

**FEASIBILITY OF DISTRIBUTED LEDGER TECHNOLOGY AND
BLOCKCHAIN IN THE FINNISH SECURITIES INDUSTRY**



Master's thesis

Visamäki Business Management and Entrepreneurship

Spring 2020

Panu Kettunen

TABLE OF CONTENTS

1	INTRODUCTION	1
1.1	Research objective	2
1.2	Research background	2
2	KEY CONCEPTS	4
2.1	Distributed Ledger	5
2.2	Blockchain	6
2.3	Accessibility and roles Distributed Ledger	11
2.4	Smart Contract	13
3	SECURITIES INDUSTRY PUBLICATIONS	14
3.1	Euroclear and Oliver Wyman Joint Report.....	14
3.2	Paper on DLT by Euroclear and Slaughter and May.....	16
3.3	The ESMA discussion paper	18
3.4	BIS report of DLT arrangements.....	20
3.5	DLT and blockchain Working Paper by The World Bank Group.....	23
3.6	R3 Corda Blockchain platform.....	25
3.7	European Central Bank's Paper on DLT in securities post-trading	27
3.8	DLT discussion paper of Committee on Capital Markets Regulation	27
3.9	Additional publications	28
3.10	Blockchain in funds	30
4	QUALITATIVE RESEARCH.....	31
4.1	Research approach, design and methods	31
4.2	Research quality	33
4.3	Research process and selection of interviewees	34
4.4	Interview results.....	35
4.4.1	Expert interview 1	35
4.4.2	Expert interview 2	38
4.4.3	Expert interview 3	40
4.4.4	Expert interview 4	42
4.4.5	Expert interview 5	45
5	RESEARCH FINDINGS	47
6	CONCLUSION	49
	LIST OF REFERENCES.....	50

Degree Programme in Business Management and Entrepreneurship
Visamäki

Author	Panu Kettunen	Year 2020
Subject	Feasibility of Distributed Ledger Technology and Blockchain in the Finnish Securities Industry	
Supervisors	Mikko Mäntyneva	

ABSTRACT

Tämän tutkimuksen tavoitteena oli selvittää lohkoketjuteknologian ja hajautettujen tilikirjojen soveltuvuutta arvo-osuuksien käsittelyyn. Lohkoketjuteknologia on saanut verrattain paljon huomioita lähinnä kryptovaluuttojen vuoksi, ja sen on arvioitu muuttavan finanssialaa tulevaisuudessa. Tutkimus keskittyi ensisijaisesti selvittämään, onko lohkoketjuteknologialla aidosti disruptiivisia ominaisuuksia, jotta se voisi muuttaa arvopaperikeskusten, keskusvastapuolten ja säilyttäjäpankkien roolia tulevaisuudessa. Täytyykö lohkoketjun olla suunniteltu juuri tietynlaiseksi, jotta sitä voitaisiin hyödyntää arvo-osuuksien käsittelyssä. Lisäksi tutkimus pyrki löytämään syitä siihen, miksi lohkoketjuteknologian ja hajautettujen tilikirjojen käyttö ei ole yleistynyt sen luvatuista hyödyistä ja mainituista perusominaisuudesta huolimatta.

Tutkimuksessa pyrittiin selvittämään, voitaisiinko hajautetulla tilikirjoilla vähentää arvopapereiden säilytykseen ja selvitykseen liittyviä riskejä, kuten selvitys-, likviditeetti- tai säilytysketjun riskejä. Lisäksi tutkimuksessa pyrittiin selvittämään, voisiko lohkoketjupohjaiset selvitys- ja säilytysjärjestelmät lisätä omaisuuden suojaa, tietosuoja, sekä lisätä läpinäkyvyyttä liikkeeseenlaskijoille, loppusijoittajille ja valvojille. Tutkimus toteutettiin puolistrukturoituina asiantuntijahaastatteluina.

Tutkimustulokset viittaavat siihen, että lohkoketjuteknologia ja hajautetut tilikirjat eivät tällä hetkellä sovellu laajamittaisesti arvopapereiden säilytykseen ja selvitykseen. Tosin, toimiala näkee mahdollisuuksia lohkoketjuteknologian soveltamiseen esim. fyysisten arvopapereiden, kuten osakeyhtiöiden osakkeiden käsittelyssä. Lohkoketjuteknologian luvatut hyödyt eivät ole toteutuneet, osittain investointien vähyyden vuoksi. Myös nykyisten järjestelmien todellisten ongelmien vähäinen määrä, sekä uuden teknologian tuomat mahdolliset hyödyt ovat osaltaan vähentäneet sen kiinnostusta toimialalla.

Keywords lohkoketju, lohkoketjuteknologia, DLT-teknologia, arvopaperikeskus, arvo-osuus

Pages 56 pages including appendices 2 pages

Degree Programme in Business Management and Entrepreneurship
Visamäki

Author	Panu Kettunen	Year 2020
Subject	Feasibility of Distributed Ledger Technology and Blockchain in the Finnish Securities Industry	
Supervisors	Mikko Mäntyneva	

ABSTRACT

The aim of the research was to investigate the feasibility of the blockchain technology and distributed ledgers in the securities industry. The blockchain technology has received much attention, mainly due to cryptocurrencies, and is expected to form the financial sector in the future. The study focused primarily on determining whether blockchain technology has genuinely disruptive elements, consequently changing the roles of the CSDs, the CCPs and the custodian banks going forward. Does the blockchain need to be designed in a specific way for it to be utilised in the securities processing. Additionally, the research aimed to understand why the blockchain technology and DLT-based solutions have not become more popular despite promised benefits and the fundamental characteristics of the technology.

The research aimed at determining whether distributed ledgers could reduce the risks associated with the safekeeping and settlement of securities, such as settlement risk, liquidity risk or risks of the custody chain. Additionally, the research pursued to define whether blockchain-based settlement and custody systems could increase asset protection, data protection, and increase transparency for issuers, end-investors, and authorities. The research was conducted as semi-structured expert interviews.

The research results suggest that the blockchain technology and distributed ledgers are not currently feasible for safekeeping and settlement of securities in larger scale. On the other hand, the industry sees opportunities to apply blockchain technology in the processing of physical securities, such as for non-listed companies' shares. The promised benefits of the blockchain technology have not materialised, partly due to the lack of investments.

Keywords blockchain, blockchain technology, distributed ledger technology, central securities depository, book-entry/dematerialised security
Pages 56 pages including appendices 2 pages

LIST OF ADDITIONAL KEYWORDS

Blockchain technology
Distributed Ledger
Distributed Ledger Technology
Distributed Ledger database
Decentralised database
Public blockchain
Private blockchain
Permissioned blockchain
Permissionless blockchain
Smart Contract
Direct holding model
Multitier or multilayer holding model
Entitlement
Beneficial owner or beneficiary
Central Securities Depository
Central Securities Depositories Regulation
Target 2 Securities
Anti-Money Laundering
Cryptocurrency
Fiat currency

LIST OF ABBREVIATIONS

DL	Distributed Ledger
DLT	Distributed Ledger Technology
CSD	Central Securities Depository
MIFID 2	Markets in Financial Instruments 2
EU	European Union
GDPR	General Data Protection Regulation
KYC	Know Your Customer
P2P	Peer-to-peer
AI	Artificial Intelligence
IoT	Internet of Things
CSDR	Central Securities Depositories Regulation
T2S	Target 2 Securities
DVP	Delivery versus payment
ESMA	European Securities and Markets Authority
FMI	Financial Market Infrastructure

1 INTRODUCTION

The blockchain technology is somewhat new phenomenon. However, it has already been largely discussed and disputed in our economies across the countries. The cryptocurrencies underpinned by the blockchain technology have disrupted the central banks' official currency mechanisms to some extent. When discussing blockchain technology, many of us know virtual currencies such as Bitcoin, Ethereum and Ripple. Occasionally, people mistakenly think that blockchain is all about cryptocurrencies. Despite all the criticism, the blockchain technology is successfully used in various businesses and contexts, not merely in the field of virtual currencies.

The blockchain is one type of a distributed ledger and the blockchain technology is regarded as part of a distributed ledger technology or as abbreviated DLT. A distributed ledger is a property database that can be distributed on a network basis among different actors, thereby each operator has a similar copy of the ledger. However, the two terms, blockchain and distributed ledger should not be mixed with each other, since distributed ledger solutions can also be implemented without utilising the blockchain technology.

Many industries have already investigated the possibilities of the distributed ledger technology. Distributed ledger technology could fundamentally change the financial sector or make it more efficient, resilient and reliable. Not necessarily the front-runners will benefit the most. Blockchain technology as a buzzword can only deliver short-term gains to businesses. However, organisations cannot afford to disregard the newish technology. Potentially, it could shape our economies years to come. DLT applications can replace some of the processes and functions that still require manual intervention or are inefficient. Ultimately, DLT solutions could increase efficiency and lower remittance costs, and potentially improve access to finance for those individuals, who are currently outside the traditional financial system.

Blockchain-based DLT, was initially applied in the cryptocurrency called Bitcoin. The concept of blockchain technology was invented by two scientist researchers, Stuart Haber and W. Scott Stornetta in 1991. They described a concept of cryptographically secured chain of blocks, whereby no one could modify with timestamps of saved documents. In 2008, an individual or group of people, named Satoshi Nakamoto, outlined the mechanics of Bitcoin. Bitcoin was a new cryptocurrency, working on the peer-to-peer basis. In the Bitcoin application facilitates online transfers, that can be sent from one node to another node without trusted third party. The Bitcoin solution is a combination of various technologies that

first verify transactions and then add these into a block. The block i.e. batch of transactions, is then appended to a chain that consists of a history of transactions. The block then follows a set of procedures and protocols. The new and created block is then transferred to the network of nodes, so that the nodes can agree upon the creation of the new blockchain, and update their copies of the ledger. The agreement process, in other words, consensus process, means linking of the most recent block cryptographically to the previous block in the same blockchain by keeping the integrity of the ledger. In other words, the ledger maintains always a history of all transactions. However, it is good to understand, that the blockchain is only one type of distributed ledger, thus not all distributed ledgers utilise blocks or chain transactions. (Nakamoto 2008.)

1.1 Research objective

Current infrastructures in the securities industry have some inefficiencies, lack transparency to all stakeholders such as issuer companies, shareholders and authorities, contain operational risks, settlement and liquidity risk due to latency and manual intervention in recordkeeping, intermediary risk etc. Distributed ledger technology and blockchain technology have some fundamental features in their essence that could potentially solve these problems. However, there are still limited number of studies available that examine this phenomenon. Furthermore, use cases, real-life implementations and market level discussions are not that common.

This master's thesis aims to understand distributed ledger technology and its feasibility for the Finnish securities industry sector. The objective of the research was to observe, how could the distributed ledger solutions underpinned by the blockchain technology be utilised in the Finnish safekeeping and custody i.e. post-trade environment, and could the technology enhance the functions rendered by the parties involved. The thesis aims to find out when a centralised register is more feasible than the distributed ledger and vice versa. It aims to outline restrictions and barriers that prevent utilising the technology in more wider contexts. Additionally, the thesis aims to describe the fundamental benefits of using the distributed ledgers in the financial services sector.

1.2 Research background

Many researchers claim that it is inevitable that blockchain as a technology will increase the reliability, transparency and efficiency. Some traditional businesses also argue that anonymity and misuse of the current innovation proves that the technology cannot be used in the wider scope.

Currently the entitlements of asset classes are recorded in the electronic format, or in the dematerialised form, or in non-physical form, all three of being nearly synonyms for each other. The industry norm is that the data regarding companies' shares i.e. stocks is stored nationally in one centralised register, which are called Central Securities Depositories i.e. CSDs. The company's shares are in dematerialised form, in the form of book-entries that are also known as securities. In Finland, the public limited companies' shares must always be issued, according to the Limited Liability Companies Act, in the dematerialised form. However, not all the asset classes are stored in these CSDs. For instance, the fund unit holder register, and the related transaction data are normally stored at the fund company managing the fund.

EU-directives, regulations, and the national legislation, set numerous obligations and restrictions to the whole financial services sector. Due to several incidents in the past decade, e.g. Lehman Brothers' bankruptcy in 2008, leakage of Panama Papers in 2016, Danske Bank's money laundering scandal in 2017, tax fraud cases in Denmark and Germany etc., the banks are e.g. obliged to gather more detailed information about their clients. The banks must classify their clients based on their understanding of investment products and financial status. This specific process is called Know Your Customer or Client or simply just KYC. Needless to say, KYC data, or any data, must be stored securely.

The EU-directive, Markets in Financial Instruments 2 (MiFID 2) has increased transparency in many ways. One of the requirements of MiFID2 is that service providers must unbundle their pricing model. In Finland, we have so called direct holding model, whereby investor-specific accounts are kept in the investors' names on the level of the CSD. This is a mandatory requirement for the Finnish citizens, legal entities and institutions, owning the Finnish company's shares. Euroclear Finland is the only central securities depository and a settlement organisation in Finland. The assets and identities of ultimate beneficial owners are publicly available to the Finnish Tax Administration and to general public, ensuring transparency. However, in Finland the nominee registration is also possible, and very much a market norm for foreign investors. The CSD systems in most EU member states, are based on nominee registration and enable indirect ownership.

Essentially, the aim of these directives and regulations is to maintain the integrity of the data, and to secure the value of underlying assets. The same data is stored in many various places. For instance, to comply with GDPR, General Data Protection Regulation, the service providers must ensure that the client data is protected and is not used for any other purpose than it has been obtained for. The fragmentation of the data in the current business environment is administratively burdensome and even challenging. Furthermore, the stock exchanges i.e. marketplaces must gather more data in advance. For instance, since 2018 stock

exchanges, have been obliged to gather more information regarding the nature of the trade. Hence the Legal Entity Identifier, LEI, is always required in financial transactions across the financial sector. Additionally, Central Securities Depositories Regulation i.e. CSDR is partly implemented by the EU-countries, pursuing to increase the asset safety and the settlement efficiency of securities transactions, and to harmonise infrastructures between EU-countries. Furthermore, the regulators are in favour of more transparent operating models, as presented in e.g. in the G20 High Level Principles of Beneficial Ownership Transparency published in 2014. (The World Bank Group and UNODC 2014)

Authorities in the EU-countries e.g. tax authorities, request for more detailed information concerning the true beneficial owner of the security or entitlement. Shareholder's Rights Directive II, pursues to obtain more information about the shareholders that are not disclosed to the issuer company, due to nominee registration of the security. The CSDs do not always explicitly record keep the entitlement owner or shareholder in their registers, hence additional record keeping is needed. There can be multiple intermediaries involved, in one specific transaction, which can make it challenging for authorities and issuer companies to obtain the information deemed necessary e.g. to comply with the tax laws. Investors invest globally, hence facilitating information interaction between authorities is necessary to maintain and built the trust to the financial sector.

2 KEY CONCEPTS

The purpose of theories is to explain and interpret a certain phenomenon, and in many cases, expand the existing understanding and knowledge, within the limitations of the basic hypotheses. The theoretical framework is a structure that keeps the hypothesis of the study. The theoretical framework also outlines the hypothesis and explains the research question(s). A theoretical framework consists of the current theory that is used for a particular study, together with interpretations and references to the applicable literature. Furthermore, the theoretical framework should show an understanding of presented theories and principles applicable, and how these are linked to a wider knowledge area being considered. (Cherry 2020.)

Often the theoretical framework is not identified easily within the existing literature. The researcher must review many sources such as lectures of the topic and the relevant research studies for theories, as well as analytical models that are relevant to the research problem at hand. The selection of the theory depends on its feasibility and is the theory explanatory. In social sciences a good theory should satisfy its main purposes, that are the essence, the meaning and the complexity of the

phenomenon in the focus. The knowledge and understanding entailing from the theory can then be used to behave in a more rational manner when the unknown phenomenon is encountered. (Cherry 2020.)

In this thesis the theoretical and conceptual framework primarily consist of white papers composed by the relevant industry influencers in the securities industry, news articles from global sources, studies and theses composed about this topic. However, the scholarly literature available is quite limited. The publications are supported by well-known consulting firms and intermediaries playing an essential role in the securities industry. Most commonly used keywords when collecting data were: blockchain, distributed ledger, blockchain technology, distributed ledger technology, dematerialised security and the CSD. The most recent publications received higher focus.

2.1 Distributed Ledger

Distributed Ledger Technology refers to the technological infrastructure and protocols allowing simultaneous validation, access and record updating in an immutable way in a network across multiple entities or locations. A distributed ledger eliminates the need for central authority. It can also be regarded as a ledger with many transactions or contracts held in a decentralised form across various locations. The information is stored in a distributed ledger securely and exactly by using cryptography. The data in the distributed ledger can be accessed by using keys and cryptographic signatures. (Majaski 2019.)

A distributed ledger technology or simply DLT, is also known as a shared ledger technology, is a consensus of copied, shared, and synchronised data, processed digitally. The data can be spread geographically across multiple institutions, sites and countries. Essentially, there is neither central administrator nor is the data stored in one place. In order to ensure the replication across nodes, it is necessary to have a peer-to-peer network that contains consensus algorithms. A node is an electronic device that is connected to a network and is capable of handling information over a communication channel in question. One form of distributed ledger design is the blockchain system, which can be either public or private. (UK Government 2016.)

Distributed ledger technology can be regarded as a digital system wherein the transactions of assets, and the details are recorded in multiple locations simultaneously. Contrary to the traditional databases, distributed ledgers do not have central data storage or administration functionality. (Rouse 2017.)

The distributed ledger can also be understood as a database which is spread across several nodes on a peer-to-peer network, where each node replicates and saves an identical copy of the ledger independently, hence

the data is shared and synchronised across multiple sites, institutions or geographies. It has been said that the lack of central authority is the main advantage of the distributed ledger. Once an update occurs in the ledger, each node creates a new transaction, and then the nodes of the network vote by pre-programmed consensus algorithm on which copy is the correct one. The participant of the network i.e. node can access the records that are shared in the network, hence has an identical copy of these records. Once a consensus has been defined and determined, the other nodes update their records with a new and an accurate copy of the ledger. The security and integrity of the data is achieved via cryptographic keys and digital signatures. (UK Government 2016.)

Distributed ledgers may be permissioned e.g. hyperledgers or permissionless e.g. Bitcoin, or public or private. Depending on the type of the distributed ledger, anyone or only approved participant can run a node to validate recorded transactions. Distributed ledgers have different consensus algorithms. In practice, these algorithms are proof of work, stake, authority, or other voting logic that is built in to each distributed ledger. Furthermore, the ledger can be mineable e.g. cryptocurrency Bitcoin, meaning that one can claim the ownership of new entitlement contributing with a node, or contrary to mineable the ledger is not mineable. In the non-Blockchain DLTs there can be the architecture on which private or public data is stored or shared. The main difference is that while blockchain requires global consensus across all nodes a DLT can achieve consensus without having to validate the data across all nodes. (UK Government 2016.)

2.2 Blockchain

As mentioned in the introduction, the blockchain is one type of a distributed ledger. All blockchains are regarded to be a form of distributed ledger technology. However, there are also distributed ledgers that are not regarded blockchain. Firstly, blockchains are generally public and permissionless, whereas, a distributed ledger generally does not enable most of these public features. (Chandler 2019.) A blockchain consists of a sequence of blocks, whereas distributed ledger does not need such a sequence. Furthermore, blockchain requires consensus across all nodes in the network, whereas DLT can achieve consensus without having to validate the data across the entire blockchain. (Belin n.d.)

Figure 1 outlines the relationship between blockchain and DLT is being illustrated.

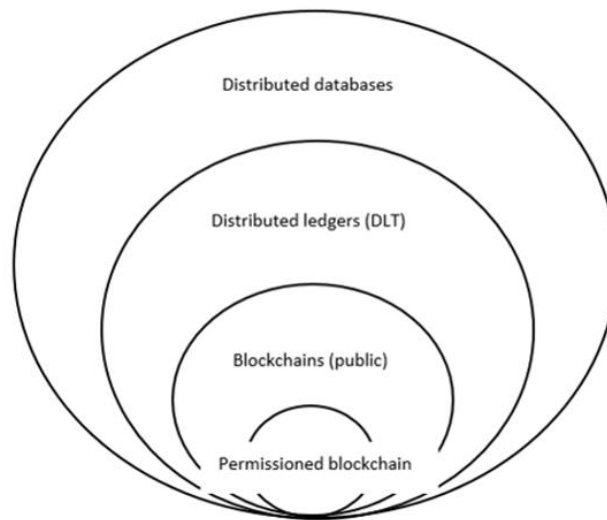


Figure 1. The relationship between blockchain and DLT (Cointelegraph n.d.).

In 1991, well before the release of the Bitcoin paper, Stuart Haber and W. Scott Stornetta published in an academic paper, and invented the concept of blockchain. The fundamental idea was to cryptographically link blocks chronologically in a an append-only data structure. The academic paper proposed calculating hash values of documents, and then saving them including timestamps. Whilst two scientist researchers mention a time-stamping server in their studies, in fact their solution also consists of a form a distributed consensus mechanism. (Beyer 2018.)

So, called Merkle Trees are a part of blockchains that is essentially important in supporting their functionality. The Merkle Tree enables fast, efficient and secure way of verifying masses of data structures. The Merkle trees allow blockchains to scale and give them hash-based design to keep up with the data integrity. It is important to understand what the cryptographic hash functions are, since they are the underlying technology enabling the functionality of the Merkle trees. (Curran 2020.)

Distributed ledgers do not need a proof of work, thereby they are more scalable, at least in theory. Also, by removing an intermediary from the equation makes the distributed ledger technology appealing. Unlike blockchain, DL does not necessarily need to have data structured into blocks. A distributed ledger may be regarded as a type of database that is spread across multiple participants i.e. nodes. In brief, all blockchains are distributed ledgers, however not all distributed ledgers are blockchains.

Whereas a blockchain represents a type of distributed ledger, it is only a subset of them. (Belin n.d.)

The logic of the blockchain technology is that it is run on a transaction ledger that is digitally distributed containing the exact same copies on each computer of the network. A distributed ledger is a database that is shared and synchronised in consent of the network and spread across multiple sites, institutions or geographies. The node participant can access the recordings that are shared across that particular network and can own an identical copy of it at all times. Any further additions or changes made to the ledger are reflected and replicated to all participants. (Majaski 2019.)

In a database, utilising the distributed ledger technology the ledger is spread across devices of the network, where each device can retrieve and save an equal copy of it. When a ledger is updated, each device validates the new transaction via built-in consensus algorithm. Once a consensus is determined, peer devices update themselves with the new, accurate copy of the same ledger. The security and integrity of the database is achieved through cryptographic signatures and keys. (Natarajan, Krause & Gradstein 2017, 1.)

The distributed ledger technology saves the transaction data, shares it, and synchronises the recorded data across participants. A blockchain is a type of data structure that is used in some but not in all distributed ledgers, whereby data is bundled into blocks which are connected in a digital chain. Blockchains utilise cryptographic and algorithmic methods in recording and synchronising the data across a network in an irrevocable way. A blockchain contains data and a hash pointer to the previous block in the blockchain. The process is called hashing that the blockchain uses to confirm its state. A blockchain operates based on the verification of the new block hash and digital signatures. (Natarajan, et al. 2017, 8)

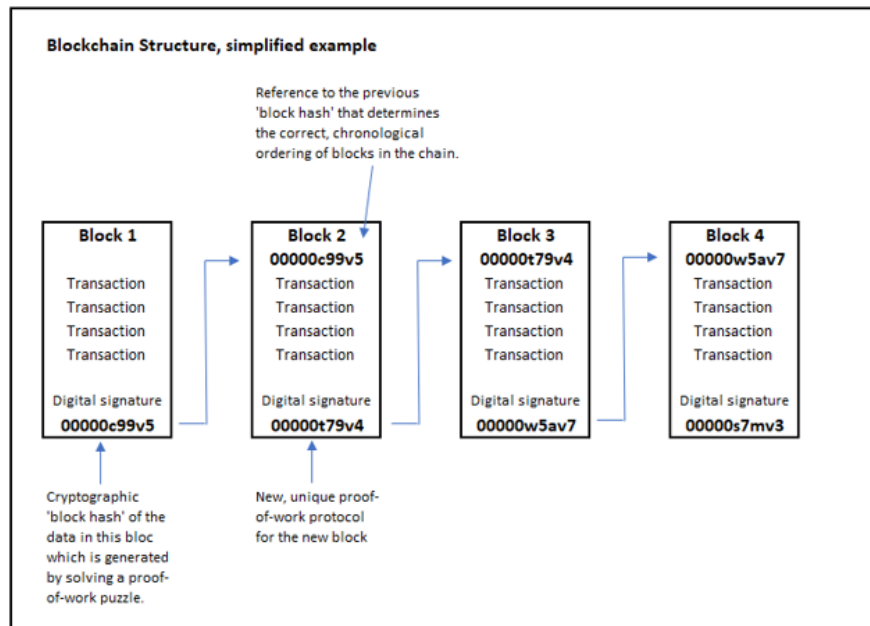


Figure 2. Blockchain Structure (Natarajan, Krause & Gradstein 2017, 9)

In public and permissionless blockchains all parties can review previous entries and create new. Created and recorded transactions are then grouped into blocks, appended one after another in a chain of blocks. The links between different blocks and the content of blocks is protected by cryptography, and the previous transactions may not be manipulated or deleted. This entails that the ledger and the transaction network are trusted without a central authority function. The blockchain is also one type of peer to peer network. (PwC Financial Services Institute 2017)

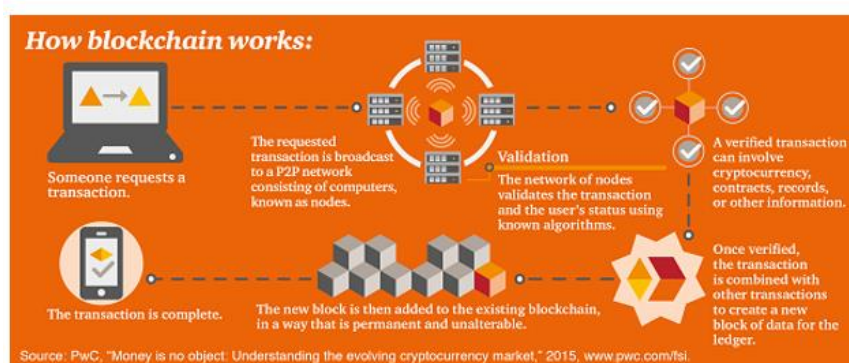


Figure 3. How blockchain works (PwC 2015).

A distributed ledger is essentially a database that can be used for tracking different type of assets and information attached to these assets. This information can then be shared among participants. For instance, the transaction data of a company's share can be tracked afterwards starting

from the issuance of the share, to the first purchases, and including all subsequent trades. (Cieplak & Leefatt 2017.)

The ledger is copied by all network participants, consequently each participant can easily detect any and all changes to the ledger, or parts of the ledger if desired. Thus, the participant can be replicate the whole ledger so only a portion of the ledger that is relevant to the participant. In both cases, the ledger is not only copied from one network participant to another. Each copy is deemed as the original copy of the ledger. (Cieplak & Leefatt 2017.)

In a network, when a trade occurs, a transaction is created resulting change in the ledger. Then the rules of the network trigger a copy of the new ledger data to be sent to all network participants. However, in a ledger system where not all participants have access to the full ledger data, the transaction data is only sent to the relevant participants. The network participants can access the information about their assets through cryptographic keys. Those parties who possess the right key, or combination of keys can execute the transaction, thus are able to transfer assets or otherwise alter the data in the ledger. (Cieplak & Leefatt 2017.)

So far, there has been five generations in the enterprise blockchain technology that are; Bitcoin, Ethereum, Hyperledger Fabric, Corda and Quorum. Whereas Bitcoin and Ethereum are permissionless and public, 3 latter blockchains are permissioned and private, yet with some modifications available. (Corda 2019)

Hyperledger Fabric was developed together with Linux Foundation and IBM. Hyperledger Fabric, or simply just Fabric, is regarded as a modular, extendable and open source framework, and it can be adopted across various industries. It is widely used private blockchain, primarily in enterprise settings to enhance transactions between multiple businesses be more efficient. Hyperledger Fabric provides the ability to modify assets using chaincode. Chaincode is software, that defines an asset and the transaction instructions for modifying those assets, hence this being the business logic. Smart contracts that are deployed to the ledger, execute the chaincode. Instead of each business having a business logic of their own, and changing their own database, the businesses in the Hyperledger Fabric network, share the business logic, and all sign off on the changes to the database. In the Fabric, the ledger is partly decentralised, thus the nodes do not have access to others' ledgers. Members of each permissioned network within Hyperledger Fabric interact with the ledger using chaincode. Members can deploy new contracts that add new business logic or invoke transactions that were already codified in the earlier contracts. To enable these permissioned networks Hyperledger Fabric provides a membership identity service that manages user IDs and authenticates all participants on the network. Furthermore, access control

lists can be used to provide additional permission layers through authorisation of specific network operations. (Rosic 2017.)

Corda is a product of R3 consortium which is developed to record and automate legal agreements between parties, that are known to each other. First, the Corda blockchain was designed by the actors in the banking and finance sector. The aim of the Corda blockchain is to pursue better scalability and resolve the privacy issues between banks, by including an external party to the blockchain e.g. notary to validate the created transactions in the network. Contrary to a permissionless and public blockchains such as Bitcoin and Ethereum, in Corda blockchain, only those parties who are parties of a contract, save the transaction data. Consequently, participants neither save nor see each other's transactions, unless they are the contracting party. Also, deals recorded by the ledger are accepted as admissible evidence and legally binding by all parties in any dispute. Corda also provides assured identity, meaning that parties will have assurance over the identity of participants in the Corda network. This is made possible due to KYC requirements of all participants of the network, and the core identity framework which enables Corda to assign a single user profile to any legal entity or individual. So technically speaking, Corda is not a blockchain, it is built on a distributed ledger technology (DLT). With the help of this logic, the scalability can be better achieved as opposed blockchain. (Morris 2018.)

Quorum blockchain was developed by JP Morgan, and it was developed for the financial services industry, aimed to support transaction and contract privacy. Quorum blockchain uses a consensus protocol QuorumChain. Quorum blockchain is modified from Ethereum and it supports both public and private contracts. Quorum is a modification of the public Ethereum Blockchain, meaning that most of the Quorum solution is actually unchanged Ethereum basecode. Similar to Corda also Ethereum-based blockchain QuorumChain or Quorum also provides transaction and contract privacy, hence the transactions and smart contracts on the blockchain can be private, allowing access to the participants only that are involved in a specific transaction. Quorum also allows access to entities such as regulatory bodies, which is essential. Public blockchains are problematic due to the fact that public ledger of transactions is not only unwanted but in many business cases illegal. Quorum also has many voting-based consensus mechanisms to validate the transactions. Quorum also allows its nodes to use smart contracts ensuring that only known parties can join the network. (Gupta 2019.)

2.3 Accessibility and roles Distributed Ledger

In terms of the accessibility, the distributed ledgers can be divided into public and private distributed ledgers. In terms of the roles, the distributed ledgers are divided into permissioned and permissionless DLs. Hence, the

blockchain-based DLs can be divided as follows: (Committee on Capital Markets Regulation 2019)

- (1) Public blockchains, wherein participants have an unrestricted access to the blockchain and can thereby transact with other participants of the blockchain. Consent of the blockchain operator is needed, should any change be made to the logic of the blockchain.
- (2) Private blockchains, wherein participants have an access only to a designated list of users, that have been approved by the operator. Transactions happen through interfaces that are offered by the blockchain operator.
- (3) Permissioned blockchains, blocks can only be added by the entities that are known to each other. Additionally, the permissioned entities control the access rights of the users.
- (4) Permissionless blockchains, any entity can add blocks to the blockchain, and users can freely access to the network.

While Bitcoin and Ethereum are categorised as public and permissionless blockchains, Corda, Hyperledger Fabric, and Quorum are regarded as private and permissioned blockchains. (Committee on Capital Markets Regulation 2019)

In some instances, blockchain can be a combination of two of the beforementioned structures. For instance Ripple, distributed open source protocol, has a permissioned ledger but all participants must validate the data. Ripple supports tokens that represent e.g. fiat currency, cryptocurrency, commodities and other value units. Consequently, their system is considered a public and permissioned ledger. On the other hand, a permissioned DLT where only certain participants validate the data should be regarded as a private and permissioned ledger. In the below figure, the distributed ledgers are classified. (Natarajan, et al. 2017, 11)

Due to fundamental differences between permissionless or permissioned distributed ledger systems there could be different risk profiles. In permissionless systems no central owner exists, who would control access rights to the network. In the permissionless network, anyone with the computer server and the relevant software can join the network and add transactions. Contrary to this, in permissioned distributed ledger systems, participants are selected in advance by the administrator of the ledger. The administrator i.e. the owner controls the network accesses and enforces the rules that are applied in the ledger. (Natarajan, et al. 2017)

Permissioned and permissionless distributed ledgers have their advantages and disadvantages which may vary with different use cases. Permissioned DL systems are more suitable for identifying and verifying

identities, and in instances where data privacy must be secured, hence central entity is needed. On the other hand, this could create a potential target for cyberattacks. Furthermore, due to the fact that there is no competition within a private blockchain solutions, there is not incentive to develop the blockchain to become faster. This means that many inhouse blockchain solutions will be nothing more than databases in the form of DL. (Natarajan, et al. 2017)

Permissioned systems are suitable for the existing legal and regulatory frameworks and arrangements of the institutional nature. Downside to this is that permissioned blockchain remove the fundamental benefits of the DLT innovation. Meaning that the integrity and security of the system is achieved via cryptographic and algorithmic solutions whereby anonymous participants ensure the accuracy of the ledger, without the need of entry barriers. (Natarajan, et al. 2017)

2.4 Smart Contract

Smart contract is a computer protocol that digitally facilitates, verifies, or enforces the negotiation or performance of a contract. The smart contracts are called self-executing contracts including the terms of the agreement agreed upon between the buyer and the seller. In practice the terms of the agreement are written into lines of code. Then the code and the agreement are copied across a distributed and decentralised blockchain network. Smart contracts execute only those transactions and agreements that are deemed reliable, further to be processed among anonymous parties without any central authority, legal system, or any external enforcing mechanism. (Frankenfield 2019.)

The very first time in 1994, the term smart contract was introduced by Nick Szabo, who is an American computer scientist. The smart contracts wherein several parties are involved, and the contracts that are more complex, require a system, that is verifiable and cannot be hacked.

Typically, smart contracts utilise blockchain technology, although other platforms can also host them. Smart contract program logic is within a block. A block is a software-generated container that bundles together the messages relating to a particular smart contract. These messages may act as inputs or outputs of the smart contract programming logic and may themselves point to another computer code. The Chamber of Digital Commerce the world's largest trade association representing the digital asset and blockchain industry published a white paper about 12 Use Cases of smart contracts. (Chamber of Digital Commerce 2017)

The technology that is used in smart contracts are somewhat comparable to the technology of a vending machine. In order to obtain an official document, an individual would normally go to a notary and pay for the

document, and then wait until the document is ready. Doing the same via smart contracts, an individual would simply put a Bitcoin into the vending machine i.e. ledger, and the official document is uploaded to the individual's account. One could say that the smart contract not only sets the rules and obligations to an agreement, but it also automatically enforces these obligations, very similar to the traditional contract. (Rosic 2017.)

In a smart contract an asset is put into a computerised program. The smart contract runs the preprogrammed code. At some point, the program automatically validates the conditions and evaluates whether the asset should be transferred, or whether it should be refunded to the person who sent it. The smart contract can also be a combination of different set of rules. If a smart contract is processed successfully, the decentralised ledger stores and replicates the document approving it, and giving a certain level of security and irrevocability. (Rosic 2017.)

3 SECURITIES INDUSTRY PUBLICATIONS

3.1 Euroclear and Oliver Wyman Joint Report

In February 2016, multiple authors from Oliver Wyman, American global management consulting firm, and from Euroclear, a Belgium-based financial services company, specialising in settlement of securities transactions, safekeeping and asset servicing of these securities, published a joint paper to assist decision makers in the capital markets to understand the potential of the blockchain technology. The report suggests that blockchain-based DLTs offer a new approach to data management and sharing. (Velde, Scott, Sartorius, Dalton, Shepherd, Allchin, Dougherty, Ryan, & Rennick 2016) According to the report, this could resolve many of the inefficiencies afflicting the capital markets and securities servicing industry. According to him, deployment of the DLTs will take time, and obstacles that need to overcome are significant. The report suggests that there are three different ways to adopt the technology:

- disruption comes outside of the capital markets ecosystem
- parties collaborate and make efforts together switching from the existing solutions to blockchain - this can take more than ten years
- regulators direct the industry participants to introduce new market infrastructure to reduce the cost, systemic risk or operational risk

The report describes how the blockchain technology works in practice. The report details securities transaction, different types of asset servicing events and transactions in derivatives, each built on smart contracts. Issuers companies would set up trading and settlement platforms for their own securities. The report also suggests that in the future scenario

accounting would be flat, whereby the multiple custody layers are combined into one single function, contrary to several layers of custody e.g. stockbroker, banks, local custodians, global custodians, CSDs. (Velde et al. 2016, 10.) The ownership of the securities or entitlements would be recorded on the investor i.e. beneficial owner level. Investors could hold their securities directly on the ledger, and the ledger would be managed by the wallet applications, hence less need for intermediaries.

In the below figure the report outlines the potential benefits for capital markets.

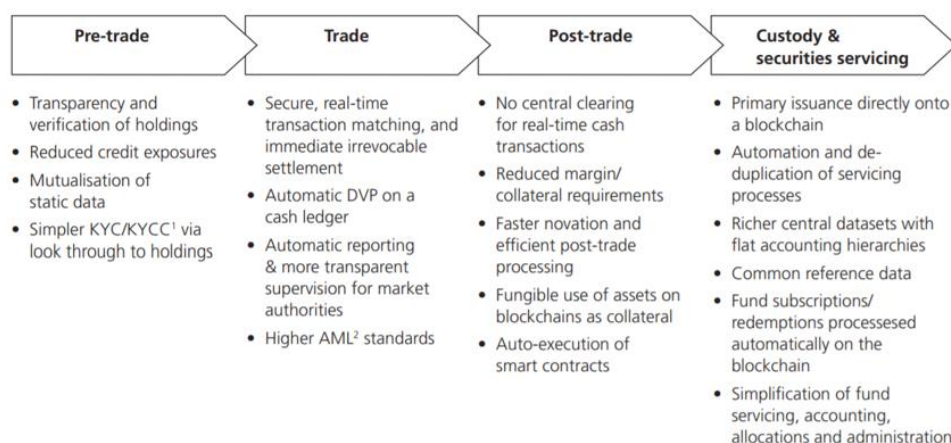


Figure 4 – benefits of adoption

¹ KYC – Know Your Customer, KYCC – Know Your Customer's Customer

² AML – Anti-Money Laundering

Figure 4. Potential benefits for capital markets (Velde et al. 2016, 12.)

According to the report, adopting the blockchain and distributed ledger would be such a fundamental change to the current infrastructures, and the roles of market participants could change as well as their business models. (Velde et al. 2016, 21.)

The report claims that many clients, particularly on the buyer side, can benefit the most due to reduced trading costs and securities services costs. The retail customers and wholesale investors could transact and execute trades securely on open markets. The brokerage firms would source liquidity for assets or take the principle risk regarding non-liquid securities. Furthermore, their role would be more in price setting, advising and execution management, contrary to providing market access as today. The report also suggests that CSDs would act as a virtual layer coordinating the role of custodians. (Velde et al. 2016, 11.)

3.2 Paper on DLT by Euroclear and Slaughter and May

In February 2016 Euroclear and with London based law firm Slaughter and May, published a paper that focuses on the existing legal and regulatory framework in the securities industry, as well as the underlying policy objectives. This paper examined in greater detail how DLT could be utilised in a post trade environment from the legal and regulatory point of view. Since the publication of the paper, many industries have acknowledged the potential for cost savings in the securities industry. Later, many initiatives have been launched aiming to deliver these cost savings. (Symons, Peeters, Yli-Jaakkola, Delhez, Scott, Mead, & Kingsley, 2016, 22.)

The report suggests that there is no need to enact a new DLT specific legislation or regulation, since it is the Central Securities Depository which is authorised and not the system that they run. On the other hand, the paper also claims that the existing legal and regulatory environment is not feasible for wider usage of DLT in the post-trade industry.

The paper outlines a few open questions and issues to be revisited: (Symons et al. 2016, 3.)

- What type of role would the central banks have in a DLT environment, and could the central bank money be used for settlement?
- Legal certainty of securities accounts, and the applicable law on these accounts
- The functions of central authorities that would have to manage the cryptographic keys, smart contracts, issuances, and regulatory treatments of such functions
- Interoperability between different systems, both DLT or non-DLT systems, which operate in many jurisdictions
- The requirements regarding the data protection and cybersecurity

The authors of the report believe that any legal and regulatory analysis on a DLT-based solution is depended on a designation of the use case. The transaction data could be shared with full transparency between nodes without a central authority's involvement. Contrary to that, the transactions could be validated by a central authority before a block is created, whereby participants would only have access to the information which they contributed. Consequently, different options could have an impact on the role of the CSD. In some instances, some of the CSD services would be abolished. On the other hand, in some instances, when adopting DLT solutions, there could be need for CSDs to provide additional infrastructure services e.g. managing private keys and smart contracts. Euroclear and Slaughter and May conclude that due to the regulatory and

legal challenges, it is very unlikely that DLT-based settlement system would work without a central authority, regardless of what the role of CSDs will eventually have. (Symons et al. 2016, 4.)

Regarding DLTs, the report suggests that there are two approaches that regulators can adopt to ensure the investor protection and systematic stability. Firstly, the regulators outline some industry guidance on DLT. This guidance could be done in cooperation with EU e.g. via the EBA and ESMA. The principles set by the guidance help to achieve consensus on how to successfully deploy DLT to the international securities settlement. As a second option, that can run in parallel, regulators at the global and EU-level, could collaborate with companies. Consequently, this could help them to overcome the regulatory, technical and monetary barriers in adopting DLT in larger scale. (Symons et al. 2016, 25.)

In the future scenario, the roles and responsibilities of the incumbent parties would change. The report suggest that the issuer companies might not be willing to take over the full responsibility maintaining the ownership ledger, when the new shares would be issued to the blockchain. Today, many issuers outsource registration of the ownership to registrars or CSDs. Additionally, CSDs and registrars would change their business models and start to offer smart contracts and then accept the liabilities for their actions. (Symons et al. 2016, 30.) In this scenario, each security or share issued by the issuer would establish its own 'mini settlement system'. Meaning that each issuer runs its own DLT, and that every security is a unique smart contract running its own settlement process. The authors also argue, would the liquidity suffice, whereby investors use the funds from sales proceedings to cover their purchases. Hence, if the purchase is then made in another share, how the liquidity for all investors is then managed and minimised in the system as whole. Minimising the total liquidity has been the aim for central banks, regulators and the CSDs. (Symons et al. 2016, 30.)

In the future scenario, it is questionable that the issuers would take over the Know Your Customer i.e. KYC duty, that could come along with the implementation of the blockchain. However, the verification of identities could be conducted by a third and trusted party. The mandate to offer the services by a trusted party could be within the smart contracts. The report questions can these third parties be held liable for accepting for frauds, errors or AML omissions. (Symons et al. 2016, 31.)

Settlement finality and ability to correct erroneous transactions is also one of the key questions to be answered. For instance, in situations where investor goes bankrupt, bankruptcy estate may request unwinding some of the transactions. Hence without regulation, there is lots of uncertainty on all settlement transactions. (Symons et al. 2016, 31.)

Lastly, the authors of the Euroclear paper believe that regulators and securities market as a whole are in favour of the blockchain-based settlement system, particularly from the cost savings point of view. In practice, an optimal result would indicate e.g. an abolishment of the settlement latency and more efficient reconciliation process. (Symons et al. 2016, 25.)

3.3 The ESMA discussion paper

In June 2016 European Securities and Markets Authority i.e. ESMA, issued a discussion paper to Fintechs and financial institutions keen on utilising DLTs in the securities markets. Their intention was to receive feedback particularly from banks, CCPs, CSDs, custodians, asset managers and investors. The reason for ESMA to issue for a discussion paper, was that they believed that the virtual currencies, and particularly the underpinning blockchain technology had some potential to disrupt the financial markets. According to ESMA DLT could bring many benefits to securities markets e.g. more efficient post-trade processes, better reporting and data management capabilities and costs reductions. Therefore, ESMA decided to examine the impacts of the adoption of distributed ledger to securities markets. In the extensive discussion paper, they focused on the potential benefits and risks that DLT could bring if applied to securities industry, and how it fits to existing EU regulation. The role of ESMA is make sure that the regulatory framework brings relevant safeguards to financial stability, investor protection and orderly markets. (European Securities and Markets Authority 2016.)

In the discussion paper, ESMA detailed the post trade ecosystem holistically; Clearing and settlement, record of the ownership, safekeeping of assets, key risks (e.g. counterparty risk, operational risks, cyber risk), collateral management, technological issues, governance and privacy issues, as well as regulatory and legal issues.

In the report ESMA, after receiving feedback from the securities industry, outlined some challenges in adopting DLTs, such as interoperability, the use of common standards, governance, central bank money accessibility, and issues in privacy and scalability. Additionally, despite several interesting proofs of concept, ESMA claims it is too early to say, if the blockchain technology will overcome the challenges. According to ESMA, DLT could create or amplify some risks, however, no exact nature and level of those risks can be described. (European Securities and Markets Authority 2016.)

ESMA's report suggests that early DLT applications will be in optimising the current processes in the securities industry. In situations where there is less dependency on the existing legal framework and less automated processed are 'the low hanging fruits'. At the later stage, there may be needed to re-evaluate the views regarding DLT and the existing market

structure. When designing DLT solutions, developers must be aware of the rules and regulations in the securities industry. Any new DLT solution or a market participant need to comply with the existing regulatory framework, that enables well-functioning financial market. (European Securities and Markets Authority 2016.)

Based on the conclusions of the report, ESMA claims that it is unlikely that CCPs and CSDs would cease to exist due to the implementation of DLT solutions. On the other hand, ESMA is of the opinion that some processes may become redundant, or the functions of certain intermediaries change over time. Also, some regulatory requirements may be less relevant, whereas some new regulatory requirements are needed to reduce the risks in the future. Due to the fact, that DLT is still evolving, and there are limited number of practical applications available, it is premature to fully understand the potential changes. ESMA has not identified any short-term major impediments in the EU regulatory framework that would prevent DLTs emerging. (European Securities and Markets Authority 2016.)

To ensure that DLT does not create any unpredictable risks and that no benefits are hindered by undue obstacles, ESMA calls for active engagement from regulators, as well as coordination at EU and international level. The legal certainty of settlement finality and the records of DLTs require further clarity. In addition to financial regulation, legal issues e.g. insolvency law, corporate law, contract law and competition law could have an impact on the deployment of DLT. (European Securities and Markets Authority 2016, 2)

According to the ESMA report, respondents believe that DLT could increase the efficiency and speed of post-trade processes, particularly in clearing and settlement of certain financial transactions. Although, some emphasise that there are alternative technologies that can provide similar benefits. DLT adaptations could add flexibility to the current settlement cycles, whereby ownership of securities and cash is transferred. Shorter settlement cycle could mitigate the counterparty risk. (European Securities and Markets Authority 2016.)

There is a consensus that DLTs could be utilised to safekeep assets and record ownership, by making the ultimate beneficial ownership transparent through the custody chain. Many respondents emphasise that smart contracts could be used in processing of corporate actions, although ask for more universal standards to achieve the real benefits of DLTs. (European Securities and Markets Authority 2016, 20). Based on the report, some claim that the role of the market infrastructure providers, for instance CSDs and custodians could become redundant when adopting DLT. Hence DLT could reduce the number of intermediaries in the post-trade ecosystem. Others claim, that e.g. CSDs could perform some alternative functions, such as notary or registration functions, yet needed

even if DLT were adopted. DLTs could be used to retrieve data for reporting, risk management and supervisory means.

Securities industry shared an opinion that DLTs would not make CCPs redundant. For instance, derivatives transactions and 'spot' transactions there is still need for delays in trade execution and settlement, hence requires clearing. Additionally, multilateral netting, which is an additional and important function for CCPs, does not seemingly apply in multiple counterparties in DLT. (European Securities and Markets Authority 2016, 21).

In ESMA report, respondents questioned capability to handle large volumes, hence raising some concerns to security and resilience of DLT systems. Many deemed DLT initiatives not on their primary focus of the current market initiatives. Because of the traceability of the transactions, processes around customer identification e.g. KYC and AML processes were regarded as an additional benefit. Prerequisite for gaining the full benefits of the DLT, is that technology is applied in homogenous and consistently across the securities industry, throughout the life cycle of the security. Based on some responses, the industry needed to identify the processes or segments where the benefits of adopting the new technology would be highest. As an example, the DLT adoption could be deployed first in low volume and relatively simple and unregulated markets. The leveraging the DLT for static data e.g. securities data, corporate action data retrieved from company notifications or prospectuses, should be deployed before transaction processing. Also, exploring alternative asset classes could bring more significant benefits. (European Securities and Markets Authority 2016, 18).

Timeframe in DLT applications to replace the legacy systems is somewhat of 10 to 20 or even 30 years, depended on the acceptance of investors. (European Securities and Markets Authority 2016, 23).

3.4 BIS report of DLT arrangements

In addition to the Euroclear reports on DLT, a Swiss based financial institution, the Bank for International Settlements (BIS) owned by central banks, issued an analytical framework report in February, 2017. BIS purpose is to pursue global financial stability and facilitate interaction between international groups. The aim of the report, conducted by the working group, was to help the central banks and other authorities to understand the uses of DLT arrangements, and to identify opportunities, challenges and risks regarding DLT. (Committee on Payments and Market Infrastructures 2017.)

BIS's report claims that it DLT, including blockchain technology, is promising, however a lot must happen until the promise is realised. The

legal base of the DLT solutions must be acceptable, governance structures must be solid, solutions of the DLT must meet the needs of the industry, and last, the date controls must be appropriate and satisfy regulatory requirements. Furthermore, there is a possibility that DLT reduces the reliance on a centralised ledger that is administrated by a party that is deemed trustworthy, when handling financial assets. The report claims that DLT could change the way how the assets are maintained and stored, any kind of obligations fulfilled, contracts enforced, and different type of risks managed. (Committee on Payments and Market Infrastructures 2017.)

Supporters of the technology highlight that DLT will transform the financials services by reducing complexity i.e. increasing transparency, improve processing speed of assets and funds, decrease the need to reconciliation of the various record-keeping infrastructures, increase irrevocability or immutability in keeping records on transactions, improve the resilience of the network via the distributed data management, and finally reduce financial and operational risks. Also, DLT solutions could enhance market transparency, should the data contained on the ledger be shared between participants, other stakeholders e.g. authorities. (Committee on Payments and Market Infrastructures 2017, 1).

Furthermore, the same report outlines few risks, which are partly currently unknown and unidentified. DLT solutions may cause new risks, or uncertainty on operational and security issues, if the technology is unable to interoperate with existing processes and infrastructures. There is also unclarity in relation to the legal bases around the distributed technology, the interpretation of the settlement finality, the integrity and privacy of the data and the governance framework. The report also suggests that the DLT has not proven to be scalable and is still evolving. (Committee on Payments and Market Infrastructures 2017, 1).

The working group suggests, that DLT arrangements could be more trustworthy, whereby there is a closed set of participants or there is a system administrator. The group also claims, that in some instances, a ledger could be utilised to retain more information than just the asset owner records. For instance, a DLT could be a central repository for financial contracts and maintain the terms of a real contract or a copy of the contract. Some DLT solutions allow automated contract tools, and self-executing codes that can be put in to the ledger, consequently the fulfilment of contract terms is automated. In these examples, the code consists of the interest calculation, remittance of the principal payment and funds distribution as described in the predefined events or the termination of contracts as agreed upon the terms. This type of built-in functionality of the contract is also called smart contract. (Committee on Payments and Market Infrastructures 2017, 3).

Description of arrangement	One entity maintains and updates the ledger (for example, a typical FMI)	Only approved entities can use the service; entities can be assigned distinct restricted roles	Only approved entities can use the service; entities can play any role	Any entity can use the service and play any role
Operation of the arrangement	Single entity	Multiple entities		
Access to the arrangement	Restricted			Unrestricted
Technical roles of nodes	Differentiated		Not differentiated	
Validation and consensus	Within a single entity	Within a single entity or across multiple entities	Across multiple entities	

Figure 5. Potential configurations of DLT arrangements (BIS 2017).

In the Figure 5, the BIS working group listed the pros and cons of the different type of DLT arrangements. In the table, they categorise restricted and unrestricted accesses to the DLT arrangements. For instance, unrestricted arrangement allows new types of participants to offer their services, hence reduce the tiering of relationships in the payment process, clearing and settlement processes. On the other hand, unrestricted access could face scalability and information security issues. This is because the nature of the blockchain is that the participants aim to find consensus, even if they are unknown to each other. Consequently, an anonymous participation calls for some additional security measures which must be taken to mitigate illegal activities such as cyber-attacks. These security measures must be incorporated into the rules of the DLT arrangement.

The above-mentioned issues are so remarkable that the DLT implementations for payments, clearing and settlement activities are currently focusing mostly on restricted arrangements, that better fit within existing legal and regulatory frameworks. The BIS working group also defined that assigning specific roles to numerous entities and their nodes could introduce other important difficulties. It is important that entities are known and trusted by participants.

For instance, if certain nodes are only given to restricted entities, it can more convenient and faster to reach a consensus already on the ledger level. Furthermore, it can also be easier for any one of these same nodes to compromise the integrity of the ledger. If the number of nodes was increased it could enhance the resilience of the network on an overall level, but the processing time would be longer. (Committee on Payments and Market Infrastructures 2017.)

If various roles and responsibilities are distributed in the DLT arrangements, it may well raise questions in relation to the governance, settlement and operational risk management. Various approaches to DLT indicate that not one single approach is appropriate when addressing all the challenges in payment, clearing and settlement. Many DLT designs

reflect attempts to realise the benefits of DLT, while acknowledging the constraints of the use cases at hand.

3.5 DLT and blockchain Working Paper by The World Bank Group

In 2017, the World Bank Group issued a working paper about DLT and the Blockchain. The working paper outlines the mechanisms of DLT, origins, key characteristics, main advantages, challenges and risks. Additionally, it proposes next steps for the World Bank in its journey, to study and evaluate areas where the distributed ledger technology could be integrated into financial sector operations within in the World Bank. According to their findings, the DLT could be utilised in the in cross-border payments, in collateral arrangements and other financial markets infrastructure in the securities industry. (Natarajan, et al. 2017)

However, the distributed ledger technology solutions are not only limited to the financial industry. The feasibility of the DLT solutions is also explored in different digital identity applications e.g. to record information on national ID, birth, marriage and death. Additionally, DLT is being used to build decentralised records of the commodities and material flow across a supply chain by using a third party to validate flows and movements. (Natarajan, et al. 2017)

The authors of the report claim, that DLT supporters often highlight the advantages of the DLT over the traditional centralised ledgers and other types of shared ledgers. These advantages being decentralisation, higher transparency, speed, execution efficiency, cost reductions, level of automation and better auditability. (Natarajan, et al. 2017)

The distributed ledger technology is evolving and could create new type of risks and challenges that would have to be resolved. The challenges and concerns outlined in the World Bank's report are security, interoperability, scalability, threat of cybersecurity, identity verification process, data privacy, handling of disputes and establishment of a legal and regulatory framework. These challenges could potentially shape the fundamentally the roles and responsibilities of the incumbent stakeholders in the financial sector. (Natarajan, et al. 2017)

Additionally, the authors outline in the working paper that that the migration costs of the legacy systems and the current infrastructures to the DLT-based infrastructures would be substantially high. Due to the beforementioned challenges, many industry influencers and observers say, that DLT applications will likely be first adopted in places where there are fewer legacy investments made in automation e.g. trade finance and syndicated loans. (Natarajan, et al. 2017)

The working paper also suggests, that the DLT is still at a very early stage of the development, and there are many open issues in relation to the data

privacy and security, scalability, interoperability, and regulatory and legal issues. Whereby, the World Bank Group could not issue general recommendations about feasibility and usability of the DLT. (Natarajan, et al. 2017)

Additionally, the report suggests that waiting or pursuing for an optimal DLT solution(s) might not be a good approach for organisations. Taken into the account the DLT's potential to structure solutions in the financial sector, the World Bank Group will monitor, and foster applicable adoptions. They also urge the financial sector not only to research but render real-life applications. (Natarajan, et al. 2017)

	'Public' (open) Blockchains	Permissioned Blockchains
Central party	No central owner or administrator	Has some degree of external administration or control
Access	Anyone can join	Only pre-selected participants can join the network
Level of Trust	Network members are not required to trust each other	Higher degree of trust among members required (as collaboration among members could alter the ledger)
Openness	Ledger is open & transparent - shared between all network members	Different degrees of openness and transparency of the ledger are possible
Security	Security through wide distribution in a large scale network	Security through access control combined with DLT in smaller scale networks
Speed	Slower transaction processing restricts transaction volume	Faster transaction processing allows for higher transaction volume
Identity	User identity anonymous or protected by pseudonyms	Identity verification typically required by owner/administrator
Consensus	Difficult proof-of-work required as consensus mechanism	Variety of consensus mechanisms possible (typically less difficult & less costly than proof-of-work in permissionless blockchains)
Asset	Typically: native cryptocurrencies. But implementations are possible where a token is used which can represent any asset.	Any asset
Legal ownership	Legal concerns over lack of ownership as no legal entity owns or controls the ledger	Greater legal clarity over ownership as owner/administrator is typically a legal entity
Examples	Bitcoin, Ethereum	R3's Corda, Hyperledger Fabric

Figure 6. Taxonomy of Blockchain (Natarajan, Krause & Gradstein 2017, 12).

In 2017, the Committee on Payment and Market Infrastructures, CPMI, of the Bank for International Settlements, BIS, outlined in their framework the viability of DLT applications in payments and in security settlements. The framework is generalised, hence is applicable for many different DLT applications in the financial sector. In its framework, the CPMI proposes the following roles for a node in the blockchain: (Natarajan, et al. 2017, 13.)

- **System administrator** is the one who maintains the network and decides who can access it. Furthermore, the system administrator

performs the notary function and administrates the rules for dispute resolution. The role is not necessary a permissionless DLT.

- **Asset issuer** issue new tokens that are used in the network. In some DLTs e.g. the Bitcoin blockchain the system itself creates new bitcoins based on specific and predefined rules, hence there is no entity that has this role. A token, which represents a digital asset value, does not typically have built-in value, however it is linked to the underlying asset containing some value.
- **Proposer** proposes new transactions to be included in the ledger
- **Validator** validates addition requests. In some instances, this role is performed by a consensus mechanism that is decentralised, consequently the distributed ledger is permissionless.
- **Auditor** views the ledger, however, is not allowed to make any changes to the ledger. For instance, this role could be ideal for external or internal auditors to conduct audit checks. Additionally, this role could be used by authorities, regulators and supervisors.

3.6 R3 Corda Blockchain platform

US-based firm, R3 LLC or simply just 'R3', is an enterprise blockchain technology company. R3 developed its blockchain Corda platform, which has been open source software since 2016. Corda is developed to record legal agreements between known participants. Corda design allows global developers to contribute to it and build on it and drive the design and the adoption. Currently R3 is working with over 300 participants broad ecosystem in various industries, both public and private sectors, aiming to develop blockchain applications on Corda platform. Industries utilising and building use cases on Corda are primarily financial services, insurance, healthcare, trade finance and digital assets. Applications that are built on the Corda platform are called CorDapps. R3 has headquarters in the New York City. (Clark 2018.)

Initially, the requirements by the financial industry formed the original basis of Corda's design, however the experience demonstrated that Corda has broad applicability within other industries than just banking. (Clark 2018.)

Corda is a decentralised database with minimal trust between nodes enabling a creation of a global ledger. Such a ledger has proven to have many useful applications. In Corda database, essentially, there is an identity management system, which allows interacting parties to know each other. Notaries ensure algorithmic agility with respect to distributed

consensus systems, and the system operates without mining or chains of blocks. (Clark 2018.)

The Corda platform consists of the set of standards, network parameters and associated governance processes, which together define the global Corda Network. It enables any organisation or even an individual on the network to transact directly with any other participant in the network. Essentially, the architecture design allows to automate real-world transactions in a legally enforceable manner. In the Corda blockchain network multiple applications can execute transactions and seamlessly interoperate across. (Clark 2018.)

In contrast to permissionless blockchain platforms, the Corda is intended to manage transactions between identifiable parties, with privacy and legal certainty. In contrast to other 'permissioned' blockchain platforms, Corda is intended to allow multiple groups of participants, and its applications to interoperate across the same open network. The governance model of Corda is designed to reflect the common interests of the various users of the platform. (Clark 2018.)

There are multiple use cases where Corda Blockchain platform has been utilised. In March 2018, financial service groups Credit Suisse and ING successfully completed the first live EUR 25 million transaction in securities on Corda platform. (Credit Suisse 2018.)

In the transaction the legal ownership of Dutch and German government securities using a collateral lending application on Corda platform. The application was developed by a third-party vendor HQLAX. In the transaction the proprietary rights of HQLAX Digital Collateral Records containing "baskets of securities,". Normally, in such case, the actual securities, issued in a CSD are transferred. (Credit Suisse 2018.)

In Finland, Corda blockchain platform is already being utilised in trading housing companies' shares in the permissioned blockchain. For example, technology prevents a home or an apartment from being sold to many buyers simultaneously. Furthermore, authorities have access to the blockchain i.e. owner information. (Kolehmainen 2017.)

Since autumn 2018, Asiakastieto, Nordea, OP Financial Group, Privanet and Tieto have developed a blockchain-based network, which enables digitisation of shareholder management of unlisted shares and trading of these shares. The consortium provides a reliable, simple and fully digital platform for managing unlisted shares and shareholders, issuing of new shares and trading shares directly between buyer and seller. Although the current system has been developed in co-operation with Finnish public and private sector actors, it is also scalable outside Finland. The platform is based on open source Corda and Hyperledger Indy technologies. (Tieto 2018)

‘With the help of the blockchain, we can solve trust-related problems and create completely new services and business models for different industries. As a result of our collaboration, we have demonstrated how this technology can be leveraged by creating a fully digital identity for companies, as well as through the digitalisation of unlisted shares.’, says Ville Sointu from Nordea. (Nordea 2018)

3.7 European Central Bank’s Paper on DLT in securities post-trading

Already in 2016 European Central Bank, ECB, issued paper about distributed ledger technologies in securities post-trading. The paper concluded that certain processes in the post-trade market for securities still must be performed by institutions. Furthermore, ECB paper claimed that DLTs could reorganise the financial markets, which could reduce reconciliation costs, streamline the value chain, and allow more efficient use of collateral and regulatory capital. It should, nevertheless, be remembered that research into DLTs and their uses is at an early stage. The scope for financial institutions to adopt DLTs and potential impact on the markets are not clear. (Pinna & Ruttenberg 2016, 2.)

3.8 DLT discussion paper of Committee on Capital Markets Regulation

In April 2019, an independent US-based research organisation, the Committee on Capital Markets Regulation is published a discussion paper about blockchain and clearing and settlement. The Committee pursues to improve clearing and settlement systems globally. In their discussion paper the organisation suggests, that the most reliable design of the blockchain for securities transactions differs considerably from an authentic blockchain designed for cryptocurrencies e.g. Bitcoin. However, there is much uncertainty if the blockchain technology would be the most ideal framework to improve the clearing and settlement systems. The discussion paper suggests that Bitcoin’s blockchain intentionally has speed bumps to assure the ledger security, and such functionality may not be feasible for settlement of securities, in contexts wherein the real-time settlement is more desired model.

In the discussion paper, the Committee on Capital Markets Regulation introduces alternative blockchains designs to Bitcoin blockchain. In the Bitcoin blockchain, the key aspect of the design is public openness. However, in the alternative blockchains, the public openness is restricted, hence blockchains are private or permissioned. (Committee on Capital Markets Regulation 2019, 7.)

3.9 Additional publications

US-based data provider, Greenwich Associates claims that by any measure distributed ledger technology is an extraordinarily efficient system. DLT is going to influence clearing and settlement of securities in the future, however if the deployment is taken too far, it may well be counterproductive. Furthermore, Greenwich Associates claim, the real-time gross settlement could save up to USD 8 billion in reserve funds at the cost of requiring hundreds of billions in prefunding. This prefunding requirement creates a burden on money markets, burden which participants have been developing systems to alleviate. (Greenwich Associates 2019)

The blockchain technology is being looked at on the following applications: (Mougayar 2016.)

- Bonds, corporate and government
- Collateral management services
- Commodities in general
- Different types of derivatives e.g. Swaps
- OTC transactions
- Syndicated instruments
- Repurchase agreements
- Unregistered and registered securities
- Futures e.g. Warehouse receipts

In order for blockchain business cases to reach wider use, transactions that are processed on the blockchain need to be regarded and acknowledged legally binding and acceptable within the compliance requirements that currently exist. This could mean that recordkeeping rules must be revisited, or at least make sure that the renewed laws and regulations do not hinder institutions from utilising the blockchain technology for these type of transactions. (Mougayar 2016.)

In 2019, HSBC together with Singapore Exchange and Temasek which is a company owned by Singapore Government, that they will study and evaluate the feasibility of the distributed ledger technology. In their use case they are looking into possibilities to issue fixed income securities and the services attached to it. According to the source, this was the first end to end testing initiative where distributed ledger technology is explored on fixed income products in Asia. (Ashar 2019.)

Many countries and their governments are investing, investigating and experimenting, how blockchain technology could be adopted more broadly. The focus is particularly on experimentations to digitise different public services pursuing to streamline these services for citizens, and make the services more transparent, secure and efficient. (The World Bank Group 2018.)

The blockchain technology, which is the technology underpinning e.g. Bitcoin, could potentially change many areas in our economic ecosystems and how they are rendered and facilitated, such as payment systems and banking in general, but also how real estate business is conducted. In financial markets specifically, blockchain and distributed ledger technology has been considered for use in securities clearing and settlement systems. However, despite blockchain's potential, it is not clear whether the technology is ideal technology to be used in securities settlement and clearing.

(Committee on Capital Markets Regulation 2019.)

The World Economic Forum's survey predicted in 2015 that by 2027 10 % of global gross domestic product will be contributed by blockchain technology. (Coindesk 2015.)

In 2017, when the value of the cryptocurrencies increased, simultaneously investments in mining capacity increased rapidly, and people began investing even more into cryptocurrencies, and investments to the blockchain technology increased. Governments in European countries, particularly in eastern part started to experiment blockchain aiming to improve their services for citizens. Some of the central banks are also exploring the issuance of their legal currency in a digital form, and some institutions are piloting blockchain applications to incorporate these applications in the existing financial infrastructure. Consequently these countries have become an important center for initial coin offerings. (The World Bank Group 2018.)

Households all over world are looking for alternative ways to save money. Incumbent financial hubs are adjusting their service models to match the competition coming from new technologies deemed disruptive such as blockchain. Blockchain technologies are particularly attractive in countries where the trust in financial institutions modest. In these countries there is a pressure on making incumbent financial intermediaries redundant. Countries that are politically unstable and where corruption is next to normal practice, thus confidence in government officials and laws is low, are more in favour of cryptocurrencies and tend to adopt them. A very good example from this is Venezuela, where people seek alternatives for the fiat currency, bolivar, the value of which been deteriorating by hyperinflation. (The World Bank Group 2018.)

In the United States, the National Settlement Depository (NSD) and the post-trade financial services organisation, Depository Trust and Clearing Corporation (DTCC) have shown willingness to utilise blockchain to expand and improve their CSD operations. For instance, the NSD, after announcing their future plans, has carried out their proof of concept of the blockchain whereby the technology could be used by the shareholders of the

company in electronic voting process. (National Settlement Depository 2016.)

Even though the financial sector is already adopting the blockchain applications, more traditional industries e.g. manufacturing is not. No matter what the business niche is, there is a very good chance that the blockchain or the DLT will affect the businesses also in manufacturing industries. More relevant question is when this will occur. Many organisations do not record of all their business activities. Instead records are distributed internally across various functions and business units. The assuring the integrity of the data across individual and private ledgers is time-consuming and errors might happen. (Iansiti & Lakhani 2017.)

It has been stated that the blockchain is interesting option for corporate cross-border payments, once the necessary regulation is introduced. It can be difficult for a private individual to lose their money when their counterparty goes bankrupt. Even so, it can be even more burdensome for corporates to wire large amounts of funds via cross-border payments, and then eventually lose these funds. As soon as the regulation is introduced, banks could offer interesting value-propositions for their customers based on the blockchain technology. Many actors are already building up the knowledge to understand better the blockchain technology and to develop the proofs of concept solutions. (Deloitte 2017.)

Target 2 Securities i.e. T2S has been subject to many deployment delays over the last few years although deadlines are fast approaching. The objective of the T2S project is to harmonise and integrate the fragmented securities settlement infrastructure in Europe. The European Central Bank highlights migration of the national depositories onto the platform occurs in waves. Since June 2015, many CSDs have already migrated to platform. Some hypotheses have been presented whether the implementation and the evolution of the blockchain technology in the post-trade industry could challenge or even replace the T2S at some point. (Harwood-Jones 2016.) After several delays, Finland is expected to join T2S in November 2022.

3.10 Blockchain in funds

In September 2017, Skandinaviska Enskilda Banken AB, a Nordic financial services group, and Nasdaq Nordic announced a pilot project to examine and develop a trading platform solution for mutual funds utilising the blockchain technology. The aim was to improve the processes both when subscribing and redeeming of funds. Essentially the pilot aimed to create a unit ledger for funds. The goal of the pilot was that the mutual funds industry actors, primarily fund companies and fund distributors could opt in to a private and permissioned blockchain. When doing so, they would share a distributed database or a ledger among participants, to which fund transactions would be recorded real-time. (Nasdaq 2017.)

There are also other examples where fund companies have examined a possibility to adopt blockchain technology for mutual funds. Calastone, the global funds transaction network, announced in December 2017 to underpin the core of Calastone's global transaction network onto the blockchain-enabled infrastructure. The company is also of the opinion that the very core of its network would be of private and permissioned blockchain infrastructure in 2019. (Cision PRNewswire 2017.)

Vanguard Group, the company offering e.g. mutual funds and a fintech company Symbiont aim to develop and utilise smart contract technology in some of Vanguard's operational processes. Vanguard and Symbiont tested the technology to streamline the data retrieving process, specifically when defining the composition of index funds. The datapoints consist of the name of companies, number of shares, how indices are weighted and various corporate actions, e.g. mergers or splits. (Coindesk 2017.)

Apparently, many private investment funds continue to develop and implement the blockchain technology and smart contracts. In the early 2017, US-based financial services company Northern Trust and IBM multinational technology company agreed upon partnership aiming to use the blockchain commercially, particularly for private funds. The partnership pursues to enhance the administration of private equities. The partnership wishes to improve the efficiency and transparency when executing private equity transactions. Both companies also wish to simplify complex and labor-intensive tasks deemed necessary in the private equity market. (Wulf 2017.)

4 QUALITATIVE RESEARCH

4.1 Research approach, design and methods

In social sciences, a semi-structured interview as a research method is often used. Contrary to structured interview which has a fixed set of questions, a semi-structured interview is open, allowing views and new ideas to be brought up during the interview based on what the interviewee says. Generally, the interviewer in a semi-structured interview should have a framework of topics or themes to be explored. The questions are loosely structured and should give interviewees opportunity to express themselves. As a research method, semi-structured interview is widely used in qualitative research, and should be distinguished from structured interview and unstructured interview methods. (Edwards & Holland 2013, 4-5.)

A research method is a technique specifying the data collection. Various tools such as surveys and semi-structured interviews may be used. Often a qualitative research is used in business related researches. Other research methods are quantitative method and a combination of two latter methods. The qualitative research method is very much focused on the verbal information, whereas the quantitative research method focuses on quantification and measurements. (Bell and Bryman, 2011)

A semi-structured interview technique consists series of questions. The interviewer can supplement or remove some of the questions or even change the order of the questions presented. In a semi-structures interview, the interviewer may ask subsequent questions depending on the answers of the interviewee. Additionally, semi-structured interview allows researcher to address the topic to the interviewee more explicitly. (Bryman and Bell, 2011).

The benefit of the semi-structured interview is the flexibility and spontaneity it gives. In this research setting a semi-structured interview method is considered extremely beneficial due to the nature of the topic, i.e. relatively new phenomenon, which disables the researcher of knowing all the relevant aspects of the topic, and the lack of available public data. Interviews are also feasible for limited number of respondents, which is why the results are not quantifiable. Since interviews are more feasible for limited number of respondents, there is a risk that the results are overgeneralised and regarded as the opinions of a wider population. (Bell, 2005)

Before choosing research objectives on the phenomenon, the author discussed with a few of his colleagues with the different professional backgrounds. The author was given many valuable insights about the distributed ledger and blockchain technologies. The author chose the qualitative research method for his research to investigate the phenomenon. The reliability and validity of the research are key concerns in this type of research. The qualitative research method was selected, as opposed to the quantitative method, since the author of the thesis is of the opinion, that the qualitative research method could answer the research questions much better. In analysing the research data, the author used the inductive approach, which is common approach when qualitative research method is used.

The research questions are:

Question 1:

Could distributed ledger technology or blockchain-based distributed ledgers change the way dematerialised securities or physical securities are handled in Finland?

Question 2

Could the DLT have an impact on CSDs', CCPs' or custodians' role in the Finnish securities industry?

Question 3

Do blockchains have to be private and permissioned or can they be public and permissionless?

Question 4:

More broadly, in what instances could DLT solutions be utilised in the securities industry?

The research started with the literature review. The literature review was collected primarily by searching electronic sources with the help of search-engine Google and Google Scholar. Additionally, other electronic sources were used e.g. theseus.fi. The most frequent keywords used were distributed ledger, distributed ledger technology, DLT, hajautettu tilikirja, blockchain, blockchain technology and smart contract, as well as combinations of these afore words. Alongside with the written material, also webinars and videos were screened in order to gain better understanding about the blockchain technology and especially about the logic how transaction data is stored to a distributed ledger. Most of the videos seen were on YouTube, and the keywords used were the same which were used to find the written material.

4.2 Research quality

Reliability and validity are concepts that are used to evaluate the quality of the research, and they indicate how good a method, technique or test measures the research topic. One could say that the reliability and validity are closely related, however they mean different things. Nonetheless, both concepts are closely connected with the quality of gathered research data. Reliability describes the consistency of the method used to measure something. If the identical research result is achieved by using the identical research method under the existing and prevailing circumstances, the method can be deemed reliable. (Middleton 2019.)

It is important to understand that a research can be reliable without being valid. Validity of the research means how accurately a method measures what it was intended to measure in the first place. If research has high validity, it means it can produce results that correspond to real characteristics and variations in the physical or social environment. The interview questions should not be guiding the respondent to a desired response. (Middleton 2019.)

To achieve validity and reliability for the research, all the interviewees had to possess the thorough understanding about DLT, relevant working experience and understanding about the securities post-trade

environment as well as technologies currently used in the financial services sector.

This research was not monetarily funded, and it was conducted without a principal and engagement to the author's current employer. Thus, any opinions, suggestions or hypothesis presented in this thesis are of the author's own and should not be regarded as opinions or statements of the current employer or the future employers.

To familiarise himself to the topic, the literature review was collected, primarily from electronic sources with the help of search-engine Google and Google Scholar. The problem with the research setting can be the fact that the search combinations do not provide a wide range of academic papers. Most of the results from google provides short journals that all share the basic principles of the blockchain and their potential in various businesses, while some of the papers were only in association with Bitcoin.

The focus of this research work was limited to the area of blockchain and distributed ledger technologies, and trusted literatures. The distributed ledger technology is relatively new phenomenon, and there are limited number of real-life cases and studies available related to this topic. The purpose of this thesis was not to gain deep understanding of the mechanics on how blockchain or distributed ledger applications are built. The thesis does not investigate how other industries have applied distributed ledger technologies or blockchain-based applications.

4.3 Research process and selection of interviewees

To collect the qualitative research data, one-to-one interviews by using the semi-structured interview technique were conducted. The list of questions was prepared (Appendix 1) including supplementary questions for the open-ended data. These questions were then used to guide the conversation. Essentially, the aim was that pre-defined questions were answered during the interview; hence the interviewer did not always ask all the questions. Each interview was audio-recorded. The duration of the interviews varied from 30 to 45 minutes. The number of interviewees was five. The interviews were conducted during March 2020. Due to Coronavirus i.e. COVID-19 outbreak, first 2 interviews were done face to face, whereas 3 of the latter interviews were done remotely via phone. The language of the interviews was Finnish.

All interviewees were treated anonymously, and it was stressed to the interviewee that neither the name of the individual nor their employer would not be attached to responses and only the interviewer could use the raw data from the recordings. The individuals that were interviewed are representatives from various organisations in the Finnish securities industry or/and financial services sector, who hold relevant positions within their organisations and have a good understanding on the DLT

applications. The interviews were done in Finland and the interviewees were all Finnish nationals. The relevant working experience for each interviewee was greater than 15 years.

Interviewee list, March 2020			
Interviewee Job title	Current Organization	Field of Organization	Location
Member of the Executive Team	Provider of Data Services	Digital Processes	Helsinki, Finland
Business Developer	Corporate Bank	Transaction Services	Helsinki, Finland / Stockholm, Sweden
Head of Blockchain Center of Excellence	System vendor	Digital Solutions	Helsinki, Finland
Council	Law firm	Financial Markets Regulation	Helsinki, Finland
Adviser, Economist	Central bank	Payment Systems Department	Helsinki, Finland

Figure 6. Interviewee list

4.4 Interview results

4.4.1 Expert interview 1

The interviewee has previously acted as head of real estate and collateral information at a company that provides data services. Furthermore, the individual has been part of the executive teams of the national central securities depositories in Finland and Sweden.

In the first question the interviewer asked from the interviewee, could the blockchain-based distributed ledgers potentially change the way how dematerialised securities or physical securities are being handled in various regions. The interviewee emphasised that the traditional centralised model has its benefits and advantages, especially in the ecosystem where market participants are known to each other. Initially, 30 years ago when the current model in Finland was created, there were also discussions, whether local banks would have kept their own registers, as opposed to the centralised register. During those times, the centralised register was certainly a good option, particularly so that the market participants could be able to handle the increasing trading volumes, record transaction data and ownership data. When looking into the future, the interviewee however argued, now that the world has changed, whether these types of infrastructures that maintain owner data, do they merely exist for the issuer companies, regardless publicly listed or unlisted, or for housing companies. This type of owner data can be offered different ways, not only via centralised source of information. One must take into consideration in any potential future model that the EU regulation e.g. CSDR, wherein the prerequisite to offer any such service, is that you have a CSDR license. Since the national CSDs have offered and maintained these services, they are likely to continue offering these services via such licence even going forward. However, the interviewee was in the opinion that the

securities infrastructures, according to the CSDR could also be provided via distributed ledgers or distributed infrastructures.

In the next question interviewer asked whether blockchain-based DLTs could disrupt CSDs', CCPs' or local or global custodians' role in the securities/post-trade industry. The interviewee was in the opinion that most certainly it could. He also highlighted that the introduction of CSDR did already change the playing field quite dramatically by promoting the competition on the EU level. Alongside with Target 2 Securities, the CSDR, by adding the interoperability requirements to the national CSDs, allowing other CSDs to access, previously national and closed registers, increases the competition between CSDs. In practice, a competing CSD can download the ownership data i.e. end-investor's holdings to another system without possibility of charging any profit margins. The downloading of ownership data does not limit the possibility to download the data to the distributed model.

Essentially, the interviewee mentioned that the requirements for the centralised register has changed. One could wonder why non-listed companies' shares are not registered in the same data system. In Finland only, there are two to three hundred thousand non-listed companies, of which shares are in the physical form. Only a few hundred companies have dematerialised their shares from physical shares. In Sweden there is a dematerialised system for non-listed companies, currently consisting somewhat of 8000 companies' shares dematerialised, yet the model is centralised. The interviewee is questioning why not all types of companies shares, publicly listed companies' and non-listed companies' shares are not registered in the one single system. The interviewee claims that the roles of the incumbent participants in the securities industry will be challenged and potentially changed with the introduction of new technologies and regulations that have changed the playing field already.

The interviewee was in the opinion that the biggest challenge or obstacle in adopting or taking advantage of the DLT, or any new technology, is the opposition of the incumbent operating models and parties. The benefits that a new solution offers, must be distributed promptly to all parties involved. Hypothetically, if such a hybrid securities safekeeping model was created, a thorough cost – benefit analysis on the total investment, should be made. The hybrid model, in this context was a securities register, in which non-listed and listed companies' shares would be issued. The benefits should be distributed not only with the end-users but also end-investors. However, the interviewee pointed out that before any such system was developed, the boards of the companies should be committed for any such a development at the early stage, the development must be justified and explained to the members of the board. Based on the interviewee's previous experiences concerning DLT and blockchain projects, where the interviewee has been part of, many times the technology has been the key driver in the project and the not the business

rationale or the benefits to the organisation. Hence, the technology should not determine what must be developed, it should be the other way around. What are the industry needs that must be met, or problems that must be resolved, and only then look for an ideal solution and technologies? The defining the needs and problems is essential to achieve satisfactory outcome. The interviewee is of the opinion, that there is demand for individuals that understand bigger contexts and can define how the blockchain technology could be utilised in different ways. Furthermore, it was said that the blockchain enhancements and projects are costly and require lots of various resources from organisations that are involved in. According to the interviewee, in order for an organization to explore DLT or blockchain technology in different contexts, one must purchase a licence. For instance, Corda licence is quite expensive, and an organisation must have long-term funding available for any development to continue.

The interviewee is also of the opinion, that despite the system, or the technology being used, in the owner register solutions, operating participants and intermediaries want to know each other, or who are they dealing with. Therefore, a sole anonymity in the system is not necessarily the best option, hence the permissioned distributed ledger solutions, in this specific context, has possibilities to succeed in the long run. As a side note, the interviewee thought that the current securities industry solutions, allowing nominee registration i.e. anonymity, is not perhaps an optimal solution, when considered holistically. Yet once again, a comprehensive cost-benefit analysis must be made, prior to any shift to a new type of logic when replacing the incumbent market infrastructures. If the current centralised systems were regarded risky in the future, e.g. due to CSDs not meeting the development requirements or hackers were considered as a threat, then potentially there could be demand for more distributed operating models, increasing asset safety and stability. Yet, currently no such risk is very realistic.

In Finland, there are a couple of examples on the national level, such as DIAS trading platform of housing company's shares. DIAS uses distributed ledger technology, where the data is stored in a decentralised manner in the databases of the banks involved in the transaction. This increases the safety and reliability of the platform. DLT technology enables a decentralised database, making it easier for parties involved in the home trade to work together reliably and securely. Settlement latency, i.e. the moment from trade execution to exchange of ownership, was not seen as an issue for non-listed companies' shares or housing companies' shares.

The regulation will further increase transparency in many ways, yet this does not necessarily mean that transaction activity or ownership data must be open to the general public. According to the interviewee, only known participants should have access to the available system. The Findy ledger, as an example, was mentioned; which is a Finnish test network and

sandbox for pilots, locally governed and run decentralised identity ledger, wherein individuals and organisations' identity can be reliably ensured.

4.4.2 Expert interview 2

The second interviewee is one of the founding members of the Trade Finance digitalisation community Standardised Trust and participates in various working groups at the Finance Finland. Furthermore, the individual writes articles actively around the digitalisation and various other topics, just to mention some key characteristics of the interviewee.

The interviewee believed that surely blockchain technology could be utilised in safekeeping and trading Finnish companies shares, yet the technology used, does not particularly have to be blockchain technology, hence it could be alternative digital technologies as well. Also, when the ownership data is distributed between users, i.e. nodes the system can be easier approved by the participants, even without the competent authorities. The interviewee was also more in favour to the permissioned distributed ledger, as opposed to the permissionless ledger, whereby the data protection could entail some unresolved issues. Though, there are already solutions that have been built on the permissionless and public blockchain, and the transaction data is protected via encrypted access right data, that can only be accessed by the trade participants. Furthermore, this access right can be forwarded to a third party.

For instance, a Swedish start-up company has patented a DLT solution that certifies the origin of a document. This solution could potentially remove the need to handle the original copies of any document, which can be time-consuming, hence expensive and burdensome. More widely, if different ecosystems could switch paper document handling to a digital form via certified and secure way, this could fundamentally change our societies. The interviewee is of the opinion, that these type of digitalisation changes could be conducted gradually, not having to do a 'big bang'.

The interviewee believes, that perhaps the biggest advantage of the blockchain technology is, if developed properly, that the data manipulation is not possible afterwards. Should some node in the network try to modify or void data, it would not be approved by other nodes, hence would be rejected, and audit trail would automatically be achieved. The current market infrastructure systems function already today quite efficiently, enabling e.g. high-frequency trading, though transfer of ownership (i.e. securities and funds) only takes place after a couple of days. The interviewee is of the opinion that prior to the deployment of any new DLT solution, the scalability should be tested and approved.

Due to the nature of the blockchain technology, and the fact that the other nodes must approve the transaction of other nodes, limits the utilitisation possibilities. Having said, the interviewee noted, that the new consensus

mechanisms are continuously being developed by the industry, which are faster and can handle higher transaction volumes. For instance, techniques whereby the consensus code is run parallel, and nodes agree bilaterally and share calculation capacity information, and then execute bilateral transactions within milliseconds, without involvement of other nodes of the network. Once these bilateral transactions have been executed in full, then the bulk of transactions is exposed to the network approval and added to the blockchain.

The interviewee argues whether public and permissionless blockchains are realistic in handling all the needed activities of the securities industry, however they could still disrupt incumbent actors' business activities and duties. Consequently, the permissioned DLT model can be taken into consideration. Any fundamental switch to DLT based technology, needless to say, calls for an approval of the whole industry landscape. The governance model in such model would be likely be built together with the incumbent actors such as banks, but also the actors in the future model. Many activities or tasks that are rendered today, could be done by pre-programmed smart contracts.

Nowadays, there is no common platform for trading in Finnish non-listed companies' shares. The interviewee also thinks that it is of utmost important for an asset owner to be able to prove his ownerships of different companies' shares in a digital form. This facilitates better credit assessment, and more reliable credit decision can be made by the credit institution, contrary to practices followed nowadays. Such a DLT could also be utilised in keeping ownership records of different asset classes, not merely non-listed companies' shares, but also any equipment or machine that is worth something, hence consists of unused capital, and can still be used during its product life-cycle. A completely new, and more sustainable, ecosystem could be created in utilising DLT, with or without blockchain technology. The interviewee claims that the regulators are in favour of the technology. Due to the nature of the DL technology, regulator would not have to acquire interpretations from various market actors, instead they could rely on information recorded in the distributed ledger or database.

The interviewee mentioned that central banks in many countries are testing blockchain-based cryptocurrencies, such as stablecoins that are relative to some asset or basket of asset, and that can be redeemed in real currency or commodity. The positive outcome of such tests, could accelerate the integration of the DLT based solutions in securities industry, claims interviewee. In today's securities systems, there is a system risk, since from the moment when the trade is executed it takes normally 2 business days when the ownership of assets is exchanged. Also, the Finnish Tax Administration (FTA) is actively involved in facilitating various tests around the DLT solutions. For instance, they are exploring possibilities to offer an electronic identity solution to Chinese individuals, to ease up their business opportunities in establishing companies in Finland.

The interviewee mentioned the trust for the most common obstacle or challenge in the finance industry. The same goes for introducing any new technology such as DLT based solutions. The trust is of most importance in conducting any type of business, not only in the financial sector. The trust between various actors in the securities industry must not be lost. If most of the market participants start to rely on the DLT based solutions, then these solutions could be used in various contexts. Any new solution should be developed together with all the market participants. The interviewee was of the opinion that Bitcoin might have had some negative impact on the future of DLT based solutions, since they challenged the traditional banks, and disrupted their businesses to some extent. The interviewee also believed that blockchain solutions that are too disruptive have the most opposition by the incumbent actors. Any entity that possesses information of any kind, has power. The power should not be misused, or else it will deteriorate the trust, hence any new DLT solution could face opposition. The data must be protected diligently. For businesses public and permissionless blockchain is a 'swearword', said the interviewee.

The interviewee also sees that non-existence of the electronic identification (eID), or the fact that eIDs are not universal across the countries, is one the biggest bottlenecks for the banking industry to introduce new DLT solutions. The lack of interoperability between blockchain solutions has also been challenging, hence ISO committee has been established to resolve this issue. The open source code of the blockchain gives better changes for it to become successful. The interviewee pointed out, that if only the data from the legacy systems is put into the DLT based solution e.g. blockchain, it does not necessarily resolve the existing issues. Any such migration should be thoroughly analysed and evaluated, so that the benefits and synergies to the legacy systems are exponential in the future solution. The concepts, Internet of Things (IoT) and MyData.org were also mentioned.

4.4.3 Expert interview 3

The interviewee has experience of two decades in building innovative digital solutions within financial services and IT industry. Currently he is acting as a head of blockchain center of excellence at the Nordic IT system vendor, building smarter and inclusive societies with the help of distributed ledger technology.

According to the interviewee, the characteristic feature in the blockchain technology-based ledgers is that no centralised authority or source of trust is needed. The historical reasons in many instances have led in that direction that centralised ownership registers have dominated many ecosystems and industries. The interviewee is of the opinion that the

blockchain solutions, or DLT solutions more broadly, will replace some of the legacy systems, or even bring new ecosystems alongside. Having said that, the interviewee wanted to emphasise that, blockchain will not replace all the registers of ownership, since it is not suitable in all cases. In some instances, there must still be a competent authority that must approve the accuracy and integrity of the information.

However, commercialised registers, e.g. register of non-listed securities is very likely scenario that could materialise and become a reality. The interviewee suggests, that the incumbent CSD register might be a bit too expensive and non-flexible for non-listed companies shares, and it has not proven to be too popular. The blockchain-based system for non-listed shares, that has been piloted and tested, can detect and identify at any time, who the owner of the shares is, and which company's shares are in question. The identification of the true beneficial owner is fundamental feature of the system, or more broadly any digitalised system. Another critical element is the 'trading module', which keeps track about the trading activity, who has traded and with whom. What is also important with the piloted system, is that it prevents double-spending of the same asset, which is currently somewhat possible in the legacy systems.

The interviewee was not able to take a stance whether the CSDs role would be impacted or if their business could be disrupted with the introductions of distributed ledgers. Although, the register would not be dependent on CSD. There could potentially be 3 different type or roles in such DLT solution. The first role would be the wallet administrator i.e. keeping records of the ownership of assets. The second role would be the regulator, who monitors and observes the transactions executed. Taxation could be automated and integrated to the blockchain solution. The third role would be a juridical entity who manages the governance model of the network and the rulebook. Such a role could be fulfilled by a joint venture or cooperative, ideally by a non-profit cooperative.

The interviewee claims that the blockchain technology, DLT or any technology is not the critical denominator. What is of most importance is the governance model of the market infrastructure, which will then define the technology that should be utilised and further enhanced. If e.g. the operability of the trading is critical for the infrastructure, then the centralised model is maybe more optimal solution, as opposed to the distributed ledger solutions. Then on the other hand, if the role of regulator or tax authority is deemed important, then the DLT solutions could more efficiently bring the desired results. From the risk mitigation perspective, centralised infrastructures are not necessarily ideal, claims the interviewee. The settlement latency was also something that was regarded risky. The interviewee mentioned an atomic swap term, which means in this context, that the ownership of security or funds could be transferred immediately, simultaneously and irrevocably between trade participants.

The interviewee believes that the financial services sector and businesses are still at the early stage of developing real DLT based solutions in handling different asset classes. The basis of the infrastructures must still be developed, which is a prerequisite for any new ecosystem, before it can be deployed and become reality.

4.4.4 Expert interview 4

The interviewee has vast experience in capital markets, financial markets regulation and international securities markets, as well as in-depth understanding on post-trade industry and its regulation. The interviewee has also largely contributed to the securities industry efforts to utilise blockchain technology, and of any applicable legal and regulatory requirements affecting technology with various potential applications in the financial industry.

Based on his previous analysis the interviewee has come into the conclusion that there is no 'silver bullet' in the blockchain technology meaning that it does not enable to cut through the complexity of the current data systems and provide immediate solutions to the problems and issues at hand. According to the interviewee, there must always be someone who makes an investment to the new infrastructure. Since the securities infrastructures are deemed very critical and important for the functioning societies, there can be too many barriers that prevent investing to new technologies. In any infrastructures the legal rights and obligations must be adequately allocated, and someone should always be responsible for these. Furthermore, such critical systems involve issues of continuity and must be sufficiently robust in contingency situations as well.

According to the interviewee, there is a myth about the blockchain technology that it lasts for anything, and it cannot be broken. The reliable connections between nodes are essential and must be able to function in all circumstances. The interviewee sees that there is some potential in the blockchain technology. For the time being, the view prevails that prerequisite for blockchain or distributed ledger to be utilised in the securities industry is that it must be of the permissioned type. The interviewee is of the opinion that the Corda blockchain is an example of a feasible model.

According to the interviewee a potential DLT solution of the CSD system should consist of one essential CSDR requirement, hence the reliably calculate the number of shares in the system at all times. The number of shares in the securities accounts should always be equal to the number of issued shares, as stated in the trade register i.e. integrity of issue. In this type of DLT solution there should be a dedicated and centralised function, that would manage the governance and the rulebook of the system. It

could also be facilitated so that each participant would nominate a participant to the board that would then take care of the governance function. Nonetheless, this function would be of utmost importance. For instance, the function would be put into force and handle the situations, wherein a DLT participant went bankrupt or insolvency. From a technological point of view, this type of function could be developed. However, the interviewee stressed that no solution should be resolved merely from the technological perspective, also business and legal aspects should be taken into consideration.

Based on the current EU-level regulation, the listed company's shares should be issued in the CSD. Having said this, the interviewee pointed out, that this does not exclude an option, wherein a CSD would replace its current system(s) with DLT based system. Hence, the model would be regarded as the direct holding model, in which end-investors' accounts are registered directly to the securities system.

The interviewee sees similarities between distributed ledger solutions and the current Finnish CSD system. In the current model custodians, or so-called account operators (Finnish: Tilinhoitajat) administrate their own clients' securities accounts via their own account operator system, which is connected to the local CSD, Euroclear Finland. In the potential DLT or blockchain model each account operator would still operate their own clients' securities accounts. Additionally, they would have to carry out some maintenance duties, currently handled by the CSD. The shift from the incumbent CSD system to the DLT based system would not be massive. The roles in the future model would somewhat be comparable to the roles of today. Additionally, the interviewee is of the opinion, that already today, many of the important functions e.g. dividend payment is handled by the account operators, leaving the CSD with fewer responsibilities. Furthermore, the account operators have the juridical relationship toward the end-investors. In many EU-member states nominee registration is a market norm, meaning that the end-investor's identity is hardly ever registered at the CSD level, rather in the systems of the custodians, or in the systems down in the custody chain. This is an additional aspect comparable to a potential DLT model. The model is also known as layered model.

The interviewee is of the opinion, that it is costly to maintain multiple systems, due to the fact that some investors require a direct holding account, and some are allowed to have nominee registration at the CSD. Nonetheless, all CSD accounts must be replicated in the custody systems of the service provider. In the layered model the securities accounts, or custody accounts need to be reconciled by the service providers at all layers. For instance, if there are three layers in the custody chain, each service provider, i.e. layer in the chain, must reconcile their records on the regular basis, normally on the daily basis. Hence, the reconciliation process is one factor that generates costs. The interviewee is of the opinion, that if

the securities infrastructure was built on the distributed ledger model, the reconciliation process would be built-in function, hence it would be a cost-benefit for the whole industry.

The interviewee sees many incentives for competent authorities in the DLT safekeeping models, since in the nominee registration model, neither authorities nor the issuer company can obtain real-time end-investor owner information, or historical owner information. In the DLT model, authorities could always have a direct access to the owner information, and this is comparable to the direct holding model. The DLT model in the securities industry could also allow settlement of transaction in real-time, whereas today, settlement, exchange of assets, occurs normally within two business days after the trade is made. The interviewee is of the opinion, that the DLT models could be reality from the authorities' perspective already today. The prerequisite would then be, that the specifications for the future model, were conducted based on the current market regulation. Most certainly, the authorities are not the ones objecting the development of such securities infrastructure. However, the interviewee sees it problematic that there are many different contradicting views and understandings, how the future DLT based or blockchain-based securities model should be built and structured. Furthermore, when EU-officials are outlining any future regulations, potential DLT based models should be in higher focus.

The interviewee sees that it is essential that there is a possibility to revoke the transactions in the DLT-based model, since sometimes transactions must be revoked e.g. due to the legal requirement. Since the irrevocability is one of the fundamental features of the DLT based models, this shortcoming must be diligently looked into. In product areas where there is only a little regulation, it can be relatively easy to put the whole product ecosystem into blockchain, that is permissionless and public. The interviewee mentioned also the Findy ledger project, which is a Finnish sandbox for pilots, locally governed and run decentralised identity ledger, wherein individuals and organisations' identity can be reliably ensured. The basic idea is that, by utilising blockchain technology, the individual can manage what information about himself is disclosed to different instances i.e. an identity wallet.

The blockchain technology can be utilised to digitise different type of asset classes. The key benefit for the service providers would be, that they do not have to maintain a separate data storage about their clients, merely the relevant data to the context would be requested from the ledger, and maintained, and the information would be reliable. For instance, if an individual would apply for a mortgage from the bank, the individual would only allow the bank to view the necessary data from his identity wallet to the bank. The information disclosed to the bank would be assured by the relevant authorities. The interviewee highlighted that there are multiple use cases available in the DLT, however viability must be evaluated

thoroughly. The essential question is, does the data require to be stored in the distributed ledger, or can it be stored centrally, in more traditional way. The technology should never be the driving factor, rather how the problem at hand can be resolved in the best possible way, and what the value proposition is, and only then to choose the technology and the solution that is pursued. The interviewee is also of the opinion, that occasionally there is pressure in the organisations to create solutions based on new technologies without a true need for it.

4.4.5 Expert interview 5

The interviewee works as an advisor at the central bank and has in-depth experience in digitalisation and various technologies. Additionally, the interviewee has worked as an economist and a consultant well over 10 years and has published several publications primarily about digital currencies and crypto assets, but also about EU-directives that regulate the banking and payment systems and cybersecurity. Currently, the interviewee is focusing on the development of digitalisation in the Finnish financial sector and the payment systems. The interviewee takes part in the EU-level working group, that is examining the possibilities of the Fintech companies to utilise different technologies e.g. in the securities handling processes, also from the regulator's point of view.

In a general level, the interviewee does not believe that the basic logic of securities handling will change in the coming years. Potentially, distributed ledgers and the DLT can be used in some areas of the securities handling process, and by some service providers in the business sector, however the basic logic will remain the same. The interviewee does not see any disruptive elements in the DLT or blockchain technology

The interviewee would like to distinguish two levels when discussing about securities industry. First, what are the roles of the actors and second, how and what technologies do they utilise. The roles in this context are not merely functional but also juridical, meaning that actors are regulated and have responsibilities and obligations. The actors conduct particular functions in the securities infrastructure. It is important to understand, that there is a certain rationale and logic as to why the infrastructure has formed what it is today, and what type of roles do the different actors possess. For instance, a central counterparty was created to mitigate the counterparty risk. The interviewee is of the opinion, that the incumbent actors and roles do not change, merely the way they carry out their functions, hence different technologies can be used.

When the interviewee reads publications about the DLT or blockchain technology, the basic assumption often is, that there is a problem that must be resolved. The interviewee is of the opinion that the current actors e.g. CSDs and CCPs are already solutions to a problem discussed in these publications. Furthermore, the interviewee is of the opinion, that there are

no new real problems that should be resolved, perhaps only the concentration of risks due to a few actors in the current infrastructure, yet there is no evidence to support this assumption. The interviewee is confident that the incumbent actors are pursuing to mitigate the risks to secure that the functionality of the securities infrastructure even going forward. The blockchain technology does not contain any specific feature or driving force that would disrupt the current securities infrastructure. For instance, if there is need to increase transparency, then authorities could be granted the access to the industry actors' interfaces. The databases can also be duplicated, and have been duplicated for many years, via other technologies than blockchain technology.

The interviewee is of the opinion, that different cloud solutions and application programming interface i.e. API solutions have much more potential than DLT or blockchain solutions. Cost efficiency is one of the main reasons why existing systems are built like they appear today. In the distributed ledger technology, much of the development focuses on how to reconcile assets, it comes with the cost. Once the data is in one location the reconciliation can be done faster and cost-efficiently. Another weakness, that the interviewee sees in the DLT solutions is the transparency aspect, which can create some issues from the data protection perspective, and the handling of the data is more difficult. The interviewee points out that there has been decentralised databases for decades, and blockchain technology is not particularly innovative solution.

On the other hand, the interviewee is of the opinion that the approach of the blockchain technology to solving problems has been different. The structure of the ledger has been rethought from the outset. Furthermore, the interviewee thinks that it could be that the blockchain technology itself will not be widely utilised, however the ideas of the characteristic features and the fundamental functionalities are looked into. For instance, chaining several transactions into one to secure integrity could be one characteristic feature. Additionally, from the data integrity point of view, encryption logic of the blockchain technology could be analysed in greater detail, so that the data could not corrupted and manipulated afterwards.

The interviewee has a great interest in understanding the reasons why blockchain technology-based development projects and use-cases have disappeared, discontinued or have not achieved the desired benefits. Additionally, the interviewee is of the opinion that there is no large-scale of publications, or any publications, on this topic. For any new technology to be introduced and deployed, it is not enough to do it another way. Ultimately, the benefits of the new technology need to be much greater in order for it to be deployed by the organisation. Often the cost pressure and the risks of switching to the new technological solution are overwhelming, and businesses tend to continue maintaining their legacy systems, since 'it gets the job done'. Could even be that the blockchain technology and DLT solutions are lacking bigger investments by the

incumbent actors, which is why there are no real-life examples in production in the securities industry.

5 RESEARCH FINDINGS

The empirical research suggests that any new technology e.g. DLT or blockchain technology, should never be the driving factor. The technology should never determine what needs to be pursued and developed. It is important to define the industry needs that must be met, or problems that must be resolved, and only then look for an ideal governance model, infrastructure and technologies to be utilised. Defining the problem at hand, and how it could be resolved in the most optimal way, evaluate the value proposition of the new technology, and only then choose the desired solution to go forward. In the Finnish securities industry the incumbent actors, the central securities depository and the local custodian banks, and central counterparties more broadly, have offered and maintained their services for many years, and they are likely to continue offering these services for many years to come. The current market infrastructure satisfies the industry needs successfully, even if the transfer of ownership only takes place after a couple of days. According to the interviewees, neither distributed ledger technology nor the blockchains bring any disruptive elements to this equation. There are available other technologies e.g. cloud technology and API's that could resolve these known inefficiencies better. The limitation of the blockchain technology to handle large transaction volumes was raised as one of the fundamental problems the prevents the industry to utilise the technology.

According to the research, in the DLT-driven projects, sometimes the technology has been the key driver, and the not the business rationale or the value proposition to the business. The research suggests that the lack of investments and the opposition of the incumbent industry actors have also held back from DLT-based and blockchain solutions being used more broadly, there must always be someone who makes an investment to the new infrastructure. Since the securities infrastructures are deemed critical and important for functioning societies, this fact may have also hindered the industry from investing in new technologies like blockchain technology. Often the cost pressure, and the risks of switching to a new technological solution, force businesses to continue maintaining and upgrading their legacy systems, since 'it gets the job done'.

Based the research, the benefits that any new technological solution brings along, should always be distributed promptly to all involved parties. A profound cost – benefit analysis of the total investment should always be made. If only the data from the existing data systems is put into the DLT based solution, it does not necessarily resolve the existing problems.

If the current centralised system was regarded more riskier going forward, for instance if the CSDs were not able to meet the regulatory requirements or e.g. computer hackers were considered as a threat, then possibly, there could be demand for more distributed operating models. Yet again, the research does not suggest any such a risk to be a realistic in the near future. Based on the research findings, the existing infrastructures and the actors, particularly CSD, are already resolving the problem, although the requirements of the centralised register have changed over the years, e.g. recently due to the implementation of the CSDR. The historical reasons in many instances have led to the direction that the centralised ownership registers have been dominating in many jurisdictions, despite that the securities infrastructures, according to the CSDR, could also be run via distributed ledgers or distributed infrastructures. Furthermore, the research findings suggest that the lack of trust between participants is the most common obstacle or challenge in the finance industry. Too disruptive technological solutions could raise opposition among market participants.

The infrastructures must analyse, does the data need to be stored in the distributed ledger, or can it be stored centrally, in more traditional way. What is of most importance is the governance model of the market infrastructure, which will then define the technology that should be utilised and further enhanced. The research findings suggest that there are no new real problems that should be resolved, perhaps only the concentration of risks due to a few actors in the current securities infrastructures, yet there is not enough evidence to support this assumption. Occasionally, organisations tend to develop new solutions based on new technologies without a true need for it.

The research suggests that it could be feasible to utilise blockchain-based model for the non-listed companies' shares, which are mostly held in the physical form here in Finland. In Finland only, there are two to three hundred thousand non-listed companies of which shares are in the physical form. Only a few hundred non-listed companies have dematerialised their shares. It is important for an asset owner to be able to prove his ownerships of different companies' shares in a digital form. For instance, dematerialising physical shares could facilitate better credit assessment. Consequently, the credit institution could make reliable credit decision with less effort.

6 CONCLUSION

The distributed ledger technology and the blockchain have become a reality or close to reality in many contexts, thanks to use cases and experiments run by various industries. The banking sector is disrupted by the virtual currencies, and the blockchain technology. The securities industry service providers have analysed and explored the potential use cases of the DLT and blockchain technology, and could it be used for instance in safekeeping of different assets classes. It is difficult, if not impossible to determine the extent of the disruption potential of the DLT-based solutions for securities industry. If the regulatory landscape changed fundamentally, for instance if the securities lending and other the derivatives were prohibited, it could have an impact on safekeeping of securities in different jurisdictions. Any fundamental switch to a DLT based technology calls for an approval of the whole industry. Although, not many development projects have materialised. However, if the DLT and blockchain-based solutions prove to be successful in the financial sector more broadly, and the efficiency and feasibility is improved, securities industry actors may have to revisit this technology. Potentially there could be a new playground with completely new actors. As a suggestion for future research, it would be useful for other organisations to understand the reasons why businesses have closed their projects down.

Bitcoin and Ethereum have proved that the blockchain technology is worthwhile examining in businesses, wherein the transactions occur, and ownership of asset changes, and entitlements must be recorded. The author of the thesis trusts that the thesis presents the readiness level of the securities industry in the utilising the blockchain technology. Possibly the DLT applications may accommodate the financial services sector to become more efficient and trustworthy in the future. The regulators, government officials, supervisors and tax authorities should pay attention to the phenomenon and take a stand, not only concerning cryptocurrencies, but also in developing solutions for other asset classes and purposes.

The observations of this research suggest how DLT-based solutions could be exploited and under what preconditions and instances. The research also pursues to explain the rationale why organisations refrain from utilising this technology in their functions and infrastructures. Surely, DLT and blockchain are phenomena that deserve further research. Lastly, the author hopes that the thesis will inspire scholars and individuals to explore distributed ledger technology, not only in the financial services and banking sectors, but also in other industries.

LIST OF REFERENCES

Ashar, J. (2019). HSBC to explore DLT in Asia. 13 November 2019. Retrieved 2 May 2020 from <https://www.theglobaltreasurer.com/2019/11/13/hsbc-to-explore-dlt-in-asia/>

Belin, O. (n.d.). The Difference Between Blockchain & Distributed Ledger Technology. Retrieved 2 May 2020 from <https://tradeix.com/distributed-ledger-technology/>

Bell, J. (2005). Doing Your Research Project: A Guide for First-Time Researchers in Education, Health and Social Science (4th Edition). Berkshire: Open University Press

Beyer, S. (2018). What Is the Difference Between Blockchain and DLT?. 23 August 2018. Retrieved 2 May 2020 from <https://blocktelegraph.io/blockchain-before-bitcoin-history/>

Bryman, A. and Bell, E. (2011). Business research methods. Oxford: Oxford University Press, USA. Retrieved 2 May 2020 from https://books.google.fi/books?hl=fi&lr=&id=J9J2DwAAQBAJ&oi=fnd&pg=PP1&ots=GLhChcbWBK&sig=zd84qcnYARvLDr8VdR02DdKp3cM&redir_esc=y#v=onepage&q&f=false

Cherry, K. (2020). Introduction to Psychology Research Methods. 16 April 2020. Retrieved 2 May 2020 from <https://libguides.usc.edu/writingguide/theoreticalframework>

Chamber of Digital Commerce 2017, 12 Use Cases of Smart Contract, Retrieved 21 January 2018 from <http://www.the-blockchain.com/docs/Smart%20Contracts%20-%2012%20Use%20Cases%20for%20Business%20and%20Beyond%20-%20Chamber%20of%20Digital%20Commerce.pdf>

Chandler, S. (2019). What Is the Difference Between Blockchain and DLT?. 2 August 2019. Retrieved 2 May 2020 from <https://cointelegraph.com/news/what-is-the-difference-between-blockchain-and-dlt>

Cision PRNewswire (2017). Calastone to Bring Mutual Funds Market Onto Blockchain in 2019. Press release 4 December, 2017. Retrieved 20 January 2018 from <https://www.prnewswire.com/news-releases/calastone-to-bring-mutual-funds-market-onto-blockchain-in-2019-661770823.html>

Clark, J. (2018). Blockchain Initiative of the Year 2018: The Nominees. 29 March 2018. Retrieved 2 May 2020 from <https://www.fnlonon.com/articles/blockchain-initiative-of-the-year-2018-the-nominees-20180325>

Coindesk (2015). World Economic Forum Survey Projects Blockchain 'Tipping Point' by 2023. Retrieved 2 May 2020 from <https://www.coindesk.com/world-economic-forum-governments-blockchain>

Coindesk (2017). Vanguard Taps Symbiont's Private Blockchain for Index Fund Data. Retrieved 20 January 2018 from <https://www.coindesk.com/vanguard-taps-symbionts-private-blockchain-for-index-fund-data/>

Committee on Capital Markets Regulation (2019). Blockchain and Securities Clearing and Settlement. Retrieved 2 May 2020 from https://www.capmksreg.org/wp-content/uploads/2019/04/CCMR_statement_Blockchain_Securities_Settlement-Final.pdf

Committee on Payments and Market Infrastructures (2017). Distributed ledger technology in payment, clearing and settlement. An analytical framework, February 2017. Retrieved from 2 May 2020 <https://www.bis.org/cpmi/publ/d157.pdf>

Corda (2019). Corda v Hyperledger v Quorum v Ethereum v Bitcoin. Retrieved 2 May 2020 from <https://www.corda.net/blog/corda-v-hyperledger-v-quorum-v-ethereum-v-bitcoin/>

Credit Suisse (2018). Credit Suisse and ING execute first live transaction using HQLAx securities lending app on R3's Corda blockchain platform. Press release 1 March 2018. Retrieved 2 May 2020 from <https://www.credit-suisse.com/about-us/news/en/articles/media-releases/cs-and-ing-execute-first-live-transaction-201803.html>

Curran, B. (2020). What is a Merkle Tree? Beginner's Guide to this Blockchain Component. 18 April 2020. Retrieved 2 May 2020 from <https://blockonomi.com/merkle-tree/>

Deloitte (2017). 5 blockchain use cases in financial services, Powering innovation in the industry. Retrieved 29 October 2017 from <https://www2.deloitte.com/nl/nl/pages/financial-services/articles/5-blockchain-use-cases-in-financial-services.html>

Edwards, R. & Holland, J. (2013). What is qualitative interviewing? What is Qualitative Interviewing?. London: Bloomsbury Academic. Retrieved 2 May 2020 from <https://www.bloomsburycollections.com/book/what-is-qualitative-interviewing/ch1-what-do-the-key-terms-used-about-qualitative-interviews-mean>

European Securities and Markets Authority (2016). Discussion paper on the Distributed Ledger Technology applied to Securities Markets. Consultation Paper 2 June 2016. Retrieved from 2 May 2020 <https://www.esma.europa.eu/document/discussion-paper-distributed-ledger-technology-applied-securities-markets>

Frankenfield, J. (2019). Smart Contracts. 8 October, 2019. Retrieved 2 May 2020 from <https://www.investopedia.com/terms/s/smart-contracts.asp#ixzz54opS1v9Q>

Greenwich Associates (2019). Steampunk Settlement. Deploying Futuristic Technology to Achieve an Anachronistic Result. Retrieved 2 May 2020 from

<http://perspectives.dtcc.com/downloads/whitepaper/steampunk-settlement-deploying-futuristic-technology-to-achieve-an-anachronistic-result>

Gupta, N. (2019). Why Hyperledger Fabric will Win Against R3 Corda and Quorum?. Blog publication 30 August 2019. Retrieved 2 May 2020 from https://akeo.tech/blog/blockchain-and-dlt/enterprise-blockchains-hyperledger-fabric-corda-quorum/?utm_source=Medium&utm_medium=Neetablog&utm_campaign=blogpost

Harwood-Jones, M. (2016). Blockchain and T2S: A potential disruptor. Retrieved 29 October 2017 from https://www.sc.com/BeyondBorders/wp-content/uploads/2016/06/2016-06-16-BeyondBorders-Report-SCB_Nema_Block-Chain-Paper-Final.pdf

Iansiti, M. & Lakhani, K. (2017). The Truth About Blockchain. *Harvard Business Review January–February 2017 Issue*, 118-127. Retrieved 2 May 2020 from <https://hbr.org/2017/01/the-truth-about-blockchain>

Jenny Cieplak & Simon Leefatt, April 2017, “Smart Contracts”: A Smart Way to Automate Performance, Retrieved 28 January 2018 from <https://www.georgetownlawtechreview.org/smart-contracts-a-smart-way-to-automate-performance/GLTR-04-2017/>

Kolehmainen, A. (2017). Lohkoketju mullistaa asuntokauppaa Suomessa. Tiivi. Retrieved 2 May 2020 from <https://www.tivi.fi/uutiset/lohkoketju-mullistaa-asuntokauppaa-suomessa/b7787731-e7a0-358e-9bde-ff160673e406>

Majaski, C. (2019). Distributed Ledgers. 26 April, 2019. Retrieved 20 January 2018 from <https://www.investopedia.com/terms/d/distributed-ledgers.asp>

Middleton, F. (2019). Reliability vs validity: what’s the difference? 3 July 2019. Retrieved 2 May 2020 from <https://www.scribbr.com/methodology/reliability-vs-validity/>

Morris, N. (2018). R3 unveils Corda Enterprise, Accenture picks blockchain winner. Retrieved 2 May 2020 from <https://www.ledgerinsights.com/corda-enterprise-accenture-blockchain-winner/>

Mougayar, W. (2016). Regulation a Doubled-Edged Sword for Blockchain Clearing and Settlement. 21 April 2016. Retrieved 2 May 2020 from https://www.finyear.com/Regulation-a-Doubled-Edged-Sword-for-Blockchain-Clearing-and-Settlement_a35918.html

Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. Retrieved 2 May 2020 from <https://bitcoin.org/bitcoin.pdf>

Nasdaq (2017). SEB and Nasdaq to Build Blockchain for Swedish Mutual Fund Market. Press release 27 September 2017. Retrieved 29 October 2017 from <https://globenewswire.com/news-release/2017/09/27/1133529/0/en/SEB-and-Nasdaq-to-Build-Blockchain-for-Swedish-Mutual-Fund-Market.html>

Natarajan, H., Krause, S.K. & Gradstein, H.L. (2017). Distributed Ledger Technology (DLT) and blockchain (English). FinTech note; no. 1. Washington, D.C.: World Bank Group. <http://documents.worldbank.org/curated/en/177911513714062215/Distributed-Ledger-Technology-DLT-and-blockchain>

National Settlement Depository (2016). Why Russia's CSD Believes Blockchain is a 'Blue Ocean' Opportunity. Retrieved 29 October 2017 from <https://www.nsd.ru/en/press/pubs/index.php?id36=629725>

Nordea (2018). Suomalaisyrietykset digitalisoivat listaamattomien osakkeiden kaupankäynnin ja osakashallinnan lohkoketjun avulla. Retrieved 2 May 2020 from <https://www.nordea.com/fi/media/uutiset-ja-lehdistotiedotteet/News-fi/2018/2018-11-28-suomalaisyrietykset-digitalisoivat-listaamattomien-osakkeiden-kaupankaynnin-ja-osakashallinnan-lohkoketjun-avulla.html>

PwC Financial Services Institute (2017). Blockchain in financial services. Retrieved 29 October 2017 from <https://www.pwc.com/us/en/financial-services/research-institute/blockchain.html>

Rosic, A. (2017). What Is Hyperledger? [The Most Comprehensive Step-by-Step Guide!]. Retrieved 2 May 2020 from <https://blockgeeks.com/guides/hyperledger/>

Rosic, A. (2017). Smart Contracts: The Blockchain Technology That will Replace Lawyers. Retrieved 21 January 2018 from <https://blockgeeks.com/guides/smart-contracts/>

Rosic, A. (2016). 5 Blockchain Applications That Are Shaping Your Future. Retrieved 28 January 2018 https://www.huffingtonpost.com/ameer-rosic/5-blockchain-applications_b_13279010.html

Rouse, M. (2016). distributed ledger technology (DLT). 3 October, 2016. Retrieved 2 May 2020 from <https://searchcio.techtarget.com/definition/distributed-ledger>

Symons, P., Peeters, I., Yli-Jaakkola, J., Delhez, A-M., Scott, A., Mead, J., & Kingsley, B. (2016). Blockchain settlement, Regulation, innovation and application. Regulatory and legal aspects related to the use of distributed ledger technology in post-trade settlement. Euroclear and Slaughter and May. <https://www.euroclear.com/dam/PDFs/Blockchain/MA3880%20Blockchain%20S&M%209NOV2016.pdf>

Tieto (2018). Asiakastieto, Nordea, OP Ryhmä, Privanet ja Tieto digitalisoivat listaamattomien osakkeiden kaupankäynnin ja osakashallinnan lohkoketjun avulla. Retrieved 2 May 2020 from <https://www.tieto.com/fi/uutishuone/kaikki-uutiset-ja-tiedotteet/yritysuutiset/2018/11/asiakastieto-nordea-op-ryhma-privanet-ja-tieto-digitalisoivat-listaamattomien-osakkeiden-kaupankaynnin-ja-osakashalli/>

UK Government (2016) Distributed Ledger Technology: beyond block chain. Retrieved 2 May 2020 from

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf

Velde, J.V.d., Scott, A., Sartorius, K., Dalton, I., Shepherd, B., Allchin, C., Dougherty, M., Ryan, P. & Rennick, E. (2016). Blockchain in Capital Markets. The Prize and the Journey. Euroclear and Oliver Wyman. <https://www.oliverwyman.com/content/dam/oliver-wyman/global/en/2016/feb/BlockChain-In-Capital-Markets.pdf>

The World Bank Group and The United Nations Office on Drugs and Crime (UNODC). The Stolen Asset Recovery Initiative (StAR) (2014). G20 High-Level Principles on Beneficial Ownership Transparency. Retrieved 2 May 2020 from https://star.worldbank.org/sites/star/files/g20_high-level_principles_beneficial_ownership_transparency.pdf

The World Bank Group (2018). Countries in Europe and Central Asia Can Provide Better Opportunities and Services for Citizens by Leveraging Blockchain Technologies. Press release 8 May 2018. Retrieved 2 May 2020 from <https://www.worldbank.org/en/news/press-release/2018/05/08/countries-in-europe-and-central-asia-can-provide-better-opportunities-and-services-for-citizens-by-leveraging-blockchain-technologies>

The World Bank Group (2018). Cryptocurrencies and Blockchain. Europe and Central Asia Economic Update. Retrieved 2 May 2020 from <https://openknowledge.worldbank.org/bitstream/handle/10986/29763/9781464812996.pdf>

Wulf, K. (2017). Blockchain Innovations for Private Investment Funds. 8 March 2017, Retrieved 28 January 2018 from <https://medium.com/@wulfkaal/blockchain-innovation-for-private-investment-funds-8fe8be024764>

Appendix 1

INTERVIEW QUESTIONS TEMPLATE IN FINNISH:

Voivatko lohkoketjuteknologiaan perustuvat hajautetut tilikirjat muuttaa arvo-osuuksien tai fyysisten arvopapereiden käsittelyä Suomessa, Euroopassa tai maailmanlaajuisesti?

Voivatko nämä hajautetut tilikirjat muuttaa arvopaperikeskusten, keskusvastapuolten ja säilyttäjäpankkien roolia tulevaisuudessa?

Jos voivat, niin miten?

Jos eivät, niin mitä näet suurimmiksi esteiksi tai rajoitteiksi lohkoketjuteknologiaan perustuvien hajautettujen tilikirjojen käyttöönottoon?

Täytyykö lohkoketjun olla suljettu ja luvanvarainen? Vai voiko se olla avoin kaikille? Minkälaisia rooleja näet tarpeellisena?

Hajautetut tietokannat, täytyykö teknologian perustua lohkoketjuteknologiaan? Mitä vaihtoehtoisia teknologioita hajautetuille tilikirjoille on olemassa?

Voitaisiinko hajautetulla tilikirjoilla vähentää arvopapereiden säilytykseen ja selvitykseen liittyviä operatiivisia riskejä (selvitys ja likviditeetti), säilytysketjun riskejä, lisätä omaisuuden suojaa, tietosuojaa, lisätä läpinäkyvyyttä liikkeeseenlaskijoille, loppusijoittajille ja valvojille? Pienentää kustannuksia selvitys-/säilytysketjussa, lyhentää selvitysaikojä/latenssia ja lopuksi vähentää omaisuustietojen manipulointia?

Missä yhteyksissä hajautettuja tilikirjoja voitaisiin hyödyntää selvitys- ja säilytysalalla? Mitä toimintoja finanssialalla tai selvitys- ja säilytystoiminnoissa näet helposti hyödynnettäväksi (i.e. low hanging fruits)?

INTERVIEW QUESTIONS TEMPLATE IN ENGLISH:

Could blockchain-based distributed ledgers change the processing of dematerialized securities or physical securities in Finland, in Europe or globally?

Could blockchain-based DLTs disrupt CSDs', CCPs' or local or global custodians' role in the securities industry? If yes, how and why? If not, why not?

Do DLTs have to be underpinned by the blockchain technology?

Do DLTs have to be private permissioned or can they be public, permissionless? If yes - how and why? If not, what restrictions or limitations are there?

Could distributed ledger applications in securities safekeeping and settlement yield benefits by reducing the operational (settlement and liquidity) and custody (intermediary) risk, increase asset safety/data security, increased transparency to issuers, end-investors and regulators, lower costs, decrease settlement latency, and finally reduce intervention of recordkeeping?

What are the biggest challenges and limitations in adopting DLTs?

In which instances could DLT adaptations be utilised in the securities industry? Can you see 'low hanging fruits'?