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# Supply Chain Transformation by Blockchain Technology

## Implementation of Blockchain Solutions in Supply Chains


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## Abstract

There are increasing disadvantages and challenges for traditional supply chains as the supply chains are getting more extended and complex, mainly due to the rapid changes in the market environment. We have various risks such as an increasing amount of corruption, lack of quality control and difficulties of tracing impacts of disruptions along the supply chain. One of the promising new disruptive technologies to solve these issues is blockchain technology. It is possible now to have supply chains with single versions of truth displayed in real-time that can contain information about quality, quantity, location, condition and custody of assets. However, behind all the promising solutions and opportunities that blockchain technology can bring, there are also challenges. Therefore, this study aims to investigate where current academic research mainly lacks mentions and analysation, which is about the motives and challenges for the implementation of blockchain solutions in supply chains, with an extensive focus on interoperability, standards, token-based solutions and traceability and visibility features.

The study is conducted in terms of a qualitative and exploratory method, with an abductive approach following a multiple case study design. Four representatives from the academic, advisory and consulting context contribute with clarities and explanation regarding the industrial view, together with three representatives from token-based solutions. The teams behind the token-based solutions represented in this study are Vechain, Ambrosus and Morpheus Network. The research concluded that companies are implementing more blockchain solutions and that blockchain might create the most significant changes in the supply chain industry for a long time. The technology is maturing and seen as necessary. Common motives for implementation are the enhancement of transparency and trust. Actors should have a clear issue before implementation where blockchain solutions can create value or save money. Blockchain will not solve everything, and the lack of knowledge is a big hurdle. Clarity issues in terms of regulations and negative associations to cryptocurrencies is another hurdle. Another challenge is the interoperability issues where incumbent technologies need to bridge to blockchain solutions. The key for success is interoperability, and it needs to be agnostic on a supply chain level. Tokenisation seems to increase and play a significant role in the future.

**Keywords:** blockchain, distributed ledger, token, tokenisation, crypto, bitcoin, supply chain, scm, logistics, transport, interoperability, standards, transparency, traceability, visibility.

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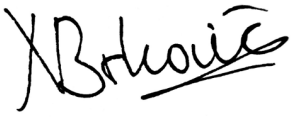

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# 1. Introduction

*This chapter starts with a background about the supply chain transformation, and then a problem discussion regarding blockchain technology that the thesis will investigate. This is followed by the purpose, the research questions, and a description of the study delimitations.*

## 1.1. Background

Supply chains are networks of units, products and services tied together with different actors. These actors can be suppliers, factories, distributors, wholesalers, retailers and all the way down to the end customers. The role of supply chain management is to integrate various entities in the supply chain and then efficiently coordinate and manage different flows. These flows can either be physical flows, financial flows, and informational flows that go both upstream and downstream in the supply chain in order to reach the goal of maximising the added value to a high degree. The aim for supply chain management is to minimise the costs, but still meet customer requirements (Simchi-Levi & Kaminsky 2007).

Supply Chain 4.0 is the new era of supply chain management and has been developed from the term Industry 4.0. This is a term that plots the beginning of digitisation and digitalisation in the different supply chain processes with the help of new disruptive technologies. Industry 4.0 is characterized by products and services that are flexible, mainly in connecting to various networks, where digital connectivity can enable automated and optimised production solutions without human interactions (Hofmann & Rüsch 2017). Connectivity is the critical enabler of visibility, which is a function that tends to remove technological barriers amongst actors in the supply chain. Visibility leads to better supply chain integration and better supply chain performance (Somapa et al. 2018). Many motives are thereby aimed to enhance more visibility as it gives many benefits. Visibility enables shorter lead times, improved forecasting, greater flexibility and better risk management (Calatayud et al. 2019). To collaborate and monitor the supply chains before the implementation of the new technologies developed side by side with Industry 4.0, was difficult. The identification and data availability was limited, with a lot of system interoperability issues (Zekhnini et al. 2020).

In the state of Supply Chain 4.0, performances can be monitored by a lot of data in collaboration with various new technologies to identify and forecast risks. Simulation models will allow predicting the future with minimal errors and also take actions automatically to prevent ongoing

and future risks (Calatayud et al. 2019). This will lead to greater agility, and Supply Chain 4.0 will, in most cases, allow organisations to have better visibility and reduce disruptions by having flexible, interoperable digital ecosystems. This is also a way to leverage new technologies in order to create smart and efficient processes (Makris et al. 2019).

There are more and more disadvantages, and challenges for traditional supply chains as the supply chains are getting more extended and complex. Supply chains are becoming more complex due to rapid changes in the market environment. The output and demand are volatile, primarly due to the COVID19 pandemic, but we also have growing international competition (Agrawal, Narain & Ullah 2020). Customers want more customisation of products and services, and often with higher service levels and lower prices. To embrace the new complicated market environment, firms need to be more agile and respond quickly. This is usually costly, and firms need to gain better visibility throughout the whole supply chain first to have better collaboration with actors in order to balance the rising costs (Ben-Daya et al. 2019).

There are challenges today with an increasing amount of various risks such as the increasing amount of corruption, lack of quality control and difficulties in evaluating the impacts of disruptions along the supply chain (Manners-Bell 2017). Information sharing is also critical and an important issue when it is done between known or unknown entities as it creates trust issues and poor transparency throughout the supply chain (Preindl et al. 2020). With interoperability issues, silo-thinking, and the lack of information sharing, we will also have visibility issues. It is challenging to verify the sources of materials when there are different kinds of inconsistencies throughout the supply chain (Frederico et al. 2019).

Chopra & Meindl (2010) explains that supply chain management often includes trade-offs, where responsiveness cannot improve without increasing costs. These new disruptive technologies could change this. The new technologies usually consist of the Internet of Things, Artificial Intelligence, Big Data Analytics, Robotics, Wearables, 3D printing, and Blockchain Technology (Zekhnini et al. 2020). Wiedenmann & Größler (2019) says that the new technologies have opened up a lot of potential in regards to networking throughout the whole supply chain. It will have implications on all business areas and lead to significant disruptions and changes in the supply chains. It is more about connecting the physical world to the digital world, and it will depend on how companies in the future acquire, handle and share data along their supply chains and its stakeholders (Preindl et al. 2020).

## 1.2. Problem Discussion

One of the promising new disruptive technologies is blockchain technology. Blockchain technology has the characteristics where organisations and various actors, for the first time, can both manage and trade different assets digitally without intermediaries. The assets can be both physical and digital, and in some cases, presented in the form of digital tokens. Trust is not achieved by third parties but through cryptographic programmable code (Tapscott 2020; Manners-Bell & Lyon 2019). It is possible now to have supply chains with single versions of truth displayed in real-time containing information about quality, quantity, location, condition and custody of assets. Smart contracts could be deployed to trigger automatic payments and documentation transfers which can reduce human interaction and legal fees as it reduces friction between actors. Even the costs could decrease due to fewer steps of administrative tasks in the supply chain. Transparency and visibility are enhanced where flows throughout the supply chain can be seen, and due to the immutable features, actors can be confident in the information. A higher volume of data, in combination with blockchain technology, can enable us to study large scale supply chain as never before. Blockchain technology has the ability to transform the global flow of assets of all kinds (Tapscott 2020).

However, behind all the promising solutions and opportunities that blockchain technology can bring, there are also challenges. All these challenges, but also motives, need further research, according to Tapscott (2020) & Teuteberg (2020). The current academic articles covering blockchain implementations in supply chains lack mentions of interoperability, standards, token-based solutions and the importance of traceability and visibility features. There are many technological challenges in the industry with immaturity that needs to be fixed. There is a need for a common framework of regulations as different actors have different policies.

There is also a lack of understanding of the technology itself. Many organisations try to operate their own blockchains, while the optimal solution is to integrate different systems. The differences between public and private blockchains lack thorough understanding, and the main feature here are tokens (Antonopoulos 2019). There is a widespread lack of awareness and lack of knowledge of what these token-based solutions can give back and what they offer interested actors in the supply chain ecosystem. When token-based solutions in the supply chain ecosystem are cited in academic research, it is mostly combined with other sectors, and there is no in-depth analysis of their motives and challenges (Teuteberg 2020).

There is also many interoperability issues, although the importance of blockchain ecosystems has increased, which according to Manners-Bell & Lyon (2019), is an area that is not having sufficient academic research. According to Kshetri (2018) should all actors in the supply chains work together and aim to set principles. International standards would need to be developed to suit blockchain development and as a requirement for interoperability between the different systems. Therefore the standards development for blockchain solutions in the supply chain industry also needs further research so it can enable further progress for authorities and enterprises (Tapscott 2020).

## 1.3. Purpose and Research Question

According to Tapscott (2020), Teuteberg (2020) & Manners-Bell & Lyon (2019), there is still a need and room for further research in regards to the motives and challenges of implementation for blockchain solutions in the supply chains. The research mainly lacks mentions and analysis of interoperability, standards, token-based solutions and the importance of traceability and visibility features. This study, therefore, aims to raise awareness about the motives and challenges of implementation for blockchain in the supply chains, with an extensive focus on non-sufficient academic research regarding interoperability, standards, token-based solutions and traceability and visibility features.

**Thereby the research question in this thesis report is:**

- What are the motives and challenges of implementation for blockchain solutions in supply chains?

## 1.4. Delimitations

Several limitations have been made to have a clear structure in the thesis. The scope of the study is the specific features of blockchain technology in supply chains that are lacking further research and understanding. Those are interoperability, standards, token-based solutions and the importance of traceability and visibility features. The main focus has been on a broad scope of supply chain activities, but regarding the respondents' backgrounds, there is a tendency to more weighting regarding logistics and transport sectors. The focus of the study is also limited as much as possible to the recently published literature, as well as available interview individuals who have experience with blockchain technology and supply chain management.

# 2. Theoretical Framework

*This chapter presents a theoretical framework, starting in the first part to describe the characteristics of blockchain technology. Terms like decentralisation, distributed ledgers, private and public blockchains, smart contracts and tokenomics and tokenization are described. The second part consists of a literature review regarding the themes of the research question about blockchain technology solutions in the supply chains.*

## 2.1. Blockchain Technology

### 2.1.1. Description of Blockchain Technology

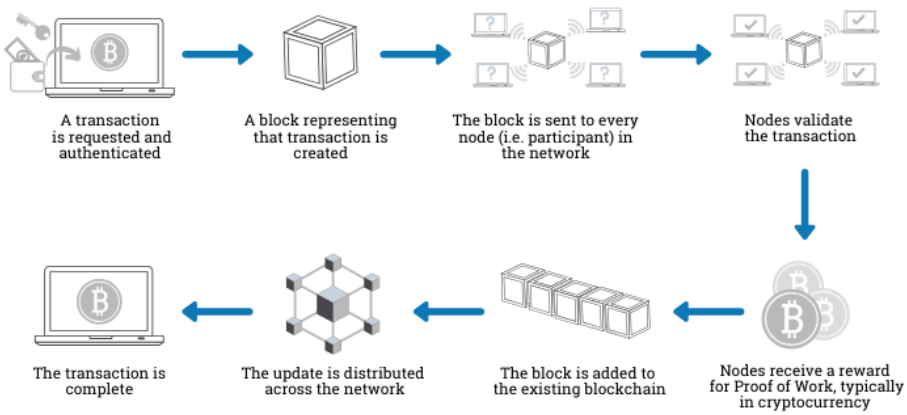
In 2008, the pseudonym Nakamoto published the white paper: ‘’Bitcoin: A Peer-to-Peer Electronic Cash System’’ (2008), where he created an infrastructure that would allow transactions in a decentralized way without intermediaries. Blockchains could be seen as an infrastructure with different features on top of it. Nakamoto (2008) explained the infrastructure as some kind of chain of connected blocks that are encrypted and that cannot be tampered with. This feature guarantees that transactions cannot be altered with once confirmed in the blockchain, unless a majority of computers or nodes in the network agree to do so at the same time. All the blocks have to be adjusted, therefore making it extremely hard to alter. Blockchain technology has, since its launch, been seen as one of the promising advances in technology in the last decade (Tapscott 2020). The information in the blockchain is stored and distributed across all computers and participants, where everyone has a replicated version, also called identical copies over a large number of separate computers worldwide, in a network that is chronologically, simultaneously, and cryptographically designed (Norberg 2019). The blocks are chained in cryptographically sealed records of transactions, and the blockchain is not split across multiple computers but copied on every computer. All actors on the blockchain that are owning a copy of the ledger are called nodes (Antonopoulos 2019).

The decentralised network reduces single point failure risks that occur within centralised networks, where one failure can shut down the network and create severe issues. Compared to centralised networks, decentralised networks reduce unnecessary traffic flows and also provides better scalability (Antonopoulos 2019). The blockchain updates in real-time with built-in immutability. This feature allows for a secure exchange of data and makes the system resilient to attacks. It is also impossible to change stored information (Norberg 2019). Every time new information is added to the blockchain in the format as a new block. Data inserted into the block

is called a hash, where each block is containing a cryptographic hash, and this is a unique value that helps to identify the block and the series of transactions. It is time-stamped and linked with previous blocks in the chain. Different blocks combined provide a complete ledger of the transaction history. This creates a chain with a single point of truth with only one version. In this, it is possible to show true ownership of a product just by accessing the transaction in the blockchain (Tapscott 2020).

It is easiest to explain the function of blockchains using the example of the cryptocurrency Bitcoin. The actor who is the owner of Bitcoin holds specific keys that shows that he is the valid owner of that specific Bitcoin. The Bitcoin is registered to that key in the blockchain, and if the actor would like to transact the Bitcoin, then a request is sent out to the blockchain network regarding the transfer of ownership of that specific Bitcoin to the recipient's keys. The distributed database will then control both keys and see if the sender is the rightful owner. The chain of all transaction on the Bitcoin network is then updated with the new transaction where the Bitcoin is registered to the recipient (Flodén 2018). Blockchain transactions are made secure by using a combination of private and public keys. The keys are based on mathematical algorithms, where one is private and secret, and the other key is public. It is not impossible to figure out the private key from the public key. Therefore the public key can be given away, but the private key should never be exposed. The matching keys can be used to verify the identity of a sender. In a transaction, the sender creates a digital signature by combining the private key and the message content, which in most cases is a monetary transaction. The signature is then verified by the receiver using the public key (Manners-Bell & Lyon 2019). For a clearer visualisation of a transaction, look at the *figure 2.1.*

**Figure 2.1. – Visualisation of a Bitcoin transaction (Euromoney 2020)**



Nothing ever gets deleted in the blockchain as the old records remain with all previous transactions. The idea is not to make it possible to tamper and manipulate transactions. This cannot be done as there is a large number of databases that need to be manipulated at the same time. If some attempt is made, then the transaction would get rejected as it will not match with other databases. In addition, blockchains are considered secure since it is almost impossible for anyone to hack or control a large enough share of the databases to make unauthorised changes (Flodén 2018). This gives a blockchain good integrity, but also transparency, since all users can be sure that the data has not been altered, and they can check that too in the network. This is very valuable in situations where there are no central authorities that can be trusted. Blockchain can also cut out intermediaries and full audit trails in many transactions, and in many cases, also improves visibility and reduces transaction costs (Tapscott 2020).

### 2.1.2. Public and Private Blockchains

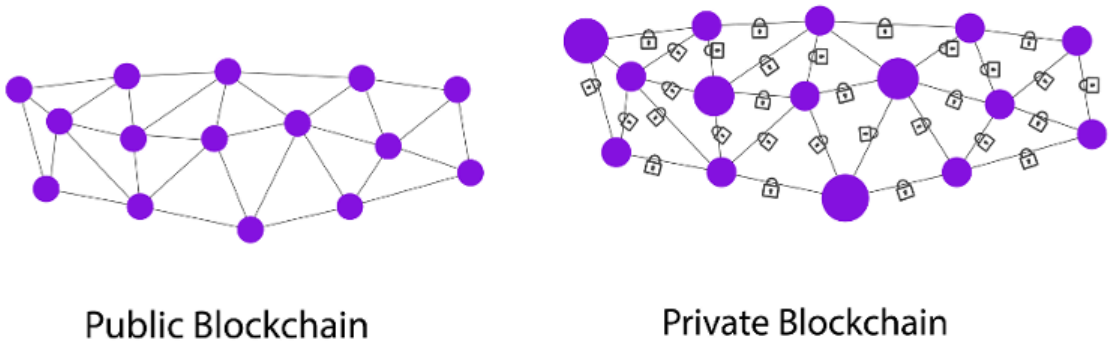
There are different types of blockchain networks that can be divided into public and private blockchains. Consortium based blockchains are often included in the term private blockchains. Public blockchains are open to anyone interested in joining the network and is considered to be the most decentralised and distributed option. In a public blockchain, the computers or nodes involved are not owned or controlled by any actor or organisation. The network of computers supporting the public blockchain can confirm, verify and record the transaction independently and thereby provide trust (Manners-Bell & Lyon 2019).

Any changes made on a public blockchain are instantly updated to all the parties involved, making it an easily trackable system. All transactions are timestamped, which creates an immutable chain. Examples of public blockchains are Bitcoin and Ethereum (Shaikh & Lashari 2017). Public blockchains are an alternative approach instead of using third parties or intermediaries between participants, for example banks. This guarantees that transactions cannot be modified once confirmed in the blockchain unless every computer or node, agree to do so at the same time (Manners-Bell & Lyon 2019). The implication of this is that public blockchains are likely to be more trusted and more secure. Other strengths of public blockchains are that they are simple, have high community support, complete and tested. Some weaknesses are that they tend to be slow and inflexible (Antonopoulos 2019).

On the other side, private blockchains require participants to be registered and follow the rules established by the owner or owners of the private blockchain. Information is available to the

users of a private blockchain network, although it is not always detailed enough in order to reveal the identity of an actor, where only a controlled group of actors have access to more detailed information (Androulaki et al. 2018). Nodes need to be authenticated in order to join, and solutions on private blockchains can be more efficient and deterministic. Other characteristics of private blockchains are that they are fast, easy to upgrade, designed for smaller private networks and currently have high enterprise support (Qian et al. 2018).

**Figure 2.2. – Public and Private Blockchain (O'Reilly 2020)**




However, questions are posed of why a private blockchain would be preferred than just build a solution around a centralised database. This is similar to when the internet became mainstream, where at the start, many companies used technologies to build their own private intranets. After creating these intranets, the companies soon realized that the open and public internet provided much more capability (Manners-Bell & Lyon 2019).

### 2.1.3. Smart Contracts

The idea of smart contracts was introduced back in 1996 by named Nick Szabo, where he predicted that the digital revolution would have a significant impact on the way contracts are handled. Smart contracts on the blockchain allow the rules to be encoded in a program that is replicated to all blocks in the blockchain. Smart contracts are encrypted as the content of contracts could contain sensitive information. The contract verification is validated and enabled through consensus mechanisms and then stored on the blockchain (Dolgui et al. 2020).

Smart contracts are described as computer protocols that, by preprogramed rules, facilitate, execute and enforce a contract between different parties. One of the most important applications in supply chains in regards to blockchain technology are smart contracts. A smart contract is a

protocol recorded on the blockchain that does not need human interaction (Cong & He 2019). Smart contracts are able to remove the need for contractual clauses. The smart contract is set up with lines of code with certain conditions that need to be met by all parties to execute pre-specified tasks or actions autonomously (Zheng et al. 2020).

Smart contracts can trigger different real-time actions if specific and certain rules are fulfilled to which all involved actors agreed upon beforehand (Liao & Wang 2018). The agreements are stored on the blockchain in an immutable way and make it accessible for all involved actors if they have the permission of accessing the smart contract. The smart contract audits can then agree on conditions and can thereby trigger intended actions if everything is valid. If the contract violates or is not following the agreement, then the underlying blockchain technology will stop the programmed actions from moving along (Gurtu & Johny 2019). Smart contracts can verify if products or services meet specific standards. Smart contracts are also enabled to secure transactions with different actors without intermediaries. All transactions are traceable and transparent due to blockchain technology in the background (Christodoulou et al. 2018).

As smart contracts can embed business rules and let them operate independently, they could act as systems that keep a record of ownership or even different kinds of lifecycles. As smart contracts are self-executing, they could be used in the registration of assets, and the smart contract will record who is using the asset and how it is used, for example. Assets could be rented, operated and funded. The smart contract is not owned by any party, and it is just information that exists on the blockchain (Manners-Bell & Lyon 2019).

### 2.1.4. DeFi – Decentralised Finance

DeFi is connected to decentralised applications that perform financial functions on blockchains. Instead of transactions being made through a centralised intermediary, transactions are directly made between participants, enabled by smart contracts. Smart contracts for the DeFi protocols run by using open-source solutions. In recent time, a lot of complex financial services have been developed due to DeFi. Financial liquidity pools in a liquidity protocol are some use cases. Decentralised exchanges are usually common regarding DeFi, which allows for trading of digital tokens, where the platform is governed by its users. There is no centralised party running these protocols, and there is no one to check the identities of the actors using the platform. It is still not clear what regulators will take on the legality of these platforms (Zetzsche, Arner & Buckley 2020).

### 2.1.5. NFT – Non-Fungible Token

A non-fungible token is a piece of data stored on a blockchain that certifies a digital asset with proof of ownership to be unique and not interchangeable, thereby non-fungible. NFTs can be used to represent physical items but also digital files (Westerkamp et al. 2020). NFTs often function as a cryptographic token, but it is non-fungible, and the transaction process ensures the authentication of each digital file by providing a digital signature to track ownership. Ownership of an NFT does not grant copyright privileges to the digital asset the token represents. NFTs are more a proof of ownership that is separate from a copyright. NFTs have many use cases, but they are primarily used in terms of art and collectable cards today (Caldarelli, Rossignoli & Zardini 2020).

### 2.1.6. DAO – Decentralised Autonomous Organisation

DAO is referred to a company or an organisation that can fully function without hierarchical management. DAO has a pre-programmed set of rules and triggering functions autonomously. Rules are often set by a smart contract. A DAO has to have internal property, which can be tokens that can be used to reward certain activities. Users could also get voting rights by investing in a DAO, and thereby the ability to influence the way it operates. After the DAO is funded, it will become fully autonomous and independent. A DAO is open-source, so the code can be viewed by anyone. And all the rules and transactions are recorded in the blockchain, which makes a DAO fully transparent and immutable. Decisions on where and how to spend the DAO funds are made via reaching a consensus. Everyone who bought a stake in a DAO can make proposals regarding the future (Metjahic 2018).

### 2.1.7. Tokenisation and Tokenomics

A better understanding of tokens and cryptocurrencies is fundamental to benefit from the disruptive potential given by blockchain technology. Sometimes a distinction can be made between cryptocurrencies and tokens. In computer science, it is defined that a cryptocurrency trades on its own independent blockchain, whereas a token is generated on a third party existing blockchain. But generally, the terms are often used with the same meaning (Oliveira et al. 2018).

Tokenomics can be seen as a creation of self-governed economic systems where rules are programmed by token creators. They are primarily industry or purpose-specific tokens, where the goal is to create common added value for all actors with tokens as the value proposition

(Freni, Ferro & Moncada 2020). Today there is still a lack of knowledge of what token holders have required in practice. This is due to that tokens on public blockchains are unregulated and often do not include any legal obligations. Blockchain token structures are usually non-standardised, and there is a unique economic feature of each token that is not based on legal rights but based on promises and functions. These promises and functions can create economic value extending from the underlying asset or organisation to the token (Lo & Medda 2020).

Ownership can be transferred on the blockchain without trusting intermediaries because of the decentralisation, transparency and distributed infrastructure of blockchain technology. These ownerships are also referred to as tokens (Teuteberg 2020). Tokenisation represents a form of digitalisation of value where tokens can be described as the unit of tradeable value created to empower users to interact with services and products. They can also be seen as privately issued currencies to exchange value. The value represented by tokens can either be proof of ownership, the right to have discounts or benefits, or rewards for solving algorithmically mathematical problems in block creation (Freni, Ferro & Moncada 2020). Tokens are mainly used to transfer value and as storage of wealth. Tokens can also enable the achievement of network effect in specific ecosystems where the goal is to incentive early adoption and to reach a mass of users for the token. Tokens are also issued to finance and fund the organisation or individuals that issued the token (Teuteberg 2020).

A token is successful if it generates value to its users, and the value can depend on the number of offerings and the seamless usage of the platform that can attract new customers and increase network effects. The token incentive is also essential so that users can obtain needed tokens to participate in the ecosystem. This can be done by exchanging other cryptocurrencies or tokens for the required token, or contribute with active work or sharing data to be rewarded with tokens. The purpose of the token also has a significant impact on the success. An example is utility tokens to offer services by the platform, and thereby the user needs to acquire tokens to participate. There are also funding tokens for fundraising, and staking tokens to acquire rights as stakeholders (Teuteberg 2020).

Public blockchain-based tokens, or on-chain tokens that operate on top of an existing blockchain, are mostly built and deployed on the decentralised Ethereum blockchain (Chanson et al. 2018). Ethereum serves as the foundation and offers smart contracts that are the technological basis of the majority of tokens and their applications. The Ethereum platform also

enables organisations to create markets worldwide and create their own tokens utilising smart contracts. The most popular use case for smart contracts were ICOs, initial coin offerings, which is a way to generate own tokens in a simple and fast way (Teuteberg 2020). The technical standard is ERC-20, and is used for issuing third party tokens on the Ethereum platform. Nevertheless, there are some limited functionality and interoperability regarding ERC-20 tokens. It needs additional steps when exchanging ERC-20 tokens with other blockchain platforms, as the transaction crosses between two different blockchains. There is also strong evidence of a positive relationship between the price of Ethereum and the price of tokens designed and deployed on the Ethereum blockchain. There is weaker evidence that Bitcoin impacts the price of tokens, and tokens that represent an underlying organisation or platform can be seen as a separate asset class apart from Bitcoin (Lo & Medda 2020).

FINMA (2018) has classified blockchain-based tokens into three categories. Payment tokens, utility tokens and asset tokens. A token can be designed towards all of these categories. Payment tokens are designed to manage value transfers, and a well-known example of such a token is Bitcoin. Utility tokens are designed to provide access to a service or application in a blockchain-based infrastructure. It can be used to exchange tokens for services or enable the distribution of processing code. Often a fee is paid in the native token. Ethereum is an example of both a payment and utility token. Asset tokens attempt to capture a physical or digital asset on a token and can, for example, promise to share profits (FINMA 2018).

Tokens can be created by any organisation or individual that sets the rules of governing tokens - like their features, incentive system and monetary value. If the tokens represent a right on an underlying asset, then the holder of a token usually trusts the token issuer that the right is represented, valid and enforceable. The token holder also trusts that the underlying asset is managed in the right way and that the token holds its value or possibly even increases in value (Freni, Ferro & Moncada 2020). Organisation issuing tokens usually have a decentralised business model with some dependence on third parties. Therefore the owner of tokens needs to both trust in the token-based platform, but also on third parties, such as the Ethereum network (Teuteberg 2020).

Tokens may claim links to organisations, where a utility token can be exchangeable for a service or application provided by the organisation, where the producer or contributor of the service or application receives the tokens (Teuteberg 2020). Lo & Medda (2020) explains that if the utility

token is limited in quantity and act as a medium of exchange, then the token price can appreciate in regards to a rise in demand for the service on the blockchain-based platform created by the token issuer. Tokens usually operate on public blockchains where the protocols are open-source with a shared infrastructure among ecosystem participants. There is no single point of control to provide trust between distrusting parties. Thereby public blockchains can create scarce tradeable tokens and digitise real-world assets. Publicly trade tokens today have relatively few users and holders, while blockchain technologies, in general, has seen some wider adoption. However, the adoption of blockchain is still slow. This adoption pace and capacity constraints correlate well with the decentralisation functionalities of public blockchains. It can be an issue in regards to replace traditional centralised systems, but the decentralisation features can enable new emerging economic structures, methods of value creation and competitors in various industries. Rather than tokenising assets like equities or other existing assets, tokens have the opportunity to capture value in abstract assets that have never been traded and exchanged digitally before (Lo & Medda 2020).

Tokens can also have different characteristics. Token functions can be divided into payments, utilities, assets and yields. Token functions are statistically significant in relation to token prices. A token feature can be staking rewards for blockchain protocols that run on a proof-of-stake consensus. Staking can either give dividends in the same token, which aggregates a holder's tokens, or dividends in other tokens, such as Ethereum. Proof-of-stake blockchain protocols often distribute tokens to nodes that participate in the consensus generation, where the token is held and numerically dilutive. It is also difficult to distribute rewards as they often are held on crypto exchanges, and thereby it can be problematic with the identification of ownership. Another feature is as a medium of exchange, often referred to as utility tokens. Bitcoin and Ethereum are the leading medium of exchanges for many tokens (Lo & Medda 2020). To be a medium of exchange on a platform, it is necessary for that token to adhere to that function to create benefits of its platform (Catalini and Gans 2018). The token distribution can be designed in many ways. It focuses on the split in economics between investors in comparison to insiders and service providers. The most common is to either have tokens reserved for insiders and the organisation, or have tokens reserved for miners and service providers (Lo & Medda, 2020). If a higher share of tokens is reserved for insiders, it can signal quality for outsiders. But it can also be an issue due to more centralisation and decreased share of platform economics by funders and investors (Chod & Lyandres 2018).

Teuteberg (2020) created a framework of archetypes regarding the approach of token-based ecosystems. The pioneering model is the cautious approach where the organisation still operate the business with high control regarding contract terms, assets and price. There is low collaboration, and tokens are mostly used for payment purposes with customers, and opportunities to increase network effects or promote the token is not taken. The expansion model is the approach where tokens are used to develop the ecosystem with stakeholders and increase the network effects to create value-added for participants. The control is lower, and partners can create their own applications on the basis of the token. Relationships are actively shaped where collaboration in business processes and information systems are important. The authority model has a similar approach as the expansion model, but the dependence on third parties is lower as they have their own blockchain system and own native token, where network effects are important. Teuteberg (2020) further explains that there is lower control on contract terms, assets and pricing. Simplification of transactions and trust can lead to a common value for all participants. It can, although still be challenging to raise awareness and attract participants. A solution can be airdropped, where free tokens are distributed for certain services. This can increase the popularity of the token and create a base of users in the beginning. Increasing the value of tokens is another challenge for organisations that use tokens as an integrative part of their business models.

## 2.2. Blockchain Technology in Supply Chains

### 2.2.1. Motives and Benefits of Implementation

The supply chains are consisting of multiple flows, like logistics, information and financial flows, but those cannot talk to each other today as they are not integrated, and blockchain technology has a huge opportunity to be the standard solution as it provides and promotes a horisontal integration (Venkatesh et al. 2020). Blockchains are solving mainly social problems and not technical ones. Ensuring shared value for all actors in the participating ecosystem is important for adoption. Therefore blockchain has the potential in the future to be the ideal platform for digitising supply chains in regards to transactions and documentation. However, to realise these benefits, blockchains have to continue to mature and work with the interoperability challenges (Bai & Sarkis 2020).

Companies that are reaching to implement blockchain solutions have to assess where it will have the most impact, and it is recommended to start with a small viable system and then grow

from there (Yang 2020). Early adopters face many challenges, first by just choosing the suitable blockchain protocol requires a lot of knowledge. But then blockchain implementations also require links to the physical world and also security for the incumbent system with the blockchain implementation (Yang 2020).

One of the motives for deploying blockchain technology is because of the increasing parties and steps in the supply chains. There are many constraints, and processes are costly and time-consuming. Blockchain technology has the ability to incorporate all suited parties and transform the supply chain by removing all unnecessary intermediaries that previously were needed for validation. This will in regards reduce the amount of physical verification and paper documents. Simultaneously the steps in the supply chain will be reduced, which will save money and time (Calatayud et al. 2019). A historical trail in a blockchain environment is much more transparent and viable than in centralised solutions. Sharing information is vital right now, and therefore, interoperability and integration with other technologies are crucial. Blockchain is slowly becoming that puzzle that can be vital for all other new technologies to get tied together in a trustless and secure way (Dinh & Thai 2018).

With the help of blockchain technology, there will also be decreasing transaction costs which will enable the growth of globalisation even further. Smaller businesses will have lower participation costs due to reduced administration and involvement of intermediaries, which is very value-adding (Philipp et al. 2019). This can lead to developments of new business models and competitiveness in the supply chain industry. When procurements are done in the supply chain, there are usually discounts involved, and those are hard to trace and see what other actors were offered. This can of course also be dealt with in privacy mode if not all actors agree on it. As more actors are integrated into a blockchain network, the lower costs will be compared to regular audits, which will benefit both the buyer-side and the seller-side (Calatayud et al. 2019).

Trade finance in supply chains could also be improved a lot by blockchain technology. Payments could be facilitated much faster and securer between importers and exporters with fewer manual verifications. This reduces frictions when signing contracts (Norberg 2019). An example is a letter of credit dilemmas, where smart contracts could solve the issue by automatically trigger actions if tasks are accomplished by both sides, and thereby the trust is improved by replacing intermediaries regarding transactions (Cong & He 2019). The speed is also important regarding transactions, and the speed of processing time could reduce from

weeks to hours. This is especially applicable in situations where real-time decision making is essential. Apart from the improved speed, the cost structure of transactions on the blockchain is also beneficial as it can almost be free to transact in some blockchains all around the world at any given time (Albayati, Kim & Rho 2020).

Global trade still uses processes that are costly and time-consuming, often where the documentation is paper-based and manually handled. This also leads to limited visibility into the movement of assets. Parties tend to cause unnecessary delays, which in the ends is costly both for importers and exporters. The digitalisation of finance processes in supply chains could reduce costs where blockchain would enable intermediaries to evaluate risks better, mostly those who use analytical tools to benefit from blockchains (Attaran 2020). The issue is that a lot of actors have their own set of platforms where multiple versions of a document can be in circulation. A lot of work is spent monitoring documents, and it is also vulnerable to human errors. Blockchain technology would reduce the operational costs and the volume of paperwork (Ghode et al. 2020). Enabling digital document handling of bills of lading and purchase orders can help streamline the process of asset tracking. Blockchain enables a single source of truth and removes away the pro-longed reconciliation process regarding document handling. It is said that end to end visibility and paperless trade will reduce both the time and cost significantly. This is one case regarding paper trails as they are difficult to trace, but with the help of blockchain, a secure digitised version will be easier to handle for all actors (Bai & Sarkis 2020).

### 2.2.2. Traceability and Visibility

The transactions on the blockchain are secure due to the distribution and immutable nature of the infrastructure, which can help to prevent fraud and expose corruption in international trade. Blockchain features give the ability to follow assets and keep track of records with accurate and clear end-to-end visibility. In this case, all actors become more equally powerful (Wang et al. 2019). Companies today are searching for ways to share their data more securely but in a cost-effective approach. Therefore is blockchain technology a good option. There is only one immutable truth that can be viewed by those who have the right access (Longo et al. 2019). Access can be programmed prior that it only pertains to certain actors where they can add and edit data, but in other phases where they only can view and follow the process to verify transactions of interest. With this possibility of tracking, actors can check if, for example, temperatures were correct, check the audit certificates or if the negotiated route was token (Gurtu & Johny 2019).

The potential for blockchain technology is to relieve bottlenecks in the supply chains. Longo et al. (2019) states that blockchain provides features for better operational performances regarding shorter process time and less manual work. This will generate more awareness about the supply chain to optimise it where it is needed and will likely reduce the bullwhip effects in the supply chain (Philipp et al. 2019). Blockchain enables trust in each step in the supply chain by having information in open access where actors can trust the information, which was not possible with the solutions prior to blockchain implementation. Shipments can be traced and be more reliably controlled where assets could be traced during the whole life cycle. This gives an opportunity for companies to evaluate potential suppliers and other actors in the supply chain, by checking at past recorded transactions before signing contracts (Christodoulou et al. 2018).

The distrust in global trade is a suitable use case for blockchain technology. Due to lack of visibility and nonessential premium costs of having trust, often results in low margin and high insurance premiums for companies. However, there is a significant value to have oversight over the trade processes in the supply chain, and the transparency of blockchain can give full visibility into transactions and enable better analysis of systematic risks. Due to the transparency features of blockchain technology, it is also easier to pinpoint risks and who carries them at the moment, and thereby also track the exposure for the risk in real-time (Rogerson & Parry 2020).

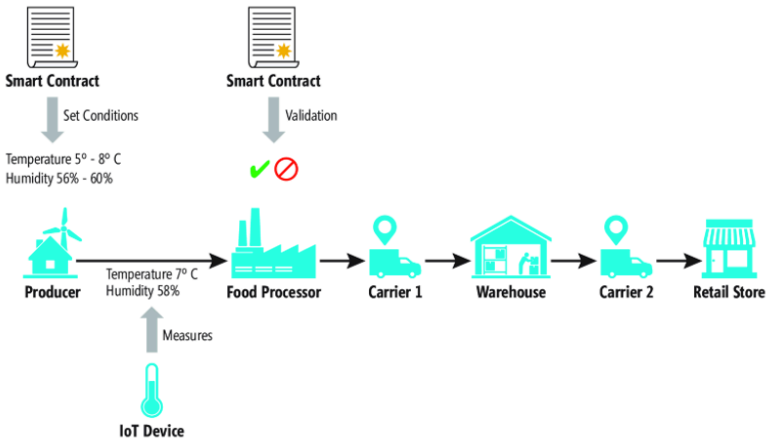
Blockchain solutions can carry ownerships on a permanent record where provenance and authenticity can be verified. Actors on the end of the supply chain are enjoying the blockchain implementations as it provides an immutable and permanent way of recording the assets, previous participants and transaction. Transparency fosters for better intimacy regarding assets and products for customers, it gives them a better connection and can, for example, enhance the local proximity to food. Blockchain can store information beyond what is required (Demestichas et al. 2020).

### 2.2.3. Smart contracts

Smart contracts in the supply chains are designed in a way that no human interaction is needed, as there are lines of code with pre-set conditions that need to be met so that the transaction could be triggered. It triggers in real-time if certain actions and rules are fulfilled (Cong & He 2019). Smart contracts are mostly used in situations with payment and documentation issues but also

with proof-of-delivery situations. For example, if a shipment is received in the right condition and terms, then a payment is automatically sent to the sender. Smart contracts therefore reduce payments that are withheld by intermediaries and improves the transaction flows in the supply chain (Liao & Wang 2018). There are many actors in the supply chain, and therefore, it can be difficult to monitor and follow all agreed conditions and contracts. In this situation, in combination with other disruptive technologies like IoT and Big Data Analytics, smart contracts could further automate processes and make transactions more efficient (Wang et al. 2019).

**Figure 2.3. – Execution of a Smart Contract in a Supply Chain (Microsoft 2020)**




Smart contracts can verify assets that regarding specific standards that can be related to the source of origin and various sustainability conditions. Actors could accept or deny products based on conditions if they have been violated, and assets could be sent back. If they are accepted, then an automatic payment is triggered (Rejeb et al. 2019). The main motives behind adopting smart contracts are secure transactions without intermediaries and that they are traceable and transparent due to the underlying blockchain technology. This will most likely decrease the need for third parties like banks, lawyers and brokers. It implies lower transaction costs and redesigning of current supply chain structures. Time-consuming processes like negotiations often include disagreements and counteroffers, where smart contracts could reduce the friction. Smart contracts offer trackable flows and automated data transfer without unnecessary forwards and backwards of physical documents, since everything is stored on the blockchain. It is also always under visibility for all actors that have permission (Philipp et al. 2019). Smart contracts also decrease costs and allow for shorter lead times than traditional contracts. Something that is even more important is that smart contracts could lower the entry barriers for smaller actors in the supply chain by reducing the amount of intermediaries and manual checkpoints (Wang et al. 2019).

### 2.2.4. Interoperability

Interoperability between technology stacks can be managed to some extent by blockchain technology, where it can scale up and combine across different application areas. In combination with IoT mechanisms, like sensors, blockchain could bridge the gap of data interoperability issues currently in the supply chains (Rejeb et al. 2019). It would also make it more secure and reliable but also give the possibility to speed up automation processes since blockchain infrastructure is robust and secure, and self-audited transactions are enabled (Chen et al. 2020).

In combination with other technologies, blockchain offers secure and permanent records in the supply chain steps, which opts for higher visibility and legitimacy. IoT devices could use blockchain systems to record data for self-verification processes but also to ensure proof-of-action and proof-of-delivery (Wang et al. 2019). In this way, IoT devices could store real-time data in a decentralised way, both general information for processes, but also hashes of important documents that are immutable but in the same way transparent to involved actors (Aryal et al. 2018). This development will most likely end up in more automated process flows and reduce both enforcement and transaction costs along with the supply chain steps. A promising feature is a reliance on better predictable information and delivery times in combination with other technologies. Therefore interoperability is crucial to be even better (Philipp et al. 2019).

Managing various risks in the supply chain will also be easier as actors enter their information at each step in the supply chain onto blockchains that others can audit. This can be done by sensors, RFID or QR codes. The information is then recorded along the supply chain and makes it easier accessible where companies can obtain greater control over certain actions (Rejeb et al. 2019). Consumers also want better transparency and pay attention to authenticity. Therefore blockchain, in combination with other technologies, could enable information about provenance, source of origin, maintenance and transportation routes and choice. Consumers and other actors in the supply chain can look more into detail also, for example, what food animals have been eating, their living conditions, which raises awareness about food safety to the next level (Mao et al. 2019). Consumers can make more enlightened choices, and it also gives first-tier actors and producers capabilities to compete with other methods than just price. They have the ability to convince with authenticity and show open reports of for example transfer of ownership. This development will also enable faster response to food safety issues and product recalls (Francisco & Swanson 2018).

Blockchain technology can act, in connection to multiple supply chain innovations, as the platform to connect the technological advances together and to create integration across the whole supply chain ecosystem. It will transform the current practices in logistics, transportation and operations by making the network more responsive and adaptable in regards to demand and crisis by helping to ensure security and visibility (Ghode et al. 2020).

The important feature of blockchain is that it is aimed to collaborate end to end across different platforms and industries, where the shift from siloes and competition towards more competition is nowadays inevitable. The integration of existing technology stacks is needed, as the efficiencies are not the same if the blockchain solution sits in a silo. Blockchain solutions should be encouraged with collaboration over competition, as a viable solution is good for all actors regarding the benefits (Wang, Chen & Zghari-Sales 2021). There will probably not be a single blockchain that will dominate, but it should instead be the focus on the interoperability of multiple chains. In order for blockchain to be adopted widely, it needs to have good performance, scalability and interoperability with various blockchains and incumbent information systems (Ghode et al. 2020).

### 2.2.5. Standards

Companies that use blockchain should also be careful of what data they integrate, as when it is published, it can never be removed again. Before considering an implementation of blockchain solutions, it is important to reflect and identify standards and consider in what way the data is going to be shared, as it is possible to have some sort of permissions to maintain data integrity. Successful usage of blockchain will require the validity of data, and an issue is the segregation of data today that is stored both on the blockchain, but also outside (Manupati et al. 2020). The standards tend to speed up the adoption of new technologies, and early adopters of blockchain have the possibility to collaborate with standard bodies and shape the future. The supply chains are complex where bridges of interoperability are intricate, but the industry needs shared standards across different systems and blockchains, in some way, they have to be implemented so that blockchains and systems could talk to each other. Standards are essential to bridge systems and to enable widely scaled traceability options, and open standards like GS1 could accelerate the adoption of blockchains as interoperability is crucial (Wang, Chen & Zghari-Sales 2021).

### 2.2.6. Public and Private Blockchains

Working groups with private blockchains are rising and can scale right now, but have potential drawbacks, for example, misaligned incentives. Private blockchains might be effective for some cases, where rapid decision making is possible, but it is not suited when moving towards commercialization. Another drawback is the entry barrier for smaller players who are not able to participate financially or bear the shared risk. There are currently no effective ways of moving information and data across blockchains as there is no consensus on what represents the better model regarding private or public blockchains (Yang 2020). Technology and governance will continue to make interoperability a challenge in this case if no standard is set. Global adoption will require global standards for doing business. The discussions are mostly about how to secure data and business relationships between these two models. They have different application requirements and often have a special purpose, but they all tend to have blockchain as a common reference (Morkunas, Paschen & Boon 2019).

### 2.2.7. Token-Based Solutions

If companies are using tokens on the blockchain, they can then use interesting programmable rights, for example, possession of tokens could mean ownership of infinite data, and also authenticate processes and owners of assets with various obligations (De Giovanni 2020). Tokens solve the problem of digital resources tied to some utility. If tokens give rights and incentives to the owners, and there is privacy, and the personal data is pseudonymized, then it can be included as privacy by design and therefore, the regulation regarding privacy can be solved when companies try to meet the disruption by the new digital technologies (Nandi & Moya 2020).

Token-based teams have tokens that are backed by either resources or asses in the ecosystem. They can also resemble a claim to something. Blockchain-based projects often have their tokens as fuel for the network to reward stakeholders for their contribution. This can be for operating the blockchain or providing services like data that is valuable. Tokens tend to represent a stake in the network that grows in value if their blockchain network also grows. This tends to incentivize the stakeholders to contribute (De Giovanni 2020).

The challenge for token-based teams is to find a way through the hype and arrive at solutions that add value to the clients. Tokens could also be much more helpful if the data and regulations were not that constrained. There is minimal compliance and interactions right now, and the

profit motive is not always compelling for investors due to the volatility (Rahmanzadeh et al. 2020).

The opportunity for tokens is that the application and infrastructure building it is complex, and companies do not have the knowledge. Companies are also unable to fund their own blockchain solutions (Nandi & Moya 2020). Smaller projects that have a niche in blockchain, tokens and supply chains are able to realize business values which can be important for the future. Tokens can also appreciate, like stock shares, and that might also be a merit in their business model for some companies. Enterprises could also be key holders of the tokens if these teams help out to build their blockchain solutions, and then companies can amplify their ROI, return of investment, as the tokens appreciate in value (Rahmanzadeh et al. 2020).

# 3. Research Methodology

*This chapter presents the methodological choices, decisions, and actions taken throughout the thesis research. The themes presented are the research strategy, method and design, the data collection and analysis, and the quality of the research method.*

## 3.1. Research Method

A qualitative approach and a quantitative approach are two research strategies for conducting research. Qualitative research includes a comprehensive analysis and can achieve a higher contribution and better understanding of a research topic. Qualitative research also enables results by interpretation of examinations (Bryman & Bell 2019). This study follows a qualitative and exploratory approach which is preferred, as blockchain technology is still a relatively new concept and technology where new research gaps evolve, and the area of blockchain technology within supply chains is not sufficient with academic research, which justifies the choice. Especially regarding new concepts within the constantly developing blockchain technology area. Therefore there is a high uncertainty resulting from a lack of knowledge.

The choice of a qualitative and exploratory research approach is also made as it is more sensible to contribute with a better understanding of a problem. It also creates more evident propositions for further research and implications made by the study in a new research field (Yin 2017). A qualitative study is helpful as it allows for follow-up questions and reflections, which creates opportunities to gather more data from the interviews, which subsequentially enables to answer the research question at a greater and more comprehensive level (Bryman & Bell 2019).

## 3.2. Research Design

In the field of qualitative research, various research designs can be applied. This study follows a multiple case study design, which is considered suitable for this study as it allows for the exploration of a new phenomenon. A multiple case study design offers a possibility to produce result through several cases and views. That is also why multiple case studies are preferred over a single case study. All different cases provide data that allows for cross-validation, which helps to understand the findings from the in-depth interviewees (Yin 2017), which is suitable for this thesis. The use of several sources to collect information to answer the research question strengthens the quality of the study. However, it can be difficult to get more profound knowledge from each case, which can complicate comparisons (Collis & Hussey 2013).

## 3.3. Research Approach

An academic report can follow a deductive, inductive or abductive approach. Deductive research is based on existing theory applied on conducted empirical data. Inductive research starts with an empirical study that aims to develop a new theory. Abductive research mixes both deductive and inductive characteristics, which can be used on the existing theory that generates new findings with the existing theories (Collis & Hussey 2013). The choice for this thesis is the abductive research approach as it gives the possibility to shift back and forward between existing theories and the empirical findings to make a comparison. First, the theoretical framework is presented, and the empirical findings are matched with the theory to gain a new understanding and to make an analysis and conclusions about the topic regarding blockchain technology in supply chains. It gives the possibility to analyse the impacts, motives and challenges in a different context presented in this multiple case study (Yin 2017). The abductive research approach overcomes limitations of the inductive and deductive approaches, and this approach is arising in studies with a lack or limited presence of theories and use cases (Eriksson & Kovalainen 2014), like blockchain technology in supply chains. This approach is found to be most appropriate and valuable, as it enables modification of the theories and develops engagement in the report, which is seen as beneficial for this research.

## 3.4. Data Collection

Data and information can be collected in a primary and secondary way (Yin 2017). This thesis follows an abductive approach with a qualitative and exploratory method that is based on a multiple case study design. The primary data is collected through interviews as the reality and industrial view of the research. The secondary data is collected through a literature review on the topic of blockchain technology in supply chains, for finding unsolved conclusions for findings and further research, and in order to do the problem issue researchable.

### 3.4.1. Secondary Data Collection

The secondary data in this thesis is collected to form a literature review, firstly on blockchain technology characteristics and features and secondly on blockchain technology in supply chains. A literature review is a baseline that gives the possibility to collect a large amount of data from mapping existing knowledge in a specific or broader research area (Bryman & Bell 2019), which also helped to reflect around the problem issue and the development of the broad research question. The secondary sources are based on published materials, such as academic

articles, academic journals and books. Only peer-reviewed articles were included in this thesis due to higher reliability, but also to reduce the bias from corporate reports, and thereby scope the relevant available articles to make an analysis of the gap and insights brought in comparison between the respondents from the empirical findings, and the existing literature.

The use of a literature review helps to gain valuable information of the context on the topic and contributes to the overall perspective prior research, which also applies well with an abductive approach. This thesis proceeded with a narrative approach, rather than a systematic approach, of a literature review as it offers more flexibility and broader scope and is, therefore, more suitable for a qualitative and abductive research approach (Blumberg, Cooper & Schindler 2011). The primary method to collect information and sources for this thesis was through GU Supersök, a service provided by the library at the University of Gothenburg that is able to search and categorise through multiple databases in a single access point. The results were limited to peer-reviewed articles written in English, aligned with the purpose and research question and published mainly between 2018 and 2021. More recently published articles have been emphasised if they provided enough knowledge and were peer-reviewed. By checking the references in the articles and books, a snowballing approach has been used to achieve a better understanding of the topic and to find more relevant information. The snowballing approach is beneficial to extract further insights and makes it easier to identify acclaimed and highly cited papers in the field (Collis & Hussey 2013). If not sufficient sources were found, then scientific databases such as Emerald, ScienceDirect, EBSCOhost and Scopus were directly used to ensure quality with the same keywords, next to Google Scholar if access was not available.

In the process of searching for academic articles, it was identified that there was a lack of variation and volume in articles in comparison to other subjects areas, especially when combining blockchain technology and supply chain. The terms and keywords were created by brainstorming and creating initial keywords with the help of corporate reports and news articles in the area of blockchain technology in supply chains. This was very helpful in deciding which terms to include in the sections of the literature review regarding relevant blockchain technology aspects suitable in supply chains. Therefore the choice was to not get into details about the infrastructure of the technology, but rather focus on characteristics relevant to the purpose and research question. This led to the findings of more keywords and knowledge about the current state and trends concerning the research topic. In this regard, the appropriate literature in this thesis was found with the use of the following keywords and queries:

- (‘’Blockchain’’ OR ‘’Blockchain Technology’’ OR ‘’DLT’’ OR ‘’Distributed Ledger) AND (‘’Supply Chain’’ OR ‘’SCM’’ OR ‘’Logistics’’ OR ‘’Transport’’)
- (‘’Token’’ OR ‘’Crypto’’ OR ‘’Tokenisation’’) AND (‘’Blockchain’’) AND (‘’Supply Chain’’ OR ‘’Logistics’’ OR ‘’Transport’’)
- (‘’Interoperability’’ OR ‘’Standard’’ OR ‘’GS1’’ OR ‘’ISO’’) AND (‘’Blockchain’’) AND (‘’Supply Chain’’ OR ‘’Logistics’’ OR ‘’Transport’’)
- (‘’Traceability’’ OR ‘’Track’’ OR ‘’Trace’’ OR ‘’Visibility’’) AND (‘’Blockchain’’) AND (‘’Supply Chain’’ OR ‘’Logistics’’ OR ‘’Transport’’)

In total, 63 peer-reviewed academic articles are included where 5 of them are from 2017, 15 from 2018, 17 from 2019, 25 from 2020 and 1 article from 2021. Blockchain is used as the word for all the active blockchains on the market. The articles included helped to form the theoretical framework and also to extend the knowledge with different aspects and concepts associated with the topic. It helped to improve the agility and accuracy of the literature review. The abductive approach contributed with more emphasis on articles with queries such as logistics and transport, as it was more aligned with the themes and background of the respondents. The secondary data also complemented and verified the validity and reliability of the data from the primary data as it is a complicated topic that needs a lot of clarifications.

### 3.4.2. Primary Data Collection

Interviews are able to fill a gap between reality and the academic literature, which is essential for this thesis in regards to get a deeper understanding. Interviews are one of the best ways of data collection in qualitative research. The interviews also have a role as confirmation or rejection of the findings done in the literature review (Eriksson & Kovalainen 2014). The interviews also play a vital role in the analysis, discussion and conclusions as the interviews have a lot of weighting in the final establishment of the thesis.

The selection of respondents is vital in this research as it targets explicitly blockchain technology in supply chains and specific problem areas at the current time. Those are specifically targeted as interoperability, standards development, token-based solutions, traceability, visibility and in general, the motives and challenges for the implementation of blockchain solutions. The respondents are selected from various different contexts and organisational levels connected to blockchain technology and supply chains. Therefore the

selection criteria for choosing respondents were mainly the knowledge level and the working experience. The respondents should have a deep understanding of both blockchain technology and supply chains in general. These types of criteria often raise the reliability of the research (Bryman & Bell 2019). The knowledge level and experience were mainly targeted around three or more years of experience in either working or researching these subjects. The purpose was to sort out all the new self-proclaimed experts in this area. The author did the basis for the respondent search prior to the study by having an interest in the topic, attending conferences, reading books and news, and having a cited network, both in reports but also on LinkedIn. All chosen respondents had at least more than three years of experience in both areas. Respondents were chosen carefully according to their expertise and experience so the research question could be answered in the best possible way, with their perspectives and first-hand information.

The sampling method for choosing respondents were expert and snowball samplings. The expert sampling was aimed to find respondents that have a deep understanding of the topic, and therefore people with those qualifications were targeted. However, to not miss out on suitable and unknown experts to the author, snowball sampling was conducted by asking the targeted expert respondents for recommendations for other suitable people to interview (Bryman & Bell 2019). One respondent was found due to the snowballing sampling. The search began by look into suitable companies in the field of blockchain technology and supply chain. It was mainly done by searching on LinkedIn, but also from previous read and written articles and contacts known by the author. Only respondents that are obviously attached to blockchain technology and supply chain were concerned, which most likely enhances the reliability of the study.

Regarding the respondent selection, the chosen ones were available for an interview and met the criteria set regarding expertise and experience. In total, seven eligible respondents were selected that fit all requirements. Additional four representatives from the academic, advisory and consulting context declined the request to participate, but they showed interest in the research area but could not participate due to unavailability. Additional three representatives for token-based solutions declined the request to participate due to unavailability. In total, only six eligible token-based solutions were found. Four representatives from the academic, advisory and consulting context contribute with clarities and explanation in regards to the industrial view, together with three representatives from the token-based projects. Representatives for the token-based solutions include Peter Zhou from Vechain, Igor Stadnyk from Ambrosus and Conrad Cubic from Morpheus Network. The respondents are presented through the following tables:

**Table 3.1. – List of Respondent Details**

| Respondent | Location | Organisation | Position |
|---|---|---|---|
| Peter Zhou | Hong Kong | Vechain | Chief Scientist |
| Magnus Jones | Norway | EY – Tax & Law | Blockchain Consultant |
| Juho Lindman | Sweden | University of Gothenburg | Associate Professor IT |
| Igor Stadnyk | Ukraine | Ambrosus | Chief Blockchain Officer |
| John Keogh | Canada | Shantalla | Advisor & Professor |
| Conrad Cubic | Ireland | Morpheus Network | Ambassador |
| Patrick Duffy | United States | Blockchain in Transport Alliance (BITA) | President |

**Table 3.2. – List of Interview Details**

| Respondent | Date | Interview Type | Duration |
|---|---|---|---|
| Peter Zhou | 31-03-2021 | Zoom Video Call | 42:00 |
| Magnus Jones | 31-03-2021 | Teams Video Call | 01:27:00 |
| Juho Lindman | 01-04-2021 | Zoom Video Call | 50:00 |
| Igor Stadnyk | 05-04-2021 | Zoom Video Call | 48:00 |
| John Keogh | 12-04-2021 | Zoom Video Call | 01:07:00 |
| Conrad Cubic | 13-04-2021 | Zoom Video Call | 46:00 |
| Patrick Duffy | 13-04-2021 | Zoom Video Call | 01:04:00 |

The interviews in this thesis are conducted with a semi-structured approach. Semi-structured interviews are mostly suited for this thesis since semi-structured interviews are more flexible and conversational, which enables deeper insights. Follow up questions are used, which primarily gives the ability to discuss relatable topics emerging during the interview and the ability to learn more from the respondents (Yin 2017). Due to the abductive approach, this could be used to search for even more relevant literature suitable for the thesis. The topics and questions were prepared beforehand to be able to get as much information as possible, but also to give the interviewee a chance to shape the content as the research is of an explorative character and thereby also reducing the influence of the author.

An interview guide was prepared to ensure relevant topics were discussed and based on Yin (2017), they were structured into themes to collect the most valuable data. The specific themes are the ones found in the initial search of the literature, and stated in the problem discussion, which are the motives and challenges for implementation of blockchain solutions in supply chains, with an extensive focus on interoperability, standards, token-based solutions and traceability and visibility features that lacks sufficient academic research. These themes are also

in focus throughout all the parts of this thesis. The literature review was crucial to find critical things to discuss during the interviews. The interviews started with warm-up questions focusing on the respondent, which then shifted focus to questions regarding the overall evaluation of blockchain technology itself, and then blockchain technology in supply chains in a general scope, and then key questions in relation to the research topic and the different themes. The categorisation into themes was also made to simplify the analysis later on. The interview guide was structured to handle more open questions and further thoughts from respondents. All respondents were requested to be elaborative in their answers for deeper insights. All respondents received the same questions, and the questions were formatted to suit all the respondents. The aim was to both bring positive and negative insights concerning the themes of the thesis. See (Appendix B) for the semi-structured interview guide. After the last interview with Patrick Duffy, variances in the answers decreased, and the data saturation was obtained. This action was taken as there were no more contradictory insights between the respondents. No more interviewing was required to conduct and begin an analysis of the empirical findings.

Before the interviews, all the respondents were directly contacted by e-mail and LinkedIn, see (Appendix A), with details and themes that would be brought up, to prepare them accordingly, but also to remind them about the date and time. All respondents had the convenience to select preferred time-slots according to their time zone, which is in accordance with Collis & Hussey (2013) regarding comfortability and availability. Due to the COVID19 pandemic, face-to-face interviews were not possible, and the only possible choice was to conduct interviews through video or audio conferencing. All respondents agreed on video calls on either Zoom or Teams. Due to the circumstances, the reason why video calls were preferred before audio calls were that video calls are the closest alternative type in comparison to face-to-face interviews, and therefore expressions and body language could be observed and interpreted throughout the interview, which is important according to Bryman & Bell (2019).

Before every interview, permission for recording the session was asked, and recording has been done in consent with the interviewees in order to collect correct information, to not miss out on important information and to be able to interact and listen carefully during the interview. It was also done to enable easier transcription. Permission was also sought regarding their names and organisation could be mentioned in the publication, and all respondents agreed on their information to be published. Interviewers were also asked for permission if the author could get in contact via e-mail in case of some misunderstandings, questions or queries.

## 3.5. Data Analysis

In order to analyse the literature reviews and the empirical findings, a thematic analysis have been applied in order to match and critically discuss the empirical findings with the support from the theoretical framework (Bryman & Bell 2019). The themes elaborated on throughout the thesis are interoperability, standards, token-based solutions and traceability and visibility features concerning the implementation of blockchain solutions in supply chains. The themes were pre-determined in the initial literature search and problem discussion and adjusted with minor changes as an abductive approach was used to use all relevant new insights and information efficiently. The analysis of the collected data started after the transcription process, which is the conversion of oral data into written data (Yin 2017), in order to familiarise with the different themes and key points that the respondents brought up during the interviews.

Coding is a process chosen in the thesis to extract meaningful information from a large volume of qualitative raw data. Each transcript of the interviews was printed out, and openly coded to conceptualise, evaluate and categorise data, and summarised into order to get deeper understanding with the purpose to extract knowledge from each case (Collis & Hussey 2013). The coding scheme used was mainly formatted in alignment with the themes, and notions in the coding used was the relevant queries used for the literature search. The notions were blockchain, supply chain, token, tokenisation, interoperability, standard, traceability, visibility, track and trace, challenges, motives and incentives. The summaries in the analysation process helped to maintain focus and carry out the analysis step by step. Preliminary categorisations of the topics were carried out with the help of the thematic analysis. The main findings led to themes aligned to the research purpose and the themes found in the theoretical framework.

The iteration between the theory, empirical findings and coding resulted in different themes regarding similarities and differences. The themes are stated previously in this chapter. The iteration was mainly done by applied colour codes for easier orientation (Bryman & Bell 2019). The empirical findings were analysed by comparing the theoretical framework together with the authors' interpretations. The analysis structure is based on the themes and headings given in the theoretical framework and thereafter interpreted with the empirical findings. The chosen structure was done in order to reach a conclusion and bring answers in regards to the motives and challenges for the implementation of blockchain solution in the supply chains, with a focus on interoperability, standards, token-based solutions, traceability and visibility features.

## 3.6. Research Quality

For a qualitative study to ensure high quality, it is important to ensure high standard where Yin (2017) and Bryman & Bell (2019) have made suggestions suitable for exploratory multiple cases studies. This thesis is measured by their evaluations, divided into validity and reliability.

### 3.6.1. Validity

Validity is referred to the quality of the conclusions to give an explanation of the topic in research. The validity of this thesis has been enhanced by collecting data from multiple cases with experts in blockchain technology and supply chains. Secondary data sources such as peer-reviewed articles are also used to ensure a high amount of suitable sources (Yin 2017). The credibility is concerning the causality, regarding how well conclusions are drawn in regards to the empirical findings (Bryman & Bell 2019). To increase the validity, transcripts of the respondents have been sent out to check for misunderstandings, and clarifications have been done to ensure the correct information was extracted. Triangulation was used to increase validity by reducing the risk of the interpretation by the author's own desired and predicted views. Therefore several sources have been conducted to ensure validity and credibility. Regarding transferability and the generalisation of the thesis, it is known that multiple case studies are challenging to be viable in other settings (Yin 2017), especially this thesis with seven respondents in a specific research area. Therefore this thesis is more generalisable to the research area of token-based projects connected to blockchain technology and supply chains, as the sample represented half of the discovered projects eligible for this thesis topic.

### 3.6.2. Reliability

Reliability is referred to how well the processes of this thesis can be repeated with the same results (Yin 2017). To increase the reliability, consistency and transparency between the author and the supervisor has been emphasised regarding the scope and aim of the research. Only experts in the research topic were conducted. Semi-structured interviews with a well-planned interview guide conducted reliable and elaborative answers. A interview guide has been included in the Appendix. As the topic covers a disruptive technology area that is evolving, the experts' views might change over time, and therefore, the results of this thesis may differ in the future. There is a risk that this research becomes less valuable in the future. This research is viable and enhances insights right now in the research fields of blockchain technology and supply chains, and is currently to be seen as a relevant study.

## 3.7. Ethical Considerations

Ethical considerations have been accounted for throughout the thesis. In the selection processes of respondents, the topic and purpose have been transparent, and the respondents have been informed about the objectives of this thesis. All respondents have participated with full knowledge, and they have also been provided to either be public or anonymous. All respondents agreed upon publishing both names and organisations they are associated with. Before the interviews, all respondents had the choice to either accept or reject to be recorded. All respondents agreed upon being recorded.

Additionally, respondents were given the possibility to read through the transcriptions of their interviews to approve or correct the transcripts of data. The data is only used for scientific purposes and not commercial purposes. This is important as it can be sensitive information given by the respondents, especially in competing terms, about blockchain technology in supply chains (Bryman & Bell 2019), therefore it was crucial to give correct interpreted information.

# 4. Empirical Findings

*This chapter presents the empirical findings from the interviews gathered by respondents from different positions in the blockchain technology space and the supply chain industry. The findings are presented following the presented themes based on the theoretical framework.*

## 4.1. Characteristics and Current Implementation

The majority of the respondents agree that we are on the cusp of major changes in the supply chains and that we should think about supply chain ecosystems. We do have not only physical products but also data, information and additional services. Keogh (Shantalla) demonstrates that if we want to build resilience into the supply chains, then the only way of doing it is in systems thinking. Companies often do not have a clue if their products are being sold as counterfeits or not. They usually ship the product abroad without doing market surveillance. Cubic (Morpheus) therefore, mentions that we need more surveillance to align with these issues and that more interoperable systems are needed to catch these problems as they start to occur.

Duffy (BITA) & Lindman (UG) states that there is a meaningful catalyst right now for digital transformation. Many companies and technology providers in the supply chain industry are looking to address data and inefficiency challenges. The participants are from all transport modes, from air, ocean, rail, trucking, to last-mile. Challenges often occur between stakeholders and the supply chains and in relation to other business transactions. Duffy (BITA) says that one of the learnings is the challenge of various types of standards and activities for different business processes, in different geographies, across different transport modes. This creates inefficiencies in data hand-offs, which has led companies to focus more on blockchain technology so that they, in a way, can create open-source interoperability solutions focused on supply chain visibility. Duffy (BITA) & Lindman (UG) has seen a lot of growing movements towards blockchain, and they frequently educate about the possibilities of blockchain and the opportunities versus existing technology stacks. More and more companies are moving to the adoption of blockchain solutions, and they think that open-source and public blockchain developments will be compelling in the future.

Jones (EY) mentions that organisations approach him in almost a 100% correlation with the Bitcoin price. When there is a nice trend with the Bitcoin price, then many organisations are interested in implementing and getting knowledge about various blockchain solutions. The

implementation of blockchain solutions is easy today and doable with the right support and knowledge. However, if organisations are looking to scale into the whole ecosystem of the supply chains, like payments and document handling, then it could take several months or years. Moreover, both Jones (EY) & Duffy (BITA) believes that what we are witnessing right now with blockchain technology development will create the largest changes that will come for the next 100 years in the supply chain ecosystems.

Stadnyk (Ambrosus) explains that there are few available options except blockchains today that are reliable and immutable in a specific way. Databases are usually controlled by one or a few entities, where things can be written without rules, and the information and data could be stalled and damaged in the worst cases. Blockchains are part of an evolution, a next step to create something better, more reliable, more trustworthy and more secure than ordinary databases. Cubic (Morpheus) & Zhou (Vechain) agrees and argues that a couple of years ago, many investors lost money due to the high promises of blockchain, but most of the solutions were based on thin air. This has hurt the image, but now projects that survived the last couple of years are making progress and taking over the area of public blockchain solutions in the supply chain industry with real use cases. Blockchains are making more progress towards being more scalable, and we are seeing the beginning of blockchain commercialisation.

Keogh (Shantalla) & Cubic (Morpheus) argues that we have accelerated significantly over the past 15 months in terms of digitalisation and blockchain technology due to the COVID19 pandemic. We are in the accelerated digital transformation mode, where digital transformation is not only about the technology, but also about the journey, change management and focus on customers. COVID19 showed vulnerabilities in the supply chains, and now enterprises want to be more resilient for the future, as it is not just about the money. Keogh (Shantalla) says that in the early days of the COVID19 pandemic, we did not have food security issues regarding the empty shelves, but we had food uncertainty issues. He expresses that we did not have interoperable platforms that could talk to each other, and thereby no visibility into the processes. The COVID19 pandemic has taught us that we need interoperable digital systems.

Keogh (Shantalla), Duffy (BITA) & Zhou (Vechain) mention when products are brought to the market, they usually go through hundreds of different services and checkpoints. These are internally, partially internally, partially outsourced and fully outsourced. This complexity in the global supply chains is where blockchain is a perfect example where it can create more value-

added work and add value in general. It can, for example, include the agronomist, food safety certifiers or even government partners that issue export licenses. All these data creators are then part of this ecosystem with the help of blockchain technology. Before blockchain, this was not possible. Keogh (Shantalla) states that when a company claims a certain thing about a product, it is often not the brand owner who owns the claim, the claim is owned by the authority who issued it. With blockchain, you can then connect that authority who provide the certification, and customers can directly go to the authority that issued it rather than the brand. That is where a significant amount of added integrity is built into our supply chains.

Jones (EY) mentions that there are currently some public blockchain solutions that try to digitise the bill of lading in terms of shipping documents, but it is all down to the people in the ecosystem to understand the benefits in relation to previous systems. Trust can be reached with verified and trusted data, and many solutions are fully implemented. However, to adopt these blockchain solutions, it has to be down to the support level from the management. There are sceptics from the elderly generations, but enthusiasts clearly see the benefits and understand partially how blockchain technology works. It is up to them to pass the message down to the whole organisation, but it also depends on how complex the supply chain is. Duffy (BITA) states that this development is something that needs to mature while blockchains are becoming more mainstream in general. The means of adoption and implementation needs to be built internally at the organisations, and then slowly built it out in the ecosystems.

Keogh (Shantalla) says that blockchain will enhance transparency significantly. This will then take out transactional friction, which could be disagreements, that usually ends up in costs. When blockchain takes out the friction, it also then enhances trust. So blockchain is very beneficial for organisations. Duffy (BITA) agrees and mentions that blockchain solutions gives an access to high-fidelity data systems where actors can provide traceability or provenance of goods with specific commerce systems. This is a huge benefit in terms of a regulatory stance and consumer protection stance. Blockchain technology is the enabler of trust. Data can be transferred hundred times and we have a lot of hand-offs. Therefore Duffy (BITA) claims that there is a significant cost of trust on a global level, which represents a meaningful component of the global GDP. This is just to figure out who is on the other side of the transaction. All respondents argue in some way that blockchains provide the solution of being able to have better trust in commercial relationships, and that actors are able to trust each other more.

Zhou (Vechain) & Cubic (Morpheus) explains that traceability on the blockchain is often used by linking physical data with a certain identity that is representing a certain product. When a product is moving along the supply chain it passes different checking points where data needs to be uploaded to create timestamps in the blockchain. This is a more beneficial way of digitising the data in the supply chain, by also achieving additional benefits due to blockchain. To integrate public blockchains in current systems, right tools, services and consulting is needed to design the systems but also give advice regarding the regulatory issues. Cubic (Morpheus) explains that there are also more regulative approaches right now that will help to automate and enable the usage of smart contracts, that will automate disputes, trigger payments etc.

Lindman (UG) states that blockchain technology is very good if you want to monitor process flows, like containers, goods, ships etc. in an immutable and auditable way on a transparent platform. Jones (EY) is aligned with this view, but also mentions that we need more transparency towards the validation of data itself. Today, a majority of the blockchain solutions in the supply chains are rubbish, they are more a nice to have, but not a need to have. It can, for example, save reconciliation time by tracing some steps back, but not more than that.

All of the respondents claim that blockchain technology is not a hype at all, it is an absolutely necessary technology. Keogh (Shantalla) & Jones (EY) mentions that blockchain is not a disruptive technology, but a foundational technology that will provide layers of trust and reduce friction in the supply chains. It will take time to implement and new technologies will come, but blockchain technologies can help to revolutionise the supply chains today. It will drive interoperability, higher levels of transparency, higher levels of trust and higher levels of certainty in the trading relationships. It could also help to reduce corruption. Duffy (BITA) also agrees that blockchain technologies will revolutionise the global supply chains, and that we are well beyond the hype phase and moving towards production of technologies that can be at production or ecosystem level. He thinks we are 3-5 years away from blockchain solutions for trade that will be endorsed widely by the supply chain industry and regulators. The ROI, return of investment, of blockchain will also fight the reluctance of enterprise leaders in the supply chain industry from sticking and holding a defensive approach with their existing technology stacks. Cubic (Morpheus) also mentions that companies are onboarding at a higher pace right now and that companies who joins later will be dissimilated by other projects and organisations and have less benefits than the early adopters. But eventually, the majority will adopt blockchain technology in one way or another, in the same way as the Internet.

Jones (EY) further mentions that blockchain technology is a necessary technical development, but that blockchain only plays a small part of the whole development of the supply chain ecosystem. Mechanisms of blockchains and decentralised finance will play a key role in the years to come, but it is hard to say what comes after that. But in order to build more trust than the current systems provide, you need to have an efficient way of connecting all necessary types of technologies in order to makes this development as transparent as possible. It is not viable to say that blockchain equals to a lot of benefits, but rather understand the implementation and applications areas of blockchain technology.

Blockchain solutions for supply chains are in some way maturing and not in the hype phase anymore according to Lindman (UG). However, he is not sure that we will see some actual disruptions being brought up, and how large these projects will be is unclear. Many know the benefits of blockchains and we have an idea that it will be picked up, but the ultimate test is how many organisations that will pick it up. Blockchain cannot solve all problems, but it can lead the way for digitalisation of specific tasks, like storing documents in a transparent and accessible way. The digitalisation of supply chains is difficult to stop, but how big slice of the digitalisation is blockchain is still unclear and we do not fully know that yet.

## 4.2. Aims and Lack of Knowledge

All respondent agree that organisations who are trying to implement a blockchain solution should know what issues they want to solve, break it down and find a significant problem where blockchain could be applied. Reducing transactional friction in invoicing between trading partners could be such an example in supply chains according to Keogh (Shantalla). Therefore organisations should not be afraid of approaching blockchain projects, but they need to be very clear on what they want to achieve with it. Lindman (UG) explains that blockchains should be used only if they are valuable and produce some specific value for the organisation using it, or being vital where blockchain is the only solution for a specific problem. A lot of early attempts of using blockchain technology in the supply chain industry was to test some ideas, but a lot of the solutions could be solved successfully with other technologies. So in the beginning it was mostly to test the technology, learn about and figure out how they can benefit and use it for their business. That time has passed. Jones (EY) mentions that over 90% of all blockchain implementations out there today are implementations that actually do not need a blockchain. We need to move from a nice to have solution to a need to have solution within supply chains.

Jones (EY) & Duffy (BITA) states that blockchain solutions should be able to be implemented into the current information systems, for example ERP systems. The users should not notice the blockchain, but just continue with the ERP system as it is today. Often in supply chain it is about the seller who sends some goods, the buyer who inspects the goods and has all valid necessary transportation documents on both sides. A lot of time is spent here. Interoperable solutions could lock-up the seller with the necessary legal ownership into a token in the ERP system, and the buyer locks up the payment in a token. Thereby the parties cannot say they will not make their transfers. When goods are shipped and inspected in regards to the INCO-terms, and all processes are accepted, then smart contracts in the blockchain could execute with the ERP system and transfer the money and the ownership documents. Hence you will have no reconciliation and those actions could also be set in various terms. Jones (EY) mentions that this way you have a need to have solution, and not only a nice to have solution. This is what is missing in the blockchain solutions today in general. Focus should be more on the whole ecosystem, and not only track and trace parts that the majority focus on today.

Stadnyk (Ambrosus) explains that each corporation is different and they have their visions on how their supply chains work, and also what levels are that could be modified and developed. Blockchains are more reliable than just databases, and have interesting features that brings different kinds of benefits. Enterprises should also know the difference between regular databases and blockchains, and then identify what kind of blockchain is suitable, and then maybe dig deeper to find niche solutions like the for supply chains. The challenges is regarding the integration, as enterprises usually have up and running solutions that are expensive and often in plan for many years to come. A new integration process would be needed and then the costs would rise as well. According to Stadnyk (Ambrosus) & Zhou (Vechain), the main resources needed for enterprises that aim to implement blockchain are time and money. Enterprises need to understand what kind of problems they are solving first, and then understand where the enterprise is losing money and how blockchain solutions could solve these issues.

Keogh (Shantalla), Duffy (BITA) & Cubic (Morpheus) expresses also that the lack of knowledge is a big hurdle for adoption of blockchain technology in the supply chains. People do not understand how blockchain is made, built, structured and executed. Blockchain technology is more of a configuration of multiple technologies, tools and methods that solves unique business cases. Encryption, cryptography, smart contracts and distributed ledgers are not new technologies, as they have existed for some decades. Therefore a solution to enlighten

people is to decompose the component parts of blockchain so that people can understand the difference. A lot of organisations say that blockchain technology is a new thing and that they do not have enough people with expertise. Keogh (Shantalla) denies that and says that blockchain technology is just pulling existing technologies together to do something differently. Most of the foundational components of blockchain are not new at all. Therefore organisations should not be afraid at all to explore and use blockchain technology.

Jones (EY) says that the majority of people and organisations that order blockchain solutions today have no clue of what they are ordering or trying to implement. They want to say that they do blockchain and are following the trends. But they do not understand that blockchain is a protocol that is supposed to be implemented in for example their existing ERP systems, and is not a standalone solution. This is a psychological burden to get across. Organisations see the marketing potential, time saving, cost savings and the good attention they get, but blockchain technology appears to them as some kind of magical new technology that will perform magic. Therefore it is critical to get them to understand what they are asking for and educate executives about private and public blockchains and how blockchains works and its implications. But both Jones (EY) & Zhou (Vechain) also mention that media and journalists have wrong information about blockchains and that people tend to believe what they are writing. This further creates confusion in the whole system.

## 4.3. Barriers and Resistance for Implementation

One of the requirements to increase adoption and implementation of blockchain technologies in supply chains is to evolve the educational component, according to Duffy (BITA). The challenge for most executives considering blockchain technology is to where to get reliable information and insights. This area needs more content, especially from the academic institutions as they are the best source and neutral independent outlet that can provide this. Duffy (BITA) & Keogh (Shantalla) explains that it could yield exciting companies and solutions over the next years, but also yield human capital for enterprises to transition to these new systems. Majority of blockchain content today is produced by technology vendors or service providers that inherently have some bias. Lindman (UG) also expresses that the delay and biggest hinder in terms of enterprises adopting blockchain solutions is mostly because of lack of clarity and stance on blockchain. This is in terms of regulatory nature surrounding blockchains and digital assets. There are various legislations in different geographies about how

data is stored, governed and used. Duffy (BITA) also argues that the multiple country-level jurisdictions are major hurdle for adoption. It is a big process to leverage blockchain technology between networks of stakeholders where it should be possible to see where the assets are, their status and also including different payment services in the bundle.

Lindman (UG) also mentions that organisations that want to adopt public blockchain solutions need to have some specific blockchain knowledge related to applications, integration, data storage and legal considerations. It is much about project management that also depends on what you are specified in. Another requirement could be someone that is facilitating and leading the effort in organisations, that brings it up internally and externally. Lindman (UG) adds that a vital barrier is the concurrency requirement of the system. Today each of the actors participating need to have the same blockchain system. That is also one of the reasons why many are seeking different private based blockchain solutions.

Stadnyk (Ambrosus) & Cubic (Morpheus) mention that another barrier is the complicated process of building the infrastructure around blockchain solutions. Blockchain solutions are not by their own, they need to be integrated with systems that currently exist in the supply chains. This can be challenging as corporations have budgets for some years, and it takes a lot of time to shape and create new business models in relation to specific software development and integrations. Therefore the integration and adoption is slow at the moment. The human mindset is also a barrier of adoption as enterprises have invested a lot of money in their existing technology stack, according to Cubic (Morpheus). Whether it is ERP systems or WMS, they tend to no get rid of it, if it is working. Cubic (Morpheus) also mentions that enterprises are starting to employ people who understand blockchain at a larger scale, which is a new thing. The unwillingness to change will break eventually.

Keogh (Shantalla) & Jones (EY) argues that an issue today with the acceptance and adoption of blockchain technology is the association with Bitcoin. It can for example be that blockchains are impacted by the image that they are using a significant amount of resources, while the world is currently focused more on a greener environment and sustainability. But also the view that blockchains are facilitating fraud and organised crime. But most organised crime that involves the usage of more traditional systems. Blockchain could in fact reduce a lot of that fraud and organised crime. Another issue is the hyping of cryptocurrencies and solutions. It brings negative effects on blockchain projects, although there are a lot out there doing good work.

Duffy (BITA) argues that the resistance of adoption and implementation is due to that many companies and executives in the supply chain and transportation space have been doing things the same way for decades. There are legacy investments, capital investments, careers built on certain business processes and relationships, and even certain technology stacks. A threat of modification is almost an existential threat to some of the companies on the market today. A lot of companies are adopting a defensive position, but it is changing slowly the last couple of years and months. The mentality have often been in this space to think that if it is not broken, do not fix it. But in the same time, there are major opportunities for public blockchain projects to take market shares and make their impact in the industry.

For companies to embrace public blockchain solutions, they often need a business case in the supply chain according to Lindman (UG). Or that somebody needs to force or provide incentives for the organisation. Digitalisation might be one such reason and monetary incentives could be needed to move to these new processes. But if organisations already have digital incumbent systems in place that are working, then there might not be any incentives to implement a blockchain system. But there could be situations where the organisation do not have any choice if it wants to continue servicing the supply chain, for example if all other actors are jumping on a specific blockchain solution driven by bigger and stronger supply chain actor. Zhou (Vechain) mentions that the implementation and adoption challenges are solved by letting enterprises see the real benefits of the blockchain solutions, they need to be convinced. It is important to understand their business and where blockchain can improve their business, either by saving money or adding value.

## 4.4. Interoperability in the Supply Chain Systems

Duffy (BITA) states that one of the well-known challenges is in regards to connecting older legacy technology stacks to next generation technology stacks where blockchain is included. There are attempts of solving this, but they are still inefficient today. For critical infrastructure level participants within supply chains, it is going to be a pro-longed and very considered approach on how organisations move from systems they rely on and know that they work, towards optimising their technology stacks for newer ones for business efficiencies. Lindman (UG) agrees and explains that almost in any kind of digitalisation effort, the main problem has to do with the incumbent and already in place systems. Interoperability issues are many, not just with current systems, but also with competing blockchains.

Zhou (Vechain) explains that the biggest implementation challenge right now is to bridge blockchain with current implemented information systems. Today there are very few templates and helpers in this area, as there is a lack of standard services and tools for enterprises to build up their systems. Smaller companies often do not have financial resources, but larger companies are also reluctant to invest millions of dollars to develop some experimental solutions. Zhou (Vechain) mentions that Vechain therefore provides tools and services with different modules so that companies have choice to build up their own systems. It can be integrated in current systems with help of APIs and middleware's, and this is what differs from other public blockchain projects. Usually other solutions have to be built from the scratch, which is not efficient, therefore already built modules and platforms are much better for interoperability.

Keogh (Shantalla) says that people have the notion that supply chains are linear, but that is not the reality. What is valid though about the linear model is that organisations are very careful about what comes in and out, especially the data and information. This often restricts the sharing of interoperable data across different platforms. Therefore we need to change the visual model of supply chains to more supply chain ecosystems. It is more about the hub in the middle and the spokes coming in and out, to be able to tie and connect in an immutable way the data that is created and the information that is shared. Both Keogh (Shantalla) & Duffy (BITA) states that the key for success for all public blockchain projects is interoperability. Proprietary solutions will not work and therefore it is critical to be interoperable with others. Many public blockchain projects want to own the whole space, but that is not possible. Eventually they will fail if they continue in that way. Traceability and agreed attributes between actors needs to be shared on the platforms where everything is interoperable and all within a bigger system.

Duffy (BITA) further explains that the opportunity over the near future is around ecosystem level platforms in the supply chain industry that can be provided or supplemented by blockchain technology. It will allow for high-fidelity data, which is not too dissimilar from cloud computing, but it allows for push and pull of information in a high-fidelity manner. It is an opportunity of moving away from centralised and siloed business data warehouses, where blockchain technology can create highly secured environment for the production, housing and consumption of data on an assonated basis, which actors can permission out with public and private keys. It all comes down to providing access to better data to drive better decision making, and Duffy (BITA) believes there will be a lot of action in this space for the coming years as global enterprises adopt blockchain.

Lindman (UG) says that interoperability is a still a major issue for blockchain solutions in supply chains. This has been tested out and stated by a number of earlier use cases. Blockchains need to be agnostic on supply chain level to have interoperability with other partners. Zhou (Vechain) & Lindman (UG) mentions that it is also possible to maintain relations with other companies that have not implemented the same blockchain solution, as long as the company have an oracle that provides reliable information on the other platform or blockchain. Something that can bridge, but also have credible third-party providers of data services. The data is not directly handled, as it is fine if enterprises want to hold their data. Original data is never stored on the blockchain, only the hash of the data.

## 4.5. Dilemmas around Private and Public Blockchains

All respondents mentions that there are a lot of discussions regarding public and private blockchain in the supply chain industry. Some organisations may feel at risk with their data, information and knowledge using public blockchains, and then feel more comfortable with a private blockchain as it is protected and taken care of by some party or parties. But Keogh (Shantalla) & Stadnyk (Ambrosus) mentions that there is a fine line if you actually could call private blockchain for blockchains, or just specific distributed ledgers. They question if companies just then are doing what they always have been doing, and maybe not really enhancing the promising qualities that public blockchains are offering. But Keogh (Shantalla) addas that at the current state, whether it is public or private blockchains, it does not really matter once it solves unique business cases.

Duffy (BITA) argues that one of the main stumbling blocks in adoption so far have been around private based blockchains, where instead of an open highway approach, it is more of a toll road regarding development and adoption. The biggest benefits of public blockchains are their distributed nature consensus mechanisms. A perfect example is the Bitcoin blockchain where no one is in control and reaping injustice benefits. But anytime there is a concentration of authority in a private blockchain environment, it introduces an aspect of anxiety and doubt. There is hard to know if there are some back-doors, other ways to authorise, modify data and what the intention and benefits are of the actors operating the private protocol. But the blockchain technology development is still very early on and we will see a lot of changes through the years. Lindman (UG) although says that we might need both public and private blockchain solutions. The most optimal would be if the supply chains were blockchain agnostic,

as long as the blockchains talk to each other. But this is the problem, they do not today. A lot of early adopters of blockchain technology worked with private blockchains, as it was more secure and actors could share governance issues. So trust could be shared with other partners, and also bring some increased transparency. These private solutions also cut some costs in terms of not developing their own blockchains or specific requirements to implement into a public blockchains with nodes etc. Private blockchains can be welcoming to grow their ecosystem, but demands are often used on those who want to onboard the nodes to the supply chain. The tendency is that the platform owner then needs to give up some control.

Lindman (UG) also mentions that the cost of public blockchain are expensive today and it might be difficult to control and foresee the price action of the tokens, therefore a lot of actors might want to have a private choice of public blockchains so they can control the price or the maintenance of the system. Performance requirements on current public blockchain might also be an issue as the lead time are too long for some supply chain activities. But there are problems with private blockchains too, for example that early blockchain project opted towards them without any other possibilities and that there are control issues in the private blockchains with power imbalances between supply chain partners as the leader or some specific actors can have more control and enforce it over the others. There is also probably a reason of choosing a blockchain solution in the first place, mainly to get rid of big actors controlling the supply chain.

Jones (EY), Cubic (Morpheus) & Zhou (Vechain) believes way more in public blockchains than in private blockchains. They say that private blockchains will never scale, but also that a lot of actors out there do not really need a blockchain today and transactions are often done between a small amount of actors, they want to control all the nodes and access to data, and hence a blockchain is not really needed. Jones (EY) also states that it is also complete nonsense that you could trust that data, even if it comes from computers and sensors, and not humans, as there is someone who controls the data and can easily amend it. Hence private blockchains do not have the value that public blockchains can bring. Although, Jones (EY) explains that in some instances private blockchains can be a good solution if you have a few amount of parties that do not trust each other by nature, often one case handlings. If a company also has a closed supply chain system, then it can work, but that will never scale. If you want to get tax authorities, customs and public authorities to private blockchains, that is impossible according, as they are not allowed by the competition authorities. So you in some way enterprises have to go for a public blockchain solution in order to build a system where different actors can join.

Jones (EY) explains that Maersk together with IBM started a private blockchain project regarding marine insurance and track and trace, but it failed to reach its aim. The founding parties even had to pay small liners to join the project so they could get positive press-releases out. But liners started to ask questions about their data as Maersk and IBM controlled all the nodes. It was difficult to withdraw and thereby these smaller liners started to understand the data challenges and started to get more interested in open-source projects handle by public blockchain teams. Private blockchains are often marketed as safe and secure and that there is trusted actors behind it. Usually it is a great on-ramp to the blockchain world according to Jones (EY), but he thinks that history will repeat itself as it did with the big data hype and cloud computing hype. First it starts off with private solutions, but then when more open-source and decentralised solutions are introduced, then the majority moves over to the public side.

Zhou (Vechain) explains that the public blockchains provide a maximal level of decentralisation and trust where actors can trust the data in most instances. Actors do not have to worry about some parties in the system that might modify the data without you noticing it. Whereas with private and consortium based blockchains, actors have to trust the companies that are running the blockchain. A lot of enterprises try out private blockchain in the start as they think it will be easier, but they often find out that running a private blockchain as a burden, with maintaining, running and upgrading the system constantly. A lot of resources are also needed to run private blockchains. But public blockchains have more communities that are dedicated to the development and working with upgrades, tools and protocols. Enterprises do only need to pay for the transaction to use public blockchains, and thereby he considers public blockchains to be an overall better choice for enterprises in the supply chain industry.

Stadnyk (Ambrosus) adds that private blockchains are more like solutions provided by Oracle or MySQL, while public blockchains have validated code and transactions by the participants, and also the features of immutability and audibility. With public blockchain it is also possible to provide profits for actors using and hosting a specific public blockchain. Cubic (Morpheus) mentions that the issue with private blockchains are the barriers for adoption, as the business model often is that they build, and the rest will come to the founders. But that progress is going very slowly, and is also time consuming and costly to build many different separate blockchains for clients. Therefore focus should be on developing public blockchains as they are more secure, which is valuable if you do not have some companies owning the data on private blockchains.

## 4.6. Token-Based Blockchain Solutions

A lot of public blockchain projects are offering tradeable tokens today. Keogh (Shantalla) says that focus is often a lot on the context of privacy laws so they could develop their solutions to be compliant. These public blockchain projects can provide the glue to allow all parties to share their information, and these teams often act as middle-layer that manages hand-offs from one platform to another. Duffy (BITA) says that in terms of leveraging public blockchains, the most excitement has come around Ethereum and the solutions on top if the last couple of years. Major enterprises have been looking towards public blockchain solutions and a lot of the projects are doing a fantastic job. Duffy (BITA) is excited about the projects that are doing an academic approach and open-source solutions, as it will be the way forward. Companies are worried about making big capital investments in case of getting stuck with a certain protocol. So it is challenging for specific projects and public blockchain teams to find capital. A lot of investors have been burned previously so they are more cautious in their approach. But both Duffy (BITA) & Keogh (Shantalla) are certain that we are moving into the direction where public blockchain solutions will dominate, it is not a question if it will going to happen.

Duffy (BITA) mentions that the interaction with the new public blockchain projects often scares away the established organisations, as they are not sure what the right way is to interact with them. They are not sure if they can be partners, if they threaten their existing value proposition or even lose customers by introducing their solutions. Any time actors work with new emerging technologies, it introduces doubt. Organisations want to provide a consistent experience and new solutions, or even worse, experimental solutions, tends to be pushed back. Therefore it is tough for public blockchain projects with tokens to get into interaction and partnerships today.

Lindman (UG) says that there could be risks with solutions that use tokens, for example smart contract risks or application related risks. There could be a failure in the code or some hacker attacks if the platform is not secured enough. This could lead to risks in interoperability made in such way that solutions are difficult to integrate. Other risks with tokens are oracle based, as the token need to correspond with something, either some value or something physical. But smaller players in the field of public blockchains could be a way to go around the issue of large scale actors that have full control and optimising the supply chains from their own viewpoint. Some blockchain benefits related to transparency and audibility might favour smaller disruptive actors, especially if more data becomes available from the supply chain activities.

Jones (EY) believe that tokens will definitely come and play a key role in the coming years, in terms of having programmability features towards different actions and activities. But it is down to the standards and how to scale the ecosystem, and also the compatibility towards different blockchains. Currently a lot of investors and organisation might be excited how different token solutions can be used to create efficiency within project challenges like track and trace, and within certain ecosystems of supply chains. But we do not have any full ecosystem today, and no projects that are out there have some sort of standard. Jones (EY) personally believes that the blockchain that will have the largest impact in the world has not been created yet.

Lindman (UG) argues that in regards to public blockchain projects that have issued tokens, actors then have a trust in the actor who supplies the tokens, and the real question is what the token is used for. It can either be to democratise something, governance, voting system, raise funds, give voice for smaller actors etc. It depends on that it is used for and we are not fully there yet to see fully implemented solutions on a large scale due to many issues and liabilities. It is also hard to foresee the price actions and especially with tokens that have a large interest-base around them. They are often not fully regulated and the development path can be unsecure with surprising disrupt changes for more traditional organisations.

Jones (EY) says that there is a lot of hype and craze regarding different tokens today, and will be for many years to come. The discussions are often that one solution is better than the other, it is down to protocol levels where everyone tries to re-invent the wheel. Jones (EY) states that the ones that will reach out to the mass-market, will also take the market. It will not be presented as today to get as many people to join your blockchain or solutions, it will likely be large parties in the supply chain ecosystems that chooses a blockchain that will then become the standard, and everyone else is somehow already connected to this via the large actors. So it is not about which projects that appear to be better than others right now.

Zhou (Vechain) mentions that a lot of big enterprises are making contact and looking for help with specific use cases in the supply chain industry. In the last couple of years, some impressive real-world applications have been brought out by Vechain. He mentions that they are seen as the leading company in their area and the future is promising with hundreds of enterprises in the pipeline. The main aim is to help with digitalization within supply chains, to make cost-efficient and development-efficient supply chain management systems using blockchain technology. An issue today is often that enterprises do not know how to build systems based on

blockchains, and the solution provided is on top of the Vechain blockchain, so that enterprises can build out their own supply chain management systems quickly and with manageable cost. Every system has its own rules for information, like modification and sharing, and therefore the protocols are not fully designed. It comes down to efficiency and interoperability with the current information systems. Zhou (Vechain) further explains that companies that are using the services provided by Vechain do not need to deal with any specific tokens, which is mainly because of the lack of laws and regulations. Companies are therefore signing contracts like with a normal service provider and use the blockchain functionalities that are provided. The token within the system is representing the computational resources and storage resources of the public blockchain, which also represents some voting rights. Enterprises could also pay their transactions with the specific token, or even invest in it if they think it will appreciate, but often Vechain takes care of the tokens after the actors pay for the services.

Stadnyk (Ambrosus) explains that the solutions of Ambrosus are niche for the supply chain industry, where ERP solutions for enterprises in regards to connecting to public blockchains are developed. The ERP solutions by Ambrosus are suitable for many situations and can be linked to both current information systems but also across different blockchains. For example, APIs can be used to connect blockchain services for regular software services. Tokenization is also growing and the usage of smart contracts, and Ambrosus got something similar on top of smart contracts with niche and specific blockchain solutions. Stadnyk (Ambrosus) explains that Ambrosus currently is best in this area and that other teams are missing those specific solutions. Stadnyk (Ambrosus) also explains that companies who use their services need to buy their tokens to pay transaction fees on the blockchain and storing data, but also participating in the network. It is also possible to stake the tokens for interest. There are partnership onboarding right now, but one of the challenges is the volatility and the hyping around tokens, as enterprises want fixed prices to be more secure. Ambrosus is also getting a lot of requests in the recent time where enterprises ask for concepts, but the majority are asking for impossible stuff.

Cubic (Morpheus) mentions that Morpheus act as a middleware and are flexible in what blockchains or information systems the clients are using. Solutions are not built beforehand, but together with the clients to reach an optimal solution. Another key point is that the solutions provided are web-based and no complicated installations are needed to start. The solution is technology agnostic and can easily connect to existing infrastructure or multiple blockchains, and allow for optimisation and streamlined processes. The unique feature is that Morpheus

digitise and automate all the processes from the purchase order until proof of delivery, in an agile manner, with highly customisable features and modules. Enterprise are able to get predicative evaluation of the costs and also use flexible permissions for certain actors in their supply chains if needed. He also mentions that the future looks bright and that the expansion is enormous. Transactions usually move through different systems and different compliance platforms, therefore tokens are used to map the transaction along the value chain, says Cubic (Morpheus). It would not be possible without the token to operate on the Morpheus platform. The token is the fuel of the platform. Companies do not need to hold tokens for the platform, but they are able to hold tokens for discounts in operating transactions. In the future, business models will be based on decentralisation, where tokens could play a more significant role and the data will be more consumer centric and belong to the enterprises more.

## 4.7. Tokenisation Implementations in Supply Chains

Keogh (Shantalla) mentions that we have a lot of power asymmetries in the supply chains, where big players have massive power. Blockchain and other disruptive technologies can help to neutralise the power by for example give primary producers the ability to monetise on the data they create. Keogh (Shantalla) sees a huge opportunity for supply chain and tokenisation.

There is a strong possibility that the underlying cryptocurrencies and tokenisation of farming holds huge upside. He explains that a beef-farmer usually sells the cows to processers who almost own the entire market. Instead, by using a node from public blockchain solution, the farmer could capture the data attributes he is involved in. This enables the farmer to get an income from sending and trading that data into different ecosystems. The farmer could also create other ecosystems like directly to traders or food services instead of the processers, or even directly to consumers. Keogh (Shantalla) further argues that a farmer could assign tokens to his cows and consumers could buy parts of the cows even before slaughter. This would create an interesting model where the farmer gets paid upfront and engages with the token-holders. Based on the value of their tokens, they can order a specific amount of meat, and when the farmer has enough, he can start to slaughter. So in the future people might invest in tokens that are connected to animals, farms etc. if they believe in the farmer and that it could be a profitable enterprise. Consumers could also invest in wheat-fields, vegetables or even orange trees where consumers get oranges from their specifically owned orange tree.

Keogh (Shantalla) & Duffy (BITA) argues that the values of cryptocurrencies are currently fluctuating a lot, so there could be some intermediaries here that will hedge the risk in the fluctuations. They state that this area is still very unexplored right now, but will be exciting to see how it evolves. Duffy (BITA) also thinks that tokenisation will possible take the form as NFTs, non-fungible tokens, of bill of ladings, that provide the authenticity in the data behind a supply chain transaction. The idea of tokenizing data that can be leveraged and moved between stakeholders will certainly accelerate in usage according to him.

Jones (EY) states that there is a lot of talk regarding more centralised blockchain projects using public blockchain, where we have actors behind the project and discussion about scaling and connecting to centralised parties, but this will not matter soon. Jones (EY) is claiming that we have already moved onto the decentralised world, without anyone paying notice to it. The ecosystem of decentralised finance, DeFi, will play a key role, where governance tokens to control the decentralised protocols will be important. There are barely anyone that understand this phenomena today, and about 15 people in the world can verify DeFi smart contracts, so we have challenges, but Jones (EY) believes that the mechanisms will be the standard as no one can compete towards the efficiency it provides. Decentralised exchanges could swap different tokens across different blockchains, and thereby solve a lot of the interoperability issues today. Governments would also have full transparency as long as it is decentralised and the code is open source with valid transactions. Thereby Jones (EY) suggests that organisations and authorities starts to invest in infrastructure to build analytical tools around public blockchains, as it often has a better overview of the transactions being made than the more traditional counterparts. We are still years ahead before we have a fully unified working ecosystem, but if one is to be created, then it needs to be built as a fully decentralised and open system.

## 4.8. Issues and Solutions for Fraudulent Data Handling

Lindman (UG) thinks that tokenisation will be more important in the coming years and grow in importance. But an issue in the supply chain industry is the reality feed or oracles, how a digital representation is established and where it comes from, but also how it is maintained. The link between the physical and digital representation needs to be secure. At the oracle process there almost always some need of trust to be established. But the real issue is that often that link cannot be established and maintained only on the blockchain, as a physical counterpart providing the feed to the blockchain is need. This makes the entry point to the blockchain weak.

Lindman (UG) explains that things that go onto the blockchain, also stays on the blockchain. But if something goes wrong in the supply chain steps, it is afterwards hard to fix, which is both good and bad in some way. This is especially applicable for supply chains that are focusing on provenance. Often supply chains begin in less trusted organisations or even developing countries, which can create situations with a number of problems in the early phases of the supply chains. If there are some mismatches it will be difficult to handle, but that is outside of blockchains as such, as blockchain is not causing the problems but mirroring the existing problems that are already in the supply chain.

Jones (EY) mentions that organisations should have more independent parties out there with different sensors and measuring mechanisms when dealing with blockchain in supply chains, and preferably a couple of data points that are verifying the data. These independent parties could verify virtual digital data or physical items that has been put into a virtual world in terms of a blockchain. But there are no quick fixes for these issues. But organisations have to trust actors either by nature or by independent third parties, where ERP systems could be evaluated and verified that data has not been tampered with. But it is always possible to tamper data that is not fully decentralised, distributed and immutable. So it is about who the organisations trust, and for the mass adoption this is something that has not fully been developed yet.

Keogh (Shantalla) explains that blockchain adds significant of value in regards to product recalls. First search endurance should be done, traced back to see which batch was tested, who tested it, which laboratory was involved and who signed up for the tests. When products are recalled, you need to verify that the product is yours, and here blockchain adds a significant foundational layer of insurance for companies to be able to verify. Even if something is fake or false, as you have immutability due to blockchain, you then have a collusion of actors, and if false information is stored in the blockchain, that is then an immutable lie which you can trace back to the cheater.

Duffy (BITA) says that issue with fraudulent data, often called the garbage-in and garbage-out problem in supply chains in connection to blockchain technology is solved in a governance approach. Whether it is adoption by mandate of the biggest participants within specific marketplaces, where they have requirements on specific data formats and type of checks and systems used, or adoption by a regulatory push. It could also maybe even in the future be done by DAOs, decentralised autonomous organisations.

Keogh (Shantalla) further elaborates on the issue with garbage-in and garbage-out dilemma with blockchain technology in supply chains. A solution is often to make built in requirements in contracts for sharing raw data and information, and that actors provide their real-time feeds or generate quality inspections. Those are then put up onto the blockchain immediately which could help. But there are also opportunities where human error or intervention could introduce a vulnerability. Those activities or tasks could be replaced by smart contracts combined with IoT devices. Keogh (Shantalla) brings up an example with trucking and cold chains. There IoT devices could be connected to have real-time signals regarding ambient, temperature, humidity, accelerometer and stress levels. If the truck breaks down, then the driver could be notified with help of the IoT sensors in real-time to drive to the closest city to distribute the cooled articles in good condition, which another trucker later could transport, instead of getting them spoiled. These sensors in connection to blockchain could also trigger payments with smart contracts, which can replace the human activity and guesswork. This could eliminate the risk of vulnerability of a human doing something they should or should not be doing.

Lindman (UG) solution to solve the false data input into blockchains, are some kind of sanctions that could be implemented if it is done repeatedly by the same actors. But often it is a game of where things are put in terms of representation in the blockchain versus where it actually came from. This is a huge weak point in the current system, especially supply chain systems that often rely on it. Actors can get caught for manipulation or fraud if there are audits and checks, but it might be tricky, especially with batches and mixed products. So there is definitely gaming for an incentivizing structure. Blockchain will not remove theft or scams, but it will make it visible ot track back when it is stored in a transparent way.

Jones (EY) states that it is doable to trace back and find the fraudulent actors, but the core question is how to verify the data, and that is not a job for the blockchain itself. The blockchain is only supposed to verify the input data and not the source. It is the source that needs trust and blockchain cannot help with that. Often in supply chain solutions with blockchains, parties are asked to verify their own data and then put it into a blockchain. Of course they would not register any pollution, fraud or child labour, it would most certainly all look nice. But the industry therefore needs to connect to independent third-parties, but also other methods and sensors to at least have a couple of data points to give reliable trust. Then all this trusted data could for example be put into a token and linked towards other independent databases. If you have machines and humans involved, you can never get anything 100% right.

Zhou (Vechain) mentions that Vechain is working with third-party assurance companies to solve fraud in the supply chains, especially with wrong information put onto the blockchain. The assurance companies provides a service that makes sure that the data is filtered and verified before it is stored in the blockchain system. It can also penalize misbehaviour if fraud is detected, but blockchain itself cannot solve problems that are occurring in the real-world activities. Stadnyk (Ambrosus) further mentions that Ambrosus uses own sensors, where each sensor is validated and not being able to manipulate by any actors. Hardware solutions are implemented to reduce the fraud and wrong data into the blockchain, which creates data to the blockchain, and Ambrosus is operating on top of it. Therefore a lot of errors are avoided, although errors could be made by sensors and chips, but those are easier to clean up and easy to find.

## 4.9. Standards and Certificates

Standard bodies in the supply chains are important, and a lot of work has got into these at national level and by industry over decades, according to Keogh (Shantalla). Standards take out significant amount of friction and drives both automation and efficiency. Standards gives us frameworks that are technology neutral and independent. So for example GS1, ISO and W3C are very much aligned and interoperable. If this part is left out to individual companies, then we would have non-interoperable systems with many different standards. The same goes if companies come along and say they do not want to use for example GS1 standards, then they are shooting themselves in the foot. Keogh (Shantalla) says that there are many companies that right now are doing well in the blockchain world, but that have assigned unique identifiers that are proprietary. Often they think they have the ownership of the product, but it does not take over the identity of the product, as the identity of the product remains the global serialised trade item number that is set by GS1, ISO and W3C. With a combination of these standards you then have a foundational layer to make supply ecosystems work. There are a couple of teams out there with tokens that went fully aligned with standards from the start, but some did not.

Implementing and developing industry standards for public blockchains in the supply chain industry is really challenging according to Duffy (BITA). A lot of actors try to create standards, but it would be more beneficial if actors could get together and work together on them. Duffy (BITA) claims that there are about 500 different standards initiatives worldwide and it is

overwhelming for average participants getting into the space. It is hard to figure out what current standards exists, how to interact with the right ones, how to do due-diligence etc.
There are no good answers right now and it is hard to say what will be the meta-layer standards that will allow these new blockchain systems to go from network of transportation companies, talking to a network of financial service companies or regulators. Duffy (BITA) mentions that there are opportunities, but it is hard and slow work with a lot of challenges, and it is going slower than what the market would like.

Lindman (UG) thinks that standards would be an optimal solution as blockchain-based supply chain solutions need to have all the actors married to a specific blockchain, or maybe have different kind of blockchain standards so the blockchain can talk to each other. We are although not there yet. Standards for information systems have been in work for many decades, but standards have not fully been able to help to solve interoperability problems, and therefore Lindman (UG) does not think that the current road will take us the full way of where many actors aims at with standard developments for blockchain in supply chains.

It often depends on the purpose with the system setup regarding standards for blockchain technologies in supply chains, according to Jones (EY). He says that there are some initiatives in the industry in general, mainly about tracing and payment, but there are no clear ISO initiatives towards an ecosystem of this. The blockchain space is under constant development where new solutions and token standards are coming up. Zhou (Vechain) explains that Vechain is working closely with the biggest assurance companies in the world that are experts on standards, and also with other actors that specialise on standards. Zhou (Vechain) says that Vechain is not doing consultation about standards, but if some clients have requirements, they will the work with third-party assurance companies to make sure the system is compliant with certain standards, like the ISO standards.

# 5. Analysis and Discussion

*This chapter analyses and discusses the motives and challenges for blockchain solutions in the supply chains based on the empirical findings and the theoretical framework.*

## 5.1. Motives and Benefits

An interesting notion is that more and more companies are moving onto the adoption and implementation of blockchain solutions, and Jones (EY), Stadnyk (Ambrosus), Zhou (Vechain) & Cubic (Morpheus) are constantly in contact with new organisations that are interested in implementing blockchain solutions. The majority of the respondents believe that blockchain technology is way beyond hype right now and that it will create the most prominent changes that will come for the next 100 years in the supply chain ecosystems. This is also something that the literature believes in, where blockchain technology has a huge opportunity to be the standard solution as it provides and promotes a horizontal integration (Venkatesh et al. 2020). These findings shows clear signs that a lot of parties are on the same side and see a bright future for blockchain solutions in supply chains. Zhou (Vechain) mentions that the implementation and adoption challenges are solved by letting enterprises see the real benefits of the blockchain solutions, and they need to be convinced. It is important to understand their business and where blockchain can improve their business, either by saving money or adding value.

The literature has shown that to realize the benefits of blockchains, and then blockchains have to continue to mature and work with the interoperability challenges (Bai & Sarkis 2020). This finding is aligned with the thoughts expressed by Duffy (BITA) that states that the blockchain development is something that needs to mature while blockchains are becoming more mainstream in general. The means of adoption and implementation needs to be built internally at the organisations, and then slowly built it out in the ecosystems. The literature also states that companies that are reaching to implement blockchain solutions have to assess where it will have the most impact, and it is recommended to start with a small viable system and then grow from there (Yang 2020). This is something that all respondents agree that organisations who are trying to implement a blockchain solution should know what issues they want to solve, break it down and find a significant problem where blockchain could be applied. Organisations should not be afraid of approaching blockchain projects, according to Keogh (Shantalla), but Jones (EY) states that over 90% of all blockchain implementations out there today are

implementations that actually do not need a blockchain. The focus should be to shift from a nice to have solution, to a need to have solution.

The literature further mentions in alignment that blockchain is slowly becoming that puzzle that can be vital for all other new technologies to get tied together in a trustless and secure way (Dinh & Thai 2018). Blockchains are part of an evolution, a next step to create something better, more reliable, more trustworthy and more secure than ordinary databases, according to Stadnyk (Ambrosus). Duffy (BITA) is in the same thoughts where he says that blockchain technology can create a highly secured environment for the production, housing and consumption of data on an assonated basis. In an another setting, Keogh (Shantalla) states that with blockchain, you can then connect that authority who provide the certification, and customers can directly go to the authority that issued it rather than the brand. That is where a significant amount of added integrity is built into our supply chains. However, there are many constraints and processes are costly and time-consuming. Blockchain technology has the ability to incorporate all appropriate parties and transform the supply chain by removing all unnecessary intermediaries that previously were needed for validation (Calatayud et al. 2019).

Payments could be facilitated much faster and securer between importers and exporters with less manual verifications. This reduces frictions when signing contracts (Norberg 2019). This is something that Keogh (Shantalla) expresses similarly regarding that blockchain will enhance transparency significantly. This will then take out transactional friction, which could be disagreements, that usually ends up in costs. Jones (EY) further mentions that blockchain is a foundational technology that will provide layers of trust and reduce friction in the supply chains. It will take time to implement, and new technologies will come, but blockchain technologies can help to revolutionize the supply chains today.

Smaller businesses will have lower participation costs due to reduced administration and involvement of intermediaries, which is very value-adding (Philipp et al. 2019). This finding can lead to developments of new business model and competitiveness in the supply chain industry. This is something that Lindman (UG) also mentions where smaller players in the field of blockchains could be a way to go around the issue of large scale actors that have full control and optimising the supply chains from their own viewpoint.

## 5.2. Traceability and Visibility

Keogh (Shantalla) states that we did not have interoperable platforms that could talk to each other, and thereby no visibility into the processes. Philipp et al. (2019) agrees and mentions that blockchain enables trust in each step in the supply chain by having information in open access where actors can trust the information, which was not possible with the solutions prior to blockchain implementation. Duffy (BITA) explains that inefficiencies in data hand-offs have led companies to focus more on blockchain technology so that they can create interoperability solutions focused on supply chain visibility. In the literature, it says that blockchain features give the ability to follow assets and keep track of records with accurate and clear end-to-end visibility. In this case, all actors become more equally powerful (Wang et al. 2019).

With the possibility of tracking regarding transparency, actors can check if, for example, temperatures were correct, check the audit certificates or if the negotiated route was token (Gurtu & Johny 2019). In the findings, Lindman (UG) states that blockchain technology is very good if you want to monitor process flows, like containers, goods, ships and so on, in an immutable and auditable way on a transparent platform. Jones (EY) is aligned both views, but also mentions that we need more transparency towards the validation of data itself.

Shipments can be traced and be more reliably controlled where assets could be traced during the whole life cycle. This gives an opportunity for companies to evaluate potential suppliers and other actors in the supply chain, by checking at past recorded transactions, before signing contracts (Christodoulou et al. 2018). Thereby Stadnyk (Ambrosus) implies that blockchains are part of an evolution, the next step to create something better, more reliable, more trustworthy and more secure than ordinary databases.

There is a significant value to have oversight over the trade processes in the supply chain, and the transparency of blockchain can give complete visibility into transactions and enable better analysis of systematic risks. Due to the transparency features of blockchain technology, it is also easier to pinpoint risks and who carries it at the moment, and thereby also track the exposure for the risk in real-time (Rogerson & Parry 2020). Jones (EY) have the same thoughts in order to build more trust than the current systems provide, you need to have an efficient way of connecting all necessary types of technologies in order to make this development as transparent as possible.

## 5.3. Interoperability Issues

Interoperability between technology stacks can be managed to some extent by blockchain technology, where it can scale up and combine across different application areas. In combination with IoT mechanisms, like sensors, blockchain could bridge the gap of data interoperability issues currently in the supply chains (Rejeb et al. 2019). Duffy (BITA) is not as optimistic and states that one of the well-known challenges is in regards to connecting older legacy technology stacks to next-generation technology stacks where blockchain is included. There are attempts of solving this, but they are still inefficient today. Zhou (Vechain) & Lindman (UG) also says the biggest implementation challenge right now is to bridge blockchain with currently implemented information systems. Thereby, interoperability issues are many, not just with current systems, but also with competing blockchains.

A promising feature is the reliance on better predictable information and delivery times in combination with other technologies. Therefore interoperability is very important to be even better (Philipp et al. 2019). Keogh (Shantalla) agrees that the key for success to all blockchain projects is interoperability. Proprietary solutions will not work, and therefore, it is critical to be interoperable with others. However, organisations are very careful about what comes in and out, especially their data and information. This can then be analysed to often restrict the sharing of interoperable data across different platforms. Therefore a notion is that we need to change the visual model of supply chains to a visual model as supply chain ecosystems.

Cubic (Morpheus) mentions that we need more surveillance to align with these issues and that more interoperable systems are needed to catch these problems as they start to occur. Keogh (Shantalla) is on the same path, and adds that it means that blockchain drives interoperability, higher levels of transparency, higher levels of trust and higher levels of certainty in the trading relationships. It could also help to reduce corruption. Managing various risks in the supply chain will also be easier as actors enter their information at each step in the supply chain onto blockchains that others can audit. Therefore in alignment with the literature, blockchain, in combination with other technologies, could enable information about provenance, source of origin, maintenance and transportation routes and choice (Rejeb et al. 2019).

Jones (EY) states that in order to build more trust than the current systems provide, you need to have an efficient way of connecting all necessary types of technologies in order to make this

development as transparent as possible. It is not viable to say that blockchain equals to a lot of benefits, but rather understand the implementation and applications areas of blockchain technology. However, the literature says that blockchain technology can act, in connection to multiple supply chain innovations, as the platform to connect the technological advances together and to create integration across the whole supply chain ecosystem. It will transform the current practices in logistics, transportation and operations by making the network more responsive and adaptable in regards to demand and crisis, by helping to ensure security and visibility (Ghode et al. 2020). Zhou (Vechain) explains that already built modules and platforms for the clients who want blockchain solutions are much better for interoperability into their systems. Every system has its own rules for information, like modification and sharing, and therefore the protocols are not fully designed. It could thereby be said that it comes down to efficiency and interoperability with the current information systems.

The vital feature of blockchain is that it is aimed to collaborate end-to-end across different platforms and industries, where the shift from siloes and competition towards more competition is nowadays inevitable. The integration of existing technology stacks is needed, as the efficiencies are not the same if the blockchain solution sits in a silo. The literature states that blockchain solutions should be encouraged with collaboration over competition, as a viable solution is suitable for all actors regarding the benefits (Wang, Chen & Zghari-Sales 2021). However, Lindman (UG) says that interoperability is still a significant issue for blockchain solutions in supply chains. This has been tested out and stated by a number of earlier use cases. Therefore, blockchains need to be agnostic on the supply chain level to have interoperability with other partners.

There will probably not be a single blockchain that will dominate, but it should instead be the focus on the interoperability of multiple chains. In order for blockchain to be adopted widely, it needs to have good performance, scalability and interoperability with various blockchains and incumbent information systems (Ghode et al. 2020). Jones (EY) takes another approach to interoperability and mentions that the mechanisms of decentralised finance will be the standard as no one can compete towards the efficiency it provides. Decentralised exchanges could swap different tokens across different blockchains, and thereby solve a lot of the interoperability issues today.

## 5.4. Standards Development

Before considering the implementation of blockchain solutions, it is important to reflect and identify standards (Manupati et al. 2020). However, Duffy (BITA) says that it is hard to figure out what current standards exist, how to interact with the right ones, how to do due diligence and so on. There are no good answers right now, and it is hard to say what will be the meta-layer standards that will allow these new blockchain systems to go from a network of transportation companies, talking to a network of financial service companies or regulators.

It would be good with different kind of blockchain standards so the blockchain can talk to each other. We are although not there yet. Standards for information systems have been in work for many decades, but standards have not fully been able to help to solve interoperability problems, and therefore Lindman (UG) does not think that the current road will take us the full way of where many actors aim at, with standards developments for blockchain in supply chains.

Duffy (BITA) explains that implementing and developing industry standards for public blockchains in the supply chain industry is really challenging. A lot of actors try to create standards, but it would be more beneficial if actors could get together and work together on them. Jones (EY) mentions that it depends on the purpose with the system setup regarding standards for blockchains, and there are no clear ISO initiatives towards an ecosystem of this. The blockchain space is under constant development. The literature explains that the standards tend to speed up the adoption of new technologies and early adopters of blockchain have the possibility to collaborate with standard bodies and shape the future. The supply chains are complex where bridges of interoperability are hard, but the industry needs shared standards across different systems and blockchains, in some way, they have to be implemented so that blockchains and systems could talk to each other (Wang, Chen & Zghari-Sales 2021).

Standard bodies in the supply chains are important, and a lot of work has got into these at a national level and by industry over decades, according to Keogh (Shantalla). Standards take out a significant amount of friction and drive both automation and efficiency. Standards give us frameworks that are technology-neutral and independent. The literature explains the same things, regarding that standards are essential to bridge systems and to enable widely scaled traceability options, and open standards like GS1 could accelerate the adoption of blockchains as interoperability is crucial (Wang, Chen & Zghari-Sales 2021).

## 5.5. Token-Based Solutions

Token-based teams have tokens that are backed by either resources or asses in the ecosystem. They can also resemble a claim to something. Blockchain-based projects often have their tokens as fuel for the network to reward stakeholders for their contribution. This can be for operating the blockchain or providing services like data that is valuable. Tokens tend to represent a stake in the network that grows in value if their blockchain network also grows. This tends to incentivise the stakeholders to contribute (De Giovanni 2020).

For comparison, the challenge for token-based teams is to find a way through the hype and arrive at solutions that add value to the clients. Tokens could also be much more useful if the data and regulations were not that constrained. There is minimal compliance and interactions right now, and the profit motive is not always compelling for investors due to the volatility (Rahmanzadeh et al. 2020). Enterprises have been looking towards public blockchain solutions, and a lot of the projects are doing a fantastic job. Duffy (BITA) is excited about the projects that are doing an academic approach and open-source solutions, but it is challenging for specific projects and public blockchain teams to find capital. A lot of investors have been burned previously, so they are more cautious in their approach.

Thereby, if companies are using tokens on the blockchain, they can then use interesting programmable rights, for example, possession of tokens could mean ownership of infinite data, and also authenticate processes and owners of assets with various obligations (De Giovanni 2020). Jones (EY) believe that tokens will definitely come and play a key role in the coming years, in terms of having programmability features towards different actions and activities. But Jones also mentions that there is a lot of hype and craze regarding different tokens today, and will be for many years to come. The discussions are often that one solution is better than the other, and it is often down to protocol levels where everyone tries to re-invent the wheel.

In combination of literature and respondent views, smaller projects that have a niche in blockchain, tokens and supply chains are able to realise business values which can be important for the future. Tokens can also appreciate, like stock shares, and that might also be a merit in their business model for some companies. Enterprises could also be key holders of the tokens, if these teams help out to build their blockchain solutions, and then companies can amplify their ROI as the tokens appreciate (Rahmanzadeh et al. 2020). Lindman (UG) says that there could

be risks with solutions that use tokens, for example smart contract risks or application-related risks. There could be a failure in the code. However, he also says that it might favour smaller disruptive actors, especially if more data becomes available from the supply chain activities. Lindman (UG) then mentions that actors have trust in the actor who supplies the tokens, and the real question is what the token is used for. It can either be to democratize something, governance, voting system, raise funds, give a voice for smaller actors and so on. It depends on what it is used for, and we are not fully there yet to see fully implemented solutions on a large scale due to many issues and liabilities.

Duffy (BITA) mentions that the interaction with the new token-based blockchain projects often scares away the established organisations, as they are not sure what the right way is to interact with them. They are not sure if they can be partners, if they threaten their existing value proposition or even lose customers by introducing their solutions. Tough for public blockchain projects with tokens to get into interaction and partnerships today. The literature is on the same path, and the opportunity for tokens is that the application and infrastructure to build is difficult, and companies do not have the right knowledge for it. Companies are also unable to fund their own blockchain solutions (Nandi & Moya 2020).

Cubic (Morpheus), Zhou (Vechain) and Stadnyk (Ambrosus) says that a lot of big enterprises are making contact and looking for help with specific use cases in the supply chain industry. There is a lot of partnerships in the pipelines, and the future looks bright for token-based solutions. One of the challenges is the volatility and the hyping around tokens, as enterprises want fixed prices to be more secure. But usually companies do not need to deal with any specific tokens, which is mainly because of the lack of laws and regulations. Tokens could play a more significant role, and the data will be more consumer-centric and belong to the enterprises more.

Keogh (Shantalla) sees a huge opportunity for supply chain and tokenisation, where in the future, people might invest in tokens that are connected to animals, farms and so on. This would create an interesting model where the farmer gets paid upfront and engages with the token-holders. Duffy (BITA) also thinks that tokenisation will possible take the form as NFTs, non-fungible tokens, of the bill of ladings, that provide the authenticity in the data behind a supply chain transaction. Even DAOs could be future of governing companies. The idea of tokenising data that can be leveraged and moved between stakeholders will certainly accelerate in usage, according to Duffy (BITA).

## 5.6. Public and Private Blockchains

All respondents mentioned that there are a lot of discussions regarding public and private blockchain in the supply chain industry. Some organisations may feel at risk with their data, information and knowledge using public blockchains and then feel more comfortable with a private blockchain as it is protected and taken care of by some party or parties.

The literature points out that private blockchains might be effective for some cases, where rapid decision making is possible, but it is not suited when moving towards commercialisation. Another drawback is the entry barrier for smaller players who are not able to participate financially or bear the shared risk. There are currently no effective ways of moving information and data across blockchains as there is no consensus on what represents the better model regarding private or public blockchains (Yang 2020).

Duffy (BITA) argues that one of the main stumbling blocks in adoption so far have been around private based blockchains, where instead of an open highway approach, it is more of a toll road regarding development and adoption. There is hard to know if there are some back-doors, other ways to authorise, modify data and what the intention and benefits are of the actors operating the private protocol. Jones (EY), Cubic (Morpheus) & Zhou (Vechain) believes way more in public blockchains than in private blockchains. They say that private blockchains will never scale, but also that a lot of actors out there do not really need a blockchain today and transactions are often done between a small amount of actors, they want to control all the nodes and access to data, and hence a blockchain is not really needed. The owners control the data and can easily amend it. Hence private blockchains do not have the value that public blockchains can bring. Cubic (Morpheus) mentions that the issue with private blockchains are the barriers to adoption, as the business model often is that they build, and the rest will come to the founders.

Lindman (UG) & Keogh (Shantalla) are more neutral in their opinions that we might need both public and private blockchain solutions, as at the current state, whether it is public or private blockchains, it does not really matter once it solves unique business cases. Lindman (UG) also mentions that the cost of public blockchains are expensive today, and it might be difficult to control and foresee the price action of the tokens, and therefore a lot of actors might want to have a private choice. Performance requirements on the current public blockchains might also be an issue as the lead times are too long.

# 6. Conclusions

*The last chapter presents the conclusion and answers the research question. Subsequent to the conclusions, implications, contribution, limitations, proposal for future research is presented.*

## 6.1. Conclusions

### 6.1.1. Motives and Challenges of Implementation for Blockchain Solutions in Supply Chains

This study has shown that more and more companies are onboarding and implementing blockchain solutions, and a lot of the respondents and academic articles believe that this will create the most significant changes in the supply chain ecosystem for a long time. It might be that the ones that are standing behind will be dissimilated, but in the overall picture, it seems that the majority of enterprises will eventually adopt and implement blockchain solutions. Blockchain as a technology is maturing and is a necessary technology today, well beyond the hype phase. It is a foundational technology that provides layers of trust. Digitalization and blockchain have accelerated significantly due to the COVID19 pandemic, which has shown severe vulnerabilities in the supply chains. Common motives to implement blockchain are enhancement of traceability as it takes out the friction, but also enhancement of trust. There are benefits in terms of regulatory and consumer stances. Support from the management is crucial for successful implementation, and the implementation should start internally and slowly be built out in the ecosystem. Right tools, services and consultation is needed when implementing blockchain. Although blockchain technology cannot operate alone, therefore it will be a part of the whole development of supply chains. It is still unclear if we will see major disruptions, but the test will be to see how many organisations will pick up blockchain solutions over the years and how big a slice of the digitalisation is blockchain, which is still unclear.

This study presents that enterprises should not be afraid of approaching blockchain solutions, as blockchain technology pulls existing technologies together to create a more beneficial solution. Nevertheless, it has been discovered that it is important that enterprises know what kind of issue they want to solve and how to apply specific blockchain solutions. It should only be done if it can create value, save money or if it is the only solution available. However, the majority of blockchain implementations nowadays do not actually need a blockchain and could be handled with a modified database for specific issues. The challenge is to get over the psychological burden that blockchain will solve everything, the wrong information reported by media, and that many resources are needed in terms of money and time. Lack of knowledge has been shown to be a big hurdle for adoption.

To solve the most critical challenges regarding implementation, the educational component needs to be evolved so that there is reliable information. However, in this industry, there are a lot of clarity issues, especially in terms of regulation and jurisdictions in different countries. A challenge is also to have actors facilitating and leading efforts, but also that often, the same type of blockchain system is needed so it can function. The tendency is that building blockchain infrastructure is complicated and that adoption is slow. Other challenges are the negative associations and hype around cryptocurrencies, where a lot of investors have lost money in the last couple of years. There is resistance in a lot of companies today to still adopt as activities in the supply chain are often done in the same manner for decades. There are therefore major opportunities for smaller public blockchain token-based teams to take market share. In some cases, there is sometimes not even a choice if you want to implement or not, as it is driven by bigger actors in the supply chains, and smaller enterprises then need to adapt.

A significant challenge is the interoperability issues where incumbent technology stacks need to be connected to the new generation stacks where blockchain belongs. It will take a lot of time, and the implementation challenge right now is how to bridge blockchains into traditional information systems. Smaller companies usually do not have a lot of financial resources and therefore reluctant to invest. However, provided solutions from token-based projects makes it possible to easier implement blockchain solutions. The key to success is interoperability and needs to be agnostic on a supply chain level. A solution demonstrated is using oracles or credible third-party providers to handle data and information safely. But sound systems can allow for high-quality data and enable push and pull of information, enabling traceability to a greater extent. It comes down to provide better access to data and drive better decision making.

There are many arguments regarding if private blockchains or public blockchains are the most suitable ones in the supply chains. Companies may feel safer with their data with a private blockchain, as it is protected by central parties. However, private blockchains are often seen as hinders to further adoption and implementation. It creates barriers as the actors who built it often want total control. Both are possibly needed today, and right now, it does not really matter as long as it solves the business case, but it seems that public blockchains will dominate in the future. Private blockchains might be welcoming, but there are demands, and costs can vary. However, the costs are high for public blockchains too, and they have poor performance requirements today as lead times are too long. A challenge with private blockchains is the power imbalance where supply chain partners may enforce over others. It is hard to know if there are

other ways for actors to authorise or modify the data in private. The majority seems to believe more in public blockchains, as the private ones will never scale. The data can never really be secure there, and it is not easy to get the same benefits as with public blockchains. Private blockchains can be used for some instance with few parties, but it is impossible to have authorities involved with private blockchains. Enterprises try out private blockchains first, but they are also more interested in joining public open-source projects as it gives the maximal level of decentralisation and no trust is needed to specific actors, but only to the protocol itself.

A lot of token-based projects are doing a fantastic job today, and enterprises are looking more into these public solutions. Projects often act as middle-layer that handle hand-off data between traditional systems and blockchain protocols. Token-based projects need to focus a lot on privacy laws and find capital, as it is challenging today due to the previous hype and craze having scared away investors. Interaction with token-based projects scares away many organisations as they are unsure if they will be partners or competitors. There are also challenges with token-based projects in terms of smart contract risks, application risks and failure in the code that can exploit information. Many think that tokens will play a vital role in the coming years as it has programmability features, but it comes down to how to scale the ecosystem and how to be compatible with other companies and teams. We do not have a complete ecosystem today, and no projects are seen as standards. Actors that implement token-based solutions also need to trust the token issuer and what the tokens really are used for. There is yet no fully implemented solutions regarding token-based blockchain solutions, and they have many challenges in regards to regulatory issues. It is also hard for enterprises to foresee price actions which can scare many away. There are although enterprise that tries to implement solutions, and it differs between the teams if tokens need to bought or not to utilize their services. All of the teams claim that they are best in their area and that the future looks bright.

Due to the immense power asymmetries in supply chains, blockchain can neutralise by giving smaller actors the ability to monetize on various aspects. There is a huge opportunity for tokenisation in supply chains, and people might in the future invest in tokens that give them specific rights and possibilities. However, market capitalisation valuation of tokens are fluctuating a lot, and it is still an unexplored area right now. Results show that tokenising data will accelerate in usage, and there are possibilities that NFTs will be the major thing in regards to tokenization, but also DeFi plays a central role where we are moving to a more decentralised world. Solutions need to be fully decentralised and open to bring on adoption.

There are major issues in the supply chains with reality feeds and oracle. A challenge is often how a digital representation is established and maintained in a secure way, as trust will always be needed since the entry point to the blockchain is weak. Organisations should therefore have independent parties or mechanisms with data points that are verifying the data. The data is currently in the solutions easy to tamper, and there is not a solution yet that can fix fraudulent data inserts into the blockchains. But blockchain technology can offer immutable lies, which is easy to track backwards. Solutions to fix this can also make inbuilt requirements or even execute DAOs, decentralised autonomous organisations, where smart contracts and IoT takes over, and smart contracts could replace human activity and guesswork. Sanctions are also possible to include if someone is caught due to audits and checks, but that is also tricky. The blockchain only verifies data. If humans and machines are involved, then nothing can be totally secure.

Standard bodies in the supply chains are also important as it takes out a significant amount of friction and can lead to automation and efficient processes faster. Those who do not follow standards are usually left behind. There are a couple of token-based projects that have aligned, but it is challenging to develop industry standards for blockchains. There are many initiatives which overwhelming for new participants. There are opportunities, but it is slow work, and standards for different kinds of information systems have been in work for decades, but nothing has yet been able to solve interoperability problems, and it is unlikely that it will be solved soon for blockchains either. Blockchains are constantly under development and upgrades, so no clear initiatives cover all the essential areas yet. The opportunities are there to take market shares by leveraging blockchain technology, and the future will be exciting to see where it all ends.

## 6.2. Contribution and Implications

This thesis is contributing with new insights in the area of implementation of blockchain solutions in supply chains, with a focus on token-based projects, interoperability issues and standards dilemmas. This study also makes a practical contribution to supply chain management for enterprises that are interested in and considering the implementation of blockchain technology. The study highlights different kinds of motives and challenges in a broad perspective in the supply chains. This study can also be used to search for interesting areas in the blockchain space to make a more robust research on. This study also enables further progress for authorities and enterprises, but also regulatory bodies who can conduct insights from experts, academia and from individuals working with token-based projects.

## 6.3. Limitations

There are some limitations identified in this thesis as the field of blockchain technology in connection to supply chains is relatively new, and therefore, there has not been a lot of research done previously. As the literature is limited, therefore a lot of weight was placed on the respondents that are experts in these area regarding blockchain technology and supply chains. The respondents came from different positions and could supplement the missing information sufficiently. There were also seven interviews due to the fact that there are not many individuals with expertise in this area, as more interviews could have provided some deeper insights. The current ongoing COVID19 pandemic also limited the possibility for face-to-face interviews and likely impacted the possible conduction of empirical data.

## 6.4. Future Research Suggestions

The rise of tokenisation will continue and make much impact on supply chains. Therefore a suggestion is to investigate the opportunities and challenges regarding tokenisation in a specific market segment. It could be agriculture, containerisation, retailing and so on. Leveraging proof of ownership in a digital way with the help of blockchain technology can create new business models and disrupt old infrastructures in place.

Another suggestion is to investigate the token-based projects in detail and see their value propositions, development paths, white papers and continued progress in the supply chain space. More and more token-based projects are getting partnerships with major authorities, and the on-ramp from the traditional systems to blockchain system with the help of tokens and public blockchains can bring new insights to the academic space.

The last suggestion is to research the relationship between decentralised finance and supply chains, especially trade finance. Decentralised finance provides unique possibilities to transfer transactions in efficient ways without intermediaries seamlessly. It also enhances the beneficial features that blockchain technologies provide. This area is barely researched today.

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# Appendix

## Appendix A: Invite Message for Interview (Email/LinkedIn)

Hi!

My name is Nermin Brkovic and I am a student from the School of Business, Economics and Law at the University of Gothenburg in Sweden, studying the MSc in Logistics and Transport Management. I am currently researching about the motives and challenges for blockchain solutions in supply chains. The focus is on operability, standards development, traceability and visibility, and token-based solutions.

I have previously conducted a research in this area regarding adoption and implementation of blockchain technology and cryptocurrencies in Swedish stock-listed companies, and also published an academic article about blockchain.

The reason why I am contacting you is to make an interview with you as you/your team seem to be very interesting and suitable for this topic. Information will be collected from several respondents that are suitable for this topic.

The discussion will cover general supply chain issues today, blockchain development in supply chains, and how you/your team/platform handle this. Focus will mostly be on adoption, implementation, operability, standards development, traceability and visibility, and token-based solutions. I want to raise awareness for these solutions in the academic fields. The interview will not be very technical.

Do you have the possibility to participate? Preferably between (date) to (date).

Thank you in advance!

Best regards,

# Appendix B: Interview Guide

- Could you give a short presentation about yourself and what kind of experience/knowledge you have in regards to blockchain and supply chains?

- What pros and cons is there with blockchain technology in supply chains?
- Provenance, trust, transparency, traceability and immutability is often connected to blockchains in supply chains. How does blockchain-based projects work with this?

- What is the perceived usefulness of having a blockchain containing details of the assets and ability to track an asset throughout the supply chains? Thoughts in regards to transparency and visibility?

- What resources and capabilities are needed to implement blockchain in the supply chains? In regards to have transparency, traceability, audibility, trust etc.
- What requirements do you see as necessary to integrate blockchain technology into today's supply chains?

- What do you believe would be, or are some challenges to implement blockchain solutions that teams/projects developed in the supply chains today?
- How do you believe that blockchain will transform collaboration and relationship in the supply chains?

- Why do companies/token-based teams use blockchain and not something else?

- How do you link the physical asset with a digital representation?
- Is tokenizing physical assets and using blockchain  a way to track how it move throughout the supply chain? How does that work exactly?
- Do you think tokenization will be adopted more and grow in importance?

- What are the opportunities for enterprises or organisations of applying blockchains, specifically public and token-based in the supply chain industry today?

- How is the future looking for token-based projects?

- Are the interoperability questions important? In today's IT systems or other blockchains? What do you need to focus on? How to reach partners/deals?
- What are the major interoperability issues?

- What are the challenges/barriers for organisations of applying public blockchains or token-based solutions in the supply chain industry?
- What challenges are most problematic? In which context?

- What would you say are the biggest implementation challenges right now?
- What is the aim to solve them? Solutions? Across current systems or even across different blockchains?

- Why not build on a private permissioned blockchain?
- Why build on public permission-less blockchain?
- How would you say that specific public solutions differ from private based blockchains?
- What are the benefits of choosing public? Are there some things that are better with private blockchain based solutions?

- How is the work done in regards to industry standards? For example ISO, or GS1 standards related to the supply chain industry? Partnerships? Implementations?
- What are the main challenges or motives in regards to standards development?

- What influences do you see in the implementation of blockchain technologies?

- What kind of resistance do you see from companies who are used to do business in a certain way, and you ask them to take on blockchain solutions?
- Are companies resistant to change?
- What is the biggest implementation challenge for adoption today?
- Why would supply chain focused enterprises let smaller startups handle their data on a public blockchain?

- To what extent is it possible to maintain relationships with other companies if they do not implement blockchain technology?

- How do you work with the garbage-in, garbage-out data, for example if supplier put in wrong information to the blockchain?
- Are there any solutions to fix this?

- Could you explain the tokenomics and token distribution?
- What is the utility of a token/cryptocurrency?
- Is it fair, risks of centralization with too much power in teams holding?
- Contribution of enterprises/teams to platforms?
- How are they rewarded? Are they rewarded for choosing you in some way?
- What are the rights of a token holder?

- Do you think blockchain technology will revolutionize the supply chain industry?
- Is blockchain in a hype phase or necessary today?

- Finally, do you have any final thoughts you would like to add?