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ABSTRACT

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Abstract

Since its creation, blockchain technology has received plenty of speculation. Nevertheless, potential use cases have been identified in various industries worldwide for blockchain technology. One of the first industries to recognise the potential for this emerging technology was the banking and finance industry. However, large scale implementations are limited still today. The technology is still in its development phase, and not all benefits and challenges have yet been identified. The theory presents that the benefits of blockchain technology are efficiencies and costs benefits. For the challenges, the theory focuses mostly on the technological and regulatory challenges of blockchain technology in banking and finance. The current literature on the subject has not examined real-life application thoroughly. Therefore, the current knowledge on the topic is still highly theoretical and speculative and requires more actual experience-based data.

This research aims to primarily analyse the empirical data through semi-structured interviews from blockchain and banking and finance professionals. The collected data will introduce benefits, challenges and future outlook of blockchain technology in banking and finance, based on real-life experience or expectations on blockchain-based applications within the industry. The current trends of banking and finance are also discussed to better reflect blockchain technology to the industry requirements

The outcome of the research provides a realistic perspective of the benefits, challenges and current outlook on blockchain technology in the industry. The assumed benefits reflect well with the current literature, as the core benefits assumed were improved efficiency and cost savings. This research discovered that the current challenges focus primarily on building a network and not the technical challenges of blockchain technology as the contemporary literature implies. The empirical data suggests that it is crucial to first create solid foundations for blockchain technology to ease a more wide-scale adaption. Hence, one of the most important blockchain applications identified was the digital identity network. Once the network is operational, it creates the opportunity for other prominent blockchain-based applications, such as trade financing, to receive broader acceptance in the industry. However, the future of blockchain technology in banking and finance is still relatively uncertain. But it could be stated that it is probable that there will be some use cases for blockchain, but perhaps it is not as disruptive as preliminary speculated, at least in the short-term.

Key words	Blockchain, Fintech, Banking, Finance, Digital Identity

TIIVISTELMÄ

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Tiivistelmä

Spekulaatiot lohkoketjujen toimivuudesta ja käyttökelpoisuudesta ovat olleet yleisiä heti lohkoketjujen syntymästä lähtien. Siitä huolimatta lohkoketjuteknologian mahdollisuudet eri toimialoilla on tunnistettu maailmanlaajuisesti. Yksi ensimmäisistä toimialoista, mikä tunnisti tämän teknologian potentiaalin, oli pankki- ja rahoitusala. Laajan mittakaavan toteutukset alalla ovat kuitenkin vielä rajallisia. Teknologia on edelleen kehitysvaiheessa, eikä kaikkia etuja ja haasteita ole vielä tunnistettu. Tehokkuus sekä kustannus säästöt ovat esitetty lohkoketjujen hyödyiksi teorian näkökulmasta. Teorian mukaan lohkoketjujen päähaasteet liittyvät teknologisiin ja lainsäädännöllisiin haasteisiin. Aihetta käsittelevissä nykyisessä kirjallisuudessa ei ole tutkittu tosielämän sovelluksia perusteellisesti. Siksi kirjallisuuteen pohjautuva ajankohtainen tieto aiheesta on edelleen erittäin teoreettista ja spekulatiivista ja vaatii enemmän empiiristä tutkimusta.

Tämän tutkimuksen tarkoituksena on empiirisen aineiston pohjalta korostaa dataa, joka on kerätty teemahaastatteluja hyödyntäen lohkoketjun sekä pankki- ja rahoitusalan ammattilaisilta. Kerätty empiriatieto tässä tutkimuksessa tuo esiin lohkoketjujen etuja, haasteita ja tulevaisuuden näkymiä pankki- ja rahoitusalalla. Nämä tiedot perustuvat tosielämän kokemuksiin tai odotuksiin lohkoketjusovelluksista.

Tutkimuksen tulos tarjoaa realistisen näkökulman lohkoketjujen eduista, haasteista ja tulevaisuuden odotuksista pankki- ja rahoitusalalla. Lohkoketjujen hyödyiksi identifioitiin pääsiasiassa tehokkuus ja kustannussäästöt. Tutkimus havaitsi, että nykyiset ongelmat ovat ensisijaisesti verkoston rakentamiseen liittyviä, eivätkä lohkoketjujen teknisiin haasteisiin, kuten viimeisin kirjallisuus viittaa. Empiria viittaa myös siihen, että on ensiarvoisen tärkeää luoda ensin vankka perusta lohkoketjuille, jotta helpotettaisiin laajemman käyttöönoton mahdollisuuksia alalle. Siksi yksi tärkeimmistä tunnistetuista lohkoketjusovelluksista oli digitaalinen identiteettiverkosto. Kun verkosto on toiminnassa, se luo mahdollisuuden muille lupaaville lohkoketjupohjaisille sovelluksille, saada laaja-alaisempi implementaatio pankki- ja rahoitusalalla.Vaikka lohkoketjujen tulevaisuus alalla on melko epävarmaa, voidaan todeta, että on todennäköistä, että lohkoketjut löytävät tulevaisuudessa ainakin joitain käyttökohteita, mutta teknologia ei ehkä ole yhtä mullistava kuin alustavasti spekuloitu, ainakaan lyhyellä aikavälillä.

Avainsanat	Lohkoketju, Fintech, Pankki ja Finanssisektori, Digitaalinen Identiteetti

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Economics

BLOCKCHAIN TECHNOLOGY BENEFITS, CHALLENGES AND CURRENT OUTLOOK IN BANKING AND FINANCE

Master's Thesis
in Accounting and Finance

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GLOSSARY

AI	Artificial intelligence
AML	Anti-Money Laundering
AML/CFT	Anti-Money Laundering / Combating the Financing of Terrorism
API	Application Programming Interface
Blockchain	a decentralised peer-to-peer network or a digital distributed network
Corda	A permissioned blockchain platform developed by the company R3
DAO	Decentralised Autonomous Organisation
DIAS	A Finnish digital real estate trading platform
Findy	Digital identity platform based on blockchain technology
Fintech	Financial technology (Fintech) is a new technology that seeks to improve and automate the delivery and use of financial services.
GDPR	General Data Protection Regulation
GSMA	Global System for Mobile Communications Association
IT	Information Technology
KYC	Know Your Customer
Proof-Of-Work	A consensus mechanism used on permissionless blockchains such as Bitcoin
Smart contract	A self-executing digital contract that operates through blockchain technology
SME	Small and medium-sized enterprises
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TPS	Transactions per second

1 INTRODUCTION

1.1 Introduction to the thesis

The banking and financial industry has a crucial role in the global economy. Banks' primary purpose is to be a trusted intermediary for companies and the public to deposit, withdraw, and transfer value. This industry's fundamental principles have remained the same for centuries since the initiative was first created. (Vesna et al. 2015, 11) Traditionally the banking and finance industry has been secure, stable and profitable for businesses. Also, it could be argued that the financial sector is known to be conservative towards innovation and adopting new technologies within their core businesses. In recent years this perception has changed drastically. The industry has become more volatile for competition as new emerging technologies, and financial technology firms have flooded into the industry. (Wewege & Thomsett, 2020.)

During recent years, there has been a lot of speculation around the possible changes involving the financial industry's future. One aspect seems to be clear: banking and finance are already experiencing digitalisation, and new emerging technologies and fintech are entering the sector, whether digitalisation, artificial intelligence, big data, or automation. Accenture (2017, 2) presented that one of the most frequently discussed subjects regarding banking change and innovation is blockchain technology. Blockchain technology first sparked up plenty of interest around 2016 because of its connection to the well-known and perhaps controversial cryptocurrency Bitcoin. Cryptocurrencies, and especially Bitcoin, created a lot of conversation worldwide. Cryptocurrencies raised plenty of questions, and no one seemed to understand how cryptocurrencies work and what type of technology operates behind them. Besides, cryptocurrencies received speculation whether they are just a quick fad or the monetary system's future as we know it. Today understanding of cryptocurrencies have increased, and they seem to have reached a more permanent position in today's society. However, there are still plenty of uncertainties regarding them from legal and public opinion.

The interest in Bitcoin and other cryptocurrencies quickly shifted towards the enabling technology, blockchain technology. The technology received plenty of praise for its potential to disrupt and create fundamental changes within various industries, from healthcare to finance (Innovecs 2020). According to a survey conducted by Accenture, 90% of the participating banking executives said their bank is testing the possibilities that blockchain technology could offer to payments (Accenture 2017, 3). Nevertheless, blockchain technology is still young, and its actual impact on various industries are still speculated. For instance, a respected Silicon Valley capitalist, Marc Andreessen stated, that blockchain technology is the most important invention since the internet itself was invented (Crosby et al. 2016, 8). On the other hand, Filippi and Wright (2018, 46) expressed that comparing blockchain technology to the internet is misleading since the technologies and their use cases are different.

Satoshi Nakomoto invented blockchain technology in 2008. Nakamoto created the technology after the financial crisis resulted in a lack of trust in the sector (Antonopoulos 2015, 3). The attractiveness of blockchain technology comes from its credibility, openness, sharing and unforgeability. At its core, blockchain technology is a globally shared digital distributed ledger or a database. The banking and finance industry and other industries are currently studying and investing heavily in blockchain technology to unlock its disruptive potential. (Qingquan 2021, 1.) Polyviou et al. (2019, 1-2) believe that blockchain technology has the potential to solve many long-lasting problems in the industry. They believe that blockchain technology can enhance information credibility and information sharing in various banking operations by utilising blockchain decentralised network architecture.

Despite the interest generated behind blockchain technology in banking and finance, real-life operational applications of blockchain-based solutions are still limited within the industry. Due to the scarcity of operational use cases, the current research on blockchain technology lacks experience-based studies. Therefore, the existing literature on blockchain-based applications is still rather speculative. Furthermore, the research on blockchain technology in banking and finance is still relatively young compared to many other emerging technologies. Most papers related to the topic have been published in the past few years. This thesis aims to provide more insights into experiences over real-life blockchain implementations and complement or challenge existing literature.

1.2 Research questions and objectives

This thesis investigates blockchain technology's current development in the banking and financial sector. This thesis aims to display the benefits and challenges of blockchain technology in the banking and finance industry. Regarding the first objective, the goal is to contribute to the current academic literature in either complementing or challenging the previous findings through empirical research. In addition, if new benefits or challenges are identified, any new results are highlighted. After the benefits and challenges have been identified, this research recognises current prominent or operational application in the industry. The thesis also focuses on the current status and outlook of blockchain technology in banking and finance. The research questions that this thesis aims to answer are the following:

- What are the opportunities and challenges of blockchain technology in the banking and financial sector?
- What are the most prominent blockchain-based applications today in banking and finance?
- What is the future outlook of blockchain technology in banking and finance?

This thesis will aim to provide a realistic overview of blockchain technology in the banking and finance sectors. The first research question will be attempted to be answered with the combination of current academic research and empirical research conducted for this thesis. The second and third research question will rely more on empirical research due to the limited amount of literature on actual blockchain-based solutions in the banking and finance industry. The objective is to enhance understanding and knowledge of the phenomenon at hand. The technical details of blockchain technology will not be within the research scope. However, they are explained in required detail to enable a comprehensive understanding of the research objectives. Blockchain technology will be viewed from the business perspective, which means how this technology could create value for banks and other financial institutes and whether the technology truly has the required attributes to have a lasting effect on the industry. This thesis also covers a high level of the current trends and requirements of the banking and finance industry so that the operating environment and context of blockchain technology in the industry can be viewed.

This thesis limits to examining the banking and finance sector, as this sector has had active blockchain studies and operations. This study does not focus on managerial accounting. As mentioned that the current literature for blockchain-based applications is still rather speculative and therefore did not provide a sufficient foundation for a theoretical framework for blockchain technology implementation. The purpose of this study is not to examine how the implementation of blockchain technology should be conducted. The objective is purely to discover the current views on the benefits, challenges and future outlook of blockchain technology in the banking and financial sector

1.3 Research design and methods

The term research design can have several definitions. The narrow definition of the term refers to the method of collecting data. These data collection methods could be related to experiments, interviews or surveys. The broader term of research design is a complete structure or plan of conducting a study. This structure or method includes the entire research process from the preliminary research questions, data collection and analysis, interpretation and reporting. (Vogt et al. 2012.) Creswell (2014) defines a research design as selecting methods and techniques to answer research questions and conduct the research efficiently. A well thought out research design is a valuable tool for the researcher. It can be seen as a step by step guide to successful research.

Like most other studies, this thesis aims to fill a specific purpose. This study aims to display the benefits and challenges of blockchain technology in the banking and financial sector. The thesis seeks to provide a comprehensive view of the current and future expectations for blockchain-based banking and finance applications. Therefore, by nature, this research is exploratory. Leavy (2017) considers an exploratory study suitable when the topic of the research is relatively under-researched. Exploratory research is ideal for new and emerging topics, and it aims to fill in gaps in our knowledge on the subject. Often, when conducting exploratory research, a literature review may be limited as there is a shortage of adequate scientific research. Therefore, the researcher should develop a suitable methodological plan for the study. Saunders et al. (2010, 139) find exploratory research a valuable tool to discover new findings and figure out what is happening. Exploratory research method may include various data collection methods. Open and semi-structured interviews have been identified as appropriate methods for most cases. As a primary data collection method, this thesis utilises semi-structured interviews. Semi-structured interviews provide a sufficient balance between structured boundaries and open discussion. Structured boundaries could be described as internal controls for the interview. Clear boundaries support the researcher in staying on the research topic and pursuing answers for the most critical research questions. The flexibility and more open dialogue during the interview enable the interview to go into more depth. The researcher may discover topics and findings that they might not have considered before without open dialogue. (Saunders et al. 2010, 139.)

1.4 The structure of the thesis

This thesis is divided into six chapters. The first chapter will provide the introduction and motivation to the subject of the thesis. In addition, the research questions, research objectives and the research design are included in the first chapter. Finally, the chapter provides the structure of the thesis.

The second chapter entails the literature review. The second chapter will provide the theoretical basis for the thesis. The literature review is split into four main segments: banking and finance, blockchain technology, blockchain technology in banking and finance, and future outlooks and applications. The first segment will focus on the banking and financial sector. The aim is to provide a good overview of the traditional banking and financial sector. This segment will introduce a brief history of the banking and financial sector. It will also aim to give the reader an understanding of the sector’s current state.

The first segment will also look into possible banking and finance changes and provide a short introduction to fintech and banking.

After the world of banking and finance has been introduced, the second chapter will focus on blockchain technology. This chapter will attempt to explain blockchains and answer the following questions: how do blockchains work and the differences between different blockchains? This segment will not go into specific in-depth details on the technology as it is not part of this thesis. The second segment aims to give the reader an understanding of what blockchains are and how they work without the need to understand the entire technical aspect of it. The literature review aims to provide the reader with the basis of the technology to help understand what benefits and challenges blockchains might offer to the financial sector.

The third segment of the chapter will link the two previous pieces together. This segment will first explain why the financial sector could be interested in blockchains. This part will then go into more detail about what benefits blockchain could provide to the financial industry. The literature review will also investigate what challenges the technology should overcome to be adopted widely by banks and other financial institutions. The literature review aims to provide a good idea of the thesis and provide a comprehensive understanding of the central topics. The literature review will also function as the empirical study's theoretical foundation. The final subchapter of the literature review will speculate future outlook and prominent blockchain applications in banking and finance, based on the current literature.

The third chapter will provide an introduction to the empirical research of this thesis. This chapter will introduce the methods of data collection and analysis. The chapter will also provide an introduction of the interviewees for the semi-structured interviews. In addition, reliability and validity are assessed in the fourth chapter of the thesis.

The fourth chapter will present the qualitative interviews. This chapter will aim to provide a current realistic overview of blockchain technology in the industry. Industry professionals are interviewed on the benefits and challenges of blockchain technology. Also, the interviews will focus on the prominent applications and aim to provide a realistic outlook on the future steps of blockchain technology in banking and finance.

The fifth chapter will provide the research findings of this thesis. In this chapter, the results will be analysed. The research findings will consider both the literature review and empirical research when conducting the interpretations and results.

Finally, the sixth chapter will provide the conclusions of the thesis. This chapter evaluates the academic and managerial contributions of the thesis. In addition, the chapter will examine whether the objectives of the research were met. Finally, the limitations and future research opportunities are expressed.

2 LITERATURE REVIEW

2.1 Overview of the banking and financial sector

The banking and financial sector play a crucial and impactful role in every economy today (Vesna et al. 2015, 11; Berger et al. 2010, 1). In general, the banking and financial sector's purpose is to be a secure institute to deposit funds, be a source of credit, and operate the payment systems globally. The banking and financial sector's primary responsibility is to allocate assets from parties in surplus, depositors, to parties in deficit, borrowers, transferring capital from smaller liquid deposits to bigger illiquid loans. The more secure, trustworthy, and efficient the sector and the mentioned activities are, the lower costs of operation and interests are achieved. Creating benefits for all parties involved and, therefore, to the entire economy. (Berger et al. 2010, 1; Walter 2003, 1) Vesna et al. (2015, 11) described the banking and financial sector as the brains of the entire world's economy due to its central and responsible role. Banks represent most of all financial services within the financial services sector. (Vesna et al. 2015, 11.) According to the Business Research Company (2020), the financial services market will reach $28,52 Trillion by the year 2025, making it one of the biggest industries in the world.

The development of the banking and financial sector has long routes in history. Banks have been around before the creation of currency. The first banking activities date back to about 1800 B.C. to Babylonia. The banking practices followed the laws and regulations of the time, such as the Code of Hammurabi. (Smith & Walter 2003, 4; Wewege & Thomsett 2020, 9) Wewege & Thomsett (2020, 9) describe that even from the very beginning of banking history, banking principles were very similar as they are today. For example, the prevailing laws during the Babylonian era had intricate rules on the loan and credit processes. For example, these laws regulated the maximum interest for different commodities (Smith & Walter 2003, 4). Even though the deposits during the Babylonian era were primarily made of commodities such as grain, corps, and precious metals and not capital, the fundamentals of banking were still firmly prevalent. Grain and other valuables were stored in a centralised trusted location, where the public made deposits, withdrew loans, and paid interests. (Wewege & Thomsett 2020, 9.) This suggests that since the start of civilisation, the banking and financial sector was created out of a need to satisfy the market and provide a safe and reliable way to transfer assets between the public. For this, a trusted intermediary had to be established.

Both Wewege & Thomsett (2020, 9-12) and Smith & Walter (2003, 4-15) continue presenting the history and development of banking to its modern form. The banking and financial sector went through various eras, innovations, and crisis's and slowly, new items, financial instruments, and regulations were added to the industry. Through these changes, some competitors have disappeared, and new competitors have been created.

Fast forward to the 20th century, the principles and fundamentals of banking and finance, though developed, are very similar to the very beginning in Babylonia.

Around the turn of the 21st century, the economic climate was encouraging for the banking and financial industry. Due to the high demand from governments and companies for financial services, the sector achieved record-high growth. (Wewege & Thomsett 2020, 14.) According to Berger et al. (2010, 4-12), banks and other financial institutions achieved record profits. The profits were not only achieved through the favourable economic climate, but also from the deregulation of the financial industry as well as the ascending idea of risks being diminished. The soaring profits, deregulation and the "risk-free" climate impacted the structure of the financial sector strongly (Wewege & Thomsett 2020, 14). During the beginning of the 2000s, the banking and financial sector started to change faster than before. Similar industry principles were still evident, but the larger banks began to develop into multi-product financial service conglomerates through mergers and acquisitions. (Berger et al. 2010, 9; Wewege & Thomsett 2020, 14.) According to Wewege & Thomsett (2020, 14), banks' soaring profits and deregulation raised the interest of other financial intermediaries or nonbank financial institutions. The profitability of most traditional retail banks suffered substantially as nonbanks created a new competitive threat within the industry. Traditional retail banks were encouraged by the US Treasury to discover other financial instruments. The idea was that banks would diversify their business and improve their liquidity. (Wewege & Thomsett 2020, 15.) Banks began offering various financial services, from retail and investment banking to insurance and brokerage activities, to name a few. This consolidation impacted the number of banks heavily as they started to decrease and be more centralised as well as function in a global manner. (Berger et al. 2010, 9.) As traditional retail banks began to adopt new financial instruments, so did the nonbanking institutions. This gradually led to banking and non-banking industries becoming more comparable as their services became similar. The significant change and increase in the competition were primary triggers for the banking and financial industry to shift into a new digital era. The development of the internet, personal computers and smartphones furthered the change significantly. (Wewege & Thomsett 2020, 15.)

2.2 Regulatory impact on banking and finance

As mentioned in the previous chapter, the banking and financial industry has been compared as being the brains of the economy because of its significant impact on the entire world. The power to impact comes alongside a lot of responsibilities and small margins for error. The above statement is further verified by Smith & Walter (2010, 335). They state that the banking and financial sector has always been under substantial public authority supervision and regulation. If mistakes or financial fraud occurs, it may have devastating consequences worldwide due to the fiduciary role of the banking and financial industry. Berger et al. (2010, 3018-3019) explain that even though the banking and financial sector regulation is heavy and is often portrayed in literature as a “tax on banking income,” most banking professionals understand the purpose of the laws. Bankers have identified the benefits of the regulations and recognise them as more of back-office financial services that may even generate costs benefits for banks. The cost savings are created through three different benefits: improved customer convenience, improved customer confidence and resisted effort to accumulate and exercise market power.

At the end of the day, the main objective of banking and financial regulations is to sustain a safe, stable and trustworthy banking system. This includes upholding a healthy credit allocation and preventing fraudulent activity. Maintaining these principles should prevent the financial sector and, therefore, the entire world economy from collapsing. (Smith & Walter 2010, 337.) Vives (2019, 55-57) points outs the importance of linking stability and competition within the banking and financial sector. He argues that unregulated banking activities and harsh competitions, such as vigorous growth and excessive risk-taking, have led to all the financial failures through history. Whether it has been the creation and lack of regulations of investment trusts, mutual funds etc., in 1907 leading to the Panic of 1907 or the turbulent fast-changing banking and financial sector, as explained above, hundred years later leading to the financial crisis in 2007-2009. Meaning that the lack of control over the industry in the past has triggered instability and induced problems.

As noted, regulating the industry is extremely important, but it is also tricky. Even small regulatory changes may have profound alterations to the banking and financial sector and impact the world economy. This leads to the problem that the world and markets often develop faster than the regulatory playing field. Meaning that regulators come across the dilemma of whether to value institutional and systematic safety and stability or creativity and financial efficiency. As the sector impacts almost everything else in the economy, the regulators have often learned to prefer the former. (Smith & Walter 2010, 336.) In his article Vives (2019, 56) emphasises that today, the banking and financial sector, is going through a potential disruption due to fintech competitors and digital technology. This may have a negative effect on traditional banking and finance profitability and therefore increase competition. Reflecting on history, regulation has not been successful in limiting financial innovation and regulatory arbitrage. He continues to highlight the importance of proper and sufficient laws to prevent regulatory failure and the cycle of regulatory liberalisation, crisis and re-regulation as seen throughout history. However, Vives underlines that competition is an essential driver for efficiency. When adequate regulations are in place, competition is unmistakably socially beneficial. (Vives 2019, 56).

2.3 The modern age of banking and finance

The banking and finance industry is often perceived as a conservative industry that is very resistant to change. As it has become evident in previous chapters, the banking and finance industry has been relatively similar throughout its history. The industry has had well-defined boundaries, precise business models and often functions in a stable business environment. (Mougayar & Buterin 2016, 73–74.) These factors result in a predictive and linear business environment with little change and innovation compared to other industries. Though the perception of the industry has changed drastically during recent years. (Vesna et al. 2015, 11) Wewege & Thomsett (2020, 25-27) argue that the financial crisis in 2007-2009 was a big trigger point for the industry. Not only did it result in significant losses as well as leading some established banks to bankruptcies. It also heavily affected the public's trust in the banking and financial sector in general. These factors offered a gateway for significant industry changes and increased digitalisation and financial technology or fintech. On the other hand, the crisis opened up a possibility for a new era in the banking and finance sector (Wewege & Thomsett 2020, 25-27.)

Today the industry is significantly different. The fast development and growth of electronic communication and information technologies have created a more volatile business environment. This has led to short life cycles for products and innovations and made the sector highly competitive. Today, banks and financial institutes have immense pressure to transform and digitalise their business. Digitalisation has also broken-down industry barriers and changed competitive dynamics and required strategies. This phenomenon is called "digital disruption" and will reshape the industry in the near future. (Vesna et al. 2015, 11.) Wewege & Thomsett (2020,1-2) have also recognised the power of digitalisation and emerging technologies to reshape industries and switch up the competition. For example, when Google launched its navigation app, Google Maps, it took only 18 months for Google to wipe out competition and gain 85% of the market. (Wewege & Thomsett 2020, 1-2.)

As stated, the banking industry is not traditionally recognised as an agile and rapidly changing sector. So was the case at the beginning of digitalisation. At first, it seemed banks and other financial institutes did not focus enough on digitalisation and its potential. (Vesna et al. 2015, 11.) PayPal, for instance, could be seen as the first disruptor in the banking and finance sector. At first, the industry did not perceive PayPal as a threat to the profitable payments sector. Quickly PayPal reached $15,45 billion in revenue with an average growth rate of 18% per year and became more valuable than its parent company eBay. (Wewege & Thomsett 2020, 1.)

On the other hand, it comes with no great surprise that the traditional industry was slow to innovate and implement digital solutions. Businesses require a lot of flexibility and fast-paced changes to internalise digital disruption in their business processes. Business processes must be able to change smoothly and efficiently to be able to execute unexpected changes internally as well as externally. (Vesna et al. 2015, 11.) Contrary to the traditional banking and finance services, PayPal managed to transform the payment services due to its speed and convenience and changed the payments space through technology and innovation (Wewege & Thomsett 2020, 2).

According to Vives (2019, 57-58), the banking and finance industry has been exposed to extensive technological and regulatory changes during recent years. The recent changes have implied that the industry is shifting towards more market-based systems resulting in increased competition. The recent liberalisation and deregulation in the sector have decreased entry barriers for new financial technologies to flood into the industry and create new competition. (Vives 2019, 57-58; Wewege & Thomsett 2020, 2.) PayPal, for instance, has now been licenced as a bank in Europe. In 2018, the Central bank of Ireland gave Facebook the authority to handle payments across the European Union. Potential significant competitors do not stop here, as also Google, Apple, to name a few, have entered the market with their financial services. (Wewege & Thomsett 2020, 2.) These non-bank finance companies may even be more efficient and have a competitive edge against the traditional banking and finance firms due to their ability to offer specialisation and economies of scale (Vives 2019, 58).

Wewege & Thomsett (2020, 3) explained that competing against influential digital players such as Google, Apple, or Amazon requires dramatic actions from traditional banks to reform their existing strategy. It is not sufficient that banks become more technologically advanced or streamline their activities. Conventional financial institutes must develop user-friendly online and mobile banking services. To succeed in this competitive climate, financial service companies must be innovative and outsmart the competition. The former implies that traditional institutes must redefine their old business approaches to adapt to changes effectively. (Vives et al 2015, 11; Wewege & Thomsett 2020, 3)

Banks and other traditional financial institutes may still have a competitive edge now that the industry is stepping into the digital era. Even though conventional banks' reputation experienced significant setbacks after the economic crisis and the public lack trust in the banking and financial industry. The people still tend to rank banks that they conduct business with relatively high regarding trustworthiness. This is critical as the digital era relies heavily on personal, confidential and sensitive data. The public still trusts their banks to secure their data more than other intermediaries. (Wewege & Thomsett 2020, 26.)

2.4 Blockchain technology

2.4.1 The basics of the blockchain technology

Blockchain technology was developed by a software developer or a group of developers behind the alias Satoshi Nakamoto in 2008 (Antonopoulos 2015, 3). Blockchain technology is the underlying technology behind the cryptocurrency Bitcoin. Blockchain's definition could be categorised in three different but complimentary ways: legal, technical and business. The legal description of blockchain is that it is a mechanism that validates transactions and does not need the assistance of trusted intermediaries. Technically speaking, blockchain is an openly distributed ledger that is maintained by a back-end database. From the business perspective, blockchain is an exchange network for moving value between peers. Blockchain is a "platform" on top of the internet, just like the World Wide Web. (Moygayar & Buterin 2016, 22–23.)

In the book Blockchain: Blueprint for a new economy, the author Melanie Swan (2015, 1) describes blockchain as a decentralised, transparent public ledger constructed of a network of computer nodes, in Bitcoin's case, record transactions. Blockchain's database is shared to all network nodes updated by computers referred to as miners and supervised by everyone. It is available to everyone, and anyone can update and confirm transactions. Blockchain is basically a massive interactive spreadsheet. (Swan 2015, 1.) There is typically no permission needed to join the network, and there is no central authority that controls the blockchain (Walch 2015, 844).

Swan (2015, 2) explains that blockchain technology provides a resolution for digital currencies as it solves the established problem, the double-spending problem. The double-spending problem means that digital money was easy to copy before blockchain cryptography, just like copying an email, and it could be transferred multiple times. The solution to this problem is commonly found with central intermediaries. The trusted central authority, like a bank, checks every transaction for double-spending. The trusted third party keeps a ledger and confirms that the digital money is spent only once (Nakamoto 2008, 2; Swan 2016, 2). Nakamoto states in the Bitcoin white paper (2008, 2) that, to accomplish solving the problem of double-spending without the supervision of third parties, the transactions must be publicly available for anyone. Blockchain technology solves the problem by utilising a distributed peer-to-peer network where all the transactions are timestamped and publicly announced to all of the nodes participating in the system. Thus, everybody can have access to the full copy of the blockchain that contains every transaction ever executed, making the information of transactions and the value of each account available to anyone at any point in history (Mainelli & Smith 2015, 8).

2.4.2 Technology behind blockchain

Peters and Panayi (2015, 3) explain that blockchain relies on public-private key cryptography for data security like various other internet technologies. In a blockchain network, each user has a private and a public key. The public key represents an account number and addresses transactions to the right person. The public key is available for anyone to see. Even though it is public, it is a pseudonym as it does not reveal the personal information of the person holding it. The private key represents the password to the account, and therefore, it is personal. With the private key, the person provides proof to the network of the ownership of assets. (Huckle et al. 2016, 463.) The difference between the private key and a password to an account is that if a person forgets or loses their private key, they cannot get a new one from a central authority such as a bank. Therefore, they will lose all their assets behind that private key as they cannot gain access to them anymore. (Kosba et al. 2016, 20.)

Blockchain is a chain of blocks, and each block contains information (Nofer et al. 2017, 183). Bradbury (2015, 69) describes the blockchain as a digital skyscraper, where each building floor is a block of data. In Bitcoin's case, the block of data contains information about transactions that happened on the network when the block was being created. In Bitcoins blockchain, a block is built every ten minutes, forming a continuous lengthening tower of blocks. The blockchain is open, and anyone can download it and examine what transactions have been made. (Bradbury 2015, 69.)

Each block contains data, a hash and a hash of the previous block. The data in the block depends on the type of the blockchain, in Bitcoin's case transactions. The data contained in the blocks can be anything you could download to your computer's files, for example, documents, pdf files and pictures. (Moygayar & Buterin 2016, 35.) The hash of a block is a 64-character code computed from the block's data using an algorithm. No matter how much data the block contains, it is compressed into a 64-character code. The hash of the block is the digital fingerprint of the block. (Swan 2016, 37; Moygayar & Buterin 2016, 27.) The hash is always unique and reflects the exact data of the block. The 64-character hash is secure and cannot be computed backwards. The hash is included in transactions, which adds the timestamps. (Swan 2016, 37.) The block's hash is timestamped in a timestamp server and published just like a newspaper (Nakamoto 2008, 2). The timestamp provides proof that the data has existed at the time. If there were no data, the hash would not be calculated cryptographically (Swan 2016, 37; Nakamoto 2008, 2). The third part of a block is the hash of the previous block. This means that the block always contains all the information of prior transactions or data. This is how the blocks in the blockchain are linked together and provide trust by hashing and timestamping the transactions in order. (Nakamoto 2008, 2.) An example of a blockchain and its components is shown below in Figure 1.

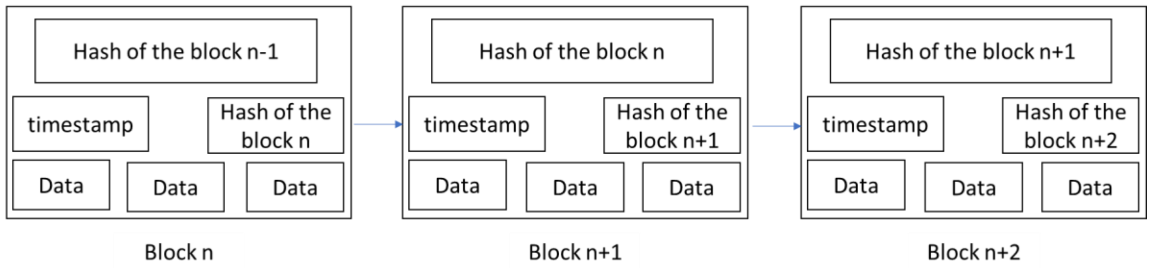

Figure 1 Example of a Blockchain Structure (Nofer et al. 2017)

A new block is added to the blockchain when the majority of the nodes in the network have reached a consensus on the validity of the transactions made. In Bitcoins blockchain, this consensus method is called Proof-Of-Work (Nofer et al. 2017, 184). Swanson (2015, 4) explains that the Proof-Of-Work is a process where over 50% of the network validators agree on the ledger's state. Therefore, transactions cannot be automatically added to the ledger as they must be voted for, and the majority's approval must be reached. This consensus process takes time, and hence in the Bitcoin blockchain, a block is created every 10 minutes. (Swanson 2015, 4.) After a block has been verified, the information in the block cannot be changed. If someone tries to change the block's data, the block's hash will automatically change. As the blocks contain the hashes of the previous block, the change in a hash will be noticed. The tampered block will not fit in the chain anymore. This will be seen quickly by the network, and they will vote against it and prevent the change in the data. (Nofer et al. 2017, 184.)

2.4.3 Different types of blockchains

Blockchain is not another Internet. Instead, it is a new practice that sits on top of the internet, just like the World Wide Web. There is only one Web, but there can be many blockchains with different features to one another. (Mougayar & Buterin 2016, 23.) Different applications for the blockchain require different structures. Some blockchains are permissionless, like the Bitcoin blockchain, where anyone can join the network and verify transactions. On the other hand, there are permissioned blockchains where a central authority or a consortium grants permission to enter the blockchain network. As the structure of these blockchains is different, so are the approaches to achieving consensus and providing incentives. (Peters & Panayi 2015, 2, 5.) Therefore, according to Buterin (2015), the idea of one proper way of "blockchaining" is totally wrong, and both permissionless and permissioned blockchain have their advantages and disadvantages.

2.4.3.1 Permissionless blockchains

Permissionless blockchains are public blockchains. Anyone can join the network in a permissionless blockchain and verify actions in the blockchain without permission from a central authority. (Peters & Panayi 2015, 4.) Permissionless blockchains are also open for anybody to read. (Buterin 2015.) The well-known permissionless blockchains are Bitcoin and Ethereum (World Bank Group (WBG) 2017, 11).

The permissionless blockchains provide the freedom for network participants to come and go as they please (WBG 2017, 11). According to Buterin (2015), this freedom, neutrality and openness are commonly promoted advantages of the permissionless blockchain. He also states that public blockchains offer protection to the users of an application from the developers. Public blockchains provide users with the security that even the application developers have no authority to control certain aspects of the network. The reasons why developers are willing to give up this authority is to create trust in the network. When it is hard or impossible for the developer to control the network, it builds trust, and people are more likely to interact with the ecosystem. (Buterin 2015.) The involvement of the network is also vital for verifying transactions in the Proof-Of-Work process. This is why participation is encouraged by incentives paid to the verifiers when new blocks have been created. (Peters & Panayi 2015, 5.) The other reason why the developers are willing to lesser their authority in the application is that they cannot be forced or pressured by another entity such as the government, as they have no power over it. (Buterin 2015.) This, according to Buterin (2015), makes permissionless blockchain "censorship-resistant".

Permissionless blockchains are open, and therefore, it is expected that many entities join the network and network effects are gained (Euro Banking Association (EBA) 2016, 18). Buterin (2015) gives an example of a domain name escrow. He explains that if Compay A wants to sell a domain name to Company B, counterparty risks are present. The counterparty risk is that Company A sends the domain first, and Company B does not transfer the money to Company A or vice versa. This problem is traditionally solved with a trusted escrow intermediary. Presumably, the central escrow intermediary charges fees of three to six per cent, for example. However, if the domain and the currency would exist on the same blockchain, it would cut costs to near-zero with the help of smart contracts. The transaction is trusted because it lives and runs on a public permissionless blockchain. For this to happen, the two different counterparties must be on the same database, which is not as likely to occur in a permissioned ledger. (Buterin 2015.)

The problem with permissionless blockchains occurs when the network grows substantially. The data stored in permissionless blockchains are held on every computer connected to the network, and all of them verify transactions. As the transactions increase, more processing power is needed for each node. Not all nodes can handle this type of processing, and verifying will decrease because only the nodes that have the required processing power will participate. This will lead to a more centralised network and limit scalability. (Peters & Panayi 2016, 6–7.)

There is a possibility that permissionless blockchains face a 51% attack. In the attack, bad actors form 51% of the network's computing power. This allows them to lie to the network by manipulating the consensus of the chain. It is assumed that no entity can now or in the future gain over half of the computing power of a permissionless blockchain network. (WBG 2017, 18.) However, this is dependent on how extensive the network is. For example, the more nodes the network has, the more unlikely it is that one entity can control over 51% of the networks processing power (Bradbury 2013, 6). However, the bitcoin blockchain or other blockchain networks have never been hacked or compromised (WBG 2017, 18).

There has also been a lot of debate over environmental issues concerning blockchain technology. For example, the Proof-Of-Work consensus method acquires a lot of electricity, leaving a big footprint behind it. This is only a problem with permissionless blockchains that use the Proof-Of-Work consensus method. (WBG 2017, 20.)

2.4.3.2 Permissioned blockchains

In permissioned blockchains, the nodes in the network have been preselected by a consortium or a central authority. Often permissioned blockchains intend to restrict data access to companies or consortium companies that run the blockchain. (WBG 2017, 11.) Swanson (2015, 44) describes fundamental differences in the capabilities and range of activities between permissionless and permissioned blockchains. Permissioned blockchains tend to be built to serve a specific purpose and maintain compatibility with existing applications. According to Peters and Panayi (2015, 6), the discussion has been increasingly moving towards using permissioned blockchains because of their specific use cases. In a permissioned blockchain, the verification process is carried out by a set of trusted parties. It is possible to add additional verifiers with the agreement of the central authority or the consortium. (Peters & Panayi 2015, 6.) Swanson (2015, 22, 26) states that permissioned blockchains are often more suitable for higher stakes activity. They are also ideal for off-chain assets such as securities, fiat currencies, and titles of ownership and therefore, permissioned blockchains are appropriate for the traditional financial sector. Swanson also believes that the permissioned blockchains will predominantly be used for these off-chain assets rather than on-chain assets such as cryptocurrencies. (Swanson 2015, 22, 26.)

Permissioned blockchains can be entirely private, or they can be formed by a consortium. In a consortium blockchain, the consensus process is operated by a pre-selected set of nodes. These pre-selected nodes could be, for example, a group of 15 financial institutions. To achieve consensus, at least 10 of these must sign every block to validate the new block. On the other hand, a fully private blockchain is controlled by one centralised organisation. The permission to read both kinds of permissioned blockchains can be public, but it can also be restricted as determined by the consortium or the centralised organisation. (Buterin 2015.)

As described in the earlier chapter, the limit of processing power can be a problem in permissionless blockchains. Permissioned blockchains have an advantage on scalability as a smaller number of participants operate the network. Often the participants are substantial institutions and can scale their computing power to match the demand of the network. (Peters & Panay 2015, 6–7.) According to Buterin (2015), this also makes the transactions cheaper in permissioned blockchains than in permissionless blockchains as the transactions do not have to be verified by tens of thousands of computers worldwide. Buterin also notes that because of incentives, transaction fees in permissionless blockchains can be over $0,01 per transaction but may become cheaper in the future with scalable blockchain technology, which has the potential to bring costs down in permissionless blockchains. (Buterin 2015.) In permissioned blockchain, incentives to nodes that offer storage and computation is not necessarily needed. Often the nodes in permissioned blockchain are trusted and maintain their own ledgers. For example, in banking applications, the participating banks maintain their shared distributed ledger. (Tsai et al. 2016, 452.)

In some blockchain applications, legislative or central regulation is needed. Buterin (2015) provides an example of national land registries, explaining that there could be no situation in which the governments would allow systems where there is no control over who gets to buy what land. Especially permissionless blockchains are difficult to regulate as no legal entity has control over it. Permissioned blockchains, on the other hand, are more straightforward for the regulators. (WBG 2017, 19.) Permissioned blockchains commonly have an administrator or an owner, in other words, the consortium or the company running it, which can regulate the network (Buterin 2015; WBG 2017, 19).

Even though according to Bradbury (2013), the 51% attack should be unlikely in permissionless blockchains. Permissioned blockchains do not have the same risk. The risk is not present because the permissioned blockchain is often operated by trusted central institutes the have agreements and are regulated. (Buterin 2015.) The consensus mechanism in permissioned blockchains are more straightforward. This is because as the nodes in a permissioned blockchain are pre-selected and trusted, there is no need for difficult proof of work processes for verifying transactions. (WBG 2017, 6.)

The fewer nodes also mean that they are trusted to be well connected, and so if faults occur, it is possible to react quickly with manual intervention. This makes it possible to use consensus algorithms with shorter block times, which means that private blockchains are more effective and can offer close to instant confirmation to a transaction. Bitcoins permissionless blockchain provides a 99.999% finality after two hours of the transaction. Permissioned blockchain will always be faster than permissionless blockchains. Permissioned blockchains can also offer better privacy as the read permission can be limited to only certain members. (Buterin 2015)

2.4.4 Comparing permissionless and permissioned blockchains

The technology of both permissionless and permissioned blockchains have now been introduced in the previous chapters. The previous chapters indicate that permissioned blockchains are more suitable for the banking and finance industry. The attributes of permissionless and permissioned blockchain have been summarised below in Table 1. Table 1 will provide the core characteristics of both blockchain methods.

Table 1 Comparing Permissionless and Permssioned Blockchains (WBG 2017; Guo & Liang 2016)

	Permissionless blockchains	**Permissioned blockchains**
Access	Anyone can freely join or leave	Central member or group controls the entrance to the network
Level of trust	No trust required between the members of the network	A higher degree of trust between members required
Privacy	Transparent, open public ledger shared between all nodes	Different options of the privacy of the ledger is possible
Identity	Identity protected by pseudonyms	Verification of identity often required by administrators
Consensus	Difficult Proof-Of-Work or other consensus methods required	Various consensus methods (often more simple and efficient than the Proof-Of-Work)
Incentive mechanism	Needed	Optional, not needed
Speed Transactions per second (TPS)	Slower transaction process, therefore transaction volume limited to 3-20 TPS	Faster transactions process, transaction volume for 1000 to “unlimited” TPS
Assets	Typically, cryptocurrencies	Any assets
Legal ownership	Legal concerns as no entity can control the network	Better legal clarity as administrators can be governed by the law
Advantages	Open and self-established credit	Efficiency and cost benefits
Typical applications	Cryptocurrencies	Clearing and audits
Example	Bitcoin, Ethereum	R3’s Corda -blockchain

As shown in Table 1, the access rights in permissioned blockchains are more suitable for the financial sector. The most important factors that make permissioned blockchain more suitable for the financial industry are access, privacy, identity, legal ownership, consensus, speed and assets. The possibility to control the entrance to the network increases the privacy and security of network participants. Legal control over the blockchain is crucial for it to be adopted in the financial sector. For the legal authority to be implemented successfully, also the identity of participants must be verified. Permissioned blockchain can support various consensus methods making the consensus process more efficient. Not only does the efficiency provide cost benefits, but it also makes it possible to have faster transactions processes. Permissionless blockchains can only carry out 3-20 transactions per second (TPS), which is insufficient in the financial sector. Permissioned blockchains are also not limited to cryptocurrencies but can carry any assets. These attributes make permissioned blockchains more suitable for the financial industry. (WBG 2017; Guo & Liang 2016.)

2.5 Blockchain in the financial sector

2.5.1 Interest in blockchain technology in the financial sector

Banks have traditionally been slow in adapting and innovating with new technology and creating new ways to operate. For instance, information technology has been an essential factor in the financial sector since the development of the first computers. However, still, banks did not realistically innovate much with the internet. Instead, banks have commonly focused more on updating their back-end operations. Generally, startups are the challengers who try to break barriers and create innovation for the whole sector. Blockchain technology is now challenging the traditional finance institutions on how much are they willing to change their business model. (Mougayar & Buterin 2016, 73–74.)

According to Guo and Liang (2016, 3, 5), the traditional banking industry has difficulties in achieving the same profits as they have in the past. For example, in China, banks are facing various burdens, such as the risks have increased and the profits have declined. Therefore, banks should develop new ways to increase profitability and growth and to do so, they must rely on new technological innovations. (Guo & Liang 2016, 3, 5; Tsai et al. 2016, 450.)

Blockchain has the ability to disrupt the financial sector we see today, and it is no longer seen as a threat by banks and financial institutions. In fact, banks and other financial institutions see it more as an opportunity to develop their business model. Many of the most prominent players in the banking sector are already investing a lot in the research for possible applications blockchains could offer. (Crosby et al. 2016; 8, 13) In their paper, Crosby et al. (2016, 13) state that nine of the world's largest banks, for example, JP-Morgan and Credit Suisse, are already working together with a fintech startup R3. This is the first time banks are cooperating to discover prominent blockchain technology applications in the financial sector. (Crosby et al. 2016; 8, 13). According to the startup R3 (2021) website, they are currently in 2021 working with over 350 different banks, financial institutions, and other partners. R3 was launched in 2015 with the objective to get rid of "legacy financial technology" that they see as inefficient, risky and costly. The startup R3, with its partners, created Corda, a distributed ledger platform designed specifically for financial services. (R3 2021). World Bank Group (2017) mentioned that 16 stock exchanges globally are working on blockchain-based solutions for securities trading. For example, in 2015, Nasdaq Stock Market accomplished to transact securities for the first time on a blockchain-based transaction platform called Linq (Crosby et al. 2016, 13). In these instances, blockchains have the potential to disrupt the future of the stock exchange (WBG 2017, 21).

According to the World Bank Group (2017, 18), the financial sector has requirements towards blockchains before they could be used in their applications. The industry players require that the identity of counterparties must be validated in transactions. The transactions should not be public and should only be seen on a need-to-know basis, which means that the visibility of the transactions is limited. The financial sector also requires that blockchains should be able to interface with multiple other blockchains. Blockchains should also be able to support different consensus methods for various applications. For example, just the attending counterparties in a transaction could participate in the consensus process. The financial sector also has concerns about the legal issues concerning blockchains. (WBG 2017, 18.)

2.5.2 Benefits of the blockchain technology in banking and finance

As stated before, banks and other financial institutes have noticed the possible benefits that blockchain could offer them (Crosby et al. 2016, 8, 13). Blockchains are believed to bring efficiency, cost and security benefits to the financial sector (WBG 2017, 15–16; Guo & Liang 2016, 6; EBA 2016, 15). According to Guo and Liang (2016, 6), blockchains could solve most financial sector problems such as transaction lag, efficiency bottlenecks, operation risks, and fraud. Although all the benefits listed result to cost benefits, the benefits are divided here into two groups: "Speed, efficiency and cost-effectiveness" and "Transparency and easier auditability leading to fraud reduction". These benefits provide banks with various possible use cases for blockchains in the financial sector. Some blockchain applications identified in the literature are presented in chapter 2.6.

2.5.2.1 Speed, efficiency and cost-effectiveness

The benefits of blockchain technology can be linked to various scenarios in the financial sector, such as point-to-point value transfer and asset digitalisation. With blockchain technology, banks can increase efficiency in the clearing and settlement processes after the transactions of financial assets. The increased efficiency will naturally reduce the costs of these processes. (Guo & Liang 2016, 6.) Blockchains make it possible to exchange information in real-time by automating processes and removing unnecessary intermediaries. This will increase the efficiency and speed of the clearing and settlement processes. (WBG 2017, 14; EBA 2016, 16.) Banks are not the only ones to benefit from blockchains as companies will benefit from the faster processes, which will improve their working capital and liquidity (EBA 2016, 15).

In addition to simpler processes, blockchains can replace costly databases and middleware processing applications. Banks are already feeling the pressure of declining revenue because of the increasing costs of operations and traditional IT. (Tsai et al. 2016, 450). By a more modern internal IT architecture, many complicated silos in the older systems are removed, making manual processing and paper unnecessary. This will lead to significant cost savings and allow banks to concentrate on core aspects of their business and possibly increase revenue. (EBA 2016, 16.) According to Tsai et al. (2016, 450), banks are looking forward to implementing blockchain technology to gain efficiency and cost reductions.

The transparency of blockchains also provide ways to reduce fraud (WBG 2017, 15). Furthermore, the total transparency of blockchains reduces, for example, credit risk, error rate and therefore, lower costs and higher efficiency is earned (EBA 2016, 4). The benefits of transparency will be researched in more detail below.

2.5.2.2 Transparency and easier auditability leading to fraud reduction

Blockchains can offer better transparency. As mentioned earlier, new information is added to the blockchain if consensus is reached. As soon as the latest data is added, all the blockchain copies are updated in real-time, automatically. (WBG 2017, 15.) The transparency provides ways to expand auditability and prevent fraud (EBA 2016, 9; WBG 2017, 16). According to Tsai et al. (2016, 450), in addition to avoiding fraud, transparency would also be beneficial in anti-money laundering protection. Therefore, many financial institutions have started to embrace blockchain technology.

The risk assessment and credit rating procedures could also be improved with the help of blockchain technology. Credit risk is a central part of financing trades. The transparency and easier auditability provided by blockchains enable banks to view both buyers' or sellers' credit history, which helps assess the risk better. With a better understanding of risk, banks guarantee better security and provide better pricing for clients they have not financed earlier. (EBA 2016, 10.) According to the World Bank Group (2017, 16), this could possibly save the financial sector approximately $15-20 billion per year.

Particularly the supply chain and trade processes benefit from transparency. Using a blockchain, all parties (bank, corporate, shipping company, customs office, etc.) involved in the supply chain get all the needed transaction details such as transfer of ownership, invoice and shipment data, customs clearance and payments in real-time. This will make the entire process flow much smoother than if they all had their own ledger, where information is gathered manually and updated to the central ledger manually. (EBA 2016, 9.) Furthermore, as the blockchain provides an instant “shared truth”, no counterparties have their own versions of the truth. Therefore, there is no need for the reconciliation of the fact between the counterparties. This saves time and effort and will also lead to substantial cost savings for each party involved. (WBG 2017, 16.) This is achieved especially with smart contracts (EBA 2016, 9; WBG 2017, 16). Smart contracts and their possible use cases will be examined in more detail in the next chapter.

Blockchain technology also helps prevent the Byzantine Generals Problem (Tsai et al. 2016, 452). The Byzantines Generals Problem originally means that if a third of the generals in decision making are bad actors or traitors, they could prevent the decisions of the good or loyal generals. This problem reflects the distributed computer systems, where the nodes are synonyms for the generals. Meaning that only one-third of the nodes have to be bad to break the consensus of the network. (Lamport et al. 1983, 382.**)** The blockchain solves the problem with its consensus method and hashing so that there should be more than 50% of bad actors to prevent the actions of the good ones (Zou et al. 2016, 42). According to Castro and Liskov (1999, 10), the security and reliability of the system increase as the copies of the ledger increases. Tsai et al. (2016, 453) calculated that in a blockchain with 16 nodes, the failure rate is 0,01 a day, and it would take the system about 373,000 years to fail once. If the number of nodes increases to 31, it will take the system 389 billion years to fail even once. Meaning that blockchains do not need many nodes to be secure and reliable. (Tsai et al. 2016, 453.)

2.5.3 Challenges in blockchain technology in banking and finance

As mentioned before in the benefits chapter, blockchain technology can provide new, better, and more efficient ways to operate in the financial sector. However, as blockchain technology, it is still relatively young, and it is still evolving. Blockchains are not perfect and will not solve all the problems in the world, and the technology faces different challenges. The challenges have been categorised into two segments: technological challenges and legal and regulatory challenges. The most commonly mentioned challenges for the financial sector in these segments are: scalability, data security, interoperability, identity verification etc. (WBG 2017, 17.) Before blockchains are adopted widely in the financial sector, they will most likely meet resistance. There are still a lot of unknowns and challenges concerning blockchains. On the other hand, the internet had similar issues from 1994 to 1998, but its perception has changed remarkably. (Mougayar & Buterin 2016, 59.)

As explained before, there are many differences between permissioned and permissionless blockchains. They both have their own advantages and disadvantages. Because of the open and uncontrollable nature of the permissionless blockchain, financial institutions find it difficult to integrate it into their operations. Complying with the existing regulatory and compliance framework and identifying verification is difficult in permissionless blockchains. Therefore, financial institutions are more interested in permissioned blockchains and have already been investing in them. (WBG 2017, 13.)

2.5.3.1 Technical

The financial sector has expensive traditional IT systems, operational arrangements and institutional frameworks. Therefore, it will be very costly and challenging for blockchain technology to disrupt the industry to blockchain-based infrastructure. (WBG 2017, IX.) According to Mougayar and Buterin (2015, 64), there are two problems regarding legacy systems. First, it is hard to integrate new solutions and technology into the existing applications. Secondly, it might be hard to figure out what pieces of the old systems should be replaced. Because of this, it is often noted that blockchain-based solutions will be first seen in areas where there are not many legacy investments, such as trade finance and syndicate loans. (WBG 2017, IX; Mougayar & Buterin 2015, 64.)

One of the challenges that blockchain technology faces in the financial sector is its lack of maturity. Blockchain technology is still at the early stage of development. As a result, the technology faces concerns about its robustness and resilience. The main problems are the ability to carry out large amounts of transactions, availability of hardware and software applications that are uniform enough. Also, there is not yet a sufficient supply of trained professionals. (WBG 2017, 17.) The persistence and reliability of any technology in the financial sector are vital. Any temporary suspension of operation of the technology may lead up to substantial monetary losses. For instance, hundreds of millions of dollars would be lost if the stock-trading system would fail during market hours. (Tsai et al. 2016, 451.) Mougayar and Buterin (2016, 61–62) describe that blockchain in 2016 is equal to the Web in its application in the year 1995. A stable blockchain infrastructure and a lively ecosystem around it must be created during the beginning stages. Without the research and adaption, minor impact and development is expected. (Mougayar & Buterin 2016, 61–62.)

As World Bank Group (2017, 17) mentioned, the financial sector is concerned about the number of trained professionals in blockchain technology. It is estimated that in 2016 there were around 5000 developers dedicated to developing blockchain software and another 20 000 developers playing around with it. Comparing the number of blockchain developers to Java, with 9 million developers around the world or to the other 18.5 million software developers worldwide, shows that the amount of blockchain developers is marginal. (Mougayar & Buterin 2016, 63.) However, the amount of developers is continuously rising, as major traditional IT companies such as IBM and Microsoft and financial companies like Mastercard and Visa are developing blockchain-based products and services. (WBG 2017, 17.) The programming language in blockchains also has similarities to popular software such as Java or Python (Mougayar & Buterin 2016, 63–64).

The second problem is the scalability and transaction speed of blockchain technology. This problem occurs mainly in permissionless blockchains. (WBG 2017, 17; Mougayar & Buterin 2016, 63.) According to Tsai et al. (2016, 451), the stock trading system must record 100,000 transactions per second. For example, because the block size in the Bitcoin blockchain is limited to one megabyte, it can only carry out 4–7 transactions per second. The more the size of the block is increased, the longer it would take to be accepted throughout the whole network. The problem could be solved as technology advances. For example, Ethereum does not have as severe problems as the Bitcoin network as it has o faster transaction process. (WBG 2017, 17.) Permissioned blockchain will most likely always be faster than permissionless blockchains. They are more efficient and, therefore, can carry out a sufficient amount of transactions per second. (Buterin 2015.) This comes with the cost of the blockchain being more centralised and thus losing some of the benefits of the more distributed and transparent permissionless blockchain (WBG 2017, 17).

Different types of possible problems with scalability are the adoption of the technology in the financial sector. If only some banks adopt blockchains in their processes, such as payments, they cannot utilise this network to send assets to banks that rely on legacy systems. (EBA 2016, 14.) The costs for blockchains to be introduced in scale to the financial sector are also immense as they must be integrated with existing systems. They must also be interoperable with other ledgers. If blockchain technology is integrated into the financial sector (such as payment and clearing processes), cooperation, collaboration, and significant investments throughout the industry will be required. This collaboration is already happening as various financial institutions are developing the distributed ledger Corda by R3. Corda and R3 are focusing primarily on the use of blockchains in the financial sector. (WBG 2017, 18).

2.5.3.2 Legal

Blockchain technology is being studied by regulators worldwide, and the regulatory steps are still in their early phases. It is still unclear how laws and regulations will be crafted. (EBA 2016, 13.) Commonly regulators have three different types of policies when facing new technology. They either do nothing and allow the market to mature or control choke points, such as software providers who are required to get a license for their operations. The third policy is to insert automatic regulations. (Mougayar & Buterin 2016, 68.) The industry standards of regulatory vetting and development are necessary, but they might be challenging to implement (WBP 2017, 19). According to Euro Banking Association (2016, 13), this is one of the critical issues for banks. As long as banks are unsure of regulatory compliance, they are unlikely to provide blockchain-based products and services to customers.

Many permissionless blockchains operate on public-key encryption, which does not reveal the identity of a person transferring or receiving the money. This makes it impossible for regulators to supervise that no requirements of Anti-Money Laundering/Combating the Financing of Terrorism (AML/CFT) regulations are broken. (WBG 2017, 19.) It is vital for banks and, therefore, their blockchain systems to comply with Know You Customer (KYC) and Customer Due Diligence (CDD) requirements to prevent misconducts (EBA 2016, 13; WBG 2017, 19). If banks fail to follow these regulations, it could lead to fines and possible criminal charges (EBA 2016, 13.) Many exchange services such as Coinbase offer faster verifications and transfers times to users who have verified their information. Permissioned blockchains do not have a similar problem. As trusted preselected authorities control the network, the identity of the participant must be verified. This assures the AML/CFT compliance of the whole network. (WBG 2017, 19.) The European Banking Association (2016, 13) also points out that it will be interesting to see whether KYC and AML/CTF procedures are updated to fit better with blockchains. Or is blockchain technology seen as any other technology that should be compliant with the established regulations and laws.

Security and privacy are critical concerns in permissionless blockchains such as Bitcoin and Ethereum (WBC 2017, 20). Meaning that as the transactions are visible and open, anyone can track the path and the value of the transaction (Mougayar & Buterin 2016, 65). Even though the identity of a user is encrypted, the participant could be identified based on transaction patterns or other markers (WBC 2017, 20). As earlier mentioned, the access to read data on permissioned blockchains can be restricted, creating a more secure and private network (Buterin 2015).

2.6 Use cases in banking and finance and future outlook

2.6.1 Smart contracts

Blockchains are now most commonly used in transmitting different financial data like cryptocurrencies, but blockchain has many opportunities outside this area. Smart contracts provide the foundations for the most prominent applications for blockchains in or out of the financial sector. A smart contract is a type of computer code that is stored in the blockchain. (Flynt 2016, 2–7.) Theoretically, any instructions that a computer could implement could be run by a smart contract (WBG 2017, 29). The code is activated when the blockchain registers that the pre-set agreements have been fulfilled. The smart contract then creates its own block, and the block is distributed as part of the chain. If the contract is generated in a permissionless blockchain, the information of the contract is public, and anyone can view the details of it with a copy of the chain. Hence, there is no debate over the smart contract as it displays all the contract details. However, despite the increased transparency, it is also problematic. Which is that smart contracts based on permissionless blockchains are entirely public, and anyone can view the contract information. (Flynt 2016, 2–7.)

The idea of smart contracts was invented already in 1997 by Nick Szabo. Szabo compared smart contracts to vending machines. Vending machines, like smart contracts, enforce pre-agreed contracts. Vending machines are mechanical devices that control the ownership of assets, for example, candy bars. The vending machines transfer the ownership of the candy bar when a predetermined input has occurred. In this case, when money has entered the machine, the ownership of the candy bar is transferred, and it cannot be reversed or stopped afterwards. A computer program could execute a similar process, and the transferred asset could be, for instance, securities. (WBG 2017, 29.) Szabo's promising idea could not be appropriately executed without blockchain technology and its programmable payments. Now smart contracts and blockchain can work together and automatically implement contracts between different parties when the conditions of the agreement are fulfilled. (Crosby et al. 2016, 13.) When the contracts are stored in a blockchain, it is in a transparent shared database. Therefore, after the contract has been activated, it cannot be deleted or tampered with. (Iansiti & Lakhani 2017.)

However, smart contracts are not yet perfect, and there may be flaws in them. Whether the agreement is written on blockchain technology or on paper, clear and specific wording is hard to achieve. This is a challenge, especially on smart contracts, as smart contracts do not understand the user’s intent but rather the computer code that has been written into them. In smart contracts, the definition of the agreement cannot be liberally interpreted, but it will instead be followed by the exact meaning of the terms and conditions. Meaning that the results of the smart contract are highly dependent on the quality of the data input. If there are any faults in the data, the results of the smart contract can go wrong. (Deloitte 2016.) For example, this happened to one Decentralized Autonomous Organization (DAO), where a flaw in the smart contract caused undesired results. DAO is an organisation that exists solely on the Ethereum blockchain as a computer code, and it doesn’t have any employees. It was launched in 2016 and gathered $150 million in crowdfunding. The organisation was hacked only three weeks later, and $50 million dollars' worth of cryptocurrencies was stolen by one of the investors. The hacker had found a loophole in the contract, which made the hacking technically legal. The unfortunate mistake in the code made it possible. (WBG 2017, 31; Deloitte 2016.)

According to Peters and Panayi (2015, 8), smart contracts are not yet legally executable. The Euro Banking Association (2016, 12) has similar concerns regarding smart contracts and explains that smart contracts are still in the proof of concept stage in many companies. Nevertheless, they still have a positive attitude towards blockchain technology and smart contracts. Believing that smart contracts will standardise and successful implications will increase as the technology matures, bringing benefits to all parties involved. (EBA 2016, 12.) The following subchapters will provide some examples of smart contract-based applications.

2.6.2 Digital real estate trade

Smart contracts can control real-life assets, and therefore one prominent application for smart contracts belongs to the real estate market (WBG 2017, 29). There are various actors involved when purchasing an apartment. The actors involved are the buyer, the seller, the buyer's banks, the seller's bank, the tax authorities, the registry and the condominium. Traditionally the process would require a lot of time, paperwork, back and forth communication and several signatures. Since the year 2019, it is possible to use blockchain technology-based services for the real estate market in Finland.

A Finnish startup, Tomorrow Labs, cooperated with five banks to build a digital trading platform for buying and selling real estate. As the privacy and security requirements are strict in the financial industry, the real estate market cannot be operated using permissionless blockchains. Therefore, it will be performed on Corda, the distributed ledger developed by the startup R3. Corda has fundamentally been built for banking requirements, and all the data is encrypted and shared only with the authorised participants. Blockchain technology enables all parties to get the required information and confirmations instantly. (Rimpiläinen, 2018) Tomorrow Labs (2021) finds that smart contracts are the most significant advantage that blockchain technology can offer to the real estate market. With smart contracts, the apartment purchaser can be sure that as they have paid the seller, the apartment ownership is automatically transferred at the same time. Also, the collateral to the bank is transferred automatically when the purchase is made. Today one out of five real estate transactions made by brokers is carried out digitally. (Tomorrow Labs 2021)

2.6.3 Trade financing

Another prominent application for smart contracts is securing trade financing processes. According to Euro Banking Association (2016, 12), smart contracts will become more popular in the future, and the development of smart contract-based applications are already underway in the financial sector. Actually, the first trade transaction using smart contracts on a blockchain platform called Wave was completed by Barclays Bank. The trade was between an Irish company called Ornua and the Seychelles Trading Company, where Ornua exported USD 100,000 worth of cheese and butter to the Seychelles Trading

Company. The transaction process only took 4 hours on the blockchain platform as the process typically takes 7–10 days to be completed. (Guo & Liang 2016, 8.)

As the smart contract creates trust and automates processes, it significantly reduces costs for banks and trade financing enterprises (EBA 2016, 11). As a result, banks' operational costs are expected to decrease by USD 13.5–15 billion annually and the cost of risk by USD 1.1–1.6 billion annually. In addition, both of the trading partners will reduce the cost of capital by USD 1.1–1.3 billion annually and operational costs by USD 1.6–2.1 billion annually. (Guo & Liang 2016, 8.)

The supply-chain finance is also heavily operated by paper-based transactions and has a substantial amount of manual inspections and different intermediaries. Blockchain in supply-chain finance could provide significant benefits as smart contracts can make various processes more efficient by reducing manual involvements. Smart contracts could be implemented to digitise processes that typically tie up a lot of paperwork. (Guo & Liang 2016, 8.) In addition to more efficient operations and cost savings, the transparency of blockchains helps to reduce the risk of fraud in the supply chain (EBA 2016, 11). When the contractual information between the supplier, buyer, and the bank is shared in a distributed ledger, smart contracts can safeguard that the payment is automatically implemented as the determined contractual agreements are reached. (Guo & Liang 2016, 8.) For example, the contract could include a clause that when customs have cleared the goods, 20% of the payment is automatically released to the seller (EBA 2016, 11).

Banks have traditionally had an essential role in securing trust between trading partners. Smart contracts could now provide perhaps even better security cheaper and more efficiently. Smart contract will not diminish the need for banks in these trading processes. Banks will have an essential role in consulting their clients on the development of trade financing processes. In addition, the terms and conditions of the contract must be settled before the agreement is written in code, and banks will have a central role in performing compliance checks such as KYC (Know Your Customer) procedures. (EBA 2016, 12.)

2.6.4 Cross-border payments and payment clearing

One potential future application for blockchain technology in the financial sector is payment clearing and cross-border payments. Transactions between different banks, often referred to as interbank payments, are operated by intermediary clearing firms. (Guo & Liang, 2016, 6–7.) Accenture (2017, 5) surveyed banking executives, and according to the survey, cross-border payments were seen as one of the most prominent banking applications for blockchains.

The existing payment system was developed in the 1970s and 1980s and has always gone through banks and central banks. The payments are implemented by using payment schemes such as SWIFT. (FinTech Network 2016, 5.) The clearing process often takes time and is expensive because the transaction processes are complicated, such as bookkeeping, transaction and balance reconciliation, etc. In addition, clearing cross-border payments are different for every country, and hence it may take up to 3 days for the remittance to arrive. (Guo & Liang, 2016, 6–7.)

According to the World Bank Group (2017, 23), individuals and SMEs face uncertainties, high costs, and long delays when making cross-border and inter-banks payments. Inter-bank and cross-border payments go through a network of banks and other money transfer providers, and they are restricted to the business hours of these central intermediaries. The payments also face transactions fees at three different points of the process. These points are fees charged by the sending institution, fees charged by the receiving institution and fees charged for the cross-border or inter-bank transfers. There can be several different intermediaries, which can add up to around 20% of total costs. (WBG 2017, 23.) An example of the cost benefits of using blockchain-based solutions in cross-border payments is shown below, in figure 2.

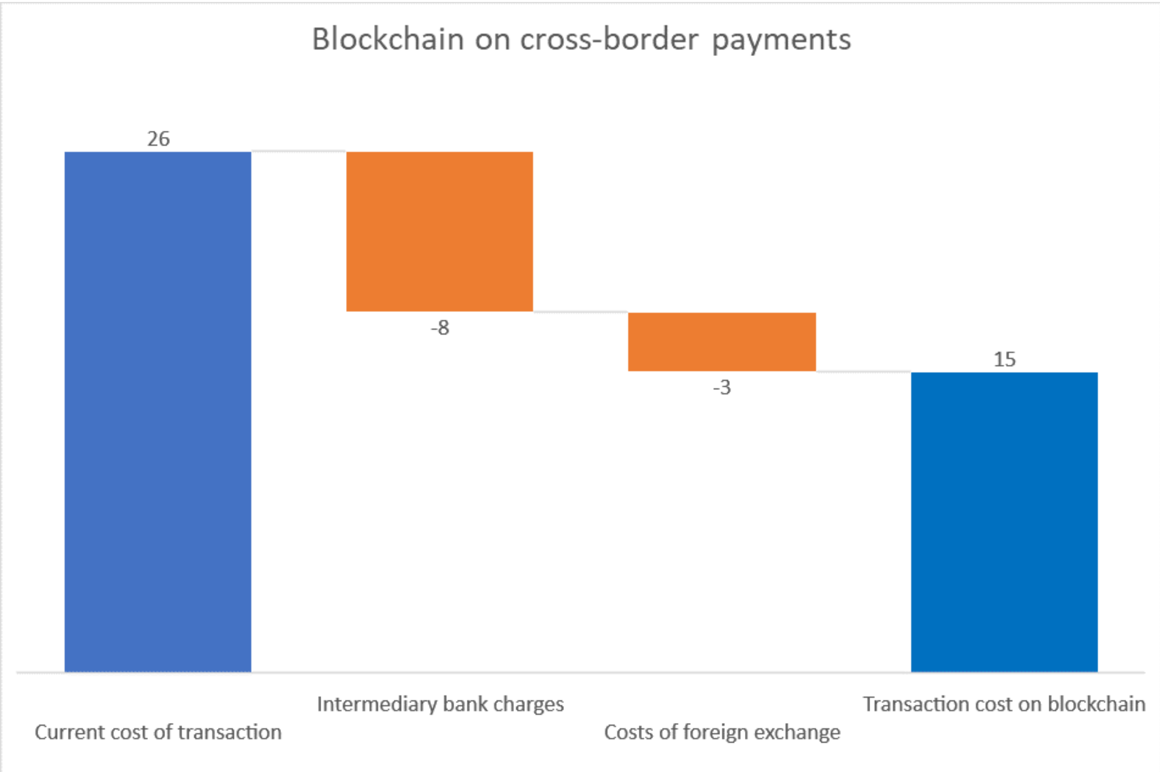

Figure 2 Cost Impact of Blockchain on Cross-Border Payments (McKinsey 2016)

As illustrated in Figure 2, there is often more than one intermediary in cross-border payments. Each time money is transferred abroad, it is sent through third-party intermediary financial institutions. Each intermediary requires a small fee for receiving and sending the transaction forward. Also, there are fees on exchanging currency from one to another. Hence, as illustrated in Figure 2, the intermediaries and current exchanges make the process inefficient and expensive. (Guo & Liang 2016) The cost savings have been calculated based on the estimated cost of each transaction (McKinsey 2016). Typically, a transaction requires a lot of back-and-forth communication with each bank and the central service provider involved in the process (Kauflin 2018). As a result, the total cost of the transaction adds up as each intermediary charges transaction fees. Therefore, the possibility to cut down unnecessary intermediaries on blockchain-based transactions results in significant cost savings. (Guo & Liang 2016.)

Banks could improve their efficiency and reduce transaction costs if they implemented the same process using blockchain technology. Blockchain would get rid of the third-party clearing firms, making the process faster and cheaper. (Guo & Liang 2016, 6–7.) The blockchain-based payment system would give benefits to both banks and consumers. It would provide banks with operational efficiencies, which would lead to cost savings (FinTech Network 2016, 5.) Accenture and Ripple have calculated that as banks could move assets without unnecessary communications and paperwork, it could provide approximately 30% cost saving on average to banks via a blockchain consortium. The 30% costs savings would add up to billions of dollars in larger banks. (FinTech Network 2016, 5; Kauflin 2018.)

In fact, various financial institutions are already testing the possibility of blockchain in cross-border payments. For example, The National Australia Bank's (NAB) employee made a cross-border transaction of 10 dollars from a NAB account to another employee account in the Canadian Imperial Bank of Commerce. The transfer was completed on Ripple, and it only took 10 seconds. (Guo & Liang 2016, 6–7.) With the help of blockchain technology, banks could also operate payments 24/7. Furthermore, there would be no need to wait for the payment over the weekend as it could be implemented directly on the blockchain instantaneously. (FinTech Network 2016, 5.)

The blockchain-based transactions network may face difficulties in mass adaption in the financial sector. Banks and other financial institutes commonly play it safe and trust traditional systems and the legacy systems such as SWIFT, which have proven to be trustworthy and secure in cross-border and domestic payments. Also, if some banks do not adopt blockchain systems and some do, the transactions between these two groups of banks cannot be executed, and they will have to rely on traditional methods. (EBA 2016, 13–14.) If banks are going to adopt blockchain-based solutions in payment clearing, co-operation between banks is needed (WBG 2017, 18).

3 EMPIRICAL RESEARCH

3.1 Overview of research methods

A qualitative research method aims to construct a comprehensive understanding of the research topic. A qualitative approach commonly relies on peoples subjective experiences and their analysis process on the specific issue. Methodologically the purpose is to create meaning and build rich and descriptive data. Often a qualitative research approach is used in exploratory or descriptive research. (Leavy 2017, 124). This research aims to provide a robust understanding of blockchain technology entering the banking and finance industry. The purpose is to be descriptive and provide new insights on the potential applications, opportunities and challenges of blockchain in the banking and finance sector. As the phenomenon of blockchain technology is still in its infancy, significant numerical data is not available. Hence, a qualitative research approach is fitting.

Semi-structured interviews have been selected as the primary data collection method for this research. The interviews aim to form a comprehensive view of blockchain technology in the banking and finance sector. The theoretical findings from the literature review will be utilized for building the structure of the interviews. The current literature is challenged or complemented by the thematic interviews. The purpose is to highlight the possible developments in blockchain technology in banking and finance, especially regarding real-life blockchain technology adoption. Hence, presenting a more realistic and current view of blockchain and banking.

3.2 Methods of data collection

3.2.1 Interview process

As the research method implies, the empirical research is based on qualitative interviews. The empirical research consists of eight semi-structured interviews. According to Eriksson & Kovalainen (2016, 87), in semi-structured interviews, the structure and subjects are predetermined before the interview. Although it is acceptable and even encouraged to deviate from the original structure of the interview, to suit better with the interviews field of expertise.

The interviews were scheduled to be from 45 minutes to 1 hour and 15 minutes long to allow sufficient time for a detailed discussion while accommodating the interviewees' schedule. However, some discussions were slightly shorter than primarily planned. The interview structure and interview questions were provided a couple of days before the discussions were conducted. The interview structure and interview questions are illustrated in Appendix 1. Even though the interview questions in a thematic interview are defined in advance, presenting the questions to the interviewees is more lenient. The order and wording of the questions can deviate from the original format the wording or order of the questions. This allows for a conversational and relaxed interview situation that provides more leeway for the discussion, and not too much control is used. (Eriksson & Kovalainen 2016, 94-129.) No preliminary results from the literature research were presented to the interviewees before each session so that the theoretical research results would not have an effect on the empirical research. However, with three of the interviewees, it was possible to receive feedback on the academic findings after the interview. Silverman (2013, 213) states that the discussions should be recorded and transcribed for further analysis. The current climate with the COVID-19 pandemic was taken into consideration when conducting the interviews. Hence the interviews are executed remotely utilising various video communication and telecommunications solutions. All interviews were recorded and transcribed, as suggested by Silverman.

The interviewees will be introduced in more detail in chapter 3.2.3. However, it should be stated that seven out of the eight interviews were conducted in Finnish due to the interviewees being from Finland. Only one interview was conducted in English. P6 lives in Sweden and does not speak any Finnish, and therefore he was interviewed in English. The interview findings will be presented in chapter 4. As the interviews were mainly in Finnish, direct quotations could not be used. The interviewees' answers are translated afterwards and freely quoted. The interviewees' message has been kept as reliable as possible and in line with the interviewees' original idea.

When collecting empirical data for qualitative research, it is crucial to consider the ethical aspects of the study. This research follows the instructions provided by the Finnish National Board of Research Integrity (TENK, 2012) on how to conduct a cohesive research regarding all the required ethical principles. All participants of the empirical study were voluntary, and no involuntary or pressured participation was evident during the empirical research. Before scheduling the interview sessions, the participants were informed about the topic and purpose of the research via email. At this stage, it was also informed that the potential interviews would be audio recorded for research purposes, assuming if consent for it was given. When the contributors had agreed to participate in the empirical research, the interviews were scheduled, and permission to record and transcribe the interviews were once again requested. Hence, written evidence on the consent was created. As stated, the interviews were conducted remotely using various video and telecommunications solutions. The platform used to perform each interview depended on the participants' choice, as companies have different standards, rules, restrictions and preferences over platforms regarding their information and data security. Before each interview session, permission to record the interview was verbally requested once more before starting the recording.

The participants had the possibility to inform whether some data collected should be deleted or should not be disclosed. In some cases, the participants presented sensitive data and requested that no screen-recording or screen captures were taken. These sections were also cut out of the audio recordings and deleted accordingly. In addition, the EU General Data Protection Regulations (GDPR, EU 679/2106) were followed with all personal data and collected empirical data. All data was stored in a secure cloud-based storage, and all sensitive data was deleted once the research had reached its completion. No financial or other company sensitive data was recorded or requested from the interviewees. All additional data presented by the interviewees was completely voluntary and not requested by the researcher. As the research depends heavily on future expectations and contains plenty of uncertainties, the interviewees and their employers were kept anonymous to minimize any potential harm reputationally or financially. However, the total anonymity of the participants turned out to be more difficult than expected due to the limited operations and professionals of the research subject. The finished thesis has been sent to the interviewees, and they have had the opportunity to read the thesis through and provide any comments if seen necessary.

3.2.2 Selecting the interviewees

Selecting suitable and knowledgeable participants for the interviews turned out to be challenging at first due to the limited amount of blockchain professionals in banking and finance. For a high-quality research, it was essential to identify participants who were truly knowledgeable on the topic, as there are many misconceptions about blockchain technology. The literature on blockchain technology is limited on the actual uses-cases and experiences on blockchain technology in banking and finance operations. The aim was to select individuals who have real-life experience developing and implementing blockchain-based products and services in the banking and finance industry. Potential participants were first sought out through internet searches of banks, financial service companies, and consulting companies working on or who have published blockchain-based applications to banking and finance operations. Once the first contact was created, a sampling method called the snowball effect was utilized.

According to Noy (2008, 330), the most frequently used sampling method is the snowball effect. The term snowball effect refers to a sampling process in which the researcher requests the contact information of potential new participants who could be beneficial to the research, hence creating an accumulative sampling process. Finally, the process ends up in saturation, when no new participants or data is retrieved (Tuomi & Sarajärvi 2009, 87). The snowball effect was discovered to be a beneficial method for this thesis. As blockchain projects are commonly developed and implemented through collaboration, and the blockchain ”circles”, at least in Finland, are rather limited, all leading Finnish blockchain professionals in banking and finance were quickly accumulated. However, the aim was to reach a more comprehensive view of blockchain technology in banking and finance, and interviewees were also searched outside of the core blockchain cluster. Often the interviewees recommended contacting the same participants. The relationships are presented in the snowball sampling tree in Figure 3 and Figure 4.

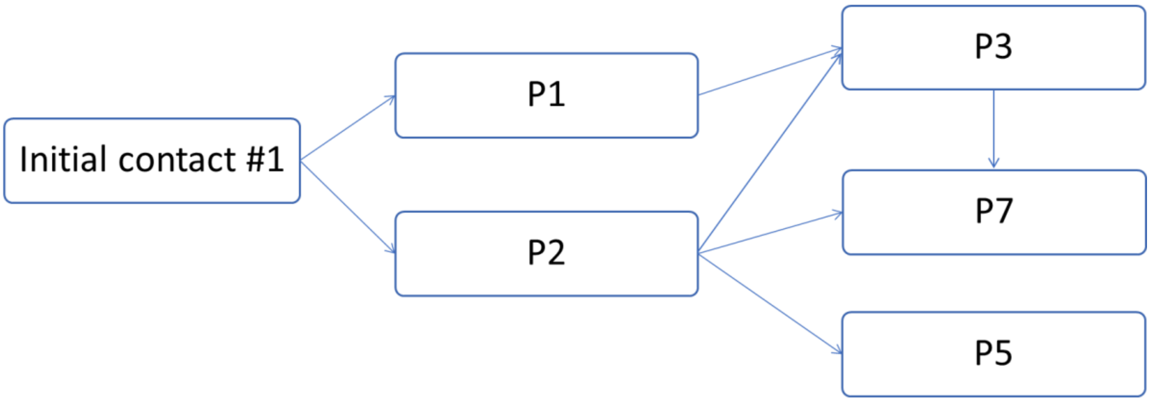

Figure 3 The Snowball Sampling Tree - Cluster 1.

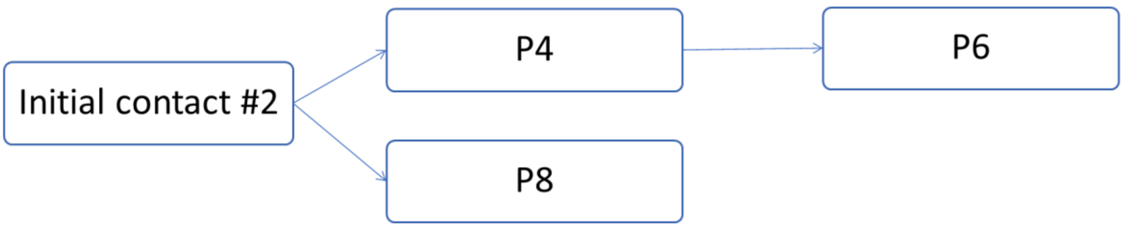

Figure 4 The Snowball Sampling Tree - Cluster 2.

The snowball sampling tree presented in Figures 3. and 4. illustrate how the participants were selected. As shown, two separate clusters were created from two different initial contacts. As seen in Figure 3, Initial contact #1 leads to the Cluster 1, which is seen, as a tight circle. A portion of the participants of Cluster 1. has been part of most of the blockchain-based applications in banking and finance in Finland. Most of the participants in Cluster 1. have collaborated before in blockchain projects and are well aware of each other. While not all of the interviewees have in blockchain projects, they all know each other from the blockchain context. As seen in Figure 4, Cluster 2 was created to reach a view outside of collaborative Cluster 1. The interviewees' background and experience on blockchain technology are introduced in the following subchapter.

3.2.3 The interviewees

In this chapter, the interviewees will be introduced in more detail. As stated in previous chapters, the empirical research consists of eight interviews. Appendix 2. will present the details of each interview session. From this point onwards, the interviewees are referred to as Person 1 (P1), Person 2 (P2) etc., relating to the order of the interviews. Next, a short introduction of each interviewee is provided in chronological order.

P1 works for a leading digital services and software company in the Nordics. The company's HQ is located in Helsinki, but it has around 24 000 employees globally. The firm offers services in over 90 countries. P1 specializes in business development and product management in the payment sector. He stated that he has followed blockchain technology for some years and has some touchpoints to blockchain consortium activities at the decision level. He has not worked with blockchain technology on a daily basis but rather has general knowledge and understanding of the big picture of blockchain technology in the payment sector.

P2 also works in consulting and is part of the same organisation as P1. He is in charge of the innovation centre, which contains a department specializing in blockchain technology. He has a long experience in banking and finance activities, from consulting firms, banking payment networks and banks. The primary focus has been on innovation, and he has also been in charge of a blockchain department for four years. He was first introduced to blockchain technology in 2015, and he has been part of building and implementing most of the blockchain-based solutions in Finland.

P3 works for a leading bank in the Nordic region. He is in charge of the emerging technologies at the group level of the company. One of his areas of responsibilities is blockchain technology and cryptocurrencies. He has been part of all blockchain projects in the company so far. According to P3, basically, he has brought in the ideas and over-seen the implementation of these products and services. He was first introduced to blockchain technology and Bitcoin in 2013. He has been part of various blockchain projects. He was part of an international blockchain project between 2013 to 2015 regarding international payments. He has then joined his current employer. P2 and P1 referred that P3 is one of the leading blockchain professionals in Finland and Europe in the sector of banking and finance.

P4 works for an established bank that has nationwide branches in six markets, mostly in the Nordic region. P4 is in charge of development activities in the Finnish market. He has followed and read about blockchain technology for a couple of years. However, he has not been part of blockchain-based projects, nor is he following the technology on a daily basis.

P5 works for one of the leading banking and financial consortiums in Finland. He is currently working as a leading technological strategist and provides advice in blockchain technology, decentralised data management, cryptocurrency and encrypted technology-related projects. He explains that he has been working with decentralised data management and decentralised data architecture for a quarter of a century, but such projects did not succeed in the earlier years. According to P5, after blockchain technology was invented, decentralised data architecture began to see the light of day again. Hence, he has a long experience in decentralised data management and cryptography related projects. P5 was also regarded by P3 as one of the leading experts in Finland.

P6 also works for the same banks as P4. However, he works at the headquarters in Sweden. P6 explains that he has over 20 years of experience in banking and finance and that he has worked mostly with banking innovation and digitalisation. P4 had first heard about blockchain when Bitcoin appeared, and he has since followed the development of other cryptocurrencies and blockchain projects. Though he has not been part of blockchain projects himself, he has a good understanding of the technology and an overview of potential blockchain use cases and applications.

P7 works for the central bank. He leads the digitalisation processes and advice and analyses emerging technologies and the effects of digitalisation. Primarily, he focuses on phenomenons that can potentially change or disrupt the activities of the central bank or the financial sector in general. P7 states that he was introduced to blockchain technology in 2015. He explains that during the last six years he has heard multiple pitches and demos of blockchain-based solutions. Startups have been very active in attempting to provide blockchain-based solutions for the central banks and other banks. P7 explains that he and the central banks were also very interested in hearing and learning about the new potential solutions and finding out how they actually work. Hence, he states that he is very familiar with the technology.

P8 is a partner of a Big 4 company. He has over 25 years of experience in consulting in the financial sector. He also focuses on various risk assessment and digitalisation activities and advisory for banks and other financial service companies. P8 has an understanding of the big picture of blockchain technology in banking and finance. However, he has not been part of blockchain-based projects as they are implemented by departments and specialities hubs located abroad due to the small size of blockchain professionals and operations in Finland.

3.3 Analysis of data

Qualitative research is formed from two types of data, primary data and secondary data. Primary data is also often referred to as field-generate data, which stems from interviews. On the other hand, secondary data is found from existing literature, social networks, and newspaper articles. Secondary data could also be referred to as found data. The qualitative data analysis aims to investigate, identify and compare themes and patterns to reach a more comprehensive understanding of the research subject. Hence, all eight interview recordings were transcribed for the purpose of a more thorough analysis. (Hair et al. 2016, 299 – 300)

Adams et al. (2007, 156) identify a five-step method of data analysis. The technique contains familiarisation of data, creating a thematic framework, coding, data charting and finally mapping and interpreting the research data. The stages can overlap with one another. The framework provided by Adams et al. (2007, 156) was applied in this research. Creating a thematic framework and coding was completed partly simultaneously.

The first step of the conducted data analysis began with listening and transcribing the interviews. The transcribed data was first read through thoroughly to internalize all information correctly. After reaching a good overview of the collected data, common themes and categories were detected from all eight interviews' transcriptions. The categories detected followed the interview structure and are the following:

- View on current banking trends
- View on benefits of blockchain technology in banking and finance
- View of challenges of blockchain technology in banking and finance
- View on blockchain applications and use cases in banking and finance

This process is identified as categorizing (Saunders et al. 2009, 492). The categories were cross-referenced with the themes gathered from the literature. The coding process was preliminary started during the categorisation phase. Corbin and Strauss (2008, 66) describe coding as an activity where the researcher transfers raw data to a concept degree. In this research, coding was completed by identifying the core points of each category. Next, commonalities and differences were discovered within the categories. Analyzing the transcriptions of the interviews enabled a more detailed understanding of differences and commonalities among the interviewees' answers within the categories.

In the next stage, the data analysis process was the mapping and assessing of the data. In practice, this was done by arranging the coded data under the categories. Common themes detected from the transcriptions were ranked according to the importance. The importance was evaluated on how frequently the themes were mentioned in the interviews. In addition to the commonalities, the differentiating factors of the themes were put into an order of importance. Finally, the interpretation of the familiarised, categorised, coded and mapped data were analyzed, and answers to the research question were searched. (Adams et al. 2007, 161)

3.4 Reliability and validity of the research

3.4.1 Basis of critical evaluation

Environments, experiences, surrounding people and other factors evidently create intrinsic biases for people; therefore, it is expected that researchers have some preconceived notions over the research topic. These factors undoubtedly have some effects on the collected data and interpreted conclusions and research analyses (Saunders et al. 2009; Hammersley & Gomm 1997). To ensure the validity and reliability of the research, it is vital for the researcher to identify potential liabilities in the study. Once potential liabilities have been recognised, the researcher should aim to minimize and point out such vulnerabilities from the conducted research results. According to Hollaway and Wheeler (2013, 298), despite the importance of research reliability and validity, no universal criteria have been agreed upon for evaluating the reliability and validity of qualitative research.

However, for instance, Creswell (2014) and Fisher & Buglear (2010) have discussed sections where the research reliability and validity is critical to be ensured and evaluated. These sections are reviewing previous studies and literature, data collection and analyses and presenting research results. The following subchapters will express the research design and assess the reliability and validity of each section according to the sections presented by Creswell (2014) and Fisher & Buglear 2010).

3.4.2 Literature selections

A solid amount of literature was collected to complement or challenge the collected empirical data. The aim of the presented literature was to provide a neutral view of the research topic, showing the advantages and limitations of blockchain technology. Literature was sourced from online and offline outlets. However, the restricted access to libraries during the writing of this thesis due to the COVID-19 pandemic forced the research to rely mainly on online sources. This turned out not to be a significant issue as most literature on blockchain technology is published online. Therefore, most literature was searched from services such as Google Scholar, Volter, ResearchGate and Scopus. In addition, the literature from some parts relied on the researcher's previous study on a similar topic for the bachelor's thesis. All previously used literature was checked whether they were still up to date, and the literature was updated with new revelations.

The aim was to utilise primarily academic literature and researches to ensure a high-quality theoretical foundation. However, due to the limited amount of academic research on the subject, some supporting literature, such as industry reports and white papers, were utilised to provide a more comprehensive basis. Supporting literature was predominantly used to point out examples and industry views on potential applications for blockchain technology.

3.4.3 Empirical data collection

The goal of the empirical research was not only to discuss the benefits and challenges of blockchain technology in banking and finance but also to showcase the current attitudes, developments and uses-cases of blockchain technology in the industry. The latter objective was especially prioritised in the empirical data collection, as literature on the subject is scarce. To receive an accurate overview of the mentioned aspects, multiple actions were considered to secure reliable and credible scientific research. When discussing the researches external validity, the intentions of the study and the selection of interviewees should be considered. This research is focused on the banking and finance industry. Hence only interviewees who operate in the industry were selected. Despite the interviewee sample size not being large, the interviewees chosen represented various perspectives on the research subject. The participants and their employees represent different sizes and levels of understanding, involvement and agendas regarding blockchain technology in banking and finance. It should be considered that the participants were selected through two separate clusters created by the snowball effect presented in chapter 3.3. Cluster 1 represents some of the participants who have worked closely together in most blockchain-based solutions implemented in Finland and could be stated as the top professionals on the topic in Finland. However, they might have biases and focus on projects they have been part of or are currently developing. In addition, to increase validity and a comprehensive view, it was essential to reach out to interviewees outside of this core circle. It should be noted that ideally, the interview sample would have been more comprehensive and diverse, especially regarding the geographical locations. This could have produced somewhat varying results on blockchain technology development and focus points in different countries.

3.4.4 Analysis and presenting research findings

Creswell (2014) recommend that to increase credibility, all research findings should be presented in the research analysis. Even unfavourable, opposing and unexpected results should be introduced in the analysis. Researchers can utilise multiple methods to guarantee credible research results. For example, the research findings from the interviews can be validated by the interviewees after a certain time period. The researcher can follow up and identify possible new outcomes or contradictions to the research results when validating research results with the interviewees. (Fisher & Buglear, 2010)

The empirical data and interview results were disclosed as genuinely as possible in the following chapters to ensure a complete view of the observed empirical data collected during the interviews. In some instances, even the participants' tone of the statement was aimed to be illustrated to provide a more genuine understanding of data. Additionally, the researchers own interpretations and conclusions were aimed to be visible in the analysis section of the research. This method was expected to persevere the research's ethical attributes and provide other researchers and readers of this study to arrive at their own conclusions and findings from the empirical data presented. It should also be acknowledged that it was difficult to compare all research findings to existing studies due to two reasons: the novelty of the research topic and the relevance of the study to the present day.

4 INTERVIEWS

4.1 Current banking trends

At the beginning of the interview, interviewees were asked to describe the banking and finance industry's current state. Also, they were requested to point out possible changes that might happen within the industry in the near future. The purpose of the initial question was to understand the most crucial trends within the industry. What is happening in banking and finance currently? What possible changes the industry is going through? What potential difficulties or threats challenge the sector phases? All interviewees were fairly unanimous regarding one topic regarding the industry. The common consensus is that the development of new technologies and digitalization has had a lasting effect on the industry. The technological development and digitalisation of services have been going on in the banking sector for some time. Two clear trends related to emerging technologies and digitalisation could be identified from the interviews: user experience through digitalisation and increased competition.

The first trend concentrates mainly on customer experience and the efficiency of services. All interviewees had a similar stance on this topic. Today, customers demand accessible, frictionless services from banks and financial institutions. Customers have shifted their focus from physical locations and services to more preferable online or mobile solutions. Therefore, banks and other financial service firms are rolling out various online and mobile banking applications and services. P3 explains that “embedded finance“ is a significant phenomenon in the industry today. Traditionally banks and financial service companies operate their platforms entirely themselves. Whether we are talking about mobile banking, online banking, or physical branch services, the operation within these platforms is controlled only by the bank that provides the specific service. Today, after leniency in regulations, banks have been able to open up application programming interfaces, APIs, for third parties. Hence, making it possible for banks to provide third-party services from their partnering companies within the banks’ platforms. Thus, enhancing accessibility for customers to interact and transact with these partners directly.

P1, whose primary expertise is in cash management and payment solutions, mentioned that the increasing popularity of e-commerce has made it critical for information and money to be transferred instantly every day of the week. It has become more critical than ever for information and money to transact 24/7 near real-time without delays. Through digitalisation, banks can better support the current fast-tempo climate of information sharing and continuous business. P1, P4, P6 and P8 all agree that the increased amount of customer data and digitalisation could provide new possibilities for banks and financial service firms to enhance the customer experience even more in the future. Through AI and machine learning, banks could provide predictive banking and financial services for customers. With predictive banking and financial services, banks and financial institutes could predict what the customer needs before they even search or ask for it. They are making the transactions even more effortless and frictionless for customers.

P2 finds that the increased digitalization and use of different technologies have made data and information security one of the most critical points in the industry. Generally speaking, banks and financial service firms must keep customers' data safe. But as most of the services today work via online connections, banks need to identify their customers correctly. Banks can monitor that AML guidelines are followed through proper identification, and no fraudulent payments are executed. He also explains that AI and machine learning could assist in the activities mentioned above.

The second trend identified through the interview process was the increased competition in the industry. During the past years, new companies have been entering the market. Not only do established banks and financial service companies have to compete between themselves, but they must also compete with new emerging companies in the market. The increased competitive climate has diversified the customers and pushed the sector to search for more cost efficiencies in their operations continuously. P7 explained that historically, the banking and financial industry has been stable regarding competition, but the threshold for entering the sector has been lowered during recent years. According to P3, the regulatory changes and the more accessible entry to the market has led to startups and established firms flooding into the industry. In addition, big tech and platform companies such as Google and Facebook have also entered the market and created significant competition with established banks and other financial service firms. P3 also brings back the phenomenon of embedded finance in this instance, but in a broader sense. He explains that as new companies and powerful platforms have entered the market, banks must try to bring their services to new digital platforms and integrate their services with, for instance, Google. These services could be, for example, various consumer credit and "pay later" products. Therefore, the influx of new competitors and intermediaries may open up new possibilities for banks to get new customers without forcing these customers to come and operate in the banks' own platforms. When successful, banks and financial service firms can reach out to a broader customer base. Still, on the other hand, the increased complexity of the new digital environment creates significant challenges for banks to be present in the critical areas.

As discovered through the literature review, the increasing competition may enhance innovation and development of the industry but, on the flip side, increase the risk for instability resulting in new financial crises. When questioning the interviewees on this subject, P7, who works at the central bank, finds both positive and negative qualities in the increasing competition. The positive attributes identified were, for instance, cost efficiencies, lower prices, better coverage, and easier access for people worldwide to modern banking and financial services. On the other hand, he agrees that new companies increase risks in the industry. The negative aspects also include possible credibility and security threats for customers. Due to the lowered regulatory requirements, new companies are entering the market rapidly. These emerging companies may not have the financial stability or data security protocols, similar to established banks and financial service companies present in the industry for longer. Besides, the increased number of operators in the field makes the governing processes more difficult. Hence, it might be challenging for customers to find genuinely trustworthy companies compared to before. In addition, the increased competition creates pressure on profitability. If the profitability decreases, this creates a more unstable competitive field. All these aspects may lead to solvency difficulties and possible bankruptcies. After weighing the positive and negative qualities, P7 finds that it would be preferable to continue supporting innovation and carefully mitigate the risks.

While emerging technology, competition and digitalisation has enhanced customer experience and innovation, the development has resulted mainly in incremental change in the industry. Both P5 and P7 agree that even though the sector is changing and becoming more digitalized and tech-savvy, no underlying operating model has been altered or developed. The development has focused chiefly on making already existing processes more efficient. P7 stated that no single case has substantially changed the industry. But the changes have mainly been all types of smaller developments, which transferring to mobile-based solutions might be the most important one.

P5 finds that today, the biggest problem in banking and finance is its complexity. The current systems and operating models have been built through decades “block-by-block”, as all innovations have been “glued” on top of the older designs. This block-by-block development and incremental changes have made the sector extremely complex. The complexity of processes has made it near impossible to create genuine significant changes to current operations. Yes, it is possible to produce small efficiency gains through more minor innovations and delicate changes to mobile banking services. But it is not possible to change or reshape the structures of banking and finance. According to P5, there are significant inefficiencies in the design of banking and finance, which is the core problem of the industry today. P5 finishes his statement by describing efficiency as one of the most critical aspects for banks and financial service companies. He concludes that today, the banking and finance industry is a continuous cost-efficiency race, which is not fun.

4.2 Blockchain benefits in banking and finance

After receiving a solid understanding of the banking and finance sector from the first part of the interview, the aim was to shift the discussion towards blockchain technology. The second part of the interview aims to determine why banks and financial service companies have been experimenting and investing in blockchain-based solutions. The goal is first to figure out why blockchain technology has sparked interest within the industry and secondly to discover what benefits the interviewees see that blockchain technology could offer to the sector. It was also interesting to see how blockchain-based solutions fit with the trends and problems stated in the first section of the interview. Through comparing the benefits of blockchain to the issues stated, it could be figured out if blockchain technology could be a solution or at least one possible solution.

When questioned why banks and financial institutions have begun researching and possibly implementing blockchain solutions in their operations, P4 stated that blockchain technology would not be researched if there were no possible benefits to be identified. P1, on the other hand, said that at first, the reason why banks and financial service companies have researched blockchain technology might have had to do with hype. Sure, benefits have been identified, but there was a lot of hype back in the day, and therefore, many banks started innovating with blockchain technology.

The interviewees, P1, P2, P3, P4, P5, P6, P8, who found benefits in blockchain technology in the banking and finance sector, were relatively unanimous. They all agreed that the advantages of blockchain technology for banks and financial service firms are rather generic as they are speed and real-time transfer and settlement processes, trust and reliability in networks and transactions. P3 clarifies that blockchain-based solutions could enable more straightforward methods than the current solutions today. Hence, creating productivity and cost-efficiency benefits. The benefits are not mutually exclusive as, for example, speed, reliability and transparency all bring cost efficiencies. The benefits mentioned by each interviewee are summarized below in Table 2. The most commonly mentioned benefits are listed in the table, and "X" is marked if the interviewee specifically cited the benefit. As seen, "Trust & Transparency", "Data Reliability & Validity", as well as "Efficiency" were mentioned the most often. P7, who is generally against blockchain technology in banking and finance, did not find that blockchain offers any benefits for the industry.

Table 2 Summary of Benefits

Benefits	P1	P2	P3	P4	P5	P6	P7	P8	Total
Trust & Transparency	X	X	X	X	X	X			6/8
Speed & Real-time transactions		X	X	X	X			X	5/8
Data Reliability & Validity		X	X	X	X	X		X	6/8
Efficiency	X	X	X		X	X		X	6/8
Cost Benefits		X	X		X	X		X	5/8

As clearly stated in the theoretical part of this thesis, blockchains create networks and are dependent on the networks' participants. P3 cleverly expressed that blockchains with only one participant are the worlds' worst databank and nothing else. Therefore, the power of blockchains comes from cooperation and networks and the projects that these create. P2, P3, P4 and P5 stated during the interviews that the more participants the blockchain network has, the more benefits it generally produces. The discussions with the benefits of blockchain during the interviews tended to lean to comparisons on centrally organised networks versus blockchain-based distributed networks.

As stated above, the interviewees who supported blockchain-based solutions viewed that blockchain technology creates trust and reliability within a network of banks and other parties. P3 and P4 explained that blockchain technology generates trust, which is crucial in networks. P3 states that, in general, it is rare to find a central party or authority that every other member of the network trusts. Hence, it is challenging and highly political to reach an agreement within the network on which party will be the central block of the network. The central block is responsible for governing the entire network and storing and distributing all the needed data across the network. Hence, having access to all critical data from all parties. Blockchain technology does not totally solve all the political network issues but does dilute these problems. The main upside of blockchain-based distributed networks is that no central authority must be appointed. In addition, the activity within the network is not dependent on any member of the network. With blockchain technology, it is possible to create multipurpose distributed networks that could theoretically interact with different distributed networks. Participants in these networks securely share only the needed critical data with only the parties involved in that specific transaction. Thus, providing a better standardization of data and maintaining better data integrity. In practice, this results in not having to build initial trust between all of the network participants as the blockchain technology and smart contracts ensure integrity. P3 continues to explain that anyone who has been involved with banks' IT, data security and risk assessment processes know how big of an advantage it is. In other words, as blockchain technology creates more trust and reliability in the network, it produces efficiencies in speed and costs.

Even P1, who is slightly sceptical on actual use cases for blockchains, stated that he sees that blockchain technology could be helpful, especially when no clear central body is already present. He provides trade financing as an example. As multiple parties and banks worldwide interact, these parties do not necessarily wholly trust each other. In addition to trust issues in trade financing, digitalisation in this sector is still low. P1 sees that, especially if the before mentioned qualities are present, lack of trust and low rate of digitalisation, blockchain-based smart contract solutions could be helpful.

In P3's view, optimally, the end-users or customers will not have to understand or see blockchain technology in their services. The goal is that blockchain technology sheerly operates in the background of these processes and services. Hence, creating better, faster, more reliable and customer-friendly services to customers. P3 underlines that, in his opinion, this is something substantial that banks can create for the world. Specifically, the enhanced trust enhances the user experience by making services significantly simpler and more efficient.

When questioned about potential concrete benefits blockchain technology could bring to banking and financial service companies, P5 also stated that efficiency is the main benefit. Through blockchain-based solutions, it is possible to modernize the banking world to be significantly simpler and more efficient than today. He emphasized that this, if anything, will motivate the industry as the current operations with the current models and technologies are extremely slow and expensive. P5 underlines that it might take some time for services to be transformed into a decentralized model, as the phenomenon is entirely new for the banking and finance sector. He is not sure when the change will happen but believes that significant development has occurred within five years. After that, there will be fundamental changes to the current banking model, which will carry out significantly more efficient services, especially in transferring value between parties. P5 states that blockchain technology could enhance efficiency in such activities ten times what they are today. He believes that banks are now facing a difficult question. Whether they start creating the new model and perhaps fall back in the competition at first, but will quickly pass competitors within a couple of years using decentralised solutions, or stay using the current old model and fall back from the competition in the long run.

4.3 Blockchain challenges in banking and finance

The conversation with interviewees was fascinating when discussing the potential challenges and disadvantages of blockchain technology in banking and finance. The responses were more varied than the answers given during the discussions about the benefits of blockchain technology. In addition, the type of responses given by the interviewees seemed to heavily rely on their personal view on blockchain technology in general. Interviewees, such as P7, who did not see any actual benefits or use cases in blockchain technology, had a significantly different point of view compared to the interviewees who were more "blockchain minded". The more welcoming interviewees to blockchain technology saw challenges more as obstacles to be solved. Similarly, to chapter 4.2. in this chapter, challenges have been summarized below in Table 3. using the same method. All interviewees mentioned the difficulty of defining blockchain technology. However, this is not the most significant of challenges to be solved. As seen in Table 3, "Network Governance & Politics" is seen as the most critical today.

Table 3 Summary of Challenges

Challenges	P1	P2	P3	P4	P5	P6	P7	P8	Total
Core Ideology (central vs. decentralised)	X						X		2/8
Initiating Projects & Scalability		X	X		X	X			4/8
Network Governance & Politics	X	X	X	X	X	X		X	7/8
Definition & Terminology	X	X	X	X	X	X	X	X	8/8
Reputation & Image		X	X		X				3/8

P7, who works for the central bank, was the most critical against blockchain technology in banking and finance. Consequently, his views differed a lot from most of the interviewees. As mentioned in the introduction, P7 has followed blockchain technology in banking since 2015. He has seen multiple startups, proof of concepts, and theoretical ideas, but no proper implementations of blockchain technology have held up to their expectations. In his own words, P7 expressed that he is in general eager to try and research new technologies and possibilities, and four years ago, he was somewhat optimistic about blockchain technology. But after following the field for six years, he is starting to become pessimistic.

In general, P7 is somewhat sceptical about defining blockchains as a technology but rather as an ideology. This is because multiple ideas loosely belong under the term "blockchain", and they are primarily various software products. These software products may vary greatly from one another but still be grouped under blockchain technology -products. He finds that defining blockchain technology is still today extremely difficult. The subject of defining blockchain technology actually came up often with other interviewees as well. Blockchain technology is now more of an umbrella term with multiple types of distributed solutions under it. Blockchain technology has been developed significantly from its first

Bitcoin blockchain. In some cases, they do not even seem to relate to each other or be recognized as being under the same category. All other interviewees also mentioned about the difficulty of defining blockchain technology.

P7 defines blockchain as being specific ledger software that originates from Bitcoin and other cryptocurrencies. In these networks, the purpose of blockchains is to operate as software for an accounting book or a ledger. Hence, in theory, blockchains could be relevant for banks in the financial industry as the banking and financial industry at its core is accounting, and all the most critical software that banks use today are accounting software. For this reason, many blockchain companies have approached banks and financial service firms and offered services and software. In principle, this makes a lot of sense.

However, P7 finds that there has happened a fundamental misunderstanding regarding blockchain technology and banking and finance. In his opinion, blockchain technology does not solve the problem that it promises to solve. The problem that it claims to solve, cost efficiencies, has already been solved much better and way earlier. P7 explains that blockchain technology was never meant to solve any cost efficiency problems, even in theory. What blockchains actually do and what problems banks want to solve do not match in the slightest, and here is where the fundamental misunderstanding is formed. In fact, P7 views that blockchain adds costs and decreases efficiencies compared to legacy systems that banks are already using. He claims that these legacy systems, such as Oracle and IBM databases, were created for banks in the 60s and 70s, and their preliminary idea is to be a ledger for banks. They are designed for banks and work extremely efficiently. P7 explains that this is something that he thinks that blockchain companies and developers have not understood. The solutions have already been solved better, and the competitors such as IBM have decades of lead and experience.

P7 returns to explain what he sees as the core purpose of blockchains in the Bitcoin network. He expresses that blockchain technology was never invented to bring up productivity or cost efficiencies. The objective was utterly different. Actually, blockchain technology makes the network purposely less cost-efficient as it aims to solve a problem, which is that anyone anywhere can operate as a bookkeeper for the network. The banking and finance sector has never had this problem, as everyone knows who the bookkeeper is, banks. P7 continues to argue against blockchains, as he believes that the banking sector cannot operate similarly to a blockchain network. Every bank has its own ledger, and every bank is the bookkeeper of the said ledger. He finds it impossible to outsource the bookkeeping duties, as every bank is responsible for its assets and liabilities. Hence, blockchains do not work in banking and finance as the structure is entirely different from the Bitcoin network. There are no issuers, banks or bookkeepers in the Bitcoin network, and therefore, distributed bookkeeping is needed. This distributed bookkeeping is achieved according to P7's opinion by compromising cost-efficiencies. This is the trade-off between the two aspects.

In P7's view, the clear problem for blockchains is that the banking and finance industry is formed to operate centrally. And these central parties in this central network trust each other, and the users and customers trust these established parties. So, the technology created for a distributed network does not fit well into the central network, as it was not created for a central environment. P1 seemed to agree with the said thought. In P1's field of payments, he finds that the trend of blockchain technology is at its "second wave", at least from his point of view. He explained that a few years ago, blockchain technology was hyped to solve all of the problems regarding payments, but these days are now over. He views that blockchain technology as just one technology that could solve these challenges in a non-centralised or distributed environment. The fact is that the current monetary industry is highly centralised, as central banks are needed, and therefore commercial banks etc., are required. Thus, in his experience, anything that could be achieved through a distributed model can be completed in the current environment through centralised solutions. He finds that trust is still built through traditional ways; therefore, the added value of blockchains is relatively limited.

P7 obviously compared permissionless blockchains and the banking and finance industry. When P7 was challenged to find any positives or use cases for permissioned blockchains in banking and finance, the response was still negative. P7 views that it does not make any sense. Blockchain technology was created for an open network and should operate as such. This is the fundamental misunderstanding that he mentioned before. If all of the nodes in the network are known and the network is closed. No core benefits of blockchain are created – anyone can be the bookkeeper in an open network. He also views that the statement "blockchain technology creates or brings trust" as false. Blockchain technology rather enables operating in an environment where there is no trust between the participants. It does not create it as it is not needed in the first place. Hence, it does not fit in with the banking and finance industry. P7 states nearly similarly to P1 that the industry is founded on trust and that there are parties that can be trusted. For instance, you take your money to the bank and trust that the bank takes care of your money. There is no greater trust. P7 finds that when companies and developers develop blockchain technology to fit the banking and finance industry better, the solutions begin to resemble traditional software. He explains that he has seen many of these projects where the end-product does not remind us of blockchain anymore.

As mentioned above rest of the interviewees generally have a more positive view of blockchain technology in banking and finance. Also, their views on challenges and possible disadvantages were different to what P7 expressed. Though there were some similarities and concerns, they were seen more as obstacles that will be solved through work and innovation.

Perhaps slightly surprisingly, the challenges did not focus on blockchain technology itself or the limitations of the technology. P1, P4 and P8 had some concerns about the technical and regulatory aspects of blockchain. For instance, P1 stated that blockchain-based solutions, in his experience, especially in payments, had been proven to be relatively slow. These solutions often had problems with supporting the required volumes or issues with data and information security. In addition to scalability and speed, he remembers that regulatory questions were seen as risks. P1 admits that the experiences he is talking about have happened some years ago and has not followed the development that closely lately. However, he believes that some of these challenges or disadvantages have probably been already addressed since then. P5 confirms P1's doubts as he expresses somewhat frankly that the mentioned problems, at least in permissioned blockchains, are no longer an issue. In his opinion, today, the network architecture and scalability do not have bottlenecks, such as in permissionless consensus-based models. He also adds to his statement that he does not see regulatory or legal questions as a problem, unlike with public blockchains. P2 also briefly comments that there are clear disadvantages to public blockchains. For example, regulation related to General Data Protection Regulation or GDPR, customer identification, and anti-money laundering bring issues with public blockchains. P2 rationales that the mentioned reasons are just a few reasons why permissioned blockchains are used. Hinting that similar problems are not evident in such models. Therefore, today, the core challenges do not seem to relate to the technology itself. The statement on behalf of permissioned blockchains was supported by P1, P2, P3, P4, P5, P6 and P8.

Even though the primary challenges related to blockchain technology are relatively under control, it does not mean that there are no challenges for blockchain in the banking and finance sector. On the contrary, P3 firmly stated that there are problems and, frankly, quite many of them. He explains that only a few blockchain technology projects have gone beyond the first meters. The reason is that when networks are first being created, they begin with a small group of actors within a specific market. This limited group of stakeholders first set up, building the network's entirety together. Then slowly start to expand the network. This, at least, is how it began in projects such as we.trade and DIAS, where P3 has been a part of. Both projects launched with similar principles; first, only a few banks began to create something new together. When "something" had been created and "it" worked, they could get more banks to join the project quickly.

P5 also identifies similar tendencies. He expresses that one core difficulty is casting the foundation for the project and determining who will fund the project. Finding adequate funding is crucial for any project. P2 informed that initiating blockchain projects can be slightly more expensive than traditional IT or software projects. Legacy or traditional technologies are usually of the shelf technologies, and no customisation is needed. In addition, only one actor typically provides these legacy technologies. Today, blockchain-based products are still modified and built from scratch. Therefore, the projects require collaboration and maybe a bit more expensive. P2 explained that the premise and implementation of blockchain-based products are very different to legacy technologies. Nevertheless, P2 believes that when operational blockchain applications create cost benefits in the long run.

Expanding the decentralised networks were identified as being one of the core challenges. P3 explained that having only a limited amount of banks at the beginning of the projects may become somewhat of a political problem for other banks outside of this primary group. The problem could be identified as a “not invented here” -type of problem. The political conflict may be that competing banks may not want to join a blockchain network created by their rivals. They instead want to build their own product and blockchain network.

Hence, the competitive situation creates the stated “not invented here”-problem. P3 explains that the mentioned problem is prevalent between banks is familiar with any other industry and stakeholders. For example, the same issue can be identified in the supply chain and trade logistics industry. In conclusion, getting blockchain projects started and creating the traditional trust between the actors is problematic. However, P3 and P5 express that banks are already used to cooperation in Finland. Thus, the situation regarding relationships, competitiveness, and trust between banks is good and healthy compared to banks in the UK or France. The rivalry between banks in the UK and France could be viewed more like mortal enemies, and therefore, it is challenging for them to reach some sort of consensus without any government-supported actions.

P2, P3 and P8 express their views that collaboration is the first challenge that blockchain technology projects phase at the beginning of projects. P2 and P3 underline that blockchain technology does not solve these types of political or networking problems mentioned above. These problems are precisely the same as in any other network projects. P2 states that it is unnecessary to blame blockchain technology for an unsuccessful project because it is often due to the failure of collaboration. Blockchain technology and building a network is an entirely separate issue that does not relate to how network effects are created.

P2 finds the mentioned challenges as inspiring regarding blockchain technology. Blockchain technology enabled us to reimagine how industry platforms or industry networks are formed. Rather than single actors trying to solve industry problems by themselves and creating their own commercial products or services, the industry cooperates and aims to solve the problems together with a common platform. He also did not find it competitively beneficial that multiple centralised platform services would form de-facto industry infrastructures or national infrastructures. In his opinion, such industry infrastructures and national infrastructures should be managed communally and more fairly.

P3 expresses another challenge regarding the first steps of launching a blockchain-based network project. He illuminates that banks have harsh IT and information security requirements and processes. Hence, if five banks collaborate in a blockchain technology project and all banks operate as nodes in the network, the blockchain software must pass all five IT and information security processes. On the flip side, when the software has passed all five security checks, it reflects a positive message about the software infrastructure — ensuring that the technology and the software infrastructure are genuinely secure, reliable and trustworthy.

Another challenge that the interviewees mentioned also relates to building networks. P3 expresses that the development and deployment phase is often challenging within these networks. When the blockchain software is updated, naturally, it must be updated in the entire distributed network. This requires that all of the nodes keep up with a similar update schedule so that the network does not break. If some nodes operate with an older version, then new problems arise. Especially when there are large-scale updates, all nodes must update their software within a specific time frame to ensure flawless continuity. Also, P3 and P4 explain that the more nodes are part of the network, the more complicated and difficult the planning process will be. Often these types of updates require that all nodes plug out of the network for a day, and the entire network is updated at once. During this period, the network switches to operate on an older generation. The process is called swap over migration, but it still results in some downtime. The maintenance and development process can be somewhat complicated in a distributed network, at least when there are more nodes involved.

P2 expresses that one central and time-consuming process related to distributed network ventures is forming a governing model for the network. Also, identifying how rules are created and enforced. P2 explains that typically the cooperating stakeholders establish a common legal entity, such as a joint venture. Through the established legal entity, the rules and decisions of the network are made. P3 and P6 confirm as they both identify challenges regarding governing a distributed network. P3 elaborates, distributed networks have multiple stakeholders, and every stakeholder requires an equal vote. Hence, resulting in a slow and complicated decision process. For example, we.trade has 13 or 14 banks, and all of these banks are part of the board and, therefore, have the right to decision making. P3 and P4 agree that the more banks are involved, the more political and complicated the decision-making process becomes. In practice, months could be spent fighting how to update the network or what functionality should be added to the software. When geographic locations are taken into consideration, the process becomes even more complicated.

For example, P3 explains that stakeholders in South America have different preferences regarding the functionalities than the actors in Finland. It is simply due to clientele, environment and culture. Thus, P3 informs that they aim to form networks with at least some homogeneity regarding legislation and regulation. We.trade, for example, only operates inside Europe. P3 believes that the future decision model for blockchain networks is distributed between homogenous regions, such as the European Union, Nordics or even within a country's borders. This ensures that decision-making is still close enough to a shared culture and environment that reaching a consensus is even possible. P3 believes that networks will be formed within a region regarding global interoperability, such as the Latin America network or the European network. These networks do not operate as one but cooperate through standard ground rules and agreements. These agreements do not directly affect the local governing requirements. P3 finds that these types of arrangements currently seem like the best way to guarantee global functionality.

P2 mentioned one more disadvantage of blockchain technology, especially for being approved within the banking and finance industry on a larger scale. P2 and P3 view that the massive hype over blockchain technology between 2015 and 2018 has harmed the image of the technology itself. There were plenty of proofs of concepts, media articles and white papers during the three years. Blockchain technology was marketed as if it could solve any problem. However, after a while, the realisation hit that blockchain technology does not solve all issues, as it requires cooperation within the industry. He elaborates that at first, everyone was so excited about the new technology that the business side was not even taken into consideration. After the initial high, many projects failed globally, as they noticed that they could not reach an agreement regarding the business model or there was no business case from the beginning. Hence, resulting in a somewhat tarnished reputation for blockchain technology, according to P2.

The reputational difficulties also relate to understanding the complex nature of blockchain technology. As mentioned, the challenge of defining blockchain technology has come up with nearly all of the interviewees. Everyone might have a slightly different view of what the term blockchain entails. For example, P7 saw public blockchains mainly as blockchains and permissioned blockchains not as much. In addition, the media coverage over blockchain technology is often unfavourable and not helpful for the problems with the definition. P2 explained that blockchain today is a rather broad terminology. The term blockchain is used differently in separate publications. Some people or publications discuss blockchains as cryptocurrencies, and some refer to blockchains in private networks. Therefore, the statements between these two publications can be completely conflicting. P2 also expresses concerns that often people who are generally perceived as vigilant in technology present opinions or perceptions about blockchains that people who have expertise in blockchains find completely false. It is noticeable, for the experts, that the person giving the statement is clueless about the topic. Often, they only have a narrow view of blockchain technology and look at it through one application.

P1 also expresses that the banking and finance sector is still fairly conservative, so rather than trying something new, the industry relies on the old and approved methods, especially if the new model does not seem to bring significant added value. P5 views that as the ideology with blockchain technology is fundamentally different from the current centralised structure, not everyone will understand its full potential and how services and the architecture would look like. Also, when you don't understand first hand, you might not support the new technology and be hesitant about the change.

4.4 Blockchain application in banking and finance

4.4.1 Prominent applications and use cases

After identifying the pros and cons of blockchain technology, the goal was to discover a current understanding of the existing and most prominent potential blockchain technology applications in banking and finance. The interviewees had often already given real-life examples and implementations of blockchain-based applications in banking and finance when describing the benefits and challenges. Hence, a good understanding was already formed at this stage of the interview. Table 4 presents the most commonly talked about applications and use cases during the interviews.

Table 4 Summary of Prominent Applications

Blockchain applications	P1	P2	P3	P4	P5	P6	P7	P8	Total
Digital Identity		X	X		X			X	4/8
Digital Real Estate		X	X	X	X	X			5/8
Trade Financing	X	X	X	X	X	X		X	7/8
Unlisted Companies Share Trading		X	X		X				3/8
Payment & Transactions		X		X	X			X	4/8
None							X		1/8

As seen from Table 4., the general theme of the identified applications and use cases relate to standardised data, data validation and sharing in activities that hold multiple different parties. Even though trade financing was mentioned the most, creating a digital identity platform was currently recognised as one of the most important projects. Once the digital identity platform has been designed, it opens up multiple other opportunities for blockchain-based applications. P7 did not find any prominent use cases for blockchain technology in banking and finance.

4.4.2 Digital identity

P2 explains that as the current trend in banking and finance is digitalisation, information security, KYC, and anti-money laundering issues have become more crucial. He believes that some of these issues can be tackled with artificial intelligence. However, he believes that blockchain technology has significant potential to assist in the said issues by creating digital identities. Both P3 and P5 commented on the topic of digital identity. P5 states that before we begin to digitalize banking services, we should digitalize the parties involved with these services. Hence, digital identities have to be created for organisations, people, and possibly even things. P2 finds that the term digital identity might be slightly misleading as it is more about confirmed data than personal identity per se. P3 enforces the statement by expressing that he feels that the topic of digital identity is easy to misunderstand. The idea originates from the thought of self-sovereign identity, meaning that you have complete control of your identity and your data. Thus, you would have digital proof of yourself and your attributes and share the evidence and characteristics with other parties when necessary.

P3 provides a simplified example of purchasing liquor from a store. Imagine a situation where you are buying a bottle of alcohol. With the help of digital identity, you could buy the bottle without revealing your name, age or any other information about yourself, i.e. you do not have to show your ID card. Therefore, you do not have to share any additional information with the sales clerk other than if you are eligible to buy alcohol or not.

P3 explains that you could share this information reliably with the sales clerk through a fact wallet or an identity wallet, and the sales clerk can trust that the data is 100% correct. P3 and P2 explain why the term digital identity or self-sovereign identity might be misleading because the information or data can be anything. It does not have to be related to your identity, such as an ID or driver's licence. It could also be a transcript of records, fishing licence, library card or information about what social-service benefits are entitled.

Therefore, self-sovereign identity includes any data related to you, which does not have identity data but is “my data”. P3 emphasizes that with the digital identity phenomenon, a decentralised infrastructure must create the “trust network”. This enables us not having to trust and focus everything on just one centralised actor, which happens to provide the wallet. Also, with multiple centralised solutions, different wallet providers would not operate together, creating silos and detached networks with unstandardized data management. He underlines that, in principle, for the wallet provider to operate adequately, the network has to have enough trust, decentralisation and openness. Furthermore, the network must be neutral so that different providers can perform and compete equally. P3 finds that in such use cases, blockchains are optimal.

P2, P3 and P5 explain that they are currently creating and cooperating on a network called Findy. Findy is a locally governed decentralized identity ledger in Finland. As P5 also stated, P2 illustrates that the goal is that with Findy, it is possible to ensure and guarantee all information related to organisations, people and perhaps even things securely. P2 elaborates the purpose even further, as he explains that traditionally, in a society, trust is generated through certificates, evidence and proof, for instance, ID, driver’s licence, transcript of records and job certificates. Typically, all the identifications and certifications are in paper format, where their originality and authenticity cannot be verified. P2 explains that Findy will digitalize certificates and identification with fact wallets based on blockchain technology. He informs that Findy is built in cooperation with the public sector, Nordea, OP and other financial organisations.

P3 expresses that from a bank’s point of view, as a trusted actor, they are interested in what opportunities these types of fact wallets and Findy could offer to customers. Both P3 and P5 state that the possibilities for the digital identity network and fact wallets are significant, especially as it enables new functionalities and applications to be built on top of the network. P5 explains that you can send information securely to someone else with a wallet in the same network once you are connected to the network. The receiver can trust that the data is correct as it has been validated. Principally, you could tell any facts about yourself. For example, you are buying new real estate. Your bank, which is also connected to the network, can guarantee that you have enough funds and financial backing to execute the trade. With some excitement P5, announces that the use cases for such networks are countless. He does not even want to begin guessing what applications come first and what arrives later. According to him, the list of possible applications is long.

P5 concludes that all in all, he believes that it is just a matter of a year's hard work, and Findy will be very close to the operational stage, at least from the technological point of view. He does not see any problems with the technical side of things. From the regulatory perspective, the new process should reflect the existing process in all aspects that, instead of paper, all the data is in digital form. Now that paper is vanishing, similar evidence is found digitally in Findy. Therefore, Findy can completely replace signed paper documents with digital versions.

4.4.3 Digital real estate trade

The DIAS platform or service was frequently mentioned during the interview as one prominent example of a functional application for blockchain technology. DIAS is a digital real estate network. The platform has already been briefly introduced in the theoretical section of this thesis. When discussing applications and implementing blockchain-based solutions, DIAS was frequently cited. P3 mentioned that blockchain-based real estate trading is prominent, at least in Finland. In fact, P5 revealed that DIAS is the world's first Corda-based operational decentralised transaction network. He is slightly hesitant to call DIAS a blockchain-based network. However, P3 states that DIAS operates on a permissioned blockchain. Corda technically utilizes DLT (Distributed Ledger Technology), which is classified as blockchain technology depending on one's definition. If DLT is not seen as blockchain technology anymore, it has originated from it. R3, the company behind Corda, also refers to it as a blockchain platform.

P3 explains that the real estate market in Finland was based completely on manual processes with plenty of paperwork. He describes that, basically, paper-based housing shares are transported from one bank vault to another. P5 explained how banks in Finland ended up joining the DIAS network. First, Finland began transforming all housing shares from paper to a digital format. Tomorrow Tech, A Finnish company behind DIAS, approached the banks in Finland and pointed out the upcoming change. Next Tomorrow Tech questioned whether banks had created any solutions for the change, and if not, they would have a modern solution based on encrypted technology. According to P5, banks did not have any proper answers at that time, so "there was nothing to lose", and they tried it out.

According to P3 and P5, two of the biggest banks in Finland (Nordea & OP) first joined the collaborative project, then once functional, all of the other banks joined later. P5 indicates that the DIAS project taught a lot. According to him, banks learned that such industry-wide problems should be tackled through the industry level. Therefore, today, banks in Finland cooperate with various blockchain trials and decentralised network projects. P3 explains that a blockchain technology solution was optimal for real estate. Once houses or apartments are traded, the document, the housing share, is transferred digitally from one bank to another. With blockchain technology, all parties can be confident that only one copy of the documents exists, and it cannot be in two places at once.

P7, who before criticized blockchain technology in general and expressed that he has not seen any proper operational blockchain-based solutions in banking and finance, was questioned whether he was familiar with DIAS. P7 said that he's familiar with the DIAS platform but does not find that it has anything to do with blockchain technology. He admits that they utilize a blockchain product, but there is no good reason for it. He states that the platform could probably function more cost-efficiently if it did not use blockchain technology. He elaborates that DIAS is a prime example of an application that has been attempted to be solved with blockchain technology products. If we first look at the problem we are trying to solve, it is not about decentralisation. In fact, on the contrary, it is about centralisation. He explains that now that the real estate market wants to be digitized, the solution is to create a database where all real estate trade is conducted. Now the result from this is that some sort of platform has been created. Therefore, the data is centralized to this platform. In P7's point of view, the information is not decentralised but completely opposite, centralised, and this is why DIAS works.

P7 was challenged whether he found that the information is decentralised within the network, enabling more frictionless transactions. P7 hesitates but disagrees with the statement. He finds that it would be even more efficient if everything would be stored together. This basically operates using cloud technology, and the entire point of cloud technology is that it is centralised to one location. Similarly, a bank's business model is based on economies of scale. Banks benefit from scaling and becoming bigger, as then the information is handled more in a central location, which creates cost efficiencies, increases trust and mitigates risks. The same benefits would be present if all data from the real estate market would be stored on the same platform. He explains that this is what the platform economy is all about. For example, Airbnb stores all apartments in one location, Wolt stores every restaurant in one platform and Uber has all taxis in one application. He expresses that you can be certain that the Wolt-database is not decentralised in any shape or form as it is highly centralised. According to P7, this is the fundamental misunderstanding that we discussed. Decentralisation does not bring benefits. Unfortunately, it's the opposite. P4 has a differing opinion on the DIAS network. As P4 lives in Sweden, he had not heard about the DIAS platform before. He explained that blockchain-based solutions are good for operations where there are fragmented documents and multiple parties involved. Once P4 heard about DIAS, he expressed that it is a perfect example of a beneficial use case for blockchain technology, as it provides efficiencies to process with increased data reliability and speed of data transfer.

4.4.4 Trade financing

Another frequently mentioned application by the interviewees was blockchain-based trade financing. P3 explained that trade financing is easy to state as a prominent application as it, like DIAS, has already been operational for a few years. According to P3, the operating trade financing platform, we.trade, has turned out to be very successful and promising. He explains that we are yet again talking about the fragmented and multilateral exchange of documents with trade financing. The core is to reach a consensus on the state of the document and who has seen and or signed the papers, and in general, what has actually happened. P1 also finds that trade finance is a suitable use case for blockchain technology. In his view, smart contracts are helpful in trade financing.

P3 describes that they created we.trade in collaboration around 13 to 14 banks across Europe. We.trade is a trade financing project for small and medium-sized businesses. As mentioned, the platform has been operational for a few years now, and it enables more frictionless trade between all customers of the cooperative banks. Once trade documents and deals have been created, the platform tracks when the goods have been shipped, where the goods are now and when the good have been received. Depending on where the goods are, the platform automatically creates payment guarantees and releases payments once the goods have reached the buyer, thereby enabling faster payment arrangements between the trading parties.

P3 indicated that the challenge with we.trade is that it is a network and that the value of the network is the sum of its participants. Even though we.trade is completely technically functional and successful, it has challenges. According to P3, if a client searches for their trading partner on we.trade, and do not find the partner with their first search, they give up immediately and go back to "normal old procedures". Therefore, the banks are currently investing a lot of time and effort to guarantee that both parties are part of the we.trade network before any trade or any other actions are taken regarding the trade itself. He explains that the platform and the clientele are still at their early stages, and therefore it still requires a lot of manual control and assists when bringing trading partners to the network. P5 expresses similar concerns on blockchain-based trade financing platforms. He explains that trade financing is challenging as it has a significant number of parties. According to P5, only when the parties have created a digital identity and own a fact wallet, the implementation will be easy.

Despite the challenges, P3 reveals that the benefit of blockchain technology is that once the network has been created and the trade connections have been made, these connections become extremely strong. So when clients have found each other from the network, they create a solid trading bond and continue trading using we.trade platform. P3 expresses confidently that this is due to the fact that the platform is simply the best way to conduct trade as it enables a seamless experience. Unfortunately, getting clients to the network was just a challenge that was identified a bit too late, perhaps because everyone was dazzled by the new technology.

P5 finds that blockchain-based trade financing platforms have enabled banks to serve a new customer base. He explains that trade financing has commonly focused on big clients. P3 agrees with this statement, as during the interview, he expresses that large companies have the possibility to solve commodity trade problems with “raw power”. However, small and medium-sized companies can't afford such complicated procedures, and therefore these digital solutions are superior. P5 explains that even smaller clients, such as kiosks or hot dog stands, belonged to the retail banking side, and due to their small size, banks could not offer similar trade financing services. P5 reminded us that blockchain technology could deliver productivity and efficiency benefits that lead to cost benefits. He explains that banks could not offer any financing services to small businesses before because the volumes were so small that setting up financing services would not be profitable.

Nevertheless, small businesses still need financing support as it takes some time before kiosks buy and sell their sausages, thus tying up capital. Today, once banks are able to provide more sophisticated and frictionless solutions that take away the complexity of trade financing, the service becomes much more efficient and more affordable. Hence, allowing serving smaller clients and accruing a much more extensive service range. P5 joyfully explains that the efficiency gains due to blockchain-based solutions could be 10x. Theoretically, banks could provide trade financing services to just about any trade size or company. Provided that a common digital identity platform has been created. P5 concludes that now that banks can provide trade financing solutions for smaller clients and transactions, the earning model for banks will change. Banks will receive smaller lump sums from several different sources and transactions, thus flipping the entire earning model of trade financing upside down.

4.4.5 Unlisted companies share trading

P5 explains that creating a decentralised identity ledger provides significant opportunities to reform how operations are currently executed. According to P5, the current banking environment is, in general, extremely complicated and slow. He explains that they are now creating a platform for trading unlisted company stocks. He confidently states that it is faster, more user-friendly and straightforward than how it is currently conducted. P2 agrees with P5 and provides an example of how trading is presently operated. P2 describes that today the trades of unlisted stocks are maintained by companies themselves. Even by law, the companies are required to update their shareowner registry. Commonly it is executed by keeping the registry on an Excel spreadsheet on someone's laptop. Thus, making digital trading complicated. In addition, the shares are typically paper copies, which are stored in a bank vault. P5 and P2 explained that the current process has been identified as a problem due to its complexity and multiple manual procedures. For a solution, a blockchain-based trading network has been created for unlisted company shares. P5 explains that the network is based on the Corda blockchain. The solution is not yet operational or approved but is currently in its Beta testing phase. He is quick to point out its benefits, informing that it is even able to set up a company within five minutes totally without any physical paperwork with only using your mobile phone. After the first five minutes, you have a company with fully digital shares. During the next five minutes, you can trade your digital shares by only using the digital platform.

In the midst of the interview, P5 is kind enough and walks us through the entire proof of concept. He explains the whole process in detail, from what technologies operate in the background to how the user interface looks like. He demonstrates how the trade is executed in practice. The process is very straightforward. Briefly illustrated, the process begins by the seller sending the buyer a message, such as an email, through the platform. Let's agree that in this instance, the buyer and seller have agreed to trade ten shares of the company. The message contains the ten shares and includes a statement that the buyer will receive the shares once he has paid the agreed-upon amount of money. Once the message has been sent, the network automatically instigates the Corda flow. Corda flow implies a trade flow, which means that the network automatically rotates the information about the trade to all the required stakeholders. First, the networks require the companies' approval if the seller is authorized to sell the said shares. If there are no limitations, the next step is to inform the tax authorities. The tax authorities check that no parties have tax debt and that the parties are allowed to carry out trade. If the trade is ok from their perspective, the tax authorities already create a tax return draft. Then the Corda flow rotates forward through the regulatory and other required parties before it ends up to the buyer. Once it has reached the buyer, the buyer approves the trade and reserves money from their account. After every party has approved the trade, the Corda notary is informed. Finally, the Corda notary validates that all trade requirements are fulfilled and notifies the stakeholders that the transaction has been completed.

P5 explains that it took about four months for four developers to code the entire process to a working protocol. He explains that the complexity of the blockchain-based solution is only a fraction of a traditional stock trading network. The blockchain-based platform only requires that all the parties involved have a digital identity or a digital wallet with all the necessary credentials to participate in the trade. This digital wallet can also store information about how many shares a person owns. He believes that once all the customers are digitized, then the digitalization of the trade financing process itself happens quickly. As mentioned in the challenges section, P5 states that getting people and organisations to join the network is the most challenging and time-consuming. Without a functional network of participants, there is no implementation. However, he believes that there is a solution if they work for it. He also expresses that this is why they are creating Findy here in Finland. P5 believes that once a functional and operational network is built, “they will come”, referring to creating digital wallets for customers. He also believes that once Findy is active, different wallet providers will create wallets and services on top of it. First simple applications and at later stage more sophisticated solutions.

4.4.6 Transaction and settlement processes

The final application that was mentioned quite frequently relates to payments and transaction settlement processes. The application had somewhat mixed opinions on it. The interviewees did recognize the potential for blockchain technology solutions, but it was not seen as a priority. Some interviewees, such as P1, found that the blockchain-based payment applications have been put on hold, at least for now. P2 and P5 both mentioned that blockchain could be used in transaction and settlement processes. P5 stated that he finds that cross border payments and clearing processes belong to the top of the list when discussing prominent blockchain-based applications. However, he expressed that he is not prioritising his focus on it himself as he is more interested in the digital identity network.

P1 finds that the increase of new operators and services in the financial sector has made payment value chains longer. For example, 15-20 years ago, the payment process involved just a few intermediaries. Before the buyer initiated a payment order to a bank, the money was transferred to the seller’s bank account within a couple of days. Today, on the other hand, there might be multiple different service providers, such as wallet or credit operators, both on the buyers and the seller's side. Moreover, both the buyers or sellers might operate in other payment channels than their bank's channel. Meaning that the value chains in payment processes have lengthened even though there is a demand for instant 24/7 payment processes. P2 indicates that over 200 or 300 banks have joined forces with R3 and the Corda network. He finds that banks have joined the network to solve efficiencies related to transactions, foreign trade, securities etc. Currently, these functionalities operate in a centralised manner within the service providers own channels. P2 believes that taking the settlement processes to a distributed network might provide some benefits.

P1 argues that the hype has died down in regards to the payment processes through blockchain technology. He finds that as the current structure is extremely centralised and parties mostly trust each other, the problems can be solved even more efficiently through centralised solutions. He explains that it was believed that a distributed model could replace SWIFT and make it faster and more efficient. However, today SWIFT has improved its operations, and the network operates faster than it did before. He expresses that in that instance, other technologies have become close or even better than blockchain technology. Hence, there is no reason to replace the older technology. P2 viewed that regarding settlement processes and security trade, the development with blockchain technology will be a long way from now. He explains that the business case is difficult to justify. According to P2, the current applications have significant investments in them that will make them complicated to replace. He states that if you even think about banks' own systems, you can find many decades-old systems or systems, even from the '70s, and replacing these systems is often a lousy business case. However, he believes that blockchain technology would be a viable option if there is a need for a new system.

P1 explained that, for example, JP Morgan is using JP Coins as their in-house cryptocurrency to clear and transfer money between departments and countries. According to P1, JP Morgan probably had the need to develop the mentioned processes and wanted to try out new technology. Therefore, blockchain technology might be beneficial for their practices. However, P1 finds that JP Morgan could have found a solution through different models as well. He explains that they could have had built a new centralised ledger system. P1 sums up by stating that there are some areas where blockchain solutions could be useful, but in his opinion, these could be solved with other methods as well.

P1 also explained how the entire SWIFT process functions. He informed that SWIFT is created for international payments, and it is a financial messaging system between banks. In SWIFT, transfers always happen between two banks. If an actor is a client of a fourth or a fifth bank, transfers are forwarded in the network until it has reached the client's bank. P1 states that this is why the SWIFT network is so slow. However, SWIFT has developed its services and focused on real-time tracking. According to P1, today, the monitoring is already reasonably good, and you can be confident that the payment is coming. Of course, there are still some costs. He also adds that services like TransferWise, which does not use blockchain technology, operate faster than the SWIFT network. P1 adds that the primary question with SWIFT and other similar networks is who you trust and which path you want to transfer money in the network. P1 is not sure how blockchain technology will affect the sector at the end of the day. During the interview, it was mentioned that SWIFT has a blockchain technology-based pilot or proof of concept ongoing, but P1 was not familiar with its specifics.

The topic of digital currencies from central banks was mentioned by multiple interviewees (P1, P2, P3 and P5). The reason for it might be that the topic was discussed in the news around the time of the interviews. P2, P2, P3, and P5 mentioned that central banks currently developing digital currencies. P1 explained that CBDC (Central Bank Digital Currency) is a digital currency that central banks are presently piloting. P1 and P2 state that it will be interesting to see whether the digital currency will be based on decentralised technology or not. P1 informed that at least blockchain technology is being tested as one solution. He explains with CBDCs that the process of transferring money from one account to another, such as in the SWIFT network, will be obsolete. P3 also finds CBDCs attractive. He believes that basically, these digital currencies are the only possible way blockchains will be used in payments. He underlines that the word possibly, as there are no guarantees that CBDCs will be based on blockchain technology or other distributed technologies.

On the contrary, P3 is relatively certain that the digital currencies will not be based on decentralised technologies as central banks are, by definition, central banks. According to him, it isn't easy to justify why central banks would use decentralised technology as their purpose is to be a central authority and a central ledger in the banking system. Both P1 and P3 still find that it is possible that some form of decentralised ledger technology could be used around the digital currencies but will not play a big part.

4.5 Future expectations

The interviewees were concluded by questioning future expectations for blockchain technology in banking and finance. How do the interviewees see blockchain technology going forward, and how does the future look like? It was clear that the interviewees would have differing opinions on the future outlook of blockchain technology in banking and finance. The views of the interviewees are simplified and summarized below in Table. 5. The interviewees' views were categorised on a scale from sceptic to disruptive, based on holistically evaluating their expectations on blockchain technology in the future of banking and finance. The most positive outlook was viewed as disruptive as they found that blockchain technology would change the entire industry. The most negative outlook was deemed as a sceptic as they did not find any use cases for blockchain technology in banking and finance. The rest were categorised as Optimistic, Neutral or Pessimistic in relation to the most positive and negative views and each other.

Table 5 Summary of Future Outlook

Future Outlook on Blockchain	P1	P2	P3	P4	P5	P6	P7	P8	Total
Disruptive					X				1/8
Optimistic		X	X						2/8
Neutral				X		X		X	3/8
Pessimistic	X								1/8
Sceptic							X		1/8

P7 explains that he does not see any future for blockchain technology. He finds that the only success story for blockchain technology is cryptocurrencies. It is developed for cryptocurrencies, and it works in and only with cryptocurrencies. His takeaway from this is that we should leave blockchain behind in the banking and finance industry. P7 expressed that he currently finds cloud technology the most crucial technology, and the industry should focus on cloud-based technology. According to him, it will provide the cost-efficiencies and safety that the industry is searching for. He explains that services operate increasingly more in the cloud, and therefore, he believes that in 10 to 20 years, banks will no longer run their own data centres. He adds that the philosophy of cloud-based services is ultimately the opposite of blockchain technology. P7 concludes his statement by expressing that cloud technology could eat blockchain for breakfast and is by far a superior paradigm.

P1 was not as critical as P7. He explains that activity relating to blockchain technology and payments is at the moment limited. He is informed that there are potential use cases and significant investments made in blockchain technology. Therefore, they follow the development and position themselves for potential breakthroughs such as the central bank's possible digital currency. However, P1 expressed that his core belief is that nearly all applications are or could be based on other technologies than blockchain technology. He explains that blockchain technology should be used when it fits the application best. Compared to other emerging technologies, such as AI, cloud technology etc., P1 did not find blockchain technology as valuable, at least today. For example, with AI and machine learning, it is possible to gain more concrete use cases in the short term. These use cases could be, for example, related to money laundering. He concludes that although blockchain is not as crucial today, it is critical to follow it as things might change quickly in the future.

P4, P6 and P8 were neutral regarding the future expectations of blockchain technology. They all see the potential but also understand the uncertainties related to the future. Therefore they took a neutral stance for blockchain technology in banking and finance. For instance, P4 stated that at this time, he does not want to take a stance on the future outlooks as it is still too early to say. P6 explains that blockchain technology could significantly impact current applications in banking and finance, but it will require broader industry-wide acceptance of blockchain technology. P6 continued to express that, in theory, the broader acceptance is possible, but the future will show what will happen. P6 concluded that if blockchain technology finds its place in banking and finance, the use cases would be more innovative and exciting compared to other technologies.

P2 first expressed that it is tranquil, at least in Finland, regarding blockchain technology, except in regards to the digital identity network. Then, P2 began to go through other Nordic countries and listing different projects. He explained that some projects are ongoing in Norway and Sweden, but in Denmark, it is limited primarily due to the negative stance from the Danish government. Although some projects were active, he concluded that blockchain technology development is relatively quiet in the entire Nordics today. At least compared to before. As did P1, P2 also finds that today AI and machine learning solutions are implemented more often. He adds that in the long term, it is more challenging to evaluate. However, P2 expressed that he is optimistic that there will be an adoption curve for these types of network and distributed technologies, referring to blockchain technology. Yet, he believes that the adoption might take a long time. At the end of the day, P2 does not mind whether it is blockchain technology or not. He is interested in and finds it beneficial that it will be a type of decentralized technology.

P3 introduced an insightful thought on the implementation of blockchain technology in banking and finance. He explained that blockchains are viewed as networks, and there are two types of networks, the first is open and global networks such as Bitcoin and Ethereum. The second type of networks are closed or permissioned networks with smaller ecosystems operated by known actors that all know each other. Then we begin to think about how do all these networks integrate. If we assume that at some point, all of these networks either work together and merge or disappear. He does not see that there is an intermediate solution. P3 then brings up a metaphor. He illustrates that if we go back to the 90s, see how GSM (Global System for Mobile Communication) and mobile networks began developing. P3 explained that it all started with the fact that each telecom operator began to build their network for their region. He explained with the first two operators in Finland (Tele and Radiolinja), you could not even call, let alone send any text messages between the two operators. After some time of development, a revolutionary feature was released. It was now possible to call and send messages between different telecom operators. First, calling between other operators was costly as the operators charged substantial fees. After a while, the costs between operators vanished, and calling between operators did not cost extra.

The following limitations for mobile networks were that mobile networks did not work abroad. In practice, your phone did not overseas if you did not get a local SIM card. Then similar development steps followed explained above in the local development in Finland. First, roaming services were so expensive that it was practically impossible to use. Then, after all, roaming fees became cheaper. If we rewind to the present day, you can use your phone wherever you are in the world and be sure that it will not be that expensive, at least inside European borders. But the most important aspect is that your phone works and you can use data precisely the same way you could at home.

P3 continues to clarify how the example relates to blockchain technology. He states that now if we look at how the development folded, it was interesting that it had a few components that he believes will be repeated in blockchains case. First, it is precisely how these networks were connected. The networks did not link through any type of global network, as there is no such thing. But the networks connected precisely through bilateral agreements and technical standards. He explains that when the GSMA, which is the alliance or industry forum, set the technical standards and best practices and provided a model on how networks work together, the network business owners i.e. mobile operators, put these models into practice and agreed on the standards. Then, voilà, the networks began to operate together.

P3 underlined that they all operate through bilateral agreements, framework agreements and technical integration. P3 strongly believes that a similar model will happen with blockchain networks as well. Then, he begins to provide an example regarding we.trade and E-Trade, a blockchain-based trade financing network from Hong Kong. He explains that today they have a bilateral agreement between the we.trade network and the E-trade network. In addition, the two networks are also directly connected technically. In practice, this enables for we.trade clients to conduct business with clients of E-trade and vice versa. However, both networks still remain independent in a sense as both have their own governing model and their own business model. The two networks only have standard practices and agreements on the technical integration and how cross-network business and trust agreements are managed.

P3 expressed that with Findy, they will use a similar model and make agreements in the future with, for instance, "Swindy" (an imaginary digital identity network from Sweden) when other countries begin to develop such networks. He states that it might even be possible that the EU will have its own network, but then they will just integrate Findy into it with the same principles as discussed above.

P5 is hopeful for the future. He expressed that it is crucial that banks, at least in Finland, have found that collaboration is vital to solving problems within the industry. The focus has shifted from single applications, such as digital real estate trading, to digitalising clients. It provides the opportunity to take a step forward and enables an even broader potential for digitalisation. P5 expressed that now that quite a significant time has been spent on laying the foundation for blockchain-based solutions with the digital identity network, it would be rewarding to begin finding and creating more specific operations for digital clients. He is hopeful that all the completed work would slowly have a positive impact on the income statement.

P4 and P5 state that compared to other emerging technologies, blockchain is the most interesting. Both agree that blockchain technology requires a fundamental change regarding the operational logic of how we view banking operations. It has the possibility to eliminate friction in banking. Therefore, they find it could revolutionise the industry. P5 explains that AI and other applications are already being implemented, and they bring many benefits today. P5, like all the others expressed, states that it will take some time before blockchain will be implemented on a larger scale. However, he finds it interesting to follow how fast it will happen once everything is ready and operational. P3, who also believes in blockchain technology and its benefits, is more neutral regarding the importance. P3 sides a lot with P2, as P3 states that it is difficult to list any preference between emerging technologies. He explains that he would not list blockchain at the top because, without blockchain technology, everything still works as they have today with centralised actors. But blockchains do enable a good foundation for building networks, and therefore is important. He concludes his statement by expressing that it is not a life-or-death technology, at least not yet today.

5 RESEARCH FINDINGS AND ANALYSIS

5.1 Presenting the research findings

The purpose of the study was to present the current view on blockchain technology in the banking and financial sector. In addition, the goal was to identify the benefits and challenges of blockchain technology in the industry through empirical research and literature review. Finally, this thesis aims to showcase present or potential future applications and expectations for blockchain technology within the sector. Showcasing the current situation of blockchain in banking and finance relied mainly on empirical research as it is the most up to date and the literature on the topic is scarce. The research findings will be categorised into five sub-sections. These sections will follow a similar pattern as the empirical research. First, thoughts on the current trends of the banking sector will be presented. The following two chapters will present the findings on the benefits and challenges of blockchain technology. After the benefits and challenges, prominent applications will be discussed. Finally, the future outlook of blockchain technology in banking and finance will be addressed.

In general terms, the current literature seems to have a more optimistic and ideological stance on blockchain technology in banking and finance than the stance provided by the empirical research. The literature turned out to be a simplified version of reality. The empirical research proved to be more realistic, and different challenges of blockchain technology, especially in the implementation phase, were highlighted significantly more. The reason for this is most likely that there are not yet that many operational blockchain-based solutions, and hence the literature and research on these solutions are minimal. The theory on blockchain-based applications mainly presents literature on theoretical and potential applications rather than the literature on actual applications and experience over these applications. However, in general, the theoretical research and empirical research results have significant similarities.

5.2 Current trends in banking and finance

Both the theoretical and empirical research conveys that the banking and finance sector has gone through a lot of change during the past years. Digitalisation has made a huge and lasting impact on banking and finance. A clear indication of change has also been the shift in customer requirements. Customers today demand more flexibility in banking and finance services as the world operates 24/7. Therefore, the services must be available for customers at any time of the day. Especially the interviewees underlined the importance of customer experience. The end goal is to provide as good and seamless services for customers as possible. At the end of the day, it does not matter what technologies banks and financial service companies use if the technology enables smoother and better solutions.

The banking and finance industry has eased entry barriers with more lenient regulations. However, this has created a more dispersed sector, as new emerging startups and big tech companies have begun to offer new competing financial services. Therefore, making the field more competitive. Both theory and interviewees recognised both the benefits and threats of new competitors and a more competitive environment. The common consensus was that if the technological change is well managed, it offers vast potential for banks and financial service companies to expand and reach out to new customers, for example, via embedded finance solutions.

5.3 Benefits of blockchain technology

Both the empirical and theoretical research reached the same general conclusion regarding the benefits of blockchain technology for the banking and financial industry. The main benefits identified are cost benefits, which are enabled by speed, efficiency, data integrity & reliability and transparency.

Blockchain technology can automate and digitalize processes, hence responding to the banking and finance trends detailed in the previous subchapter. However, blockchain technology by itself does not create the mentioned benefits as it requires collaboration and the support of a functioning network. If a suitable network can be built, the benefits will follow.

The theoretical research perhaps provides a more optimistic picture of blockchain technology's benefits. From blockchain literature, it is easy to interpret that once blockchain technology is implemented, straightaway, all participants gain significant benefits. The interviewees gave a more realistic approach, this is likely due to the fact that some interviewees have experience being part of various blockchain-based projects. However, despite the more cautious approach, the empirical research does emphasize that blockchain-based solutions have made processes smoother and more frictionless when functional. The empirical research also indicates that the benefits do take time to realise. The empirical study also discovered that banks could broaden their client base with blockchain-enabled benefits, as explained with trading financing by P5.

The identified benefits are only able to be reached with permissioned blockchain technology. Literature on blockchain technology and banking and finance focus rather heavily on identifying the best type of blockchain for banking and finance. However, the empirical research implied that it is already assumed that permissioned blockchains should be used in banking and finance. Often during interviews, the interviewee quickly mentioned that they are naturally talking about permissioned blockchain technology. It was also made clear that permissionless blockchains are not even a possibility for banking and finance today due to the uncontrolled nature and technical limitations.

5.4 Challenges of blockchain technology

The challenges related to blockchain technology were more varied compared to the benefits. In addition, the challenges differ regarding what perspective they are viewed from. To simplify, the challenges could be divided into two categories, which are ideological challenges and operational challenges.

Ideological challenges are clearly brought up by P7 during his interview. As identified previously, blockchain technology has not yet established a solid definition. People have different views on what blockchain technology is and what belongs under the said terminology. The problem seems to be shared with other new and emerging technologies. For example, artificial intelligence and machine learning have suffered from similar difficulties. The difficulty of a precise definition could stem from blockchain being a recent phenomenon. Hence, the public might still have limited knowledge on the topic, resulting in possible errors, misunderstandings, and false definitions. This could especially be the case with blockchain technology, as it is by its ideology vastly different from other technologies or solutions, especially within the banking and finance industry.

Blockchain technology suddenly raised a lot of interest in the world through Bitcoin, and blockchain-based solutions started to be researched even before it was understood correctly. As P2 and P3 also stated, in the beginning, business cases for blockchain-based solutions were often overlooked as everyone was so blinded by the new way of tackling current issues, resulting in many failed projects. The confusion, hype, failed projects and link to cryptocurrencies have not done justice to blockchain technology. P7 also admitted to being first interested in the potential of blockchain technology but later lost hope for the technology or the ideology of decentralisation in banking and finance.

Even though there are currently working blockchain solutions, his criticism is valid and needed. If a technology or ideology does not work, it should be criticised, and the focus should be shifted to other options. In addition, the principal ideology of blockchain technology was to replace the need for central intermediaries such as banks. Hence, it could be said that blockchains initially are not the best fit for a highly centralised industry. However, it does not mean that blockchain technology could not be implemented within the industry. P7s claims are generally about permissionless blockchains, which all other interviewees and literature agree is not suitable for banking and finance. Permissionless blockchains as an ideology differ slightly from permissioned blockchains. Permissioned blockchains lose some of the benefits of permissionless blockchains but, on the other hand, solve some of the challenges of permissionless blockchains, such as the need for heavy consensus protocols.

The centralised structure of the banking and finance industry is one significant challenge for blockchain technology. As stated, the ideology of blockchain and decentralisation is vastly different from what banking and finance are today. Therefore, the industry's current central infrastructure is also the opposite of the infrastructure under decentralised technologies. The conservative attitudes, centralised legacy systems are complicated and perhaps unnecessary to replace. These systems have been proven to be functional and relatively practical. This does not mean that changing to blockchain technology would not make the industry more efficient, but the change is so fundamental and extensive that it may be too difficult to implement, at least in the short term. The current applications and operations and work required for replacing them are costly, difficult, and time-consuming, making the benefits less significant.

The other challenge regarding blockchain technology in banking and finance was the operational and implementation challenges—meaning challenges on how blockchain technology can be implemented to banking and finance successfully. The theory identifies and focuses heavily on the technical and regulatory challenges regarding blockchain technology. Through interviews and empirical research, the focus has shifted from these technological challenges to challenges related to building networks. Such as, technical and regulatory questions are mainly solved. Literature linking blockchain technology and network challenges is relatively limited, which may be because the challenge was only identified after more operational applications had been launched. P5, for instance, mentioned that the problems related to building networks were identified too late. If this challenge would have been detected at an earlier stage, the applications would possibly already be operational with a broader client and partner base.

Blockchain technology has similar problems to any other network project. For successful blockchain-based solutions, collaboration with competitors or perhaps with the entire industry is required. Hence, plenty of political and governing issues arise between the stakeholders. These political challenges could even be the main cause for the downfall of blockchain technology in banking and finance. If competitors are not willing to work together to solve industry-wide problems, blockchain technology will become useless. Nonetheless, at least in Finland, positive development has been seen as banks and other financial service companies tend to trust and work together with ease. Perhaps, this is why the first Corda-based solution was operational in Finland.

5.5 Blockchain use cases in banking and finance

Multiple blockchain-based applications or use cases were identified via theory and interviewees. Blockchain-based applications aim to simplify operations and produce more streamlined and frictionless services without significant manual actions. These frictionless and more straightforward services create benefits for both customers and service providers such as banks. For clients, the operations become simple as the applications automate manual processes. Therefore, the client usually is only required to initiate or conclude the process. The applications process flow handles the rest.

The theoretical research on current and possible applications was relatively limited as not many use cases of blockchain technology are yet operational. However, the empirical research provided good and thorough implications of the current use cases and applications in use or in development.

As the importance and the challenge of building the network were recognized too late, mistakes were made in real-life implementation stages. Hence, there are fully operational blockchain-based software products, but there is a lack of clients. For this reason, the development of blockchain technology-based solutions has taken a couple of steps backwards, as clearly stated in many of the interviews. The primary focus today is building the foundations for blockchain technology in banking and finance.

The interviews highlighted the importance of the digital identity networks as a base requirement for many of the identified applications. At least in Finland, the Findy platform seems to be the number one priority before blockchain-based solutions can be scaled up to broader use. Without a solid foundation, it is challenging and time-consuming to get participants to the available blockchain-based services and products from a technological perspective. This was confirmed by P2, P3 and P5 as they stated that today, the work related to digitalizing companies for blockchain-based solutions is the most time-consuming activity. If companies are not digitalised, they do not fulfil the needed requirements to join the network, resulting in the service being useless. Once all companies have a fact wallet on the digital identity network, it is easy for them to join various blockchain-based services or networks as all their information is already digitalised in Findy.

All current and prominent blockchain technology use cases and applications in banking and finance, as in other industries, rely primarily on smart contracts or digital contracts and the automated services and reconciliation they enable. Literature on blockchain technology applications first began by focusing on the possibilities for payment solutions via blockchain technology. The link is perhaps easiest to make as blockchain technology stems from cryptocurrencies and transferring value. At least from 2-3 years back, the theoretical research and literature often indicated that blockchain technology would have revolutionised the payment infrastructure by 2021. However, the truth is entirely different. The interviewees also identify the potential for blockchain technology in payments and cross-border clearing and settlement processes, but little or no proper applications are currently operational. At least the payment solutions are not seen as a priority. There are existing proofs of concepts, but the industry still relies on the present networks and legacy systems.

The established networks and legacy systems, such as SWIFT, are functional and relatively efficient. They are also complicated and expensive to replace. The switch to a blockchain-based or decentralized operational model would require an industry-wide shift. The entry barriers for blockchain technology in payment and other highly established and centralised operations are challenging and expensive. As P1 also noted, these legacy systems and networks are also developing and making their processes more efficient; hence, new solutions are not as needed. Even though blockchain technology has not been able to disrupt the payment network as was often expected in literature, it may do it sometime in the future. It will require a lot of work, expenses and an ideological shift from the industry to work together. Perhaps the digital currencies created by central banks will shift the development towards more decentralised solutions. Although as identified through interviewees, it is improbable.

The challenges in implementing a blockchain technology-based solution to use cases with prominent and efficient solutions may give some indication why the main successful implementations focus on use cases with no existing alternative solutions. Current or prominent applications all have plenty of similarities with one another. All blockchain-based operational or upcoming applications primarily relate to fragmented documentation and information sharing with plenty of parties involved in transactions. Previously, all documents and data sharing required a significant amount of manual and paperwork since all information was stored on paper or in centralised locations. Examples of such processes are real estate trade, trade finance and unlisted company share trading. With blockchain-based solutions, it was possible to bring all parties into the same trusted network with standardized data and information management. With smart contracts, the transaction processes and the network flow can be automized, and when all requirements are fulfilled, the process flow completes itself automatically for all parties simultaneously.

In addition, there were no proper established solutions for these applications, contrary to the payment sector. Also, the digitalisation rate was low, so no digital central models were prevalent. As a result, the entry barriers for blockchain technology were significantly lower than in the payment sector. This made it possible to build decentralised solutions from the beginning without replacing any functional solution. For example, with the DIAS network, the real estate market in Finland experienced a forced digitalisation from the government, which led to searching for a new digitalised solution.

According to the interviews, once the blockchain-based platforms were functional and clients have found the network, it is very efficient and user-friendly. This implies that blockchain technology does respond well to the current demands of the industry. However, the challenges are similar to those identified before in the challenges section with building the network initially and bringing clients to the network. Therefore, the importance of the decentralized identity platform is highlighted for future blockchain products or services in banking and finance and in other industries.

5.6 Future outlook on blockchain technology in banking and finance

The banking and financial sector will continue to develop into a more digital and technological environment. As the interviews present, other emerging technologies such as AI, big data and cloud computing have already received a good standing in the industry. Blockchain technology in no way competes with these other emerging technologies, but rather these technologies could complement each other.

For blockchain technology, it seems that there is still plenty of work to be done for it to breakthrough in the industry. It seems that Finland has been somewhat of a forerunner in blockchain-based solutions in banking and finance. Obviously, in this thesis, this view is amplified as the empirical data has been gathered mainly from Finnish sources, but the literature review does seem to back this notion based on the examples presented. This may be since banks in Finland have good and trusting relationships with one another. However, blockchain technology will require a solid foundation such as the Findy platform to take motion. Once companies and people have been added to the digital identity network, different services will become significantly easier to implement. However, as discovered, building the network will be difficult, and it most likely will not happen quickly.

During the interview, P3 expressed his views on the development of blockchain technology, as he compared it to the development of the GSM network. The comparisons and development seemed realistic. Blockchain technology does provide benefits, but it might take time for them to be realised. Once enough networks have been established, and the industry notices the cost benefits, they will begin implementing blockchain-based solutions and integrating networks into one another. Ending up in a broad network with multiple smaller ecosystems and governing models.

Regardless of the benefits and opportunities of blockchain technology, it is not necessarily as revolutionary or disruptive as first believed in theoretical research. It has the potential for disruption, but it may not necessarily happen. It is highly dependent on the ideological views on how the structure and foundations of banking and finance will look in the future. For example, suppose the common consensus is that the structure of banking and finance will remain in a more centralised model. In that case, the industry will move forward as it has today, developing operations through more minor incremental changes and developments. Therefore, nothing will change drastically, but operations will become a bit more efficient as technology evolves. Naturally, there will probably still be some decentralized applications.

If the industry forms the structures to support more of a decentralised model, the operations will likely earn efficiency benefits, such as explained in the benefits chapters. However, significant changes are often also considerable risks. To conclude, the implementation might bring benefits. On the other hand, as stated by P1 and P3, most solutions that could be done with blockchain technology could be done with other technological solutions as well. Therefore, it is essential to view the business case, entry barriers and other parameters of each potential solution and carefully figure out whether to use a blockchain-based or a central solution. Then, the solution that creates the best benefits for the customer and the banks and financial service companies themselves should be implemented.

6 CONCLUSIONS

6.1 Implications of the study

6.1.1 Academic contributions

The current academic literature on the topic discusses blockchain technology in banking and finance. In the present research, blockchain technology is studied as a technology, meaning on what type form of blockchain technology is the most suitable for the industry. In addition, previous research analyses the potential challenges and benefits that blockchain technology could have in the banking and finance industry. It could be stated that the previous literature is heavily dependent on the actual technology itself. The technology is analysed in detail, and from this analysis, first permissioned blockchains were identified as the most suitable form of blockchains for the industry. From the preliminary findings, potential benefits and challenges are analysed and concluded. This research further validates the previous research findings on the above-mentioned aspects. Similar conclusions were discovered in this thesis. However, as mentioned in the current literature, the focus has been primarily on the technological aspects of blockchain technology due to the limited amount or not existing operational blockchain-based solutions in the banking and financial sector. Therefore, the literature is missing real-life experiences on blockchain-based solutions and the possible benefits and challenges these might bring to light.

As the result of this thesis, some aspects identified as missing in current literature have been taken into the research scope. This thesis has contributed to the existing literature by showcasing experiences on real-life applications and use cases. From these real-life experiences, new attributes have been identified. Observations based on experience and reality have identified what actually needs to be focused on in order to reap the benefits from blockchain-based applications in banking and finance. Most of these aspects relate to laying the foundations for blockchain-based decentralised network solutions and not the technical aspects of blockchain in itself.

The thesis provides another contributing factor to the current literature by providing a more comprehensive view of both currently developed blockchain uses-cases for banking and finance and the future outlook of blockchain technology within the industry. The thesis also provides insights on what applications are the most critical for the possible success of the technology.

It should be acknowledged that most of the identified applications of blockchain technology in banking and finance were still in their development or preliminary stages. Meaning that there is still plenty of work to be done for these applications to be the new norm. Hence, it is possible that not all benefits or hurdles have yet been identified.

6.1.2 Meeting the objectives

The objective of this thesis was to contribute to the current academic literature and provide new research findings. The main goals were to disclose the benefits and challenges of blockchain technology in banking and finance and provide a comprehensive outlook on the reality of blockchain technology in the current climate of banking and finance. In addition, to highlight potential future expectations for the technology in the industry.

The research questions of the study were the following:

- What are the opportunities and challenges of blockchain technology in the banking and financial sector?
- What are the most prominent blockchain-based applications today in banking and finance?
- What is the future outlook of blockchain technology in banking and finance?

The answer to the first research question was presented in chapters 2.5, 4.2 and 4.3. Primary foundations and the critical understanding of the topic were first provided in earlier chapters to enable the reader to internalize the answer better. Hence, the question was first considered from the current literature standpoint. Later, the same questions were brought up in the empirical research. Providing a complete overview of the results from both the current literature and empirical perspective. Finally, both views were analysed in the research findings in chapters 5.3. and 5.4. The complementing and contradicting aspects between literature and empirical data were brought up noted in the chapter.

The answers to the second and third research questions relied primarily on empirical research due to the limited amount of literature on the topic, as stated in chapter 6.1.1. However, the literature provided a good foundation for the second research question, which can be found in chapter 2.6. The literature identified the importance of smart contracts and automation of processes with fragmented data storage and management. The empirical research answered the second and third research questions in more detail in chapters 4.4. and 4.5. Finally, the complete research findings and the researcher's interpretations were presented in chapters 5.5. and 5.6. The empirical research provided detailed data for a thorough analysis.

It can be stated that the research was able to fulfil the objectives of the study. However, the research still leaves plenty of room for further investigation. The research subject is developing quickly, and new findings, especially regarding the real-life implementations, are discovered. The set time and resource of this theses restricted a more complete fulfilment of the set objectives.

6.1.3 Managerial implications

The managerial implications can be viewed from the industry perspective on whether it is beneficial to use time and resources for developing and implementing blockchain-based solutions to operations. Before presenting the results, it is crucial to consider all the required steps for successful blockchain-based development. As identified from the empirical research, the technical challenges turned out not to be the core challenges regarding blockchain technology's implementation into the industry. However, building a solid network and foundation for blockchain technology was seen as a critical challenge. Therefore, the focus should be shifted from technological challenges to a more business case perspective. As stated, the current literature is still focused mainly on the technical aspects of blockchain technology.

From the empirical research, it could be concluded that blockchain technology implementations were successful, where there are no existing established operations currently available. Furthermore, as blockchain technology did not have to replace existing structures, it was easier and cheaper to implement. Literature and earlier research also identifies payments and cross border transactions as one of the most prominent applications for blockchain technology. However, today it is not seen as important as earlier, and the empirical research implies that the level of digitalisation in the sector is already high. Banks and financial service companies may find it more difficult to motivate the switch to blockchain-based solutions as the current processes are perfectly functional and fairly efficient. This does not necessarily mean that blockchain-based solutions could not be more efficient for the industry, but the risk of switching to a new solution is high. Also, as there are only a small amount of blockchain-based products and services, which have also operated only a few years maximum, there is not enough data to argue whether blockchain-based solutions actually create cost benefits or not.

The empirical research identified that blockchain technology was the most beneficial in use cases where there are multiple parties, fragmented data, and the initial level of trust between transacting parties are low. However, today it is still common that all critical information or documents of proof are stored either on paper or in a central location. As blockchain technology operates entirely in the digital space, this brings up the first challenge. All parties, documents and critical information should be available digitally and confirmed that the data is correct. When all companies and people have been digitalised, it will be easier for them to join various blockchain-based services as all the crucial data is already in a digital format. Hence the digital identity network will lower the entry barriers of blockchain technology to existing operations. Creating an ideal environment for blockchain technology in banking and finance.

Once the initial problem of getting participants has been solved, the challenge of growing and governing the network should be tackled. The theory and example about the GSM network presented by P3 seem like a realistic approach for this challenge. Also, as expressed by P3, this method has already been utilised in trade financing services. However, for the GSM method to be successful, it requires industry-wide acceptance over blockchain technology should happen. On blockchain technology's behalf, it could be stated that once the service is operational, participants digital and that they have found each other, blockchain-based solutions were seen as frictionless, seamless and customer friendly. However, it might still be too early to say. In addition, it should be acknowledged that not all solutions should necessarily be replaced with blockchain technology. Careful consideration of the entry barriers and the efficiency of current solutions should be measured before beginning the development phase. To conclude, there are benefits to blockchain-based product and services in banking and finance, but it is important first to identify a suitable business case for it.

6.2 Limitations and future research

It is important to identify the limitations of an academic study. A couple of core limitations were identified during this research process. The primary limitation was the relatively limited data sample size both in literature and in the empirical research. The literature review proved to lack research on actual operational blockchain-based applications, and not all challenges were adequately highlighted. In addition, the study faced geographical limitations regarding data collection, as most of the empirical data were collected from Finland. There is also a limited number of professionals on blockchain technology in banking and finance, which provides a more restricted empirical data sample

Secondly, the time period for conducting the research restricted more thorough research. With the possibility of a more extended research period, follow-ups with the interview participants could have been achieved. The follow-up sessions could have brought up potential new challenges or benefits that are yet to be discovered.

The research subject presents plenty of potential topics for future research. To be able to receive a more comprehensive overview of the actual real-life challenges and benefits of blockchain-based applications in banking and finance, the scope of the research should focus on just one use case or applications. Therefore, it could be suggested to conduct thorough research on, for instance, the development of blockchain-based trade financing. Furthermore, it would be beneficial for the researcher to follow the project and development for a longer period the avoid similar restrictions as in this research. Researching specific applications opens up different research opportunities. For instance, focusing research on identifying core challenges. As stated, not all possible challenges were yet identified in current literature, and therefore it is still possible that some aspects are still not identified. In addition, as existing blockchain-based applications have only been operational for a short while, little knowledge on actual generated benefits is researched. Thus, providing a research opportunity on the specific benefits of a functional blockchain-based application. Findings from such research could have significant impacts on the speed and acceptance of blockchain implementation in the banking and finance industry. In addition, the research of blockchain technology could be expanded to other areas of accounting and finance. As blockchain technology in banking and finance has reached a point of more actual blockchain-based applications are implemented, it would be recommended to research if blockchain-based decentralised technologies follow similar implementation processes as legacy technologies. Currently, there is no literature on the said subject.

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APPENDICES

Appendix 1 Interview structure

Background questions

- Please shortly introduce yourself and describe your current position within your organisation?

Relations & Knowledge on Blockchain technology

- Do you see that the banking industry will change in the near future? And How?
- How familiar are you with blockchain technology?
- What are your thoughts about blockchain technology in general?

Blockchain opportunities in Banking and Finance

- What are the reasons for banks and financial institutions to implement blockchain-based solutions in their operations?
- What benefits do you see that blockchain technology could offer banks?

Blockchain challenges in Banking and Finance

- What do you see as the main challenges in blockchain technology in banking and finance?
- What would you identify as the main threats or roadblocks for blockchain in banking finance to succeed on a larger scale?

Future of blockchain technology in banking and finance

- What do you see as the most prominent applications for blockchain technology in banking and finance? (Top 3-5)
- What are your organization's current expectations for the future of blockchain in the banking sector?
- How would you compare the importance of blockchain technology in banking and finance compared to other emerging technologies?
- Do you see blockchain technology as an opportunity, threat or just a fading buzzword for banks?

Appendix 2 Interview details

	Industry	Relevant speciality	Blockchain Proficiency level	Interview language	Date	Length
P1	Consult-ing	Business Development & Product Management in Payment Solutions	Advanced	Finnish	23/02/2021	0:41:20
P2	Consult-ing	Innovation, Digital consult-ing and Blockchain	Expert	Finnish	04/03/2021	1:03:15
P3	Bank	Emerging technologies	Expert	Finnish	05/03/2021	0:53:28
P4	Bank	Business Development and Innovation	Intermediary	Finnish	05/03/2021	0:31:31
P5	Bank	Innovation, Technology and Distributed network tech-nologies	Expert	Finnish	09/03/2021	1:14:47
P6	Bank	Business Development and R&D	Advanced	English	12/03/2021	0:40:00
P7	Central Bank	Digitalisation and emerging technologies	Expert	Finnish	30/03/2021	0:52:42
P8	Consult-ing	Banking and Financial ad-visory and Digitalisation	Intermediary	Finnish	01/04/2021	0:50:34
					Total:	**6:47:37**