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Master Thesis

Subject: Blockchain in Government: An Analysis of Blockchain Implementation Challenges in the Context of European Blockchain Pilots

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Abstract

Blockchain is believed to fundamentally change the way organizations conduct their daily operations. Therefore, the aim of this Thesis is to explore how blockchain is implemented and used in the European public sector and how it influences organizations typically described as slow and inefficient, while thereby, being uninnovative and unprogressive. Here, the focus is set on the challenges that occur, when trying to implement the blockchain technology and build pilots for public sector services. Those challenges will be drawn from literature but more importantly from four European blockchain pilots.

The study of this Thesis is based on six semi-structured expert interviews from four pilots. This method made it possible to get personal insights on the implementation process of the pilots and also learn about specific challenges encountered by the employees in the European public sector.

The results of the study show that blockchain implementation challenges can be found in three main areas, the public sector organization, the blockchain technology and the personal bias towards new technologies.

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List of Abbreviations

AI	Artificial Intelligence
BI	Business Intelligence
BLING	Blockchain in Government
CJIB	Centraal Justitieel Incassobureau
DL	Distributed Ledger
DLT	Distributed Ledger Technology
EBSI	European Blockchain Services Infrastructure
GDPR	General Data Protection Regulation
HPC	High Performance Computing
ICT	Information and Communication Technology
IoT	Internet of Things
SSI	Self-Sovereign Identity

1 Introduction

"Blockchain is to Bitcoin, what the internet is to email. A big electronic system on top of which you can build applications. Currency is just one."

Sally Davies, FT Technology reporter

Blockchain is a technology, which is believed to fundamentally revolutionize and transform our whole economy and society (cf. Rossi et al., 2019, p.1389). It was originally used and is still mostly known for its role in the transfer and mining of the virtual currency Bitcoin (cf. Brühl, 2017, p.135). Experts say that the technology, which is based on a decentralized verification process, already disrupted the traditional business world (cf. Casino, Dasaklis & Patsakisa, 2019, p.55; Nofer et al., 2017, p.183) and will most likely influence the technological innovations of businesses and society in the next years (cf. Beck, Müller-Bloch & King, 2018, p.1020). A blockchain consists of interlinked blocks, storing pieces of data (cf. Casino, Dasaklis & Patsakisa, 2019, p.55), which cannot be altered once they have been verified (cf. Underwood, 2016, p.15). As the different blocks or transactions built on one another, manipulation of content is impossible without other parties recognizing it (cf. Beck, Müller-Bloch & King, 2018, p.1020).

The public sector consists of institutions and organizations, that are owned, controlled or contracted by the government, thereby providing services and goods to citizens (cf. Flynn, 2012, p.2). Experts believe that it is one of the areas, in which blockchain could bring the biggest benefit, which is why an increasing amount of research focusses on blockchain pilot implementation and real-life use cases in that field (cf. e.g., Berryhill, Bourgery & Hanson, 2018; Ølnes, Ubacht & Janssen, 2017). As the public sector often has the reputation of being slow and inefficient (cf. Vigoda-Gadot et al., 2008, p.307; Windrum, 2008, p.3), and the trust of citizens into public sector institutions has gone down, due to a lack of transparency and excessive bureaucracy (cf. Treiblmaier & Sillaber, 2020, p.227), blockchain could be the chance to successfully transform and change the image of the public sector for the better (cf. Frade, 2021). In that context, literature often suggests different benefits for applying and implementing blockchain in the public sector, like increased transparency, higher security and efficiency (cf. Lindman et al., 2020, p.35; Ølnes, Ubacht & Janssen, 2017, pp.359-360). Part of public sector transformation are also European-funded projects (cf. Karakas, 2002, p.3). One of those projects is the Interreg

Blockchain in Government (short BLING) project.[1] In the project, 13 European partners (universities, municipalities and governmental organizations) are investigating what role blockchain can play in governments. Thereby, the different institutions are delivering pilots and technologies for citizens, communities and companies in the North Sea Region (cf. BLING, 2021). With governments starting to adapt blockchain pilots all around the world (cf. Batubara, Ubacht, Janssen, 2018, p.1), pilots and use cases already range from e-voting and identity management to administrative and legal applications (cf. Casino, Dasaklis & Patsakisa, 2019, p.62).

The problem with blockchain implementation research is that benefits can often be generally named (cf. Ølnes, Ubacht & Janssen, 2017, pp.359-360), such as increasing transparency (cf. Berryhill, Bourgery & Hanson, 2019, p.13) or building trust in services (cf. Nofer et al., 2017, p.184) due to the immutability of information stored in the blockchain (cf. Underwood, 2016, p.15). However, challenges, can often not be related to all pilots, as they depend on the specific use case and style of blockchain used, thereby creating different implementation challenges under different circumstances and stages of maturity of the pilot (e.g. Berryhill, Bourgery & Hanson, 2019, p.29). Therefore, this Master Thesis will contribute to the specific field of blockchain implementation challenges in context of European public sector pilots and more specifically look at the challenges arising in the BLING project environment. Thereby, not only the project partners will benefit from the results, as they can learn about challenges other pilots are facing and how specific challenges have successfully been overcome, but also the whole blockchain implementation research environment would. The research question will be defined as follows: *"What challenges do local European administrations face when implementing blockchain in the municipal public sector?"* Thereby, the aim is to identify specific hindering mechanisms, barriers and problems in the project space and organizational environment related to the implementation of blockchain in the European public sector, resulting in such challenges.

In order to reach the aim of identifying the challenges related to the implementation of blockchain in European public sector government, this Master Thesis will start with

[1] This research was supported as part of BLING, an Interreg project supported by the North Sea Programme of the European Regional Development Fund of the European Union.

introducing blockchain and the blockchain technology in more detail (Chapter 2). First, blockchain and how it works will be explained. Second, an overview about the emergence and history of blockchain development will be given. Third, the different types of blockchain will be shortly described. Fourth, common blockchain related benefits and challenges will be elaborated.

After having defined, what blockchain is and what the current research surrounds, Chapter 3 will focus on the public sector government in Europe, clarifying the institutional characteristics of the blockchain implementation. First of all, the basic principles of the public sector, its structure and European common operating method will be explained. Next, the current position of innovation in the European public sector will be elaborated. Last, the different challenges related to the institutional foundation and its connection to barriers for innovation in the public sector will be discussed.

Chapter 4 will then connect the previous topics of blockchain and public sector government, by looking at current applications implemented in the European public sector and evaluation benefits and challenges. To start with, an overview of blockchain application fields in the European public sector will be given. After that, the specific benefits of blockchain for the European public sector, in connection with the common blockchain related benefits, stated in Chapter 2, will be elaborated. Furthermore, the challenges of using and implementing blockchain in the European public sector will be explained. The chapter ends in the development of a thematic framework for the empirical work.

After the connection between blockchain and public sector government is formed, Chapter 5 will focus on the methodology and methods used for investigating the challenges of blockchain implementation in Europe. For that purpose, first, the empirical research approach and the theory building approach will be explained shortly. Next, the data collection method will be elaborated. After that, the conception of the interview questions will be explained. Following, an overview of the sample of interviewees and their pilots will be given. Then, the transcription rules, as part of the data preparation will be stated, before, lastly explaining the method of data analysis, based on the thematic analysis of Braun and Clarke (2006).

Chapter 6 will present the findings of the interviews and give more insights into the implementation challenges of European blockchain pilots. The chapter will be structured based on the themes derived from the empirical data.

Following, in Chapter 7 the results of the findings in relation to the literature review will be discussed, ultimately explaining the blockchain implementation challenges in the European public sector. This will be structured, based on challenge categories derived from the theoretical framework and the interview findings. Therefore, first, challenges relating to the public sector organizational structure and its characteristics will be explained. Second, challenges resulting from blockchain technology characteristics will be discussed. Third, challenges resulting from behaviors or emotions of the targeted user group will be elaborated on.

Based on the results from the interviews and the discussion of the findings, Chapter 8 will draw managerial implications on what could benefit blockchain pilot implementation in European public sector government. Additionally, strategic recommendations will be given on how to implement blockchain pilots, based on the experience of the interviewees and previous research.

Lastly, a conclusion and critical reflection on the Thesis will be drawn in Chapter 9, giving a brief summary of the research, defining and pointing out limitations to the Thesis as well as the research approach and finally, recommending possible and further research approaches.

2 Blockchain Technology

2.1 What is Blockchain?

A blockchain is "a decentralized, transactional database technology that facilitates validated, tamper-resistant transactions" (Beck, Müller-Bloch & King, 2018, p.1020) between participants of the blockchain network (cf. Angelis & da Silva, 2018, p.305). When writing about blockchain, literature also uses names such as distributed ledger (DL) or distributed ledger technology (DLT) to describe the technology (cf. Underwood, 2016, p.15). Ledger translates to a kind of book, containing transaction information, in this case, describing the chain the information is stored on (cf. Paulavičius et al., 2019, p.730). Ultimately, blockchain is a peer-to-peer ledger system, connecting users for doing certain transactions (cf. Meinel & Gayvoronskaya, 2020, p.23).

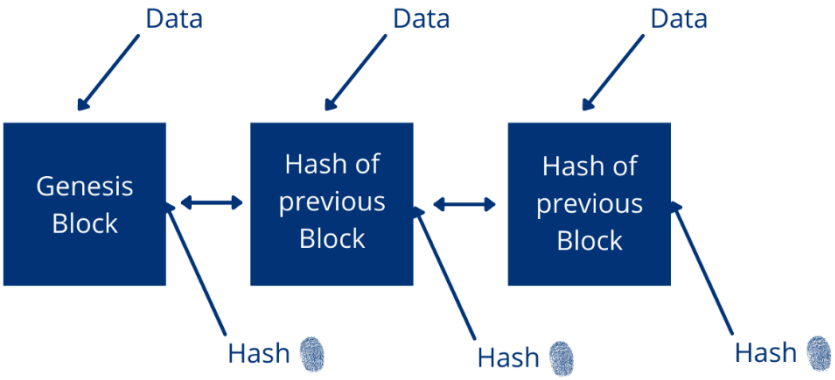

Figure 1: Blockchain and Hash, own illustration

A blockchain consists of interlinked blocks, storing pieces of information. Each block typically contains a cryptographically secure hash of the previous block, a time stamp, which is automatically added, and the transaction data (cf. Casino, Dasaklis & Patsakisa, 2019, p.55). A hash is used to identify information and ensure integrity of the stored information (cf. Paulavičius et al., 2019, p.730). This chain of blocks is stored decentralized, which means that it is not stored on, e.g. one computer but on all the computers or systems included in the blockchain network (cf. Beck, Müller-Bloch & King, 2018, p.1021). These systems or participating computers involved in the blockchain are known as nodes (cf. Odelu, 2019, p.2). Each of the different nodes has a copy of the blockchain, which means that all nodes have a copy of all the transactions made on that blockchain and are synchronized continuously (cf. Meinel & Gayvoronskaya, 2020, p.7).

The decentralized verification process of a blockchain (cf. Casino, Dasaklis & Patsakisa, 2019, p.55; Nofer et al., 2017, p.183) means that transactions can be seen by everyone but, once they are part of a blockchain, cannot be altered (cf. Meinel & Gayvoronskaya, 2020, pp.48-50). This happens after the added information, in form of a block, is verified by a trustable party, also known as the consensus mechanism, as there has to be consensus between the majority of validators (cf. Underwood, 2016, p.15). Consensus mechanisms, such as proof-of-work, which means that one node finds the solution, adds the correct block and then all the other nodes verify the solution, then all adding that correct block (cf. Fill et al., 2020, p.11), or proof-of-stake, where nodes that have a higher stake, have a higher chance to win the lottery to add the next block,[2] work by using economic incentives and should encourage participants (nodes) to participate in the creation and verification of a block, while discouraging them from creating alternative transactions (cf. Beck, Müller-Bloch & King, 2018, p.1021).

As the different blocks or transactions are added one after another (chain), and thereby confirm the correctness of the prior blocks, manipulation of content is impossible without other parties recognizing it (cf. Beck, Müller-Bloch & King, 2018, p.1020), as that would create a junction and thereby a new path (cf. Underwood, 2016, p.15). Such a junction can also occur if the nodes do not agree on what kind of block should be added (cf. Wunderlich & Saive, 2020, p.97). Overall, the special type of decentralized storing and consensus verification has the advantage of making it very hard to edit the blockchain without authorization or even hack the network, as it is not one computer that has to be hacked but the whole system would have to be overcome (cf. Meinel & Gayvoronskaya, 2020, pp.60-61).

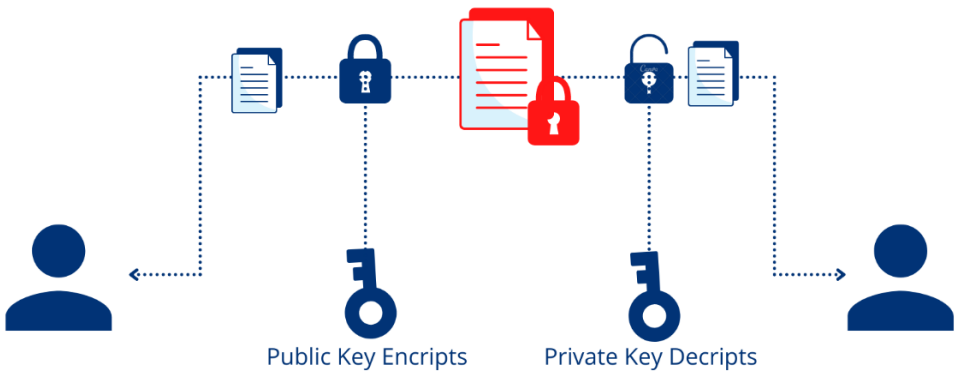

Figure 2: Digital Signature Key-Pair System, own illustration (based on Baloian, 2018)

[2] All nodes have the adding rights, if they win the lottery, even with a minimal stake.

A person can get access to and use a blockchain by getting a digital signature key-pair, also known as public key infrastructure (PKI). Here, a key consists of a private and a public key, creating a personally encrypted key also known as a key-pair. This encrypted key-pair provides every user with a unique identity (cf. Fill et al., 2020, p.9). The public key of a user is used for identification by other users (public keys are anonymized and no other user can get the identity of another through the public key), while it also gives every user the opportunity to take action or authorize transactions, in other words, sign transactions. The private key is a personal key to access, e.g. any currency stored on a blockchain a user owns or to verify transactions made by that user, which should not be shared (cf. Meinel & Gayvoronskaya, 2020, pp.18-19). The key system makes the blockchain anonymous, as the real-world identity cannot be identified without having access to both keys (cf. Fill et al., 2020, p.9). To summarize, it can be said, that a blockchain has three main features, it is stored decentralized, immutable and transparent (cf. Angelis & da Silva, 2018, p.305).

Blockchain is predicted to revolutionize our whole economy and society (cf. Rossi et al., 2019, p.1389), by increasing transparency of transactions and processes (cf. Berryhill, Bourgery & Hanson, 2018, p.13) while also making them more secure (cf. Nofer et al., 2017, p.184). Even though blockchain is still in the beginning of developing its full potential, applications, increasing efficiency in all kinds of processes, are introduced more often (cf. Akram, 2017, p.642). Thereby, decentralized applications are starting to challenge the centralized approaches in all parts of society (cf. Beck, Müller-Bloch & King, 2018, p.1020; Aristidou & Marcou, 2019, pp.293-294).

2.2 Development Stages of Blockchain

Blockchain has been an active part of the economy for around ten years (cf. Underwood, 2016, p.15). During that time, research suggests that at least three generations of blockchain development have surpassed us (cf. Angelis & da Silva, 2018, p.305), creating three main types of usage for the networks – transactions, smart contracts and applications (see Figure 3).

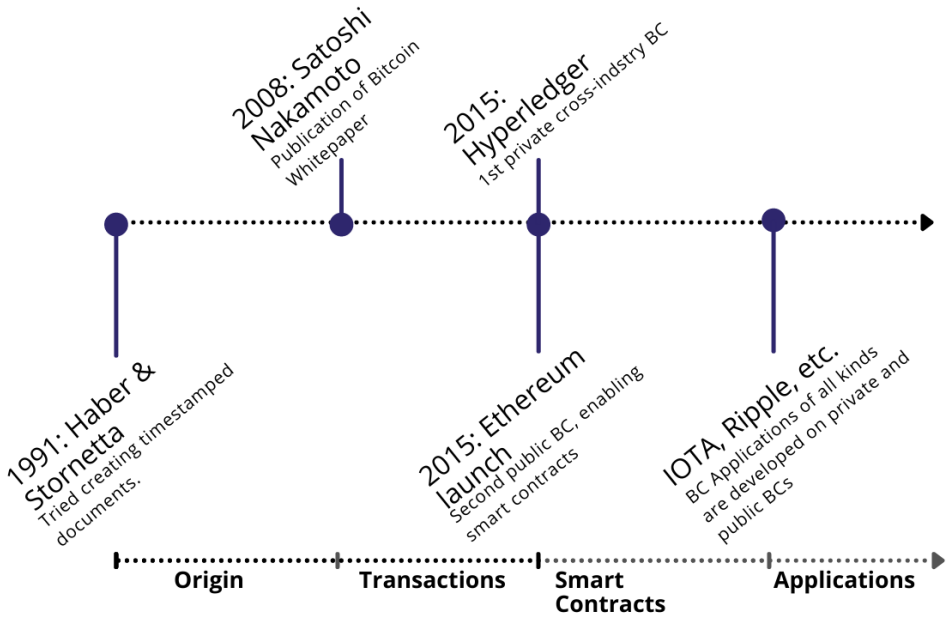

Figure 3: Blockchain Development Stages, own illustration

In 1991, Stuart Haber and W. Scott Stornetta tried to create a way that timestamps on a document could not be altered, through putting them on a cryptographically secured chain of blocks, being the first to successfully experiment with blockchain (cf. Haber & Stornetta, 1991). Even though other researchers experimented with blockchain after Haber and Stornetta, the real start of blockchain and the gain of importance for the economic world happened, when Satoshi Nakamoto (it is not known if this is a person or a group) (cf. Meinel & Gayvoronskaya, 2020, p.5) began working on the first application of the DLT in form of the peer-to-peer cryptocurrency known as Bitcoin (cf. Nakamoto, 2008). In 2009, the first version of Satoshi Nakamotos Bitcoin Software was published, officially starting the first stage of the blockchain development and related applications (cf. Meinel & Gayvoronskaya, 2020, p.5). Today, blockchain is still mostly known for its role in Bitcoin, however, it can provide far more than cryptocurrency (cf. Brühl, 2017, p.135).

The next stage of blockchain development was the start of the applications in form of smart contracts (cf. Angelis & da Silva, 2018, p.305) and the introduction of different new blockchain networks (cf. Odelu, 2019, p.2). While the blockchain containing Bitcoin was and still is limited to recording transactions around the cryptocurrency (cf. Brühl, 2017, p.135), the Ethereum chain was a public platform for developing other decentralized applications (cf. Bareis, di Angelo & Salzer, 2020, p.13). Ethereum was officially launched around 2015 as a beta version (cf. Wilcke, 2016). It introduced the second generation of blockchain

development by enabling smart contracts, representing self- executing scripts stored on the blockchain (cf. Beck, Müller-Bloch & King, 2018, p.1021). This means that the contracts were automatically processed once the set contract criteria stored on the blockchain are met (cf. Fill et al., 2020, pp.12-13). The thereby created smart contracts gave users the possibilities to create transactions, in which certain conditions had to be met and verified by all participating members, in order for it to be processed (cf. Angelis & da Silva, 2018, p.306).

However, smart contracts are not the only application running on the Ethereum blockchain, many other decentralized applications were started on that chain (cf. Marr, 2018). With the launch of Ethereum, blockchain developers realized that the possibilities of blockchain were bigger than just cryptocurrency or contracts, creating the possibility of decentralization of more markets than just the financial (cf. Beck, Müller-Bloch & King, 2018, p.1022). In the same year, the private blockchain platform Hyperledger was introduced (cf. Munoz et al., 2019, p.38). It acted as a collaborative development of DL and focused on cross-industry collaboration to further develop blockchain, as well as improving the reliability of blockchain use in business transactions (cf. Casino, Dasaklis & Patsakisa, 2019, p.57).

The third generation of the blockchain development ultimately offered more flexibility in terms of changing platforms for blockchain applications. One network is the IOTA technology. Here, developers wanted to find a way to use blockchain to further develop the Internet of Things (IoT), creating IOTA, which is an open-source DL and cryptocurrency. IOTA does not require transaction fees and offers a unique verification process (cf. Martínez, Torres & Frías, 2019, pp.110-111). The Ripple technology (open-source digital currency network) then offers a way to even perform transactions between different blockchain platforms (cf. Goncalo, Pedrosa & Lopes 2020, p.74). These are just some of the many applications developed during this blockchain generation. Additionally, in the last years, increasing research focused on the connection and implementation of Artificial Intelligence (AI) into blockchain and potential benefits that could be created (cf. Angelis & da Silva, 2018, p.306).

2.3 Different Types of Blockchain

After having stated how a blockchain generally works and how the technology developed over the years, it is important to take a closer look at the different types of blockchain and their characteristics. At the moment, blockchain can be divided between three types, public, private and federated or consortium blockchain (cf. Casino, Dasaklis & Patsakisa, 2019, p.57).

Public blockchain networks are open for all and thereby, the most used and known blockchains belong to this type. This means that everyone can participate in the actions regarding that blockchain, and all transactions are valid for all users (cf. Underwood, 2016, p.15). Blockchain networks such as Bitcoin and Ethereum are built as public blockchain (cf. Casino, Dasaklis & Patsakisa, 2019, p.57). In public blockchains, there is no need to get any kind of permission to enter, as joining requires no special validation either (cf. Honnavalli et al., 2020, p.32), some exceptions exist. In those cases, only authorized nodes can validate transactions and add them to the chain (cf. Beck, Müller-Bloch & King, 2018, p.1022). Additionally, anyone can copy and use the code of the blockchain to run a public node on their personal device (cf. Meinel & Gayvoronskaya, 2020, p.6), while everyone in the blockchain network can see and read what is being worked on and can themselves participate in the creation of new blocks / transactions (cf. Brühl, 2017, p.140).

Private blockchain networks could be described as the opposite of public blockchain networks. Instead of being open and editable by everyone, private blockchains have one owner, who has to give permission to join the blockchain or a transaction (cf. Beck, Müller-Bloch & King, 2018, p.1022) using proof-of-authority (cf. Berryhill, Bourgery & Hanson, 2018, p.32). This gives the owner full flexibility in developing the blockchain (cf. Honnavalli et al., 2020, p.32). However, transactions and multi-user participation is not the primary purpose of a private blockchain, as they are mostly used for auditing and database managing purposes inside a company (cf. Brühl, 2017, p.140). If necessary, individual companies or employees can get access to the blockchain and the transactions through permission, which mostly happens in auditing processes (cf. Meinel & Gayvoronskaya, 2020, p.57). As a private blockchain is a centralized system, the transaction cost is lower, the inheritance systems can be edited and handling documents is simpler in private blockchain networks (cf. Honnavalli et al., 2020, p.32).

Consortium blockchain networks (cf. Underwood, 2016, p.16), also known as federated blockchain networks, are slightly similar to private blockchain networks (cf. Casino, Dasaklis & Patsakisa, 2019, p.57). However, instead of one owner, federate blockchain are managed by an organizational group of leaders, which again have to give permissions to join the blockchain or a transaction (cf. Meinel & Gayvoronskaya, 2020, p.57). Here, again, people either do not get unlimited access to the chain and the verification processes, or even the right to read and see the information in the blocks is limited (cf. Casino, Dasaklis & Patsakisa, 2019, p.57). This means that the transactions made in those kinds of blockchain are handled with increased privacy (cf. Meinel & Gayvoronskaya, 2020, pp.57-58), as the consensus protocol is not open for all users, just to the leaders of the blockchain, which also makes the process of creating new blocks faster (cf. Casino, Dasaklis & Patsakisa, 2019, p.57).

2.4 Blockchain Benefits and Challenges

Blockchain applications can already be found in all kinds of different fields, such as finance, transport (incl. travel, mobility & supply chain), healthcare, education, agriculture, energy and public sector (cf. Casino, Dasaklis & Patsakisa, 2019, p.62). However, those blockchain often offer similar benefits by utilizing applications in these fields (cf. Angelis & da Silva, 2018, p.305). Blockchain is already used in various areas of our daily life and will probably influence the further digital transformation (cf. Grover, Kumar Kar & Janssen, 2019, p.751). After having differentiated between the different types of blockchain networks and having in mind the variety of fields blockchain is already used in, this chapter will elucidate on the benefits and challenges related to blockchain.

Benefits of blockchain are generally related to higher transparency, higher security, decentralization, immutability (cf. Angelis & da Silva, 2018, p.305) and lower transaction costs (especially in context of private blockchains) (cf. Casino, Dasaklis & Patsakisa, 2019, p.68). Transparency is created by the open access of especially public blockchains (cf. Angelis & da Silva, 2018, p.305). Here, everyone is able to see the transactions that are being made on the blockchain (cf. Underwood, 2016, p.16). However, even though the transaction itself is visible for everyone, the identity of the nodes taking part in the transaction are encrypted due to the key (cf. Rama, 221, p.11). This reduces uncertainty,

especially in supply chains, as the information is accessible publicly (cf. Beck, Müller-Bloch & King, 2018, p.1021).

Higher security can be created due to the decentralization as well as encryption (cf. Angelis & da Silva, 2018, p.305). As the blockchain is stored on all the nodes systems / computers, it is hard to hack the system (cf. Meinel & Gayvoronskaya, 2020, pp.60-61). Additionally, higher security can be provided due to the validation and authorization process a blockchain has for every transaction (cf. Rama, 221, p.11). When the creation and validation of the blocks is not done properly, a new path or chain would be created (cf. Underwood, 2016, p.15). The same would happen, if someone would try to alter the blockchain, the history simply cannot be changed (cf. Underwood, 2016, p.16). Therefore, the blockchain is immutable (cf. Angelis & da Silva, 2018, p.305). Furthermore, as a blockchain does not need any intermediaries, the data security is increased and no third party is able to collect any personal data (cf. Nofer et al., 2017, p.184). Lastly, the decentralized blockchain can be more cost-efficient than traditional centralized systems, as no data has to be stored in one place and thereby, the server costs are lower. Moreover, the transaction costs on the blockchain are lower (cf. Casino, Dasaklis & Patsakisa, 2019, p.68)

Common challenges connected to blockchain are technical or development challenges and therefore, limitations the technology still has to overcome (cf. Yli-Huumo et al., 2016, pp.3-4). Those challenges can be identified in three main areas. First, security, especially in relation to proof-of-stake consensus mechanisms,[3] is an issue, when it is possible for one party to get hold of 51% of the stake in the chain and thereby, has control over the verification processes (cf. Rama, 2021, p.11). Second, the huge amount of resources a blockchain consumes, as the more miners in a blockchain are doing, the more computing power is necessary, which again requires more energy (cf. Rossi et al., 2019, p.1396). Here, especially Bitcoin has fostered controversy, as the mining process is very energy intensive (cf. Paulavičius et al., 2019, p.740). Third, a low useability, in terms of user friendliness and level of simplicity is still an adaptation challenge (cf. Yli-Huumo et al., 2016, pp.3-4, 13). Additionally, concerns about privacy are a challenge in the blockchain implementation

[3] Depending on the type of consensus mechanism, security can be considered a benefit or a challenge. Especially in the above-mentioned proof-of-stake consensus, a risk of someone owning 51% of all stakes and therefore, leading the blockchain does exist. It can also occur in centralized blockchains relying on proof-of-work mechanisms.

field, as the trust in the anonymity and security of data is not that high in the society, yet (cf. Paulavičius et al., 2019, p.741). People fear the transparency a blockchain provides and do not trust or understand the anonymity or pseudonymity given by the key encryption of blockchains (cf. Rossi et al., 2019, p.1395). Lastly, regulating blockchain is still a challenge for governments, as the technology evolves too quickly, that regulations often do not develop with the new possibilities (cf. Paulavičius et al., 2019, p.742).[4]

Blockchain is often linked to lower transaction costs[5] (cf. Casino, Dasaklis & Patsakisa, 2019, p.68), higher security (cf. Angelis & da Silva, 2018, p.305) and many other potential benefits for an organization (cf. Akram, 2017, pp.642-643). However, this chapter has also taken a brief look at challenges related to using blockchain, e.g. gaining trust of users to actually adapt blockchain (cf. Yli-Huumo et al., 2016, pp.17-18). Those challenges can make it harder for all types of organizations to successfully adapt blockchain applications for their day-to-day operations (cf. ibid., 2016, p.4). As blockchain is still in its early years of real development and adaptation, the technology but also society will continue to evolve and the willingness of adaptation might increase (cf. Casino, Dasaklis & Patsakisa, 2019, p.71). Further, the more research on blockchain is being conducted the more possibilities arise (cf. Angelis & da Silva, 2018, p.305). Now that the blockchain technology, its functionality and types, as well as the benefits and challenges of using it have been discussed, Chapter 3 will take a closer look at the implementation field – the European public sector.

[4] As this is not a legal thesis, there will not be an in-depth elaboration on the legal standards and regulations regarding blockchain.

[5] For including the lower transaction costs as a benefit, the development costs have to be excluded, as the development of a blockchain can be cost intensive.

3 Public Sector in Europe

3.1 Institutional Foundation of the European Public Sector

Every country has their own approach towards what the public sector defines and what functions it has in their respective countries (cf. Evers & Laville, 2004, p.11), which is why a fixed and general definition of public sector and its functions does not exist, yet (cf. Osborne, 2008, p.5). However, countries that are a member in the EU share many characteristics within their public sectors and the related operations (cf. Flynn, 1995, p.59). Therefore, this chapter will elaborate on the generally accepted characteristics of the public sector and focus on the European approach in instrumentalizing it.

The public sector "comprises a system of public institutions that affect peoples' everyday lives" (Windrum, 2008, p.5). Thereby, it consists of institutions, organizations, and companies operated, managed or controlled by the government (cf. Flynn, 2012, p.2). It can be divided into the different levels, federal, regional (state / province) and local (municipality / county) (cf. Flynn, 1995, p.63). Due to globalization, it was proposed to add another level for governments to act, the international level. It describes the interaction and working together between different federal public sector organizations and thereby, governments and applying that on their local levels (cf. Macdonald, 2017, p.9). One of the main tasks of public sector institutions is to carry out governmental policies in their respected areas, providing regulations and offer services for its citizens (cf. Flynn & Asquer, 2017, p.44). Thereby, it bridges the gap between state/government and market (cf. Jenei & Kuti, 2008, p.12).

Additionally, public sector institutions can be differentiated between public enterprises and (general) administration, providing public goods / services (cf. Handler et al., 2006, p.400). Public enterprises are self-financed but government owned, commercially operating organizations, providing different private goods or services (cf. Pitzer & Dupuis, 2006, pp.7-8). They can make decisions autonomously but have to reach certain goals and criteria set by the government (cf. Pollitt, van Thiel & Homburg, 2007, p.3). Institutions and organizations belonging to the administration provide goods and services the whole society can equally use or benefit from, without relation to how much they pay in form of e.g. taxes or fees (cf. Flynn & Asquer, 2017, p.5; Rosenbloom, Kravchuk & Clerkin, 2015, p.199). Thereby, the public sector in Europe is a huge part in the local welfare system (cf. Evers &

Laville, 2004, p.14). Those institutions, like the education facilities or law enforcement but also national infrastructure institutions, are subsidized by the government (or higher-level institutions, like EU funds) (cf. Pitzer & Dupuis, 2006, pp.3-4). Overall, the public sector is a large sector within a country's economy (cf. Windrum, 2008, pp.5-6) and is supposed to assist citizens and improve their lives (cf. Flynn & Asquer, 2017, p.46).

Most European governments and public sector administrations are structured in a very centralized and hierarchical way (cf. European Commission, 2017a, p.10). It can be observed that many approaches and instruments within those institutions are similar (cf. Flynn, 1995, p.60). Here, three common measures and intentions can be highlighted. First, all EU members try to increase their outputs and efforts for working towards the joint goals in the most cost efficient way (cf. European Commission, 2017b, p.1). Second, the focus is on humans / citizens as the most important resource in reaching those goals (cf. European Commission, 2020, p.51). Third, the implementation of innovation needs to be planned and a scheme has to be followed, guiding through the changes (cf. Aristou and Marcou, 2019, p.303). This often happens through EU driven public sector reforms (cf. Ongaro & Kickert, 2019, pp.2, 7-8). Overall, there might be different paces and strategies of countries working towards the European goals (cf. European Commission, 2017, p.1), depending on their diversity in economic, social and cultural contexts (cf. Jenei & Kuti, 2008, p.24) but the feeling unity and working together to reach goals in a more effective and efficient way stands (cf. Flynn, 1995, p.60).

3.2 Innovation, Digital Transformation and E-Government in the European Public Sector

Especially in the last few years, no organization was able to avoid the discussion about digitalization[6] and implementing more technological innovation into their core operations in order to transform itself (cf. Schwab, 2016, p.14). To get an overview of the innovativeness of the public sector in the EU, this chapter will take a closer look at public

[6] Digitalization can be described as "the process of introducing digital technologies" into processes and operations, thereby, transforming society towards more digital approaches (cf. Riedl et al., 2017, p.475), or, in terms of technology, the translation of analog processes and actions of the real world into a language that machines can understand and connect with (cf. Rürup and Jung, 2017, p.5).

sector innovation, drivers and barriers for innovation, the digital transformation[7] towards e-government as well as emerging technologies influencing the changes.

Innovation, especially public sector innovation, is a key contributor to national growth, as well as to the welfare of individual citizens (cf. Windrum, 2008, p.3). Public sector innovation was defined by the European Commission, "as the process of generating new ideas, and implementing them to create value for society". Thereby, creating "new or improved processes and services" (cf. Karakas, 2020, p.3). The EU has recognized the need for innovation and its own role in achieving it. Therefore, the EU wants the public sector institutions to play a big part in the transformation, as those are responsible for setting the right incentives for all kinds of innovative mindsets and create the necessary regulations for innovation to be possible (cf. European Commission, 2017, p.1). Additionally, an increasing amount of funds for technological tools or applications, as well as Intereuropean communication and knowledge exchange between member states is being encouraged (cf. OECD, 2019). Nowadays, governments are increasingly open to collaboration with citizens and businesses in their projects, which allows co-production in the innovation field (cf. Steen, Brandsen & Verschuere, 2019, p.66). Public sector innovation can mostly be found in areas such as processes, products or goods, organization and communication (cf. Karakas, 2020, p.2).

One of the most prominent public sector innovation approaches, especially in regard to digitalization, is e-government (cf. Flynn, 2012, p.144), which started around 2000 (cf. Barcevičius et al., 2019, p.10) and is realized through the EU e-government action plan (cf. European Commission, 2017b, p.6). E-government aims to create easier ways for citizens, businesses and government agencies to facilitate public service related transactions and interactions (cf. Barcevičius et al., 2019, p.10; Flynn, 2012, p.144). E-government can be used in many different areas, such as tax collection, passport or ID-card application, service appointment management etc. (cf. Flynn, 2012, p.144). So far, the research on e-government can be divided into four phases, e-government, open government or e-governance, smart government and transformed government. With the later meaning the approach of a cooperation between citizen and public sector in order to quickly adapt to

[7] Digital transformation focusses on the effects and outcomes of digitalization on an institution or organization, changing its core processes (cf. Mergel, Edelmann & Haug, 2019, p. 12).

citizens and other stakeholders' needs and expectations while creating easy to access, personalized and interactive transactions and relations (cf. Barcevičius et al., 2019, pp.10-11). Even though there have been many projects and pilots in the e-government field and the adaptation is rising (cf. European Commission, 2020, p.75), the EU-wide uptake of e-government is still not accepted universally, as the efforts are lacking efficiency and some member countries are a lot further in their implementation than others (cf. European Commission, 2020, p.76). This can be explained by several reasons, such as legal questions of e.g. technology ownership, missing pilot implementation skills, missing citizen attention or lack of approach and service fit (cf. Flynn, 2012, p.147).

Even though the EU actively pushes and encourages innovation in and through the public sector (cf. Karakas, 2020, p.2), there are different drivers and barriers for it. Drivers include political and social, economic as well as technological factors (cf. Barcevičius et al., 2019, pp.54-56). Political and social factors are highly influenced by the environment of the public sector and the pace society adapts technological changes (cf. Barcevičius et al., 2019, pp.54-55). Here, the pressure, created by the private sector and the demand of citizens could lead to more public sector innovation (cf. Daly & Singham, 2012). Economic factors refer to the intrinsic motivation of public sector organizations to become more efficient and effective in their daily operations (cf. Janowski, 2015, p.13). Technological factors in the drive for innovation can partly be related to the hype about new technologies. Just as private sector companies, public sector organizations try to facilitate new technologies and their advantages for their services, hoping that they will play a mayor role in the transformation (cf. Bannister & Conolly, 2012, p.212; Barcevičius et al., 2019, p.56). Barriers for innovation can be categorized in technological, organizational, legal, ethical, social / cultural, as well as economic / financial (cf. Barcevičius et al., 2019, pp.56-63), which will be discussed further in the next chapter. Interesting here is critic from researchers, that the government's approach to public sector changes mostly focusses on policy changes or reforms rather than addressing real innovation (cf. Windrum, 2008, p.3).

There are many emerging technologies, gaining influence in the transformation of the public sector. In the last years, the most important innovative technologies were AI, the IoT and blockchain (cf. Barcevičius et al., 2019, pp.21-28). Public sector organizations frequently play a role in the development of new technologies, as they are suppliers of

complementary services and infrastructures that are needed for the effective use of private sector goods and services (cf. Windrum, 2008, p.6).

Finally, innovation in the public sector is a key contributor to overall national growth, and to the welfare of individual citizens, which is why the current aim for transformation and innovation in that sector is so important (cf. Windrum, 2008, p.3). In addition, literature suggests, that implementation of innovation and public sector reform are highly connected, as the latter is only possible through the instrumentalization of the prior (cf. Maroto & Rubalcaba, 2008, p.60).

3.3 Public Sector Challenges and Innovation Barriers

There is a lot of criticism surrounding public sector institutions, which leads to the creation of stereotypes such as them being unproductive or technologically outdated (cf. Windrum, 2008, p.3). Theses stereotypes have led to different problems for the public sector, adding to the already existing institutional challenges and all restricting the innovativeness of such organizations (cf. European Commission, 2017b, pp.1-2). The internal challenges[8] of the public sector, which this Thesis focusses on, can be divided into three categories, low trust and confidence, low employer attractiveness (cf. European Commission, 2017b, pp.1-2) and structural challenges, like outdated technological systems (cf. Vigoda-Gadot et al., 2008, p.307). Therefore, this chapter will explain the different challenges related to the institutional foundation and connect those to barriers for innovation.

The trust and confidence of citizens in government is often low (cf. European Commission, 2017b, pp.1-2). As citizen expectations towards the public sector institutions rise (cf. Aristidou & Marcou, 2019, p.292), they pay more and more attention to governmental actions and policies. Thereby, identifying inconsistencies between demands of civil society and policies, carried out by public sector institutions (cf. Maroto & Rubalcaba, 2008, p.51; Afonso, Schuknecht & Tanzi, 2010, p.2148).[9] This leads to citizens' decline of confidence (cf. Maroto & Rubalcaba, 2008, p.58) and trust in the public sector (cf. Aristidou & Marcou, 2019, p.292). In addition, the overall societal pressure of transparency has already led many

[8] Next to the issues and challenges discussed in this chapter, the public sector is challenged by many external developments, such as climate change, aging society, migration (cf. Steen, Brandsen & Verschuere, 2019, p.64) and especially the Covid-19 pandemic (cf. e.g. Fernandez, 2020).

[9] This has also been recognized by the EU resulting in their statement about reform fatigue in some countries (cf. European Commission, 2017b, p.2)

private sector companies to practice in a more transparent way. This demand is also directed towards the public sector (cf. Afonso, Schuknecht & Tanzi, 2010, p.2147). Therefore, recent initiatives of the EU to increase trust, focus on fostering more transparency in the public sector. Here, open data and the re-useability of government information by citizens should help (cf. European Commission, 2017b, p.7). In addition, different technological tools are being tested to create higher temper resistance on digital documents, as the digital transformation of governments poses another challenge for the trust of citizens. The main challenge is to find a way to make the everyday online interactions safe and trustworthy, for all parties involved and thereby, increase the trust (cf. Frade, 2021). A 2017 study found that the more transparent a country's public sector is, the more trust citizens had in its actions and policies (cf. European Commission, 2017b, p.4)

Furthermore, the perceived attractiveness of the public sector as an employer is rather low (cf. European Commission, 2017b, pp.1-2). Many employees in the public sector are aging out of the working age and cross over into retirement, which leaves a gap that has to be filled (cf. European Commission, 2017b, p.3). However, many young people do not see the public sector as an attractive field to work in or start their career in, often due to the negative stereotypes and the fear of being stuck, if private sector employers do not want to employ people from the public sector (cf. Bedürftig, Hieronmius & Klier, 2015). Additionally, the strictly vertical way of decision making in the public sector and limited freedom of choice on lower levels can prevent young people from working there (cf. Arundel, Casali & Hollanders, 2015, p.1272). Overall, this leads to the problem of missing out and scaring off talented employees, who could (with their skills and mindset) work towards the transformation of the public sector and foster innovation (cf. Barcevičius et al., 2019, p.19, 60).

The structural challenges originate in the institutional foundation of the public sector. Most European governments and public sector administrations are structured in a very centralized and hierarchical way (cf. Yli-Huumo et al., 2016, p.1). Thereby, decisions always have to be run by and approved by an employee of a higher position than the stage the decision is prepared, researched and elaborated on (cf. Vigoda-Gadot et al., 2008, p.307). Moreover, innovation is often fostered through a traditional top-down approach with low

level employees just having very little influence on the process (cf. Arundel, Casali & Hollanders, 2015, p.1272). Some literature even suggests that successful innovation is self-defeated in those classical bureaucratic models (cf. Vigoda-Gadot et al., 2008, p.307).

Innovation Barrier Factors	Main Problems	Explanation
Technological	IT infrastructures, interoperability, access to data, data storage	- Public sector IT infrastructure is outdated (cf. Barcevičius et al., 2019, p.57) - The different IT systems used by the public sector are often restricted within their own networks (cf. Bannister & Connolly, 2012, p.212) - Governments are just starting to open up data accessibility (cf. European Commission, 2017b, p.7)
Organizational	Digital strategy, workforce skills, data sharing, alignment of agencies	- Top-down approach not open for multi-level participation (cf. Arundel, Casali & Hollanders, 2015, p.1272) - Professional and management resistance to change (cf. Vigoda-Gadot et al., 2008, p.307)
Legal	New legal and regulatory frameworks, privacy, cybersecurity	- Regulatory requirements can limit innovation opportunities (cf. Vigoda-Gadot et al., 2008, p.307) - GDPR regulations interfering with technological innovation (cf. Barcevičius et al., 2019, p.61)
Ethical	Citizens' trust, accountability of new technologies, human rights	- Citizens and external organizations increasingly observe the policies and actions taken by the public sector and are not happy about it, which just fastens the decline in trust (cf. Maroto & Rubalcaba, 2008, p.51; Afonso, Schuknecht & Tanzi, 2010, p.2148) - Fear of new technologies being connected to illegal activities (cf. Barcevičius et al., 2019, p.62)
Social / Cultural	Citizens' adoption, conservative habits and cultural barriers	- Innovativeness and efficiency of reforms is highly dependent on the cultural environment and the society (cf. European Commission, 2020, p.75; European Commission, 2017, p.1) - Citizens are often hesitant to adapt new technologies (cf. Al-Hujran, 2015, p.190)
Economic / Financial	Lack of financial resources to implement and scale innovations	- Pressure to save costs create financial barriers (cf. Steen, Brandsen & Verschuere, 2019, p.64)

Table 1: Innovation Barriers in the EU Public Sector, own illustration (based on Barcevičius et al., 2019, pp.56-63)

As the chapter pointed out, there are different barriers for public sector innovation (see Table 1). Previous reforms were not perceived as efficient by the citizens (cf. Maroto & Rubalcaba, 2008, p.51). Additionally, the citizen as a customer gets more sophisticated resulting in higher expectations towards public sector services, especially in regard to technology and efficiency (cf. Aristidou & Marcou, 2019, pp.292-293). Therefore, the pressure to improve and becoming more productive is put on the public sector (cf. Handler et al., 2006, p.416). Chapter 3 has explained the public sector as the framework for (technological) innovation. The next chapter will now focus on the implementation of the blockchain technology in the public sector.

4 Blockchain in the Public Sector

4.1 Blockchain Applications and Pilots in the European Public Sector

Blockchain applications can already be found in all kinds of different sectors, such as finance, transport, healthcare, education, agriculture, energy and government (cf. Casino, Dasaklis & Patsakisa, 2019, p.62). In the government, blockchain is already being implemented or tested in many fields. This chapter will provide an overview of blockchain use cases in the European public sector and government, elaborating in more detail on the most common use case fields (see Figure 4).

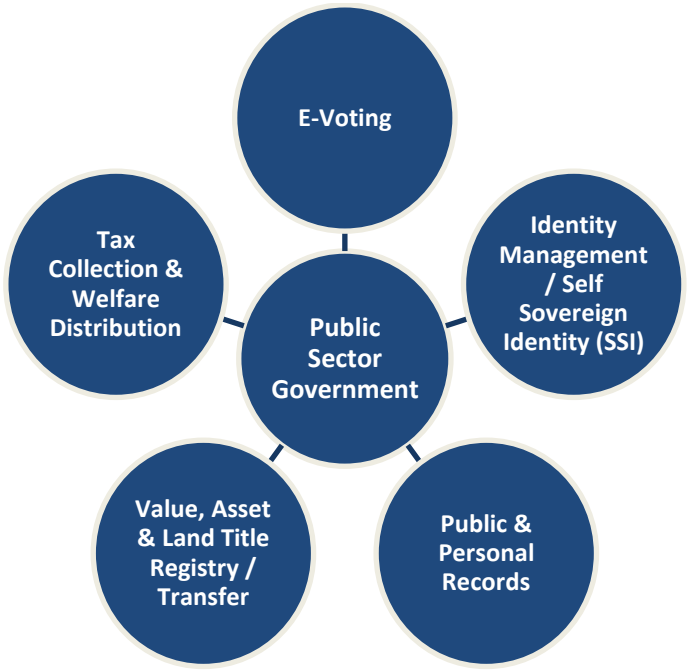

Figure 4: Public Sector Blockchain Application Fields, own illustration (based on Casino, Dasaklis & Patsakisa, 2019; CBInsights, 2021)

It is important to have in mind that applications of blockchain in the European public sector are not in a mature stage, yet and thereby are mostly not being used by a wide mass of citizens (see Lindman et al., 2020). Most of the European blockchain applications are still in a piloting stage[10] (cf. Lindman et al., 2020, p.27), which means that they are tested in different environments and application fields (cf. Schwabe and Krcmar 2000, p. 2). In the context of public sector, the most prominent applications can be found in use cases for e-

[10] Before ultimately implementing blockchain in any kind of organization or business, the technology and its application is tested in so called pilot or feasibility studies (cf. Glass, 1997). There, the application and idea are tested, the value is proven, potential bugs are identified, the user fit is determined and it is identified, if all necessary logistical adaptations for implementation are given (cf. ibid., pp.85-866). The implementation of a pilot normally happens in three stages, the planning, experimenting and implementation (cf. ibid., p.90). Over the last years, this method has been used in many public sector innovation approaches. Here, policy changes or new technologies will be tested in a confined environment, evaluated and eventually implemented for all citizens to use (cf. Steen, Brandsen & Verschuere, 2019, pp.2-364-65).

voting, digital identity management (cf. Ølnes, Ubacht & Janssen, 2017, p.357), storage and transfer of public and personal records (cf. Casino, Dasaklis & Patsakisa, 2019, p.63), value, as well as asset and land title registry (cf. Berryhill, Bourgery & Hanson, 2018, p.26) and tax collection/welfare distribution (cf. Aristidou & Marcou, 2019, p.302). Other areas include applications for tracking of goods or supply chain management (cf. Berryhill, Bourgery & Hanson, 2018, p.26), e-services (cf. Casino, Dasaklis & Patsakisa, 2019, p.64), energy management, financial services and banking, as well as contract and vendor management (cf. Berryhill, Bourgery & Hanson, 2018, pp.25-27). The focus on this chapter will be set on the five most common use cases in the EU (see Figure 4).

The first often but also complicated piloted use case field for blockchain in the European public sector is e-voting. Thereby, the often still paper-based voting processes, or even electronic voting systems with limited validation and auditability capabilities can be transformed (cf. Berryhill, Bourgery & Hanson, 2018, p.27) into voting systems, providing transparency during the process of voting, calculating votes automatically but also in maintaining and storing the voting records safely (cf. Rot, 2020, p.115). Additionally, the blockchain ensures that voters only vote once (cf. Navadkar, Nighot & Wantmure, 2018, p.2288). The first European country to use blockchain based e-voting was Denmark, in an internal voting by the Danish political party (cf. Dotson, 2014). The EU itself is not currently working on any pilots regarding blockchain based e-voting, however, they have recognized the potential benefits it could bring (cf. Boucher, 2016, p.2).

Identity management or SSI is another use case field, which is tested in many European public sector pilots. Blockchain could be used to design systems for personal identification, digital signatures and access authorization (cf. Rot, 2020, p.115) for citizens but also residents, businesses or other government stakeholders (cf. Berryhill, Bourgery & Hanson, 2018, p.25). Thereby, also helping its citizens to access public sector services more easily or preparing their data for faster processing (cf. Aristidou & Marcou, 2019, p.302), which in return would make the services more approachable and lower barriers for technology users (cf. Berryhill, Bourgery & Hanson, 2018, p.25). The use and process of digital identity management has to be made accessible for all citizens in an appropriate way (cf. Navadkar, Nighot & Wantmure, 2018, p.2289). For example, the European Blockchain Services

Infrastructure (EBSI) is currently working on a SSI model for all European citizens (cf. European Commission, 2021).

The next field of use cases for blockchain in the European public sector is highly connected to the digital identity but focusses more on the storage and sharing of public and personal records (cf. Berryhill, Bourgery & Hanson, 2018, p.25). With the help of blockchain and the digital identity, different certificates and registrations, e.g. for marriage, births or other legal documents (cf. Casino, Dasaklis & Patsakisa, 2019, p.63), could be stored on the blockchain and transferred to all kinds of public sector institutions for various services (cf. Aristidou & Marcou, 2019, p.302). By enabling and securing the transfer of documents between governmental agencies, blockchain could reduce paper-transfer and storing resources for all parties involved (cf. Rot et al., 2020, p.117). Another possibility of storing documents, would be the opportunity to store health records of citizens on the blockchain. However, in this use case, questions about privacy, confidentiality and authority have to be taken into consideration (cf. Berryhill, Bourgery & Hanson, 2018, p.25). The EBSI is again working on the EU wide opportunity to share data in a secure way between trusted parties (cf. European Commission, 2021).

Blockchain use cases in the European public sector also often evolve around the management of taxes, including refunds (cf. Rot, 2020, p.115) and distribution of welfare in the form of benefits, entitlements, or aid (cf. Berryhill, Bourgery & Hanson, 2018, p.26). The technology could help to make payments between governments and citizens more transparent and enable an efficient distribution of benefits towards selected groups (cf. Aristidou & Marcou, 2019, p.302). Moreover, automating processes of application, verification and disbursement, could be achieved by using smart contracts, thereby also ensuring that no funds are redirected towards ineligible parties (cf. Berryhill, Bourgery & Hanson, 2018, p.26). For example, in the Netherlands, a pension administration pilot runs on the blockchain, making the system more flexible and transparent, while reducing the costs for managing the funds (cf. Allessie, Vaccari & Sobolewski, 2019, p.38).

Relying on the principle of smart contracts is the last of the most piloted blockchain use cases in the European public sector, the value, asset or land title registry and transfer. The transfer of property was the original application for smart contracts, therefore, land title registry and transfer of any kind of asset seems like a natural fit for blockchain (cf. Berryhill,

Bourgery & Hanson, 2018, p.26; Ølnes, Ubacht & Janssen, 2017, p.357). The blockchain stores all transactions related to a certain piece of value or property, making it easy to follow the ownership history (cf. Ølnes & Jansen, 2018, p.7). This history would be immutable, due to the blockchain nature, thereby reducing extensive research or the involvement of third parties (cf. Berryhill, Bourgery & Hanson, 2018, p.26). Furthermore, the immutable records on the blockchain would protect the rights of a landowner in the case of a dispute (cf. Ølnes, Ubacht & Janssen, 2017, p.357). For example, the Swedish government pilots the use of smart contracts to tackle common property transaction challenges such as mistrust, long registration times and complex processes (cf. Allessie, Vaccari & Sobolewski, 2019, p.26).

The possibilities of public sector organizations utilizing blockchain are wide ranged. As this chapter has shown, there are many countries in the EU already implementing and testing blockchain pilots (cf. Lindman et al., 2020, p.15), as well as EU wide initiatives to promote and encourage the use of blockchain in the public sector (e.g. European Commission, 2021). However, as stated in the beginning, the maturity of blockchain use cases is not given, yet (cf. Lindman et al., 2020, p.27). Additionally, Aristou and Marcou (2019) argue, that it is important to only use blockchain when it really is creating a benefit in the area it should be adapted in, calling this the need-based approach. Blockchain should not be implemented just because the objective is to use blockchain in some way, rather public sector organizations should only use blockchain applications if it makes their operations easier, faster – to create value for the public (cf. Aristou and Marcou, 2019, p.303). Therefore, the next chapter will focus on specific benefits, the public sector can gain from implementing blockchain.

4.2 Benefits of Implementing Blockchain in the Public Sector

As the previous chapter has already shown, there are many ways to use blockchain in the European public sector. Therefore, the potential benefits[11] of its usage cannot be overlooked (cf. Aristidou & Marcou, 2019, pp.295). Benefits range from increasing citizen trust through higher transparency and security (cf. Batubara, Ubacht & Janssen, 2018, p.1),

[11] As there are many different forms of blockchain and if implementing it into the public sector, such as the degree of decentralization, or the permission status (private or public), the benefits may vary between the use cases (cf. Aristidou & Marcou, 2019, pp.294). Additionally, the way of implementation and adoption determines, if the potential benefits can be realized (cf. Ølnes, Ubacht & Janssen, 2017, p.360).

to promoting general organizational change in the public sector organization towards more efficiency (cf. Mikkonen et al., 2021). This chapter will elaborate on the different forms of benefits the use of blockchain could bring to help the public sector to overcome the challenges.

First of all, blockchain could help the public sector to earn back the trust of citizens through increasing transparency of information and processes. As Chapter 2 has already discussed, trust and confidence into the public sector has been decreasing (cf. European Commission, 2017b, pp.1-2). Transparency is one of the tools that could help the public sector to regain citizens trust (cf. Carullo, 2021, p.49). This transparency can be achieved by using blockchain (cf. Rot et al., 2020, p.119), as citizens can easier trace policy changes (cf. Ølnes, Ubacht & Janssen, 2017, p.359) and observe government decisions (cf. Sobolewski & Allessie, 2021, p.102). Depending on the kind of blockchain implemented, an open government could be established, where all information related to the public is accessible to the citizens (cf. Navadkar, Nighot & Wantmure, 2018, pp.2290-2291). Even if the degree of openness is lower and access restrictions are higher, citizens could still get access to certain databases and information easier,[12] by accessing it through blockchain (cf. Carullo, 2021, p.49). Additionally, all data on the blockchain would be unalterable (cf. Ølnes, Ubacht & Janssen, 2017, p.359), making it possible to research for older decisions and data (cf. Navadkar, Nighot & Wantmure, 2018, pp.2290-2291). Further, data sharing would be more transparent, as citizens could more easily see which other organizations have access to their personal information or could choose to share their information with certain organizations easier (cf. Carullo, 2021, p.55-56). Overall, a higher degree of transparency in policy and governmental decisions can help to rebuild the trust of citizens in public sector institutions (cf. Aristidou & Marcou, 2019, pp.294-295).

In addition, trust and confidence in the public sector could be built through the promise of higher security in blockchains (cf. Cheng et al., 2017, p.1). Storing a large number of personal and public data, online or offline, always bears the risk of hacker attacks (cf. Guarda et al., 2021, pp.92-93). Blockchain is characterized as hard or even impossible to hack, due to its decentralized nature (cf. Meinel & Gayvoronskaya, 2020, pp.60-61).

[12] Here, the Open Data Directive of the EU, requesting member states to openly publish their data, could play a role, however, would be out of the scope of this thesis.

Additionally, manipulation of data could be minimized due to the consensus mechanism (cf. Rot et al., 2020, p.119). Further, looking at blockchain based identities, the technology could limit identity theft, as identities running on the blockchain would be encrypted more securely (cf. Berryhill, Bourgery & Hanson, 2018, p.25). Therefore, implementing blockchain in public sector organizations to store and access personal as well as public data gives governments the opportunity to ensure a higher protection of their citizens data (cf. Guarda et al., 2021, p.94).

Furthermore, blockchain could help to digitalize the public sector and its institutions. Increasing demand of digital services in all parts of life has also put pressure on public sector institutions to become more digital (cf. Guarda et al., 2021, p.92). Blockchain could be the link for those institutions to finally step towards offering not only more digital services for their citizens (cf. Ma & Zheng, 2017, p.17) but also digitalize internal processes, driving organizational transformation (cf. Guarda et al., 2021, p.92). Overall, blockchain could boost a more digital democracy in Europe (cf. Mikkonen et al., 2021).

Moreover, the decentralized nature of blockchain and its other characteristics, along with an increasing level of digitalization, could lead to a general transformation of the public sector, eventually leading to more than just higher efficiency (cf. Sobolewski & Allessie, 2021, p.102). Blockchain could be transformative in two ways. On the one hand, it could play a supporting role in providing support and improving traditional public sector processes, e.g. automatization (cf. Ølnes, Ubacht & Janssen, 2017, p.359). On the other hand, it could transform the nature of the public sector from a centralized system towards an open government decentralized system (cf. Navadkar, Nighot & Wantmure, 2018, pp.2290-2291). In both alternatives, blockchain could be taking over large parts of the tasks public sector institutions are fulfilling in society, today (cf. Sobolewski & Allessie, 2021, p.102). Either way, blockchain could lead to lower bureaucracy (e.g. through implementing smart contracts) (cf. Allessie, Vaccari & Soboloewski, 2019, p.10), higher effectiveness and more agility (cf. Mikkonen et al., 2021), thereby reducing cost, time and process complexity (cf. Allessie, Vaccari & Soboloewski, 2019, p.10). Overall, these benefits of blockchain implementation could help the public sector to stay relevant for their citizens and meet their demands (cf. Norström & Lindman, 2020, p.7).

Lastly, blockchain implementation in the public sector could transform its services for the citizens (cf. Aristidou & Marcou, 2019, p.294), meeting the rising demands of efficiency from more sophisticated citizens (cf. ibid., p.295). Related potentials such as automatization of processes would lead to less bureaucracy for citizens (cf. Mikkonen et al., 2021). In addition, the access to public services could be made easier (cf. Rot et al., 2020, p.119), enabling citizens to self-organize their public records and public sector related services (cf. Norström & Lindman, 2020, p.7). Therefore, blockchain is a tool to enhance public sector services and experiences (cf. Aristidou & Marcou, 2019, pp.294).

Blockchain could be the long-needed factor, helping public sector institutions to become more digitalized (cf. Guarda et al., 2021, p.92) and meet the rising demands of their citizens (cf. Aristidou & Marcou, 2019, pp.295). However, the influence of blockchain and its benefits for the public sector has to be limited, as the current structure of the public sector might have to be adapted in order to fully implement blockchain and gain all related benefits (cf. Ølnes, Ubacht & Janssen, 2017, p.360). Therefore, the next chapter will focus on breaking down the potential challenges occurring, when trying to implement blockchain and thereby hindering the successful implementation.

4.3 Challenges of Implementing Blockchain in the Public Sector

Regardless of the benefits blockchain could bring to the European public sector, there is still limited usage and mature implementation (cf. Lindman et al., 2020, p.27). In addition to and in connection with the already mentioned innovation barriers of the public sector (Chapter 3), blockchain itself poses some challenges hindering its implementation (cf. Berryhill, Bourgery & Hanson, 2018, p.29). This chapter will discuss potential implementation challenges of blockchain in the European public sector.[13]

The biggest implementation challenge for blockchain in the public sector might be the decentralized nature of blockchain and the centralized nature of the public sector (cf. Aristidou & Marcou, 2019, pp.293-294). As the previous chapter already discussed, one form of new government could be the completely decentralized open government approach (cf. ibid., p.294), providing a radical level of transparency, but could also pose a

[13] Challenges such as potentially higher costs or higher energy consumption have been discussed in Chapter 2 and will not be repeated. This chapter will focus directly on public sector related challenges and its consequences for the blockchain implementation.

risk to the privacy of data (cf. Berryhill, Bourgery & Hanson, 2018, p.30). However, this could require changing the institutional processes of public sector institutions, leading to a whole new form of governance (cf. Batubara, Ubacht & Janssen, 2018, p.7).

Another challenge is the lacking digital infrastructure of public sector institutions. As Chapter 3 already discussed, the information and communication technology (ICT) structure of public sector institutions is not always up to the newest standards (cf. Barcevičius et al., 2019, p.57). Therefore, implementing blockchain in those immature technological environments could be a challenge (cf. Lindman et al., 2020). However, some experts argue, that implementing blockchain in less mature institutions could be easier, as no given structure has to be changed but the ICT structure can be built from the ground (cf. Aristidou & Marcou, 2019, p.304). Adding to the challenge of lacking ICT infrastructure, is the challenge of designing the right form (see Chapter 2) of blockchain for public sector processes. Not only does the blockchain need to be designed and coded, but the permissions and transactions have to be managed as well (cf. Berryhill, Bourgery & Hanson, 2018, p.30). This means, that technology developers, engineers and other ICT experts have to be entrusted to supervise the blockchain, giving them another form of again centralized authority (cf. Navadkar, Nighot & Wantmure, 2018, p.2291). Therefore, implementing blockchain into the public sector would require adding a new layer of governance, overseeing the blockchain (cf. Berryhill, Bourgery & Hanson, 2018, p.31)

It is often stated that blockchain would be a tool to enhance the trust of citizens into public sector institutions (cf. Aristidou & Marcou, 2019, pp.294-295). However, that is just partly true, as the citizens as well as the public sector institutions first have to find trust into the blockchain technology, its security and its benefits themselves (cf. Berryhill, Bourgery & Hanson, 2018, p.31). Aristidou and Marcou (2019) add that blockchain itself does not create any form of trust but could simply operate as a tool to achieve it (cf. Aristidou & Marcou, 2019, pp.294). Here, blockchain could even influence the trust in a negative direction, as it is not clear yet, what influence implementing blockchain could have on the trust of e.g. citizens (cf. Lindman et al, 2020, p.17). Additionally, even though, the potential of technology for making our lives easier is known, the regular news on illegal surveillance through technologies, security breaches and hacking, as well as fake news lower the belief of citizens in technology (cf. Frade, 2021). Furthermore, the blockchain technology is still

quite immature, especially to users outside the technological innovation field (cf. Aristidou & Marcou, 2019, pp.296), therefore, acceptance and trust can be low, as its reliability, to them, has not been proven yet (cf. Batubara, Ubacht & Janssen, 2018, p.7). The lack of trust in blockchain security is an additional issue that hinders the building of trust towards the technology (cf. Batubara, Ubacht & Janssen, 2018, p.6). Overall, it is important to work on the digital trust challenge in form of education on blockchain and help overcome fears that the society but also public sector employees have (cf. Berryhill, Bourgery & Hanson, 2018, p.31).

The limited scalability of blockchain can be considered another challenge for public sector use cases (cf. Batubara, Ubacht & Janssen, 2018, p.6). In the public sector databases are often used and needed to store huge amount of data, especially in form of records (cf. Berryhill, Bourgery & Hanson, 2018, p.30). However, blockchain is better known and mostly used for keeping track of and performing transactions (cf. Beck, Müller-Bloch & King, 2018, p.1020). Therefore, the better use for blockchain in the public sector would be to "maintaining a distributed and trustworthy record of transactions" (Berryhill, Bourgery & Hanson, 2018, p.30), as storing records directly on the chain would be challenging (cf. Carullo, 2021, p.50). Additionally, public records are normally stored over longer time periods and archived for an even longer period, which would also be hard to facilitate using blockchain (cf. Navadkar, Nighot & Wantmure, 2018, p.2291). Further, depending on the consensus mechanism used, the usefulness could again be limited through scalability issues, as proof-of-work consensus mechanisms could lead to longer processing times, stalling transaction, especially with many users involved (cf. Berryhill, Bourgery & Hanson, 2018, p.33).

Immutability is one of the benefits blockchain brings (cf. Underwood, 2016, p.15). However, in the public sector usage it could pose an additional challenge to core processes (cf. Treiblmaier & Sillaber, 2020, p.229). It is not unusual, that public records have to be changed or sometimes even deleted (cf. Ølnes & Jansen, 2018, p.6). For example, in Europe, certain crimes or misconducts are deleted from the personal public record after a certain amount of years passes or citizens can request that certain information is removed from government records, which is also called the right-to-be-forgotten principle) (cf. Berryhill, Bourgery & Hanson, 2018, p.29). Deleting or updating public records would not be possible

with blockchain (cf. Berryhill, Bourgery & Hanson, 2018, p.29) and would lead to less flexibility in governing (cf. Ølnes, Ubacht & Janssen, 2017, p.359). Here, additional challenges could occur in relation to the European General Data Protection Regulation (GDPR) (cf. Ølnes & Jansen, 2018, p.6), aiming to give citizens sovereignty and control over their data, allowing them to decide what kind of data about them can be stored (cf. Radinger-Peer & Kolm, 2020, p.133).[14]

As this chapter has shown, the above discussed challenges related to blockchain could limit the success of implementing the technology in the public sector. Additionally, not all blockchain characteristics often described as a benefit also improve and elevate the processes of the public sector, e.g. immutability (cf. Treiblmaier & Sillaber, 2020, p.229). Furthermore, there might be more simple technologies offering similar benefits (cf. Ølnes & Jansen, 2018, p.6), which leads to the conclusion, that implementing blockchain should not just happen as a means to itself but should be following a thoughtful process (cf. Lindman et al., 2020). Moreover, the benefits as well as the challenges of blockchain implementation into the European public sector had to be limited in regard to specific implementation forms (cf. Aristidou & Marcou, 2019, pp.294), as well as organizational structure of the public sector institution, application approach or implementation field (cf. cf. Ølnes, Ubacht & Janssen, 2017, p.360).

4.4 Resulting Theoretical Framework

The previous chapters have given an overview of blockchain application benefits and challenges in the European public sector. There, it can be seen that even though benefits of blockchain might be known by public sector organizations, many institutions either hesitate to implement blockchain, due to potential challenges, or implement blockchain pilots but fail to maintain them successfully (cf. Berryhill, Bourgery & Hanson, 2018; Aristidou & Marcou, 2019; Batubara, Ubacht & Janssen, 2018; Lindman et al, 2020). In addition, challenges are often related to specific projects, implementation environments and blockchain types (cf. Aristidou & Marcou, 2019, pp.294; Ølnes, Ubacht & Janssen, 2017, p.360), which makes it hard to generalize and transfer learnings to other pilots (cf. e.g. Berryhill, Bourgery & Hanson, 2019, p.29). Overall, especially due to the limited number of

[14] As this is not a legal thesis, there will not be an in-depth elaboration on the legal standards and regulations regarding blockchain.

public sector blockchain applications and pilots, there is not enough research on European blockchain pilots and their specific implementation, in order to understand why blockchain pilots fail, yet (cf. Lindman et al., 2020, p.27).

At this point, the Thesis will continue the research, by exploring four different European municipal blockchain pilots of Interreg projects, challenges before the implementation of blockchain pilots, as well as during the implementation (experimentation phase) of the pilots should be discovered. Those challenges add to the previously discovered literature challenges and provide a deeper understanding of what challenges occur during the implementation of blockchain pilots in the European public sector. Based on the literature review, the following thematic framework for implementation challenges and their propositions can be derived (see Figure 5).

As it can be seen in the theoretical framework, the challenges are separated in three categories – Public Sector Organization Structure Characteristics (institutional challenges), Blockchain Technology Characteristics (technological challenges) and the individual related challenges. Here, one overall proposition was formulated for each category, with sub-propositions for each challenge sorted in that category. First, public sector organization structure and general characteristics (see Chapter 3) can be seen as implementation challenges. Second, blockchain characteristics could lead to a misfit between organization, application and technological characteristic, thereby, challenging the blockchain implementation. Third, the Individual factor describes challenges created by an individuals' behavior or characteristics negatively influencing the blockchain implementation Those propositions were derived from the previous literature review and will be further explored and evaluated based on the empirical data collected.

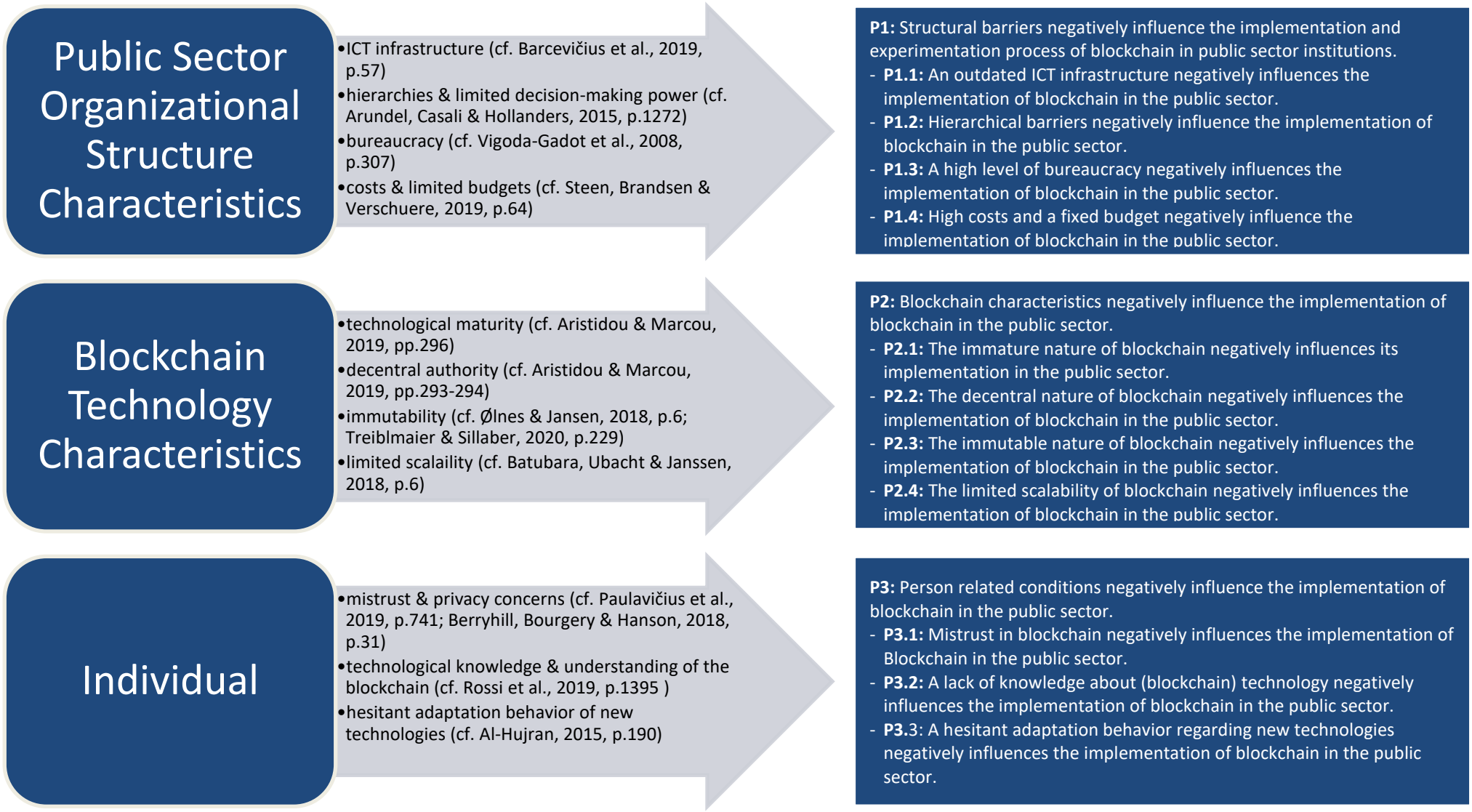

Figure 5: Theoretical Framework "Blockchain Implementation Challenges in the European Public Sector", own illustration

By contributing to the research of blockchain implementation challenges in the public sector, not only the project partners will benefit from the results, as they can learn about challenges other pilots are facing and how specific challenges have successfully been overcome already, but also the whole blockchain implementation research environment would get additional insights, leading to a better understanding of blockchain implementation challenges. It can be expected to find challenges in all three areas, organizational, technology or individual related. Additionally, many organizations are following a push approach with implementing blockchain. This means, that due to a lack of blockchain knowledge and understanding of the technology, many organizations are trying to push blockchain into specific usages, without considering what the technology can actually do. As this means neglecting specific characteristics, which could benefit the organization, those approaches often fail and are considered a fitting issue between blockchain and the organization. Moreover, this approach neglects considering the specific societal problems, when a technological solution is pushed towards one direction without considering other options (cf. Ølnes, Ubacht & Janssen, 2017, p.362). Overall, the Master Thesis will pose as a (mid-) conclusion / outlook for the project report of the BLING project, as already existing problems will be discovered, and possible solutions should be developed. The research question will be defined as follows: *"What challenges do local European administrations face when implementing blockchain in the municipal public sector?"* Thereby, the aim is to identify specific challenges the implementation of blockchain brings, when being implemented in the European public sector. In the following chapter, the methodology for identifying the challenges will be presented.

5 Method & Methodology

5.1 Empirical Approach and Theory Building

To gather the empirical data, a qualitative approach of semi-structured expert interviews with Interreg project partners based on pre-sent interview guiding questions was used. Thereby, an inductive research approach on multiple experts' case studies was followed, as the aim of the study is to derive challenges of blockchain implementation in the European public sector. Each case in the study is one blockchain pilot implemented in the European public sector, represented by the interviewees. The findings of the study are used to identify implementation challenges and answer the research question: *"What challenges do local European administrations face when implementing blockchain in the municipal public sector?"*. Therefore, the purpose of these interviews is to get insights into the specific blockchain pilots, their implementation processes and especially on any challenges arising through that process, as well as ways they might have overcome those challenges.

The theory of this Thesis will be based on the before developed thematic framework and the literature research, therefore, following a conceptual theory building approach. As the previous chapter pointed out in the theoretical framework, challenges and propositions were derived based on the literature review. Those theories (propositions) will be tested during the interviews, as interviewees will be asked for their experiences with blockchain implementation, aiming to add, support (or not support) the before developed propositions.

5.2 Data Collection

The data collection method were six investigative, semi-structured interviews, provided by the same interview guidelines for all interview partners. The semi-structure allows the interviewer to vary the exact wording during the interviews, change the order of the questions or add new questions in case of additional requests (cf. Helfferich, 2014, p.560). The interview guideline has two functions. First, it serves to structure the subject area as well as a concrete aid in the surveying situation (cf. Bogner, Littig and Menz, 2014, p.28). Second, as the questions for the interview are sent before it was conducted, the interviewees are able to prepare and collect the important information they want to talk about (cf. Helfferich, 2014, p.570). The semi-structured approach generally serves as a method for collecting verbal data. This method is particularly suitable for gaining insight

into the thoughts of the expert (cf. ibid., p.572). The qualitative process requires respondents to be able and willing to reflect on their own motivations and views and formulate them. The focus of the interview is the principle of openness. The questions should be adapted to the respondents and formulated in a simple and understandable way. Thereby, the respondent is given the opportunity to respond in such a way that knowledge and interests are expressed (cf. ibid., pp.570-573).

The interviews were conducted in English, as the selected interviewees are from different European countries. The participants' answers are anonymized (Interviewees were given numbers) in order to ensure privacy. Due to the current Covid-19 pandemic and the location of the interviewees, the interviews were conducted via Microsoft Teams. To avoid acoustic overlap and consequently missing information of the interviewees in the recording, the interviewer tried not to speak or make approving sounds during the interviews. All interviews were conducted between the 28th of June and 9th of July 2021. The interview guiding questions were sent to the interviewees before the interviews, in order to give them the opportunity to prepare the answers (cf. Bogner, Littig & Menz, 2014, p.30). All interviews were recorded using the Samsung voice recorder and the computer of the interviewer.

5.3 Interview Questions

The interview guideline (see Appendix A) is structured in a way, that the author was able to cover three different topics and get the necessary information needed for this thesis. The questions are divided into five sections. In addition, to the three theme-based question sections, there was an introduction and ending section, to make the start of the interview more comfortable and start the conversation, as well as give the ending a closing remark (cf. Bogner, Littig and Menz, 2014, pp.59-60). The first section is the introduction, where the interviewee introduced him- or herself. The second section covers general information about the blockchain pilot the interviewee works on and how/why it utilizes blockchain. The third section then focusses on the implementation stage and process of the pilot, as well as challenges before and during that implementation process. In section four the interviewee were asked for ways he or she has handled and overcome the before stated challenges, what was learned from the process and what takeaways for other blockchain pilot implementations are. To close the interview, the interviewee was thanked again and

asked, if he or she has anything else to add, to before given answers. The interview guidelines have an additional question, which was asked, in case there was time left and the questions were not answered earlier, so in case the interviewer thought additional value would be created by asking the interviewees those questions.

The questions generally have the purpose of giving the interviewee the opportunity to be as free as possible in talking about their experiences. Therefore, the questions have been designed open and investigative (cf. Helfferich, 2014, p.566). Additionally, the structure of five sections gives the interviewee an overview of themes and what the focus of the questions is (cf. Bogner, Littig and Menz, 2014, p.27).

5.4 Sample: Interviewees and Pilots

In this study, six interviews with partners from Interreg[15] projects were conducted. three interviewees are part of the Interreg Project BLING,[16] one interviewee is part of the Interreg project Blockstart[17] and two interviewees implemented the pilot in context of the finished Interreg project LIKE!.[18] All Interviewees are primarily involved in the pilot in their organization / institution and responsible for the implementation of the blockchain pilot.

To ensure, that the selected interviewees were able to answer the questions in a way that benefitted the research aim of this thesis, selection criteria for their blockchain pilots cases were defined and discussed with all project partners, to find suited pilots. Most important in the selection process of identifying fitting pilots, was that those interviewees and their pilots already are implemented and in the experimenting phase of their blockchain pilots, as only then they have the needed experience with potential implementation challenges. Additionally, their pilot should have at least one user who is not employed by or related to

[15] **Interreg** aims to help local and regional European governments to develop and deliver better policies by sharing knowledge and innovation, as well as invest and implement those innovations in the most sustainable way (cf. Interreg Europe, 2021). Overall, different Interreg Programs exist, focusing on different European (some even over-European) regions (cf. Interreg, 2021). The projects in this thesis are part of Interreg North Sea Region and Interreg North-West Europe.

[16] **BLING** or Blockchain in Government is a European funded Interreg project, running from 2018-2023. 13 European partners (universities, municipalities and governmental organizations) investigate what role blockchain can play in governments, delivering pilots and technologies for citizens, communities and SMEs in the North Sea Region (cf. BLING, 2021).

[17] The **Blockstart** Interreg NWE is a EU funded project, aiming to increase SME competitiveness by using and implementing blockchain (cf. Blockstart, 2021).

[18] **LIKE!** is a European funded Interreg project, which ran between 2014 and 2020. There, 10 partners in 5 countries (local governments, citizens, universities and SMEs) came together to co-create smarter, more efficient and more innovative public services through 9 transnational pilots that cover 3 core themes: Innovation Culture Approach, Smart Services, Digital Dashboards (cf. LIKE!, 2021).

the BLING project. Furthermore, interviewees should have collected data during the implementation and experimentation process of their pilots. Moreover, to ensure that the provided data is more viable, the pilots should have had a testing or implementation phase of at least four to eight weeks. Thereby, also ensuring, that the implementation process is long enough to have encountered potential challenges and interviewees have worked on or at least thought about how to overcome the challenges and maybe even adapt the pilots in the process. These criteria should ensure, that the interviewees have basic experience with implementing blockchain pilots in the European public sector. Appendix B provides a table with more information on the selected pilots.

Overall, this sample of interviewees was selected, due to their expertise in the field of implement blockchain in the European public sector. All Interviewees are part of the same research consortium (Interreg) and are thereby willing to learn from one another by sharing data and conducting joint projects. All chosen pilot projects fulfill the before defined selection criteria and found helpful as part of the author's research for identifying implementation challenges of blockchain.

Interviewee	Pilot	Organization	Position	Implementation Field	Problem to solve
Interviewee 1	Stadjerspas Groningen	Gemeente Groningen (NL)	Project Manager Stadjerspass	Municipal Services	Enable a social life and social activities for people with a low income in the city of Groningen.
Interviewee 2	Fit4Work	HOWEST (BE)	Project Manager for European Projects	Health in the Office (Municipal Service)	Raise awareness about data ownership and data privacy during the use of fitness wearables and apps on the Internet.
Interviewee 3	Fit4Work	Stad Roeselare (BE)	Project Leader	Health in the Office (Municipal Service)	Digitalize and corona-proof the local fit4work challenge for employees of the City of Roeselare. Help people stay active during lockdown ad encourage them to maintain a healthy (physical and mental) lifestyle during their work day.
Interviewee 4	Heerlens Heitje	Stad Heerlen (NL)	Senior Project Leader	Municipal Services	Incentivizing citizens, to take part in improving and maintaining public facilities and places. Support local shops and encourage local shopping of citizens.
Interviewee 5	Financial Emergency Brake (Red Button)	Centraal Justitieel Incassobureau - CJIB (NL)	Operational Manager (data, information, BI)	Municipal and Regional Services	Simplify the identification of indebted people in order to ensure fee financing possibilities between the CJIB, local municipalities and citizens in debt.
Interviewee 6	Stadjerspas Groningen	Gemeente Groningen (NL)	Policy Advisor	Municipal Services	Enable a social life and social activities for people with a low income in the city of Groningen.

Table 2: Overview Interviewees and Their Pilots (based on Interviews; Appendix D)

5.5 Data Preparation: Transcription Rules

In order to make the collected data from the interviews accessible for analysis, they must first be transcribed (Transcripts can be found in Appendix C). All interviewees consented to recording the interviews, so that a detailed transcription is possible. The resulting transcripts are necessary for the evaluation of the results because they make the fleeting conversational behavior permanently available for scientific analysis. The transcription system is therefore, not designed for communicative but rather for analytical purposes, which is why changes made in the transcript should lead to a better reading and understanding of the text (cf. Meyer & Meier van Verl, 2014, pp.253-254).

In the following, the specific rules for the transcripts in this paper will be defined, based on Braun and Clarke (2013, pp.165-166). Special characters indicate abnormalities of the language such as pauses, emphases, tone (e.g. for questions) and laughter during transcription. The used punctuation has a syntactic function and makes the transcript more structured, by adding characters like “,”, “.” or “?”. Pauses are indicated with a (.). Laughter is indicated by (laugh). Expressions of approval while the interviewee speaks did not appear because of the nature of the interview (telephone interviews). A fast or bad record connection is represented by “(/)”. The end of each speaking section will be highlighted with the time of the recording. In addition, misspellings will be corrected, to make it easier to read the transcript (cf. Braun & Clarke, 2013, pp.165-166). For the transcript, the interviewer will be titled as “IR”, while the interviewee will be titled as “IE” plus the number of the interview.

5.6. Data Analysis: Thematic Analysis

In order to analyze the information from the interviews, the transcripts have to further be structured in terms of finding the important information. Therefore, the transcripts were paraphrased and the most important information from the answers were collected. The analysis was developed and executed with the help of the software ATLAS.ti.

The method, which was used in this process is part of the thematic analysis approach by Braun and Clarke. Even though thematic analysis is the umbrella term for pattern identification approaches (cf. Braun et al, 2019, p.844), in the context of this thesis, the approach from 2006 was used for analyzing the transcribed material. First, initial codes

were created (cf. Braun & Clarke, 2006, p.77, 87),[19] by creating clear labels for certain meanings of data (cf. Braun et al., 2019, p.853), which are descriptive for the associated data, that they are neither interchangeable nor reductant (cf. Norwell et al., 2017, p.6). Second, themes were constructed by searching for similar answers and topics and defining a general meaning in them (cf. Braun & Clarke, 2006, p.88), here the interview questions gave additional structure on guidance, to which theme network a code can be sorted. This also means that the themes are loosely based on prior research, as the interview questions were derived from that. Third, the initial codes and themes were reviewed and reduced to broader topics but precise themes answering the research question (cf. Braun & Clarke, 2006, p.89, 91). As the initial teams were already based on the interview questions, refinement was just needed in some themes. Fourth, the themes were defined and named (cf. Braun & Clarke, 2006, p.92). Last, the report in form of the findings (Chapter 6) was produced (cf. ibid., p.93). This thematic analysis helped to organize and describe the data set (cf. Braun & Clarke, 2013, p.249). Nowell et al. (2017) was used as additional help for a better process in identifying the important information and execute the thematic analysis.

The thematic analysis was conducted individually with all interview transcripts. Afterwards, the findings from the different stages of the analysis were compared and brought together as theme networks to find similarities between the different interviews (see Appendix D). The different theme networks are based on the interview questions and the information interviewees provided by answering them, whereby the answers were categorized per pilot. The different statements are divided by pilot and marked with the capital letters of the pilot names (HB= Healthy on the Blockchain, HH= ’t Heerlens Heitje, RB= Red Button / Financial Emergency Brake, SP= Stadjerspas). Therefore, the findings in Chapter 6 will be divided into the results of the theme networks of the different interviews, before being brought together for Chapter 7. In addition to the themes derived from the interview questions, the category of “Beneficial for Blockchain Implementation” was added, to find reasons for lower and less implementation barriers. As the implementation challenges are the main focus of this thesis, the challenges were derived by identifying specific problems interviewees encountered during the implementation process of their pilots, leading then

[19] Some literature suggests a prior step in which the interviewer familiarizes himself / herself with the material by reading the transcript or listening to the recording, just taking broad notes on what is interesting (cf. Braun et al., 2019, p.852).

to the discussion (Chapter 7) and the merging of findings from the literature review and empirical findings.

During the analysis, the interviewer specifically searched for the different types of challenges, in order to categorize them and further analyze the problems public sector executives are confronted with, when implementing blockchain in their organizations. For example, the challenges could occur in the technological level, if e.g. the connectivity is lacking, or on the organizational level, if e.g. the municipality halts the implementation process of the pilot. Due to the order of research and the theoretical framework being written before conducting the interviews, there was an influence of the identified challenges in the literature on the code and theme creation.

6 Empirical Findings

During the analysis of the transcripts, 356 citations were coded. Out of these codes, 18 theme networks were formed, of which 12 will be explicated in this chapter. Exclusions were made, as the network of interviewee positions was only relevant for the interviewee description in the previous chapter, while the pilot description theme networks for the different pilots were designed to create Table 3 (see Appendix B). Therefore, this chapter will describe the findings of the interviews structured into the remaining 12 theme networks (see Figure 6).

Reasons for Blockchain
Why was a blockchain technology solution chosen for the pilot?

Blockchain Alternative
Were there possible alternative technologies, which could have been used?

Blockchain Downsides
Were there any downsides to working with blockchain?

Easy During the Implementation
Was there something easy during implementing a blockchain solution?

Initial Implementation Hurdles or Difficulties
What were initial challenges when implementing the pilot?

Evolvement of Challenges or New Challenges
Did the initial challenges evolve and did any new challenges occur?

Overcoming Challenges
What was done to overcome the challenges?

Do Anything Different?
What would be done differnetly, if the pilot had to be implemented again?

Advice for Blockchain Pilots
What would be helpful for other blockchain enthusiasts to know or do, to implement blockchain pilots?

Biggest Implementation Challenges in the European Public Sector
What are the biggest challenges when implementing blockchain based solutions in the European public sector?

Beneficial for Blockchain Implementation
What were factors that benefitted the implementation of blockchain?

Figure 6: Theme Networks and Descriptions, own illustration

6.1 Reasons for Blockchain

In the Healthy on the Blockchain (Fit4Work) pilot interviews, the interviewees named two main reasons for choosing blockchain. First, the decentralized nature makes it difficult to hack – IE2: *"if we use blockchain we have a decentralized setup enlargo environment"* and

"it is a proof of concept so it's difficult to hack". Therefore, the security a blockchain ensures was a factor in the decision – IE2: *"we implement blockchain because we want to strengthen the data security and data privacy".* Additionally, the privacy of data was an important factor for choosing blockchain – IE2: *"the main goal is not only data privacy but also data security*. This goes along with the goal of the pilot, which was not only the fitness of participants but also raising their awareness about their data – IE2: *"the objectives of […] this pilot was to raise awareness about data ownership and data privacy"* and IE3: *"blockchain […] was really the part of people getting aware of what happens with their data"*.

In the 't Heerlens Heitje pilot, the goal was always to use blockchain – IE4: *"we decided actually from the start we said hey maybe we should implement blockchain in this situation because then we can make […] it's a private blockchain"*. Here, the prior knowledge and enthusiasm for blockchain by the project leader was the main reason to implement the pilot with blockchain – IE4: *"and I saw a really that […] blockchain technology was here to stay so […] couple of years later, I initiated the project within the municipality"*. Moreover, the project team is planning to decentralize the verification process and let citizens make more decisions in the process of choosing and verifying tasks, which can just be done with blockchain – IE4: *"let's say a neighborhood […] will be accessing their tasks for themselves, so we as a municipality will not decide anymore, if the task has been done correctly or not, the people from the neighborhood themselves […] verify, if the task has been done correctly or not […] then the municipality is […] really like decentralized and still you get some kind of […] consensus within […] those neighborhoods, so […] there's the real opportunity for the blockchain technology"* and *"in the future we really like to expand to make more use of blockchain"*.

The CJIB and the operational manager of the Financial Emergency Brake (Red Button) decided to use blockchain due to the utilization of SSI and zero-knowledge proof – IE5: *"as the blockchain is that underlying technique and it's all about self-sovereign identity and zero knowledge proof"*. Thereby, the blockchain gives autonomy about data sharing on the blockchain to the users of the Financial Emergency Brake (Red Button) – IE5: *"autonomy about revealing or sharing their data that's what […] it's all about and blockchain enables this because these credentials they are able to share or not [..] the correctness of this*

information that is stored on the blockchain, so there is no privacy information stored in the blockchain". In addition, the immutability of blockchain was seen as important, because it makes the information more trustable – IE5: *"it's all about immutability that's important for us because the proof […] must be reliable for us […] blockchain makes that possible"*. Furthermore, for the CJIB, the blockchain can replace the untrustable third party in the verification process, depending on the blockchain form – IE5: *"it's really about trust on the Internet which it is enabling, without a third party because who would that be in this dept world, who would we all trust and now […] we all trust or don't trust each other because blockchain makes this possible"*.

In the Stadjerspas, blockchain was chosen, as it is interesting and has certain advantages – IE6: *"blockchain was very interesting and that it had certain advantages"*. One of those advantages was that the blockchain would be easy to manage – IE6: *"that way things could be well, easily managed"* and *"there's like a self-management part of it"*. Therefore, the project team hoped for an efficient and self-propelling trained blockchain – IE6: *"it was so efficient and self-propelling"*. Further, the pilot benefitted from an experienced partner, which led to a win-win situation – IE1: *"it would be win-win because they would like to have to get some experience in a real system […] and for us it was quite interesting to cooperate with them because […] those new technologies and new experiences"* and *"it was just the […] possibility to cooperate with his experience"*.

6.2 Blockchain Alternative

During the interviews, a database was often named as an alternative for a blockchain as the underlying system of the pilot. Here, Interviewee 4 ('t Heerlens Heitje) named a database as a possibility – IE4: *"yes we could have provided it with just a database"*, as it would also be easier to erase data in such a system – IE4: *"in a database it's really […] easy […] if you're moving towards another municipality, another city or whatever [you] just delete it and put another user in"*. Interviewee 1 and Interviewee 6 (Stadjerspas) suggested the same – IE1: "we could also do with […] a database" and IE6: *"99 out of 100 times a central database is going to be a better fit for your goal"*. In this pilot, the system was ultimately changed to a database in 2021 – IE1: *"now we are working with the database again"*.

6.3 Blockchain Downsides

For the Healthy on the Blockchain (Fit 4Work) pilot, two main downsides of blockchain were identified. First, building a strong blockchain ecosystem and network – IE2: *"so that is the most difficult part I think, it's first step that you have to build an ecosystem with all partners convinced and on board"*. Second, for some of the project related aspects, technology wasn't the answer and couldn't be utilized – IE3: *"for some aspects of a project technology isn't the answer"*.

The project leader of 't Heerlens Heitje named GDPR and the immutable nature of blockchain as the biggest downside of using blockchain for the pilot – IE4: *"it's all about GDPR, it's really tough, once you're in a blockchain […] which works with personal data, it's really tough to […] change"*.

In the Financial Emergency Brake (Red Button) interview two main downsides of working with blockchain were mentioned. The first downside is related to the algorithms behind blockchain, as it is complicated to explain – IE5: *"the main things we are encountering now is […] the difficulty to explain it to people who are not technically ready for it"* and *"that concept is a difficult one to explain"*. A second downside, which was mentioned was the controversy about bitcoin and other cryptocurrency, which not only negatively influenced the trust in blockchain but also lowered the willingness to use blockchain – IE5: *"all the stuff, which is going on Bitcoin, on blockchain, it doesn't help at this moment, because everybody is trying to kill blockchain or to kill Bitcoin or to kill crypto"*. Overall, Interviewee 5 stated that it is hard to explain to people why blockchain might be the best solution for a pilot system – IE5: *"it's an unknown technique that's one so it's very hard to explain to people why this is one of the solutions the main solution we are working right now"*.

Interviewee 6 (Stadjerspas) named blockchain characteristics as well as the blockchain hype as downsides of working with the blockchain technology. Here, the immutability becomes obvious – IE6: *"blockchain has certain […] uses and one of them is that you can't do rollbacks […] what's in the system never comes out, if you make a mistake and it gets written on the blockchain, you are screwed, it's a new reality, you can't to rollbacks and what the thing is in municipal services, related to citizens is that there is almost no application or service, where you never have to do […] a rollback".* In addition, the decentral

nature of blockchain was named as a downside – IE6: *"blockchain is a decentral system, which basically has no majority power but there is no need to have that specific well feature when it comes to municipal servers, there is explicitly in municipal services, one entity which has all the power and it's the municipality, so why would you want a system that basically takes the power away"* are downsides in the pilot process. Additionally, the blockchain hype first led to overenthusiasm in adapting blockchain for projects – IE6: *"at the moment there was blockchain hype, which went really deep a lot of people were like how we're going to use blockchain but actually had no idea what it was and what it was doing"* and then dyed down – IE6: *"the interest for blockchain developments via municipalities was waning it was like the hype was over"* and *"once the hype died down it kind of dragged down the positive sides of blockchain"*. Furthermore, Interviewee 6 suggested blockchain might be more suited for general transactions and smart contracts than public services – IE6: *"blockchain could be useful in certain situations it's more on the business side of transactional services then on the governmental"*. Lastly, the technical nature of blockchain was a downside, as municipalities are not experimental – IE6: *"municipality are not very much eager for doing something experimental"*.

6.4 Implementation Process Healthy on the Blockchain and Financial Emergency Brake

Only the pilot implementation process of Healthy on the Blockchain (Fit4Work) and the Emergency Brake (Red Button) will be described here, as they were the only ones describing a detailed process of implementing their pilot.

The Healthy on the Blockchain (Fit4Work) pilot was implemented based on a communication plan of the project leader at the City of Roeselare. To get the word out, three newsletters were designed, each focusing on different aspects of the pilot, first the health, second the pilot and last, the blockchain and privacy aspect. For all interested employees, four info sessions on different dates and times were planned. All interested employees then had the chance to fill in their information (e.g. age, activity level, health status, etc.) into a questionnaire. Those questionnaires were screened carefully to filter for people with preconditions and people who are already very active. The project team then made the final decision of 20 participants who would take part in the pilot. Those participants then had an online kick-off meeting with the coach and also received additional information on the goals of the pilot. In order to ensure that the technology and the

wearables work, the project team had an internal testing of everything. Before starting with the three month testing period, the wearables were worn by the 20 participants to get them used to the feeling and checking if all connections between app and wearable are working. During the test period of three months, continuous feedback meetings via Microsoft Teams were held. After the test period, a final evaluation was filled out by the participants. The final report for the pilot test will be published in October 2021.

The Financial Emergency Brake (Red Button) pilot is, by the definition of the operations manager, still in the testing and proving stage. However, the implementation stages of the pilot so far were described as follows. The first phase was creating the proof of concept, which meant creating a working solution and making it GDPR compliant. The second phase was the preparation of the implementation and the increase in scale. The third phase would then be to implement and scale up. However, it was realized by the CJIB, that the increase of scale would mean an increase in costs. Additionally, not all municipalities in the Netherlands could be involved and convinced to participate, yet. Further, the blockchain network in the different municipalities is not set up, yet. Therefore, the CJIB took a step back and now focusses on proving again, this time trying to prove the social value, while also proving, detecting, searching for what kind of business processes improvements or adjustments are needed in the municipalities and in the CJIB. This proving is done in two municipalities, where the pilot is implemented and used. A full implementation is expected in around three to five years.

6.5 Easy During the Implementation

Interviewee 2 (Healthy on the Blockchain (Fit4Work)) described the recruiting of participants as surprisingly easy during the implementation of their pilot. This could be related to the fact that the pilot was started as part of an already existing program, the Fit4Wwork challenge – IE2: *"to have this people on board, because of this interesting package of 'you will get a more healthy lifestyle and trainer' […] it was not because of the blockchain or the innovation behind it […] because that was the strength of our pilot that it was something very familiar [with] an extra […] innovative layer on top […] fit4work"* and *"because […] it was attached to a product that was already known"*.

Interviewee 4 ('t Heerlens Heitje) stated that it was surprisingly easy to get shop owners to accept the new coins – IE4: *"one thing went quite well and it was the support from the shop owners"*, *"we thought that that would be way more difficult to make them enthusiastic about these new coins"* and "*that surprised me somehow that there is a big that they are really looking forward to join this project "*. Interviewee 4 stated that even though in the beginning of the pilot it was hard work to contact all the shop owners, explain the pilot and get them to accept the coins, now the shop owners contact the project leader to participate in the pilot – IE4: *"in the first period we have to really get to those entrepreneurs and say please join us with our project […] now already the moment is there that we got emails from other entrepreneurs that hey please don't […] skip me, I really want to, hook me up in this project so"*.

For Interviewee 5 (Financial Emergency Brake (Red Button)) getting funding was quite easy due to their membership in a blockchain project, as well as the overall blockchain curiosity – IE5: "*BLING is in that respect very valuable for us*" and *"oh what was easy […] to get money in, because I think until […] 2020 everybody was still curious about blockchain, so […] there was money available to put in this project"*. Additionally, the willingness of the network to use blockchain was a surprise, as well as the network's passion about the blockchain project – IE5: *"what was easy was […] the willingness in the network, working with each other because we are all passionate about this solution"*.

Interviewee 6 (Stadjerspas) explained that the blockchain hype led to many people being interested in the pilot – IE6: *"but at the moment there was blockchain hype, which went really deep a lot of people were like how we're going to use blockchain"*. Regarding the blockchain it was, due to the fast technological development of the blockchain – IE1: *"I was quite surprised that they could develop a working system in only three months' time"*, it was easy to use blockchain and gain benefits from its efficiency, as the blockchain automatically processes transactions and creates the payment plan necessary for the system – IE6: "*once the transaction was made, the system kind of did everything themselves, itself you didn't really need to do any […] work on the system when it comes to the data part"* and *"when it came to payments and kind of the blockchain system spit out once a month list of all the all the shops that use credit and needed to get money"*.

6.6 Initial Implementation Hurdles or Difficulties

The Healthy on the Blockchain (Fit4Work) project members mentioned several different implementation hurdles, most of them blockchain technology related – IE3: *"blockchain that was the main difficulty"* and *"main challenges within the project were technical"*. The challenge was to create a secure blockchain – IE2: *"difficult before and after blockchain, because there are a lot of technical connections and steps and then you can make your blockchain as secure and as good as and robust as possible"*, which is GDPR proof – IE3: *"and the blockchain here was really about GDPR proof and not selling your data to another firm"* and the app and wearable connect properly – IE2: *"we also have the app, we have the web platform, we have so many steps and that is where a weakness can come in system not because of the blockchain but all the other connections"*. Additionally, it was difficult to explain the blockchain concept to participants of the pilot – IE3: *"we can't really talk about blockchain because people won't understand"* and *"at the end we mention blockchain but then in the info sessions we really explain down with a little movie about blockchain, so people would really understand what was behind it but not getting into detail"*. Therefore, it was important to explain blockchain in a way to not make people afraid of the technology – IE3: *"the hurdle, was how are we going to communicate it"* and *"we can't really talk about blockchain because people won't understand, and people will be afraid"*. Moreover, not only the study and pilot participants had to be convinced but an additional hurdle was convincing the internal stakeholders – IE2: *"it was very difficult to have their internal stakeholders, having them convinced to have this pilot"*. This was explained by Interviewee 3, as people often do not like new technologies – IE3: *"a lot of people don't really like new stuff"* and therefore, it was important to convincingly sell the project to the organization – IE3: *"so I have to like sell the project to them"*.

For the project leader of 't Heerlens Heitje it was the most tough to convince and convene people inside the organization to create a blockchain solution – IE4: *"I think […] inside my organization or inside the municipality it was the toughest"* and *"within the municipality it's convincing people that's, that this project really could work"*. It was mentioned that governments might prefer a slower but safe pace – IE4: *"a lot of people in my organization always said just easy, go easy think it through, go to the next step"*, it is important to ensure the highest possible safety – IE4: *"the coins there that this everything is hackable but please do at least everything within your power to not get hacked"* and *"the application needs to*

be really, like really safe" and sometimes check again before going live – IE4: *"problem is because I'm working for a municipality and because I'm working for the government I have to do everything by the book"*. Another challenge was again the GDPR regulation in connection with personal data of citizens (Social Security numbers) – IE4: *"it's all about GDPR, it's really tough, once you're in a blockchain […] which works with personal data, it's really tough to […] change"* and *"here in the Netherlands, also got our own Social Security numbers and that's like a really hard thing with […] GDPR because we cannot just collect them because it's yeah it's some say it's privacy and we cannot use those numbers, so that was a bit tricky"*.

In the Financial Emergency Brake (Red Button) pilot Interviewee 5 explained that challenges differed between technological and educational / person related. For the project team it was difficult to define the necessary information and translate it into the claim – IE5: *"a difficult one is, what should be in this claim, what should be in this credential, what does it represent, what is the value of this claim"* and *"the value of the claim and how is it translated into this claim […] into this verifiable credential that was a last inside which occurred during the project"*, as well as implementing the nodes in the blockchain network – IE5: *"the implementation of a blockchain node in our own network is a problem"* and making those nodes secure – IE5: *"so that's the security issue that is a difficult one"*. Further, making the blockchain network and pilot GDPR compliant was an initial hurdle – IE5: *"make it GDPR compliant legal people have looked into it"*. On the personal education side, the project team of the Financial Emergency Brake (Red Button) pilot had difficulties to explain the blockchain concept – IE5: *"main things we are encountering now is that the difficulty to explain it to people who are not technically ready for it"* and *"unknown technique"*, while they also had to justify and explain why they have chosen blockchain for their solution – IE5: *"very hard to explain to people why this is […] the main solution we are working right now […] why blockchain"* and *"why should we use blockchain for this, we always have to explain this"*. Lastly, they had problems with the distrust of people into blockchain – IE5: *"distrusted new technique"*.

While during the Stadjerspas pilot implementation, no real implementation challenges occurred regarding blockchain – IE1: *"we didn't have any implementation challenges"*, Interviewee 6 talked about the reputation and the blockchain hype being a difficulty during

the implementation process – IE6: *"blockchain had a big false start in Europe with the hype, which came with Bitcoin"* and *"hype was over"*. Furthermore, the interviewees mentioned that municipalities are not really experimental – IE1: *"municipality are not very much eager for doing something experimental"* and therefore, no cheering should be expected when wanting to implement a new technology in an organization – IE6: *"I think that comes mostly with every implementation when something is new, people don't really are cheering, that they have to learn something new"*.

6.7 Evolvement of Challenges or New Challenges

When asking for the evolvement of challenges and the rise of new challenges, the Healthy on the Blockchain (Fit4Work) Interviewees referred again to the technological challenges as the main challenges– IE3: *"main challenges within the project were technical"* and *"make your blockchain as secure and as good as and robust as possible"*. In addition, the regular feedback sessions led to a lot of feedback from the participants, which the project team tried to implement in the course of the pilot – IE3: *"we had to really look into, ok people this is the scope of the project what you're asking is actually out of scope […] we had to really look at what are most frequently asked questions and then put our into that, so that's maybe a challenge"* and *"the lot of feedback we had and just making sure that people are happy with the changes we made and making sure that the changes we do first or the changes that were mostly asked"*. However, those feedback evaluations were considered very time intensive – IE3: *"I think the biggest challenge […] was maybe I think my own challenge […] because we had like feedback forms and then I had two days to really get all the feedback together"*. This also led to the statement that working with the people and all the partners was quite challenging, especially regarding different working standards and expectations – IE2: *"the coach is used to use Google form, we have now Google form in our [pilot] that is not something, that is known for being very secure and save"*.

Interviewee 4 explained that the challenges during the 't Heerlens Heitje pilot evolved in a way that it is most difficult to integrate additional features into the pilot, such as the teaming up function – IE4: *"but there was already a question from hey we are a football club and we've got 15 people volunteers, who really like to do"* and *"we are now implementing the teaming up function"*. Moreover, as the project team plans to go more decentralized, involving the citizens more is part of the new challenges – IE4: "*trying to get*

more input out of […] the city, out of the citizen" and *"then the municipality is […] really like decentralized and still you get some kind of […] consensus within […] those neighborhoods"*.

Interviewee 5 (Financial Emergency Brake (Red Button)) did not talk about additional and evolved challenges in the pilot implementation process.

When talking about the downsides of blockchain, Interviewee 6 (Stadjerspas) again mentioned blockchain characteristics in relation to the implementation challenges. First, the immutable nature of blockchain was a challenge in relation to mistakes happening on the citizen side (e.g. during filling in an application) as well as mistakes in the transaction system (e.g. double bookings) (see Interview 6). Here, especially a trained blockchain could cause problems, if it develops its transactions in another direction than the project team wants it to go – IE6: *"when it comes to a true blockchain platform […] there's like a self-management part of it, which really works in certain ways but if the blockchain system goes left and you want it to go right"*. Second, the decentral system might not be the best fit in this case – IE6: "*blockchain is a decentral system, which basically has no majority power but there is no need to have that specific well feature when it comes to municipal servers, there is explicitly in municipal services, one entity which has all the power and it's the municipality, so why would you want a system that basically takes the power away"*. Third, as the Stadjerspas is now based on a central database, the biggest challenge and the major reason for changing away from blockchain was the increase of blockchain efficiency but constant fees paid to the 3rd party contractor – IE6: *"the costs blockchain got significantly […] one of the things that happens […] when the technology gets developing, was that the system got more efficient and so writing transactions became cheaper but we had flat fee so we paid like 2.5€ […] per transaction"*. Last, it was suggested that blockchain might be more suited for general transactions and smart contracts than public services – IE6: *"blockchain could be useful in certain situations it's more on the business side of transactional services then on the governmental"*.

6.8 Overcoming Challenges

In order to overcome the implementation challenges, the Healthy on the Blockchain (Fit4Work) pilot team constantly improved their blockchain, as well as the related fitness app and adapted to the feedback of the participants – IE2: *"all the feedback that we could,*

implement like adding graphs, like adding a second reminder" and *"blockchain, improvements to raise, privacy and security, so from both sides"* and *"the amount of feedback that we got from the test group an reworked the app to a better product"*.

In case of the 't Heerlens Heitje pilot, Interviewee 4 had three strategies to overcome the challenges. First, asking superiors for help – IE4: *"you'll go around their backs for example and just ok if my manager says it can't be done then I go to the manager of my manager and said hey I have a problem with my manager and think it can be done"*. Second, to not take 'no' for an answer and push through – IE4: *"don't take no for an answer"* and *"just push through"*. Third, to implement and promote teamwork and positive team attitude – IE4: *"that whole spirit is it's in me and it's also in my team and that makes us maybe unique"* and "*me and also my team we are really like pushing this thing forward we all believe in this project"*.

Interviewee 5 focused a lot on explaining and demonstrating the Financial Emergency Brake (Red Button) pilot in order to overcome the challenges – IE5: *"we gave a lot of demos" and "we talked a lot about it"*. Additionally, they involved different partners and experts in their progress – IE5: *"talked with experts about what we did what would be in next phase"* and *"scaled up in partners we are working together with"* and *"got parties involved, who looked at this solution from a completely different perspective and brought in new […] ideas and new values"*. Lastly, they tried to learn as much as possible from their process and adjust and improve their pilot: *"learning starting with new, getting new ideas that is a continuous flow of learning"* and *"proving detecting, searching for what kind of business process improvements or adjustments"* and *"then we learned again"*.

When asking, Interviewee 1 and Interviewee 6 (Stadjerspas) did not mention any specific strategies or advice on how they have overcome their pilot implementation challenges. This relates to the statement of Interviewee 1, that they did not encounter any challenges.

6.9 Do Anything Different?

When answering the question if they would do anything different when implementing the pilot again, Interviewee 3 (Healthy on the Blockchain (Fit4Work)) stated that the focus should less be on technology, for example, workouts should be integrated more physically and socially – IE3: *"I think […] if we would do a second pilot and the corona measures said*

like you can do this, then we would more do physical meetings with people because I really missed the physical aspect" and *"for some aspects of a project technology isn't the answer"*. Interviewee 2 mentioned that a shorter test period for testing the technology would be sufficient – IE2: *"test period of twelve weeks is way too long"*.

Interviewee 4 ('t Heerlens Heitje) stated that the focus should be set on taking more risks and fixing problems later, if the pilot would be started again – IE4: *"we could have come in a lot of trouble but on the other hand, we got the project up and running maybe a year earlier than now"*, *"just launch before you're ready"* and *"fix the things later"* and *"just go for it"*.

If the Financial Emergency Brake (Red Button) pilot would be developed and implemented from the start again, the focus should be made clearer – IE5: *"I would like to have us had more focus"*. Additionally, more people with a clear focus should be involved – IE5: *"more people with focus working on this, I think then we could have reached learning points at a fast speed"*.

Regarding the Stadjerspas implementation, Interviewee 6 explained that sometimes being the second to implement a new technology could help save time and costs – IE6: *"maybe you're better off as a public agency to always lag behind a bit and don't be the first one to try […] as a municipality you better just wait it out a bit, see how it goes and then maybe tag along the bandwagon than to be the first to get in because then I think a lot of investments were lost because of that"*. Further, the interviewees stated, that the question for why using blockchain should be clear as blockchain is not a goal but just a tool – IE6: *"you should always start with why"* and in the case of this pilot, the why wasn't clear – IE6: *"we kind of identified that blockchain was hot, but we weren't sure why"*.

6.10 Advice for Blockchain Pilots

All interviewees were asked, if they had any advice for other blockchain enthusiasts implementing blockchain in the public sector. This advice will be based on the individual interviewee's answers, as well as their answers to overcoming the challenges and doing anything different the next time.

Interviewee 1 (Stadjerspas) gave the advice to ask other people for help – IE1: *"got some advices is from people and I asked about the risks and so I wanted to be sure about the risks and there seems to be no risk"*. In addition, when trying to launch a blockchain pilot, it should be kept in mind, that blockchain should not be the goal, just a tool – IE1: "*blockchain is not a goal, it's not a purpose, it's just to mean"*, *"it worked well, but it's not a necessary tool"* and *"it's an important tool […] but you have to always to have the view about goals and tools […] but it's not a necessary tool"*.

Interviewee 2 (Healthy on the Blockchain (Fit4Work)) stated six pieces of advice. First, project teams should connect to other projects and get to know other technologies – IE2: *"I really want to learn more about […] the other pilots […] as well [as] the technology behind it"*. Second, the project team should be led by a strong project leader – IE2: *"you need a strong, projects leads in public sector about blockchain"* and "*this person has to support blockchain innovation and that's the message"*. Third, in that context, teamwork is important – IE2: *"you can work as a team"* and fourth, listening to those team members and other peoples ideas is advisable – IE2: *"the people in the public sector I think that they have a lot of good ideas what can be better and then […] the first step is really to be open to capture those ideas"*. Fifth, trying is important or a project team might never make any progress – IE2: *"there are lot of things just to say about this pilot and what we could done better but as long as you do not do it, you do not know it"*. Last, managing expectations with stakeholders and users should be a priority (see Interview 2).

For Interviewee 3 (Healthy on the Blockchain (Fit4Work)), the target group is an important factor, when implementing a blockchain pilot. Therefore, getting to know the target group – IE3: *"you have to really get into your target group and know what motivates them"* and knowing how to incentivize and motivate them is important – IE3: *"people also said [for] the pilot […] we would add competitive part also to the fit4work challenge"*. In addition, the timing of introducing blockchain to participants and users is crucial and should be considered carefully – IE3: *"make sure that you enter this blockchain in the right phase"*.

When implementing a blockchain pilot, team members and their attitude is the most important factor says Interviewee 4 ('t Heerlens Heitje). It is stated that everyone should believe in their work – IE4: *"me and also my team […] we all believe in this project"* and

"you have to believe in it". Furthermore, instead of waiting, project teams should just go for it and push their solution – IE4: *"just go for it"* and *"be a bit more naughty just ******* go for it"* and *"me and also a couple of team members are always push forward"*. Thereby, consequences can be risked in order to drive the experimentation – IE4: *"we could have come in a lot of trouble but on the other hand, we got the project up and running maybe a year earlier than now"*. Moreover, launching before you are ready, a lot of testing and fixing problems later are additional advice – IE4: *"fix the things later"*, *"just launch before you're ready"* and *"test the **** out of it"*. Overall, project teams need to convince decision makers and make them believe in the pilot as well – IE4: *"just make your proof of concept worthwhile"* and *"if you just know that blockchain is […] a real solution for the project or for the problems that the municipality or the local government faces, then make the people who […] have to decide […] believe in what the power of the blockchain is and what it can do and how it can help"* and *"if someone says it can't be done, just prove them wrong"*.

Interviewee 5 (Financial Emergency Brake (Red Button)) gave the advice to not be disappointed with the implementation speed – IE5: *"don't be disappointed when things are not going as fast as you would like"*. Here, the network is highlighted – IE5: *"work hard on your network"* and should be used to connect to all kinds of experts – IE5: *"use your Twitter or what sources on the network in your socials to get acquainted with the experts on this field and not only the technical experts but also the regulator experts"*. Ideas should be shared – IE5: *"be very curious and sharing your ideas"*, which could be done in form of blockchain projects – IE5: *"BLING is in that respect very valuable for us"*.

Interviewee 6 (Stadjerspas) emphasizes how important it is to define the 'why' before implementing a pilot – IE6: *"you should always start with why"* and that not explicitly looking at blockchain for a solution could lead to finding it in the process – IE6: *"you maybe just don't look for it, if you're looking for a solution for a problem and down the line you find blockchain, then it's fine but don't start with 'we're gonna solve it with blockchain'"*, thereby highlighting how important it could be to look at all options – IE6: "*really look at all your options"*. Further, as the kind of public sector plays an important factor in how successful a blockchain implementation could be, matching the blockchain advantages with the specific goals could be helpful – IE6: *"you really have to look for you really have to match the specific advantages to the goals you wanna achieve"*.

6.11 Biggest Implementation Challenges in the European Public Sector

The additional interview question about the biggest blockchain implementation challenges in the European public sector was only asked during the course of three interviews (Interview 2, Interview 3 and Interview 5). Interviewee 5 stated that standardization might be the biggest challenges when implementing blockchain at the moment – IE5: *"Standardization in the European perspective and most, maybe even in a world perspective"*. Interviewee 2 mentioned building a strong blockchain ecosystem – IE2: *"you have to have a really strong ecosystem with convinced blockchain or innovation, people on board"*, the internal ICT structure of public sector organizations – IE2: *"you have so many hurdles, like the internal ICT"*, the bureaucracy – IE2: *"different, governmental layers and the dependency"* and the blockchain bias – IE2: *"well that we are completely blockchain biased of course"*. Interviewee 3 says the challenges mostly focus on getting approval for starting a pilot, getting people to work together and getting to the implementation phase – IE3: *"I think that's the main issue of a blockchain pilot I guess is getting everybody into the same track and giving and getting approval for everything"*.

6.12 Beneficial for Blockchain Implementation

During the course of the interviews, an additional theme revealed itself, as some of the pilots did have very low barriers and not a lot of challenges. To analyze this further, the theme *Beneficial for Blockchain Implementation* was added to the prior networks.

The two interviewees from the Healthy on the Blockchain (Fit 4Work) pilot talked about three different factors being beneficial for the implementation of blockchain. First, due to the current Covid-19 app discussions in Belgium, explaining GDPR and the benefits blockchain had in relation to it was easier – IE3: *"in Belgium we also had some things about GDPR because of the corona apps and stuff, so we really could use that kind of information because people already know what we were talking about"*. Second, being part of a blockchain project not only lead to knowledge exchanges with other partners – IE2: *"we learn a lot and it was very interesting and […] if we didn't have this project didn't have the pilot and we didn't know anything more so it's very good to have […] Interreg stimulating innovation and the North Sea Region"*, but also lowered the organizational barriers for a pilot, as supervisors were already aware of the blockchain technology – IE3: *"no because these political spocks and administrative spocks, they had to sign off on the BLING project*

one year ago so they already knew what we were going to do so I think [name] had to convince them a year before hand, so I didn't have to do a lot of convincing". Third, having the support and enthusiasm from their supervisors and stakeholders makes it easier to implement a pilot – IE2: *"for healthy on the blockchain, the stakeholders where on board, that's why we have this pilot now"* and – IE3: *"our administrative spock who is someone who is really into, he's also like his previous job was in ICT and consulting and stuff so he is really into that flow and he understands new technology so for him it's quite easy to understand and we don't have, yeah we have to do convince"*.

Interviewee 4 ('t Heerlens Heitje) believes that personal investment into the project, ambition for innovation – IE4: *"me and also a couple of team members are always push forward"* and *"you have to believe in it"*, as well as teamwork – IE4: *"think it can be done and that is, that whole spirit […] it's in me and it's also in my team and that makes us […] unique"* and attitude are beneficial for blockchain implementations – IE4: *"but me and also my team we are really like pushing this thing forward we all believe in this project"*.

During the implementation phases of the Financial Emergency Brake (Red Button), two factors were seen as beneficial for the implementation of the pilot, according to Interviewee 5. First, the membership and participation in a blockchain project, as well as the overall blockchain curiosity helped with the implementation and the funding of the project – IE5: *"oh what was easy […] to get money in, because I think until […] 2020 everybody was still curious about blockchain, so […] there was money available to put in this project"* and "*BLING is in that respect very valuable for us*". Second, passion about blockchain and the pilot project are important to implement a pilot – IE5: *"the willingness in the network, working with each other because we are all passionate about this solution"*.

For implementing the Stadjerspas, the hype and blockchain enthusiasm benefitted the implementation, as people were interested in the technology – IE6: *"at the moment there was blockchain hype, which went really deep a lot of people were like how we're going to use blockchain"* and – IE1: *"we had a lot of attention, public attention, because we work with this"*. In addition, the innovative and progressive mindset of the project leader led to a positive implementation – IE1: *"I personally am very fond of doing experiments"* and –

IE6: *“while he might be a bit old school, his thinking, I thought it was quite progressive, so that's why I also think that they didn't really have many problems”*.

Having explored the findings from the different interviews and already listed some of the different challenges encountered by the Interviewees, in the next chapter, the blockchain implementation challenges will be discussed and brought into relation with the findings from the literature review.

7 Blockchain Implementation Challenges

Having drawn the findings from the different interviews, this chapter will discuss the blockchain implementation hurdles. The discussion will be conducted by merging the findings from the interviews, especially downsides, initial hurdles and evolved / new challenges, as well as the findings from the literature review. All challenges will be sorted and thereby, structured into challenge categories formed in the thematic framework – Public Sector Organization Structure and Characteristics, Blockchain Technology Characteristics and Individual related challenges, adding an additional challenge category derived from the interviews – the blockchain hype. After the discussion of each challenge, the connected proposition will be declared as supported or not supported by the empirical data. As the number of interviewees was limited and their answers varied between their experiences, the statement (supported / not supported) will be declared, if interviewees named and described the challenge as part of their implementation process.

7.1 Institutional Challenges

Literature	Experts
•ICT infrastructure •hierarchies & limited decision-making power •bureaucracy •costs & limited budgets	•ICT infrastructure •convincing internal stakeholders •bureaucracy •building a blockchain ecosystem

Figure 7: Public Sector Organizational Structure and Characteristics Challenges, own illustration

Figure 7 shows the Public Sector Organizational Structure and Characteristics related challenges derived from the literature review (see also Thematic Framework) and the interviews. It can be observed that the challenges seem quite similar. Three of the challenges derived from the literature are also mentioned by the interviewees, while one new challenge was added by them. Further, costs and the limited budget seem to not be a challenge experienced by the interviewees when trying to implement their pilots.

Looking at the findings from the interviews and putting them in relation to the findings from the literature review, it can be observed that the ICT infrastructure of public sector organizations is named as a blockchain implementation challenge by both. Barcevičius et al. (2019) states that the public sector ICT infrastructure is outdated, which is confirmed by Interviewee 2 - IE2: *“you have so many hurdles, like the internal ICT”*.

- **P1.1:** *An outdated ICT infrastructure negatively influences the implementation of blockchain in the public sector.* → Supported

While the literature focusses on hierarchies and the limited decision-making power of public sector employees as an implementation challenge (cf. Arundel, Casali & Hollanders, 2015, p.1272), the interviewees named the process of convincing internal stakeholders and getting approval for their blockchain pilots as one of the biggest challenges, when trying to implement blockchain in the European public sector – IE3: *"I think that's the main issue of a blockchain pilot I guess is getting everybody into the same track and giving and getting approval for everything".* In addition, the interviewees have mentioned that convincing and explaining to stakeholders that blockchain is the best solution for their problem is a challenge – IE5: *"very hard to explain to people why this is […] the main solution we are working right now […] why blockchain"*. Furthermore, the possibility that municipalities are not really open and eager to experiment (see Interview 1 and 7) adds to the challenges of implementing blockchain as a possible solution. Therefore, Interviewee 3 suggests that it is important to convincingly sell the project to the organization to get their approval (see Interview 3). However, that statement included the project not the specific pilot. Interviewee 3 stated that the participation within the blockchain project started before the implementation of the pilot, hinting towards an earlier convincing process and getting approval for the specific pilot rather easy – IE3: *"I think [name] had to convince them a year before hand, so I […] didn't have to do a lot of convincing"*.

In addition to convincing the internal stakeholders, the interviewees named building a strong blockchain ecosystem as a challenge when trying to implement blockchain in their organization. Interviewee 2 states that one of the most difficult parts of getting a pilot running is to convince all partners involved, acquiring external knowledge as well (see Interview 2). Getting external knowledge is also mentioned as an important factor (see Interview 5). Moreover, while working with the partners, it can be challenging to adapt to their working routines and standards, especially in the technological field, when different kinds of technologies and programs are used (see Interview 2).

- **P1.2:** *Hierarchical barriers negatively influence the implementation of blockchain in the public sector.* → Supported

Vigoda-Gadot et al. (2008) state that innovation is often defeated by classic bureaucratic models of the public sector (cf. Vigoda-Gadot et al., 2008, p.307). Interviewee 2 agrees with that statement and mentions the *"different, governmental layers and the dependency"* as a challenging factor in implementing blockchain in the public sector. Here, Interviewee 4 suggests that governments generally might prefer a slower but in their opinion eventually saver way of facilitating innovation.

- **P1.3:** *A high level of bureaucracy negatively influences the implementation of blockchain in the public sector.* → Supported

While costs and a limited budget of public sector organizations was mentioned as an innovation barrier for technologies implemented in those organizations, costs were not mentioned as one of the main challenges hindering blockchain implementation. Only Interviewee 6 states that the non-decreasing costs of running the blockchain, even though the efficiency of the blockchain increased significantly, were a factor in abandoning blockchain in the end – IE6: *"the system got more efficient and so writing transactions became cheaper but we had flat fee so we paid like 2.5€ for per transaction"*. However, this was also due to their third-party contract, which had a fixed fee pert transaction, not taking into consideration any efficiency increase by the blockchain.

- **P1.4:** *High costs and a fixed budget negatively influence the implementation of blockchain in the public sector.* → Not Supported

Overall, **Proposition 1:** *Structural barriers negatively influence the implementation and experimentation process of blockchain in public sector institutions*, can be supported. The interviewees name convincing stakeholders as well as building a strong blockchain ecosystem as one of the main challenges when trying to implement blockchain in their organizations. However, especially regarding the challenge of costs mentioned as a barrier for innovation in the literature review, it has to be mentioned that the pilots are all (at least partially) funded by Interreg. Therefore, it cannot be fully ruled out that costs of innovation are a challenge for implementing blockchain in the European public sector.

Moreover, this gives room for forming a new proposition. As some of the interviewees did not encounter a lot of organization related challenges, with Interviewee 1 even stating that

"we didn't have any implementation challenges", it could be questioned if being part of an Interreg project actually lowers their implementation barriers. The prior discussion shows that even though the interviewees had to convince their stakeholders, not all of them were struggling with getting approval for their pilot (see Interview 3). In addition, the costs of development and generally the pilot approach are partially funded by Interreg, making this factor less dependable. Interviewee 3 also mentions that the supervisor had to convince the organization to participate in the project one years prior and thereby, evened the path of getting approval for the specific pilot (see Interview 3). Even though this proposition cannot be supported during this study, it might be interesting to keep it in mind for future research.

7.2 Technological Challenges

Literature	Experts
•technological maturity •decentral authority •immutability •limited scalability	•creating a secure blockchain •decentral system & authority •immutability •making the blockchain GDPR proof •developing a bockchain that works for the pilot

Figure 8: Blockchain Technology Characteristics Challenges, own illustration

When looking at the blockchain technology characteristic related challenges were found during the interviews and the literature review. It can be seen that only the decentral as well as the immutable nature of blockchain are named by both (see Figure 8). While the literature mentions the maturity of the blockchain technology (cf. Aristidou & Marcou, 2019, pp.296) and its limited scalability (cf. Batubara, Ubacht & Janssen, 2018, p.6) as a challenge, the interviewees had more problems with creating a secure blockchain, making it GDPR proof and ultimately developing and maintaining the blockchain for their pilot.

Aristidou and Marcou (2019) argued that the fit between the decentral blockchain and the central public sector system might not be the best working, especially with the blockchain systems used at the moment (cf. Aristidou & Marcou, 2019, pp.293-294). Interviewee 6 agrees with that thought by stating *"blockchain is a decentral system, which basically has no majority power but there is no need to have that specific well feature when it comes to municipal servers, there is explicitly in municipal services, one entity which has all the power and it's the municipality, so why would you want a system that basically takes the power*

away". This statement strongly adds to the proposition that the decentral nature of blockchain might challenge a successful implementation in the public sector.

- **P2.2:** *The decentral nature of blockchain negatively influences the implementation of blockchain in the public sector*. → Supported

Another key characteristic of blockchain, immutability, was mentioned as a challenge by the interviewees. The problem is that in municipal and generally public sector environments, mistakes are always possible – IE6: *"in municipal services, related to citizens is that there is almost no application or service, where you never have to do […] a rollback".* In central databases, it is no problem erasing data (see Interview 4) but in blockchain a transaction cannot be taken back or deleted. Ølnes & Jansen (2018) also mentioned immutability as a challenge for implementing blockchain, as they make the remark that it is not unusual that public records need to be changed or deleted (cf. Ølnes & Jansen, 2018, p.6) thereby, again challenging the fit between blockchain and public sector use cases. Furthermore, Interviewee 6 raised concerns about the autonomy of a trained blockchain and the problem of not correcting any mistakes happening during those autonomous transactions – IE6: *"when it comes to a true blockchain platform […] there's like a self-management part of it, which really works in certain ways but if the blockchain system goes left and you want it to go right"*.

The immutability also causes challenges regarding the European GDPR. Even though the interviewees did not mention GDPR as a direct challenge, it was often mentioned as an additional factor during the development and implementation to make the blockchain GDPR proof – IE6: *"make it GDPR compliant legal people have looked into it"*. Moreover, as data, which is once on the blockchain cannot be removed, Interviewee 4 added that it was a challenge to create the right characteristics and requirements to go around that problem – IE4: *"here in the Netherlands, also got our own Social Security numbers and that's like a really hard thing with […] GDPR because we cannot just collect them because it's yeah it's some say it's privacy and we cannot use those numbers, so that was a bit tricky"*.

- **P2.3:** *The immutable nature of blockchain negatively influences the implementation of blockchain in the public sector*. → Supported

More challenges could be discovered in the developing, improving and maintaining process of the interviewees pilots. In this context, challenges such as translating necessary information into a transaction claim, adding more features to the pilot app, evaluating feedback and implementing all necessary nodes in the network were mentioned. Berryhill, Bourgery and Hanson (2018) already stated that apart from the ICT infrastructure, the creation of the right blockchain for a public sector use case can be difficult (cf. Berryhill, Bourgery & Hanson, 2018, p.30). Moreover, for the interviewees, creating a secure blockchain and ensuring the overall safety of the information stored on the blockchain was one of the main challenges in relation to the blockchain technology characteristics – IE2: *"difficult before and after blockchain, because there are a lot of technical connections and steps and then you can make your blockchain as secure and as good as and robust as possible"*. This is especially relevant in the public sector context, as Interviewee 4 and Interviewee 5 mentioned, security is especially important for government institutions and all their projects (see Interview 4 and Interview 5).

Overall, it was stated that technology related issues were one of the main challenges when developing but also implementing and maintaining the pilot – IE3: *"blockchain that was the main difficulty"* and *"main challenges within the project were technical"*. Therefore, **Proposition 2:** *Blockchain characteristics negatively influence the implementation of blockchain in the public sector* can be declared supported. The decentral and the immutable nature of blockchain networks are making is challenging to implement blockchain in the European public sector, as those organizations are based on central authority and changing public records. **P2.1:** *The immature nature of blockchain negatively influences its implementation in the public sector*[20] and **P2.4:** *The limited scalability of blockchain negatively influences the implementation of blockchain in the public sector* can be declared as not supported at this moment, as interviewees had no experience with that.

[20] A possible relation could be drawn between the blockchain hype and the immaturity of the technology leading to many misconceptions. Further research is needed.

7.3 Individual Related Challenges

Literature	Experts
•mistrust & privacy concerns •technological knowledge & understanding of the blockchain •hesitant adaptation behavior of new technologies	•mistrust, esp. due to Bitcoin controversy •technological knowledge & understanding of the blockchain by outsiders •hesitant adaptation behavior of new technologies

Figure 9: Individual Related Challenges, own illustration

The Individual related challenges describe how behavior or emotion of the targeted user group can influence the implementation of blockchain in the European public sector. It can already be seen in Figure 9 that the challenges related to individuals are described similarly between the literature and the interviewed experts.

Paulavičius et al. (2019) stated that that the concerns about privacy, anonymity and security decrease citizens trust in blockchain (cf. Paulavičius et al., 2019, p.741) and thereby, challenge the implementation. Interviewee 5 agrees with that statement and claims that blockchain is a "distrusted new technique" (see Interview 5). Moreover, the controversy around bitcoin and other cryptocurrency, negatively influences the trust in blockchain, while also lowering the willingness to use blockchain in public sector organizations – IE5*: "all the stuff, which is going on Bitcoin, on blockchain, it doesn't help at this moment, because everybody is trying to kill blockchain or to kill Bitcoin or to kill crypto"*. This can be seen as a critical factor, as citizens and public sector institutions first have to find trust the blockchain technology, its security and benefits. Tackling this digital trust challenge mentioned by Berryhill, Bourgery and Hanson (2018) is crucial for overcoming mistrust and building trust in the technology (cf. Berryhill, Bourgery & Hanson, 2018, p.31).

In context of blockchain controversies, Interviewee 6 added the blockchain hype and overenthusiasm as an implementation challenge – IE6: *"at the moment there was blockchain hype, which went really deep a lot of people were like how we're going to use blockchain but actually had no idea what it was and what it was doing"*. This hype led to many blockchain projects and trials but without a real goal or purpose. With the dying down of the hype, the public sector organizations lost interest in experimenting and this false reputation, which was created through the blockchain use cases without purposes stayed, especially when the controversies around Bitcoin got more – IE6: *"blockchain had a big false start in Europe with the hype, which came with Bitcoin"*. This is described by

Interviewee 2 as a blockchain bias, which exists in public sector organizations and people's minds (see Interview 2).

- **P3.1:** *Mistrust in blockchain negatively influences the implementation of blockchain in the public sector.* → Supported

Rossi et al. (2019) stated that people fear the transparency a blockchain provides and do not trust or understand the characteristic of providing anonymity (cf. Rossi et al., 2019, p.1395). The interviewees did not mention the people's view on this matter during the interviews. However, Interviewee 5 stated that it was difficult for them to explain the blockchain to people who were not technically ready and involved – IE5: *"the main things we are encountering now is […] the difficulty to explain it to people who are not technically ready for it"*. Interviewee 3 added that they had to be very cautious about the timing of introducing blockchain as part of their pilot, as they feared to scare people away with too much information on such a complex technology – IE3: *"we can't really talk about blockchain because people won't understand, and people will be afraid"*. However, regarding the targeted user group, it might not even be necessary to educate them about blockchain, as most end users do not really know or care, which technology is behind the app or service (cf. Lindman et al., 2020, p.23). It is rather necessary to have the developers and people responsible for approving the implementation on board and educate them on possible problems (see Interview 4).

- **P3.2:** *A lack of knowledge about (blockchain) technology negatively influences the implementation of blockchain in the public sector*. → Indistinctive

Al-Hujran (2015) shares that the adaptation behavior for blockchain and all kinds of new technologies is often hesitant rather than optimistic (cf. Al-Hujran, 2015, p.190). This was also discovered in the context of this study – IE3: *"a lot of people don't really like new stuff"* and IE6: *"I think that comes mostly with every implementation when something is new, people don't really are cheering, that they have to learn something new".*

- **P3.3:** *A hesitant adaptation behavior regarding new technologies negatively influences the implementation of blockchain in the public sector*. → Supported

The study has shown that especially the mistrust in regard to blockchain, connected to the lacking knowledge about the technology challenges the implementation of blockchain pilots. Therefore, **Proposition 3:** *Person related conditions negatively influence the implementation of blockchain in the public sector* can be partially supported, as P.3.2 could not be clearly declared supported or not supported with the data derived from the interviews. However, just as in the previous chapter, a new proposition for future research in regard to the blockchain hypes influence on the mistrust of people and thereby, a challenge in the implementation could be formulated. In addition, there needs to be further investigation regarding the blockchain knowledge and its influence on pilot implementation in the European public sector.

8 Managerial Implications and Strategic Recommendations

The interviewees shared their implementation process and how they worked on overcoming challenges during the process in the interview. Therefore, this chapter will take those interview findings, combine them with suggestions from the literature and develop managerial and strategic recommendations for implementing blockchain pilots in the European public sector. This is based on the steps portrayed in Figure 10. Those steps do not portray a detailed instruction on how to successfully implement a blockchain pilot but state important strategic advice for actions that should be taken and followed in the implementation process in order to increase the possibility of a successful implementation.

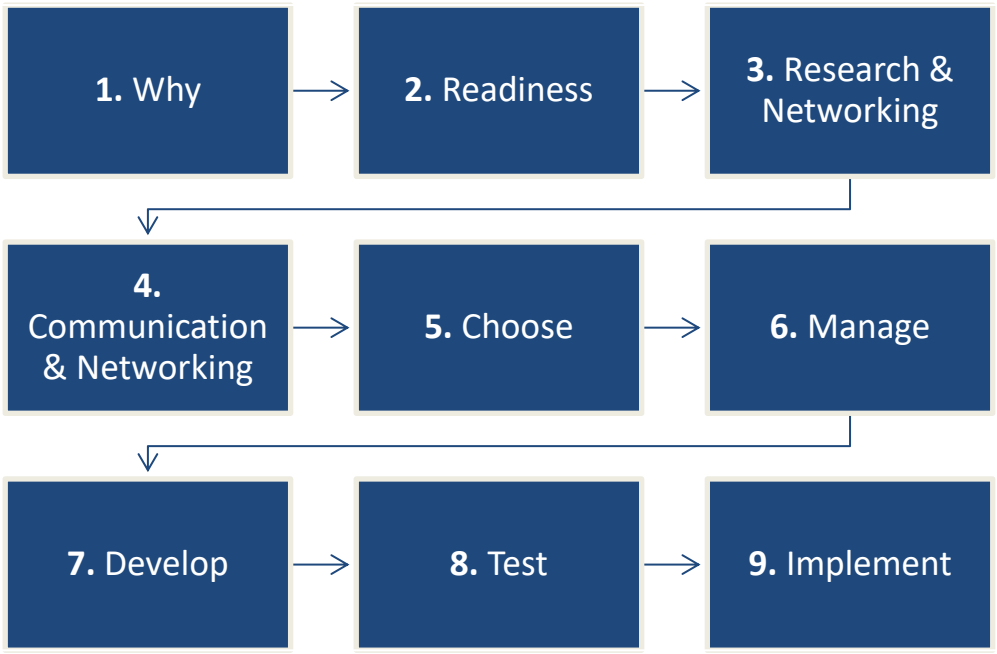

Figure 10: Steps for successfully implementing blockchain pilots in the European public sector

In the beginning of a blockchain pilot, the most important step is to define the **'why'**, by setting strategy and goals. Why is a blockchain solution the best solution and why can the societal problem the solution is supposed to tackle be solved best by utilizing the blockchain technology? Interviewee 6 states that, if the 'why' is not clear, the probability of the pilot failing or not starting at all, might be higher (see Interview 6). Therefore, the advice is given to not specifically start with searching for a blockchain solution but starting with the societal problem and looking at different ways of solving it. If blockchain turns out to be one of those solutions, that should be explored. If after careful evaluation, blockchain turns out to be the best solution, it should be used. In this case, the process of searching for fitting solutions will deliver the explicit reasons of 'why blockchain is the best way to solve the problem'. Interviewee 1 adds that blockchain itself should never be the reason

for a pilot but rather a tool to achieve a problem-solving pilot – IE1: *"blockchain is not a goal, it's not a purpose, it's just to mean"*.

In a second step, the **readiness** for blockchain should be explored – of the organization but also of the people potentially involved in the pilot. Regarding the ICT infrastructure, necessary preparations or improvements for a blockchain implementation need to be discovered and analyzed. There are tools and models available, which can help organizations to assess their ICT infrastructure and their blockchain readiness, e.g. the Blockchain Readiness Assessment Tool developed by the University of Gothenburg (cf. BLING, 2020). Regarding the stakeholders, it should be investigated how their acceptance of new technology is and how it is motivated. Interviewee 2 and Interviewee 3 add that having the supervisors and other stakeholders is a big advantage when implementing a blockchain pilot (see Interview 3). Especially, people higher up the hierarchy, who are interested in technology and are open to new approaches are beneficial for the implementation (see Interview 2).

In the next step, it should be **researched**, if other blockchain pilots with similar problems and solutions exist already. Gaining knowledge and especially benefitting from other knowledge but also exchaning knowledge is a huge benefit, when working with a still new technology like blockchain. People in the blockchain world want to further develop the technology and when sharing knowledge, everybody can benefit from the ideas and experiences (see Interview 2 and Interview 5). The resulting **networks** can benefit and ease the development but also implementation process. Especially, when problems occur, advice from experts in the network can help overcome the challenges (see Interview 2). Here, it can be extra beneficial, if the organization is able to join a blockchain related project. Participating in such a project not only automatically establishes a network of blockchain enthusiasts, which can exchange their ideas, but also cost might be partially funded and skills could be exchanged in closer cooperation of different organizations. An additional benefit of participating in a blockchain project was stated by Interviewee 3, as the process of getting approval for their specific pilot was easy and fast, as the convincing was done in order to get the organization to participate in the project (see Interview 3).

Carefully **communicating** and presenting the pilot to the organization can be done parallel to **connecting** to other blockchain pilot experts. Interviewee 5 mentioned in the interview that most of the work the project team did was explaining, demonstrating and proofing the pilot and its possible benefits (see Interview 5). The reasons for blockchain should be highlighted and a suitable method of educating non-technical people about blockchain should be found. Here, Interviewee 3 states that the timing of introducing blockchain plays and important role in the presentation process as well (see Interview 3). Blockchain is such a complex theme and the bitcoin controversy did not help its reputation. Therefore, the problem and the solution at the center of the pilot should be the focus and blockchain should only play a side role. Lastly, managing the expectations of stakeholders before and during the process of the pilot development and implementation is important, so that no misunderstandings or misconceptions arise and challenge the implementation (see Interview 2).

An important step before starting to develop the blockchain is **choosing** the right kind of blockchain. Williams (2018) mentions that a lot of blockchain solutions in different forms and encryption settings exist, which means that an organization has to ensure that their chosen form fits the purpose of their pilot (cf. Williams, 2018). Organizations also have to consider, if they are able to create the blockchain themselves, hire a third party or find a cooperation partner who programs the blockchain with them. Interviewee 6 adds that also the kind of public sector plays an important role in what blockchain to use and how successful an implementation could be – IE6: *"you really have to look for you really have to match the specific advantages to the goals you wanna achieve"*.

In addition to choosing the right blockchain, the responsibilities regarding the pilot but also the blockchain **management** after the implementation should be established prior to development. Even though the public sector organization might ultimately be responsible for the blockchain pilot, the responsibilities and tasks of all stakeholders involved in the pilot project need to be defined (cf. Navadkar, Nighot & Wantmure, 2018, p.2291). Here, the project leader plays an important role, as their enthusiasm and decisions define the course of the whole pilot – IE2: *"you need a strong, projects leads in public sector about blockchain"*. The project leader needs to be passionate about their pilot, believe in the solution and show ambition and personal investment, as he or she is responsible for

representing the pilot and the ideas behind it (see Interview 4 and Interview 2). Therefore, a project leader with an innovative and progressive mindset should be chosen, who is willing to eventually fight or push for an implementation of the pilot (see Interview 6 and Interview 4). Apart from the project leader, the team and the teamwork needs to be promoted to create a fruitful and positive team attitude (see Interview 2 and Interview 4). It is important that the project leader and the team work together and listen to each other's ideas but also criticize – IE2: *"the people in the public sector I think that they have a lot of good ideas what can be better and then […] the first step is really to be open to capture those ideas"*.

When the blockchain pilot is **developed**, it is important to be open for feedback and to making changes. The project partners of the Healthy on the Blockchain (fit4work) pilot in Roeselare had regular feedback sessions and continuously developed and improved the app connected with the blockchain pilot (see Interview 2). Adapting and reworking are part of creating a technological solution. Therefore, the before built network and possible partnerships should be used to get more insights and ideas during the development process (see Interview 5). Here again, Interviewee 2 and Interviewee 3 used the method of having regular feedback sessions and questionnaires to gain insights from their participants.

When **testing** the pilot, it needs to be clearly explored, if the blockchain solution and the problem fit. Interviewee 5 advises to learn as much as possible from every test or implementation and use those learnings to ultimately improve the pilot (see Interview 5). Here, there is no shame in failing at the first attempt, because without trying no process could be made at all (see Interview 2). Therefore, Interviewee 4 states that sometimes implementing before being ready might be a good approach as well, while it is generally important to not take no for an answer and continue pushing the pilot, if the team is certain and confident about the blockchain solutions fit for the problem (see Interview 4).

Lastly, while **implementing** the blockchain pilot, patience is key – IE5: *"don't be disappointed when things are not going as fast as you would like"*. Especially, if many stakeholders are involved in the process, the implementation could take time. Here, education about blockchain and the pilot could again be beneficial (see Interview 3), especially when end users are involved in the adaptation process (cf. Navadkar, Nighot &

Wantmure, 2018, p.2291). At this point, involving partners from the network and other experts is again advisable, as they can provide different perspectives and bring their advice on certain solutions (see Interview 5).

9 Conclusion and Critical Reflection

9.1 Summary

Blockchain is a decentral system, storing and facilitating transactions (cf. Beck, Müller-Bloch & King, 2018, p.1020). The system is claimed to be more secure that central databases (cf. Nofer et al., 2017, p.184), as the transactions are stored decentral (cf. Aristidou & Marcou, 2019, pp.293-294) and every transaction made is immutable (cf. Angelis & da Silva, 2018, p.305). Over the last years, many applications, different types of blockchain and new systems have been developed, offering different benefits to businesses, organizations and private persons all over the world (cf. Casino, Dasaklis & Patsakisa, 2019, p.68). However, an implementation of blockchain could also be related to challenges (cf. Yli-Huumo et al., 2016, pp.3-4). Especially in organizations, where a central authority is needed to confirm or authorize certain steps and transactions, implementing the decentral database could be a challenge (cf. Aristidou & Marcou, 2019, pp.293-294).

A central authority is the underlying system of the European public sector (cf. Yli-Huumo et al., 2016, p.1). Decisions are mostly made in a top-down approach (cf. Arundel, Casali & Hollanders, 2015, p.1272) and the innovativeness of such organizations is often questioned and criticized (cf. Barcevičius et al., 2019, pp.56-63). Therefore, it could be expected that implementing a revolutionizing technology such as blockchain (cf. Underwood, 2016, p.15) in a public sector environment poses several challenges (e.g. Berryhill, Bourgery & Hanson, 2018, p.29) but could also bring many benefits to the citizens (cf. e.g. Ølnes, Ubacht & Janssen, 2017, pp.359-360; Lindman et al., 2020, p.35).

Regarding the research question *“What challenges do local European administrations face when implementing blockchain in the municipal public sector?”, t*his Thesis has shown that the implementation of blockchain in the European public sector is connected to many different challenges. Those challenges can be found in three main areas – the public sector organization, the blockchain technology and the personal bias towards new technologies. The general organizational structure of the public sector often negatively influences the implementation of blockchain and blockchains need to be developed carefully to make them fit with public sector needs. However, the individuals’ or personal influence on the implementation of blockchain might be the strongest driver but also challenge for a successful blockchain implementation. If a project leader and team is innovative and able

to drive a pilot with their ambition, other challenges, especially in regard to the organizational structure could be overcome more easily, leading to a more successful implementation. If the contrary is given, and the project leader and the project team themselves have trouble understanding and implementing blockchain, then other challenges related to the organizational structure or blockchain itself could become even bigger challenges.

However, even though those challenges exist and were discovered in the context of this thesis, most interviewees were able to overcome the posing challenges and described their implementation process without big challenges completely stopping their pilot. Therefore, it could be concluded that as those challenges might be known and partially experienced by local European administrations, when trying to implement blockchain pilots into their public sector organizations, those challenges do not have an imminent negative impact on the pilot. While this conclusion could be drawn in the context of this thesis, the author questions, if the participation in a blockchain project could have ultimately led to those results and lowered the implementation hurdles for the interviewed experts and their blockchain pilots.

9.2 Limitations

This Thesis and the results of the study can be limited on two levels, the theoretical methodology level and the study execution and results level. On the theoretical methodology level, the interview method of expert interviews to gather the data as well as the thematic analysis to examine the data have to be limited. On the study execution and result level, pilot, interviewee and data related limitations occur.

Even though interviewing experts provides in-depth knowledge and experiences, the interviewing method has its limitations. First, the interview questions could be biased, due to them being based on the literature review, and influence the answers of the interviewees. Even though the interview questions were carefully selected, especially the optional examples in the end could have influenced the interviewees in their questions. However, looking at their answers, they did not, as the answers varied a lot between the different interviewees giving no indication for a bias. Second, the openness of questions can lead to unstructured and a wide range of answers. Even though the same questions

were asked to the interviewees, the answers varied. This made it harder to find common challenges and to combine all the statements into clear answers for declaring the propositions as supported or not supported. Third, the selection of experts and their involvement with the project, pilot and their organization could bias the answers to the questions, as they could be cautious about what to say openly and what to keep enclosed within the project. In this study, only experts with implemented blockchain pilots were interviewed, excluding pilots who completely failed to being implemented or are not implemented, yet. In addition, only experts within Interreg projects were part of the study, which means that the circumstances regarding their implementation could vary from people who are trying to implement blockchain without being part of a blockchain project. However, having interviewed experts from the Stadjerspas, a pilot no longer running on blockchain, gave additional insights on "failed" implementation attempts. Overall, the expert interviews gave in-depth but focused insights on the implementation challenges, eventually neglecting challenges not in mind during the interview.

Limitations do also occur in regard to the thematic analysis. First of all, the main benefit, a thematic analysis provides in form of flexibility, can also pose challenges. The codes are developed very flexible, based on the data set. Themes created from those codes can therefore be very broad and different between the different data sets (cf. Nowell et al., 2017, p.3). However, in this Thesis this was prevented due to the theme creation based on the interview questions. Those themes gave an additional guideline for how the themes and the codes are constructed. Furthermore, the approach of the thematic analysis is phrase-based and sometimes, phrases cannot capture the whole meaning of what was said (cf. Javadi & Zarea, 2016, p.38). Generally, a limited amount of literature on thematic analysis defines the process of how to execute such an analysis, which could lead to execution problems, if the descriptions are not detailed enough (cf. Nowell et al., 2017, p.3, 11)

One of the biggest limitations in the process of collecting data for this thesis has to be seen in the limited number of interviews conducted and more importantly the limited number of blockchain pilots in the project environment. This Thesis was written as part of the Interreg project BLING. While on the one hand, the project participation meant having access to many different experts, the pilots and especially the number of implemented

pilots was low. Therefore, pilots from other Interreg projects were chosen to be interviewed in this study. However, even with the extension of the scope, the number of possible interviewees was still limited. In addition, some partners denied the interview request or did ultimately not fulfill all criteria. While the propositions were declared supported or not supported based on those answers, the low number of approving or verifying statements leads in this case to a verification of the propositions but it can be argued that those statements are representative. Overall, more data, in form of e.g. quantitative research or other interviews with experts further from the project environment, would be needed to fully understand the challenges derived from the literature and the interviews.

An additional challenge in that respect is that implementation phase is defined differently by each individual. Even though the author explained the concept and the selection criteria before the interviews, not all pilots were in similar stages of that process, which influenced the interviewees answers. Here, answers in regard to the implementation but more importantly on the challenges experienced during their process varied hard.

Even though this Thesis was conducted in a project environment, not all partners were open to participating in interviews or sharing their knowledge and experience with implementing a pilot. Additionally, some partners, who were responsible for the pilot implementation or generally responsible for the pilot of a project partner organization left the project and were not as easily accessible for interviews.

All limitations lead to the conclusion that the results of this study might help to further understand the blockchain implementation in the European public sector and the related challenges, but with the limited number of interviewees and the different statements they have given on their challenges, the results might not be representative for the whole field of European public sector blockchain pilots. However, as the BLING project will be running for around two more years and other projects might continue the pilots and research started in this field, additional findings might be collected during those years.

9.3 Further Research

Resulting from the scope and limitations, as well as the results of this study, new opportunities for future research can be developed. First of all, as a blockchain is not the

solution to all public sector problems (cf. Berryhill, Bourgery & Hanson, 2018, p.29) and the fit between blockchain, organization and problem is often determined by the specific blockchain solution created (cf. Aristidou & Marcou, 2019, pp.294), there needs to be more research into the specific needs and problems the public sector organizations can tackle. In addition, it needs to be specified in which particular form blockchain can help with understanding and solving those needs.

In addition, the focus in blockchain development and blockchain research needs to focus more on the 'why' behind the blockchain solution, rather than the technological side. Ølnes, Ubacht and Janssen (2017) state that blockchain pilots and solutions are technology driven rather than driven by the (societal) problems behind them. Therefore, they advise to change from technology-driven to need-driven approaches in working with and on blockchain pilots (cf. Ølnes, Ubacht & Janssen, 2017, p.362). This can also be seen in this thesis. The question of 'why' blockchain is often unanswered in the process of creating a pilot and the technology is the purpose in such cases. It needs to be further explored, why experts in the public sector use this attempt and do not start with 'why', in order to better understand the success or failure of blockchain pilots in the European public sector.

Furthermore, the study has opened the question, whether the participation in a blockchain, innovation or generally funded project could lower implementation barriers, especially organizational, as the organization already accepted the project. Therefore, a comparison or in-depth analysis between self-driven and project-driven blockchain solutions, as well as the exact circumstances of the planning, development and implementation of the pilots could give more insights into benefitting circumstances for a blockchain implementation.

Moreover, as many interviewees stated the blockchain hype as something that benefitted but also challenged the implementation process, in terms of e.g. lower trust or blockchain over enthusiasm, exploring the influence of the blockchain hype on people and organizations would help to further understand related challenges, especially in the personal context. Connecting with this would also be to further investigate the blockchain knowledge in the European public sector and its influence on pilot implementation.

Overall, there is still a limited number of blockchain pilots, applications and use cases present in the public sector, which could be researched and evaluated (cf. Lindman et al.,

2020, p.27). As blockchain is predicted to change the world as we know it (cf. Underwood, 2016, p.15), a focus should be set on systematically and structured exploring blockchain opportunities in a need-driven approach within the European public sector, to allow insights and benefits for all citizens.

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Appendix B: Pilot Descriptions

Pilot	EU Project	Implementation Field	Description	Phase / Maturity
Stadjerspas Groningen	LIKE!	Municipal Services	The Stadjerspas of the municipality Groningen is a voucher and discount system for low-income citizens and families. Citizens with an income below 120% of the normal social benefits can apply to get a Stadjerspass card. For family households that is an income of around 1.650€ and for single households, an income of 1.100€. In Groningen, around 23.000 people are eligible for a membership. Children, living at home, below the age of 18 are also included in the Stadjerspas. The Stadjerspass is supposed to help those citizens taking part in social activities, as they get discounts on many activities and articles in the city (by selected providers), as well as some free offers. In addition, members can shop for essential things for their children. Citizens who are eligible for the Stadjerspas can apply for a card, which has a personalized QR-code on the back. The municipality provides credit funds at certain partner shops so members can shop cheaper. When they buy something in a participating store, the store gets reimbursed for the discount by the municipality.	- Started in 1995 as a yearly booklet of vouchers. - The digital Stadjerspas in form of print-at-home vouchers via e-mail started in 2013. - The decision to use blockchain was made in 2015. - The blockchain based Stadjerspas was developed by a 3rd party blockchain company. - The blockchain based Stadjerspas ran from 2016 until the end of 2020.
Financial Emergency Brake **(Red Button)**	BLING	Municipal / Regional Services	In the Netherlands, the CJIB sends out fines, for e.g. speeding. If a citizen is in debt, those fines only make their situation worse and as they are not able to pay any fines added onto the fine for not paying, they could get into serious troubles. In the Netherlands, around 5% of the citizens are not able to pay their fines. Municipalities often know about people being in debt, but due to privacy regulations (GDPR), are not able to share that information with the CJIB. The Financial Emergency Brake (also called Red Button) uses blockchain, SSI and zero-knowledge proof, to help identifying people in debt, without sharing their personal information. Therefore, if citizens cannot pay a claim or fine, this pilot will let the CJIB know that it is not possible and in return, an agreement as to how the debt can be paid (in the future), can be made, which helps prevent debt problems from worsening. Additionally, aa algorithm call Debt Alert, was created, which can predict whether someone is at risk of either going into debt or being in debt.	- Blockchain was developed by Ledger Leopard in 2019. - TU Deft contributed to the development with their knowledge. - Pilot started in two different Dutch municipalities (proving worth). - Plan to go fully live after summer of 2021, but full implementation might take between 3 and 5 years

`t Heerlens Heitje	Blockstart	Municipal Services	`t Heerlens Heitje are based on the old Dutch practice of children going around in the neighborhood, asking for something to do (e.g. chores in the garden) and in return getting a few coins for their work. In the Dutch municipality Heerlen, citizens above the age of 21 can now contribute in the same manner to their neighborhood and environment. Using an App, citizens can claim local chores and additional instructions on them. Any needed tools for executing the job can be collected by the municipality. When the work is done, citizens can get local coins as a reward / payment (the work is checked by a local supervisor/municipal worker). The coins can only be spent in the city of Heerlen, by scanning a QR-code in the related app. At the moment, between 10 and 12 local shops accept the coins earned, with more and more shop owners asking to participate. For now, tasks can only be claimed individually by one citizen. The development team is working on implementing a teaming up function as well as making the pilot more decentralized. This should be achieved by letting citizens suggest and create tasks. Ultimately, the verification process of checking a task should also be done by citizens. With this pilot, Heerlen aims to tackle three challenges. First, the vacant city centers and bad economic situation of shop owners. Second, the problem of citizens not feeling connected to the city and missing participation possibilities. Third, the bad maintenance of public spaces, especially further away from the city center.	- Implemented in the municipality Heerlen in the Netherlands - Plans to expand to other Dutch municipalities
Healthy on the Blockchain **(Fit4Work)**	BLING	Health in the Office (Municipal Service)	Before Corona, the City of Roeselare offered their employees after work sports programs as part of their fit4work challenge. The related pilot Healthy on the Blockchain was planned by Roeselare and HOWEST, before the pandemic and related measures forbid the contact and group sports, but the pandemic actually helped them launch their pilot. The Healthy on the Blockchain pilot has 2 goals. First, raising awareness about data ownership and data privacy while using fitness wearables and apps on the Internet. Second, help people to stay active during lockdown and encourage them to maintain a healthy (physical and mental) lifestyle during their workday. During the pilot, participants were equipped with a wearable, measuring their sleep, heart rate and activity (e.g. steps).	- 12-week pilot started in March 2021. - Planning to start a second pilot based on Android.

			113 people were interested in participating. The project team used questionnaires, info sessions and conversations to reduce participants to the test group of 20. HOWEST created and maintained the iOS based fit4work app used to track the data collected by the fitness wearable. Both ran on a private blockchain, to which just the coach had access. Therefore, the pilot was GDPR proof. All participants had a personalized dashboard with their recent activity and data. They were also guided in their activity by personalized exercise videos. In the process of the pilot, the project team held continuous feedback sessions with the participants. Overall, the participants exercised more, felt energetic and learned something about nutrition and food. In the end, the project team got positive feedback and reached their goal of making the participants more aware of data on the internet.	

Table 3: Selected Pilots Description, own illustration