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BLOCKCHAIN TECHNOLOGY:

OPPORTUNITIES AND CHALLENGES FOR KOREAN FINANCIAL INDUSTRY

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ABSTRACT:

Certain technologies have a transformative effect on an economy. Heralded as the next big thing (Giancarlo, 2016), Blockchain technology (also referred to as distributed ledger technology) carries strong potential to revamp public and private sector institutions (Walport, 2015; Swan, 2015). Blockchain technology is internet based and it allows for faster transactions transmission at extremely low transaction costs, transparent ledger capability, record keeping capacity, open access network ability and internet-based global reach. Given these benefits, Blockchain technology can be quite lucrative for the finance industry (Brainard, 2016)). Distributed ledger technology has broad applications, even beyond the finance sector. Blockchain based tools such as Ethereum and smart contracts allow for automated low risk decision-making, enhanced productivity, machine-to-machine connectivity and even 'internet economy' (Pureswaran and Brody, 2015; Mougayar,

2016). Several governments, financial institutions and organizations have therefore shown an avid interest in the research, development and application of Blockchain technology. South Korea, one of the most connected (wired) (ICT, 2015) and technologically advanced countries, has much to gain by investing in distributed ledger technology. South Korea is also familiar with the older version of the technology, Bitcoin Blockchain 1.0 (Lee, 2013; Kim, 2014; Coindesk a., 2014). However, while governments and firms in the west have moved on to testing, Blockchain 2.0, South Korea is yet to move forward. By building on its existing understanding of the distributed ledger technology, South Korea has much to gain by investing in Blockchain 2.0, a sentiment also supported by Korea's central bank, Bank of Korea (Kim, 2016).

In this paper, we look at Blockchain technology's potential application in Korea with a focus on the Korean financial industry. In conducting research and analysis, since distributed ledger technology is rather new (conceptualized in 2008) and given the limited amount of data, this paper applies comparative research methodology to identify opportunities and challenges for the Korean finance markets. Additionally as distributed ledger technology has broad applications for different financial products, the paper limits its analysis to potential applications for 'the near future'[1]. This paper is divided in four sections. Section I provides a

[1] This paper follows the Euroclear timeline for 'near future' application of blockchain technology, namely a period of approximately five to ten years (Oliver Wyman and Euroclear, 2015).

brief introduction of distributed ledger technology in the wider context of the current fintech trend. Section II of the paper provides a literature review of Blockchain technology including details on its technical background, general advantages, limitations, and contemporary worldview towards the technology. Section III of the paper looks at the Korean case, and identifies areas of opportunity and challenges for the Korean financial industry. The final part of the paper provides policy suggestions and recommendations for application of the technology in Korean financial markets.

Based on existing detailed studies of distributed ledger technology, Korean financial markets structure, and user cases, the paper concludes that lucrative opportunities for application of distributed ledger technology exist in financial functions of post-trade settlements, cross-border payments, remittances, corporate payments, trade monitoring, reporting, risk management and collateral management. In aligning these opportunities to specific financial markets, opportunities are deemed to exist in money markets, capital markets, derivatives market and foreign exchange markets of the Korean finance industry. The paper also lists challenges of regulatory restrictions, scalability issues, data security, data privacy and data reliability concerns, and social issues that need to be addressed for the successful integration of distributed ledger technology in Korean finance markets.

Keywords: Blockchain, Distributed Ledger Technology (DLT), Korea, Fintech, Finance, Smart Contracts, R3CEV, Ripple, Chain.

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I] INTRODUCTION

Technology is instrumental in fostering economic activity. In the past, innovations that helped in faster transmission of information contributed immensely to economic growth and led to the creation of new industries. Newspapers (15th century), printing press (16th century), telegraph (17th century), Morse code (18th century), telephones (19th century), computers and Internet (20th century) are notable innovations that underlined key economic and business activities of the time. More recently, Internet and computers were seen to play a significant role in globalization (Friedman, 2005). With 'the Great Recession[2]' that slowed down global economic growth, many have looked forward to the next technological trend or innovation that will spur economic growth in our century. Several influential leaders[3][4][5][6] believe this trend to be 'digitalization' of economy and have made digital finance a priority[7].

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[2] The Great Recession began in December 2007 and ended in June 2009, which makes it the longest recession since World War II. Reference: http://www.federalreservehistory.org/Events/DetailView/58

[3] A directive issued by President Obama on May 23, 2012 titled 'Building a 21st Century Digital Government' aims at delivering better digital services to American people. http://www.state.gov/digitalstrategy/

[4] In 2015, Indian government passed a 'Digital India' initiative aimed at 'taking the nation forward-digitally and economically.' http://www.digitalindia.gov.in/content/vision-and-vision-areas

[5] The Chinese Mission to the EU, Yang Xiaoguang, political counsellor's speech at 10th Digital Regulation Forum. http://www.chinaeu.eu/

[6] Speech by Mr. S. Iswaran, Singaporean Minister of Trade and Industry at the Singapore-China Digital Economy Forum on 19th January 2016.

Fintech' (portmanteau for financial technology) or technology led financial services has not been a new trend. In fact the word seems to be coined first by Citicorp in 1993 when it started a banking research project called 'Fintech' to keep up with the times (Kutler, 1993). However recently, since the 2008 financial crisis, 'Fintech' has come to describe tech led innovative financial services that carry the potential for revenue generation and cost savings. Fintech therefore is now associated with business services such as peer to peer lending (P2P) and crowdsourcing; mobile payment services such as Apple Pay, Samsung Pay and Google Wallet; and even cryptocurrencies such as Bitcoin. Since fintech solutions now offer innovative financial services not previously considered, there is much hype in investing and developing fintech products. For instance, Bitcoin's blockchain technology leverages Internet reach and mobile market penetration to service consumers (in both developed and developing countries) that were previously not serviced (e.g. for micro transactions or in countries that lacked adequate financial infrastructure). Bitcoin is one of the predecessors of the contemporary fintech trend. While Bitcoin itself is not very popular among established financial markets owing to its security, reliability (Antonopoulos, 2014;

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https://www.mti.gov.sg/NewsRoom/Pages/Speech-by-Min-Iswaran-at-SG-China-Digital-Economy-Forum-2016.aspx

[7] In the recent G20 summit in Shanghai, Central bank governors agreed to produce a framework for implementation of the 'G20 SME Finance Action Plan' and to explore development of 'a set of high-level principles on digital financial inclusion, and improving data collection and indicators.' http://wjb.mof.gov.cn/pindaoliebiao/gongzuodongtai/201604/t20160416_1952794.html

Popper, 2015) and regulatory issues (Murphy, Murphy and Seitzinger, 2015), its underlying technology (Blockchain) has gained a lot of positive industry[8] (Irrera, 2014) and government attention[9][10].

Blockchain technology is a transparent, distributed ledger technology that allows for fast peer-to-peer transactions at very low transaction costs. As it is Internet based, its payment structure has global reach. Using Blockchain technology, users in even least developed countries are able to remit payments across borders within a day at very low transaction costs[11]. Blockchain technology is also unique in that the technology is the transaction ledger itself. Also the ledger is supported not in a centralized location, but is rather held across the entire transaction network (Nakamoto, 2008). The distributed nature of the ledger helps to ensure that the transactions data doesn't get compromised from potentially targeted centralized attacks or accidents. While distributed ledger technology itself is quite lucrative, Blockchain based technologies such as 'Ethereum', 'smart contracts' and 'bittorrent' also make available opportunities for 'Internet of Things' based economy (IBM, 2015; Gokhale, 2016). For these and several of its other

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[8] Bill Gates remarks on Blockchain technology at the SWIFT Sibos conference in Boston on October 3, 2014 (Banking is changing).
https://www.sibos.com/sites/default/files/Sibos_Issues_2014_Friday.pdf

[9] Australian Government's Treasurer speaks of the ASX's (Australian Securities Exchange) plans of leveraging Blockchain technology for its clearing and settlements processes.
http://fintech.treasury.gov.au/

[10] Federal Reserve Vice Chairman Stanley Fisher's remarks on (Blockchain) 'distributed-ledger type technology' at the IMF and World Bank's annual meeting in Washington D.C. October 12, 2014.
http://www.imf.org/external/mmedia/view.aspx?vid=3835541830001

[11] https://www.bitpesa.co/

traits, Blockchain technology holds strong potential for both financial and non-financial sectors.

Distributed ledger technologies, being Internet based, require a strong ICT infrastructure in place. In pursuit of its 'Knowledge based economy' (World Bank, 2000) and 'Creative economy' goals (OECD, 2015), South Korea has made a consistent effort to develop and establish a strong ICT infrastructure (see Figure 1) (KISDI report, 2014; OECD, 2014). Indeed fintech innovations such as electronic currency (T-Money in 2004) (Kwon, 2010) and recent ones like mobile payments (Samsung Pay) (Burlacu, 2015) were fast integrated in this technologically advanced nation. As an active investor in fintech technologies, South Korea was also one of the first countries to have Bitcoin ATMs (Coindesk b., 2014). With an existing understanding of Blockchain technology and with avid government and private sector interest in a tech innovation driven economy[12], South Korea can further catapult its economic growth through Blockchain based fintech technology.

Before exploring Blockchain opportunities for the Korean finance industry, we briefly review some key terms and concepts tied to the distributed ledger technology in the next section.

[12] http://english.msip.go.kr/english/msipContents/contents.do?mId=Mjcx

II] LITERATURE REVIEW

1. BACKGROUND: Bitcoin, Blockchain (versions 1.0 & 2.0) and Smart Contracts.

The 2008 financial crisis ('The Great Recession') brought to light high costs associated with misplaced trust, lack of transparency and lax accountability in financial institutions (Shaun et. al, 2009; Kramer, 2009.) The credit crisis led to a new consumer demand for a decentralized and transparent financial transactions platform. Around this time, Satoshi Nakamoto, the pseudonymous person or group, published a white paper "Bitcoin: A Peer-to-Peer Electronic Cash System" that laid the foundation for Blockchain technology (protocol 1.0) and Blockchain *based* technologies such as Bitcoin cryptocurrency (Nakamoto, 2008) and Ethereum (Buterin, 2014).

Blockchain technology has its roots in Bitcoin. As is described in Nakamoto's white paper, Bitcoin is a decentralized electronic currency [13]and payments system that allows for online payments (Bitcoins) to be transmitted from one party to another, without any third party involvement. The technical details of a Bitcoin transaction (Blockchain ledger 1.0) are as follows (Nakamoto, 2008)-

[13] The virtual currency, Bitcoin, is essentially a chain of digital signatures. Bitcoins are generated as a reward for the 'miners' for their payment processing work (Nakamoto, 2008).

A user sends a payment transaction to its intended recipient via the Bitcoin network using digital signatures and a pair of 'keys'[14]; namely, a private key (decryption key) and a public key (encryption key). The private key helps one to access his or her Bitcoins (the way one would use an ATM pin.) The public key acts as an address that indicates the sender of the Bitcoin payment. Both the sender and recipient of the Bitcoin payment make their public keys known to each other to send the transaction (peer-to-peer) over the Bitcoin network[15]. However, neither of the keys carries any personal details of the transacting party. Therefore, as long as a public key of the counterparty is known, it is possible for two anonymous individuals to transact directly with each other. Once the transaction gets transmitted, it gets added, as part of a block of transactions, to the longest chain of transaction records (Blockchain) held across the Bitcoin network. Transactions get transmitted to the network at random intervals. A block of transactions (approximately 1MB in size) joins the ledger approximately every ten minutes. It typically consists of transaction records, a reference

[14] The keys are unique and one of a kind. They are electronically generated and made available to the user when one signs up for the Bitcoin service.

[15] Bitcoin Network is a peer-to-peer payment network that is based on encryption protocol. Payments sent across the network are broadcasted across the whole network through digital signatures ('digitally signed messages'). Transactions sent to the network get verified and recorded by 'miners' on to a publicly transparent distributed database. The database (ledger) has a record of all transactions ever sent to the Bitcoin network (Blockchain or distributed ledger). The Blockchain is distributed across the network using peer-to-peer file sharing technologies such as DHT. While several chains (linked blocks of records) can be formed at a time, only the longest chain is chosen as the true record of confirmed transactions. All other chains get discarded. If a transaction is included in a discarded chain, it does not go through i.e. the transfer of bitcoins will not take place. Transactions sent to the Bitcoin network are irreversible. Therefore to reverse a sent payment, another transaction headed in the opposite direction (from the recipient of the original transaction back to the sender) will have to be sent.

to the last linked block in the ledger (hash), a solution to '*nonce*'[16] and a digital signature. Once the transmitted transaction gets verified as part of the block verification-generation process, payment gets transmitted to the recipient.

The Bitcoin network is essential a general ledger consisting of a long list of transactions held in blocks (Blockchain). The Bitcoin ledger holds a record of all transactions transacted since the transmission of the first Bitcoin 'genesis block'. Every new transactions block that is sent to the network and confirmed by 'miners', gets linked to the longest chain through 'time-stamping and hashcash proof-of-work'[17] functions performed by Bitcoin miners. 'Miners' are individuals that verify existing record of transaction blocks and who link a new transaction block to the last verified one. Because the verification process takes immense computing power, resources and time, miners are rewarded[18] a certain number of bitcoins for every verified block. Miners also charge a small transaction fee (0.000129 bitcoins) for an average sized transaction (125 bytes). It is technically and economically not profitable for an individual to

[16] Nonce: "The "nonce" in a bitcoin block is a 32-bit (4-byte) field whose value is set so that the hash of the block will contain a run of zeros. The rest of the fields may not be changed, as they have a defined meaning. Any change to the block data (such as the nonce) will make the block hash completely different. Since it is believed infeasible to predict which combination of bits will result in the right hash, many different nonce values are tried, and the hash is recomputed for each value until a hash containing the required number of zero bits is found. As this iterative calculation requires time and resources, the presentation of the block with the correct nonce value constitutes proof of work." (Reference: Bitcoin wiki).

[17] Timestamp: Unix time i.e. number of seconds elapsed since (previously stamped time). Hashcash Proof-of-work: "a piece of data which is difficult (costly, time-consuming) to produce but easy for others to verify and which satisfies certain requirements." (Reference: Bitcoin wiki).

[18] Currently (As of April 2016) the mining reward consists of 25 Bitcoins.

> attempt mining all Bitcoins. This helps to avoid any single individual or entity from dominating the governance of the peer-to-peer digital payment process. Additionally, as transaction data in the not centralized, but is rather held across the Internet nodes, transaction history is secured.

Since payment transactions get through within approximately ten minutes at very low transaction costs (0.0000001 bitcoins per byte[19]), Bitcoin's Blockchain protocol 1.0 (mentioned above) can be a lucrative business opportunity, particularly in the payments processing area. Not only money, but the distributed ledger technology also allows for transfer of assets and property (Assia et al., 2012). Since 2012 to date, Bitcoin startups have raised approximately $1,140.24 million in Venture capital funding[20]. But since Blockchain 1.0 is tied to Bitcoin framework, it is exposed to the same regulatory, security, accountability, governance, and scalability issues faced by Bitcoin. Therefore, several market participants have expressed reservations about the commercial use of Blockchain 1.0 (ECB 2012; Rainer et al., 2014, R3CEV, 2015)[21]. However, recently several Blockchain based

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[19] http://www.coindesk.com/new-service-finds-optimum-bitcoin-transaction-fee/

[20] Coindesk Bitcoin Venture Funding tracker: http://www.coindesk.com/bitcoin-venture-capital/

[21] Bitcoin is decentralized, not regulated by any central banks and not specific to any national jurisdiction. It also allows for user anonymity. Bitcoin is therefore often used by illegal market participants to fund their illegal activities (Popper, 2015; FBI, 2015; IBM, 2014). Additionally, theft of Bitcoins is common owing to the issues with keeping ones public and private Bitcoin access keys secure, e.g. Mt. Gox Bitcoin theft (Jeffries, 2013). Another concern has been Bitcoin's scalability issues and long-term transaction fees. Since transactions are supported on individual user nodes, there have been serious concerns if the Blockchain 1.0 protocol would have the capacity of handling financial market level global transactions. Additionally since the maximum number of Bitcoins that

startups and firms have been able to isolate the distributed ledger technology from the Bitcoin framework and have used it to create innovative solutions for the financial industry.

The enhanced version of Blockchain, Blockchain 2.0, can now be found in two forms: 'Permissioned distributed ledgers' and 'Permissionless distributed ledgers' (R3CEV, 2015). As described by Swanson in his R3CEV report[22], a permissioned distributed ledger is private ledger wherein authorization for blockchain data access and transactions processing (verification and recording of blockchain transactions) is given to known 'permissioned' entities. A permissionless distributed ledger is a public ledger (similar to the Blockchain protocol 1.0) wherein blockchain data is public and anyone with the right computing capacity and resources can verify and record transactions transmitted to the ledger. Both permissioned and permissionless distributed ledger technologies fulfill the following basic traits of Blockchain technology (Bitfury, 2015)- the transactions are (1) authorized (digital signatures for permissionless ledger; authorized digital signatures for permissioned ledgers) (2) irreversible (once a transaction is sent to the distributed ledger, it cannot be modified) (3) unmodifiable

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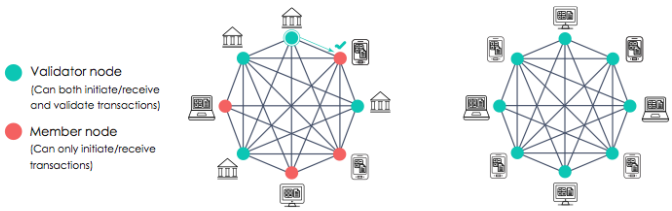
can be in circulation will soon reach its limit (21 million) by 2040, there have been concerns if the transaction fees will increase immensely in the future (R3CEV, 2016). Finally, as Bitcoin is a digital currency used frequently by followers of libertarian perspectives (Edwards, 2013), the technology is looked upon as being potentially disruptive for existing establishments, currencies and markets (ECB, 2012).

[22] R3CEV LLC is a Blockchain technology company that is leading a consortium of 42 financial firms to research and apply distributed ledger technology to global financial markets (R3CEV, 2016).

(transactions cannot be modified once they are transmitted to the ledger) (4) final (once recorded to the distributed ledger, transactions can never be deleted) and (5) censorship resistant (transactions that follow the respective distributed ledger protocol get eventually added to the ledger). The two versions of the distributed ledger technology thus satisfy certain basic needs of financial institutions and governments (such as monitoring and recording). Unlike Bitcoin's permissionless ledger, the controlled environment of the permissioned ledger technology allows for enhanced performance (much faster and accurate transaction processing and verification, given that pre-authorized users transmit the transactions), a governance structure, accountability (since a group of authorized individuals are responsible for transaction processing, regulators and firm executives are able to hold these individuals accountable for their actions) and relatively better security (given accountability and firms' resources, authorized users of the distributed ledger have greater incentive and capacity to secure their public and private keys.)

Figure 1: Permissioned distributed ledger vs. Permissionless distributed ledger (Evry, 2015).



	Permissioned Blockchain (Private)	Permissionless Blockchain (public)
How do you get access to the network?	Authorized access	Open access
How are their approach to laws and regulations?	Aims to follow financial regulations such as AML/KYC	Aims to create censorship resistant, anonymous transactions, outside current legal framework
Who are the validators?	Pre-selected, trusted validators	Anonymous, fully decentralized validators
What can it be used for?	Enterprise-level systems	Permissionless innovation, open-access applications

Besides Blockchain 2.0, another blockchain-based technology making waves is Ethereum's smart contracts. Nick Szabo first introduced the concept of 'smart contract' in the late 1990s in his whitepaper, wherein he attempted to tie in 'highly evolved practices of contract law' with electronic commerce (Szabo, 1997). Vitalik Buterin recognized wider potential for smart contracts on blockchains when he created Ethereum (Buterin, 2014). Per Buterin, smart contracts are "cryptographic "boxes" that contain value' and that get unlocked only when certain conditions are met" i.e. they are electronic protocols with conditions that can be placed on blockchain transactions. Once all conditions in the smart contract are met, they self execute. Smart contract technology is therefore being seriously considered by financial institutions for the transaction processing of financial instruments such as derivatives (Shadab, 2014; Yermack, 2016).

Smart contracts and distributed ledger technology offer a lot of value to firms and institutions. Blockchain based opportunities and challenges are discussed in further detail in the next section.

2. BLOCKCHAIN: Opportunities & Challenges.

Opportunities:

Several opportunities exist for the application of Blockchain technology. A closer look at the benefits from its application could point us to core functions of interest. Blockchains i.e. distributed ledger technology carries the following positive traits: (1) It carries the entire data record history (data held is reliable) (2) information on the ledger cannot be changed or deleted (authenticity is maintained) (3) the information is supported on the blockchain across all nodes (therefore duplication of information is not required) (4) information is transparent to all users with access to the distributed ledger and the information held on the ledger is current (real-time status of information held on the ledger becomes available to anyone with access to the ledger. Therefore information accuracy improves and human error is reduced. Additionally, reconciliation requirements diminish through distributed ledger technology as everyone with access to the ledger sees the same current information.) (5) Blockchain technology is an Internet based technology. Therefore, as long as users are able to access the Internet, they can partake in

blockchain based activities (this feature is especially helpful for countries with poor financial infrastructure). (6) The distributed ledger holds information in a decentralized fashion across all nodes. (Thus, information is not easily lost from cyber attacks or accidents in any one location). (7) The distributed ledger allows user anonymity (this can be a helpful feature if the distributed ledger technology is used for voting function (Yermack, 2015)).

For such reasons, the distributed ledger technology is being explored for a variety of functions such as payment systems (Robleh et al. 2014; US Fed, 2015); record keeping and land registries (Honduras) (World Bank, 2015); information reporting such as for tax and regulatory compliance (Walport, 2016; Oliver Wyman and Euroclear, 2016; Giancarlo, 2016; R3CEV 2015) and even for reducing corruption (Yermack, 2015). Several market makers also see potential in applying distributed ledger technology, along with using tokens and smart contracts. Blockchain technology is being considered for financial functions (Evry, 2015; Oliver Wyman and Euroclear, 2016; Brainard, 2016; R3CEV, 2015; Santander, 2015) such as transaction processing, financial clearing, settlements, reconciliation, asset transfer and securities lending in derivatives and capital markets; functions like remittance and cross border settlements in foreign exchange markets; and for asset servicing functions like margin tracking in Funds market (see figures 2, 3 and 4).

Figure 2: Utopian view of capital markets using blockchains (Oliver Wyman and Euroclear, 2016)

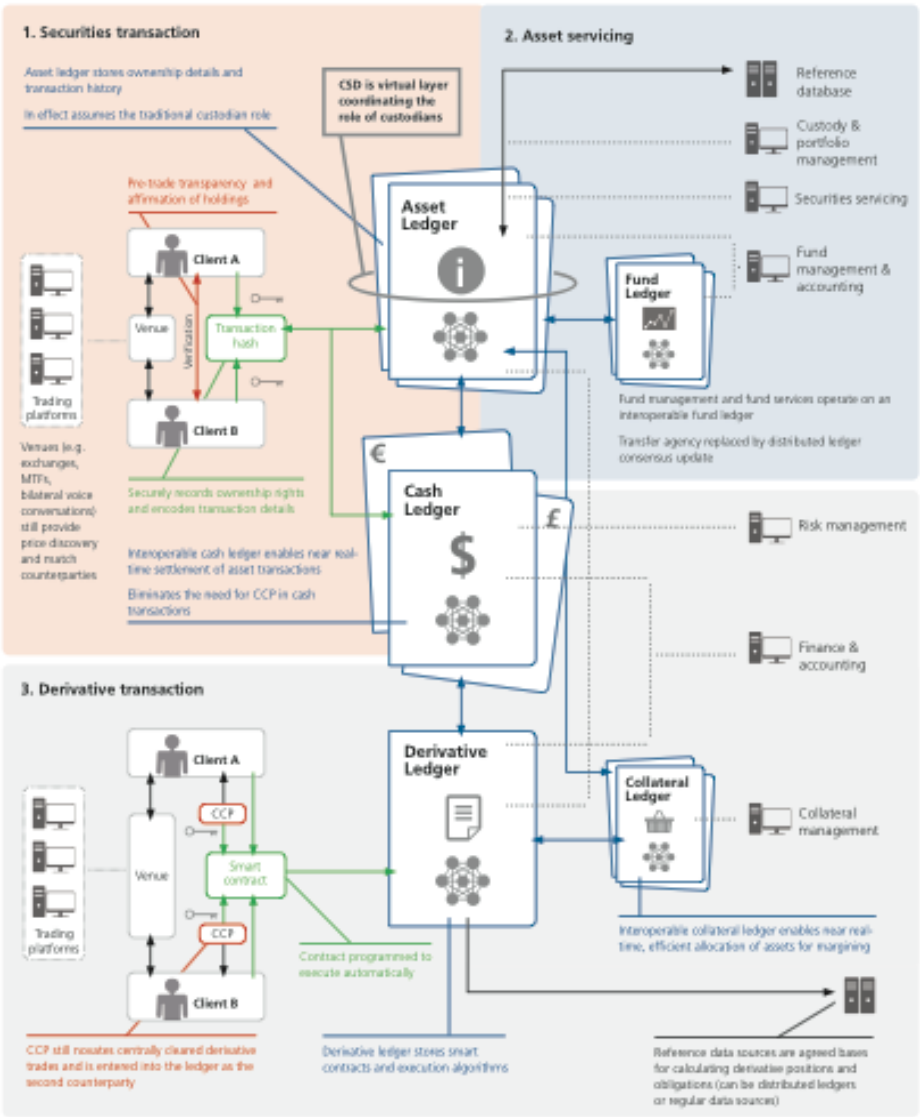


Figure 3: Potential benefits from application of distributed ledger technology (Citi, 2016)

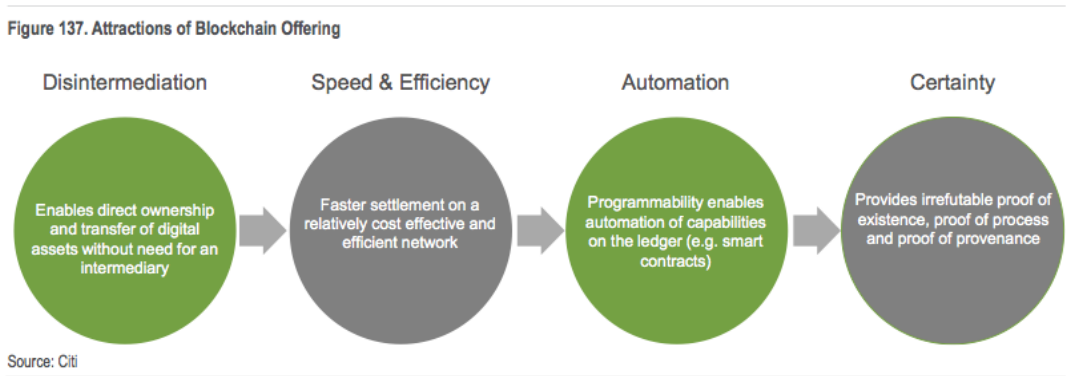
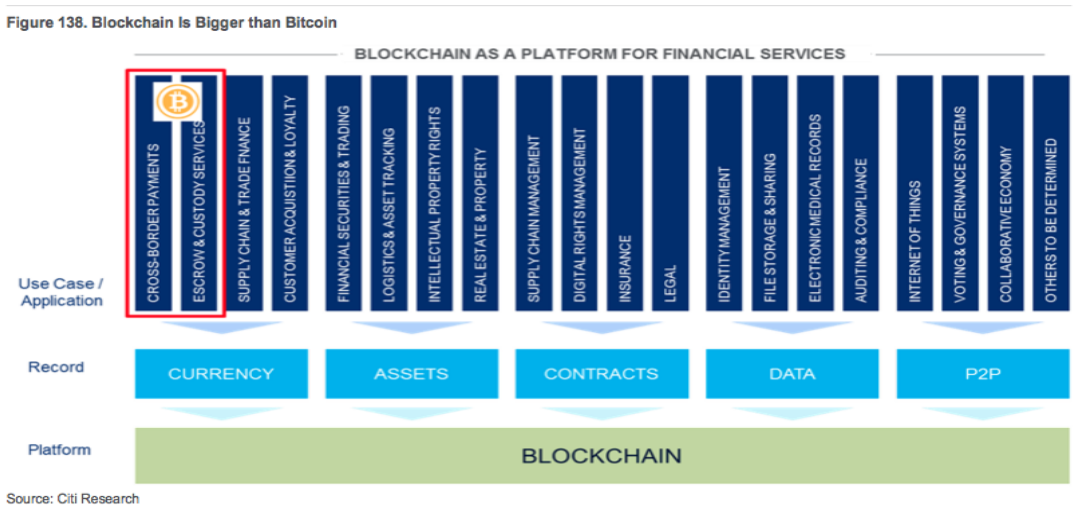


Figure 4: Blockchain as a ledger for financial services (Citi, 2016)



Challenges:

Challenges in applying blockchain technology are as follows:

(1) New Technology:

Distributed ledger technology is a relatively new (conceptualized in 2008). Therefore prior to its mass application, the technology needs to be vetted and tested for robustness, scalability, long-term sustainability and data-integrity by engaging market participants, regulators and other stakeholders affected by application of blockchain technology (Bank of England, 2015; Santander, 2015; James et al., 2016; Oliver Wyman and Euroclear, 2016).

(2) Reliability and Authenticity: Currently while the information held on the blockchain is reliable, users may not be reliable enough to input accurate information into the distributed ledger. In some cases, a corrupt user may purposely include erroneous information into the ledger that would then be considered to be true copy once transmitted to the distributed ledger (World Bank, 2015). As transaction information included in the blockchain ledger cannot be modified, deleted, reversed or altered, incorrect information could compromise data integrity of the entire transactions network and pose a serious challenge.

(3) Security: As institutions and financial markets move forward with permissioned distributed ledgers, steps need to be taken to ensure that access keys (public and private keys) to the distributed ledgers are kept safe and private. Additionally as the distributed ledger holds a history of all transacted transactions, unauthorized access to the ledger can expose an infiltrator to the transaction details of all other ledger users (as the distributed ledger holds a record for all information, unauthorized access to the ledger can expose the entire transaction history to a cyber attacker) (Walport, 2015; World Bank, 2015.)

(4) Regulatory issues: Application of distributed ledger technology in financial transactions will require financial regulations to be revised (Duhaime, 2014; Bank of England, 2015; US Fed, 2015; Oliver Wyman and Euroclear, 2016). For instance, regulations for application of KYC-AML, inter-state payments, cross-border payments or foreign exchange may need to be revisited. In other cases, new laws and regulations will be needed. For instance, regulating blockchain based smart contract driven derivatives transactions and asset transfers; creation of laws for crowdsales; creation of securities laws for software accessed tokens (tokens on a blockchain represent ownership of an asset) or creation of new copy right and proof of

purchase laws (Coindesk, 2015). Appropriate governance, risk management and security standards will also need to be established (US Fed, 2015; Walport, 2015).

(5) Market Disruption: The distributed ledger technology in several ways replaces the role of the 'middle man' (Yermack, 2015). Therefore as the technology gets applied across industries including the financial sector, issues such as unemployment[23] will need to be addressed.

[23] Citibank recently published a report titled 'Digital Disruption' on fintech's disruption of the industry. The report indicated layoffs of another 30% of its staff from 2015-2025 as Citibank slowly integrates blockchain technology (Crowe, 2016).

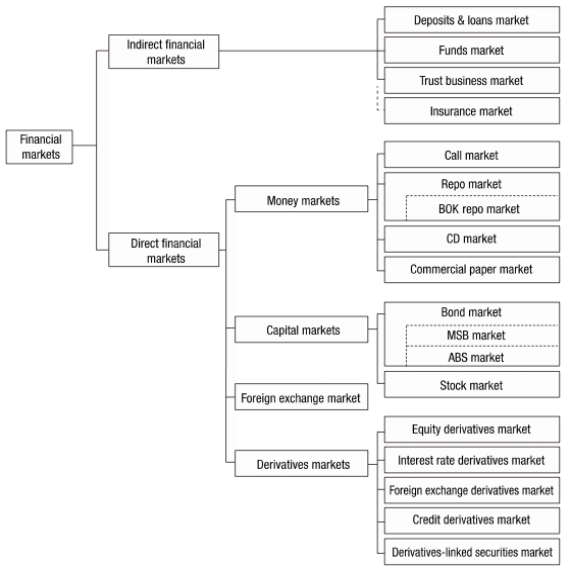
III] BLOCKCHAIN & KOREAN FINANCE INDUSTRY

A look at the Korean finance industry can help us identify areas of opportunity for application of distributed ledger technology.

1. KOREAN FINANCE INDUSTRY STRUCTURE:

Per Bank of Korea's 2013 industry publication "Financial Markets in Korea", Korean financial markets are classified into 'Direct financial markets' and 'Indirect financial markets'. This classification is based on whether financial transactions are processed by financial intermediaries or by other institutions. Korea's direct financial markets consist of four submarkets; namely capital markets, money markets, foreign exchange markets and derivatives market. Korean indirect financial markets comprise of deposit and loans market, funds market, trust business market and insurance market.

Figure 5: An overview of Korean financial market structure (Bank of Korea, 2013).



Direct financial markets[24]:

Since the 1990s, Korea's money markets and capital markets have grown quite a bit (table 1) and have contributed significantly to Korean financial growth[25]. The two markets are therefore of notable importance to Korean economy.

[24] While opportunities for application of distributed ledger technology exist in both direct and indirect financial markets, as the paper focuses on the near future application of blockchain technology, we focus mainly on direct financial market structure wherein such opportunities can be realized in the near future (the paper follows Euroclear timeline of 'near future' application of blockchain technology i.e. a period of approximately five to ten years (Oliver Wyman and Euroclear, 2016)).

[25] "As of end-June 2012 the direct financial markets, comprising the capital and the money markets, were worth a total of 2,708 trillion Korean won (KRW) - a whopping 17 times greater than the 158 trillion won figure in 1990. Consequently, the ratios of the financial market to Lf (Liquidity aggregate of financial institutions) and to loans had increased from 80% and 87% respectively in 1990 to 113% and 135% as of end-June 2012. **The ratio of financial market value to nominal GDP also rose from 83% to 212% during this period**. Looked at on an individual market basis, in the capital markets remarkable 35-fold growth in the bond market and 15-fold growth in the stock market were seen between 1990 and 2012, while the money markets expanded seven times" (Bank of Korea, 2013).

Table 1: Korean financial market volume from 1990s to 2013 (Bank of Korea, 2013).

[Table 1] Financial market volumes

(outstanding balances at period-ends)

Unit : trillion won

	1990(A)	2000	2010	2012.6 (B)	B/A
Money markets[1]	44.3	138.8	267.5	305.5	6.9
Capital markets	114.0	640.7	2,352.7	2,402.3	21.1
Bonds[2]	35.0	423.6	1,112.9	1,228.0	35.1
Stocks[3]	79.0	217.1	1,239.9	1,174.3	14.9
Total (C)	158.3	753.0	2,620.3	2,707.8	17.1
C / Lf[4] (%)	79.9	82.6	122.6	113.3	—
C / Loans[5] (%)	86.9	111.2	143.4	135.3	—
C / Nominal GDP (%)	82.7	124.8	223.3	212.0	—

Notes : 1) Call, RP, CP, CD, cover bill, Monetary Stabilization Bond (1-year maturity or less) and T-bill
2) Figures are for listed bonds (excluding Monetary Stabilization Bonds with maturities of one year or less and T-bills)
3) Aggregate value of listed stocks on Korea Exchange's KOSPI and KOSDAQ Markets
4) Liquidity aggregate of financial institutions (= M2 + savings products with maturities of two years or longer + deposits in Korea Securities Finance Corp., etc. + insurance reserves of life insurance companies, etc.)
5) Loans in Flow of Funds Tables (excluding Bank of Korea loans)

Sources : Bank of Korea, ECOS; Korea Exchange

Capital markets:

Korea's capital markets trade financial products with maturities greater than a year. Korean capital markets consist of bonds market and stock market (Bank of Korea, 2013). Bonds market deals with government bonds, corporate bonds, bank debentures, and securities such as asset-backed securities (ABS) and monetary stabilization bonds (MSB). The Bonds market is further subdivided into a primary market, wherein government issued bonds and corporate bonds are traded; and a secondary market, wherein bonds are traded on stock exchanges and over-the-counter markets. Korea Securities Depository is the primary clearing house for Korean financial market bond trades. Bonds are registered at Bank of Korea (government bonds and MSBs) and Korea Securities Depository (municipal bonds,

financial bonds and corporate bonds). Typically, bond trades settle on the next trade day (T+1) using the delivery vs. payment system (DVP) (Bank of Korea, 2013).

Korea's Stock market comprises of a primary market, wherein stocks are issued through IPO[26]s; and a secondary market that deals with listed and unlisted securities. Listed securities get traded on the KOSPI and KOSDAQ exchanges, and unlisted securities get traded on Free Board market.

Money markets:

Korea's money markets trade financial products with maturities of one year or less. Korea's money markets mostly include a call market, repo[27] market (RP), certificate of deposits market (CD) and commercial paper market (CP) (Bank of Korea, 2013).

In the call market, Korean financial firms lend and borrow money from each other on a short-term basis. Asset management firms are the typical lenders in this market and domestic banks are typical borrowers. Besides financial institutions (such as banks), at present financial institutions that are uninvolved in savings or deposit activities, or with no obligations of meeting Korean financial reserve requirements, can also participate in call trades as borrowers or lenders.

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[26] Initial Public Offering.

[27] Repurchase Agreement market.

Collateralized trading in Korea is rather slow because the procedures involved in establishment of related rights of pledge and delivery of collateral are complicated. While both collateralized and uncollateralized call trading takes place in the Korean call market, the later is more common than the former. Overall, the call market is important to the Korean finance industry as it acts as a reserve market 'to smooth out shortages or excess of reserves' (Bank of Korea, 2013).

The Repo market is also of equal importance to the Korean finance industry as Bank of Korea (Korea's central bank) uses the Repo market to adjust market liquidity (Bank of Korea, 2013). The repo market addresses any shortages or excess of short-term funds faced by repo market participants. The repo market is divided into institutional repo market (over-the-counter market), BOK repo market (Bank of Korea participates in the repo market to manage money supply), and customer repo market. Korean financial institutions are the major participants of the institutional repo market, whereas security firms, banks, Korea Securities Finance Corporation, merchant banks, Korea Post, individuals, corporations and trusts participate in customer repo market. Institutional repo transactions have a tri-party settlement, whereas customer repo trades settle bilaterally.

Going through brokerage institutions is the norm for Korea's call market and repo market (Bank of Korea, 2013). For the call market, the following brokerage institutions are involved: Korea Money Brokerage Corporation, Seoul Money Brokerage Services and KIDB Money Brokerage Corporation. These

institutions charge transaction processing and brokerage fees to participants on both sides of the call trade. Typical broker fee rate for a call trade stands at 80 won per 100 million won traded. On the other hand, Interbank call transactions get processed through BOK Wire+ call trading system operated by Bank of Korea. In regards to Korea's repo markets, Korea Securities Depository (KSD) acts as an intermediary for its repo institutional market. KSD customers are charged three different fees based on services provided, namely securities lending-borrowing (SLB) fee, intermediation fee (typically 2% of SLB fee) and facilitation fee[28].

Overall, Korea's money markets are big and play a key role in meeting liquidity needs of Korean financial markets (call market and repo market).

Table 2: Money market volume in Korea from 1990 to 2012 (Bank of Korea, 2013.)

[28] https://www.ksd.or.kr/eng/static/EB0503000000.home?menuNo=70

[Table 2] Money market volumes

(outstanding balances at period-ends)

Units : billion won, %

	1990		2000		2010		2012.6	
	value	share	value	share	value	share	value	share
Call	3,397	7.7	16,058	11.6	22,501	8.4	20,006	6.5
Repo	3,377	7.6	26,115	18.8	76,871	28.7	90,270	29.5
CP[1]	12,740	28.7	44,677	32.2	80,916	30.2	106,175	34.8
CD	6,804	15.3	14,218	10.2	44,472	16.6	29,653	9.7
Cover bill	277	0.6	11,201	8.1	1,604	0.6	1,671	0.5
MSB[2]	15,241	34.4	26,488	19.1	41,140	15.4	49,550	16.2
T-bill[3]	2,500	5.7	0	0.0	0	0.0	8,161	2.7
Total	44,335	100.0	138,757	100.0	267,504	100.0	305,486	100.0

Notes : 1) Based on figures from Flow of Funds Tables

2) MSB refers here to short-term Monetary Stabilization Bonds with maturities of one year or less.

3) T-bills were not issued from 1994 to March 2003.

Source : Bank of Korea, Money and Banking Statistics, Flow of Funds Tables

Financial derivatives market:

Korea's financial derivatives market comprises of equity derivatives market, interest rate derivatives market, foreign-exchange derivatives market, credit derivatives market and derivatives-linked securities market (Bank of Korea, 2013). Financial derivative instruments traded in this market include- forwards, futures, options and swaps. Korea's equity derivatives market is further divided into stock index futures market (traded on KOSPI200) and stock index options market (traded on KOSPI200, KOSDAQ50 and Single Stock Options market). Korea's interest rate derivatives market consists of interest rate futures and interest rate swaps market. Trades for Korea interest rate futures market are listed on the Korea stock exchange. Unlike developed countries wherein payment and

settlement is handled by an independent settlement organization (like DTCC in the U.S.), Korea stock exchange has an in-house department that processes and settles interest rate futures transactions. Korea's foreign exchange derivatives market consists of foreign currency swap market, foreign exchange market and credit derivatives market. The credit derivatives market deals with products such as credit default swaps (CDS), total return swaps (TRS), credit-linked notes (CLN), synthetic collateralized debt obligations (CDOs), derivatives-linked securities (DLS) and equity-linked securities (ELS). Currently Korea stock exchange charges its participants three fees based on services offered, namely 'trading fee', 'listing fee' and 'clearing and settlement fee'[29].

Given a basic understanding of the Korean financial market structure and Korean direct financial markets, in the next section we identify opportunities and potential benefits from application of distributed ledger technology to Korean (direct) financial markets.

2. BLOCKCHAIN: OPPORTUNITIES & CHALLENGES

OPPORTUNITIES

Distributed ledger technology allows for reduced operational inefficiencies, improved transaction transparency, reduced transaction time, enhanced capital

[29] https://global.krx.co.kr/contents/GLB/02/0203/0203000000/GLB0203000000.jsp#ab8758eced0475769e200e7e309baf77=1&view=20405

management and improved risk management. To this regards, Blockchain technology (permissioned ledger technology) can be leveraged in Korean Financial markets for improving performance and reducing costs in the following functions in the near future[30]: (1) Post-trade settlements (trade matching, trade confirmations, assumption of obligations, guarantee of settlements and reconciliation) (2) Payments services (corporate payments, cross-border payments and remittances) (3) Monitoring, reporting and liquidity management (reducing trade related fees and collateral obligations).

(1) Securities transactions: Post-trade settlements

Current state:

In Korea, securities transactions are conducted on Korea Stock Exchange (KRX) and Korea Securities Depository (KSD) through Securities Settlements Systems (SSS) (figure: 6 and 7). Time taken for a trade to settle on KRX and KSD is about 2 days on average. Under the FSCM Act[31], KRX is responsible for not only trade confirmations, but also for conducting assumption of obligation, netting, providing confirmation of settlement funds and securities, and for providing guarantee of final transaction settlement for KOSPI, KOSDAQ and derivatives markets transactions. KSD is similarly responsible for trade confirmations of OTC securities trades.

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[30] This paper follows the Euroclear definition of 'near future,' a period of approximately five to ten years (Oliver Wyman and Euroclear, 2016).
[31] FSCM: Financial Services and Capital Markets Act

Figure 6: Securities settlements in Korea (Bank of Korea, 2010.)

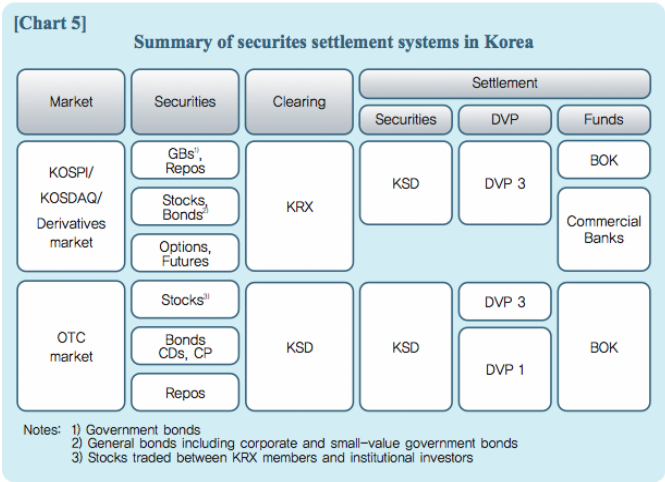


Figure 7: Summary of securities transaction settlement through KRX and KSD entities (Bank of Korea, 2013).

[Table 9]
Summary of securities transaction settlement through the KRX markets

Markets	KOSPI			KOSDAQ	Derivatives
Securities traded	stocks	government bonds	general bonds	stocks	options, futures
Clearing agent	KRX	KRX	KRX	KRX	KRX
Settlement (funds)	banks	BOK	banks	banks	banks
Settlement (securities)	KSD	KSD	KSD	KSD	—
Settlement day	T+2	T+1[1]	T	T+2	T+1
DVP type	DVP3	DVP3	DVP3	DVP3	DVP3
Number of members[2]	61	85	85	61	63

Notes: 1) Day T for repo transactions 2) As of end-2009

[Table 10]
Summary of OTC securities transaction settlement

Securities	Bonds	CDs, CP	Repos	Stocks[1]
Clearing	KSD	KSD	KSD	KSD
Settlement (funds)	BOK	BOK	BOK	BOK
Settlement (securities)	KSD	KSD	KSD	KSD
Settlement day	T+1	T	T	T+2
DVP type	DVP1	DVP1	DVP1	DVP3
Number of members[2]	240	240	82	157

Notes: 1) Stocks traded between KRX members and institutional investors 2) As of end-2009

Trades settled through KRX and KSD include the following key steps (Bank of Korea, 2010):

(i) Buy order and sell order gets sent by member firms to the exchange (KRX) or the depository (KSD for OTC securities).

(ii) Price discovery occurs on the exchange and the two orders get matched.

(iii) Trade details get sent back to trading firms for verification.

(iv) Any errors detected get rectified and trade details get confirmed.

(v) Trading parties then assume that the counter-party has the assets and securities to follow-through on the trade and trade settlement details get confirmed.

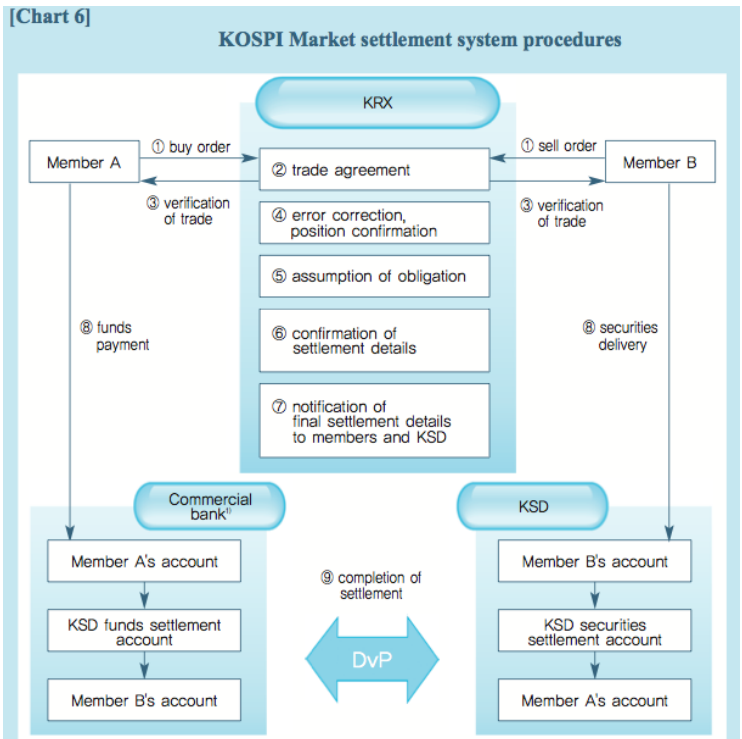
(vi) Final settlement trade details get confirmed with the trading parties and KSD.

(vii) Trade settles on the exchange via DVP (Delivery vs. Payment) / RVP (Receipt vs. Payment.

(viii) Funds and securities get delivered to the appropriate counter-party.

(ix) Final settlement of trade gets completed.

Figure 8: Market settlement procedure for KOSPI trade on KRX (Bank of Korea, 2010).



Distributed Ledger Technology benefits:

By using distributed ledger technology and smart contracts, a trade would get traded and settled as follows:

1. Stock exchange (e.g. KRX) or the settlement entity (e.g. KSD) would share a permissioned distributed ledger with preauthorized representatives (e.g. traders) of member firms.

2. Buy and Sell orders would get sent to the exchange via permissioned distributed ledger transactions[32].
3. Trade order conditions embedded in the distributed ledger transactions would get met (matching, confirmation and asset/fund verification), trade would settle and final settlement would get executed[33].
4. Distributed ledger would then announce the final trade settlement to authorized members accessing the ledger.

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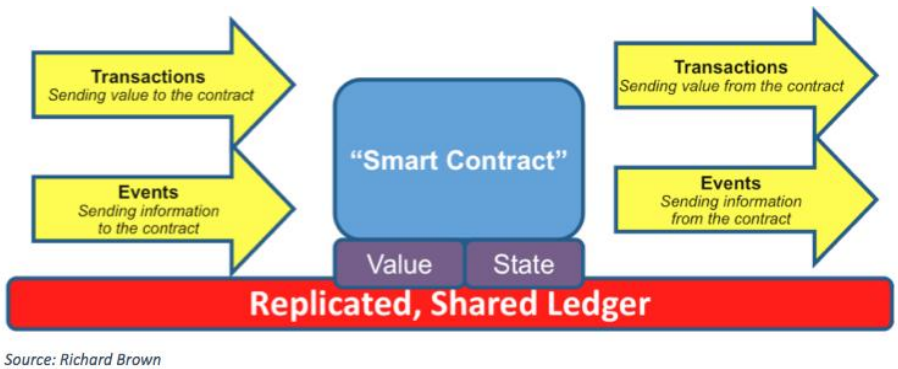
[32] Member firm's authorized trader would send in a buy order with the appropriate trade details (digital signature, settlement instructions, date of settlement, amount, security traded etc.) that would get included in the Blockchain transaction's meta data and its smart contract. Another member firm's authorized trader would send in a sell order with similar trade details needed for selling a security (this information would be embedded in the Blockchain transaction's meta data and its smart contract). Also embedded in the meta data of the buy and sell orders would be asset tokens (sell order) and fund tokens (buy order).

[33] Once the trade orders' conditions and trade details match on the ledger, the smart contracts associated with the respective buy and sell orders of the Blockchain transactions would self-execute. As the buy and sell order blockchain transactions would also carry asset and fund tokens from the respective trading parties (asset or fund value can be embedded in a blockchain transaction allowing for property or fund transfer), final settlement of transaction would occur at the same time as the self-execution of smart contracts. The final settlement would take place in a Delivery vs. Payment format (embedded asset and fund tokens would get exchanged (released to the other party) on the permissioned distributed ledger).

Figure 9: Illustration of trade execution using distributed ledger technology and smart contracts (R3CEV, 2015).



Blockchain technology application (permissioned distributed ledger technology) in post-trade settlements therefore brings forth following lucrative advantages:

- Reduced transaction costs and shorter trade life cycle:

  Since several steps in the post trade settlement step get significantly consolidated (matching, confirmation, verification, settlement confirmation, final settlement) or removed (obligation assumption); distributed ledger technology helps in significant transaction costs savings and reduced trade settlement periods. Also, currently members to KRX pay three different kinds of fees (trading fee, clearing and settlement fee, and access fee) based on transaction values and volume. By consolidating post-trade settlement processes using Blockchain technology, KRX and KSD trade participants can significantly reduce transaction fees associated with trade processing and settlements.

- Improved risk management and reduced margin/ collateral requirements: Since distributed ledger technology allows for instantaneous final settlement of a trade once trade conditions get met on the ledger, trading parties no longer have to worry about trade settlement delays or failure of payments. Additionally, because firms can have lower margin or collateral requirements given reduced counterparty failure risks, trading firms can benefit from new opportunities to further invest freed up capital (e.g. reallocate or invest freed up funds.)

- Improved reconciliation:
  As distributed ledger transactions are current and visible to all parties with authorized access, trading parties would look at the same trade details involved in a trade settlement. Also since the permissioned distributed ledger updates positions (asset and capital positions) once the smart contracts self execute and final settlement takes place, permissioned distributed ledger could allow trading firms to significantly cut down on reconciliation costs and time.

Figure: 10 Benefits from adoption of distributed ledger technology for trade settlement (Oliver Wyman and Euroclear, 2016).

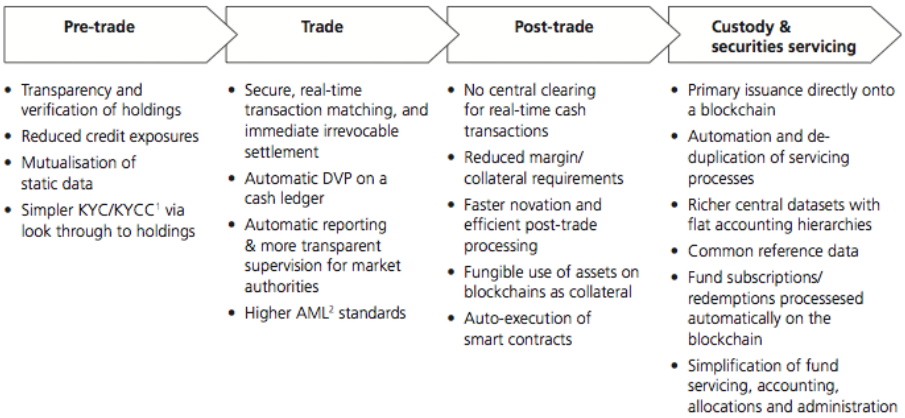


Figure 4 – benefits of adoption

[1] *KYC – Know Your Customer, KYCC – Know Your Customer's Customer*
[2] *AML – Anti-Money Laundering*

User cases:

Chain[34] is a start-up group that offers Blockchain technology based solutions to financial institutions. Several financial institutions including NASDAQ, Citigroup Inc., State Street and Visa have partnered with Chain to apply its Blockchain technology (Linq) solutions to various financial services in an effort to reduce operational inefficiencies (such as retiring legacy Mainframe systems) and to create new financial services (such as transfer of capital and assets over blockchains). On May 2, 2016, Chain in collaboration with NASDAQ successfully tested its Linq technology by demonstrating instant private trade transaction settlement (instant

[34] https://chain.com/showcase/

share settlement and debit-credit of digital dollar) on NASDAQ and Chain's permissioned distributed ledger (Bloomberg, 2016).

'SetL' is another blockchain-based startup that is making headway in the application of distributed ledger technology for post-trade settlements processes[35]. U.S.' Depository Trust & Clearing Corporation (DTCC) early this year (April 2016) announced the successful testing of credit default swaps (CDS) using a permissioned distributed ledger with four global firms (Bank of America Merrill Lynch, Citi, Credit Suisse and JP Morgan Chase) (DTCC, 2016). SetL recently partnered up with Computershare[36] in a joint initiative to establish securities ownership registers using Blockchain technology (Kelly, 2016).

Similar to NASDAQ, Australia Stock Exchange (ASX) (in working with Digital Assets Holdings group)[37] and Korea Stock Exchange (KRX) have also recently announced interest in investing in distributed ledger technology for near real time trade settlements. While ASX is interested in leveraging Blockchain technology for

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[35] https://setl.io/

[36] Computershare Limited is an Australian stock transfer company that provides corporate trust, stock transfer and employee share plan services in a number of different countries.(http://www.computershare.com/au)

[37] Financial Times, 2016 http://www.ft.com/fastft/2016/01/22/asx-to-test-blockchain-for-trade-settlement/

its equity trades settlements, KRX is interested in revamping its OTC trades settlements structure using distributed ledger technology (Nam, 2016).

Per Bank of Korea's 2013 report on payments, BOK and members of Korea's payment system have been considering building a new infrastructure for OTC derivatives market that would include a central counter-party clearing house (CCP) and trade repository (none exists for Korean OTC markets at present). Distributed ledger technology could be a possible solution for meeting Korean central bank's and its members' long-term OTC infrastructure goals.

(2) Payments services: Cross-border payments, remittances and corporate payments.

Current State:

Current structure of Korean domestic and international wires is similar to that of traditional international payments structures. When a Korean bank wants to make cross-border payments, it goes through domestic and international clearing-houses, and domestic and international foreign exchange banks. Between the end of day payment batch cutoffs and foreign exchange trade settlements, a wired payment takes approximately three to five business days to reach its destination (Bank of Korea, 2010).

Distributed Ledger Technology benefits:

Since distributed ledger technology is Internet based, and the asset (currency token) is embedded within the blockchain itself, from a purely technical standpoint, time taken for sending cross-border payments can be reduced to as little as ten minutes (Nakamoto, 2008) or even six seconds (see figures 11, 12 and 13).

Figure 11: Advantages of Ripple protocol for cross border payments (Ripple, 2015).

	Typical payment	Payment via Ripple
Reserves	Provided by bank	Provided by 3rd party
Compliance costs	Limited visibility = high costs	Full visibility = lower costs
Reconciliation	Manual	Automatic
Speed (cross-border)	2+ days to settle	5 seconds to settle
Speed (domestic)	Up to 2 days to settle	5 seconds to settle
Risk	Multiple failure points	Straight-through processing
FX	One FX provider	Competitive marketplace

Figure 12: Ripple solution for cross border payments (Ripple, 2015).

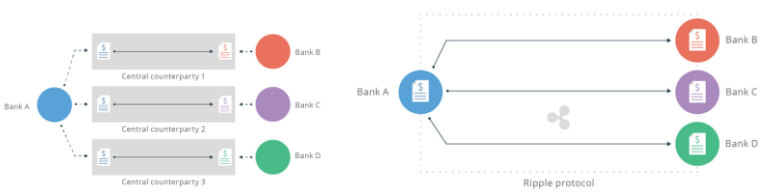
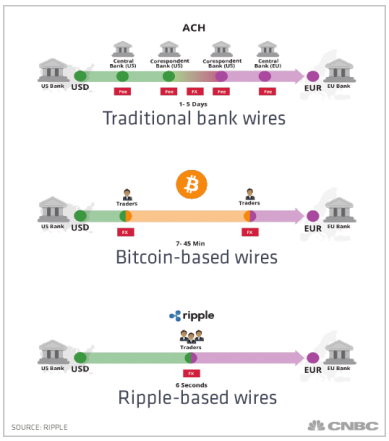


Figure 13: Comparison diagrams of cross border payment structures (CNBC, 2014).



While transaction time for cross border payments and remittance can be significantly reduced; several non-technical barriers remain to be addressed. For instance, legal and regulatory laws tied to foreign exchange payments and cross-border payments will need to be revisited. Additionally federal nod and approval from central banks towards the usage of distributed ledger technology will go a long way towards the implementation of faster (Blockchain based) cross border payments mechanism.

User cases:

In 2015, Citigroup announced creation of a digital token 'Citicoin', which it was testing in its research labs for blockchain based cross-border payments and remittances (Allison, 2015). Per Ken Moore (Head of Citi's Innovation labs), Citicoin can help to reduce counter-party risk from cross-border payments, reduce cash collateral requirements with smaller local banks and potentially perform

‘immediate’ FX transactions. Per Moore, Citigroup is testing Blockchain technology to penetrate markets with low presence of financial services such as Kenya[38]. In partnering with Safaricom (Kenya’s largest mobile operator), Citigroup has successfully tested mobile banking for Kenyan markets via Citicoin and mobile wallets.

JP Morgan Chase & Co. also recently tested distributed ledger technology on digital payments transfers between London and Tokyo for its 2,200 clients (Glazer, 2016). The firm is invested in further developing its ledger technology to realize cross-border payments efficiencies.

The Society for Worldwide Interbank Financial Telecommunication organization (SWIFT) is also seriously considering Blockchain technology. It recently launched a ‘Global Payments Innovation Initiative’ (GPI) through which it plans to enhance its cross-border messaging service by providing for same day use of funds, near to real-time end-to-end tracking of financial payments, transparency and predictability of fees, and transfer of rich payments information (SWIFT, 2016).

[38] While Kenya has 70-80% mobile penetration, only 40% of Kenyans hold bank accounts (Allison, 2015).

In Korea as well, Shinhan bank and Kookmin bank, in collaboration with Streami[39] (Jisong, 2015) and Coinplug[40] (NASDAQ (a), 2016) respectively, expressed interest in developing distributed ledger technology platforms for achieving efficient cross border payments system efficiencies.

(3) Monitoring, reporting and liquidity management

Current State:

Per regulations on financial oversights such as Bank of Korea Act (BOK Act[41]), the Financial Investment Services and Capital Markets Act (FSCM Act[42]) and the Electronic Financial Transactions Act (EFT Act[43]), Bank of Korea (BOK) is responsible for the smooth functioning of Korea's payments and settlements system (Bank of Korea, 2013). Currently BOK monitors payments systems' and market's activities in four ways: real-time monitoring, periodic monitoring, occasional monitoring and monitoring based on the systems concerned. Per BOK 2013 report, 'real-time' monitoring is carried out by observing payment and settlements systems operations and is based on information shared by systems

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[39] http://www.streami.co/

[40] https://www.coinplug.com/

[41] http://gbld.org/downloads/Korea/BK.pdf

[42] http://english.kca.go.kr/down/eng/laws/Financial_Investment_Services_and_Capital_Markets_Act.pdf

[43] http://www.moleg.go.kr/english/korLawEng;jsessionid=L37GUPKWnKPXXK5X1BWaX9JgYoGOROREdBtXoUCk1LbIWnQaHw8Y6hfsw31hSV8D?pstSeq=57381

operators. Periodical monitoring is also based on information made available by system operators and Occasional monitoring is conducted when unexpected circumstances or urgency arises.

Distributed Ledger Technology benefits:

The distributed ledger of Blockchain technology is a transparent record of *all* executed transactions, and it is held across the whole ledger network at any given time. Additionally, the ledger is always current as it automatically adjusts participating transacting members' positions (capital and asset) in near real-time based on executed trades. Finally as everyone with access to the ledger sees the same information (final settlements), there is little room for misinformation or human error in reporting. Thus based on current information available on the ledger, institutions like Bank of Korea can monitor market performance in near real time, and can generate performance and risk reports based on current positions reflected on the ledger. Having an understanding of close to real time market performance can also help institutions like Bank of Korea to respond faster to unexpected market events or liquidity shortages. Finally, as the ledger reflects participating member firms' current positions, entities like Bank of Korea can better manage its capital and collateral by reallocating or investing it.

Korean financial regulatory bodies can also benefit from Blockchain technology based financial markets as the technology will allow the government bodies to make better industry risk assessments, market forecasts and financial reports based on close to real-time trade data of participating member firms.

User cases:

Blockchain technology is still relatively new. As governments across the globe are still in the process of evaluating and testing the technology, a sample user case cannot yet be included. While the Estonian government, an early adopter of the technology, has been proactive in testing blockchain technology for handling its citizens data[44][45], it is still too early to conclude whether this experiment will be deemed successful.

Given above understanding of distributed ledger technology's *functional* benefits to Korean financial markets, opportunities for Blockchain application can be identified in the following financial market sectors:

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[44] http://ir.nasdaq.com/releasedetail.cfm?releaseid=954654

[45] https://govinsider.asia/innovation/estonia-using-blockchain-to-secure-health-records/

1. Money markets:

As the call market is used by Bank of Korea to smooth out excess or shortage of reserves, a permissioned distributed ledger that reflects money market transactions in real-time can be helpful to the central bank in gauging and adjusting market reserves faster. As noted in an earlier section, Bank of Korea uses repo transactions to adjust market liquidity. Trading members also use repo markets to address any excesses or shortages of short-term funds. A permissioned distributed ledger that provides Bank of Korea and authorized representatives of market participants with access to real-time repo market transactions can help both the bank and participants to make faster adjustments and financial trade investment decisions. Currently, both the call market and repo market go through Korean brokerage firms and intermediaries - Korea Money Brokerage Corporation, Seoul Money Brokerage Services, KIDB Money Brokerage Corporation and Korea Securities Depository. Digitalizing brokerage functions through smart contracts (transaction details matching, settlement, clearing, reconciliation, collateral management, risk assessment etc.) can help firms realize operational cost savings (such as brokerage fees and transaction costs), time efficiency and increased productivity.

As majority call trading today is uncollateralized, real-time information on counter-party's transaction activities and transaction history can help intermediate and transacting firms to make better trade decisions.

2. Capital market, Derivatives market and Bond market[46]:

Major operational savings for the capital markets and derivatives market can come from using a permissioned distributed ledger to enhance transaction processing, clearance and settlements trade functions. As a trade transmitted to the ledger gets broadcasted to the entire network, transaction processing and transmission time can be significantly reduced. Also since execution of the smart contract transaction leads to immediate settlement, reduced trade lifecycle (less than T+3) and cost savings can be realized. Further on, access to the ledger and ledger transparency allows all authorized transacting parties to see the same transaction detail. This feature can help in reducing reconciliation costs. Finally, this trait can also help transacting parties to make better investment decisions on collateral and margin requirements.

[46] To better understand blockchain application for capital and derivatives market, Sir Wilport's 2015 report (Wilport, 2015), R3CEV report (R3CEV, 2016) and Oliver Wyman & Euroclear report (Oliver Wyman and Euroclear, 2015) were referenced.

3. Foreign Exchange markets:

Korean foreign exchange markets can improve their payments processing and cross border remittances by leveraging permissioned distributed ledgers for cross border interbank payment activities. Permissioned distributed ledgers are capable of completing cross border payment transfers within a day and at very low transaction costs (Ripple solutions is capable of transmitting cross-border payments in 5 to 6 seconds at low transaction costs (Ripple, 2015)). Korean finance industry can thus improve its interbank cross-border payments structures and foreign exchange markets by taking advantage of the opportunities offered by distributed ledger technology.

CHALLENGES

Challenges in the application of blockchain technology for the Korean financial industry are as follows:

(1) Reliability, scalability, data integrity and data privacy concerns:

Blockchain technology is relatively new. In order to apply this technology on an industrial scale, it needs to have a capacity for handling trillions of transactions per day (currently, blockchain

scalability has been tested for a billion transactions)[47]. Additionally, prior to its mass integration in Korean financial markets, distributed ledger technology needs to be thoroughly tested for its robustness, security and data integrity. Also in order to safeguard data privacy for domestic and international firms transacting on distributed ledger platforms, Korea needs to meet international data privacy and security standards to handle international financial transactions. Information held on the permissioned distributed ledger is transparent to any user with access to the ledger system. Also as the ledger holds the entire transaction history on the network at any given time, a corrupt user can have access to the entire transaction history if security protocols get compromised. In the past, Korean banks have often been targets of cyber attacks that lead to data leakage (Choe, 2014). Higher standards of data security and privacy will therefore be crucial towards maintaining data integrity of financial market transactions and market participants (domestic and international). While transaction transparency is an important feature of the distributed ledger technology (from market participant and regulators' perspectives), a certain level of anonymity will also be needed (e.g. for market

[47] http://www.wsj.com/articles/bitcoins-blockchain-technology-proves-itself-in-wall-street-test-1460021421

participants to conduct high volume trade transactions anonymously). Therefore it will be crucial for Korean firms to appropriately address the needs of transparency and anonymity when applying distributed ledger technology to their financial markets.

(2) Operational risk from transition to the new platform:

A *smooth* transition from existing financial market infrastructure to one supported by Blockchain technology will be integral towards maintaining stable market conditions over the transitional period. Also it will be important to provide dual support services, BAU services (business as usual) and new Blockchain technology based financial services, to support existing and new market participants. The dual service framework will also help to support Korean firms that choose to not integrate the technology. Also as there is diversity in the operational functions supported by distributed ledger technology platforms and since different platforms have their own governance and coding standards; it will be important for Korean financial markets to choose a distributed ledger technology solution that meets the technology and Korean regulatory requirements of various supported financial services and products. Finally, the chosen distributed ledger technology solution will not only need to meet local

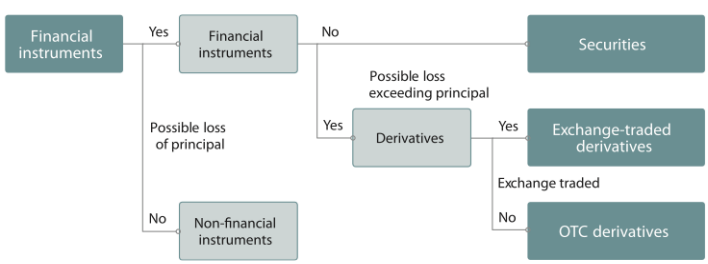
Korean standards for data integrity and governance, but also meet international market standards for the same.

(3) Regulatory readiness:

Thus far Korean government regulation has not kept pace with the advancement of Blockchain technology integration in Korean private sector (Chung, 2015 and Jisung, 2016). A regulatory framework will be needed to guide the development, integration and implementation of Blockchain technology in Korean financial markets. By providing a set of regulatory and legislative compliance standards, Korean government will be able to affect the development and application of the technology right from the design stage. For instance, current blockchain technology protocol (2.0) does not allow for reversal or tampering of transactions. However regulatory requirements may require reversal of transactions under certain circumstances (e.g. fraudulent transactions). Therefore having regulatory input from the beginning will help to enhance technology design to make it compatible with regulatory requirements. Besides the requirement for creation of a regulatory framework to guide Blockchain technology's development, revision and reinterpretation of existing Korean financial regulations and legislations will also be needed. For

instance, a financial product under Korean FSCMA law (KOFIA, 2014) is defined as 'any financial product with investment risk' and investment risk is defined as 'possible loss of principal'. Financial Instruments get treated based on existence of loss of principal risk (see figure 14; KOFIA, 2014). Under Blockchain technology, as principal and security are exchanged through final settlement transaction in near real time, investment risk associated with loss of principal is considerably low (almost non-existent as the transaction will not settle under a smart contract if the conditions for exchange of security and funds are not met). Therefore under a new blockchain technology based financial market infrastructure, key regulations, legislation and definitions may need to be revisited and revised.

Figure 14: Classification of (Korean) Financial Investment Instruments under FSCMA law (KOFIA, 2014).



(4) Cost assessment:

A cost assessment of opportunity costs and implementation costs will be crucial in taking a position on the potential application of Blockchain technology. Transitioning from existing financial market platforms to potentially blockchain technology based platforms is a huge undertaking for the financial markets. There will be significant time and money costs associated with testing and implementation of the new technology, replacement of impacted institutions, creation of new services, creation of new regulatory oversight bodies etc. On the other hand, as financial markets in the West (e.g. U.S., U.K and Estonia) and the East (e.g. Singapore, Japan and China) pursue Blockchain technology for their private sector; a serious consideration needs to be given to the opportunity costs associated with foregoing application of distributed ledger technology for the financial markets. Noting opportunity costs and cost savings, Bank of Korea recently made a recommendation to look into the distributed ledger technology in a report published earlier this year (Kim, 2016). Thus, a sustained interest in investigation, research and potential development of the distributed ledger technology, and engagement of Korean regulators, market participants and industry leaders will be crucial in making accurate cost assessments.

(5) Market Disruption:

As mentioned in the earlier section, distributed ledger technology is disruptive with potential for industry-wide impact. While the technology brings forth prospects of job creation for services not considered before, it also calls forth attention to concerns of human capital development and reallocation of unemployed resources. Addressing such concerns will be key in the development, application and long-term acceptance of Blockchain technology integration in Korean financial industries.

IV] POLICY SUGGESTIONS

Following policy recommendations can be suggested for the successful testing and potential application of blockchain technology for the Korean financial industry:

1. Taking an official position on distributed ledger technology:
   While Korean banks have announced plans to develop and apply Blockchain technology (LG in partnership with CoinStack, Shinhan bank in working with the Blockchain startup 'FuturesLab' and Samsung in partnership with IBM on ADEPT) (Our Next Block, 2016; IBM, 2015)); the Korean government is yet to take an official position on the potential integration or rejection of distributed ledger technology. Conducting an objective assessment while weighing in the costs and benefits of the technology will help the Korean government to either move ahead with development of this technology or pursue alternate solutions to bring Korean financial markets on par with market efficiencies being pursued by international markets.

2. Information sharing and consultation with industry experts:
   Engaging in global international forums on blockchain technology or consulting blockchain firms and Wall Street firms that are testing distributed ledger technology, will help Korean government move forward

on its distributed ledger technology assessment. While the Korean government is still investigating the technology, Korean firms such as Hana bank have already taken steps to seriously test distributed ledger technology (Chung, 2016). Moving forward on information sharing, consultation and collaboration with technology experts will help Korean government to develop solutions for enhancing efficiency in its Korean financial markets. Neighboring economies such as China have taken similar steps. China is now enroute to develop its blockchain ledger technology (ChinaLedger) based on guidance received from distributed ledger technology experts (NASDAQ (b), 2016).

3. Customizing distributed ledger technology for Korea:

   As different distributed ledger technology platforms address difference operational needs and regulatory requirements, Korea should choose a blockchain ledger solution that is suitable for the Korean financial and regulatory environment. Choosing the level of centralization and the operational functionality that the government would like to digitize, Korean government can choose from several different blockchain ledger technology platforms offered today (e.g. HyperLedger[48], R3CEV[49],

[48] https://www.hyperledger.org/
[49] http://r3cev.com/

Ripple[50] etc.) or even create its own ledger customized for the Korean financial market needs. When choosing the level of centralization for its distributed ledger technology solution, the Korean government should note that data security of the ledger technology is positively correlated with Internet nodes in operation (greater the number of ledger users, higher is the ability to catch an anomaly by other ledger accessing users). Therefore data security of the distributed ledger can be considered to increase with an increase in number of users with access to the ledger. Also when choosing industry standards to apply towards the distributed ledger technology, in terms of transaction scalability, data security and industry standardization, a global blockchain based solution may be more effective for the Korean financial markets.

4. Next steps:

   In an effort to address the application or rejection of distributed ledger technology, the Korean government can create a committee that (a) overlooks and ensures the research and assessment of blockchain technology (b) establishes a working group or forum comprising of representatives of market leaders, regulators, central bank and other

[50] https://ripple.com/solutions/

stakeholders to ensure all regulatory and economic concerns are accounted for (c) establishes a working group dedicated to research solutions for addressing disruptive effects from blockchain technology (d) interacts with central banks, regulatory bodies, financial market leaders in the West and East to understand how similar issues are being resolved by their respective governing bodies and market participants.

APPENDIX

1. Oliver Wyman and Euroclear, 2016.

a) Simplified view of distributed ledger approach.

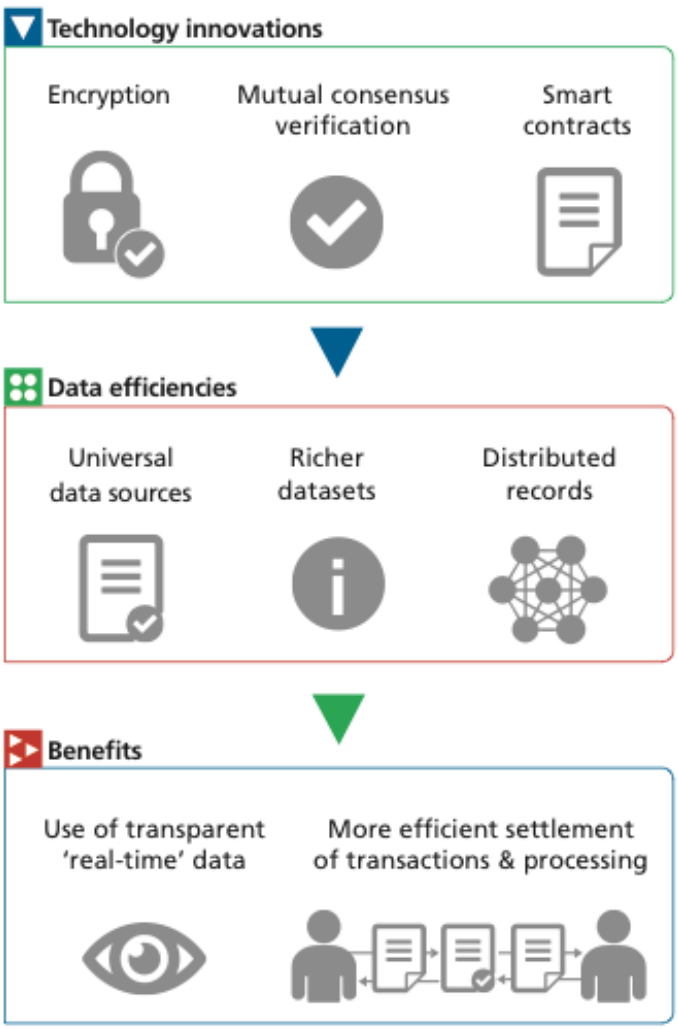


Figure 1: Simplified view of Distributed Ledger approach

b) Use cases for application of blockchain technology in financial markets

Type	Use case	Capital markets examples	Other industry examples	Rationale for adoption
First order adoption – works as standalone	• Tokenising assets not currently on a common ledger (new blockchains or tokens on Bitcoin)	• Pre-IPO equities • Syndicated loans • Depository receipts	• Physical objects e.g. diamonds, paintings	• Proof of ownership/ provenance • Settlement efficiency
	• New blockchains to share data between participants	• KYC data sharing • Collateral ledger to support efficient margining • Reference and market data	• Supply chain data invoicing • Trade finance	• Efficiency of information collection
	• New blockchains to process transactions	• Corporate finance bookrunning • Fund portfolio management	• Inter-bank blockchain to support cross-border banking payments • Intra-bank blockchain to support cross-bank accounting	• Disintermediation of actors • Simplified data and infrastructure
Second order adoption – reliant upon critical mass of assets on blockchains	• Monitoring of richer datasets	• Concentration monitoring • Market surveillance • Pricing data	• Trade flows, transit data	• Powerful understanding of data
	• Processing using blockchains	• Securities servicing • Regulatory reporting		• Efficient processing capabilities

Innovation type	Lead innovators	System created	Adoption path
Challengers	• Fintechs • Competitors from other parts of the value chain	• Competing with the existing system	• Customer by customer
Collaboration	• Existing participants, market infrastructures • Industry consortia	• Parallel to the existing system	• Firm by firm based on each individual's economic interests
Mandated policy	• Policy makers	• Replacements to the existing system	• System-wide (or by sub-segments) • Mandated by policymakers or regulators

Figure 6 – adoption paths

2) Evry Labs, 2015.

a) Generalized view of blockchain transaction.

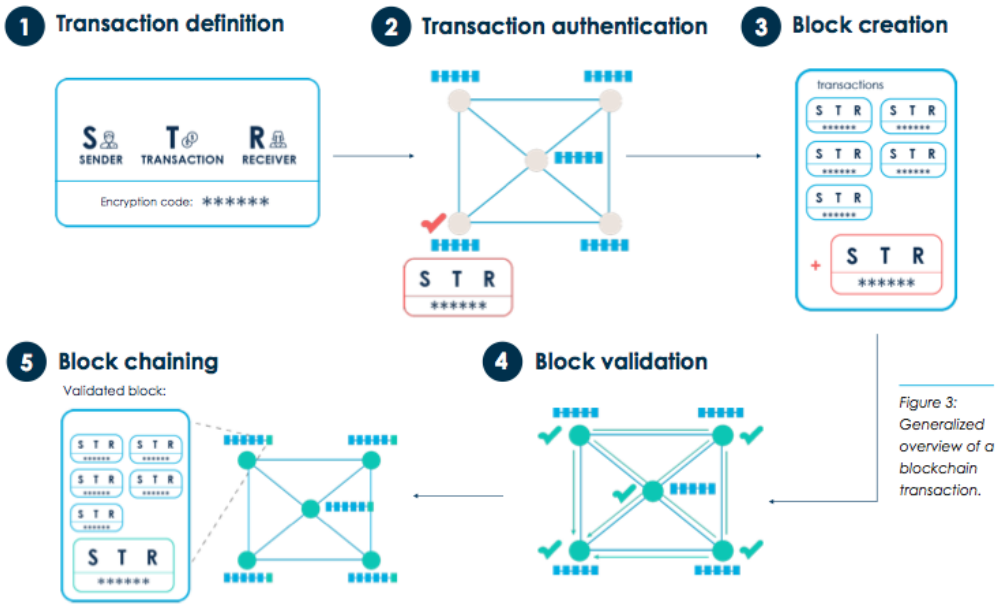
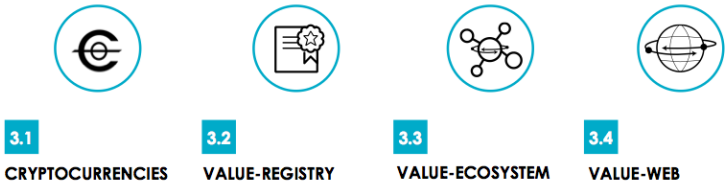


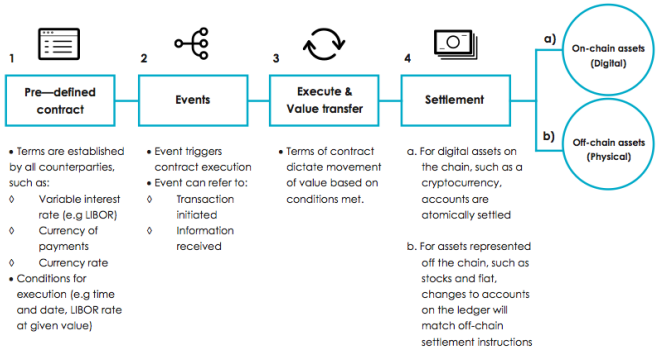
Figure 3: Generalized overview of a blockchain transaction.

b) Future applications for blockchain technology:



c) 5 user cases

d) Transaction settlement using Smart Contract.



d) Visualization of Ripple's international payments solution.

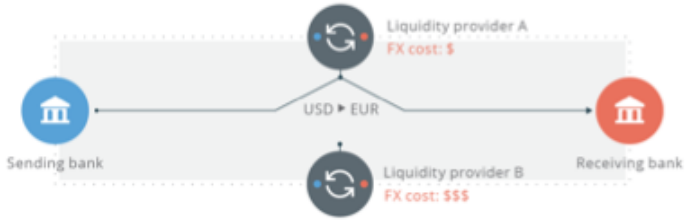
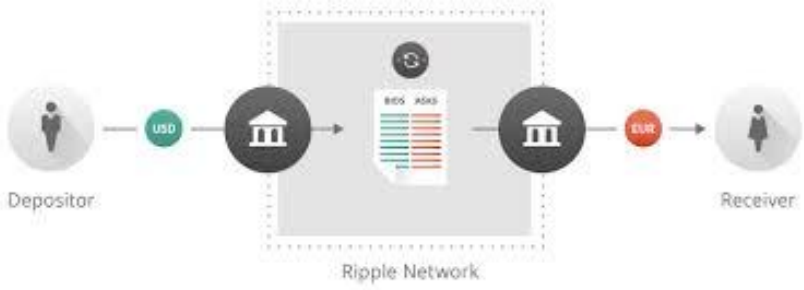
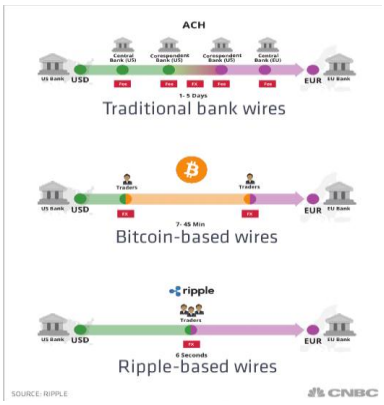


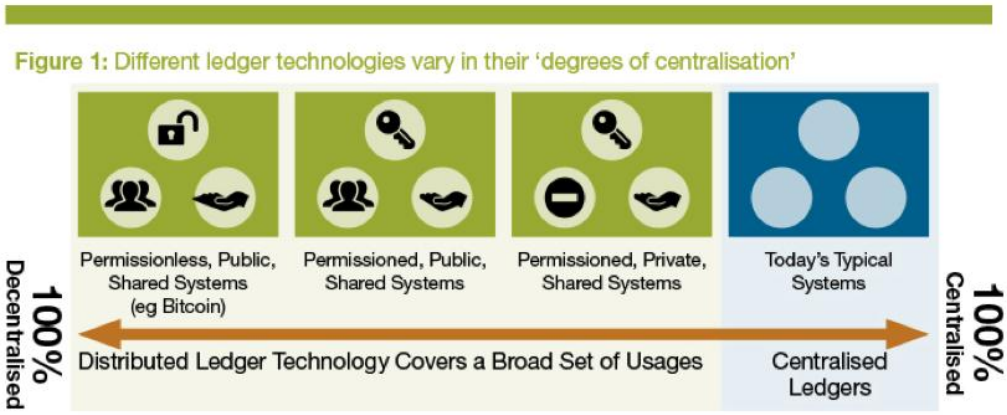
Figure 9: Visualization of Ripple international payments solution, where an US bank transmits to a bank in EU. The Ripple network automatically chooses the market maker with the best USD->EUR conversion rate





3) Walport, 2016.

a) Different Ledger technologies with varies levels of centralization.



4) World Bank, 2015.

a) Overview of how Bitcoin creates and updates a distributed public ledger.

Table 1. Overview of how Bitcoin creates and updates a distributed public ledger

START – Bitcoin wallet A proposes the transfer of Bitcoin to another wallet B
2 – The Bitcoin "mesh" network checks the distributed public ledger that sufficient Bitcoin exists in wallet A
3 - If there is sufficient Bitcoin, specialized nodes called miners will bundle the proposal with other reputable transactions to create a new block for the Blockchain
4 – The blocks are cryptographically "hashed"
5 - That hash is put, along with some other data (e.g., a nonce), into the header of the proposed block
6 - This header then becomes the basis for the "proof of work" performed by the "miner" nodes on the Bitcoin network
7 - When a miner arrives at a solution, other nodes check it and then each node that confirms the solution updates the Blockchain with the hash of the header of the proposed block. This becomes the new block's identifying string, now part of the distributed ledger in the Blockchain.
END – Wallet A's payment to Wallet B's transaction, and all the other transactions the block contains, are confirmed

b) FACTOM solution for Honduras Land Registry.

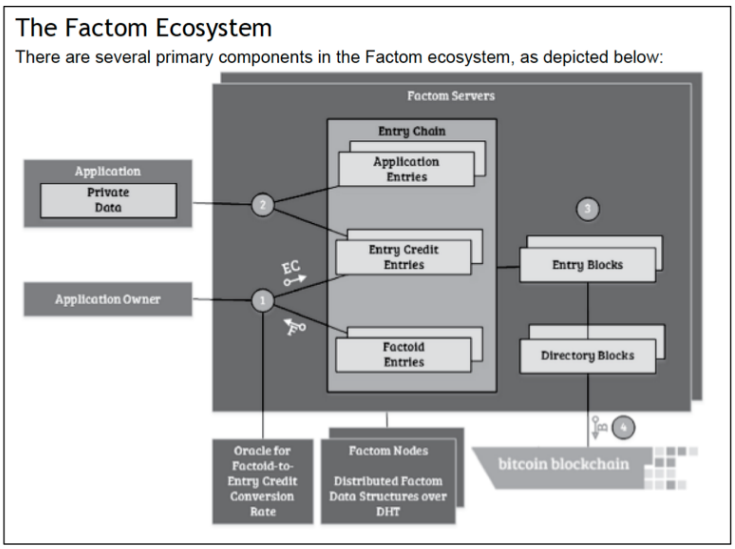


Figure 5. The Factom Ecosystem [Source: Snow et al 2014]

5) Payment Systems in Korea, October 2010 (Bank of Korea, 2010)

a) Summary of Securities Settlement system in Korea.

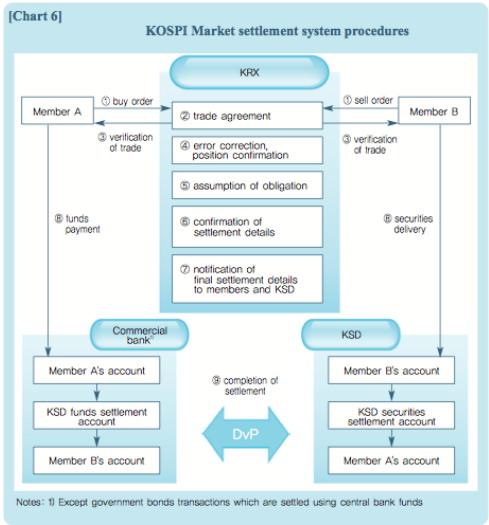
[Chart 5]

Summary of securites settlement systems in Korea

Market	Securities	Clearing	Settlement		
			Securities	DVP	Funds
KOSPI/ KOSDAQ/ Derivatives market	GBs[1], Repos	KRX	KSD	DVP 3	BOK
	Stocks, Bonds[2]				Commercial Banks
	Options, Futures				
OTC market	Stocks[3]	KSD	KSD	DVP 3	BOK
	Bonds CDs, CP			DVP 1	
	Repos				

Notes: 1) Government bonds
2) General bonds including corporate and small-value government bonds
3) Stocks traded between KRX members and institutional investors

b) KOSPI Market Settlement Procedure



6) R3CEV, 2015

a) Projections of long term Bitcoin Blockchain transaction fees.

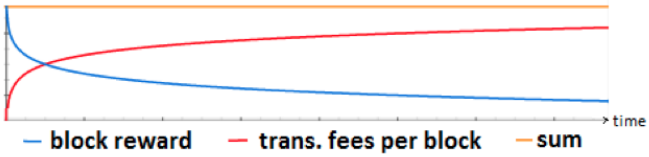


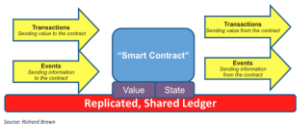
Image credit: Kerem Kaskaloglu

b) Different blockchain ledger technology groupings.

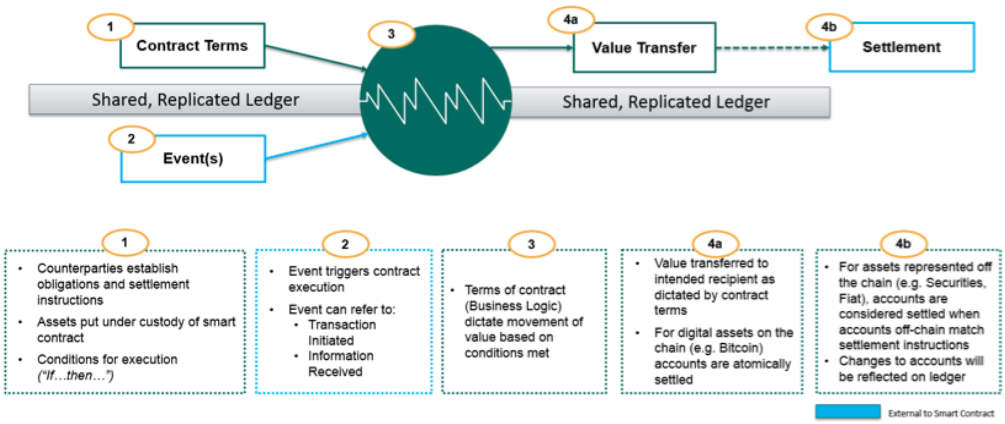
		Who do I trust to maintain a truthful record?			
		A central authority	A group of known actors	A group of actors, some known	Nobody
What is the universe of "things" I need people to agree on?	Ownership of on-platform assets	Central Bank, Commercial Bank		Ripple (XRP)	Bitcoin
	Ownership of off-platform assets	Custodian Bank	Hyperledger	Ripple (Gateways)	Colored Coins, Counterparty
	Obligations and rights arising from an agreement	Clearing House	Eris	Ripple (Codius)	Ethereum

Source: Richard Brown

c) Simple view of a transaction sent through a blockchain.

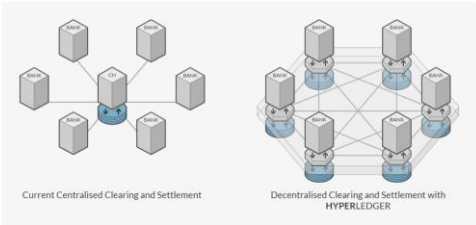


d) R3CEV solution



Source: Jo Lang / R3 CEV

e) HyperLedger solution



f) Ripple solution

g) Comparison chart of various blockchain technology solutions.

Table 1: Distributed ledgers with *permissioned* validators

	Ledgers with an internal token	Ledgers without an internal token
Ledgers based on Ripple	Ripple (XRP) Tillit	Tembusu
Ledgers based on Hyperledger		Hyperledger (PBFT)
Ledgers based on a Bitcoin-like blockchain	CryptoCorp (fork of Bitcoin, based on a colored coin implementation)	
Ledgers based on an Ethereum-like blockchain	Eris (with "Junk")	Eris (without "Junk") Clearmatics (see EU Electronic Money Directive)
Ledgers based on a Tezos-like Blockchain	Tezos (consensus agnostic)	Tezos (consensus agnostic)

7) "Decentralizing Privacy: Using Blockchain to Protect Personal Data" by Guy Zyskind MIT Media Lab, Alex 'Sandy' Pentland MIT Media Lab and Oz Nathan Tel-Aviv University.

a) MIT proposed solutions for improving data privacy.

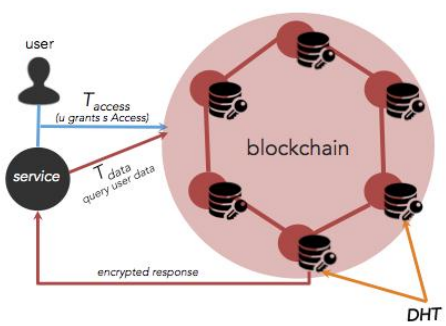
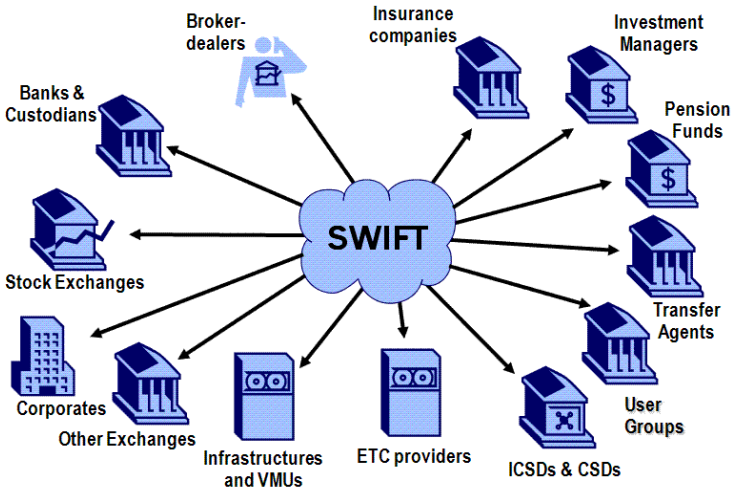


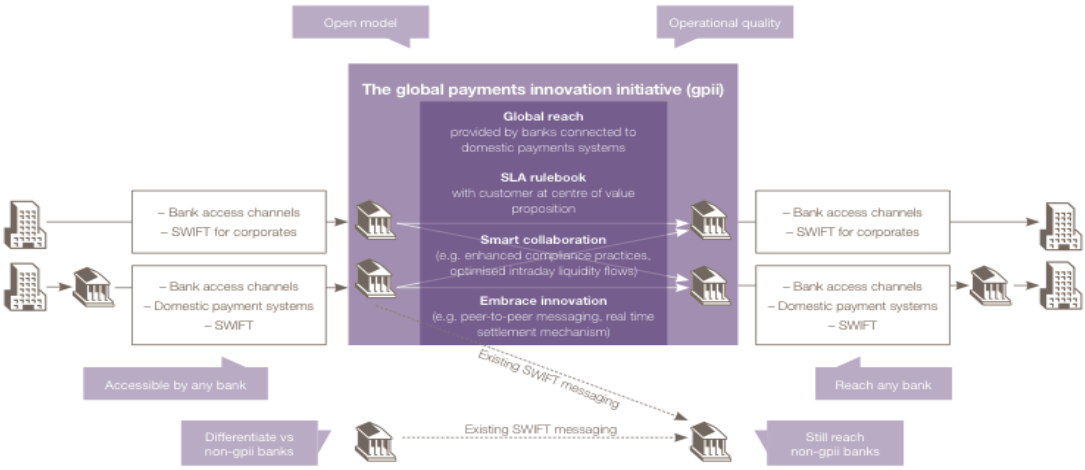
Fig. 1. Overview of the decentralized platform.

8) **SWIFT, 2016. Global Payments Innovation Initiative**

a) Current state



b) Global Payments Innovation Initiative (Future State)



The global payments innovation initiative (gpii)

9) Euro Bankking Association, 2014.

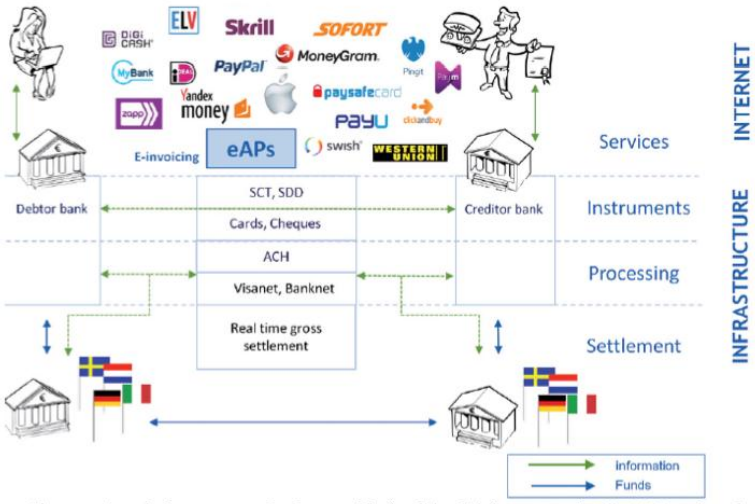


Figure 4.2 A stacked ecosystem evolved on top of the "traditional" infrastructure for SCT, SDD, cards and cheques. Source: EBA (2014)

10) CoinGecko, 2015.

Comparison of payment through Bitcoin vs. WesternUnion

	Bitpesa	Western Union
Amount sent	USD 100	USD 100
Amount received	KES 8,966	KES 8,953.15
Fees	3% margin on the BTC to KES exchange rate	From credit/debit card to receiver's mobile wallet: USD7 transfer fee) From bank account to cash at agent location: USD5
Transfer time	Within minutes to mobile wallet	From credit/debit card to receiver's mobile wallet: in minutes From bank account to cash at agent location: 3 days

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