BLOCKCHAIN TECHNOLOGY ADOPTION IN THE FINANCIAL SECTOR

Lappeenranta–Lahti University of Technology LUT

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Examiner: Post-Doctoral Researcher Anna Vuorio

ABSTRACT

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Digitalisation has significantly impacted the development of the financial sector in recent years. Thus, emerging technologies have attracted increasing research attention. Blockchain technology is a prominent emerging technology architecture that enables the creation of digital data structures in a distributed environment. Furthermore, it is widely considered as the latest technological advancement from the financial sector's point of view. Hence, the objective of this study is to examine the adoption of blockchain technology in the financial sector by investigating the associated benefits, challenges, and applications.

This study was conducted using a qualitative and exploratory approach. Applying semi-structured interviews as a method of data collection, three professionals in blockchain technology currently working in the financial sector in Finland were interviewed. The analysis of the interview data was carried out as thematic content analysis. Moreover, a blockchain technology acceptance model was derived from the widely used technology acceptance model (TAM) framework to support the analysis.

The results of this study indicate that blockchain technology holds significant potential that could be utilised to increase the efficiency and security of various processes in the financial sector. However, it was also found that blockchain technology is based on relatively weak foundations due to several persisting technological, environmental, and organisational challenges. At this day these challenges function as adoption barriers in many cases.

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Digitalisaatiolla on ollut huomattava vaikutus finanssialan kehitykseen lähivuosina, ja tämän seurauksena kehittyvät teknologiat ovat kohdanneet kasvavaa huomiota kehitys- ja tutkimustyön osalta. Lohkoketjuteknologia on kehittyvä teknologia-arkkitehtuuri, joka mahdollistaa hajautettujen digitaalisten datarakenteiden luomisen. Finanssialan näkökulmasta se on laajasti tunnistettu yhtenä merkittävimpänä teknologisena edistyksenä. Tämän tutkimuksen tarkoituksena on täten tarkastella lohkoketjuteknologian käyttöönottoa finanssialalla tutkimalla sen käyttöönottoon liittyviä hyötyjä, haasteita ja sovelluskohteita.

Tämä tutkimus toteutettiin kvalitatiivisena ja eksploratiivisena tutkimuksena. Aineistonkeruumenetelmänä käytettiin teemahaastatteluja, joiden avulla kolmea Suomessa työskentelevää finanssialan lohkoketjuteknologia-asiantuntijaa haastateltiin. Aineisto analysoitiin sisällönanalyysin avulla painottaen teemapohjaista lähestymistapaa. Lisäksi laajasti käytetystä teknologian hyväksymismallista (TAM) johdettiin lohkoketjuteknologian käyttöönottoon pohjautuva hyväksymismalli tukemaan analyysia.

Tämän tutkimuksen tulokset osoittavat, että lohkoketjuteknologia sisältää huomattavaa potentiaalia, jota voitaisiin monipuolisesti hyödyntää tehostamaan finanssialan eri prosesseja ja tekemään niistä entistäkin turvallisempia. Toisaalta tuloksien pohjalta kuitenkin havaittiin, että lohkoketjuteknologian perusta on tänä päivänä vielä suhteellisen heikko, sillä useita niin teknologiaan kuin toimintaympäristöönkin pohjautuvia käyttöönoton esteinä toimivia haasteita esiintyy edelleen.

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1. Introduction

Digitalisation and the use of digital technologies in social and economic life are impacting and transforming businesses and even sections of the economy (Ekinci 2021). The pace of technological advancements has rapidly accelerated in recent years, and as a result, several new technologies have emerged. Ekinci (2021) states that these technological advancements and emerging technologies are enabling beneficial qualities for different processes across industries, such as increasing productivity, cost-efficiency and enhancing security. Consequently, this has raised interest in the adoption of such technologies. Du, Pan, Dorothy, Leidner, and Ying (2019) argue that one of the most prominent emerging technologies on which to focus is blockchain technology. It is considered a promising and revolutionising technological innovation that is at the core of modern trends of digitalisation and has the capability to increase efficiency and security of processes across different systems and sectors of the economy (Ali, Ally, Clutterbuck, and Dwivedi 2020). Therefore, researching blockchain technology in different contexts is valuable in the contemporary world.

The financial sector is one sector of the economy on which digitalisation, and particularly the development of information technologies, has had a significant impact (Puschmann 2017). The impact is shown in the increasing automation of processes, as well as in the diffusion and restructuring of financial services and products. Puschmann (2017) reasons that this is due to the nature of the financial sector as its services are based on information to a large extent. This perception is supported by Ekinci (2021) who argues that digitalisation and information technology play an essential role in the development of the financial sector. From the financial sector's perspective, the impact of technologies has established an area of research and a reflecting term known as financial technology (FinTech) (Puschmann 2017).

Blockchain technology is at the core of FinTech (Du et al. 2019). It represents the system and architecture behind various distributed ledgers, called blockchains. Succinctly, blockchains are digital data structures that record information in a distributed environment, meaning that the data stored in blockchains is verifiable, secure, transparent, traceable, and immutable (Knezevic 2018). Blockchain technology was conceptualised and popularised in 2008 by a person or a group of people using the pseudonym Satoshi Nakamoto in a white paper publication “Bitcoin: A Peer-to-Peer Electronic Cash System”, which described a public and decentralised payment system called Bitcoin (Nakamoto 2008). Nakamoto (2008) noted that this system of electronic cash for online payments allows transacting parties to execute transactions without needing to rely on a trusted third party. Instead, Bitcoin transactions utilise a peer-to-peer (P2P) network and cryptographic proof to execute a trustworthy and transparent transaction directly between two anonymous parties. Since the introduction of the cryptocurrency Bitcoin, blockchain technology has also been used as a platform for a plethora of other cryptocurrencies. Subsequently, cryptocurrencies have become the most well-known use case of the technology (Kruglova and Dolbezhkin 2018). Blockchain technology was first overshadowed by the cryptocurrency phenomenon (Du et al. 2019). However, in recent years the underlying technology has been receiving increasing and broader attention as its potential has been more widely recognised (Polyviou, Velanas, and Soldatos 2019). In turn, this has shifted the focus of research towards blockchain technology applications beyond cryptocurrencies. This study examines blockchain technology adoption in the financial sector by investigating the associated benefits, challenges, and applications.

1.1 Literature review

Blockchain technology is only emerging, and its applications are a relatively new phenomenon and still at early stages (Ali et al. 2020; Frizzo-Barker, Chow-White, Adams, Mentanko, Ha, and Green 2020). However, it is developing rapidly towards becoming a central element of various processes in the financial sector (Frizzo-Barker et al. 2020). Even though being in its infancy, the adoption of blockchain technology has been discussed to some extent. Previous literature has identified benefits associated with the adoption of blockchain technology, as well as recognised possible applications. Ali et al. (2020) argue that blockchain technology has the potential to increase trust, security, transparency, and traceability, which are the most sought-after qualities in the financial sector. Furthermore, the authors state that blockchain technology could positively impact processes, such as user authentication, encryption of data and recording of data. Polyviou et al. (2019) reason that the use of blockchain technology could be the answer for various prominent long-term issues in the financial sector. They claim that blockchain technology could be utilised in Know Your Customer (KYC) processes, collaborative security, credit scoring, customer profile management and insurance claims. Additionally, Knezevic (2018) notes that blockchain technology enables benefits, such as attestation, cost-efficiency and increasing transaction speed, which in turn have the potential to transform payment systems, banking, accounting, auditing, and insurance.

Conversely, challenges that influence the success and extent of blockchain technology adoption have also been identified. The most significant of such challenges are scalability, regulation, security, and increasing transaction costs (Ali et al. 2020; Chang Baudier, Zhang, Xu, Zhang, and Arami 2020). Folkinshteyn and Lennon (2016) and Kruglova and Dolbezhkin (2018) deepen the challenges related to regulation claiming that there is insufficient compliance due to regulatory and legal uncertainty. Chang et al. (2020) argue that efficiency challenges, such as scalability, result in wasted resources and increasing costs. Additionally, they recognise challenges related to security and privacy by claiming that blockchains are vulnerable to malicious attacks. Also, according to a study conducted by Osmani, El-Haddadeh, Hindi, Janssen, and Weerakkody (2020) interoperability between blockchain technology and current systems of the financial sector is a challenge.

Blockchain technology adoption has also been marginally studied applying a theoretical framework known as the technology acceptance model (TAM). Studies conducted by Albayati, Kim, and Rho (2020), Folkinshteyn and Lennon (2016), Sciarelli, Prisco, Gheith, and Muto (2021) and Shrestha, Vassileva, Joshi, and Just (2021) have investigated the factors that influence the acceptance or rejection of blockchain technology adoption with the TAM framework in various contexts using different approaches. They have recognised the TAM as a valuable theoretical framework for studying blockchain technology adoption by modifying and extending the model.

However, while increasing over time, the overall amount of research conducted on blockchain technology adoption and applications is not extensive. There is a shortage of blockchain-related studies, particularly in the ones that relate to the financial sector (Ali et al. 2020). Nofer, Gomber, and Hinz (2017) note that studies and research conducted on the adoption of blockchain technology are valuable, while Frizzo-Barker et al. (2020) point out the need for empirical studies on the factors that influence blockchain technology adoption. Furthermore, there is a lack of theoretical orientation (Ali et al. 2020). Only a few studies have applied theoretical frameworks to examine blockchain technology adoption. Thus, such research to explain and predict the acceptance or rejection of blockchain technology adoption in different contexts using various approaches is valuable (Folkinshteyn and Lennon 2016). This study addresses these research gaps identified by previous literature and contributes to the research of blockchain technology in the financial sector.

1.2 Research objective, questions, and limitations

As discussed above, blockchain technology is only emerging and consequently moderately studied. It holds significant potential, yet questions remain considering its adoption. Thus, further research and analysis of blockchain technology adoption are essential (Nofer et al. 2017; Frizzo-Barker et al. 2020; Ali et al. 2020). Accordingly, the objective of this study is to examine the adoption of blockchain technology in the financial sector by investigating the associated benefits, challenges, and applications. Furthermore, this study aims to answer three central research questions related to the objective. The research questions, which's purpose is to support and guide the study, are as follows:

1. *How can blockchain technology benefit the financial sector?*
2. *What challenges influence the adoption of blockchain technology in the financial sector?*
3. *What are the applications of blockchain technology in the financial sector?*

Comparative analysis on benefits and challenges, as well as considering applications, plays a significant role in determining technology adoption. Thus, these research questions are profoundly related to each other. Together they manage to outline the impact of blockchain technology in the financial sector. These research questions will be addressed in both theoretical and empirical sections of the study.

Blockchain technology is linked in various ways to different industries and sectors of the economy, such as financial services, supply chains, healthcare, energy, and education (Frizzo-Barker et al. 2020). However, the scope of this study is limited to investigating its significance only from the financial sector's point of view. A healthy and functioning financial sector is a prerequisite for almost all aspects of society, meaning that it plays an essential role in the economic system and contributes to the whole national economy (Finanssiala 2018). Thus, it is one of the most important and influential sectors of the economy and its stability, growth, and development are valuable for households, companies, and governments (Finanssiala 2018). The scope of this study is also geographically limited to Finland, indicating that the results are not directly applicable to different countries and regions. This is a consequence of the differences in operational business environments, as economic, social, political, and technological factors vary globally (Hans 2018). Additionally, examining the technological properties of blockchains in significant detail surpasses the scope of this study, as the adoption and applications of blockchain technology is emphasised rather than the technology itself. Though, a comprehensive overview of the technological properties is provided in order to evaluate the results and meet the set objective of the study.

1.3 Theoretical framework

This study examines and analyses blockchain technology as a financial technology by applying the technology acceptance model (TAM) as a supportive and guiding theoretical framework that provides the background for technology adoption. In brief, the TAM is a theory in information systems that models technology adoption and usage. It was derived from the theory of reasonable action (TRA) by Davis (1986) to explain and predict the factors that affect behavioural intention, which in turn determines the acceptance or rejection of technology adoption. The TAM is based on two major beliefs, which are perceived usefulness and perceived ease of use (Davis 1986, 24-26).

The original TAM was modified and extended to fit the context of this study. Consequently, a blockchain acceptance model was developed to analyse the factors that influence blockchain technology adoption in the financial sector. The proposed model assesses blockchain adoption and usage by analysing the associated benefits and challenges through perceived usefulness and perceived ease of use. Moreover, it suggests efficiency, security, costs, and accessibility as the determinants that comprise the dimensions of the benefits and challenges.

1.4 Research methodology

This study was conducted adopting a qualitative and exploratory approach. Qualitative research methods are efficient for gathering holistic information on an emerging research phenomenon, which suits the purpose of this study (Eriksson and Kovalainen 2008, 5-6). Furthermore, the most appropriate and therefore selected method of research and data collection was semi-structured interviews since they enable gathering versatile data (Galletta and Cross 2013, 45-46). Three professionals in blockchain technology currently employed in the financial sector in Finland were interviewed to gain an understanding of blockchain technology as a financial technology. The interview data was then analysed by the proposed blockchain acceptance model derived from the TAM framework to conclude on the adoption of blockchain technology in the financial sector. This study applied content analysis and thematic design as the method of data analysis. The perceptions of the interviewees were also compared to the findings of previous literature, which provided obtaining a comprehensive overview of the topic.

1.5 Structure of the study

The introduction section established the background for this study by reviewing previous literature and defining the research objective, questions, and limitations. Additionally, it described the applied theoretical framework and research methodology in brief. This study proceeds in six chapters. Chapter two covers the core concepts of blockchain technology by providing an overview of its technical properties. Chapter three focuses on technology adoption by presenting the TAM framework and the proposed blockchain acceptance model. Chapter four describes the research methodology in detail. Chapter five then presents the results of this study. Chapter six discusses the results and gained insight, as well as provides answers for the set research questions. Chapter seven ends the study by concluding on the outcome of the research by summarising the findings and providing suggestions for further research.

2. Blockchain technology

This chapter provides an overview of the technological properties of blockchains and outlines the relevant aspects surrounding the technology. It describes the principles of blockchain technology, different types of blockchains, consensus protocols and smart contracts. These attributes of blockchain technology are crucial to examine prior to investigating its adoption in detail.

2.1 Principles of blockchain technology

Blockchain technology is a type of distributed ledger technology, meaning that distributed ledger technology is the framework underlying blockchains. Consequently, all blockchains are inherently distributed ledgers, yet not all distributed ledgers are blockchains (Rutland 2017). Distributed ledgers can be described as data structures, that are controlled by multiple participants simultaneously (R3 2021). This is the most recognisable feature of distributed ledgers, which also makes conventional centralised databases and distributed ledgers distinguishable. The terms distributed ledger technology and blockchain technology are often used interchangeably or as synonyms (Ostern 2020). However, it is important to clarify that they are in fact distinctive technologies (Rutland 2017). While the difference between the two is ambiguous, what typically makes them distinguishable is their structure.

Blockchains are databases that record digital data and informational transactions in a distributed network (Imteaj, Amini, and Pardalos 2021, 3). This means that there is no controlling central authority. Conversely, blockchain data structures are synchronically controlled by several participants simultaneously, which in turn removes the risk of having a single point of failure. These participants (e.g., computers) are called nodes, and together they form a peer-to-peer (P2P) network on which a blockchain operates (Ali et al. 2020). As a result, the data stored in blockchains is validated and consistent across the entire distributed network of participants. This results in the data being verifiable, secure, transparent, traceable, and immutable (Knezevic 2018).

Blockchains are typically defined as decentralised data structures, meaning that every participant in the P2P network have equal rights and are part of the decision-making and validation of information (Rutland 2017). Furthermore, this means that the recorded transactions are verified across the entirety of the network (Imteaj et al. 2021, 3, 8-9). Decentralisation is a key feature of public blockchains. However, blockchain data structures can be also configured in a more centralised way with permissioned private and consortium blockchains (Zhu, Gai, and Li 2019, 3-4). These different types of blockchains are discussed later in this chapter.

The transaction information that blockchains contain is stored in data blocks, which are then connected via cryptographic signatures called hashes (Zhu et al. 2019, 4, 11-13). Every block contains transaction data, a cryptographic hash of the previous block, as well as a timestamp (Chang et al. 2020). Each block added to an existing chain will connect to the previous block's hash, therefore recording the digital transaction data in chronological order (Morkunas, Paschen, and Boon 2019). The initial block in a blockchain is called the genesis block, and each block added after that is typically numbered according to the order of addition (Zhu et al. 2019, 13). Visualisation of a blockchain example is presented in figure 1.

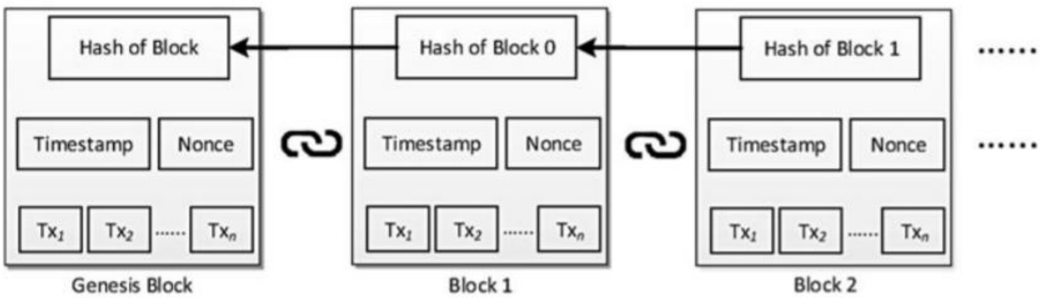

Figure 1. An example of a blockchain (Zhu et al. 2019, 11)

If a block is tampered with, the hash value of that block will change, meaning that it will no longer connect to other blocks in the chain. Consequently, that tampered block will be omitted from the blockchain (Imteaj et al. 2021, 3). However, if a block has not been tampered with, the hash value will stay the same and the block will be approved as a part of the blockchain (Imteaj et al. 2021, 3). Consequently, blockchains manage to portray a historical, irreversible, and verified list of records that comprise all the executed transactions (Morkunas et al. 2019).

2.2 Types of blockchains

Blockchains can be configured and designed in ways that vary depending on the use case of the blockchain. Different categorisations of the types of blockchains have been identified and discussed. For example, Helliar, Crawford, Rocca, Teodori, and Veneziani (2020) recognise different blockchains as permissionless and permissioned types, while Guo and Liang (2016) argue that blockchains can be categorised into three different types, which are public, private and consortium blockchains. Nevertheless, these categorisations are not exclusive to each other. They are based on the same principles and display the properties similarly. However, the different types of blockchains differ from each other in significant ways. The most notable differences are the degree of decentralisation, participant selection and anonymity of participants (Guo and Liang 2016). Mentioned properties and typical use cases of the different types of blockchains are discussed below.

Public blockchains are permissionless, meaning that they allow anyone to interact with another transacting party and freely participate in the blockchain network (Morkunas et al. 2019). This means, that in public domains every transacting party can view, validate, and add blocks of information to the blockchain (Kaur, Chaturvedi, Sharma, Kar, and He 2021). The transacting parties in public blockchain networks are anonymous or at least using a pseudonym (Morkunas et al. 2019). Furthermore, every transacting party has the same privileges meaning that public blockchain networks are not dependant on a centralised authority and therefore they are truly decentralised (Xu, Pautasso, Zhu, Gramoli, Ponomarev, Tran, and Chen 2016).

Conversely, private blockchains are permissioned meaning that they are restricted from the public and only allow validated nodes to access the ledger and participate in the blockchain network (Morkunas et al. 2019). In private domains only selected nodes can view, validate, and add blocks of information to the blockchain (Kaur et al. 2021). In contrast to public blockchains, the identities of all transacting parties in private blockchains are known before transacting (Morkunas et al. 2019). Furthermore, private blockchains are controlled and governed by a single authority or organisation that oversees the decision-making and participant selection in the network (Xu et al. 2016). As a result, the configuration of private blockchains is more centralised than with public blockchains.

Consortium blockchains, which are sometimes called federated blockchains, are typically classified as a variant of private blockchains. Similarly, they are permissioned and restricted from the public, meaning that not anyone can participate in the blockchain network (Morkunas et al. 2019). As with private blockchains, the identities of transacting parties in consortium blockchains are known before transacting. However, consortium blockchains are not controlled or governed by a single entity but a group of organisations (Morkunas et al. 2019). This group of organisations known as a consortium has the same privileges while sharing the leadership of the blockchain, meaning that the configuration of said blockchains is multi-centralised. Thus, they are more decentralised than private blockchains yet more centralised than public blockchains (Guo and Liang 2016).

According to Helliar et al. (2020), permissionless blockchains have become the platform for cryptocurrencies, while permissioned blockchains have become the platform for organisational and institutional business practices. Two of the most well-known cryptocurrencies, Bitcoin and Ethereum, operate on permissionless public blockchains (Niranjanamurthy, Nithya, and Jagannatha 2018). Permissioned private blockchains, on the other hand, are typically adopted by organisations as secure and private databases (Kaur et al. 2021). Furthermore, consortium blockchains are typically adopted by a group of organisations in different business systems. For example, the financial sector is well known for utilising permissioned consortium blockchains (Helliar et al. 2020).

The different types of blockchains have their advantages and disadvantages. One of the most notable disadvantages, particularly with public blockchains, is the scalability issue (Xu et al. 2016). As public blockchains allow anyone to participate and interact in the blockchain network the number of nodes can be substantial. Since blockchains verify and store each block of information across all nodes in the network, the increasing number of nodes and volume of transactions results in scalability issues (Xu et al. 2016). Furthermore, this results in decreasing transaction speed (Guo and Liang 2016). Jackson (2018) portrayed an example of the scalability issue and suffering transaction speed with public blockchains arguing that Visa as the fastest payment network processes around 24 000 transactions per second, while cryptocurrencies operating on a public blockchain, such as Bitcoin and Ethereum, are capable of processing merely 7 and 20 transactions per second. Conversely, permissioned private and consortium blockchains consist typically of a small number of nodes, which means that they enable high efficiency (Guo and Liang 2016). Thus, public blockchains are not capable of scaling the increasing volume of transactions, while permissioned private and consortium blockchains handle this issue with greater success. Additionally, permissioned private and consortium blockchains offer better privacy and they are more easily managed (Xu et al. 2016). However, due to the number of nodes and degree of decentralisation, permissionless public blockchains are considered more trustworthy and secure than permissioned private and consortium blockchains (Xu et al. 2016).

2.3 Consensus protocols

Bamakan, Motavali, and Babaei Bondarti (2020) state that reaching an agreement between the nodes in a blockchain network is a complex process and it has raised concerns. As there is no trusted central authority in a blockchain network, it requires a mechanism to indicate that the blockchain and its information is valid (Imteaj et al. 2021, 19). These mechanisms used by blockchains are known as consensus protocols. Consensus protocols are computational algorithms, that serve a purpose in verifying and validating the blocks added to the chain (Bamakan et al. 2020). When a block validated by a consensus protocol is added to the chain, it is not feasible to modify or delete it (Imteaj et al. 2021, 19). Therefore, a unified agreement on the validation of the record is achieved. Furthermore, to tamper or forge a record in a blockchain one must manage at least 51% of the reporting nodes in the network (Chang et al. 2020). Several consensus protocols have been developed for different use cases, and they develop continuously along with the development of blockchain technology (Salimitari, Chatterjee, and Fallah 2020). These different consensus protocols have their advantages and disadvantages, and their usability is dependent on the configuration and design of the blockchain (Bamakan et al. 2020). The following paragraphs provide an overview of three of the most important consensus protocols, Proof of Work, Proof of Stake and Practical Byzantine Fault Tolerance.

Proof of Work (PoW) is the most well-known and used consensus protocol (Imteaj et al. 2021, 19). It was introduced by Nakamoto in 2008 along with the introduction of Bitcoin (Nakamoto 2008). The PoW consensus protocol is based on solving cryptographic, randomised, and complex mathematical formulas (Bamakan et al. 2020). These mathematical formulas called hashes are used to confirm and validate the data blocks. To solve such mathematical problems, nodes attempt to find the specific hash value that satisfies the preliminarily defined conditions (Bamakan et al. 2020). This is achieved through executing countless computations. The process of solving cryptographic hash functions is called mining, and the nodes solving them are called miners (Salimitari et al. 2020). The PoW has been proven to be a secure and functioning consensus protocol, especially with cryptocurrencies (Salimitari et al. 2020). However, the process of solving hash functions requires a considerable amount of energy and computational power, which in turn leads to latency issues and extensive bandwidth requirements meaning that the process of reaching consensus is often inefficient and costly (Bamakan et al. 2020).

Proof of Stake (PoS) is another frequently used consensus protocol. It was developed and proposed as an alternative for the PoW (Bamakan et al. 2020). The main idea behind the PoS consensus protocols is that the selection of the node creating the next block should be dependent on stored stake, as well as randomisation (Kaur et al. 2021). The process of choosing the reporting node is executed through quasi-random selection, meaning that the proportion of stake owned by a node affects the chances of selection (Bamakan et al. 2020). Moreover, this results in energy efficiency compared to the PoW consensus protocol, since validating and adding data blocks is based on the stake of the selected node rather than computing power (Salimitari et al. 2020). However, this means that decentralised blockchain networks using the PoS consensus protocol can become centralised, as they are mainly dependent on and influenced by nodes with a higher stake (Imteaj et al. 2021, 20-21). Additionally, the PoS faces a problem called “nothing at stake”, which refers to a situation where a selected node misbehaves intentionally since it has nothing to lose (Salimitari et al. 2020).

Practical Byzantine Fault Tolerance (PBFT) is a consensus protocol based on solving the Byzantine general problem (Bamakan et al. 2020). In brief, the Byzantine general problem displays a problem that is solvable if and only if two-thirds of participants reach an agreement. It is rooted in the idea that a trusted computer system needs to cope with malfunctioning and misbehaving components (Lamport, Shostak, and Pease 1982). With the PBFT, the consensus in blockchain platforms is reached when at least two-thirds of the nodes reach an agreement, meaning that it can tolerate one-third of malicious behaviour by the nodes in the distributed network (Salimitari et al. 2020). The PBFT is energy efficient, and it does not require extensive computational power (Imteaj et al. 2021, 22). However, it might suffer from delays as consensus is not reached until all the nodes in the network have voted and two-thirds of them agree favourably (Bamakan et al. 2020). Salimitari et al. (2020) argue that the PBFT consensus protocol is applicable for permissioned private and consortium blockchains, while it is not the optimal choice for permissionless public blockchains.

2.4 Smart contracts

Smart contracts are an integral element of blockchain technology’s potential and applications. Dhaiouir and Assar (2020) describe smart contracts as digitalised legal contracts, that bind transacting parties to an agreement of transaction execution. Furthermore, Macrinici, Cartofeanu, and Gao (2018) point out that to execute a smart contract and its terms and conditions the transacting parties are bound to fulfil the obligations of the agreement. The authors compare smart contracts to the contractual agreements of the real world, identifying one major difference, which is the fact that smart contracts are digitalised and executed in the cyber world.

Smart contracts operate on blockchains as a programming code intending to enforce and facilitate terms and conditions according to an agreement, as well as automatically execute the agreement when these specified conditions are fulfilled (Alharby and van Moorsel 2017). Since smart contracts are executed on blockchains, they are inherently verified by the nodes in the distributed network (Alharby and van Moorsel 2017). As a result, the involvement of intermediary operators is not required between the transacting parties. Blockchain-enabled smart contracts seek to establish trusted systems that facilitate greater transparency, traceability, and security (Dhaiouir and Assar 2020).

Szabo (1994) introduced the original idea behind smart contracts, but it did not receive significant attention until the introduction of blockchain technology. However, in recent years the development of smart contracts has advanced together with the development of blockchains (Alharby and van Moorsel 2017). As a result, several applications of smart contracts have been introduced and suggested across industries (Macrinici et al. 2018). These applications include, for example, e-commerce, digital right management, identity management and payment systems (Alharby and van Moorsel 2017). Two of the most well-known blockchain platforms that utilise smart contracts are cryptocurrency Ethereum and open-source consortium blockchain Hyperledger Fabric (Dhaiouir and Assar 2020). In addition, Alharby and van Moorsel (2017) argue that smart contracts can be deployed and developed further across different blockchain platforms, that exhibit distinctive characteristics.

Various issues and limitations regarding smart contracts have been identified. Alharby and van Moorsel (2017) identify four key issues with smart contracts, which consist of codifying, security, privacy, and performance issues. This perception is supported by Dhaiouir and Assar (2020) who point out the same categorisation of issues. According to Alharby and van Moorsel (2017), the codifying issues are related to the difficulty and complexity of programming smart contracts. Security issues comprise the vulnerability of smart contracts to malicious attacks. Privacy issues, on the other hand, comprises the lack of transactional data privacy. Lastly, performance issues are based on the execution scalability of smart contracts.

3. Technology adoption

Marangunic and Granic (2014) state that digitalisation and the development of technologies, particularly in information systems, has attracted interest in questions considering technology adoption. The authors reason that at the core of such questions is the need to understand the factors that influence decision-making behind technology adoption. This has created an area for research and studies, which subsequently has resulted in the introduction of theories and models that endeavours to address these questions. One of the most influential and widely used information systems theories for technology adoption is the technology acceptance model (TAM) (Marangunic and Granic 2014). This chapter provides an overview of the TAM and its characteristics, as well as introduces the blockchain acceptance model that was derived from the original TAM framework.

3.1 Technology acceptance model

The TAM, introduced by Davis (1986), is a theory that models the acceptance or rejection of technology adoption and usage. It aims to predict and explain the behavioural factors that can be considered as the reasons behind the decision-making. Davis (1986) considers that the adoption and usage of an information system is behaviour and affected by attitudes. Due to this consideration, the TAM was derived from the theory of reasonable action (TRA), which is a psychology-based theory that similarly aims to explain and understand behaviour and attitudes (Davis, Bagozzi, and Warshaw 1989).

The TAM provides a background for understanding technology adoption as a phenomenon. It suggests and recognises that the decision of adopting and using a technology is influenced by several factors, yet it can be modelled based on only two major beliefs, which are perceived usefulness and perceived ease of use (Davis 1986, 24-26). Moreover, Davis et al. (1989) argue that these two distinct beliefs are sufficient to predict technology adoption and usage.

Davis (1986) claims that the attitude of a possible user towards using an information system determines behavioural intention, which in turn determines the actual use of the system. Furthermore, the author states that the external variables of the model, which comprises factors such as system characteristics and design, do not have a direct effect on attitude or behaviour. Instead, these variables influence attitude and behaviour indirectly through a direct relationship with perceived usefulness and perceived ease of use (Davis 1986, 24.26). Visualisation of the TAM is presented in figure 2.

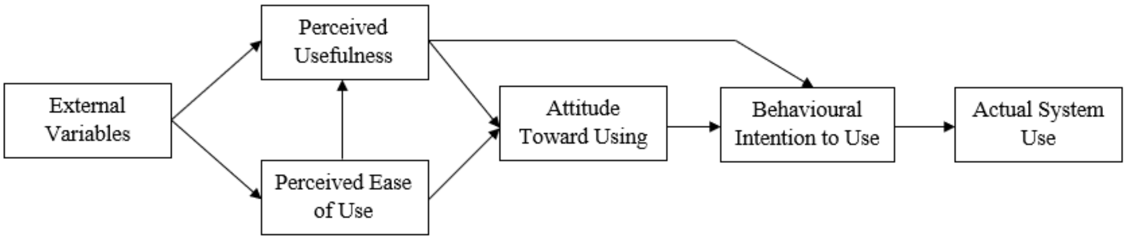

Figure 2. Technology acceptance model (Davis et al. 1989)

Perceived usefulness, as defined by Davis (1986, 26), is “the degree of which an individual believes that using a particular system would enhance his or her job performance”. Davis (1989) argues that the adoption and usage of a technology is accepted or rejected based on the extent that possible users believe that it will be advantageous or disadvantageous. At the core of perceived usefulness is to consider if a technology has the capability to provide beneficial qualities for processes. Consequently, the more beneficial technology adoption is for the possible user, the more likely it is to be accepted (Davis 1989). Therefore, as proposed by Davis (1986), the adoption and usage of an information technology is theorised to be influenced by perceived usefulness.

Perceived ease of use, on the other hand, is defined as “the degree to which an individual believes that using a particular system would be free of physical and mental effort” (Davis 1986, 26). Davis (1989) argues that although an information technology is beneficial for the possible user through perceived usefulness, its adoption and usage might still be rejected due to the required effort and difficulty of usage. Therefore, perceived ease of use has a direct influence on perceived usefulness. Furthermore, the easier technology adoption and usage are for the possible user, the more likely it is for it to be accepted (Davis 1989). Consequently, the adoption and usage of an information technology are also theorised to be influenced by perceived ease of use (Davis 1989).

3.2 Blockchain acceptance model

Marangunic and Granic (2014) claim that the TAM is an extensively used, valid and robust model that has wide applicability in different use cases and contexts. Additionally, Sciarelli et al. (2021) argue that the TAM is a useful and efficient model to predict the adoption of various technologies, such as blockchain technology. Furthermore, Folkinshteyn and Lennon (2016) suggest that the TAM is an efficient, applicable, and valuable framework for the analysis of blockchain technology adoption as a financial technology. Given these perceptions of the TAM, it was selected as a theoretical framework for this study to support the research.

As mentioned earlier, the emerging and nascent nature of blockchain technology signifies that the research considering its adoption is not extensive. Moreover, the research applying the TAM theoretical framework to examine its adoption is also in its infancy. However, the TAM has been used by a few scholars to analyse and investigate blockchain adoption in different contexts by extending the model and adding various external variables. Folkinshteyn and Lennon (2016) analysed Bitcoin and blockchain technology adoption as a financial technology with the TAM framework using a qualitative approach. They find significant general value in the adoption of blockchain technology, while also identifying risks and challenges associated with specific applications. Sciarelli et al. (2021) quantitatively studied the influence of efficiency, security and reducing costs on blockchain technology adoption in innovative Italian companies finding that efficiency and security influence blockchain adoption significantly, while reducing costs does not. Additionally, Albayati et al. (2020) studied the acceptance of blockchain technology and cryptocurrency transactions, finding that the acceptance is influenced mainly by the user's trust in the system. Most of the studies applying the TAM framework are in the quantitative paradigm.

However, according to a study conducted by Vogelsang, Steinhueser, and Hoppe (2013), qualitative approaches to the TAM framework are effective and unrepresented.

Considering the adoption of blockchain technology in the financial sector, this study applies the TAM as an analytical tool and a supportive theoretical framework. Furthermore, the original TAM framework was modified to fit the context of this study, and thus a blockchain acceptance model was developed. The blockchain acceptance model derived from the TAM evaluates the adoption of blockchains by analysing the associated benefits and challenges through the two factors of perceived usefulness and perceived ease of use. These factors are assessed based on the proposed framework, which suggests and investigates four major determinants for the two beliefs, which are efficiency, security, costs, and accessibility. These external constructs are incorporated into the model to further explain and predict the benefits and challenges of blockchain technology adoption. Visualisation of the blockchain acceptance model is presented in figure 3.

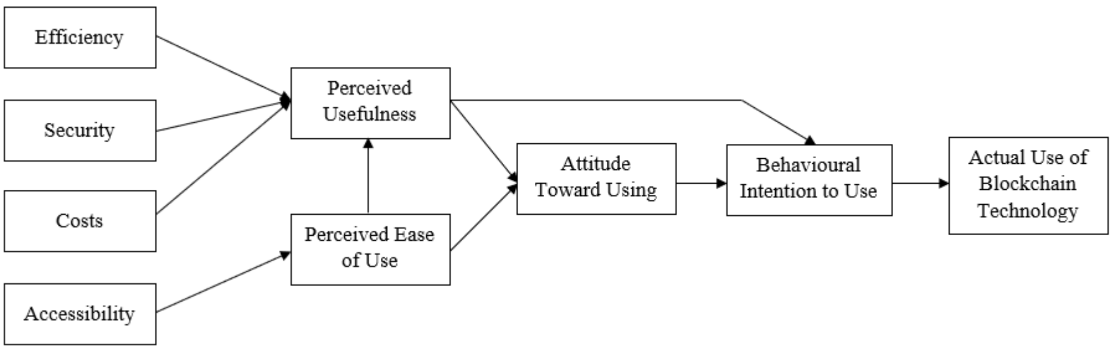

Figure 3. Blockchain acceptance model

Applying the blockchain acceptance model the adoption of blockchain technology is studied generally through analysing the associated benefits and challenges. To achieve the set objective of this study the proposed model focuses primarily on determining the perceived usefulness and perceived ease of use of blockchain technology. Examining the two beliefs is sufficient to determine blockchain adoption through attitude and behavioural intention.

4. Research methodology

This study was conducted adopting qualitative research methodology. Qualitative research was chosen as the most suitable approach for this study due to its attributes and exploratory tendency. Eriksson and Kovalainen (2008, 5-6) state that qualitative research methods are relevant especially in cases where the researched phenomenon is emerging and moderately studied. Additionally, the authors point out that qualitative research methods focus on gathering holistic understanding and information of a phenomenon and its causal relationships, which suits the set objective of this study.

This study applied semi-structured interviews to examine blockchain technology adoption in the financial sector. Semi-structured interviews, which are commonly adopted in qualitative research, were selected as the most appropriate research and data collection method for this study since they enable to obtain a large volume of comprehensive data. According to Galletta and Cross (2013, 45-46), semi-structured interviews focus on obtaining versatile information on a phenomenon by allowing new ideas and meanings to be brought up by combining open-ended and theoretical questions. Moreover, the authors state that semi-structured interviews aim to gain multi-dimensional insight and understanding of a phenomenon by discussing the topic through experiences and knowledge. Semi-structured interviews combine the aspects of unstructured and structured interviews meaning that they offer control over the discussion while enabling the interviewee to fully express their opinions (Given 2008, 811).

4.1 Data collection

As discussed above, the data for this study was collected using semi-structured interviews. Three professionals in blockchain technology, currently working in the financial sector in Finland, were interviewed on blockchain technology as a financial technology. The interviews were conducted in Finnish as Microsoft Teams meetings lasting 30 to 45 minutes. All meetings were recorded, transcribed, and later translated to English. The interviewees were chosen based on their experience and expertise in information technologies and distributed ledger technologies with an emphasis on blockchain technology. Furthermore, employment in the financial sector in Finland was a requirement. The interviewees were discovered by examining articles and websites concerning blockchain technology, distributed ledger technologies, FinTech and digitalisation in the financial sector. The interviewees were then contacted by the means of e-mail and an interview request was sent to arrange a meeting. A brief description of each interviewee is provided below.

Interviewee 1 is currently working with emerging technologies in an executive role. They have studied telecommunication and management. With over 15 years of experience in FinTech and over 8 years of experience in distributed ledgers and blockchains, they have constituted in various blockchain application processes.

Interviewee 2 is a leading specialist in digitalisation for five years. They have studied network technology and technology law and they have master’s degrees in both engineering and law. Blockchain technology is a relevant subject in their current work, while the emphasis of their work is primarily based on the regulation of the financial sector more broadly.

Interviewee 3 is an experienced specialist in distributed ledger technologies and blockchains. They have a master’s degree in industrial engineering and management. They have comprehensive experience in information technologies, with over 15 years of experience in decentralised data management.

The interviews followed a preliminarily created interview frame (appendix 1). The interview frame consists of five different sections, which all included questions related to a certain theme. The questions in the first section provided general information about the interviewee and insight into the relationship between the interviewee and blockchain technology. The questions in the second section focused exclusively on the benefits and applications of blockchain technology. The questions in the third section, on the other hand, focused exclusively on the challenges associated with blockchain technology adoption. The fourth section concentrated on the current state and readiness of blockchain technology. Lastly, due to the nature of semi-structured interviews, the fifth section allowed the interviewee to add complementary information on the discussed topics.

The asked questions and discussed themes were slightly weighted depending on the expertise and experience of the interviewee. However, each interviewee was asked the same questions so that the data could be analysed comparatively. The interviewees were informed about the topic of the study, as well as given a brief introduction of the major themes and the structure of the study prior to conducting the interview. However, the interview frame was not sent to the interviewees in advance. Furthermore, the interviews were conducted anonymously so that the answers could not be associated with the interviewee as a person nor to the organisation they represent. These choices were made based on obtaining authentic and unbiased answers and expression of opinions.

4.2 Analysis

This study applied content analysis and thematic design as the method of data analysis. The aim of thematic content analysis is to gain a holistic understanding and a conceptualised view of the studied issue by inspecting recurring themes and concepts from the qualitative material (Eriksson and Kovalainen 2008, 187-189). Moreover, it enables systematic and objective examination of transcribed data through contextual observation (Eriksson and Kovalainen 2008, 187).

The thematic content analysis used in this study combined characteristics of both inductive and deductive approaches. An inductive approach was emphasised, as blockchain technology adoption was studied by identifying recurring themes and concepts from the interview data to gain a conceptualised view of the topic. However, a deductive approach was also utilised as the analysis was supported by the blockchain acceptance model that was derived from the widely used TAM framework.

The recorded interviews were first transcribed and categorised according to the interview frame and discussed themes. The transcripts were then combined into one file that was to be analysed. The recorded interviews and the transcribed data were reviewed multiple times to assimilate the information. Based on the set research objective and questions, the relevant and meaningful information was then highlighted from the transcript. The transcribed text data was also colour-coded based on the recurring themes and concepts. Subsequently, the data was described and interpreted by the blockchain acceptance model to conclude on the adoption of blockchain technology in the financial sector and to find a conceptualised view of the research topic. Furthermore, the perceptions of the interviewees were also compared to previous literature in order to form a comprehensive overview of the topic.

5. Results

This chapter presents the results of this study by describing and interpreting the obtained interview data. Based on the proposed blockchain acceptance model derived from the TAM, the challenges and benefits related to efficiency, security, costs, and accessibility are examined. Furthermore, the applications of blockchain technology are addressed. Direct quotes from the interviewees are included to support the presentation of the results. The results are presented objectively and responses from all interviewees have been considered even-handedly.

5.1 Blockchain technology adoption benefits

The interviewees identified significant benefits associated with the adoption of blockchain technology in the financial sector. Some of the identified benefits have been proven to be achievable, while some of them are only speculative and still developing. The digitalisation of executing transactions and contracts, as well as the potential to store and share trustable and verifiable data in a computational form between entities, were recognised as the main motivators behind the adoption of blockchain technology. Furthermore, these were perceived as the main determinants for the usefulness of blockchains.

A prominent benefit emphasised the most, was increasing efficiency through automation, transaction speed and cost-efficiency. Processes in the financial sector are typically complex transactions based on forming agreements and executing contracts between transacting parties. Furthermore, they usually require the involvement of several different entities and intermediaries. This complicates and slows down the overall execution of these processes and increases transactional costs. However, all the interviewees stated that by utilising blockchain technology executing transactions and contracts, as well as moving assets could be carried out more efficiently than currently.

> *"The use of blockchain technology helps us in a situation, where we manage a node in a network that includes only the data of our customers. We can then share the data to the participants in the network in an efficient and secure way to complete transactions and contractual agreements."* Interviewee 1

> *"Harmonically tagged information with blockchains further increases efficiency and makes several processes easier. Blockchains [...] could enable efficiency through trustworthiness and transparency."* Interviewee 2

> *"Reduction of friction. All kinds of complex processes can be carried out in a more simplified way. [...] the promise of cryptographic technologies and trust chains is the increased efficiency of processes related to moving value"* Interviewee 3

Digital housing sale was used as an example of a process where efficiency has already increased with the use of blockchain technology. DIAS, which is a digital blockchain-inspired platform for housing sales developed in Finland, was brought up by two of the interviewees. It was stated that DIAS benefits housing sales by automating, simplifying, and expediting steps of the process.

> *"All operators in DIAS manage their own node in the network. It utilises a decentralised structure to execute housing sales without the need to trust to a centralised base."* Interviewee 1

> *"With DIAS the process of housing sales can be executed in a simplified way without the need for paper contracts. When paper is not needed, one does not need to book several meetings with different intermediaries and the majority of these steps can be automatised."* Interviewee 3

The interviewees identified enhancing security as another benefit. Financial services and products are based on trust to a large extent and a significant amount of trustworthy information is constantly distributed between entities to form agreements and execute transactions and contracts. Consequently, secure, and trustable distributed networks such as blockchains are of significant value to the financial sector. They enable digitalised transactions and contracts that can be verified across all participating nodes by cryptographic signatures. Moreover, the execution of such transactions and contracts can be monitored every step of the way due to traceability and transparency. This results in efficient architecture that enhances security and decreases the risk of several processes.

> *"With digital and cryptographic signatures, we have a confirmed agreement that we can keep track of constantly, and therefore we can determine and reduce the associated risks."* Interviewee 1

Interviewee 1 also pointed out that the decentralised nature of blockchains removes the risk of having a single point of failure, which results in resilience. Transactions and contracts are constantly executed across different systems, and the intermediary financial institutions and organisations play a major role in carrying them out. If the underlying network behind transaction and contract execution is of centralised nature, malfunction is a significant risk for the network. However, as there are multiple nodes in a decentralised network the risk of malfunction is not as prominent. Consequently, resilience is a benefit that results in robustness, as well as in increased availability of financial services

> *"Compared to having a malfunctioning centralised service, now if a node or two malfunctions we can still continue to do business. This is a benefit that decentralisation makes possible."* Interviewee 1

Additionally, interviewee 1 claimed that blockchain technology has broadened the view of how different processes in the financial sector can be carried out, while simultaneously creating new ways of conducting business. Furthermore, they stated that this shifting mindset and attitude is valuable for the development of the financial sector since it aids in providing new solutions for long-term issues. It results in cooperation between financial operators to pursue ways that further increase the efficiency and security of processes.

> *"This new way to work together increases open-minded thinking […]. This change has helped us to carry things forward."* Interviewee 1

5.2 Blockchain technology adoption challenges

Although the interviewees recognised beneficial qualities and significant motivators behind the adoption of blockchain technology, they emphasised that the benefits are not achievable without facing challenges. Subsequently, the interviewees identified several challenges influencing the usefulness and ease of use of blockchain technology. The identified challenges comprise technological, environmental, and organisational aspects.

Blockchain technology's promise of increasing efficiency is not necessarily accurate in all applications. As mentioned earlier, blockchain-enabled efficiency can result in reducing costs of processes. However, the overall costs of blockchain adoption are ambiguous and need to be considered. The interviewees agreed that decentralised databases and data structures are costly to manage. Developing, maintaining, and updating blockchains is expensive, complex, and risky compared to conventional centralised data structures. Furthermore, such processes include a significant amount of redundancy, which in turn results in scalability issues and extensive computational requirements. Interviewees 2 also stated that a challenge is to identify the processes where improved efficiency surpasses the increasing costs, complexity, and riskiness.

> *"Blockchains are expensive to manage. The processes include a lot of redundance since the transactions and contracts are executed multiple times with different network participants."* Interviewee 1

> *"A challenge is to recognise where the use of blockchains is cost-efficient compared to some conventional centralised solutions."* Interviewee 2

All interviewees also unanimously agreed that regulation and legislation function as significant barriers to the adoption of blockchain technology. The financial sector is a heavily regulated sector of the economy, meaning that various laws, requirements, and demands are issued by several authorities that need to be complied with. Regulation is typically directed towards a liable central entity, that manages the network. However, if the network is decentralised there is no central authority on which the regulation should be directed to. This results in regulatory and legislative challenges since it is uncertain how the requirements can be fulfilled. Additionally, interviewee 2 pointed out that a change in regulation and legislation in certain areas is needed prior to adopting blockchains at a larger scale.

> *"Compliance at this time seems problematic, and blockchain might not be beneficial for tackling this issue."* Interviewee 1

> *"In some areas, regulation must change, and this change is slow. I don't think there is necessarily a negative stance towards blockchains at EU level, it's more about the slowness of regulation change."* Interviewee 2

Interviewee 2 also raised an issue by stating that standardisation concerning blockchain technology is in its infancy. Moreover, they claimed that there are no robust principles of standardisation for blockchain technology and its applications. This is a challenge because in order to start developing and creating a homogenous and functional system, such as with the internet, proper standardisation is required.

> *"Standardisation is in early stages, and there is still a lot of room for improvement to create a system with large scalability where participating and building upon it is easy."* Interviewee 2

Lack of relevant standardisation is also influencing the interoperability of different systems. The interoperability of decentralised and centralised networks is an aspect that was considered a challenge, yet its dimension is still speculative. There is a possibility that blockchains do not function with the current systems of the financial sector. Interviewee 1 stated that only a few real-life applications have faced interoperability in practice, which means that there is no clear perception of it yet. However, interviewee 1 also identified a beneficial side to interoperability by claiming that successful interoperability between systems could result in significant synergy benefits.

> *"The vision of the future is to interconnect these networks by different means. It has already been attempted, but the launch of such projects has been slow."* Interviewee 1

The interviewees also stated that it is difficult to find professional developers of decentralised architecture with proper expertise and competence. Moreover, even if these professional developers are found, they are expensive to hire and difficult to get to participate in blockchain-related projects. Interviewees 1 and 3 argued that blockchain configurations and designs that are applicable for the financial sector have been only produced marginally. Also, they stated that not many networks reach the production stage after the initial introduction. Thus, decentralised architecture is relatively difficult to find and develop. Improved understanding and knowledge surrounding blockchain technology are needed, and the lack of them was recognised as a challenge.

> *"Developers of decentralised architecture are hard to find. […] only a few of such networks have reached the stage of production and they are difficult to find, even globally.* Interviewee 1

> *"It is clear, that there are still hills to climb. Further understanding and know-how are still needed in many places.* Interviewee 2

A rapidly increasing amount of discussion has surrounded blockchain technology in recent years. However, all three interviewees agreed that there is uncertainty on the actual potential of blockchains, and the surrounding talk is primarily speculative. Interviewee 3 also claimed that blockchain technology is surrounded by misconceptions. The foundations on which blockchain networks are built are still in a state of development, and the connection between the real world and the cyber realm requires further understanding.

> *"Certainly, blockchains are talked about a lot, but it is difficult to comprehend what you can actually do with them."* Interviewee 2

> *"Fundamentals have been misunderstood. […] foundations on which blockchains are built are shaky. To this day, blockchain technology and the cyber realm founded on it are separated from the real world."* Interviewee 3

5.3 Blockchain technology applications

The configuration and design of blockchains need to be considered prior to adoption. As described in chapter 2.2, different types of blockchains consist of distinct qualities, some of which are beneficial while others are not suitable for the financial sector. All three of the interviewees unanimously agreed that public permissionless networks do not fit the current state of the financial sector. According to regulation and legislation, financial institutions and organisations have the responsibility and are obliged to identify and know their counterparties. Additionally, the origin of assets must be clarified to prevent criminal activity and money laundering. Therefore, blockchain networks where participation is not restricted and transactions are conducted anonymously or with a pseudonym, are not suitable for most processes in the financial sector.

> *"For now, it is juridically impossible to operate in public permissionless blockchains."* Interviewee 1

> *"As the financial sector is so significantly based on trust and valid agreements between transacting parties, I don't see that there would be demand for public blockchains."* Interviewee 2

> *"Public permissionless networks are not applicable as a platform for transaction and contract execution, since the mechanism includes processes overseen by someone who does not exist outside the cyber realm. […]. Processes in the financial sector are based on agreements, which in turn are based on knowing and trusting the counterparty in a way where you can complete the transaction."* Interviewee 3

Thus, public permissionless blockchains are out of the discussion of adoption and the focus is directed more towards permissioned private and consortium blockchains. Such permissioned blockchains have developed in the right direction from the financial sector's point of view. However, this does not indicate that they are necessarily the optimal choice for all processes. It is important to evaluate the architecture to conclude if it is correct for the development of a specific network.

The interviewees agreed, that at this time blockchain technology applications and their future development is primarily related to digital identity and digital signatures, which in turn are based on cryptography. Furthermore, interviewees 1 and 3 stated that digital identity and digital signatures could provide an efficient platform for the use of smart contracts. Secure networks of trust and efficient sharing of valid and verifiable data could be developed by utilising digital identity and digital signatures. Additionally, agreement and contract execution could be automatised with juridically binding digitalised contracts. Such architecture and robust foundations could provide efficient solutions for different processes, and therefore the interviewees considered this as the roadmap for blockchain technology's development as a financial technology. According to the interviewees, processes where digital identity, digital signature and smart contracts could be applied to include the likes of know your customer (KYC) processes, sales transactions, and loan applications.

> *"The start of the blockchain applications of the future is based on digital identity. It is beneficial to first create digital identities for transacting parties. After digitalising transacting parties, it is also easier to digitalise the process itself."* Interviewee 3

> *"When we are able to digitalise the versions of contracts, that are in link with digital identities and the actual contract, we create efficient architecture for transaction and contract execution. Also, this way we achieve real trust in these networks."* Interviewee 1

Interestingly, two of the three interviewees addressed self-sovereign identity as a central aspect of digital identity. Essentially, self-sovereign identity enables individuals to control and manage their own digital identity through a digital wallet. With such identity models, individuals can share valid and verifiable data about themselves. Thus, proof of valid information can be distributed to different operators to increase efficiency and lower the risks of processes.

> *"With self-sovereign digital identity data sharing could be done in an interesting way. Rather than sharing actual information, you can share proof of that information."* Interviewee 1

> *"In a self-sovereign network […] transacting parties can communicate using verifiable and factual information, and this enables the digitalised contracts."* Interviewee 3

The interviewees pointed out that blockchain technology is in a state of transition and change. Decisions regarding its adoption are the next step in the development of the technology. However, while several beneficial qualities and applications have been recognised the adoption and direction of future development is still under discussion.

> *"Development of blockchains has been slower than originally envisioned. […] The benefits haven't necessarily realised in a way where the development should continue with such blockchain structures."* Interviewee 1

Additionally, the interviewees emphasised that the discussed benefits, challenges, and applications are not exclusively related to just blockchains. Other blockchain-inspired distributed ledger technologies and trust chains are as valuable, if not even more valuable. Therefore, to achieve creating efficient and secure architecture for transaction and contract execution, a broader view of distributed ledger technology and cryptographic trust chains is required. The focus of the development should not be directed only towards blockchains.

> *"Many of these discussed elements are not exclusively related to blockchain technology, but future networks of trust inspired and enabled by blockchain technology are looked at and developed."* Interviewee 1

> *"Cryptographic trust chains and technologies, as well as other distributed networks are certainly a big deal. However, it might turn out that blockchains are not needed and as an information technology they are of lesser value than originally envisioned. […] Cryptographic trust chains are important and valuable, but it is not necessary to organise them in the form of blockchains."* Interviewee 3

6. Discussion

This chapter interprets and discusses the meaning of the results presented in the previous chapter and provides answers for the set research questions of this study. The results are compared with the findings of previous studies and their value and significance for the financial sector is evaluated. Furthermore, the reliability of the results and the limitations of the research are addressed and discussed.

Based on the results of this study, blockchain technology is perceived as a useful innovation through benefits related to efficiency, security, and costs. Its ease of use, on the other hand, is perceived problematic due to several accessibility challenges. Consistent with the findings of Folkinshteyn and Lennon (2016), this study found that the influence of perceived usefulness and perceived ease of use on blockchain technology adoption is profoundly dependent on the configuration of the blockchain network. Therefore, they vary depending on the application and the extent of their influence is not ambiguous, meaning that determining them is difficult without conducting application-specific research. However, the current state of blockchain technology in the financial sector can be outlined on a general level based on the results. A summary of the results can be found in table 1.

Perceived usefulness (Application-specific)	Perceived ease of use (Application-specific)
Efficiency:	**Accessibility:**
Automation (+)	Regulation and legislation (–)
Transaction speed (+)	Standardisation (–)
Scalability (–)	Lack of know-how (–)
Security:	Interoperability (+/–)
Enhanced security (+)	
Resilience (+)	
Costs:	
Cost-efficiency (+)	
Maintenance costs (–)	

Table 1. Summary of the results

The results of this study indicate that blockchain technology has significant potential and it could provide several benefits for the financial sector. Automation, transaction speed, cost-efficiency, security, resilience, and interoperability were identified as blockchain-enabled benefits, thus providing an answer for the first research question: "*How can blockchain technology benefit the financial sector?*" These benefits result in perceiving blockchain technology as a useful innovation through efficiency, security, costs, and accessibility. However, the degree of the usefulness is still primarily speculative and therefore determined more precisely by future development.

Based on the results, blockchain technology could increase the efficiency of processes through automation, increasing transaction speed, and cost-efficiency. This means that the complex processes of the financial sector could be simplified, expedited, and further optimised in terms of resource use. This perception is supported by Ali et al. (2020), Folkinshteyn and Lennon (2016) and Knezevic (2018) who claim that increasing efficiency is at the core of blockchain-enabled benefits.

Another incentive for the adoption of blockchain technology is its potential to enhance security and provide resilience. Security benefits, which are achievable through decentralisation, transparency, and traceability, are valuable for the financial sector due to its nature to base services on trust and encrypted information. Enhancing security prevents losses and decreases risks of processes, which is essential for both service providers and customers. Furthermore, resilience achieved by the removal of a single point of failure further enhances security and increases the availability of financial services. Consistent with such findings, Chang et al. (2020) and Polyviou et al. (2019) also found the capability of blockchains to create safe environments on which to operate.

Interestingly, while Osmani et al. (2020) suggest that interoperability is a challenge associated with blockchain technology adoption, this study identified a beneficial side to it. This beneficial side of interoperability is achievable in a situation where blockchain networks work harmonically with the current systems of the financial sector. It was found that successful interoperability could further strengthen the mentioned benefits through increasing synergy.

Several challenges that influence the adoption of blockchain technology and function as adoption barriers were also identified. Based on the results, scalability, maintenance costs, regulation, legislation, standardisation, lack of know-how, and interoperability are challenges associated with the adoption of blockchain technology, thus providing an answer for the second research question: "*What challenges influence the adoption of blockchain technology in the financial sector?"* These challenges influence both perceived usefulness and perceived ease of use of blockchain technology through efficiency, costs, and accessibility. Overall, such challenges are significant, to say the least, and they require solutions prior to larger-scale adoption.

Costly maintenance, as well as scalability issues and extensive computational requirements, are significant deterrents for the adoption of blockchain technology. They are challenges that influence the extent of the mentioned efficiency benefits. Furthermore, such challenges could overshadow the increasing efficiency resulting in wasted resources and inadequate optimisation. This is consistent with the findings of Xu et al. (2016), who identified increasing costs and scalability issues associated with different consensus protocols and configurations of blockchains. Also, Ali et al. (2020) and Chang et al. (2020) have addressed scalability issues and extensive computational requirements as core challenges of blockchain technology.

According to Folkinshteyn and Lennon (2016), Helliar et al. (2020) and Kruglova and Dolbezhkin (2018), regulation and laws function as significant barriers for blockchain technology adoption. This perception is supported by the results of this study, as it was found that compliance with regulations and laws is currently problematic due to uncertainty. Also, Morkunas et al. (2019) argue that blockchain networks are not standardised. This study follows this view partly by identifying only infant standardisation considering blockchain technology. The current state of regulation, legislation, and standardisation complicates the process of adopting blockchain technology, hence they are core challenges.

Prior studies have highlighted that blockchain technology and the surrounding aspects are emerging and still in their infancy. This finds support by the results of this study. It was discovered that a profound understanding and know-how surrounding blockchains has not yet been established, due to the immaturity of the technology. This is a challenge, as it directly influences the availability and development of blockchains further complicating the process of adoption.

Interestingly, Chang et al. (2020) identified security and privacy challenges claiming that blockchains are vulnerable to malicious attacks. However, the results of this study did not take a strong stand on that issue. In addition, previous studies conducted by Ali et al. (2020) and Frizzo-Barker et al. (2020) portray blockchain technology as the latest revolutionary technological advancement that has the potential to transform various aspects of the financial sector. However, the results of this study indicate that this perception is primarily speculative and that the technological revolution is not as prominent as initially perceived. It was recognised that blockchain technology might not live up to its expectations and that the foundations might need to be considered again from the beginning.

Beyond the benefits and challenges, this study also managed to identify blockchain technology applications. The results of this study indicate that blockchain applications in the financial sector are primarily related to digital identity, digital signatures, and smart contracts, by which the third and final research question: *"What are the future applications of blockchain technology in the financial sector?*" is answered. Consistent with the findings of Knezevic (2018) this study found that by utilising blockchain-enabled digital identity and digital signatures, financial institutions and organisations could increase trust and verify the information distributed to them. Thus, processes such as user authentication and financing could be carried out more efficiently and securely. This is based on providing attestations and proof of valid information so that there is no need to speculate if the received information is valid or not. Also, blockchain-enabled smart contracts were identified as a prominent application that could provide solutions for the inefficiencies of the financial sector through automation and accuracy of transaction and contract execution. Interestingly, previous studies have emphasised the applicability of smart contracts to a larger extent than digital identities and digital signatures, such as in studies conducted by Chang et al. (2020) and Folkinshteyn and Lennon (2016). However, the three of the mentioned applications are equally as important as their usefulness is dependent on them operating successfully together.

Based on the applications of digital identity, digital signatures and smart contracts, processes where they could be utilised were also identified. Derived from the results, the most prominent of such processes are KYC processes, sales transactions, and loan applications. This follows partly the view of Chang et al. (2020) and Polyviou et al. (2019) who also found KYC processes and financing as central use cases.

Based on the results of this study, blockchain technology does not seem like a ground-breaking innovation to adopt currently due to immaturity and relatively weak foundations. However, it does not mean that robust foundations and efficient architectures are not achievable. The technology and the surrounding know-how are developing rapidly, and as with all innovations, a learning process is needed prior to establishing something valuable. The learning process with blockchain technology is still a work in progress, and thus the future development will further determine its actual applicability. However, the focus of the future development should also be targeted beyond blockchains to evaluate different distributed ledger technologies and cryptographic trust chains that provide solutions to the discussed challenges, while still enabling similar valuable benefits.

6.1 Limitations and reliability of research

This research has limitations that affect the validity of the results. This study was limited to the financial sector in Finland meaning that the results are not applicable or generalisable for other countries and environments. Also, the proposed blockchain acceptance model only addressed benefits and challenges related to efficiency, security, costs, and accessibility. Thus, it did not consider other constructs that might influence the adoption of blockchain technology, such as social influence or technological anxiety (Albayati et al. 2020; Sciarelli et al. 2021). Additionally, as this study was not application-specific, determining the influence of the perceived usefulness and perceived ease of use was based on making generalisations.

The depth of discussion was compromised at many levels due to a shortage of relevant previous studies on the topic. Only a few studies have applied the TAM framework to examine blockchain technology adoption. Furthermore, the methods, approaches and contexts between such studies vary significantly meaning that the results are difficult to compare reliably. Thus, the results of this study were compared to relevant studies and findings more broadly.

The qualitative data obtained by the semi-structured interviews was comprehensive and reliable enough to draw conclusions, due to it being obtained by interviewees that had a deep understanding and an experienced view of the topic. In addition, the views of the interviewees were in line with each other further strengthening the reliability of the results. However, the sample size was merely three interviewees and not sufficient enough to portray results that apply to the whole financial sector in Finland.

7. Conclusions and suggestions for future research

As digitalisation and the development of information technology are impacting the financial sector, emerging financial technologies such as blockchain technology are attracting increased attention and growing as fields of research. This study contributed to the research of blockchain technology in the financial sector. The objective of the study was to examine the adoption of blockchain technology in the financial sector by investigating the associated benefits, challenges, and applications. This was studied by applying semi-structured interviews as a method of research. Three professionals in blockchain technology currently employed in the financial sector in Finland were interviewed. The views of the interviewees were analysed by the blockchain acceptance model derived from the TAM to address the blockchain-enabled benefits and challenges. Subsequently, the applications and adoption of blockchain technology were discussed.

This study identified automation, increasing transaction speed, enhancing security, resilience, and cost-efficiency as benefits that influence the perceived usefulness of blockchain technology. Conversely, scalability issues and increasing maintenance costs were found to have a negative impact on it. Additionally, this study found that regulation, legislation, standardisation, and lack of know-how are accessibility challenges that influence the perceived ease of use of blockchain technology. Interoperability, on the other hand, was recognised primarily as an accessibility challenge, yet a beneficial side to it was also identified. Beyond the benefits and challenges, the results of this study indicated that blockchain technology applications that provide solutions for the inefficiencies and long-term issues of the financial sector exists. The most prominent of such applications recognised were digital identity, digital signatures, and smart contracts. It was found that they have the capability to benefit various processes in the financial sector in terms of efficiency, security, and costs, such as KYC processes, sales transactions, and loan applications.

From the financial sector's perspective, blockchain technology is a valuable technology and it holds significant potential. With the adoption of blockchain technology the execution of transactions and contracts, as well as storing and sharing data could be completed more efficiently and securely than currently. However, its widespread adoption remains a problem due to relatively weak foundations and several challenges that function as adoption barriers. Blockchain technology adoption and applications are emerging and still at early stages. Although adoption barriers persist, the development is rapid and overcoming them is achievable. Thus, the future development of blockchain technology and the environment surrounding it will determine the degree of its applicability.

The limitations of this study, as well as the nascent nature of blockchain technology, provide opportunities for further research in the field of blockchain technology adoption as a financial technology. Further research should study blockchain technology adoption in different contexts by focusing on varying environments and financial applications. Different qualitative and quantitative research methods and approaches to the TAM by extending and modifying the framework are valuable to gain more insight on the emerging topic. Furthermore, application-specific research applying the TAM framework is required to determine the influence of perceived usefulness and perceived ease of use on blockchain technology adoption in more detail. Other researchers should emphasise theoretical approaches by applying varying frameworks to establish a more comprehensive theoretical orientation considering blockchain technology adoption.

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Appendices

Appendix 1: Interview frame for semi-structured interviews

Interview frame

1. General

What is your professional background?

How relevant is blockchain technology in your current job? In what way?

2. Benefits and applications of blockchain technology

In what extent have blockchain technology been adopted in the financial sector?

How does/will blockchain technology impact the financial sector?

What are the most significant blockchain-enabled benefits? Why?

What are the most significant applications of blockchain technology in the financial sector? Why?

How do you see the applicability of the different types of blockchains in the financial sector? Why?

3. Challenges of blockchain technology

What are the most significant challenges associated with the adoption of blockchain technology?

What causes these challenges?

4. Readiness of blockchain technology

What is the technological readiness of blockchain technology?

Is blockchain technology mature enough to be adopted? Why?

5. Complementary information

Do you have any complementary information to add to the discussed themes?