be private. Or if the parties have concerns about private chains (perhaps because of competitors participating in those chains), they may prefer to submit to the public Bitcoin blockchain, which has a longer track record of robust operation than any private chain.

Need for trusted parties

Although the distributed ledger can be maintained independently of a trusted party, the issue of trust resurfaces in the interaction between the ledger and the real world.

Where a blockchain is developed for real-world assets such as fiat money (central bank money – US dollars, sterling) or physical assets (diamonds, cars, shipping containers) only the record of these assets can reside on the blockchain. (If the asset can be expressed in digital form it could be submitted to the chain, but then it could not be used in the real world.) It is therefore necessary for a trusted party to provide the interface between the blockchain and the assets concerned – to certify the asset's existence and quality, and to effect the required transaction (such as delivery of the asset to the specified blockchain participant).

A similar need arises in respect of smart contracts on the blockchain. A smart contract is an 'if when then' piece of programming which acts upon a predetermined set of conditions. In conjunction with the validated, immutable and unique information in the blockchain the smart contract is a very powerful device. However, smart contracts require information from the real world (such as time, date, identity of persons, etc.) in order to effect the transaction and update the ledger. A trusted party is needed to provide the information.

A DLT-operated swap agreement can be taken as an example. A swap agreement requires a daily payment to be made between two counterparty banks, such payment being based on the level of interest rates at a given time during the day. The blockchain does not have information on time or interest rates; accordingly, it needs to obtain these from a source which is trusted by the users of the blockchain and is certified as such.

Appendix 2 – Differing Predictions for DLT Development

Given DLT's nascent state, there are wide-ranging views on how the technology might develop. Five views are summarised below.

- *Four phases.*[32] Phase One was the development of the Bitcoin Blockchain in 2008-09 and its emergence as a functional means of transferring payments. Phase Two is beginning now, as people see opportunities in the technology beyond Bitcoin and are investing to explore this potential. Phase Three will come as players begin to exploit the revenue potential of these opportunities, and explore ledger interoperability. Phase Four arrives with interoperability and standard global ledgers; the full potential of the technology will be realised, involving the Internet of Things, decentralised marketplaces, distributed autonomous organisations, and more. Industries will take different timescales to arrive at Phase Four. Financial services may take longer, but by then it may not be a distinct industry.

- *Like the Internet*. The Internet started as a means to transmit letters more efficiently (via email), and then moved on to transform industries such as music and bookselling, and then to permeate and enrich all areas of economic and social interaction, with the promise of even more fundamental changes to come via the emerging Internet of Things. However, Internet development has taken decades – arguably, it began in 1969 – and there have been visionary periods that ultimately disappointed (the late-1990s dotcom bubble).

- *From pilot to transformation.* Banks typically begin with a pilot study on how DLT might make a particular process more efficient. However, '... while these may be highly valuable uses, it is the entirely new business scenarios that have the potential to disrupt and remake entire industries'.[33] How do we get to these 'entirely new business scenarios'? Perhaps when people will look at a blockchain application they will begin to ask whether particular actors are needed. In this scenario, transformation would emerge naturally.

- *Unbundling blockchain*. In designing their prototype Corda, the R3 team have unbundled the DLT proposition, selecting only elements that will help record and reconcile inter-bank transactions efficiently – a mix and match approach. Corda follows the traditional blockchain design closely in respect of Immutability and Authenticity, allows other

[32] *The evolution of distributed ledgers and the future of financial services,* E&Y, 2016. ('E&Y Tech')

[33] *E&Y Tech*, page 10, ibid.

options in respect of Uniqueness, and departs from traditional DLT by limiting Consensus and Validation to the transacting parties, only. Corda starts with legal agreements, and is interoperable with existing systems and practices.[34]

- *Periphery first*. DTCC acknowledges weaknesses in the current financial market system – multiple versions of the truth, complexity, and unavailability for 24/7/365 processing – which blockchain could potentially help address. However, rather than replacing core securities market processes in their entirety, DTCC expects blockchain technology to be useful initially in peripheral processes, such as master data management, securities issuance and servicing, and trade/contract validation, recording and matching for the more complex asset types that currently do not have strong solutions. It advocates a role for central authorities (such as itself) to coordinate and ensure common standards.[35]

[34] *Introducing R3 Corda™: A Distributed Ledger Designed for Financial Services*, R3, 5 April 2016.

[35] *DTCC*, ibid.

Appendix 3 – Blockchain Initiatives of Selected Jurisdictions

1. The UK

The UK Government has devoted resources to exploring DLT, producing a number of detailed reports. The Bank of England has written a number of papers exploring digital currencies[36], while the Office of the Chief Scientific Adviser has released a comprehensive paper on the potential of digital ledger technology to transform government services.[37] This last paper takes as its starting point the recognition that in modern society government has become increasingly remote and inefficient in both the collection and the distribution of resources and services; digital ledger technology has the potential to improve efficiency and transform the relationship between government and citizen. The paper has eight recommendations for the UK government, in areas such as identifying a lead government unit for DLT initiatives, partnering with industry to develop standards and promote research, and performing as a smart customer in digital ledger technology procurement – see Table 1 below.

The paper suggests the following characteristics of 'advancing digital nations':

- A digitally-informed leadership;
- An empowered focused government department for all national digital transformation, which is internationally minded and collaborates closely with all industry sectors;
- A living, collaborative national plan, which is industry-led with government investment;
- Technologically aware, qualified and experienced senior political officials in every government organisation;
- Engineers and digital business leaders as politicians.[38]

In June 2016, the UK Department of Work and Pensions trialled a DLT-based prototype for welfare payments.[39] Welfare recipients use a mobile phone app to track and receive and spend their benefits, with all actions being recorded on a digital ledger. However, the trial

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[36] Including, *Innovations in payment technologies and the emergence of digital currencies*, and, *The economics of digital currencies*, Bank of England Quarterly Bulletin Q3 2014.

[37] *Distributed Ledger Technology: beyond block chain*, UK Government Chief Scientific Adviser, 2016 ('*UK Govt Report*').

[38] *UK Govt Report*, page 16, ibid.

[39] *DWP trials blockchain technology for benefit payments*, computerweekly.com, 11 July 2016.

was criticised as providing government with the ability to control rather than empower claimants[40], as well as risking the leadage of personal data, and was stopped.

Table 1. Recommendations for the UK government to promote DLT development	
Areas	**Recommendations**
Government leadership	1. Ministerial leadership for DLT within government: Government Data Service should lead on government as user, DCMS Digital Economy Unit should lead on government as enabler of distributed ledgers (with Dept of Business, Innovation and Skills and with Innovate UK). Appoint expert group to advise.
Research	2. UK research community should invest in DLT research–eg cryptography, cybersecurity, algorithms, etc.
	3. Government should support the creation of DLT demonstrators for local government to test the technology and its apps.
Regulation	4. Government (DCMS Digital Economy Unit) should consider regulatory framework for DLT, to develop in parallel with new applications. Government should also consider how to achieve regulatory goals via technical code as well as legal code.
Security and privacy	5. Government should work with academia and industry to ensure that standards are set via law and code for DLT integrity, security and privacy.
Authentication and identification	6. Government should work with academia and industry to ensure that the most effective and usable identification and authentication protocols are implemented for individuals and organisations, in concert with international standards.
Trialling	7. Government should establish trials of distributed ledgers in order to assess DLT's usability within the public sector, coordinated like clinical trials – e.g. in protection of national infrastructure, reducing market friction for SMEs, distribution of funds from government departments
Procurement and capability-building	8. Government should establish a cross-government community of interest to generate and develop potential 'use cases' and create knowledge and expertise within civil service. GDS and Data Science Partnership (GDS, Office for National Statistics, Cabinet Office and Government Office for Science) could act as convenors. Government to stimulate the business sector by acting as a smart customer in procuring DLT applications.

Source: *UK Govt Report*, ibid.

[40] *DWP benefit Blockchain trial slammed by digital experts*, publictechnology.net, 13 July 2016.

2. Isle of Man

The Isle of Man, a UK crown dependency, has adopted a deliberate strategy of pursuing blockchain business, earning the nickname, 'Bitcoin Island'[41]. The island has EU access, having implemented all relevant EU protocols. With its experience as a centre for e-gaming over the preceding decade – and having accumulated the data centres, power supplies, IT skills and related resources requisite for that role – the island is well-positioned for DLT. Digital currency operators began approaching the Manx authorities in 2013, and the regulatory framework for digital currencies, including strong KYC and anti-money-laundering rules, was in place by November 2015. The island has attracted a cluster of blockchain software and technology companies.

As a demonstration project, the Manx government is cooperating with a private company to launch a blockchain-based register of its digital currency companies (of which there are some 25). Another public-private project is the development of a DLT-based security solution for the Internet of Things. The government is enthusiastic, as one spokesman says, 'The potential for this technology is absolutely huge. It is the blockchain side of things that we are excited about. We may not be Bitcoin Island so much as Distributed Ledger Island.'[42]

3. Estonia

Estonia, independent of the former Soviet Union in 1991, faced the challenge of reinventing itself and has made determined efforts to carve out new space. The nation that gave birth to Skype has a vision of the borderless state, where people can access services from any nation, regardless of their place of birth. In the year 2000, the government implemented an e-government system via a chip-enabled ID card (the world's only public key infrastructure (PKI)-enabled ID card) that gives citizens instant access currently to more than 1,000 government e-services, including filing taxes and voting and checking the integrity of their records on government databases (whereupon they are provided with a log of persons attempting to access their record). In 2014, in partnership with Bitnation, the government introduced the concept of e-residency, available to people resident and non-resident in Estonia. E-residents are able to notarise birth certificates, marriages, and business contracts, '... the

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41 *Isle of Man: Bitcoin island turns blockchain trailblazer*, Fusionwire, 27 June 2016.

42 Head of Isle of Man Department of Economic Development, quoted in, *Bitcoin: How the Isle of Man is leading a cryptocurrency revolution*, Independent, 4 January 2016.

distributed and immutable nature of this public notary [making] it more secure than any notary currently offered by traditional nation states,' as the provider comments.

The government has been exploring a version of distributed ledger technology (namely Keyless Signature Infrastructure, KSI, developed by an Estonian company) to maintain 1 million patient health records securely within the e-government system. (Hacking of health records is a major problem worldwide – 113 million US health records were hacked in 2015.[43]) KSI is to be introduced in all levels of government under a frame agreement with the Estonian Information Systems Authority. In another development, the government is partnering with US stock exchange NASDAQ to introduce an e-voting service, based on the existing Estonian e-residency. Estonian e-residents and citizens who are shareholders of companies listed on the Tallinn stock exchange will be able to vote electronically in their shareholders' meetings.[44]

4. Dubai

Taking advantage of Dubai's existing role as a technology and finance centre for the Middle East, the Dubai authorities are proactively seeking to position the United Arab Emirates city state as a hub for blockchain development and digital financial innovation.

In February 2016, the government announced the formation of the Global Blockchain Council aimed at blockchain advocacy and experimentation, with an eye on next-generation smart city initiatives. The council comprises an initial 32 members (currently 47) including government entities Smart Dubai Office, Dubai Smart Government, and the Dubai Multi Commodities Centre, international tech companies (Cisco, IBM, SAP, Microsoft) and local blockchain start-ups.[45] In May 2016, the Dubai Global Blockchain Council announced seven PoCs covering health records, the diamond trade, title transfer, business registration, digital wills, tourism engagement, and improvements to the shipping and financing of trade goods. The Council expects to announce 35 PoCs by the year end.[46]

The government-backed Dubai Future Foundation has launched the Dubai Future Accelerators initiative, an AED1 billion (US$275 million) start-up investment fund, which is

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43 *Has health care hacking become an epidemic?* pbs.org, 23 March 2016.

44 *Nasdaq successfully completes blockchain test in Estonia*, Reuters.com, 23 January 2017.

45 *Dubai Government Backs Expansive Blockchain Research Effort*, Coindesk.com, 17 February 2016.

46 *Dubai's Global Blockchain Council Unveils First Pilot Projects*, Coindesk.com, 30 May 2016.

considered likely to invest in blockchain-related ventures.[47] The event, starting on 12 September 2016, flies in entrepreneurs from around the world for a 12-week workshop with seven challenges – a transportation prototype that reduces CO2 emissions, another environmental application, a tracking platform for Dubai law enforcement, a healthcare project, an academic protocol, a real-estate solution, and a water and electricity project.[48] In October 2016, the sultan of Dubai announced a blockchain strategy under which all government documents would be put onto the blockchain by 2020, facilitating government efficiency and the provision of services by the private sector. The database would be opened to other cities with the aim of facilitating international travel and cooperation.[49] The strategy has three-pillars – government efficiency, industry creation, and global leadership.[50]

5. Mainland China

In Mainland China, blockchain initiatives were initially undertaken by academia, research institutes and private enterprises, although still mostly at a pre-launch stage. Banks, which internationally have been among the leaders in blockchain exploration, were until recently reticent. A Shanghai Global Blockchain Summit was held in late 2015, and interest has since risen. The government initially adopted a wait-and-see attitude, but in the run-up to the September 2016 Shanghai Global Blockchain Summit, the Ministry of Industry and Information Technology joined with two existing consortia – China Ledger Alliance and Financial Blockchain Shenzhen Consortium, to form a blockchain working group.[51]

The Ministry's Department of Information and Software Service nominated the China Electronics Standardisation Institute to lead the working group. A blockchain white paper was presented at the Shanghai conference; it highlights the benefits of the technology, advocates greater standardisation, and recommends Finance as the priority area for blockchain applications.[52] China also took a leading role in the formation of the Global Blockchain Business Council at Davos in January 2017.

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47 *Dubai Government Seeks Blockchain Projects for Startup Fund*, Coindesk.com, 9 August 2016.

48 *Dubai Leaders Fund Blockchain Acceleration Event*, news.bitcoin.com, 2 August 2016.

49 *Dubai Wants All Government Documents on Blockchain By 2020*, Coindesk.com, 5 October 2016.

50 *Dubai Blockchain Strategy*, www.smartdubai.ae, December 2016.

51 *Strategic Alliance Formed to Speed Up Adoption of Blockchain Technology in China*, bitcoinmagazine.com, 22 August 2016.

52 *Chinese Government Publishes Blockchain Financial Whitepaper*, new.bitcoin.com, 19 October 2016.

The PBC has completed trials of its own digital currency[53], attracted by the ability to avoid the problems associated with paper currency, and is establishing a digital currency research institute. If the initiative goes ahead, the PBC is likely to introduce the digital currency in phases and initially the digital RMB will be issued to commercial banks in Mainland China, although issuance to China-interested banks outside Mainland China has not been ruled out. In early 2017, the PBC, apparently concerned about capital flight, pressured China's three leading Bitcoin exchanges to prevent withdrawals and charge fees for trading.[54]

A new draft of Mainland China's civil code was introduced in the National People's Congress in June 2016. This will apparently designate all virtual networks, data and information as property equivalent to physical and other financial assets, extending property rights to digital property – although some commentators doubt that it will be effective.[55]

Ant Financial has launched a blockchain based platform on Alipay for monitoring charitable donations – an area which in Mainland China is plagued by scandals.[56]

On 3 August 2016, the Qianhai International Blockchain Ecosphere Alliance was launched, aiming to establish an efficient ecosystem for the development of blockchain technology and its application by combining Mainland and international talent, technology and capital. The alliance hopes to accelerate the commercialisation of R&D on blockchain technology and promote its application to support Mainland China's social and economic development. Members comprise 27 enterprises and investment agencies, including Microsoft and IBM partners, and Hong Kong's ASTRI.[57]

Apart from these high-level developments, most blockchain companies are focusing on DLT applications in the area of FinTech, securities, supply chains, copyright, and notarisation. However, as with blockchain developers elsewhere, pain-points in current DLT platforms are hindering its adoption. These pain-points include, entry barriers; difficulties in integrating with current ecosystems; lack of security protection for application data, logic and operating environment; lack of protection on individual privacy and business secrets. Developer PDX

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53 *China's Central Bank Completes Digital Currency Trial on a Blockchain*, Cryptocoinsnews.com, 30 January 2017.

54 *China Bitcoin Exchanges Halt Withdrawals After PBOC Talks*, Bloomberg, 10 February 2017.

55 *China Signals a New, Accepting Approach to Digital Currencies*, bitcoinmagazine.com, 29 June 2016.

56 *Jack Ma Takes on Murky Chinese Charities in Blockchain Foray*, Bloomberg.com, 31 July 2016.

57 *ASTRI becomes member of the Qianhai International Blockchain Ecosphere Alliance*, 3 August 2016.

has developed a blockchain PaaS (Platform-as-a-Service) offering, dubbed DaaP (Decentralization-as-a-Platform), to reduce entry barriers and time to market.

The semi-governmental National Association of Internet Finance is researching on blockchain technology stacks, with the goal of evaluating and experimenting with blockchain technology, and making recommendations to the central government on the technology and use cases. The non-governmental ChinaLedger is evaluating blockchain technologies and working with domestic financial institutions with the goal of becoming China's R3.

6. Singapore

On 24 November 2014, Singapore's Prime Minister announced plans to become the world's first Smart Nation. Aiming to develop a Smart Financial Centre[58], as part of the Smart Nation programme, the Monetary Authority of Singapore (MAS) is pushing out a number of measures to promote and develop FinTech. These developments in turn build upon Singapore's ten-year masterplan announced in 2005 to develop the Infocomm sector as part of the transition to An Intelligent Nation, A Global City.[59]

One such measure is the MAS's S$225 million FinTech investment programme, the Financial Sector Technology and Innovation scheme. As part of this, the MAS has announced funding for blockchain-based record-keeping systems. The scheme itself is part of a broader effort to upgrade Singapore's financial sector by streamlining compliance processes, automating financial monitoring, improving education and encouraging start-ups.

The MAS encourages financial institutions to launch new solutions themselves without first obtaining regulatory guidance, as long as they are satisfied with their own due diligence and there is no breach of legal and regulatory requirements. The institutions typically experiment in production environment, limiting the solution to particular customer-types or setting limits on transaction values. Alternatively, for initiatives in regulatory grey areas, a regulatory sandbox is provided for experimentation within certain boundary conditions such as time limits; institutions should work with the MAS.[60] Under the sandbox approach, the MAS provides regulatory support by relaxing specific legal and regulatory requirements.

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58 See, for example, *"A Smart Financial Centre"*, MAS, 29 Jun 2015.

59 https://www.ida.gov.sg/Tech-Scene-News/iN2015-Masterplan, viewed on 29 August 2016.

60 *Singapore Central Bank Funds Blockchain Recordkeeping Project*, Coindesk.com, 1 July 2016.

Working with the MAS under the sandbox approach, Hitachi and Bank of Tokyo-Mitsubishi UFJ, Ltd (BTMU) announced a PoC that uses blockchain technology for digitisation of cheques in Singapore.[61]

In August 2016, HSBC, Bank of America Merrill Lynch and Singapore's Infocomm Development Authority (IDA) announced their partnership to trial a new blockchain prototype to execute import-export deals automatically using smart contract technology.[62] The prototype uses the Linux Foundation's open-source Hyperledger Project blockchain technology to generate a letter of credit, allowing digitisation of the current highly paper-based process by sharing all relevant information and steps of the trade finance deal among the counterparties and their banks on a private distributed ledger. Smart contracts are used to automate the negotiation and enforcement of the agreement.

In the same month, the MAS proposed a new regulatory framework for payments providers, including Bitcoin exchanges. Such companies would be required to obtain a licence, such licence permitting several payment activities. The proposed framework aims to strengthen standards of consumer protection, anti-money laundering, and cyber security related to payment activities while facilitating innovation and system interoperability. A National Payments Council would also be created.[63] The MAS, the Singapore Exchange, and eight banks have embarked on a PoC project to use blockchain technology for inter-bank payments, including cross-border transactions in foreign currency, supported by the R3 consortium. Banks will be able to deposit cash as collateral with the MAS in exchange for MAS-issued digital currency, later redeeming the digital currency for cash.[64]

On 12 July 2016, IBM announced that it would establish its first Blockchain Innovation Center in the city state, partnering with the Economic Development Board of Singapore, the MAS, and the Infocomm Development Authority of Singapore, as well as start-ups.[65] In its first projects, the Center will look at blockchain-based trade solutions to improve efficiency of multi-party trade finance processes and transactions.

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61 *Hitachi and Bank of Tokyo-Mitsubishi start testing blockchain technology for electronic check processing in Singapore*, bravenewcoin.com, 23 August 2016.

62 *Singapore, HSBC, BofA ML Trial Blockchain for Trade Finance*, blockchain-finance.com, 18 August 2016.

63 *Proposed Activity-based Payments Framework and Establishment of a National Payments Council - First Consultation*, MAS, 25 August 2016.

64 *Singapore's FinTech Journey – Where We Are, What Is Next*, MAS, 16 November 2016.

65 *IBM to open first blockchain innovation centre in Singapore, to create applications and grow new markets in finance and trade*, straitstimes.com, 12 July 2016.

7. Australia

Australian banks, private firms and public authorities have taken a proactive interest in blockchain. The Australian Taxation Office, the Australian Prudential Regulation Authority, the Reserve Bank of Australia, the Australian Securities and Investments Commission, and the security forces are all taking an interest in digital ledger technology.[66] A Digital Transformation Office was established in July 2015 within the government, with the vision that, '… Australia can become the best in the world at delivering public services'.[67] Data 61, the digital arm of the governmental Commonwealth Scientific and Industrial Research Organisation, is partnering with the Australian Treasury to conduct a nine-month study of blockchain technology and how it could be applied in Australia, with a view to productivity gains.[68] Standards Australia has proposed a roadmap towards developing standards for blockchain, referencing the International Standards Organisation.[69]

Australian banks have been active members of the R3 consortium. Commonwealth Bank of Australia has successfully trialled a blockchain-based application for trade finance.[70]

Australia Post is proposing a DLT solution for local elections that '… would allow for a location-agnostic, "tamper proof" system that would provide traceability, prevent manipulation, yet allow anonymity, and be resistant to denial of service attacks'.[71] The securities exchange ASX has developed a blockchain prototype as a possible replacement for its equities clearing and settlement system.[72] Pillar Administration, a superannuation fund administrator, is partnering with a consultant to launch blockchain-based solutions to help improve customer engagement, create new revenue streams, cut unnecessary costs, and improve efficiency with real-time settlement. Seventeen use-cases in the superannuation value chain have been identified. Prototypes are being launched, with the aim of finalisation by the year end.[73]

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66 *Blockchain is not just for Bitcoin - it is a digital ledger of transactions*, theaustralian.com, 15 April 2016.

67 www.dto.gov.au, viewed on 23 August 2016.

68 *Data61, Treasury to investigate blockchain*, itnews.com.au, 4 May 2016.

69 *Roadmap for Blockchain*, Standards Australia, March 2017.

70 *CBA blockchain deal creates the future of trade finance*, afr.com, 24 October 2016.

71 *Australia Post details plan to use blockchain for voting*, zednet.com, 22 August 2016.

72 *ASX targets end of year for blockchain powered clearing platform*, thetradenews.com, 20 February 2017.

73 *Pillar banking on blockchain with new trial*, financialobserver.com.au, 22 April 2016.

In August 2016, a trial began in the village of Busselton, Western Australia to trade energy captured by solar panels on residents' houses, using a blockchain to record transactions.[74] Separately in December 2016, a successful trial was held of a blockchain-based system for settling wheat transactions.[75]

[74] *Blockchain grid to let neighbours trade solar power in Australia*, www.newscientist.com, 18 August 2016.

[75] *Wheat farmers trial blockchain to sell grain and find it is fast and reliable*, Financial Review, 21 December 2016.

Appendix 4 – Hong Kong Government Efforts on Innovation And Technology

Capability-building

Although Hong Kong has limited DLT-related activity so far, it comes to the technology with certain strengths. In 2015, Hong Kong ranked first globally on technological infrastructure, and had the third highest internet connection speed (of 16.7 Mbps). Internet penetration is high, with household broadband at 83.5% and mobile penetration at 233%.[76] Hong Kong has over 80,000 Information and Communications Technology (ICT) professionals at present (about half of these being in-house personnel in the user organisations), representing 2.1% of the Hong Kong workforce.[77] As of 2013, the ICT sector had some 17,000 businesses generating revenue of HK$1,694 billion and representing 6.6% of GDP.[78] The sector is growing.

Education is important. Efforts to improve IT-related education in Hong Kong include the 2014-15 Budget's HK$75 million programme to enrich IT classes and IT activities in secondary schools.[79] Hong Kong has several universities with good science / engineering / computing faculties. These need to train students to evaluate technology and innovate with it.

Hong Kong has several research facilities and institutions – the Science Park, the Cyberport, the five R&D centres under the Information and Technology Bureau (ITB), of which the ASTRI is one and the LSCM another, in addition to the universities and the R&D of tech firms. However, university research has tended to be academic and 'supply-driven', while the tech firms are small.

Supporting technological innovation

The Cyberport has a number of support programmes for technology businesses. The Cyberport Creative Micro Fund provides seed funding for ventures aimed at turning innovative ideas into prototypes. The Cyberport also runs an incubation programme for new start-ups with business advisory, financial and technical support. The Cyberport Accelerator

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[76] Legco briefing paper, *Legislative Council Panel on Information Technology and Broadcasting: 'Facilitating a Digital Economy'*, 17 July 2015 ('*Legco Briefing'*).

[77] http://www.ogcio.gov.hk/en/business/industry_support/ict_manpower/student_it_corner/career_corner/hk_it_manpower/

[78] *Legco Briefing*,page1, ibid.

[79] *Legco Briefing*, page 4, ibid.

Support Programme launched in 2014 supports its incubatees and alumni financially to participate in accelerator programmes locally and overseas; these provide guidance on overseas expansion and fundraising. The Science Park has a similar programme.

The Office of the Chief Information Officer (OGCIO, the ITB's executive arm) has established a portal for technology start-ups, and provides opportunities for them to showcase their products. The Hong Kong Government works with the Mainland authorities to foster mutual development of their respective ICT industries; mutual recognition of electronic signatures has been agreed with Guangdong.

The 2016-17 Budget[80] announced that the Science Park is considering establishing a HK$8.2 billion smart manufacturing facility at Tseung Kwan O. The Government has set up a HK$500 million Innovation and Technology Fund for Better Living. HK$5 billion will be injected into the Innovation and Technology Fund. Additionally, HK$2 billion is being provided to support a Midstream Research Programme for Universities; the Public Sector Trial Scheme is being extended to cover Cyberport and Science Park incubatees; and schemes to support technology transfer from the universities are being extended. The Financial Secretary also expressed support specifically for exploration of blockchain.[81]

A HK$2 billion Innovation and Technology Venture Fund is being set up to co-invest with private venture capital funds on a matching basis in local tech start-ups. The Science Park is to provide an extra 70,000 square metres for start-ups and tech companies by 2020, and the Cyberport will allocate HK$200 million to invest in its start-ups.

[80] *The 2016-17 Budget*, 24 February 2016, paragraphs 47-66.

[81] *The 2017-18 Budget*, 12 February 2017, paragraph 130.

About the Financial Services Development Council

The Hong Kong SAR Government announced in January 2013 the establishment of the Financial Services Development Council (FSDC) as a high-level and cross-sector platform to engage the industry and formulate proposals to promote the further development of Hong Kong's financial services industry and map out the strategic direction for development. The FSDC advises the Government on areas related to diversifying the financial services industry, enhancing Hong Kong's position and functions as an international financial centre of our country and in the region, and further consolidating our competitiveness through leveraging the Mainland to become more global.

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