The Application of Blockchain Technology on Public Procurement in Sweden

- Implementational obstacles

Thesis for Bachelor's Degree in Informatics

Noah Boekelman
Birk Åkesson Norling
Johan Tin-Tin Qvam

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Authors: Noah Boekelman, Birk Åkesson Norling, Johan Tin-Tin Qvam

Mentor: Anders Hjalmarsson Jordanius

Abstract

The purpose of this paper is defined to research the obstacles that hamper the implementation of blockchain technology in Swedish procurement. The identification of a knowledge gap in prior research related to this field is uncovered by substantial literature research. Previous research in this area is mainly conducted with an orientation towards the implementational benefits and design or implementation examples This paper thereby leads to a fulfillment of the discovered knowledge gap and contributes to the field. The research question; *"What obstacles hamper the implementation of blockchain technology in the process of public procurement in Sweden?"* Exploration of this is conducted through a qualitative research study with a geographical limit set to the country of Sweden. The study is conducted with the use of four different perspectives that consists of professionals with expertise in different fields. Obstacles that could hamper the merger between blockchain technology and procurement are identified, both using categories that are defined in a cross-perspective environment and individual obstacle topics. Further research ideas are also presented suggesting future studies surrounding the obstacle dynamics of this study.

Sammanfattning

Syftet med denna studie är att undersöka vilka hinder som försvårar implementeringen av blockkedjeteknologi i svensk upphandling. Identifieringen av en kunskapslucka i tidigare forskning relaterad till detta område avslöjas av omfattande litteraturforskning. Tidigare studier bedrivs huvudsakligen med inriktning mot implementeringsfördelar och design- eller implementeringsexempel. Denna studie leder därmed till en uppfyllelse av den upptäckta kunskapsluckan och bidrar till området. Forskningsfrågan; "Vilka hinder försvårar implementeringen av blockkedjeteknologi i offentlig upphandling i Sverige?" Utforskning av detta sker genom en kvalitativ forskningsstudie med en geografisk gräns satt till landet Sverige. Studien genomförs med användning av fyra olika perspektiv som består av experter med bred kompetens inom sina respektive områden. Hinder som kan hämma sammanslagningen mellan blockkedjeteknologi och upphandling i Sverige identifieras, både med hjälp av kategorier som definieras i en tvärperspektivmiljö och som individuella hinderämnen. Ytterligare forskningsidéer presenteras och föreslår framtida studier kring hinderdynamiken i denna studie.

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Keywords and definitions

BCT - Blockchain Technology

Hamper - To prevent progress.

Decentralization - Decisions are made amongst many entities instead of one central authority.

Consensus - An agreement that is of general acceptance.

Nodes - Network participants.

Peer-to-Peer network - A group of computers that are linked together and each peer has the responsibility of processing and storing data.

Chainization - The process of creating a chain using blocks.

Upphandlingsmyndigheten - The National Agency for Public Procurement in Sweden.

TABLE OF CONTENTS

Introduction **9**
1.1 Opening statement 9
1.2 Research overview 9
1.3 Discussion of problems 11
1.4 Definition of given problems and purpose 11
1.5 Target audience 12

Method **13**
2.1 Research strategy 13
2.2 Sampling of respondents 14
2.3 Data collection 15
2.4 Data analysis 16
2.5 Ethical considerations 17

Theory **18**
3.1 What is Blockchain Technology? 18
3.1.1 Blockchain summary 18
3.1.2 The fundamentals of blockchain technology 19
3.1.3 Cryptography 20
3.1.4 Security 22
3.1.5 Smart contracts 26
3.1.6 Usability 26
3.2 What is Public Procurement? 28
3.2.1 The procurement process in Sweden 28
3.2.2 Preparation phase 29
3.2.3 Procurement phase 30
3.2.4 Realization phase 31
3.3 Theoretical Framework 33
3.3.1 Starting point 33
3.3.2 Knowledge gap and contribution 35
3.3.3 Qualitative research study 36

Analysis **38**
4.1 Grouping of statements 38
4.1.1 Technical perspective 38
4.1.2 Legal perspective 40
4.1.3 Procuring perspective 41
4.1.4 Tendering perspective 43
4.2 Categorization 44
4.2.1 Proof-of-Improving Concepts 45
4.2.2 Legal obstacles 45
4.2.3 Political Obstacles 46
4.2.4 Competence obstacles 46
4.2.5 Other 47

Results **48**
5.1 Categories 48
5.2 Category definition 49

5.3 Obstacle dynamics 49

Discussion **51**

6.1 Knowledge gap 51

6.2 Results compared to prior research 51

Conclusions and final statements **52**

7.2 Method reflections 52

7.3 Future research ideas 53

REFERENCES **54**

APPENDICES **58**

Appendix A - Interview Guide, Individual interviews 58

1. Introduction

The introduction chapter is constructed to help establish the subject area, the relevance of the subject, the creation of carefully delimited research questions, a purpose and a target audience. A knowledge gap and the possibility of knowledge contribution is identified as well.

1.1 Opening statement

The interest in blockchain technology (BCT) is increasing and big companies are exploring the technology and its capabilities. According to Browne (2022) the funding for blockchain start-ups has soared from $600 million in 2015 to $25,2 billion in 2021. Large investments are also being made from the public sector and the EU commission provided blockchain projects with €180 million from 2016-2019 through the programme Horizon Europe and wants to increase this to €400-500 million during the period beginning of 2020 to the beginning of 2021. (Shaping Europe's digital future 2022) In 2019, Swedish public procurement transactions amassed SEK 803 billion, with an increasing trend following years. This amounted to one-sixth of Sweden's GDP in 2019 and/or 80,000 SEK per Swedish citizen. (Konkurrensverket, 2021) With that being said, the interest in blockchain technology is increasing and public procurement in Sweden amounts to a substantial proportion of the Swedish economy.

Prior research is extensive and has discovered various possibilities and presents implementation based examples of the merger of blockchain technology and public procurement. Despite this, a discovery was made. There is a shortage of research that focuses on the implementation obstacles within the merger of blockchain and public procurement. There is also no empirical prior research conducted on the merger with Sweden as geographical delimitation. These two reasons are the key success factors that introduce this further exploration of the two domains under the undiscovered limitation and with obstacles as a focus.

1.2 Research overview

The prior research that presents and explores the merger between blockchain technology and public procurement will be introduced and summarized. When this is presented, any problems will be identified and examined.

In the paper (1) "Transparency And Accountability in Urban Public Procurement: Design of a Self-Sovereign Blockchain App" (Balan, Alboaie, Kourtit & Nijkamp 2020) the authors identify the use of blockchain in procurement within the functioning of smart city policy. This paper concludes blockchain technology may provide a more secure procurement procedure and counteract the false playing in public tendering. A visual representation in the form of a design is presented as evidence of this and as the beneficial artifact of a merger between these two domains.

Another study located in the Philippines titled (2) “Blockchain-based system evaluation: The effectiveness of blockchain on e-procurement” (Thio-ac, Serut, Torrejos, Rivo & Velasco 2019) implemented a blockchain based procurement platform. This platform was tested by several private entities on the basis of 4 different variables that were to be evaluated in a survey later given to the entities. These 4 variables; efficiency, responsiveness, safety and security, and aesthetics all concluded in overwhelmingly positive results.

In (3) “A Framework for the Adoption of Blockchain-Based e-Procurement Systems in the Public Sector A Case Study of Nigeria” (Akaba, Norta, Udokwu & Draheim 2020) the merger is explored in a Nigerian case study that is based on a real world implementation of blockchain technology on the public procurement procedure. The reason for this case study is to determine the enhancement of effectiveness, efficiency and transparency in public procurement. The authors argue that these weak points are caused by the current state of the procurement process that results in lack of transparency and trust, weak system structures, bad record keeping and documentation along with corruption.

The paper (4) “Permissioned blockchain based public procurement system” (Deshpande, Gowda, Dixit, Khubbar, Jayasri & Lokesh 2020) proposes a new public procurement system for India using a multi-organization blockchain network in the Hyperledger Fabric. The proposed system is made more transparent and secure with decentralized databases, automation and decentralization of the auction process, distributed control and validation of auction and monitoring improving the whole bidding process.

(5) “The Implementation of Decentralised Ledger Technologies for Public Procurement” (Nin Sánchez 2019) focuses on the possibilities of implementing blockchain technology in procurement, how this could be done and some possible legal challenges. Based on prior projects within the area of merging the two domains the paper states the promises of transparency, integrity, autonomy and an effective procurement process as a result of the technological implementation.

Another paper that focuses on the implementation of blockchain technology in the process of procurement is (6) “Blockchain Based Full Privacy Preserving Public Procurement”. (Baranwal 2020) The authors argue that e-procurement systems are recommended to fight corruption and could result in other beneficial aspects such as detection of irregularities and accessibility of documentation. In this paper they also identify the problem of privacy within the process of procurement and present a blockchain-based first-price sealed-bid auction protocol as a resolvement of the issue. The research is obstacle oriented at its core.

(7) “Effective use of blockchain technology for facilities management procurement process” (Gunasekara, Sridarran & Rajaratnam 2021) conducted research that presents the technology as implemented in the facilities management procurement process. The study states that their current systems of e-procurement or manual procurement contains several problems regarding transparency, corruption etc. The study then states that these problems can be

solved utilizing blockchain technology features and thereby stating the possibilities with such an implementation.

(8) “A Blockchain-Based Platform for the e-Procurement Management in the Public Sector” (Elalaoui Elabdallaoui, Elfazziki & Sadgal 2021) presents a practical implementation of a prototype of a blockchain-based solution for procurement management and the open tendering process using smart contracts as a means of recording and verifying submitted tenders for Morocco. The benefits regarding such an implementation of blockchain technology is presented.

1.3 Discussion of problems

As seen in the previous section, research conducted in the area of merging blockchain technology and public procurement is relatively substantial with various papers documenting beneficial impacts, protocols, designs and implementation examples. Most of the focus areas that are defined and stated within prior research are primarily or exclusively problems with the current procurement process that results in benefits as a result of an implementation and the use of blockchain technology. Some research states challenges or limitations with such an implementation but the majority do not. This is problematic as this could lead to false positivity and will decrease the level of objectivity in the studies of such an implementation. From an implementation perspective the possible obstacles with the development of e-procurement systems will most likely need to be identified if the implementation is going to be adopted by the government. This is investigated further in (3.3.1 Starting point) where the presence of obstacle observations in prior research is explored.

1.4 Definition of given problems and purpose

A gap in knowledge in prior research was uncovered and for that reason the focus will be on the potential obstacles identified in the implementation of blockchain technology. This will result in the fulfillment of the purpose which is to reach a theoretical contribution by enhancing the state of knowledge in the field. The research will be based on an explorative research question that meets these criteria.

For the delimitation of the research question Sweden is used as the geographical location. This comes naturally based on the fact that the qualitative research will be conducted in Sweden and also the exploration of the Swedish procurement process is the main focus thus making the results more applicable in Sweden.

The research question is defined as:

> *“What obstacles hamper the implementation of blockchain technology in the process of public procurement in Sweden?”*

The direction of the paper was changed by redefining the research question to only identify the obstacles with an implementation instead of both the impacts and the obstacles as seen in the first version of this paper. By doing this, the new research question enables for a more narrow and focused area of research.

1.5 Target audience

The target audience is defined as people and/or organizations that could benefit from reading and interacting with the information, models and interviews with answers from key stakeholders that will be presented in this research paper. The paper seeks to find possible obstacles when implementing a blockchain based procurement system, as such the paper's result should serve as a benchmark for future research. This paper is therefore suited for anyone seeking to further evolve the research surrounding the implementation of BCT on the Swedish procurement system.

The paper is also relevant for the Swedish national agency of procurement as well as the Swedish government. If or when they show interest in a BCT based procurement system, the obstacles will be key for comprehending such an implementation.

Lastly, anyone interested in BCT and/or public procurement as a whole may find this paper interesting as it explains a great deal about both and their possibilities as a merged phenomenon.

2. Method

The method section consists of the research method motivation and suitability in accordance with the paper's purpose and research question. This section also covers the conduct of the qualitative research chapter along with the ethical considerations. A description of a carefully thought out sample for empirical research will also be presented. After this the extent of empirical evidence is sufficient to support the purpose and achieve a correspondence between declared and applied methods. Method reflection is found in (7.2 Method reflections).

2.1 Research strategy

The research study in this paper follows a strategy where a qualitative research study is conducted and carried through with a qualitative methodological approach. First, in order to comprehend the research area fully, the need to present the reader with the basics of blockchain technology and public procurement is noticeable. Based on the fact that blockchain technology is a relatively new phenomenon and public procurement is a highly complicated process, the paper includes sections covering these two domains.

Jacobsen (2017) explains that when research is of explorative nature there exists a need for a nuance in the collected data. This is best achieved by deep diving into and concentrating on a small number of survey units, also called intensive design. By investigating an explorative research question the researcher needs to use a method that helps gather nuanced data from respondents that results in a qualitative survey with open data.

A knowledge gap was investigated and so the qualitative research study will be of explorative nature based on the lack of obstacle oriented prior research. An intensive design is therefore used but with a focus on four respondents from four different perspectives. The perspectives will result in even more nuanced data and thereby ensure the relevance of the results even more. Based on the small number of respondents and the explorative research, the qualitative approach with an intensive design is best suited for this study according to Jacobsen (2017).

To quote Bryman (2018), “Semi-structured interviews are more likely to be used to address specific concerns if the researcher begins his or her research with a relatively definite focus, rather than a general desire to study an area or theme.” Based on the fact that the research question is constructed with a clear focus in mind, i.e. the obstacles with implementing BCT in procurement, the semi-structured interview is appropriate as an interview structure.

Bryman (2018) also mentions that in a semi-structured interview the researcher has a list of relatively specific topics to be addressed (see appendix A - interview guide), but the interviewer has great freedom to design the answers in their own way. The questions do not have to be in the same order as in the interview guide. Questions that are not included in the interview guide can also be asked, if the interviewer finds it applicable to something that the respondent said. But in general, the questions will be asked in the original order and with the original wording. This question structure will continue to help generate nuanced answers with specific themes as a focus, rather than solely focusing on specific predefined questions.

According to Jacobsen, (2017) nuanced answers are what is wanted in qualitative and explorative research of a phenomenon and that is what this study will receive using this strategy.

To further ensure the research validity, respondents with expertise in their respective fields were interviewed as the first step to significant study results. The validity is later further analyzed based on critical thinking regarding the categorization and relation mapping process. The use of four respondents from four different fields in which each respondent is professionally engaged makes the collected data trustworthy based on specific and differentiating expertise, ultimately increasing the reliability.

2.2 Sampling of respondents

As the qualitative research is to be represented by different perspectives, all concerning the areas of BCT and public procurement, a theoretical population was created. According to Jacobsen (2017) the theoretical population comes from obtaining a complete overview of everyone you would like to examine if time, money and analytical possibilities were unlimited. The result was a vast range of entities occupying roles within the two subject areas. This, of course, due to not having unlimited time and the number of perspectives were narrowed down to four perspectives with one entity representing each.

The perspectives are as follows:

- The juridical perspective - An entity involved in the juridical area concerning public procurement in Sweden.
- The procuring perspective - An entity involved in the procurement process, representing the Borås municipality in Sweden.
- The tendering perspective - An entity involved in the procurement process, representing the tenderers.
- The technical perspective - An entity involved in blockchain technology, representing expert level knowledge concerning BCT.

The sampling was then restricted to a time frame. The most important thing to consider here was that anyone relevant should be actively working or involved in their respective perspective. Certain perspectives are highly sensitive to variations or new discoveries that happen through time, in the sense that an entity involved in one of the perspectives, such as BCT, a constantly evolving technology, one year ago may not know certain changes or discoveries that have been made now. It is imperative as well that entities representing a perspective possess first hand and present time experience in being part of projects. The most reliable way to do so was to assure that all respondents are presently involved, in an industry or academic sense, in the perspective they each represent.

This implies that the sampling is based on information, which Jacobsen (2017) states is done by selecting respondents the researchers believe can provide extensive and initiated information they are interested in.

The criteria are then as follows:

- The juridical perspective
    - Works within public procurement in Sweden
    - Has juridical competency within procurement in Sweden
    - Has experience in procuring for an authority
- The procuring perspective
    - Works within a contracting authority in Sweden
    - Has experience procuring for government authorities
- The tendering perspective
    - Has experience going through the procurement process as a tenderer.
    - Has experience with the procurement process in sweden.
- The technical perspective
    - Has worked and/or has academic knowledge within blockchain technology.
    - Has experience with the technical parts of BCT.
    - Has experience with BCT in the public sector.

Worth mentioning is the sampling when choosing the tendering respondent for the research study in this paper. There exists a parental relationship between the tenderer and the interviewer. The respondent was therefore informed about the interview structure with the different themes as a starting point and this resulted in increased dialogue and formulation of answers in that particular interview. The decision to interview the tenderer in question is based on his work environment within tech, procurement experience and his basic understanding of blockchain technology.

2.3 Data collection

Collection of data from the sample group was carried out through semi-structured individual interviews. The use of the interview structure presented by Bryman (2018) resulted in the interview being focused around specific topics that are addressed, which are called themes in this paper. The questions were then formulated partly based on predefined questions and partly on the respondents' answers.

The contents of the interviews were based on predetermined themes (see Appendix A - Interview Guide) and the same question was asked in relevance to each theme. The themes covered were political, economic, social, technological, legal and environmental, with a question for each theme concerning the possible obstacles in implementing blockchain technology on the Swedish procurement system. Complimentary follow-up questions were then asked at some instances to further strengthen the quality of the data. These follow-up questions were not prepared and are not included in the appendices section. The interviews were then transcribed and analyzed. The themes explored and used as interview topics were:

Political theme: As blockchain is a new technology it may or may not lead to political obstacles within governance, as all new technology usually does.

Economical theme: An understanding of the financial aspects of an implementation is somewhat mandatory to define, as this will be used as a point of evaluation when adopting a new technology by government institutions.

Social theme: The social theme helps to better understand the societal obstacles that may occur in the case of implementation. This is an extensive theme that is important for the development of obstacle discoverance.

Technological theme: With the orientation of this paper taken into account this theme will be naturally explored.

Legal theme: This theme will be naturally explored as well in one of the perspectives. Although, this subject will serve as a focus in all other interviews as well, as legal aspects are seen in prior research as a potential limitation area.

Environmental theme: In regard to the environmental concerns all around the globe the focus towards this theme is obviously taken into consideration and further explored.

2.4 Data analysis

When analyzing the data collected a defined analysis model that contains six steps was utilized. The analysis model used in this paper is based on the work of Fejes and Thornberg (2015) where they present the phenomenographic analysis model. This model was altered within limits to fit the analysis needs of this paper but many of the steps in the phenomenographic analysis model were used in full. Interaction between the different steps was present throughout the analysis process and the protocol for this analysis is presented in this section.

- Step 1 - *Understanding of the material*

Firstly, the material is explored until an understanding of the material is determined.

- Step 2 - *Reduction and condensation*

In this step, the key statements made from respondents during the interviews that are most important and relevant to the subject matter are highlighted. Patterns will be easier to identify using this highlighting technique and help during the rest of the process.

- Step 3 - *Comparison*

The different highlighted parts of the interviews that have been defined in Step 2 are analyzed and compared. Through all highlighted material the differences and similarities of these parts are highlighted.

- Step 4 - *Grouping of differences and similarities*

The differences and similarities identified in Step 3 are grouped together and correlations between the different findings in the form of highlighted materials are discovered. The parts are then related to each other.

- Step 5 - *Categorization*

If the similarities are greater than the differences in the highlighted material in question, then they are grouped together thus creating a category with a majority of the same properties.

- Step 6 - *Category naming*

Last but not least the categories are named, and this results in the significance of the material and the data can later be useful.

2.5 Ethical considerations

The ethical approach of this study is based on Bryman´s (2018) definition of three basic requirements as the starting point for today's research ethics. These requirements are linked to the relationship between researchers and those who the research is conducted on: *Informed consent*, *Right to privacy* and *Correct respondent represententation*.

- Informed consent

The person being examined must voluntarily participate in the study, and the voluntary participation is based on the examinee knowing all about the risks and benefits that such participation may entail as presented by Bryman (2018). The interview-respondents were well informed of the purpose of the study and their participation. Participants were asked if they agreed to the interviews being recorded and whether they preferred to be referred to using aliases. All respondents agreed to share their real identity and be recorded.

- Right to privacy

Those who are interviewed in this paper all had the right to a private life, i.e. a free zone in life that should not necessarily be examined. This is emphasized by Bryman (2018) and based on this the themes and questions asked during interviews are designed to not be of private or sensitive nature. Information related to the respondents private life was considered as not needed or relevant for the study.

- Correct respondent represententation

The context in which data from interviews is taken must according to Bryman (2018) be considered when presenting the results. So that the result correctly represents what has actually been said. This is taken into consideration during analysis of the raw data. All interviews used to gain results were based on the focus towards topic observation’s state of correlation between interview statements, and they therefore present both a context view and separate statement declaration.

3. Theory

In this section the background of blockchain technology and public procurement is first presented in order to help gain a basic understanding of the fundamentals within the two domains. Secondly the theoretical framework is explained in a nuanced way, motivating the choice of theory, establishing the relevance of the theory in relation to the research question, and covering the area of theory. Knowledge gaps and knowledge contributions are identified as well.

3.1 What is Blockchain Technology?

This chapter will cover the fundamentals of blockchain technology. To briefly summarize the technology of a blockchain it can be described as a distributed ledger that has no central authority. Instead all decisions are made in a decentralized manner and the transactions or other records are broadcasted to all participants of the network. All participants also keep a locally stored version of the last state of the blockchain making it hard to alter records that are already stored, unless a majority of participants agree to make a change. (Hirsh & Alman 2020) The technology of blockchain will be further delved into in the following subsections.

3.1.1 Blockchain summary

The technical aspects of blockchain are broad and the security measures involved ensuring the decentralization and asymmetric encryption of information results in numerous potential areas of implementation. These basic technical parts are essential to understand possible use cases and areas of usability. To summarize the blockchain chapter of this paper:

- Cryptography (3.1.3 Cryptography)

This technique is used to ensure asymmetric information sharing between users using public/private key relationships and enables participants to send messages and/or transactions to one another in a private manner on the blockchain. This contributes to transparency of data broadcasted on the blockchain accessible to all while still maintaining identity privacy amongst participants. Bertaccini (2022) covers the aspects of this further by discussing the problems and potential solutions with encryption. The groundwork that enables the understanding of this is the explanation of algorithms by Chaudhuri (2020) to comprehend the cryptography.

- Security (3.1.4 Security)

Hashes and the merkle tree structure are used to create data blocks that are linked together using previous block hashes presented by Shen, Zhu and Xu (2020) and is the very structure that makes the blockchain. This functionality alongside a consensus protocol that is explained with the help of Huang (2020) enables the decentralization of the blockchain and are the two main security measures taken in the peer-to-peer network.

- Smart contracts (3.1.5 Smart contracts)

The nature of smart contracts enables participants on the blockchain to develop digital contracts that are automated using predefined conditions which allow for less human interaction, decrease in bias, higher quality of services and less administrative costs. The definition of smart contracts is presented by Mukhopadhyay (2018) together with design examples and condition definitions.

- Usability (3.1.6 Usability)

Jaoude and Saade (2019) state that there are several areas where blockchain implementation is feasible and would result in a number of benefits. Some of these areas are Internet of Things, energy, finance, healthcare and government. All of these implementational areas benefit from cryptography, security and smart contracts in various ways.

3.1.2 The fundamentals of blockchain technology

Some of the first useful ideas that made blockchain technology possible are to be traced back decades. One example of this is the research on improvements in time-stamping on digital documents that was introduced by Stuart Haber and W. Scott Stornetta. They found that it was of great importance to introduce a way to securely confirm that a digital document is time-stamped correctly and the signature of this document to be untamperable. This was first introduced to secure intellectual property matters. Haber and Scott Stornetta did see some difficulties in the signing and verification of documents and they proposed that the process needed to introduce either a completely trustworthy central authority to manage the process and verifying and store a copy of every signed document, or to distribute the required trust amongst the participants within the process and service. (Haber & Stornetta 1991) This ultimately paved the way for blockchain and Satoshi Nakamoto.

Satoshi Nakamoto was a pseudonym consisting of one person or an organization of people, that published “Bitcoin: A Peer-to-Peer Electronic Cash System” in 2008. In the white paper Nakamoto described a peer-to-peer digital payment system purely based on decentralized trust amongst participants and with a digital currency named “Bitcoin”. This is being done partly by applying the hash-based time-stamping but there was still one problem, the double-spending. Nakamoto speaks on the double-spending problem, where there needs to be some way of deciding the cash balance of all accounts and what transactions are being sent first. If two transactions are to be sent simultaneously there needs to be a way to determine which one should be sent first. This is where proof-of-work consensus has its functional implementations. Proof-of-work was introduced to fix the double-spending problem by taking the hash-based transactions and storing these in a block, which results in that one transaction will always be processed before the other. All participants (nodes) in the peer-to-peer network will then use computational power to validate the block and all the transactions it contains. When the block is validated by the majority of nodes, the block will be broadcasted onto the blockchain and the validation process of a new block will continue. This, along with the hash-functions, will ensure that all account balances are updated and that

there will be no double-spending, without the help of a trusted third party such as a traditional bank. (Nakamoto 2022)

While bitcoin had and still has a lot of areas of implementation and value, the real superstructure of the blockchain was introduced later by Vitalik Buterin in 2014. He states in the Ethereum white paper that Nakamoto managed to fix a lot of problems with the use of blockchain technology but that the usability of the blockchain could expand further. Buterin introduces concepts such as colored coins, smart properties, non-fungible assets and decentralized exchanges. He also mentions smart contracts that could enable the use of arbitrary pre-defined rules to move digital assets by spending the digital currency Ethereum on the blockchain. These useful concepts introduced by Buterin later resulted in more areas of implementation and a substantial improvement in the underlying technology behind blockchain. (Buterin 2014)

3.1.3 Cryptography

In this chapter an overview of the cryptography side of blockchain will be covered, by understanding how it works and why the implementation takes place. To understand cryptography, it is first required to examine the meaning and functionality of an algorithm.

- Algorithms

An algorithm is one of the core concepts of computer programming and is best described as a sequential set of steps to take an input and generate a given output.

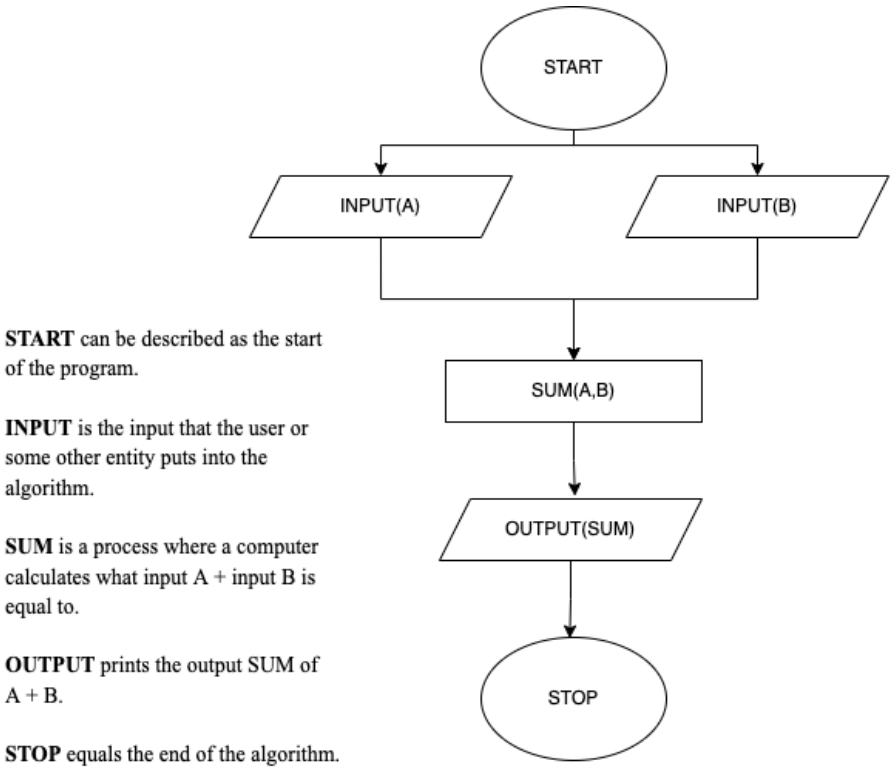

Figure 1: A flowchart of the algorithm process

An algorithm can be executed in different ways with different inputs, outputs and sets of steps i.e. tasks. Many inputs can generate the same output and thus the implementations are unlimited. An algorithm can then be used to solve a problem or a set of problems through a computer language that transforms text into binary code understandable to a computer. (Chaudhuri 2020)

- Encryption and decryption

Cryptography builds on algorithms that work as a way to send a message in a one-to-one secure way that is unreadable for unauthorized participants. The process of this is called a cipher. The cipher takes the input of readable text and makes the message unreadable for everyone except the person in possesion of the receiver-key. A cipher consists of two main functions. One is the encryption of a message that makes it unreadable, and the second is decryption that decrypts the unreadable message (cryptogram) and makes it readable again. A key is needed for both encryption and decryption of the message to be interpreted correctly. Both the receiver and sender of the message needs to be in possession of a key. (Bertaccini 2022)

There also needs to be a way to secure the privacy of every user's keys when encrypting/decrypting messages. Otherwise when user A sends a message to user B they get access to the private key of user B and user A can use the private key of user B to decrypt/encrypt messages in their “name”. This led to the introduction of the public/private key relationship in cryptography. The public key is generated from the private key and is used to receive messages and/or to authenticate the user. The private key is known only by the owner and the owner can use this key to encrypt/decrypt messages. (Bertaccini 2022)

Cryptography is used by participants on the blockchain when sending and/or receiving messages on the network. Messages such as transactions, smart contracts and non-fungible assets are securely being transferred in a one-to-one environment. The underlying importance of cryptography within blockchain is crucial for its survival and this also results in total privacy amongst all participants, given that no one gives out their private key. Anyone that has access to a hash function within the network that allows for a message to be encrypted/decrypted can generate a keypair that has functionality on the given blockchain. (Bertaccini 2022)

- Hash functions

A cryptographic hash function takes an arbitrary length string and converts it into a string of fixed length, most commonly between 128 and 512 bits. The hash function is then used as a way to authenticate messages, detect modifications and/or for digital signatures. The message authentication hash function takes a message authentication code (MAC) and uses this together with a private key to determine the authenticity of the message and its “owner”. The modification detection is based on the fact that a hash function of a string always will result in the same fixed length string. For example, the string “Noah to Birk” results in the hash “8C7BC95637212AA29AEE5296EE29D11327A2544C” using the SHA1 hash function algorithm. If the string were to be changed to “Birk to Noah” the hash will look different and

the modification of the data will be detected. The private and public key is generated using a digital signature scheme where algorithms for key generation, signing and verification are executed. This explanation points to some of the many different use cases of hash functions. (Aumasson, Meier, Phan & Henzen 2015)

3.1.4 Security

The pillars that secure a blockchain network are many. In this research section their entirety and the security aspects will be covered and put into perspective. The previous chapter discussed ways to securely share the data in the form of encrypted one-to-one messages on the blockchain using hash functions. One of the main areas that secure the network as a whole and the information sharing functions is the creation of blocks containing information and also the chainization of these data blocks. (Shen, Zhu & Xu 2020)

- Blocks

A block in blockchain technology is composed of a set of data. This data is collected from a given time period and stored in blocks. The block contains a block header and a block body. Inside the block header there is data related to the block itself, and the block body is responsible for storing all transactions within the block. (Shen, Zhu & Xu 2020)

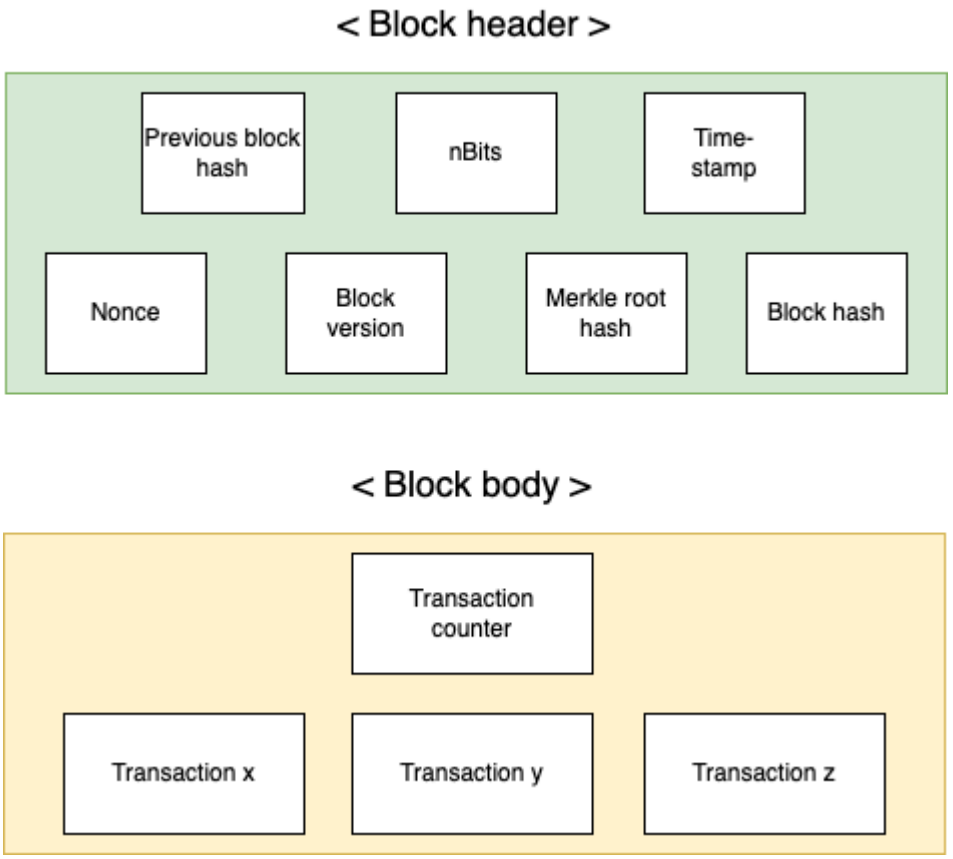

Figure 2: The block structure and its components

- Contents of the block header

The previous hash indicates the block hash of the previous block. This is how the blocks are tied together and this function is what makes the blockchain. The nBits in the block header represent the validation of a block and its hash. Time-stamp is the time that the block has been validated and accepted by all validators (miners). Nonce is the hash that will be computed by miners when the block is to be validated. Block version is the protocol which states the rules that miners must follow in order to validate a block. Merkle root hash is the hash that represents all transactions and information contained in the current block. Lastly all the data stored within a block is given a hash, that represents the block and is used as a key for identification on the blockchain. (Shen, Zhu & Xu 2020)

- Contents of the block body

The block body stores all transactions that will be stored in the block and also a transaction counter that works as a tool to determine how many transactions a block should support before reaching the validation stage. All transactions are also hashed multiple times using the merkle tree. The transactions in the block body could also better be described as messages on some blockchains like ERC-20 because of the possibility for information other than transactions to be stored such as smart contracts and/or digital assets.
(Shen, Zhu & Xu 2020

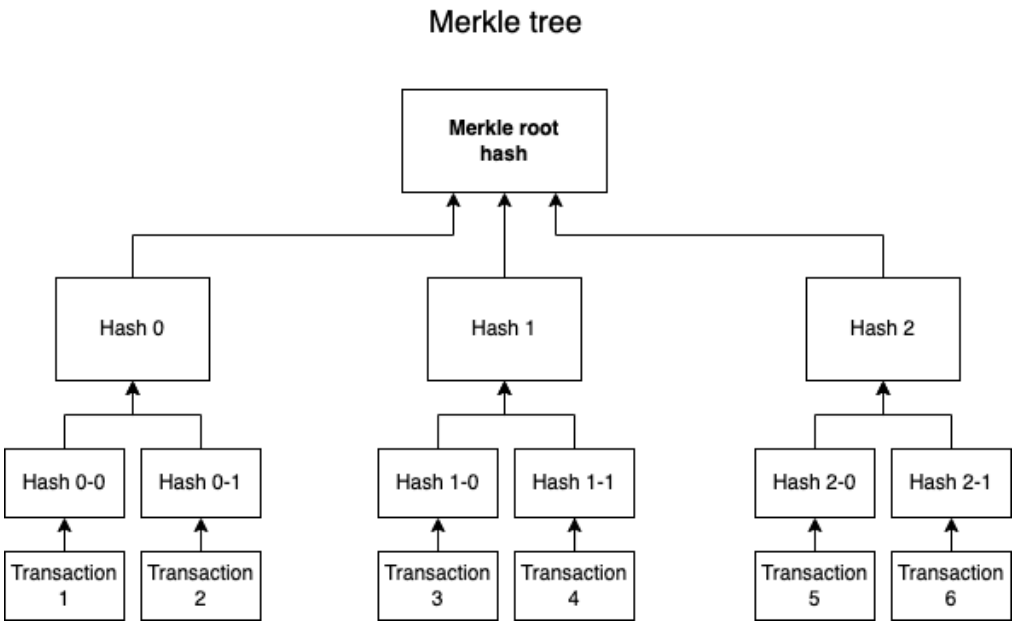

Figure 3: Visual representation of the merkle tree and its hash functions

- Merkle tree and the merkle root hash

At its core the merkle tree consists of data in the form of transactions as illustrated in the figure above. In this example there are six transactions that together get stored in a block. Transaction 1 and Transaction 2 gets assigned a hash value and these hash values (Hash 0-0 and 0-1) later gets hashed again creating Hash 0. The three last hash values (Hash 0, Hash 1

and Hash 2) get assigned a “summary hash” called a merkle root hash, representing all the hashes of transactions in the merkle tree. This hash is then used in the block header, to represent all transactions within the block creating the possibility for multiple transactions in one block. (Shen, Zhu & Xu 2020)

- Chainization of blocks

For the blockchain to become a blockchain there needs to be a chainization of the data blocks, and this chainization is enabled through block hashes. Every block that gets created and validated gets assigned a block hash that represents all the data in the block header and body.

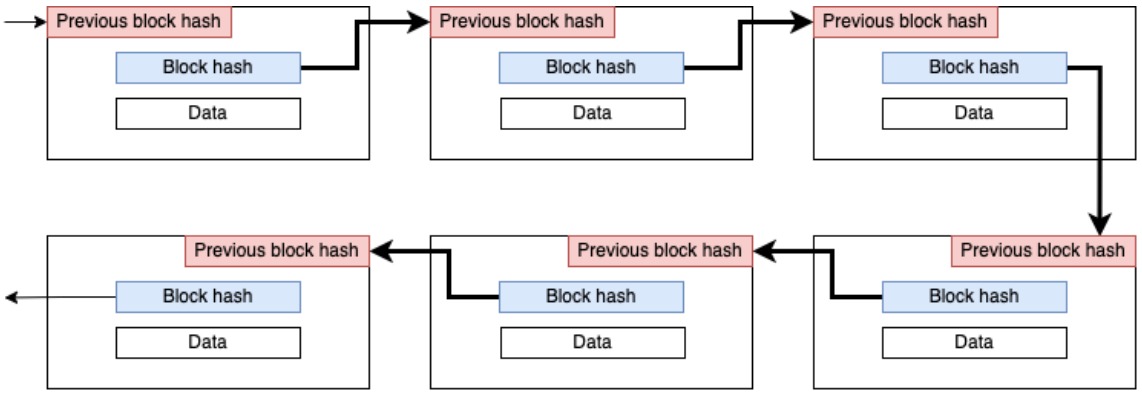

Figure 4: The process of block chainization

- Key components for chainization

All blocks contain a previous block hash and other data concerning the current block. This information is then hashed and the final output is the block hash. This block hash is then used in the next block as the previous block hash. This creates the blockchain where all blocks are created in chronological order, linked together and stored as a chain. What this means for the security aspects of the blockchain is that the security is intamperable. If one block’s data were to be malicious and edited the hashes would not match the previous or next block, making the blockchain invalid. The edited block would not be validated as true by the validators of the network, which is the second aspect of the blockchain’s security called the consensus layer. (Shen, Zhu & Xu 2020)

- The consensus layer

In blockchain technology there are multiple peer-to-peer protocols that are used as a set of rules for the validation of each new block. The two most common protocols, the various aspects and key entities are examined here. The consensus protocol of a blockchain is built on the foundation of peer-to-peer agreements on the current state of the blockchain. Every participant in the validation process is acting as a node and stores a copy of the latest state of the blockchain. Each time a new block is being proposed and then later validated the newest state of the blockchain is being broadcasted to the network and this copy acts as the new true version. This algorithm makes the validation and update process of the blockchain feasible by

broadcasting a new true version of the blockchain to all nodes and this is called the consensus mechanism. There are also centralized versions of some consensus protocols implemented on some blockchains. (Huang et al. 2020)

- Proof-of-Work (PoW)

This was the consensus protocol introduced by Satoshi Nakamoto in 2009, when bitcoin was first launched. It later became adopted by many blockchains and is today the most commonly used consensus protocol. The foundation of this consensus mechanism is computational power. Each node has to make a contribution (work) to be a part of the validation process of new blocks using its Central Processing Unit (CPU) or Graphics Processing Unit (GPU) power to solve a mathematical problem. This work that has to be done in order to participate is called “mining”. A new block that is accepted by the network is generated roughly every 10 minutes. The incentives for mining and participating in the validation process of the network are that every time a miner solves the mathematical problem and generates the right hash, the miner is given a reward in the form of digital currency. More computational power equals in most cases a higher chance of mining the block thus getting a reward for the work that is done. There are some disadvantages of using the PoW consensus protocol. One of these disadvantages is that if 51% of the miners choose to manipulate the network and accept blocks that are malicious by combining all their computational power, the network is no longer trustworthy. This is called the 51% attack and is highly unlikely to happen. Some also argue that PoW is an extremely inefficient use of electric power and the environmental challenges that this consensus protocol results in are catastrophic. This is one of the top reasons why there is a lot of research being done in the area of blockchain consensus to discover new ways of reaching consensus without the electric waste. This is where the consensus protocol Proof-of-Stake is advantageous. (Huang et al. 2020)

- Proof-of-Stake (PoS)

PoS is the second most popular consensus protocol that has been implemented on blockchains. Within this protocol all “miners” are being addressed as validators. The task being executed by validators is validating the blocks and adding them to the blockchain, just like miners in PoW. The key difference is that the validators do not perform any work to validate new blocks. Instead they get elected as validators of a new block based on the amount of digital currency they possess on the blockchain. All validators that would like to be involved in the validation process as a validator have to freeze their currency balance (stake) for as long as they want to validate blocks. This ensures the validator's legitimacy and if the validator accepts a malicious block and thereby jeopardizes the authenticity of the blockchain, their stake would be burned. As a result of this consensus, the more digital currency you have the greater chance of validating a new block which can create a “the rich gets richer” scheme. However, this consensus protocol ensures that there is no unnecessary computational power being wasted searching for a hash and also less chance of being a subject to a 51% attack although it is still possible but really expensive. (Huang et al. 2020)

For example in the case of the ERC-20 blockchain with Ethereum as its main digital currency, a 51% attack using the PoS consensus protocol would cost the attackers

approximately 160 billion US dollars to execute. This is based on the current total market capitalization of 305 billion dollars. (Coinmarketcap 2022) The result of this would most likely be that the digital currency used for the attack would be burned, costing the attackers the 160 billion dollars worth of Ethereum to execute the attack.

3.1.5 Smart contracts

The definition of a smart contract was described by Nick Szabo in his paper *Smart Contracts: Building Blocks for Digital Markets*. The definition was "A smart contract is a set of promises, specified in digital form, including protocols within which the parties perform on the promises." A smart contract is a digital contract that contains a predefined set of rules that when followed allows for *x* number of participants to transfer digital currency or digital assets on the blockchain. (Mukhopadhyay 2018)

- Conditions of a smart contract

Conditions are set before the deployment of a smart contract. These conditions declare the first state of the contract and the actual state after some business actions have taken place. For example, a simple business transaction of a property sale on the blockchain between a buyer and seller as a smart contract:

Key Entities: Buyer, Seller
Conditions:
IF Buyer pays Seller *x* amount within 30 days,
THEN the house is sold to Buyer.
ELSE IF Buyer do not send Seller *x* amount,
THEN the house is not sold.
ELSE IF house is not sold,
THEN repeat the process.

These IF and ELSE IF conditions are predefined before deploying the smart contract and can be altered to fit specific business actions and transactions. The above smart contract in pseudocode is a container of a contract entirely defined in code, but this is not necessarily the case in all deployments of smart contracts. Some smart contracts could also include actions with data from outside sources to support the smart contract. For example a website can trigger a yes/no response in accordance with an input from a user that triggers an action in a smart contract. These outside sources are called "Oracles" and work as an intermediary that takes physical actions and turns them into actions linked to conditions in the smart contract. (Mukhopadhyay 2018)

3.1.6 Usability

The use cases for blockchain technology are many. Research has been and is being conducted in many fields and the fields with most research being conducted is Internet of Things, Energy, Finance, Healthcare and Government.

- Internet of Things

In this area cryptography within blockchain technology could result in better security and keeping the integrity of the data intact and prevent unauthorized users from interfering with the devices. Also the anonymity of users is important. Blockchain technology could improve the preservation of user data in a way that makes it hard for companies to profit on selling the data to third parties. Smart contracts could also simplify the supply chain management with IoT devices connected to the process and smart contracts that executes predefined conditions. The process could be a shipment of goods that gets tracked using RFID chips and executing conditions such as payments depending on the location of the goods. (Jaoude & Saade 2019)

- Energy

Blockchain could help control the electricity market between machines. Information regarding the market could be decentralized and result in fair market pricing and also real-time reliable information about energy consumption statistics. The anonymity of each user and information supplier in this area is also crucial and accomplishable using blockchain. There are also other security aspects involved in the energy trade such as hacker attacks. The technology behind blockchain could also be a solution to this, as the decentralized model is more immune to single-handed attacks and would need a majority of the network to perform the attack. Authentication regarding the source of the energy is also implementable on the blockchain and will most likely result in more energy providers to increase their interest in renewable energy thus helping the environment. (Jaoude & Saade 2019)

- Finance

A decrease in transaction times and thereby costs is a big positive in the finance world and could be accomplished by using digital currencies on the blockchain. A sustainable financial market is also achievable with blockchain and the decentralized structure should result in a more divided asset management system. Traditional banks are also vulnerable to security breaches and hacks and this could also be prevented. Data privacy within finance is also advantageous in a way that makes identification of a specific asset holder harder. The use of smart contracts could also benefit the financial market as it could minimize individual involvement and thereby decrease costs for contract management. (Jaoude & Saade 2019)

- Healthcare

Easier access to medical data and sharing of this data are two main reasons as to why the healthcare sector is doing a lot of research around blockchain implementation. The private/public key phenomenon could result in privacy while sharing medical documentation of a patient and allow for this information to be accessible for anyone on the blockchain and still be encrypted. All medical institutions would share the same database of information (the blockchain) and as a result the management of patient records will be easier to maintain. (Jaoude & Saade 2019)

- Government

Blockchain technology could have various possible use cases within governmental institutions. One is e-Government which includes ways of utilizing digital tools to improve governance services and deliver better ways of communication to citizens. The level of simplicity in management of services when implemented on the blockchain could result in higher quality and availability of current services which could also mean an increase in the number of services provided. Anonymity of the blockchain with the identity of service providers being encrypted would bring forth more transparency to citizens without the identity of providers being exposed. As a result, overall justice services will also improve by the blockchain assisting in the elimination of bias. Identification could also be implemented using public/private key cryptography on a blockchain to eliminate both the paper based version of an ID that exists today and to more safely share your personal information with others. E-Voting is another area that could be realized using blockchain technology, although this is a very delicate process that has no room for errors and the fact is that a theft of a lot of private keys could result in a disastrous outcome of an election. (Jaoude & Saade 2019)

3.2 What is Public Procurement?

Public procurement is the process in which organizations from the public sector utilize to make purchases. As public organizations utilize the people's money, obtained through taxes etc. they must follow strict rules and therefore go through the national agency of procurement when making purchases. (Upphandlingsmyndigheten u.å. a) The procurement process in Sweden consists of three phases (see figure 5) preparation, procurement and realization, each phase with their own steps.

3.2.1 The procurement process in Sweden

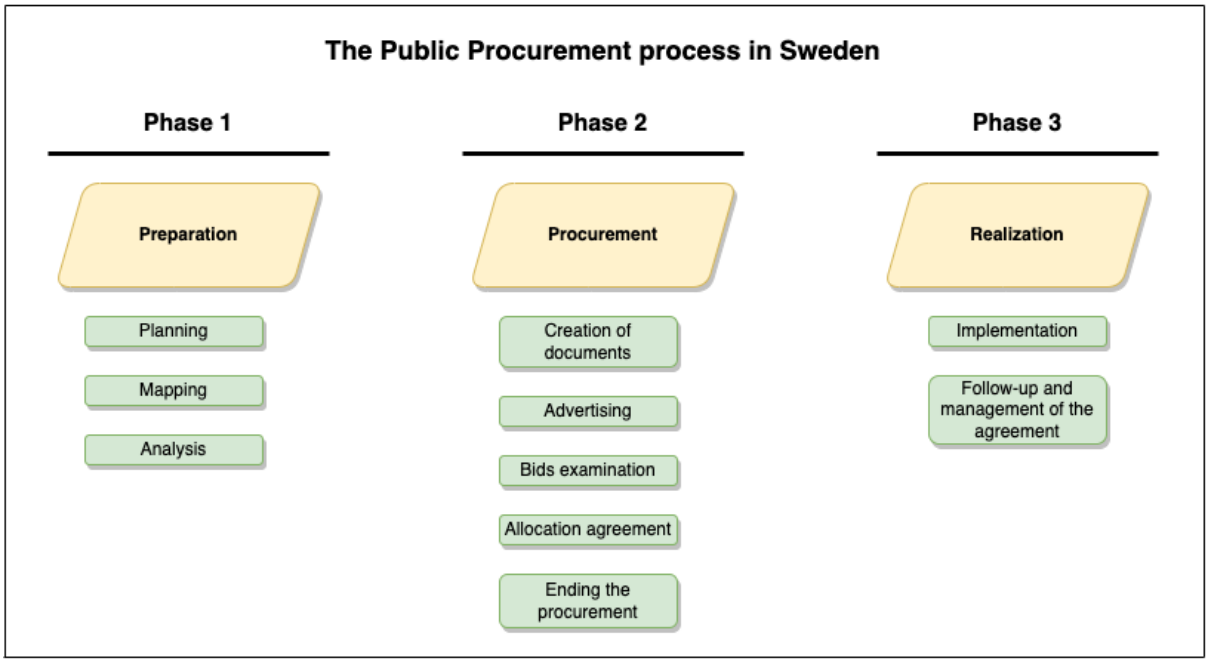

Figure 5: Model of the procurement process by the The National Agency for Public Procurement in Sweden

3.2.2 Preparation phase

According to the Swedish procurement authority, the public procurement procedure is divided into three phases or "zones". The first phase is preparation, which entails planning, in other words scheduling time, resources, and who will be involved in the procurement process, thereafter, mapping of risks, requirements and market, and lastly analysis in which the information from the mapping process is analyzed in order to select an appropriate procurement procedure. (Upphandlingsmyndigheten u.å. b)

- Planning

During the planning step, before beginning the procurement, a work group should be created. Here, the competencies and resources that are required should be identified, such as jurists, eco-coordinators, security-coordinators, economists and the entities involved in the procurement itself. The next step is to determine which internal and external competencies should be involved in the procurement process, and to ensure that they are involved early. This is done to ensure that multiple perspectives are present, reducing the danger of corruption.

Thereafter comes the time- and activity schedule. It should represent an overview of which activities that must be completed prior to, during, and after the procurement. This is critical because it establishes the foundation for a high-quality, efficient procurement process. (Upphandlingsmyndigheten u.å. b)

- Mapping

After the planning step is completed, one enters the mapping and analysis step. At the start of this step a thorough requirement analysis should be conducted to acquire all procurement requirements. The requirements should be researched and specified in this analysis, which will serve as the foundation for the procurement. The next step is to do a market analysis to determine what the market can supply, and which suppliers are available and of course, the results of the requirement analysis should be used in this step to provide the suppliers with a clear picture of what is required. It is also important to note that in this step dialogues will be held with suppliers, and that it is of utmost importance that these dialogues are conducted fairly. So that all suppliers are treated the same, no negotiations are begun prematurely, no affirmations of future deliveries are given, and no supplier obtains any competitive advantage that can affect the design of the procurement documents. (Upphandlingsmyndigheten u.å. b)

- Analysis

Following the mapping and analysis step comes the risk analysis. A thorough risk analysis sets the stage for a successful procurement. It outlines the risks, their potential repercussions, and the likelihood of them occurring. This is so that one may make informed decisions and prepare ahead with action plans while also prioritizing the work with risks in mind.

Based on the now completed analyses, a procedure for the procurement has to be selected. This decision is made based on the entire amount of the procurement, whether it is a service,

and what type of service it is. The process will therefore differ based on what procedure is selected as this choice determines how the procurement is carried out, what deadlines must be met and when to negotiate with the supplier or not. This also implies that the time schedule may have to be altered as various procedures can require more or less time than others. (Upphandlingsmyndigheten u.å. b)

3.2.3 Procurement phase

- Creation of documents

The procurement phase starts off with the creation of the procurement documents, these documents determine the contents of a procurement. These documents are meant to include all relevant information needed for the suppliers to get a complete picture of what the contracting authority is requesting. (Upphandlingsmyndigheten u.å. c)

Procurement documents usually include the following:

- General information about the procurement.
- Formal requirements that apply for the suppliers to be able to submit tenders.
- Requirements for the suppliers to be able to qualify and grounds for exclusion. A supplier often has the opportunity to submit a so-called self-declaration (ESPD) to preliminarily certify that there is no basis for exclusion and that their operation meets the qualification requirements.
- Technical specification, meaning requirements for the subject of the procurement.
- Basis for evaluation. Which evaluation basis and which award criteria will be used to identify the most economically advantageous tender.
- Contract terms. The rights and obligations that exist for both parties and how the delivery or assignment is to be performed, information about the payment process and more. (Upphandlingsmyndigheten u.å c)

- Advertising

When the procurement documents are finalized, the procurement is announced as advertisement in an advertising database. All procurements that are not exempt from the advertising obligation, such as direct procurements, must be published in a registered advertising database. If the value of the procurement exceeds the threshold value, it must also be published in the EU's joint advertising database TED (Tenders Electronic Daily). An advertisement may not be published at national level until it has been published in TED, unless the contracting organization has not been notified that the advertisement has been published within 48 hours after the contracting authority has received a confirmation of receipt of the advertisement. Suppliers are always free to ask questions concerning the procurement. The answers are to be submitted in writing to all suppliers participating in the procurement. All suppliers must receive the same information at the same time, regardless of who requested the additional information. If such questions result in the contracting authority providing additional information about the procurement documents, the tender period may need to be extended. If the changes made in the procurement documents are so significant

that the nature of the procurement changes, the procurement must be redone. (Upphandlingsmyndigheten u.å. c)

- Bids examination

Tenders must be kept unopened until the tender period has expired. Before this period, the tender or application in a procurement does not become a public document with the contracting authority. When the tender period has expired, the tenders are to be evaluated. Suppliers and the tenders are assessed against the requirements set in the procurement documents and the tenders that best meets the award criteria is evaluated. Until a decision is made on allocation, redoing, or canceling the procurement, absolute secrecy applies. If a received tender is remarkably low, the contracting authority is required to question the supplier regarding the low price. The supplier must then be able to explain the low price in a satisfactory manner, otherwise the tender must be rejected. (Upphandlingsmyndigheten u.å. c)

- Allocation agreement

After evaluation of the tenders, it's decided which tenderer or tenderers are to be awarded the contract. The award decision is announced in writing to the candidates and tenderers as soon as possible. (Upphandlingsmyndigheten u.å. c)

- Ending the procurement

After the allocation decision has been sent out, a contract lock of at least 10 days applies if the allocation decision has been sent electronically. Only when the contract lock has expired can the contracting organization sign an agreement with the supplier. If the decision has been sent in another way than by electronic means, an agreement may not be entered into until 15 days have elapsed from the dispatch. The contracting organization can apply a longer contract lock, but never shorter than at least 10 or 15 days, from the moment the award decision has been sent. The contract lock does not apply to direct procurement. The content of the agreement shall be based on the advertisement, the procurement documents, the tender and the result of any negotiation as well as correction or clarification. Within 30 days after entering into the agreement. Procurements both above and below the threshold values must be post-advertised, meaning after the procurement is completed, a specific advertisement is published containing certain information to benefit transparency. For procurements above the threshold values, post-advertising must be made following a special form in TED. (Upphandlingsmyndigheten u.å. c)

3.2.4 Realization phase

The third and final phase is the realization phase where the contract is realized. It consists of the implementation of the agreement and the maintenance in which contract management and follow-up assures that the selected supplier will deliver. (Upphandlingsmyndigheten u.å. d)

- Implementation

The first step in this phase is implementing the agreement. Here the procurement authority begins with having a start-up meeting with the suppliers after the contract block has elapsed. procurers, purchasers, and other interested parties should be included. This meeting could include developing a contract follow-up plan, determining how this should be documented, and defining the terms of the contract with both parts.

Next comes establishing continuous contact with all parts. It is critical to have continuous meetings with the supplier prior to the start of the agreement and during the contract time to follow up on the agreement. The frequency of these meetings is determined by the terms of the agreement as well as the procurement authority's and supplier's demands. Next it is critical that everyone who will be affected by the agreement has the knowledge they need to use it properly and the procurement authority should therefore inform everyone involved regarding the contract. (Upphandlingsmyndigheten u.å. d)

- Follow-up and management of the agreement

The next step in this phase is follow-up and management of the agreement. The agreement follow-up consists of activities aimed at ensuring that the supplier satisfies the requirements specified in the procurement documents and that the contractual authority or entity gets what is asked for. The contract management includes an internal administration of all the organization's agreements, in addition to contract follow-up. This includes recording the agreement in an agreement database and monitoring any extensions or pricing revisions, among other things. Furthermore, contract management entails adhering to contract fidelity, which entails making purchases from suppliers with whom you have contracts. It is important to note as well that the contract follow-up and management should be adapted to the organization in question.

Planning the agreement follow-up and management is next. This plan should support the ongoing follow-up process and define what to implement, who is accountable for implementing it, and when it will be implemented. (Upphandlingsmyndigheten u.å. d)

Next, the contract follow-up must be implemented. The procurement authority should keep track of the procurement requirements. It covers the following:

- Supplier requirements (qualification requirements)
- Good/service requirements (subject matter of the procurement)
- Other contract terms and award criteria

The procurement authority must also deal with deviations or inadequacies on a regular basis and indicate how they should be addressed. Many contracts include a so-called punishment staircase or action plan for dealing with defects and deviations. The actions adopted must be proportional to the divergence.

Lastly, before the contracting authority decides on contract renewal or termination, a summary of how the agreement has functioned should be completed. This serves as the foundation for the coming contract management. (Upphandlingsmyndigheten u.å. d)

3.3 Theoretical Framework

What makes a useful theory? A good theory consists of various criteria according to research and to summarize this, a useful theory needs to tell an enlightening story about some phenomenon. This story needs to bring forth brand new insights that support the expansion of the knowledge of a phenomenon. (Anfara & Mertz 2006) In light of this, the lack of obstacle observations in prior research covering the implementation of blockchain technology in procurement as a phenomenon is explained. This is done by covering prior research and finding knowledge gaps which in the final analysis will result in possibilities of generating knowledge contribution to the research area. The theory development is supported by this process and leads to further qualitative research.

3.3.1 Starting point

Prior studies in the merger of blockchain technology and public procurement is the starting point of the research. Using prior research as an indicator makes it possible to establish conclusions regarding the presence of obstacle observations and the magnitude of this in these papers.

In order to determine the presence of obstacle observations and orientation in the research area of the merger between blockchain technology and procurement a table with (15) articles in regard to the subject is presented. The article title, publishing year, author and the focus alongside occurring obstacles in the article will be presented. The keywords used for developing this table and the search of articles are “blockchain procurement” to achieve an inclusive search that is limited to the two domains. Research is done through Primo which is a database at University of Borås, that also sometimes forwards to different institutional and organizational databases such as IEEE Xplore. A majority of prior research presented is peer-reviewed and the material that is non-peer-reviewed is used as a result of a deficiency of relevant articles.

Table 1: Prior research table

No.	Article	Year	Author(s)	Focus	Obstacle(s)
1	“Transparency And Accountability in Urban Public Procurement: Design of a Self-Sovereign Blockchain App” (*Peer-Reviewed)*	2020	Ana Balan, Sînică Alboaie, Karima Kourtit, Peter Nijkamp	Benefits and a design of the implementation	No obstacles identified. Not obstacle oriented
2	“Blockchain-based system evaluation: The effectiveness of blockchain on e-procurement” (Non-*Peer-Reviewed*)	2019	August Thio-ac, Alfred Keanu Serut, Rayn Louise Torrejos, Keenan Dave Rivo, Jessica Velasco	Implementation and positive results of the implementation	No obstacles identified. Not obstacle oriented

3	"A Framework for the Adoption of Blockchain-Based e-Procurement Systems in the Public Sector A Case Study of Nigeria" (*Peer-Reviewed*)	2020	Temofe Isaac Akaba, Alex Norta, Chibuzor Udokwu, Dirk Draheim	Benefits of implementing blockchain technology	No obstacles identified. Not obstacle oriented
4	"Permissioned blockchain based public procurement system" (*Non-Peer-Reviewed*)	2020	J J Deshpande, M Gowda, M Dixit, M S Khubbar, B S Jayasri, S Lokesh	Benefits of implementing blockchain technology in permissioned matter	No obstacles identified. Not obstacle oriented
5	"The Implementation of Decentralised Ledger Technologies for Public Procurement" (*Non-Peer-Reviewed*)	2019	Sergi Nin Sánchez	Possibilities, benefits and legal challenges of an implementation	Some possible challenges are identified. Not obstacle oriented
6	"Blockchain Based Full Privacy Preserving Public Procurement" (*Peer-Reviewed*)	2020	Prem Ratan Baranwal	Shortcomings in current e-procurement and a solutions to these privacy concerns are presented	Obstacle oriented. Privacy obstacles in current e-procurement systems are identified
7	"Effective use of blockchain technology for facilities management procurement process" (*Peer-Reviewed*)	2021	Hasni Gayathma Gunasekara, Pournima Sridarran and Dilakshan Rajaratnam	Possibilities and benefits of an implementation of blockchain technology	No obstacles identified. Not obstacle oriented
8	"A Blockchain-Based Platform for the e-Procurement Management in the Public Sector" (*Peer-Reviewed*)	2021	Hasna Elalaoui Elabdallaoui, Abdelaziz Elfazziki, Mohamed Sadgal	An implementation and the benefits of the implementation	No obstacles identified. Not obstacle oriented
9	"Automating Procurement Contracts in the Healthcare Supply Chain Using Blockchain Smart Contracts" (*Peer-Reviewed*)	2021	Ilhaam A. Omar, Raja Jayaraman, Mazin S. Debe, Khaled Salah, Ibrar Yaqoob, Mohammed Omar	Presents a beneficial framework and implementation	No obstacles identified. Not obstacle oriented

10	“SecTEP: Enabling secure tender evaluation with sealed prices and quality evaluation in procurement bidding systems over blockchain” (*Peer-Reviewed*)	2021	Li Li, Jiayong Liu, Peng Jia	Proposes a secure tender evaluation mechanism based on identified limits from previous research	Obstacle oriented. Privacy concerns are the focus of this article
11	“Procurement, traceability and advance cash credit payment transactions in supply chain using blockchain smart contracts” (*Peer-Reviewed*)	2022	Praveen Vijaya Raj Pushpa Raj, Sunil Kumar Jauhar, M. Ramkumar, Saurabh Pratap	Present a smart contract-based conceptual framework. Considers positive effects of an implementation	No identified implementation obstacles. Not obstacle oriented
12	“An interdisciplinary review of digital technologies to facilitate anti-corruption, transparency and accountability in medicines procurement” (*Peer-Reviewed*)	2020	Tim K. Mackey, Raphael E. Cuomo	Presents benefits with an e-procurement implementation and the need for more research on success factors and failures	Not obstacle oriented
13	“Fostering Customer Bargaining and E-Procurement Through a Decentralised Marketplace on the Blockchain” (*Peer-Reviewed*)	2022	João Martins, Manuel Parente, Mário Amorim-Lopes, Luís Amaral, Gonçalo Figueira, Pedro Rocha, Pedro Amorim	Demonstrates an implementation example and identifies benefits and some limitations with the implementation	Some limitations are identified. Not obstacle oriented
14	“Blockchain-based System Evaluation: The Effectiveness of Blockchain on E-Procurements” (*Non-Peer-Reviewed*)	2019	August Thio-ac, Alfred Keanu Serut, Rayn Louise Torrejos, Keenan Dave Rivo, Jessica Velasco	Mainly focuses on the effectiveness and benefits of an implementation	No obstacles identified. Not obstacle oriented
15	“How ENI Can Improve Procurement Through Blockchain Technology” (*Non-Peer-Reviewed*)	2021	Audet Victoire Malonga Bibila, Pietro De Giovanni	Identifies use cases, limitations and benefits	Limitations are identified. Not obstacle oriented

3.3.2 Knowledge gap and contribution

Using the above table, the knowledge gap in obstacle oriented research is identified within the field. Out of the fifteen examined articles only two could be described as aimed towards obstacle identification, while thirteen articles were not. Out of these thirteen articles that were

not fully obstacle oriented, three mentioned potential limitations. The focus amongst the majority of all papers were the flaws in the current procurement process resulting in the benefits and possibilities of blockchain as well as implementation examples and designs.

In the light of the existing knowledge gap the conclusion is made that a knowledge contribution is possible to obtain. This gives reason to research this phenomenon with an obstacle-oriented approach and thereby shaping the theory with the use of a qualitative research study. By approaching this knowledge gap with key insights from professionals representing four different perspectives a way was paved for the paper to base its theory on reliable data. This made the analyzing process and its results more extensive so that significant conclusions could then be ensured to the largest extent to answer the research question.

3.3.3 Qualitative research study

The qualitative research of this paper contains four explorative interviews with four different perspectives regarding the possible obstacles of an implementation of blockchain technology on the process for public procurement in Sweden. All perspectives were asked the same main question in accordance with the obstacle orientation.

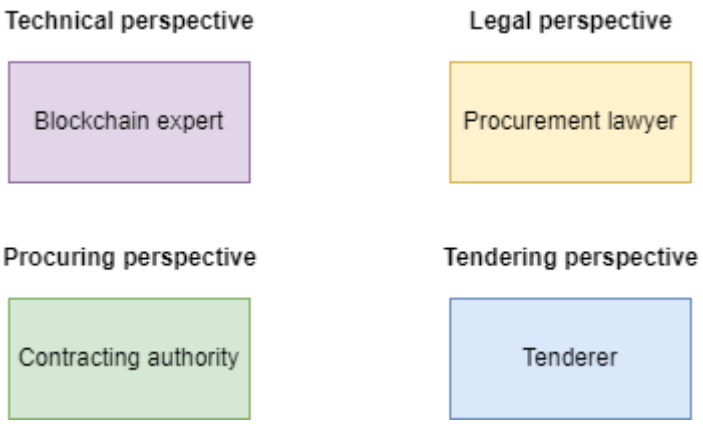

Figure 6: The different perspectives of the qualitative research

The question asked:
"*What possible obstacles do you think exist for the implementation of blockchain technology in the process of public procurement in Sweden?*"

The same question was asked several times only with emphasis, concerning the obstacles, on five themes. Political, economical, social, technological, legal and environmental. Follow-up questions were asked as well. The length of the interviews varied but the approximate goal was set to around 30 minutes and the number of characters transcripted in each interview were 18 474 (Blockchain expert), 7 217 (Procurement lawyer), 9 202 (Tenderer) and 6 710 (Contracting Authority) resulting in a total of 41 603 characters from all transcripts.

Table 2: Respondents table

Approach	Who	Organization	Perspective
Individual semi-structured interview	Juho Lindman	The University of Gothenburg Blockchain Lab	Technical perspective
Individual semi-structured interview	Rasmus Lundqvist	Borås municipality, Sweden	Legal perspective
Individual semi-structured interview	Jan Nilsson	Borås municipality, Sweden	Procuring perspective
Individual semi-structured interview	Jasper Sundh	Mindflower AB, Sweden	Tenderer perspective

Juho Lindman is an associate professor at the University of Gothenburg and the director of the University of Gothenburg Blockchain Lab. He holds several titles of docent and has published many papers related to blockchain and the public sector and this makes him an appropriate candidate to represent the technical perspective.

Rasmus Lundqvist is a lawyer and specializes in procurement legislation and has several years of experience in this area. He is currently working at the Borås municipality. Because of this expertise he is well suited as the representative for the legal perspective.

Jan Nilsson works as a procurer at the contracting authority Borås municipality and has a broad experience and knowledge base in procurement. He specializes in the procurement of IT systems and is therefore well-suited for participation as representative for the procuring perspective in this paper.

Jasper Sundh is a tenderer and has been involved in multiple procurements. He is the CEO of the tech company Mindflower located in Västerås, Sweden. He has a basic understanding of blockchain technology and a wide knowledge of procurement based on his previous experience in the process as a tenderer representing the tendering perspective.

4. Analysis

In accordance with our data analysis process defined in (2.4 Data analysis) we analyze the data collected through the research study. In this process the groundwork and analysis that is needed to support the obstacle categorization results is presented.

4.1 Grouping of statements

Patterns have emerged from identification of obstacles in all interviews and through the lens of the four different perspectives and respondents. First each perspective's data was analyzed separately, and the statements were grouped into obstacle topics in regard to each perspective. The groups of topics were then used as the basis for category development in a cross-perspective environment.

4.1.1 Technical perspective

The first topic that got identified by grouping the statements in the interview with the blockchain expert is the answers covering the *High risk, uncertain reward* aspect of the implementation of BCT in procurement. The blockchain expert states that:

> "…so the problem is that organizations are super polarized in terms of kind of buying it so they don't fully see the business benefit, I think at least. That is partly because it's unclear what the business benefit is so it hasn't been proven with enough evidence that it will provide specific business values, if you like." -Blockchain expert

> "It could be looked at as innovation projects where more risk and less parameters are needed to go for that but that would be one way to kind of mitigate that economic risk. But I think a lot of the economic risks just comes from the lack evidence really, so not directly related to that." -Blockchain expert

> "...it is seen as a cost and not as an investment. So what it basically means is that it doesn't stay on the balance sheet it just gets immediately thrown away which is of course the most dumbest thing I have ever heard how they deal with innovation projects."
> -Blockchain expert

What this means is that governments are very restrictive when it comes to making an investment and implementing blockchain. The public sector organizations that could implement blockchain technology in their operations do not see the benefits clearly enough due to the lack of evidence supporting these potential benefits that could enhance key business values and metrics. The blockchain expert then shapes the argument that the investments from organizations in implementing blockchain could be seen as innovation projects, to justify the economic risks involved. This is not how it is done today as the investments are not reported as assets but rather as a cost thus reducing the value of such fundings from an economical point of view.

Furthermore, the *Government use cases for blockchain solutions* is discussed and the blockchain expert points out that:

> "…many of the public sector blockchain projects are run under very kind of strictly runned under this kind of logic of new public management. Where the logic is that we are looking for short-term efficiencies from this innovation investments and I don't think it's a very good way to look at this. So, one of the issues that this causes is that many of the public sector pilots that we have seen they are very kind of oriented towards standardized environments, control of users and efficiencies. There is a lot less public sector blockchain projects that will be looking at more progressive issues or giving people more power to kind of deal with a more decentralized manner and numbers of these kinds of issues." -Blockchain expert

> "So it's kind of very control oriented public sector services that are being used around the blockchain sphere and a lot less deliberative or giving more freedom and autonomy to the citizens." -Blockchain expert

During the interview the blockchain expert emphasized that blockchain in the public sector is currently used mainly to benefit the efficiency and other business metrics of the organization, rather than focusing on the benefits of decentralization or other citizen-focused contributions of blockchain. He pointed out that the focus is wrong and that the benefits with the citizens as focus should be of concern to the governmental institutions, not business metrics improvements.

On top of this the *Legal limitations* of implementing BCT in procurement is also considered. This is mostly in regard to the current data privacy law in Europe also known as GDPR and the blockchain expert mentions that:

> "Many blockchain solutions are not super compatible with GDPR solutions." - Blockchain expert

> "...depending on how the GDPR requirements are formulated in the procurement call it probably has a huge design implication for blockchain systems that can be put in there." -Blockchain expert

> "...it's hard to use a permissionless blockchain in that situation." -Blockchain expert

> "...the institutional legal environment is not fully yet to support many of these decentralized blockchains or more disruptive blockchains and that is one of the reason to why we are seeing kind of more not so innovative or not so disruptive blockchains. More incremental blockchains are taken into usage in the public sector organizations." -Blockchain expert

Statements regarding legal challenges connected to GDPR when implementing BCT are made in the interview. These challenges could result in design implications and lead to the inability to use permissionless (decentralized) blockchains. This could also be part of the reasons as to why government use cases for blockchain solutions are not progressing in the direction of disruptive innovation.

When talking about blockchain and its disruptive behavior by the use of decentralization and so forth, this could cause tension and *Political pressure* as discussed in the interview with the blockchain expert. He states that:

> "They don't truly try to change things in the traditional environment that are rather conservative in terms of disruption that they are going for." -Blockchain expert

> "…if you have any real large scale pilots that changes for example income distribution in society, or just big in terms of users, then it's a risk that it might kind of become political or politicized in this way I guess." -Blockchain expert

> "Yeah, so we have problems basically with voting systems and then we have issues with kind of everything that becomes big in society in terms of that it changes and that contains a high risk of it becoming political. Third the environment related to blockchain is quite loaded and there is tensions in there, so people have opinions about it both good and bad opinions. So this kind of area can be quite easily politically used to say haha they are doing blockchain or you know they do not know what they are doing. So that's maybe those three points." -Blockchain expert

These statements demonstrate a clear view of the political aspects when implementing BCT in procurement. Firstly, it is stated that governmental institutions are static and not very prone to change. Also, when changes would result in disruptive behavior the attitudes towards the changes would most likely be a highly debated political question resulting in political concern.

4.1.2 Legal perspective

Firstly, the topic of *Data privacy* was identified where the respondent covered the different issues regarding data being public due to confidentiality. He states that:

> "In earlier stages, we have confidentiality and then it does not work with open data at all." -Procurement lawyer

> "…there is certain information we must keep secret, unit prices for example." -Procurement lawyer

The procurement lawyer highlights the importance of confidentiality to ensure data privacy in regard to the handling of procurement information affecting the key stakeholders of the process. The disclosure of pricing information or other sensitive information could most likely lead to bad social relations and other bad outcomes.

The bidding process is also strictly regulated according to the procurement lawyer and the procuring authority must maintain the *Secrecy of information* and the statement made around this is:

> "If we're talking about tenders, we have periods where we are not allowed to know who submitted the tender before the tender period has expired. Other bidders must absolutely not know who else has submitted a tender until we have decided who we will award the contract to. There is total secrecy there. After we have awarded, the total bid amount is public." -Procurement lawyer

This statement made from the lawyer has its basis in the need for bid sealing where the tenderers are totally unaware of all bids.

On top of the secrecy and data privacy issues the obstacle with *Compatibility with EU regulations and requirements* is congruent with the theme of legislative issues that is pointed out and the respondent states:

> "Then I will add that we have legislation that sets requirements for how a procurement system should work and what it should contain in order for it to merge with the entire EU. We have certain systems that are approved and these are the ones we are allowed to use." -Procurement lawyer

> "Yes, certain technical requirements. There must be a certain functionality and security must be guaranteed and so on. There are four systems in Sweden that meet this, I think." -Procurement lawyer

For a new procurement system and new technology such as BCT supporting this system it needs to adapt to the requirements that are set in the European legislation, and thereby not only adhering to Swedish laws. To get a new system approved there are legal requirements that consist of technical, functional, and security considerations.

For the *Identification of users* some legislation is also occurring in order to ensure validity of procurement documentation and the procurement lawyer underlines this by saying that:

> "I came up with another problem. In order for the agreements to be valid, it must be stated in the procurement documents who the contracting authority is. So even though it should not be in the system, it must be in the documents. In the ad or any of the attached documents. Otherwise we can not use the agreement." -Procurement lawyer

> "There have been cases where you have missed writing one of your companies in the procurement and then they have not been able to use the agreements." -Procurement lawyer

The procurement lawyer emphasizes the legislation around the validity of contracts and the fact that the contracting authority must be identified by name. This could present some technical difficulties concerning the anonymity structure of blockchain and the usability of this in procurement to anonymize the identity of all stakeholders in the procurement process.

4.1.3 Procuring perspective

The contractor first point to the use of *Secrecy and internal handling of information* in the procurement process and made statements being:

> "The thing with information becoming public, where we have the problem with procurement secrecy, etc. In some way, you must still be able to have it within a closed circle during the time you work with the work itself and keep the information within it then. " -Contractor

The contractor sees the importance of keeping the handling of data or information internal until the process of procurement has reached the awarding phase. He also argues that the procurement secrecy accounts for the importance of this.

Secondly the *Competence concerns* are discussed in the interview with the procuring perspective and the contractor emphasizes this by stating that:

> "As I said, you need a blockchain specialist who should be able to understand what can and cannot be done." -Contractor
>
> "…We need someone who understands the technology and someone who understands the procurement process…" -Contractor
>
> "I think you need someone who knows blockchains and someone who knows public procurement and has a good understanding of the other perspective." -Contractor
>
> "You can not have two experts standing there who have no knowledge of the other's field. Then I think it's difficult. I think it's hard to get a person who can get the whole thing, without having to get support from one or the other specialist competence for both to get each other." -Contractor
>
> "I do not think that as a single procuring authority you would start using this and implement this and understand how it would work. But you need to have a system integrator or a software provider or the like that develops a solution that becomes practically useful based on this technology." -Contractor

Competence concerns both regarding the actual implementation of BCT and the education of users to fully understand the technology and how to use it. As for the implementational aspects the contractor sees the need for a professional that understands both BCT and the procurement process. He also points out that this will be hard to achieve and that two professionals, one for each domain, needs to collaborate thoroughly to overcome the competence obstacle.

The interview with the contracting authority also covers the *Commitment criteria* that the authority wants to be presentable if commitment is to be made to the implementation of BCT. The contractor says that:

> "I think there needs to be someone who develops a solution or who makes an implementation with the help of the blockchain, much like we have suppliers of procurement systems today that we buy from and pay for." -Contractor
>
> "…if it saves time and gives us easier traceability or that we would get document storage in a more efficient way." -Contractor
>
> "…you have to make a calculation if it is something that is useful and if it were a new technology that contributes to a simplified process that would save time with us, then it is clear that it would be very interesting to implement it even if it might be more expensive than today's system support, if it saves time and gives us easier traceability or that we would get document storage in a more efficient way." -Contractor

The contractor concentrates on the need for an already developed blockchain solution that can be used for procurement. He also stresses the importance of the criteria in improving business processes and metrics if the implementation is to be considered by the contracting authority.

4.1.4 Tendering perspective

When interviewing the tenderer, the topic of *Security concerns* was discussed in association with the information handling and the current cybercrime wave. He states that:

> "…then there is also the issue of personal information and security when it comes to the information which has to be secured to spread to the public…" -Tenderer

> "They should be of very very high quality and they should be certified for the highest level of security as well and that might be a challenge." -Tenderer

> "Well of course there is a buzzword right now that is cybercrime. So technology is always sensitive and will always be used in cybercrime and in illegal data collection." -Tenderer

> "I think it is sensitive for criminals and criminal intents. Also when saying it is 100 percent secure, nothing is 100 percent secure and technology should be secure and very safe before everybody will be able to use it and before everybody will trust it enough to use it." -Tenderer

> "And then again protection of the systems and its users when it comes to cybercrime and illegal data collection." -Tenderer

The tenderer refers to "they" as the blockchains and underlines the importance of security certifications where the BCT could guarantee a safe procurement process development and execution. He sees the security aspects of the implementation of BCT as a challenge and states the buzzword cybercrime and that new technologies are sensitive to criminal intentions and data collection.

During the interview the *Skepticism towards blockchain* was also widely discussed and the tenderer made various statements regarding this such as:

> "I think they would be very suspicious." -Tenderer

> "…blockchain is supposed to be secure, but I think a lot of people put question marks behind that." -Tenderer

> "…you know the machine running everything and that where you might lose the human touch and the soft values." -Tenderer

> "…people in general don't like machines to tell them what to do." -Tenderer

> "…people trust people more than machines." -Tenderer

These statements are referred to the attitudes that people have in general towards blockchain and new technologies. Statements suggest that the attitude would result in skepticism towards blockchain and new technologies as a whole.

The seriousness when it comes to *Education of users* is considered a high priority by the tenderer in order for fair market competition to be met. He points out that:

> "…we will need to educate and train users and make sure that the competence levels for the majority of the suppliers is at the right level to create fair competition." -Tenderer

> "To give you an example. If only two people out of the one hundred suppliers understands how this works, then suddenly you only have two suppliers making you public offers. Instead of one hundred, which is also now very good for competition." -Tenderer

The tenderer argues that there needs to be comprehensive education of users to obtain fair market competition and therefore the values of market pricing for procurement. This could otherwise be leading to economic consequences both in the process and for the key stakeholders.

Lastly the *Political hesitations* when considering implementing BCT in procurement is considered and the tenderer mentions that:

> *"*There is a political situation when it comes to machine learning and artificial intelligence and also that is maybe sort of connected to the legal side of it because it's also not very sure how that looks right now and therefore the politicians are hesitant to go forward when it comes to blockchain." -Tenderer

> "And also, when you look into politics when it comes to organizations right now the decision makers that are taking care of these processes are scared of their jobs and they want to keep on doing their jobs and that is why they try to keep it from being blockchained. Also it is pretty definite that as a result of using technology for these processes the political bias will disappear. And right now, people can influence people and that means that politics might still have some kind of weight to put into the scale." -Tenderer

> "And there might also be some political information that are not meant to be spread to the public." -Tenderer

The current political environment of new technology is discussed by the tenderer covering the complications regarding political scarcity and political bias being undermined. Also some legal aspects in politics and political information disclosure is debated.

4.2 Categorization

This section will cover the categorization of the different topics identified in each perspective's interview. These topics are then analyzed in comparison to each other creating a cross-perspective environment for the definition of categories. By defining categories, the qualitative substance of the paper increases and each statement acquires increasingly

argumentative impact force. In this section we will analyze and argue for the topic properties and the making of categories.

4.2.1 Proof-of-Improving Concepts

This categorization is based on several respondents' statements concerning the public sector's restrictiveness towards blockchain implementation. This is due to there not being enough proof of benefits in present research, as stated by the blockchain expert in *High risk, uncertain reward* (4.1.1). He also states here that BCT as an innovation project is frequently seen as a cost and not an asset, in addition to that, In *Government use cases for blockchain solutions* (4.1.1) the blockchain expert states that the public sector looks at blockchain innovation as a means to achieve short-term efficiencies and not long term, neither what benefits it may have for civilians. In *Commitment criteria* (4.1.3) the contractor states something along the same lines. That if they are to make a commitment to BCT it must have certain proven benefits and efficiencies. The contractor also states that the blockchain solution must be developed before the municipality will implement this into the procurement process. There exist some interesting correlations between the statements made from the blockchain expert and the ones made from the contractor. We see a clear connection between the technical perspective's observation of obstacles regarding the solution interest in government and the intended use cases with the statements by the contractor that highlights exactly this. Both of these respondent's views on this could be seen as obstacles in regard to the distinction of attitudes between the perspectives around the same topics. For this reason, these topics by the respondents are categorized as "Proof-of-Improving Concepts".

4.2.2 Legal obstacles

This category refers to obstacles concerning law and legislation. It was created as several respondents expressed concerns regarding BCT's ability to adhere to the various strict regulations set by the EU and Swedish government on procurement systems.

We see various topics all throughout the interviews stating that there are legal obstacles regarding the implementation process of BCT in procurement. *Legal limitations* (4.1.1) are seen as obstacles by the blockchain expert where he states the challenges that the sphere of blockchain faces concerning GDPR. This could also lead to implicational problems for such BCT solutions. This seems reasonable considering that blockchain is a publicly accessible platform and based on the concept of anonymity, the implementation could most likely be affected by current legislation. *Data privacy* (4.1.2), *Secrecy of information* (4.1.2), *Compatibility with EU regulations and requirements* (4.1.2) and *Identification of users* (4.1.2) are brought to light by the procurement lawyer and how all of these topics could be influential to the implementation of blockchain and seen as obstacles as current laws, both in Sweden and the EU, could be compromised or forbid blockchain solutions in procurement. Based on statements made from the contractor around the *Secrecy and internal handling of information* (4.1.3) the contractor expresses that it is of utter importance that the secrecy is maintained to fulfill their legal obligations as implied throughout the interview. All of the statements and topics identified can be referenced to current legislation as they all are

obstacles that have its basis in current laws and the laws compatibility with BCT. As a result of this, the categorization of these obstacle topics resulted in the creation of the category named “Legal Obstacles”.

4.2.3 Political Obstacles

During the interview with the blockchain expert the topic about the *Political pressure* (4.1.1) concerning BCT solutions development in procurement is introduced. Concern is pointed towards conservatism in current environments and how blockchain implementation projects such as a new procurement system could be easily affected by politics. This as a result of blockchain having the capabilities to be a revolutionary technology and pilot projects show that this could have political complications and is seen as an obstacle. The *Political hesitations* (4.1.4) is also a topic that is covered in the interview with the tenderer where he mentions governmental attitudes towards new technologies as an obstacle. Spread of political information is also seen as a potential obstacle along with the sacrifice of political bias in the process of procurement. The political sides are seen as reasons for hesitation in government and politics around the implementation of BCT. Both these respondents based all their statements regarding these topics in politics and therefore these are defined in a category named “Political Obstacles”. Notable is the correlation between legislation and politics where much of politics accounts for changes in regulating laws and such. This has been taken into consideration to the largest extent when developing both categories.

4.2.4 Competence obstacles

Competence related concerns were expressed at several instances. Regarding both the competence of those involved in the technical implementation and the education needed for users of the system.

Competence concerns (4.1.3) were identified and this topic was highlighted in the interview conducted with the contractor as the procuring perspective. The concernments regarding competence levels were focused partly towards the stakeholders of the actual implementation of BCT in procurement and the ability for communication between domain specialists, or an expert that masters both domains which could be rather difficult to acquire according to the contractor. In addition to this the worries regarding competence were also focused on the users understanding of the BCT solution in procurement and the respondent emphasizes that this could not be obtained without a system integrator. The tenderer then builds onto this subject further by expressing competence concerns regarding *Education of users* (4.1.4) specifically and states that if the user’s understanding of the system is not achieved fully there could be market pricing repercussions resulting in economic disadvantage and an unfair procurement market. Both the respondents raise awareness of the obstacles regarding competence requirements for satisfactory results when implementing BCT in procurement. This observation leads to the creation of the category “Competence Obstacles”.

4.2.5 Other

This category was defined as a result of topics covered in interviews that were not able to be cross-sectioned with statements made in other interviews. The category was developed based on the fact that there still exists identified obstacles in the interview with the tenderer regarding the *Security concerns* (4.1.4) and *Skepticism towards blockchain* (4.1.4) even though this topic was not a broad concern among all respondents. To summarize, this category is used to not undermine the entirety of the obstacle observation.

5. Results

With the use of the data analysis method stated in (2.4 Data analysis) results can be obtained from the data collected in the qualitative research study. By getting familiar with, reductioning and condensing this material a variety of comparisons could be made between the identified obstacles from the different respondents and perspectives. This led to groups of statements that finally got categorized in a cross-perspective environment and finally named. The final results of the data analysis process (category names) will be presented in this section.

5.1 Categories

Table 3: Category table

Cross-perspective Obstacle Categories	Obstacle Topics (found in…)
Proof-of-Improving Concepts	*High risk, uncertain reward* (4.1.1)
	Government use cases for blockchain solutions (4.1.1)
	Commitment criteria (4.1.3)
Legal Obstacles	*Legal limitations* (4.1.1)
	Data privacy (4.1.2)
	Secrecy of information (4.1.2)
	Compatibility with EU regulations and requirements (4.1.2)
	Identification of users (4.1.2)
	Secrecy and internal handling of information (4.1.3)
Political Obstacles	*Political pressure* (4.1.1)
	Political hesitations (4.1.4)
Competence Obstacles	*Competence concerns* (4.1.3)
	Education of users (4.1.4)
Other	*Security concerns* (4.1.4)
	Skepticism towards blockchain (4.1.4)

5.2 Category definition

- Proof-of-Improving Concepts

In the interview with the blockchain expert he pointed out that the interest in blockchain by the government is unsuitable for the capabilities of disruption in BCT and aimed at improving business effectiveness and efficiency. The benefits of blockchain are also not clearly identified and this results in lack of investments in the blockchain sphere by governments. The statements made from the contractor supports these claims and underlines the obstacles in the area of what is named “Proof-of-Improving Concepts” in this paper.

- Legal obstacles

This category summarizes the various obstacle topics related to legislation that are discussed and identified in interviews by three respondents. This is found in three perspectives and what these have in common is their obstacle observation based in legislation and laws thus generating this legislatively aligned category.

- Political obstacles

The topics resulting in this category are all focused on political hesitation and concern when it comes to new technologies as a result of BCT’s ability to disrupt the current environment. The concerns are identified within two perspectives by both the blockchain expert and the tenderer.

- Competence obstacles

Competence obstacles refers to the statements made by respondents from two perspectives in regard to assuring a satisfactory implementation of BCT in procurement and users' ability to understand the implemented BCT system. Competence in both BCT and public procurement is imperative to a successful implementation. Then there is also importance in the user's ability to use the system, as competence must be assured there as well. This category therefore refers to the respondents statements concerning “competence obstacles”.

- Other

This category is used to identify the obstacle topics that did not find cross-perspective relevance. Even though this relevance is not obtained, the obstacle topics are still admissible as hampering obstacle statements made from a respondent in the exploratory interview as part of the research study. This category contains obstacle topics found in an interview with the tenderer.

5.3 Obstacle dynamics

As mentioned before, the correlations between different obstacle categories could possibly result in obstacle categories influencing each other. For example, political intentions will most likely affect the legal obstacles in implementing BCT in procurement, thereby creating a tension between these two categories. Politics also has the ability to influence the interest and funding for BCT solutions resulting in the Proof-of-Improving Concepts obstacle category. The legal obstacles will also add to the hampering of Proof-of-Improving Concepts by static

environments and a slowly evolving legislative process that results in the need for improving concepts but somewhat contradicts this realization. Obstacle dynamics could also benefit from further research that investigates these categories and their relations even more.

6. Discussion

This chapter is defined to interpret the results in comparison to prior research studies and is explicitly concentrated towards the theoretical framework. Traceability between the theory, study, analysis and the results is then achieved.

6.1 Knowledge gap

The knowledge gap is defined by comprehensively analyzing prior research in the subject sphere and this is done to the greatest extent possible given the paper's deadline. This work contributes to the field of research by adding this obstacle-focused study to the current literature, thereby filling the knowledge gap.

6.2 Results compared to prior research

Based on the contents of prior research found in (3.3.1 Starting point), that vaguely mentions some limitations in the implementation of BCT in procurement, the legal obstacles were expected as an analytical outcome of this paper. Some of the results in this paper were thereby in line with the prior research obstacle conclusions in the field. As seen in the paper by Li, Liu and Jia (2021), the privacy protection in current BCT solutions for procurement are seen as a challenge and limitation. In the research done by Baranwal (2020) the privacy concerns are also the main subject. Both these studies are based on this problem and suggest possible solutions to this by using Zero-knowledge proof. This obstacle can also be seen within our obstacle category named “Legal Obstacles” where several respondents emphasize the importance of bid sealing and concern around data privacy. The problems with data privacy and need for bid sealing processes is rooted in legislation. The obstacles identified in this paper's category “Competence concerns” regarding the challenges in education of users was also present in the article written by De Giovanni and Bibila (2022). They also state the immaturity of BCT and how this could potentially result in the “Proof-of-Improving Concepts” obstacles that were identified in the research study.

The “Political” obstacles identified in the conducted research study of this paper was not expected based on prior research. The “Other” obstacle category identified in the research study was identified in prior research. These categories and thereby obstacles were not expected as outcomes and results in knowledge contribution.

The majority of prior research found does not cover the implementational obstacles. Given the obstacle orientation of this paper the differences between this paper and prior studies are substantial based on different intentions and this is a result of the discovered knowledge gap. The majority of these articles are therefore irrelevant to the discussion concerning theory on implementation obstacles in a BCT based procurement system. Despite the fact that these articles have a different focus than this study, they will nonetheless help to solidify the research field by improving its relevance.

7. Conclusions and final statements

By conducting the research study, results were obtained both individually and in a cross-perspective environment by thoroughly categorizing the different obstacle topics identified in the individual interviews. The results of this study were the creation of five obstacle categories identified among respondents. By analyzing the categories the names were determined resulting in *Proof-of-Improving Concepts, Legal obstacles, Political obstacles, Competence obstacles and Other* to describe each category in an inclusive and comprehensive manner.

In this research paper the aim was to first find a knowledge gap. The starting point defined in the theoretical framework brings on the arguments for an existing knowledge gap in prior research in the field of BCT implementation in procurement. These claims are based on comprehensive literature analysis of prior research and by doing this the relevance of the research study's purpose and research question is substantiated. After finding the knowledge gap the goal of this study was to identify the obstacles that hampers the merger between BCT and procurement.

This paper has found a defined knowledge gap that points to the importance of obstacle oriented research. The results obtained from the conducted research study then underlines the misguided focus in the field. For the implementation of BCT in procurement to be realized effectively, obstacles must be taken into consideration before exploring actual blockchain solutions.

7.2 Method reflections

There were some difficult aspects regarding the qualitative research conducted within the merger between public procurement and blockchain technology. A complete understanding of both domains is not guaranteed among key stakeholders as they are specialized within their respective fields. This is why some respondents had to be presented with additional information regarding the basics of blockchain technology before starting the interview.

Some critique could potentially be pointed towards the number of respondents and interviews conducted in this paper. This was brought on by the time limitation, difficulty finding blockchain experts and bad response rate in general. When limiting the study to Sweden this also became a limitation when trying to find more respondents to each perspective as respondents in other countries were excluded based on their geographical location. Even though the limitation was set to Sweden and the total number of respondents was small this resulted in significant empirical proof in relation to the merger between blockchain technology and procurement in this country.

To gain even more insights of the potential obstacles around the implementation, introducing more participants from different perspectives in the same interview could be beneficial, so that they can reason with each other and thereby enhancing qualitative discussion and results.

Even though this was a challenge combining the perspective of two different domains, all of the respondents came to conclusions and some common obstacle observations could be seen.

Lastly, given that we translated the answers from two of the interviews, this could potentially influence the context interpretation.

7.3 Future research ideas

The correlation between different obstacle categories found in (5.3 Obstacle dynamics) could be explored further to determine the level of influence and dependence between these different areas by cross-examination. What is the level of dependence between these obstacle categories? Could the correlation and influence between obstacles areas be limited or excluded and how? How are the obstacle categories influenced by one another?

This could potentially be done by researching the obstacles in accordance with the limitations of this paper or based on a larger geographical area, allowing the research of potential barriers in a cross-country perspective. This could also result in a wider range of respondents from all perspectives and limits the number of useful respondents to a larger quantity.

Further research could also be focused on the key success factors achieved if the identified obstacles of this paper are solved. This could lead to more possibilities and more arguments for future implementation. When establishing the key success factors the actual implementation could be investigated with the deployment of smart contracts and information on a blockchain and/or the modeling process of the implementation.

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APPENDICES

Appendix A - Interview Guide, Individual interviews

Interviewer: Noah Boekelman
Respondents: Blockchain expert, Procurement lawyer, Contracting authority, Tenderer
Duration: Approximately 30 minutes

Introduction

-Presentation of the topic and research question

Main question:

What possible obstacles do you think exist for the implementation of blockchain technology in the process of public procurement in Sweden?

Themes to cover:

-Economical obstacles
-Social obstacles
-Technical obstacles
-Legal obstacles
-Environmental obstacles
-Political obstacles