The Role of Blockchain in Commodity Trading

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Abstract

The commodity industry, the transaction lifecycle of commodities, its value chain and supply chain are complex systems with many parties involved. Ownership of cargoes are determined by who is holding the physical paper, the Bill of Lading. The participants in the industry require constant verification between parties, and this results in cumbersome paper-heavy back-office operations which are exposed to human errors.

The entire commodity transaction life-cycle involves the value chain and supply chain, and it creates a complicated and long chain involving several intermediaries, each taking a piece of the pie and adds to transaction costs for producers. The roles of intermediaries in the commodity industry can be financing trades, facilitating trade, managing risk, on-site inspection and verification of cargoes, shipping, and logistics.

Blockchain technology is the technology underlying bitcoins and most of the cryptocurrencies in existence. Bitcoin enabled people to transfer money, peer-to-peer without an intermediary to establish trust and facilitate transactions. Bitcoin has paved the way for further use-cases of the technology, which has a much broader use-case spectrum than just being the underlying technology of cryptocurrencies.

Blockchain is a decentralized, distributed ledger, where transactions are stored in blocks and secured with cryptography. It allows anyone to execute trade without an intermediary to establish trust between parties. It allows for one single source of the truth between counterparties through enhancing transparency, visibility and availability of transactions data and information.

Blockchains can be fully transparent, but a blockchain can also allow for privacy. There are different types of blockchain, public/private/hybrid, and each of these types serves its purpose a little bit differently. In a private or hybrid blockchain, information that is sensitive to a certain trade remains private by only allowing the counterparties of that trade transparency into the transactions of that certain trade.

The blockchain technology enhances cyber security through decentralization and cryptography. Digital tokens can replace the Bill of Lading to track ownership of cargoes. Smart contracts that self-execute triggered upon a set of predetermined conditions are among the features of blockchain technology. The convenience of blockchain technology, is that anyone at any time

can build its own decentralized application on top of already existing blockchain platforms like Ethereum, Hyperledger and others. These factors create for a unique opportunity to digitalize the commodity industry, gaining security, efficiency and opening up possibilities for new trade models in trade finance.

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1 Introduction

Blockchain technology is something most people associate with cryptocurrencies like bitcoins. This is not wrong, but blockchain technology has vast potential outside just being the backbone of a currency. In this thesis, the author will focus on blockchain in physical commodity trading between companies.

In early November 2017, it was announced that Equinor: at that time Statoil, were entering into a consortium. Together with other energy companies, banks and trading houses, these are; BP, Shell, ABN Amro, ING, Societe Generale, Gunvor, Koch Supply & Trading, and Mercuria. This consortium is building blockchain software that will enable them to trade commodities more effectively between businesses. The product of this consortium is an independent company owned equally between the nine consortium members and is named VAKT. “By applying new technology, we can have a more efficient process and use more of our operators’ and deal handlers’ time on value adding activities,” Redwan Zeroual, Equinor’s project leader in this new venture (Equinor, 2017).

Blockchain in commodity trading is in its very early stages. It would be impossible to write a thesis that examined actual results, because there exists only a couple of actual real-life results from using blockchain technology in commodity trading. Therefore, when exploring the potential of blockchain implementation in commodity trading, this thesis will take on a qualitative approach, based upon the physical commodity trading industry in general. However, the thesis will try to go more in-depth by applying the case study approach to the consortium-company VAKT. The case-study will be based upon expert interviews and public announcements regarding this consortium and VAKT.

1.1 Background of the thesis

The author had little to none knowledge about blockchain prior to writing this thesis, but it sounded very interesting. In collaboration with the author's supervisor a couple of different approaches to blockchain were discussed.

- A general approach, i.e. what blockchain is, how it works and what it can do is well covered in terms of studies, talks, articles. This would also imply a more technical approach than an economic one.
- Compare different industries and their interest, investment and potential in terms of blockchain technology.
- How blockchain can influence the supply-chain in certain industries
- Take base in a company or group/consortium were blockchain was the key element in a project

After some initial research the author decided to focus on the potential of blockchain technology in the physical commodity trading industry in general and to apply the case study approach to the consortium company VAKT that had recently been created, building a blockchain platform that was going to target the entire commodity transaction life-cycle, existing of Energy giants; Equinor, BP, Shell, banks and trading houses.

1.2 Purpose of the thesis

In recent years blockchain has been on many technologist's and economist's minds. There are tons of literature about blockchain in general and an increasing number of businesses are looking at ways to implement blockchain into their business-models. Most of the literature is concerned about the basics of blockchain and the technology aspect. What it is, how it works, cryptography, coding, its potential use-cases etc. In the last couple of years there has also been published a great deal of more specific literature concerning blockchains potential in different industries and among them are the physical commodity trading industry.

The purpose of this thesis is to identify the problems and challenges in the commodity transaction life-cycle today and what solutions blockchain can provide to these problems and challenges. What will happen to intermediaries and transaction cost? What are the underlying reasons that companies like Equinor and the rest of the consortium is putting their resources into development of blockchain software to cover the entire transaction life-cycle of crude oil and natural gas.

1.3 Introduction to the transaction life-cycle, the value and supply chain

The commodity transaction life-cycle incorporates the value and the supply chain, and today these are long and complex. The process of commodities going from raw materials to finished products involves many intermediaries and the roles of these intermediaries are; financing of trade, facilitating trade, insurance and risk management, inspection, certification, verification, shipping, and logistics. The level of involvement for commodity suppliers in the value and supply-chain varies from company to company and it also varies across the different types of commodities. There will always be intermediaries involved in a commodity trade, even though the number of intermediaries may vary.

1.3.1 The value chain

Value chains are complex systems, used to describe activities that different actors within an industry performs in the time between raw materials are mined/harvested/produced and until it is sold to consumers (Amarender A, 2013). The idea of the value chain is to illustrate how different actors adds value by a process that can involve any sort of resource; money, labor, materials, equipment, administration and management. The way value chain activities are performed determines transaction costs. Some key challenges within the value chain are sharing information between systems, unsynchronized payments and deliveries, and auditing (Dütsch & Steinecke, 2017).

Economist and author of "Competitive Advantage: Creating and Sustaining Superior Performance" Michael E. Porter identifies five primary activities in the value chain and four secondary activities. The primary activities are all important in adding value to a product or service and creating a competitive advantage. The secondary activities help the progress of the primary activities.

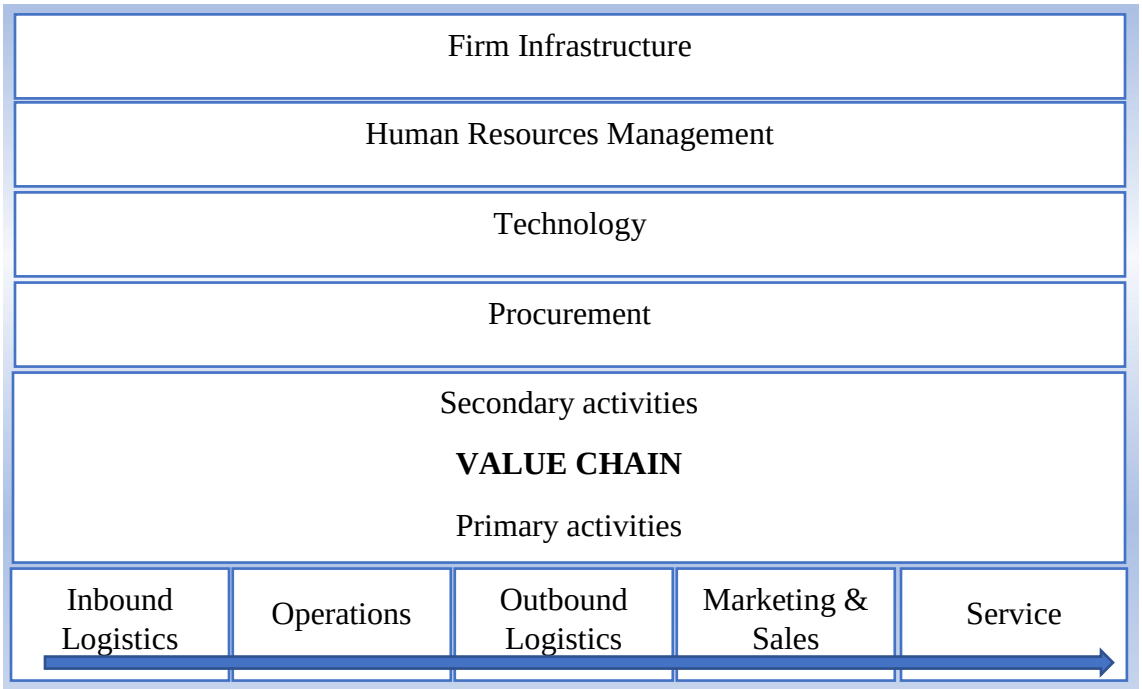

Figure 1 – Porters value chain

1.3.2 The supply chain

Supply chains illustrates a set of market-based transactions that include every business that takes part in getting a product or service to market. Currently, each party in the supply chain purchases goods, adds value and sells these goods to the next actor in the chain (Dütsch & Steinecke, 2017). The management of supply chain is very important as its main function is to optimize the balance of being highly efficient and adhering to cost reduction strategies (Perepa, 2014). The design and function of the supply chain depends on the commodity in question, but references indicate that a general five-step supply chain model across the various commodities looks like this;

Figure 2 - A simplified and general illustration of a supply chain

The commodity transaction life-cycle incorporates both the value chain and the supply chain. The value chain describes a set of product-based activities and it is broader than the supply chain. The supply chain describes a link of market-based transactions, and the supply chain is one specific part of the value chain. What they have in common is that the fundamentals of both chains are based on trust between parties. Today this trust is gained by independent third parties (intermediaries).

1.4 Introduction to Blockchain

In 2018, it is safe to say that even though the amount of people with a basic understanding of what blockchain is, are increasing. The majority of people who hears the word “Blockchain” will either have no clue, or immediately associate it with bitcoins. While there is nothing wrong with this association, it is important to know that even though bitcoins are blockchain, blockchain is not necessarily bitcoins. “Blockchain is to bitcoin, what the internet is to email. A big electronic system, on top of which you can build applications. Currency is just one” (Sally Davies, FT Technology Reporter)

Blockchain is a “Digital Ledger Technology” (DLT), and DLT is the technology underlying all cryptocurrency including bitcoins. To this date, blockchain is the DLT that has had the most attention, but there are many other DLTs, some examples are; Block lattice, IOTA tangle, and Radix, but this thesis will not go further into these

The quote by Sally Davies can be applied to explain the relationship between Blockchain and DLT. “Blockchain is to DLT like the Bitcoin is to Blockchain”. The distributed ledger is the very basic principle of the technology, and this principle can be achieved through different approaches.

To sum it up; bitcoin is one application of blockchain technology, it is currently the biggest cryptocurrency and has had the most attention out of all the blockchain applications in the world today. Blockchain is one approach to distributed ledger technology, and it is to date the DLT that has had the most attention.

1.4.1 What is blockchain and what is blockchain taking care of?

Blockchain is an incorruptible, decentralized, digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value (Tapscott, 2016).

Today, people and companies rely entirely on centralized intermediaries to establish trust between parties. It does work, the intermediaries are essentially doing a good job, but there are problems (Tapscott, 2016).

- The intermediaries are taking high fees for doing what they do, adding to transaction cost and slimming down the margins of businesses.
- Work done by humans will always be exposed to human errors.
- Cyberattacks, or hacking is a growing problem and centralized databases will always be at risk, no matter how much security.
- It can potentially take a long time for value to be transferred from one party to another. Especially for cross-border transactions.

The theory about blockchain says that it is trying to solve all these problems. The idea is that by using blockchain, - a decentralized, distributed ledger secured with cryptography, the need for an independent intermediary to establish trust is gone. By being decentralized and distributed it is far less exposed to cyberattacks. A blockchain is less exposed to human errors by clever coding of smart contracts and constant consensus between the nodes on the blockchain, and transactions on a blockchain happens in near real-time.

In 2009 an unknown person or group under the pseudonym “Satoshi Nakamoto” launched the first ever application of blockchain, the Bitcoin. Bitcoins enabled people to transfer digital currency without third parties (Acheson, 2018b). There are many problems with bitcoin though, such as the amount of computing power it takes for miners to verify the transactions and also substantial fees on transactions. Bitcoins are also very volatile. Taking into consideration all of these key problems, one can assume that bitcoins will never be a dominating, mainstream currency. But what bitcoin has done, is to pave the way for other currency and applications by showing that the technology works (Fiorillo, 2018).

1.4.2 How does a blockchain work?

People will instinctively not trust one another when it comes to trading. The whole point of using a blockchain is to let people share valuable data in a secure, tamperproof way (Orcutt, 2018). To achieve the required security for this trust to happen without the need of an independent intermediary. Blockchains use a proof-of-work mechanism, cryptography, the ledger of transactions is distributed, and the system is decentralized (Acheson, 2018b).

Proof-of-work and Cryptography

Blockchain uses a mechanism called proof-of-work. The bitcoin blockchain is a great example to illustrate how this works. Every time a transaction is submitted to the ledger it needs to be verified, and the process of verifying is called mining. This is done by computers, solving advanced mathematical problems. The proof-of-work requires coding, all the transactions that are verified gets its own unique hash. A hash is basically a digital cryptographic fingerprint, which is unique for every block of data. The blocks are then linked together in a chain, hence blockchain. Each block contains transaction data, its own hash, and the hash of the previous block. The incentive for verifying (mining), is that in the process of mining, you create new bitcoin, and these belongs to the miner (Acheson, 2018a).

The ledger is distributed

Blockchain is a distributed ledger. The ledger is consensually shared, and the data is stored in multiple copies on a network of computers, these are called “nodes”. Each time someone submits a transaction to the ledger, the nodes check to make sure the transaction is valid. The transaction would only be verified and added to the blockchain if all the nodes agree on its validity (CoinDesk, 2018b). If someone would try to tamper with a transaction, this would be visible to all the nodes on the network in a matter of seconds. As a consequence of a hash in a block changing, the hash of all the previous blocks in the chain would also change. This makes it easy to spot and reject.

Decentralized

A blockchain is not run from the same place, but on every node that is a part of the blockchain. This means that a blockchain has no single point of failure and this makes it an infinite time more secure versus cyberattacks. A hacker would not only have to hack into one single database but on every computer-node that is a part of the blockchain at the same time, which is practically impossible.

1.4.3 Types of blockchains

There are three types of blockchain or three blockchain categories if you will, and these are:

Public Blockchains

Public blockchains allow access to their full functionality to anyone who wants to become part of the network. They are likely to be used by many actors (Dütsch & Steinecke, 2017). Which again leads to a greater level of decentralization as the participants on a blockchain increases. Public blockchains are great when full transparency is great. Everyone on a public blockchain can observe transactions - there is no privacy. Bitcoin and other cryptocurrencies are run on public blockchains.

Private Blockchains

In a fully private blockchain, write permissions are centralized to one party and read permissions may be public or private. Rules can be easily changed, and transactions reverted, validators are known, and transactions are cheaper (Dütsch & Steinecke, 2017). A private blockchain is not really decentralized, but rather a distributed ledger where transactions are stored in blocks and encrypted.

Hybrid Blockchains

A definition given by Vitalik Buterin, the co-founder of Ethereum and creator of Bitcoin magazine sounds like this “So far there has been little emphasis on the distinction between consortium blockchains and fully private blockchains, although it is important: the former provides a hybrid between the “low-trust” provided by public blockchains and the “single highly-trusted entity” model of private blockchains, whereas the latter can be more accurately described as a traditional centralized system with a degree of cryptographic auditability attached “ (Buterin, 2015).

A hybrid platform provides many of the same benefits affiliated with private blockchain – efficiency and transaction privacy. They operate under the leadership of a group instead of a single entity which makes them somewhat decentralized, and this type of blockchain is great for organizational collaboration.

1.4.4 Blockchain use-cases

In recent years, many has started to explore blockchain in all different kinds of industry. Blockchain technology has already come a far way and moved on from just being the underlying technology of cryptocurrencies. The table below is a list of industries and sectors where certain companies, institutions and start-ups have already implemented blockchain or is planning to implement blockchain.

Financial services	Asset management: Trade processing and settlement Insurance: claims processing • Peer-to-peer flight insurance policies • Micro insurance Cross border payments Anti-money laundering
Energy, Utilities & Mining	Smart utility metering system Decentralized energy data platform
Healthcare	Storage of healthcare records Population health and clinical studies
Entertainment & Media	Control of ownership rights of digital media Disintermediation of record labels, streaming sites and music streaming platforms
Government	Public value / community Land ownership Tamper-proof voting records Vested Responsibility Digital identity of citizens • Passports • Birth, wedding, and death certificates • Personal identification •
Transportation & Logistics	Freight transport • Trade documentation (e.g. Bill of Lading) • Trade finance • Supply chain transparency Aviation • Distribution of tickets and ancillary services • Loyalty programs • Passenger identity management

Table 1 - List of blockchain use-cases (Dütsch & Steinecke, 2017)

Table 1 does not cover every blockchain-project out there and the author will not go further into details about any of the blockchain use-cases that is not relevant to the thesis. Table 1 is meant to illustrate the broad spectrum of use-cases that is being explored in the world today. Applications of blockchain technology use the different types of blockchain, depending on the business requirements.

The main source of data for table 1 is (Dütsch & Steinecke, 2017). The secondary source of data used to create this table is the authors own experiences reading and learning about blockchain use-cases.

1.5 Research questions

In the process of formulating the research questions, it was important to make sure that the underlying aspects of the research questions were of the business, economic and strategic nature, rather than informational technology.

The two research questions for this thesis is listed below. These are created with the objective to gain and provide insight and understanding to some of the business/economic/strategic effects blockchain can have on physical commodity trading between companies.

Literature on blockchain promises to eliminate the need for intermediaries to establish trust and facilitate trade between parties, and as a consequence of this, reduced transaction costs. The consortium company VAKT that were briefly presented in the very first chapter, is creating a blockchain platform that will incorporate the entire transaction life-cycle for crude oil and natural gas trading, with these objectives in mind, and in light of the literature on blockchain, the questions to be studied are:

1. What are the characteristic problems and challenges in commodity trading today?
    - What are the underlying reasons that makes Equinor and others to put their resources into blockchain?
    - Which intermediaries will be redundant if blockchain proves to be successful in commodity trading?

2. Which transaction costs can be eliminated for a commodity supplier, by implementing blockchain technology in physical commodity trading between businesses?

1.6 Structure of the thesis

Chapter 1 is an introduction to the thesis; this chapter tries to paint a picture of the background and purpose of the thesis. The chapter will try to explain what blockchain is, what it does, how it works, different types of blockchain, and it's use cases. The author has tried to be as comprehensive as possible without making the introduction too long, with the goal in mind that anyone without any prerequisite knowledge about blockchain can read and understand the thesis. The introduction chapter will end with a presentation of the research questions.

In the second chapter, the foundation for the thesis will be presented, starting off by describing the physical commodity trading industry, the transaction life-cycle, the value and supply chain, and explaining the problems and challenges within the these. This chapter will create the basis for chapter 3, which contains the theoretical framework; blockchain connected to the problems and challenges described in chapter 2, together with other relevant theory that will help to make an analysis and provide answers to the research questions

Chapter 4 describes the methodological approach that has been performed in order to answer the research questions. Empirical data, expert interviews and a single case-study. Chapter 5 presents the case study of the consortium company VAKT, where Equinor is one of nine members in the consortium that is equally owning the blockchain based company. VAKT are creating a blockchain platform for physical commodity trading between businesses that will incorporate the entire commodity transaction life-cycle. Chapter 6 is the analysis chapter which will end by providing answers to the research questions and a short discussion about implications for further research. Chapter 7, the last chapter; a conclusion will be the ending of the thesis.

2 The foundation for the thesis

This chapter will create the foundation for the thesis by describing the problems and challenges throughout the commodity transaction life-cycle.

2.1 Problems and challenges in the commodity transaction life-cycle

The terms value chain, supply chain, commodity transaction life-cycles are often used in the same settings in literature about commodity trading. The way the author understands these terms is that the value chain covers a wider range of activity than the supply chain, but that the supply chain is a big part of the value chain. The commodity transaction life cycle speaks for itself, it is the entire cycle of transactions that is related to commodities and commodity trading. The relationship between the transaction life-cycle, the value chain and the supply chain are illustrated in the figure below. The transaction life-cycle incorporates the value and supply chain, and it starts even before commodities are mined/harvested/produced, because for some commodities, like for example oil, gas and precious metals, one would first have to find and discover them.

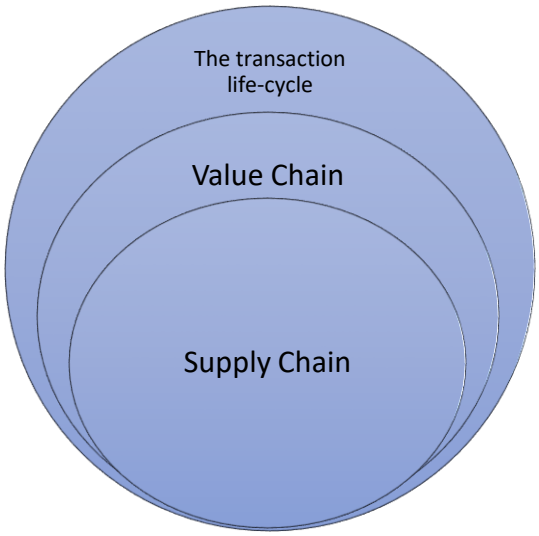

Figure 3 - The relationship between the transaction life-cycle, the value chain and the supply chain

2.1.1 The commodity transaction life-cycle

The commodity transaction life-cycle incorporates the value and supply chain and the function of the commodity transaction life-cycle is to describe what in between the commodities moving from sourcing/origination(production), to consumers. This may sound easy and uncomplicated, but the commodity transaction life-cycle is long and complex, it involves many different actors to bring the commodities from producer to consumer. [According to Porter (1985)] In the value chain, value gets added to the product by different actors utilizing resources like; money, labor, materials, equipment, administration and management. The supply chain illustrates a set of market-based transactions that include every business that takes part in getting a product or service to market by balancing efficiency and cost reduction strategies (Perepa, 2014).

The commodity trading industry is a very diverse industry. Trades can range from small local operations, to trades between huge multinational companies. The products are as diverse as coffee, grain, sugar, cotton, oil, natural gas, precious metals and more. Information is the glue that holds value chains together, and it used to be proprietary, at least to some degree, in commodity trading. Increasingly, however, information is becoming available broadly, in real time and at lower cost, reducing the competitive advantage that incumbents used to gain through access to superior information (Belt & Boudier, 2017). The transaction life-cycle, the value and supply chain, also consists of several intermediaries offering services. Such as trade finance, facilitating trade, insurance and risk management, on-site inspection, verification, certification, shipping, and logistics. The commodity trading industry is a volume business, and the margins tends to be slim due to so any actors participating and each actor taking a piece of the pie.

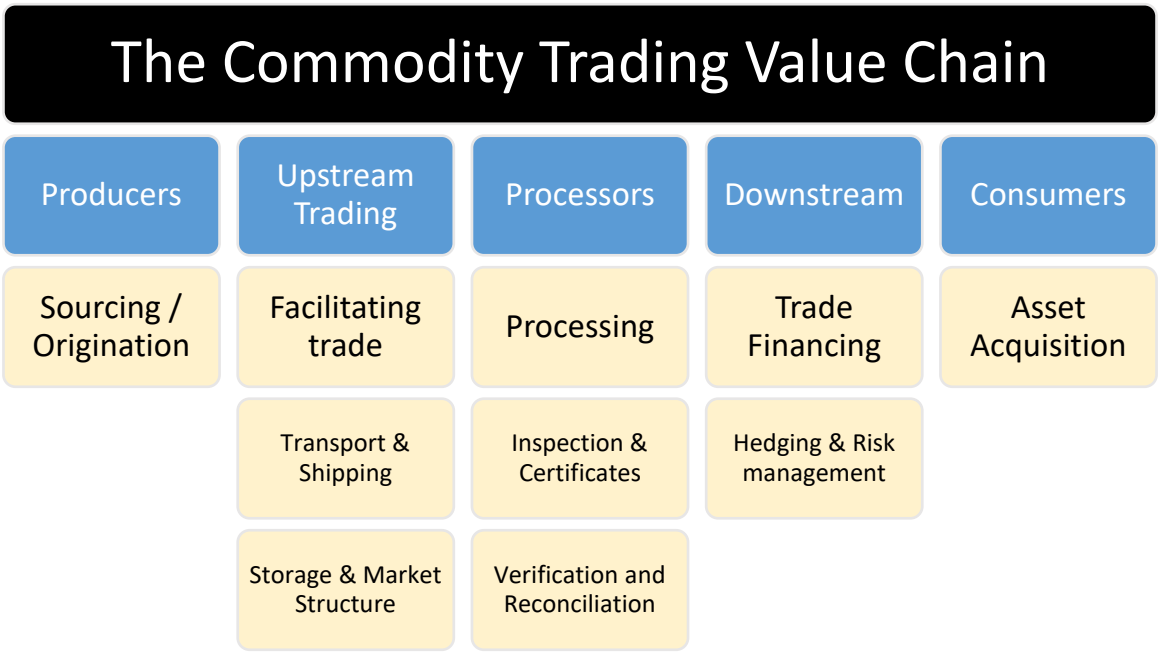

Figure 4 - The commodity trading value chain

Producers

Upstream oil (exploration and production), coal mines, upstream gas, ore mines, soft commodity producers.

- *Sourcing / origination*: In origination, it requires the physical presence of both buyers and sellers. It consists of the purchase, sometimes the production, or cooperating in the production of commodities. The job of the originator is to extend the reach of the trading desk (STSA, 2017).

Upstream Trading

Integrated traders, large independent traders, integrated agriculture focus, midsize and small niche traders.

- *Facilitating trade:* To establish trust required for purchase and sale. Counterparties needs an independent intermediary to help out with facilitating the trade, this can involve broker relationships, price discovery system, centralized trading platforms to show bid and offer

information, organizing of transport and management of risk (Reitman, Radcliffe, & Reitman, 2018).

- *Transport and shipping*: Commodity trading being the volume business as it is, transportation is typically accomplished by ships: tankers, bulk carriers or containers. Ships can be chartered, or shipping can be done using container lines (STSA, 2017). Some commodity suppliers are taking care of their own transport and shipping, but it is typically done by an intermediary.
- *Storage and market* structure: Traders can transform the commodities in time by storing them – purchasing them now and keeping them for future sale or delivery. Therefore, they own or operate storage facilities, tanks, and sometimes going as far as chartering ships for floating storage (STSA, 2017). This is determined by market structure.
    - Contango; the futures price is greater than the current(spot) price. It pays to purchase, store and sell at a future date.
    - Backwardation; the futures prices is lower than the spot price. It pays to sell now.

Processors

Integrated refiners, independent refiners, trading refiners, gas fractionation, coal washing, metal smelters, milling/grinding for soft commodities.

- *Processing*: Traders can transform commodities in form by processing them: this is necessary for some commodities (STSA, 2017).
- *Inspection &* Certification: Modern commodity trading requires that quality and nature of goods remain constant and known always. To this end, traders employ inspection companies which assess and test cargos at ports (STSA, 2017).

Downstream

Integrated Traders, large independent traders, integrated agriculture focus, midsize and niche traders.

- *Trade financing*: Most of the time, because of the low margin – high volume nature of the commodity industry, commodity traders are often highly levered, and trades needs to be

financed. Commonly, letters of credit with security and guarantees from banks are used for these transactions (Dütsch & Steinecke, 2017).

- *Hedging and risk management*: Often performed by trading houses, hedging against currency risk and price risk. This is often done by purchasing option contracts for the underlying commodities.
- *Verification and reconciliation*: This is often called back office operations, transfer of ownership needs to be verified, and payments needs reconciliation between counterparties. These processes are often duplicative, tiresome and very paper-heavy.

Consumers

Power companies, petrochemical firms, downstream oil firms, industry, retail.

The primary sources for describing the commodity transaction life-cycle is (DeBlanc & Carter, 2015), and (STSA, 2017).

Traditionally, commodity traders have created value by applying three primary tools to build advantage: access to superior information, control of critical assets, and superior trading capabilities, which stem, in part, from strong IT systems and agile and entrepreneurial traders and trading teams (Belt & Boudier, 2017).

2.1.2 Tracking ownership of cargoes

Raw materials are called commodities, but when they are loaded onto a ship or other form for transportation it becomes a cargo. The related transfers of ownership are often still recorded on paper and fraud remains a persistent risk (Dütsch & Steinecke, 2017).

According to analysis done by Bloomberg, a cargo of crude oil can be worth more than $122 million and $2.7 billion worth of crude oil are traded daily (Vinn & Blewitt, 2018). The ownership of these cargoes is determined by who is holding the physical paper, the Bill of Lading.

The Bill of Lading is a legal document that contains details about the cargo, and it also serves the purpose as a receipt when the carrier delivers the goods at the predetermined destination. The Bill of Lading is signed after the cargo is loaded by two representatives, one from the supplier and one from the transporter. When arriving at the destination the Bill of Lading again has to be signed by a representative from the receiving party and the transporter.

The very basic, main reason for this system, is that if party A buys a cargo from party B, then A wants to be completely sure that B does not sell this cargo to anyone else either by accident or on purpose. The Bill of Lading that verifies ownership of commodities has been, and still is the most important part of the oil transaction (Paraskova, 2018).

The second reason to why the ownership of commodities is tracked by a physical paper contract is that one must be completely sure about who owns the commodity and where it is. Certain financial instruments sole value relies on representing an underlying physical asset. This value disappears if details about the underlying physical asset is unclear. Without complete trust that the commodity exists in its given location, the financial instrument loses value – and investors lose their money (Gutgutia, 2018).

2.1.3 Cumbersome, paperwork-heavy, back-office operations

Currently, "The way we do our title transfers and post trade execution is very heavy on paperwork," Alistair Cross, global head of operations at Mercuria Energy Group, told Bloomberg. "And the paperwork hasn't really evolved over the last couple of hundred years" (Vinn & Blewitt, 2018). There is a lot of paperwork that goes around in a commodity trade, and this consists of both physical paper and pdf-files today. Every party in the chain needs constant verification of consensus with one another, and the individual parties often comes across different type of information tracking systems. This creates challenges regarding the optimization of the shipment process (Dütsch & Steinecke, 2017).

Dütsch and Steinecke's publication "Use cases for Blockchain Technology in Energy & Commodity Trading", says that the key challenges Stratumn, (an insurance company) identifies are sharing information between systems, unsynchronized payments and deliveries, and auditing (Dütsch & Steinecke, 2017).

The counterparties must constantly reconcile and verify transaction data between execution and settlement of a transaction, this involves processes such as deal validation, risk management and compliance monitoring, as well as external-facing processes such as confirmation, trade reconciliation, chain of custody documentation and settlement (EY, 2017). The counterparties must also, through the transaction life-cycle interact with several intermediaries such as; exchanges, brokers, logistics providers, banks, regulators and price reporters (EY, 2017). In addition to a company having to deal with different systems for tracking information, at the same time the company must maintain their own internal systems.

The entirety of all the required consensus between parties, the verification and the tracking of ownership of cargos across different systems and reconciliation of payments results in a very cumbersome process. It is working, and it has been working for a very long time. On the other hand, it has massive potential for efficiency improvements in the digital world we live in today.

2.1.4 Human errors in decision-making and business

Work done by humans will always be exposed to human errors, no matter how much skill or experience a person has.

Human errors range from simple "Fat-finger errors" where a person miss-clicks a button right next to the button he was supposed to push, to catastrophic consequences of reckless behavior. With "Human errors" the author is not referring to people doing bad work, or not having enough skill or qualification to do a job. Errors in form of slips/mistakes, bad information or psychological errors. To illustrate some different types of human errors, the author has identified three categories of human errors and some examples within each category are listed in the table below.

Mistakes	**Information**	**Psychological**
• "Fat-finger errors" • Exhaustion / fatigue	• Misguided information • Poor communication • Lack of knowledge	• Confirmation bias – seeking information that confirms your initial thoughts or views • Availability heuristic – putting more weight to information that "comes easy to mind"

Table 2 - Categories & Examples of Human Errors

2.1.5 Intermediaries in the commodity industry

An intermediary, third-party, central authority or middleman are all the same thing. The life-cycle's persistent bottleneck is its dependence on intermediaries (Delloite, 2016). The author has identified seven roles that is often or always performed by intermediaries in the commodity trading transaction life-cycle. These are; trade finance, facilitating of trade, insurance and risk management, on-site inspection, certification, shipping and logistics.

Many producers are found in remote locations, often in emerging economies. Traders need to deliver commodities to consumption centers on the other side of the world. Commodity trading firms rely on efficient logistics and shipping to transport commodities cost-effectively (Trafigura, 2018).

The inspection and certification process are often performed by an intermediary independent from the trade, trusted by both seller and buyer. The inspection process consists of on-site quantitative and qualitative verification of traded goods or cargoes (STSA, 2017). Inspection take place at numerous points of the supply-chain, from production to consumption. Certificates are used, as a basis for the payment of the goods (STSA, 2017). The amount of inspection and certification needed is different across different commodities, some commodities have a wider range of quality than others.

Banks and trading houses play an important role in the commodity value chain today. The banks and trading houses play three key roles in the commodity trading value chain.

1. ***Facilitating trade:*** Trusted by both seller and buyer, helping to organize the trade.
2. ***Trade finance***: Letters of credit, payment processing, syndicated loans, capital rising.
3. ***Insurance and risk management***: Hedging for currency, commodity prices, supply/demand shocks

2.1.6 Transaction cost

Transaction costs represents the time and labor required to bring a good or a service to market, these costs can for a commodity supplier be both internal and external, external in form of intermediaries performing services. Transaction costs consist thus of the efforts devoted to finding a market, negotiating, signing a contract, controlling contract compliance, switching costs in case of premature termination of the contract, and any lost opportunities (Eaton, Meijerink, & Bijman, 2008).

Eaton, Meijerink, and Bijman goes on by describing in general three types of transaction costs related to commercial exchange: search and information costs, bargaining and decision costs, and supervision and enforcement costs (Eaton, Meijerink, & Bijman, 2008).

Building on Eaton, Meijerink, and Bijman three categories of transaction costs, some examples of transaction costs in the commodity trading industry for a commodity supplier will be presented in the table below.

Search and information costs	Cost of travel, cost of communication between parties, consulting cost, costs associated with trade financing / letter of credit
Bargaining and decision costs	Costs associated with credit checks, licensing fees, insurance costs, storage costs, transport costs, costs associated with payment, risk mitigation costs
Supervision and enforcement costs	Auditing cost, costs associated with inspection/certification/verification/reconciliation, legal costs, costs associated with the Bill of Lading.

Table 3 - Potential transaction costs for a commodity supplier

The transaction cost for a commodity supplier can be substantial, specially within inefficient systems. These costs diminish returns and eats away at the margins for commodity suppliers. When transaction costs diminish, an economy becomes more efficient.

3 Theoretical foundation

In this chapter, the author will present literature on blockchain that is relevant to the problems and challenges presented in the previous chapter. The chapter will also present some key aspects and features of blockchain technology that is important when we talk about blockchains role in the commodity industry. This will create the theoretical foundation that will in addition to the case study in chapter 5, be the basis of the analysis chapter.

3.1 Blockchain in the physical commodity transaction life-cycle

Through the application of blockchain technology there is opportunity to streamline internal processes and processes shared with external market participants (EY, 2017). The foundation for all trade is trust, and trust has up until today been created by independent intermediaries. Blockchain promises to create trust between parties without a central authority, and the way blockchain achieves this is done by two features.

Proof-of-work & Cryptography: The author has covered this previously in the thesis, but in short: securing the transactions in blocks using cryptography, and every block being chained together. Each block containing its own cryptographic hash, which works like a digital fingerprint and the previous blocks cryptographic hash. Makes the blockchain immutable and tamper-proof.

Transparency: On a public blockchain, every participant can read the ledger and the transparency is complete. On a private or consortium blockchain, every involved party can view the transaction which create transparency among the those who needs transparency in order to trust one another. The key though, is that it also assures privacy, participants on the blockchain not directly involved in the trade will not have the opportunity to view the transaction.

The benefits of parties being able to trust one another without the need of an independent intermediary are removal of the need for a broker relationship, centralized exchanges, price discovery systems, because the seller is able to directly communicate with the buyers and see actual prices at which the buyer is willing to buy and because the seller and purchaser are able to enter into the transaction directly with each other (Reitman, Radcliffe, & Reitman, 2018). Removal of intermediaries also has the potential to reduce complexity (e.g. multiple reconciliations) (Dütsch & Steinecke, 2017).

3.1.1 Blockchain - Tracking ownership of cargoes

When a shipment sits in on a barge or vessel for a month or in a factory for a year, its ownership can change multiple times. The same would apply to barrels of oil or bags of coffee (Goldberg, 2017). This means that the physical paper "Bill of Lading" can potentially be sent around and change ownership several times, without the commodities even moving or being of any use. There is nothing wrong with commodities being stored and changing ownership, but the process of sending the Bill of Lading is paperwork heavy, time consuming and costly.

A blockchain solution for the tracking of physical commodities along the supply chain addresses the key challenges and can reduce costs significantly (Dütsch & Steinecke, 2017). Digital blockchain tokens can be used to track the ownership of a cargo.

Blockchain technology enables market participants to track a product through its entire lifecycle. RFID tags, IoT sensors, and barcodes are already widely used across commodity supply chains (Eka, 2017). All these tracking devices can be coded to work together with a smart contract, a key feature of blockchain technology, and blockchain tokens to represent ownership of cargoes gives the commodity industry the possibility of tracking products through every step of the chain without sending and waiting for the arrival of "Bill of Lading".

3.1.2 Blockchain - Digitalized tokens

In its essence, a dollar bill functions as a token, the paper has no actual value but through a universal understanding it represents the value that is associated with that dollar bill. Tokens representing the value of an asset is not at all revolutionary, but the blockchain technology provides a new impulse to the process. Digital tokens on a blockchain function like currencies on the blockchain: they assign and track ownership of digital assets (Von Tonder, 2017).

In the case of currencies, the token is given a numerical value that represents a monetary digital asset. The token can be programmed to represent any asset, allowing for a new type of granularity in the concept of ownership (Von Tonder, 2017). The way tokens of ownership work on a blockchain is that the token represents sort of a key that is cryptographically secured and will let the owner of that key to write a new transaction on the blockchain. This is how the ownership again can be transferred, only the person or party in possession of that key can transfer the ownership of that token to someone else.

A blockchain token representing the ownership of an asset, can be coded to work together with a smart contract. The token can be transferred to another party, and pending some predetermined conditions of the smart contract, typically payment, the token transfer can be accepted by the recipient.

3.1.3 Blockchain – Cumbersome, paperwork-heavy, back-office operations

The present-day "need for speed" in the execution of secure payments in global commerce has particularly overburdened existing paper-based back offices, which often rely on faxes, phone calls and paper-ledgers to execute transborder transactions (NetworkNewsWire, 2018).

Commodity market participants can register the transfer of goods, information and transaction data; identifying the parties involved, price, date, location, quality, current state of the product, and any other information that would be relevant to managing the value chain on the ledger (Eka, 2017). Blockchains provide different degrees of data transparency between public, private and hybrid blockchains. By using a hybrid blockchain as example here, the information is visible to the counterparties of a certain trade and could be visible to others if this is necessary for that

certain trade, and there is consensus among the counterparties. At the same time, the transaction data is private and only transparent among the involved counterparties.

Blockchain can help relieve the cumbersome, paperwork-heavy back-office operations by allowing full transparency among counterparties involved in the trade, by providing one single source of truth to all relevant information and transaction data, and greater visibility on logistics data. The benefits here are greater efficiency as a product of less time consuming manual paperwork-based verification and reconciliation processes.

3.1.4 Blockchain - Smart contracts

Way back in 1994, Nick Szabo, a legal scholar, and cryptographer, realized that the decentralized ledger could be used for smart contracts, otherwise called self-executing contracts (Blockgeeks, 2016a).

A smart contract is like a regular contract in its essence, but the key difference is that by clever coding and cryptography a smart contract is self-enforced by matching a set of predetermined conditions in the contract. Because smart contracts run on the blockchain, they run exactly as programmed without any possibility of censorship, downtime, fraud or third-party interference (Blockgeeks, 2016b).

Smart contracts are seeing use-cases across all sorts of industry. In commodity trading, for example, a commodities trade deal can automatically execute if the terms of a multiparty agreement are met, such as a certain price and volume conditions (Tobin, 2017).

Despite bringing several benefits, smart contracts are not without faults. Smart contracts code is written by humans, and smart contracts are only as “smart” as the people who write them. Code bugs or oversights can lead to unintended adverse actions being taken. If a mistake in the code gets exploited, there is no efficient way in which an attack or exploitation can be stopped other than obtaining a network consensus and rewriting underlying code (Blockgeeks, 2016b).

3.2 Blockchain platforms vs Blockchain applications

One key feature of blockchain technology that is very important to understand. Is that for a consortium, company or any individual trying to implement blockchain into their business or create a company based on blockchain technology. One would not necessarily have to build the entire infrastructure from the ground up. Blockchain platforms like Ethereum, Hyperledger and others allow for the creation of applications on top of their existing infrastructure. And these underlying blockchain platforms does not possess the ability to make any changes, have any control, or have anything at all to do with the applications that are built on top of their respective platforms. The platforms gain the advantage of a greater decentralization and thus security, which again benefits the applications on top of the platform.

A blockchain platform is a digital, decentralized and distributed system, built from the ground up. As illustrated in the figure below, its foundation consists of network/communication, the blocks of transactions are secured by strong cryptography. The platform contains storage, digital identity, digital signature and wallet. The platform runs on application programming interface(API), which describes the protocol that the blockchain uses to validate transactions. It is also open source and incentivized (Blockgeeks, 2017a). The level of which a blockchain platform is decentralized, distributed, incentivized, open source and what type of protocol is being used varies between different platforms and what type of blockchain it is – public/private/hybrid.

Examples of open source blockchain platforms on top of which one can build applications are Ethereum and Hyperledger. Ethereum and Hyperledger is somewhat different, but their principles are similar. If one were to compare Ethereum or Hyperledger compared to for example Bitcoin, the differences are much bigger. They all inherit all the basics of being a digital, decentralized and distributed ledger secured with cryptography. Bitcoin is a cryptocurrency and "only" a cryptocurrency. The whole idea of bitcoin is to enable peer-to-peer transactions without the need for a central authority or intermediary. Ethereum and Hyperledger on the other hand is very different from Bitcoin. Ethereum has its own currency, called ether, but the Ethereum blockchain is not limited to its currency.

Ethereum and Hyperledger is both open source blockchain platforms on top of which one can build decentralized applications or "DApps". Dapps are software applications that are running

their code on top of an already existing blockchain platform and require no middleman to run. Once a decentralized blockchain is created, its contracts (code), exists in an open state outside of the control of its creator (Lielacher, 2018).

Dapps also inherits the key features of blockchain; digital, decentralized, distributed, open source, incentivized, and a Dapp can also be public, private or hybrid

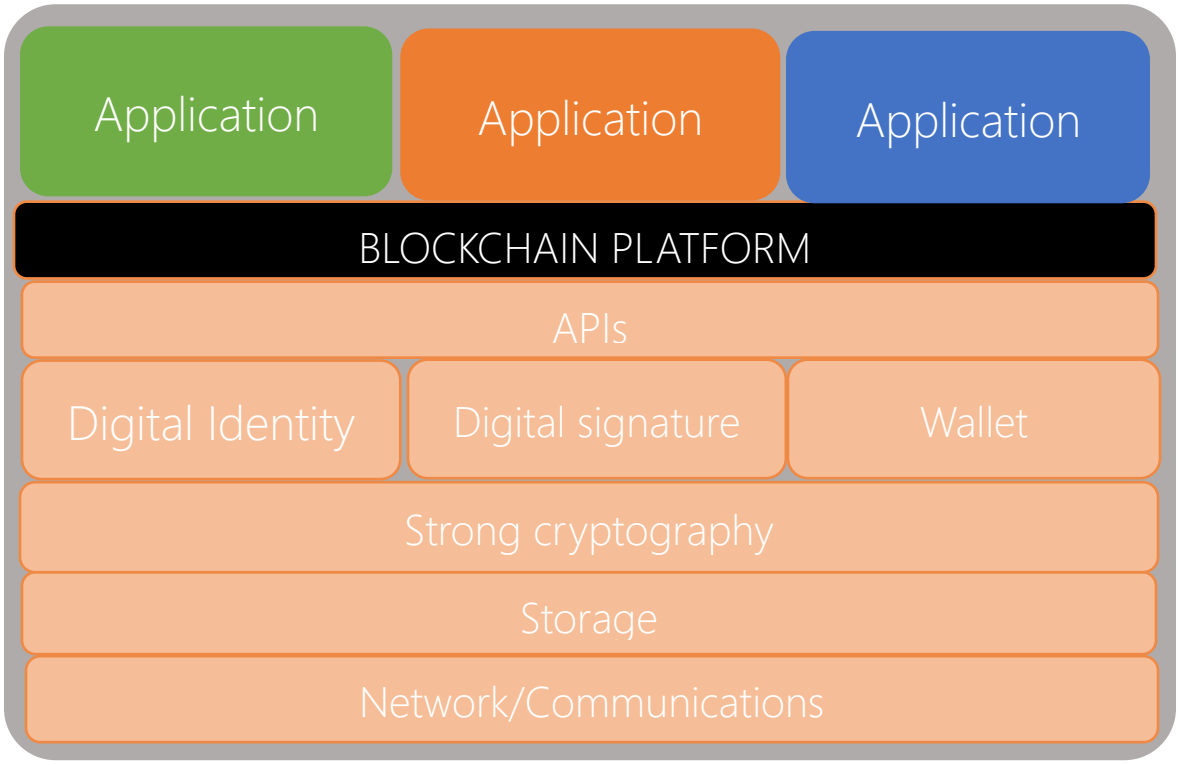

Figure 5 - The relationship between blockchain platforms and blockchain applications (This figure was created with help from the expert in one of the interviews).

3.3 Blockchain platforms

In this sub-chapter the author will present two different blockchain platforms. The purpose of this is not to go in-depth about the different mechanics of these two platforms, how they are similar and how they differentiate. The purpose is rather to give a general presentation of two blockchain platforms on top of which anyone can build decentralized application. This will also create context for the case study in chapter 5. The consortium company VAKT is building blockchain software to be incorporated in the entire commodity transaction life-cycle, but essentially it is a Dapp on top of the Ethereum blockchain. Hyperledger is probably the closest alternative to Ethereum for the purposes of VAKT.

3.3.1 Ethereum

Ethereum was developed by a young Canadian named Vitalik Butarin. At its simplest, Ethereum is an open software platform based on blockchain technology that enables developers to build and deploy decentralized applications (Blockgeeks, 2016b). Like Bitcoin, Ethereum is a digital, decentralized distributed public blockchain network, secured with cryptography. Ethereum is also using the proof-of-work mechanism, but instead of mining for bitcoin, the miners receive ether which is the cryptocurrency of Ethereum (Blockgeeks, 2016b).

Ethereum was the first blockchain to really explore the possibility of enabling developers to build and deploy decentralized applications (Blockgeeks, 2016b). One could make an analogy to the internet when explaining Ethereum and it's Dapps; Applications like Gmail, Facebook, Amazon and Google which one could say is just giant digital versions of letters, social registries, supermarkets and encyclopedias, are all applications built on top of the internet. Ethereum gives the same opportunities to centralized applications making them decentralized, as the internet enables physical entities to become digital. According to Ethereum every centralized intermediary service that exist across hundreds of different industries can be made decentralized (Blockgeeks, 2016b).

A noticeable feature of Ethereum is the Ethereum Virtual Machine (EVM), which is a Turing complete software that runs on the Ethereum network (Blockgeeks, 2016b). It makes the processes of creating Dapps easier because it allows anyone to run any program, regardless of the programming language given enough time and memory (Blockgeeks, 2016b).

3.3.2 Hyperledger

The Linux foundation, a non-profit organization enabling mass innovation through open source announced in December 2015 the Hyperledger project (Hyperledger, 2016).

"Hyperledger is an open sourced community of communities to benefit an ecosystem of Hyperledger based solution providers and users focused on blockchain related use cases that will work across a variety of industrial sectors" – Brian Behlendorf (Executive Director, Hyperledger)

In simpler terms, Hyperledger can be thought of as a software which everyone can use to create one's own personalized blockchain service. This is like Ethereum, but Hyperledger does not support its own currency.

Today Hyperledger has an impressive list of more than 100 members. The list covers a wide spectrum of industries, and many of the world's largest companies in Tech and Finance meet at Hyperledger with some of the hottest blockchain startups Blockgeeks (2017b)

Mobility tech	Airbus, Daimler
IT-companies	IBM, Fujitsu, SAP, Huawai, Nokia, Intel, Samsung
Financial institutions	Deutsche Börse, American Express, J.P. Morgan, BBVA, BNP Paribas, Well Fargo.
Blockchain start-ups	Blockstream, Netki, Lykke, Factom, bloq, Consensys

Table 4 - Some of the members of Hyperledger - Blockgeeks (2017b)

Hyperledger incubates and promotes a range of business blockchain technologies and among these are Hyperledger Fabric (Blockgeeks, 2017b). Hyperledger fabric supports distributed ledger solutions on permissioned networks for a wide range of industries (Weed Cocco & Singh, 2018). An example of a Hyperledger Fabric application is Everledger, a global digital registry for diamonds. Tracking conflict diamonds through the supply chain to protect suppliers, buyers, and shippers from theft and counterfeiting (Weed Cocco & Singh, 2018).

3.4 Corda R3

Corda is an implementation of the distributed ledger technology (DLT) developed by a company called R3 (Torvekar, 2017). Corda is not blockchain, but another version of (DLT), it works somewhat similar to a blockchain like Ethereum and Hyperledger but there are some differences. "We don't have blocks and we don't have a chain" – Tim Grant, CEO, R3 Lab and Research center. In Corda, there is a concept of state changes and transactions instead of blocks and a chain. (Torvekar, 2017).

Corda has in recent months opened to a wider range of businesses, from starting with financial institutions exclusively. In collaboration with Corda R3 there has been completed two real-life tests by blockchain applications built on Corda.

1. Reuters reported that; "In March 2018, a couple of financial institutions have completed a 25 million euros securities lending transaction using blockchain-based software. Banks swapping baskets of securities through an application created by bank consortium R3. The trade was one of the first examples of real-life capital markets transaction of its kind taking place on a system that uses blockchain." Irrera (2018).

2. Global trade review reported that; "In April 2018 a blockchain-powered platform called Fusion LenderComm for syndicated loans is the first app to go live on R3's Corda platform. In short, Fusion LenderComm streamlines and digitalizes information exchange in the syndicated loan market. Through the platform, agent banks can easily publish detailed loan information, including credit agreements, accrual balances, position information and other transaction data, and extend self-service capabilities to lenders. Today, this communication is predominantly done manually, over phone, fax or email." Wass (2018).

3.5 Summary of Ethereum, Hyperledger and Corda R3

These three platforms have different visions in mind with respect to possible fields of application. Corda being more concrete towards the financial industry. Hyperledger intends to provide a more extendable architecture that can be employed in various industries. Ethereum presents itself as utterly independent of any specific field of application (Sandner, 2017). These three short presentations don't capture the entire complexity surrounding the platforms, but it shows that the technology is maturing. By observing successful real-life tests of applications on top of these platforms goes to show that the platforms and the applications are working. Even though it is not necessarily within the commodity industry and the real-life tests presented does not contain transactions involving commodities, the principles are similar.

4 Methodology

This chapter will elaborate on the method that has been applied to answer the research questions. There will be no analysis in this chapter, but rather a description of which tools that has been used in order to analyze the data and to reach a conclusion. The chapter will describe the research design, the data acquisition and the process of analyzing data.

4.1 Research design

Due to the nature of the thesis and the research questions, a qualitative approach was an obvious approach to take. The main reason for this is that the blockchain technology is still a relatively new technology. In terms of relevant, actual real-life results, there are very few, if any at the time the process of writing this thesis started.

The qualitative approach will consist of:

- Empirical data obtained from public articles, blogs, web-pages, blockchain learning platforms. This data has been used to identify problems within the commodity transaction life-cycle and to explore what solutions blockchain can provide to these problems.

- Two expert-interviews with the same person – working in Equinor, specializing in software solutions for the oil and gas industry. These interviews have together with public announcements from Equinor and the blockchain-based consortium that Equinor is a part of, created a foundation for the case study.

- A single case-study on the consortium company VAKT. The primary objective of the case study has been to go more in-depth in blockchains role in commodity trading.

4.2 Data acquisition

The idea for this thesis all started with an announcement that the author read on e24.no. “Statoil confirms blockchain plans”, Statoil plans to execute the first energy trades with blockchain-technology in 2018 in collaboration with Shell, BP, Societe Generale and commodity giant Gunvor (Malkenes Hovland, 2017). (Statoil at the time of the announcement, now Equinor).

The primary source of data for the case-study and the case-study analysis, is the expert interviews accompanied by public announcements about the company VAKT. In addition to this, VAKT launched their webpage in early June, a week or two before the thesis due date.

The primary source of data for the rest of the analysis has been empirical data obtained from public articles, studies, blogs, web-pages, news articles and announcements. Basically, every piece of information the author has come across that was found relevant to the role of blockchain in commodity trading. This data is also backed up by the expert interviews.

On a general note, it must be pointed out that the expert that has been interviewed is working in Equinor, one of nine consortium members owning the company VAKT. Naturally, he might not be completely unbiased.

4.2.1 Empirical data obtained from public articles, documents and studies.

The empirical data obtained comes from public documents such as studies, articles and blogs written by individuals, groups or consultant companies with stake in blockchain technology such as BCG, PWC, EY, Delloite and others. News articles and announcements from Equinor and other companies that is exploring blockchain in commodity trading, and online public blockchain learning platforms such as blockgeeks and coindesk.

Blockgeeks, describes themselves as "We are an online affordable Blockchain training technology educational platform for learning and teaching online where students are mastering new skills and achieving their goals by learning from developers, hardworking entrepreneurs, investors, and leaders about the rapidly evolving world of blockchain technologies (Blockgeeks, 2018).

Coindesk, describes themselves as "CoinDesk is the leading digital media, events and information services company for the crypto asset and blockchain technology community. Its mandate is to inform, educate and connect the global community as the authorative daily news provider dedicated to chronicling the space (CoinDesk, 2018a).

4.2.2 Expert interviews

To back up and complement the empirical data acquired, and to create a foundation for the case study, the author managed to come in contact with an expert on blockchain in physical commodity trading, working in Equinor. This person has 20 years' experience as a professional software engineer specializing in software for the oil and gas industry, with the last six years spent working as a solution architect with focus on researching large scale software solutions for the oil and gas chain. This person has been very cooperative and helpful, and the author was able to contact and conduct two interviews.

Taking into consideration that the consortium company "VAKT" had been announced in November 2017, the thesis started in January 2018 and were due June 2018 while the first blockchain application beta of VAKT was originally planned to be released in February 2019. It was important for the author to interview the expert more than once. Taking into consideration the probability of potentially changes in developments over the course of the project and the span of the thesis.

4.2.3 Case-study – Consortium company VAKT

To explore the role of blockchain in commodity trading more in-depth, and to obtain solid backup for the empirical data. The author of this thesis has conducted a case study. A "case study," I argue is best defined as an intensive study of a single unit with an aim to generalize across a larger set of units. (Gerring, 2004).

VAKT is an independent company, owned equally by Equinor and the eight other consortium members. VAKT is building a Blockchain application on top of the Ethereum blockchain platform, and the idea is to create a blockchain platform that will be applied to the entire commodity transaction life-cycle. The company VAKT has currently (May 2018), four employees and the original plans to release the first beta was February 2019.

(Even though it is called "a blockchain ***platform*** that will be applied to the entire commodity transaction life-cycle" it is blockchain software in form of a decentralized application that is built on top of the Ethereum blockchain).

4.3 The author and analysis of data

If one were to define this thesis with two simple terms it would be "Blockchain" and "Commodity transaction life-cycle". Without any prior knowledge about neither of these two subjects, the author has tried to gain as much knowledge about these two subjects as possible. What it is, how it works, what it can do, blockchain role in the commodity transaction life-cycle compared to the commodity transaction life-cycle today.

It has been a challenge to learn enough about blockchain and commodity trading to write a thesis about it. The hardest part of writing this thesis has been the limited amount of relevant and good information about the subject. On the other hand, it has been interesting to observe that over the course of writing this thesis, (January-June 2018), there has been published an increasing amount of relevant and good data about the role of blockchain in commodity trading.

One could argue that having no prior knowledge about the subjects combined with a flexible research approach has been a good thing, being open minded to every idea and impulse.

5 Case study: VAKT – building a blockchain platform for commodity trading

The data presented in this chapter is all related to VAKT. The data sources applied in this case study is primarily the expert interviews and public announcements and statements issued related to this consortium and the company VAKT. In addition to this, VAKT launched their webpage in early June, a week or two before the thesis due date. The case-study presented in this chapter will be the basis of the case-study analysis in the analysis chapter.

5.1 Background

On the 6th of November 2017, Reuters reported that A consortium had been created with the intention of implementing blockchain technology for energy commodities trading.

The consortium

Oil firms	BP, Shell, Statoil (now Equinor)
Trading houses	Gunvor, Koch Supply & Trading, Mercuria
Banks	ABN Amro, ING and Societe Generale

Table 5 - Consortium members owning the company VAKT

"Ideally, it would help to eliminate any confusion over ownership of a cargo and potentially help to managing risk more exact if there are accurate timestamps to each part of the trade," said Edward Bell, commodities analyst at Dubai-based lender Emirates NBD PJSC (Reuters, 2017).

The new venture is seeking regulatory approvals and would be run as an independent entity, the consortium said in a statement. "The platform aims to reduce administrative operational risks and costs of physical energy trading, and improve the reliability and efficiency of back-end trading operations…," (Reuters, 2017).

VAKT's vision is to digitize the global commodities trading industry, creating a secure, trusted ecosystem, powered by blockchain.

5.2 Key problems and challenges to be addressed

In the first interview, the expert highlighted three key problems in the physical commodity trading industry that VAKT is trying to address using blockchain. These three corresponds to the problems described in the foundation chapter, 2.1.2 – 2.1.4.

1. *Tracking ownership of cargoes*

The ownership of a cargo is unequivocally determined by who is holding the physical paper "The Bill of Lading". The simple reason for this is that the buyer naturally wants to be completely sure that the seller doesn't sell to anyone else. There is no good solution to this today and the expert emphasizes that Equinor ideally wants to avoid the use of intermediaries like brokers to handle the ownership of cargoes.

2. *Cumbersome, paper-heavy, back-office operations.*

The second big issue that VAKT is addressing is the back-office post trade operations. In the long and complex commodity transaction life-cycle, the order in which processes happen is very important. This requires constant consensus and verification among counterparties. After a deal is done, there is a lot of manual work involved in making sure the money is in the bank, and ownership of the commodity is transferred from the seller to the buyer. Pdf-files and physical paper-contracts is used today. These processes are archaic and the paper trail is substantial, resulting in delays, increased costs and risks. Equinor (2017).

3. *Human errors*

The expert points out that with how the entire process works today; the way ownership is being determined, and with all of the verification processes and reconciliation processes being paper-heavy and done manually, the entire system is heavily exposed to human errors.

5.3 Blockchain addressing these problems and challenges

In the first interview with the expert, among the questions that were asked was; “Have these problems been addressed before without success? or is it because of blockchain that these problems are being addressed?”. Which to the expert replied that these were problems they had been trying to solve for a long time but there had not been any good solutions to it, and that blockchain gave them this opportunity on an entirely different level than before.

The follow-up question the author asked in the interview was: “Are the reasons for Equinor putting resources into blockchain because of some new regulations? or a need to lower transaction cost and eliminate inefficiencies due to the prices of oil and gas being substantially lower than before? Which to he responded, that the new focus on blockchain was neither due to new regulations or lower oil prices that required cost reduction. It was simply just good timing, and that the industry was recognizing that the technology was entering into a more mature stage.

There are two statements that stands out regarding the role of blockchain in commodity trading in the first announcement issued by Equinor.

“By applying new technology, we can have a more efficient process and use more of our operators and deal handlers time on value adding activities” Redwan Zeroual, Equinor’s project leader in this new venture (Equinor, 2017).

“What we see with blockchain is that it can be used in energy trading, but also in other parts of our business such as logistics and distributed energy systems when we grow the company’s New energy solutions business area.” Owen Williams, senior advisor in Equinor’s innovation unit (Equinor, 2017).

The expert also emphasizes an important point of why he thinks blockchain is great. The fact that the amount of infrastructure required for this project is in fact very low, VAKT is not building its own blockchain platform from the ground up, but rather a blockchain-application on top of the already existing Ethereum blockchain. He describes this as “90-95% of the work is already done.”

1. *Blockchain - Tracking ownership of cargoes*

By using blockchain in commodity trading, instead of sending the physical paper around, one could track the ownership of a cargoes by using digital tokens. This would eliminate all cost associated with the bill of lading which the expert estimates roughly for Equinor to be "3000 NOK per document, 5 times per cargo, 10 times per day for 365 days which comes out to 55 million NOK".

2. *Blockchain - Cumbersome, paper-heavy, back-office operations*

In the long and complex commodity transaction life-cycle, the expert emphasizes that the order in which processes happen is very important. By replacing the current systems with a blockchain solution based on smart contracts, will allow for greater visibility on logistics data, resulting in improved scheduling and decision making. Replacing current systems for trading oil and natural gas with the blockchain platform, post trade processes is forecast to unlock up to 40% savings across operations, accounting, settlements and IT (VAKT, 2018).

3. *Human errors*

Removing all the manual tracking of ownership and post trade verification and reconciliation labor and replacing it with digital solutions and smart contracts will remove all mistakes related to misguided information and poor communication. By using a shared digital ledger, that makes both counterparties possess a single source of truth, operational data errors will be eliminated. (VAKT, 2018)

4. *Challenges to blockchain*

In the second announcement, Chief Operations and IT Officer at Gunvor Group Eren Zekioglu said that the main challenge in setting up VAKT has been the technology itself, "which continues to mature very quickly." "We've had to keep pace and jump in while everything evolves. This means establishing a true subject-matter collaboration in terms of trading and technology." (Hall & Hall, 2018). In the first interview, the expert says that in terms of challenges, there has been very few. If one were to pin-point something that could potentially be a problem for the project, it is widespread adoption within the industry. Trading partners would naturally have to be participants on the blockchain platform in order to conduct trade using the blockchain platform.

5.4 Partners, competitors and rival projects

In the first announcement issued it says that pending regulatory clearance, the platform would be opened to the whole commodity industry after it has been tested by investors (Reuters, 2017). In the second announcement Zekioglu said, "The amount of interest we've seen since the launch of the project has been overwhelming. The biggest names in our respective industries have all contacted us, expressing an interest in taking part in this movement."

In the first interview, according to the expert there are no rival projects out there to his knowledge. However, there exists some similar projects, for example; a European natural gas post-trade reconciliation blockchain platform being developed by Canada's BTL. This project also seeks to cut back office costs and errors by applying blockchain technology.
BTL completed a 12-week pilot project last June with BP, Eni and Wien Energie to show how its Interbit blockchain platform could automate trade reconciliation processes using smart contracts (Hall & Hall, 2018).

6 Analysis

In this chapter, the author will present the results and findings by having applied the chosen methodological approach. The chapter will end with answers to the research questions being provided and a discussion and implications for further research on blockchain in commodity trading.

6.1 Blockchain and the commodity transaction life cycle

Blockchain seems like a good fit for commodity trading, and the technology has use-cases throughout the entire trade life-cycle. Ownership tracking, trade finance, paper-heavy back-office verification and reconciliation processes, and security, are all parts of the commodity transaction life-cycle that can benefit from blockchain technology. Most of the problems associated with the technology itself is more connected to public blockchains with an unlimited number of participants, the energy consumption for verification of transactions, the criminal connection and scalability.

6.1.1 Efficiency

Tracking ownership of cargoes

It seems weird that in 2018, such an enormous industry relies on physical paper contracts to determine and verify ownership of cargoes. These systems have been challenged before but there have apparently never been any solutions good enough to disrupt the current systems. Blockchain enables the possibility of using digital tokens to track assets. A token works like a key that enables the person or party that is holding this token to be able to submit a new transaction to the blockchain ledger. This is the way for the holder of the token to transfer the asset to anyone else. This can work together with a smart contract. Party A sending the token to Party B, and pending party B's acceptance of the token, triggers the smart contract that then executes payment. This would eliminate all the cost that is related to the Bill of Lading document that is used for tracking ownership of cargoes today.

Post-trade operations and logistics

The ownership of commodities is determined by physical paper contracts, and commodities can change ownership several times, even without the commodities moving. This causes for duplicative paper-heavy back-office operations of verification and reconciliation. A blockchain platform for post-trade management would make transaction information more transparent, there would be greater visibility into logistics data and the counterparties would share one single source of truth, which would reduce operational data errors, maybe even eliminate them. These features, combined with the use of smart contracts coded to automatically validate transactions depending on a set of predetermined conditions being met, would make the verification and reconciliation processes way more efficient.

The costs of labor for verification and reconciliation are defined as transaction costs. Elimination of inefficiencies within back-office operations contributes to greatly reduced transaction costs for a commodity supplier. Most of the labor that is streamlined can according to the expert interviewed, be reallocated to more value adding activities.

6.1.2 Cyber security and privacy

A commodity trading platform based on blockchain technology would probably be closest to the type of a hybrid blockchain. It is not fully private, neither is it public and open for anyone. The decentralization and distributed part in a hybrid blockchain is not as strong as in a public blockchain, but all trade data would still be somewhat decentralized, distributed and fully encrypted. Counterparties will have an immutable ledger of the trade activity data. On a blockchain platform, this data would only be visible for the counterparties involved in any certain trade but could be made visible for a third party if this is necessary. This creates for the required privacy when trading within such an industry.

6.1.3 Trade financing

Trade financing includes the services of trading houses, providing insurance and risk mitigation and banks, providing cash flow. Trading houses are taking premiums and banks gets paid interest on their loans. This is often a labor intensive and expensive process. With direct visibility of relevant trade data, and digital documentation, banks and trading houses can improve their own operations, which again will make room for lower premiums and faster settlements.

6.1.4 The convenience of blockchain

The fact that there are existing open source blockchain platforms like Ethereum and others, that enables anyone to build any application on top of their platform makes it incredibly easy for individuals and companies that are trying to implement blockchain into their business, compared to if you had to build the blockchain from ground up.

In the second interview with the expert, he points out how convenient it is to build a decentralized application on top of the already existing Ethereum blockchain platform, the expert goes further on by describing it as "90-95% of the work is already done".

6.1.5 Problems and challenges – blockchain in the commodity trading industry

It seems like most of the problems associated with blockchain is more connected to the type of a public blockchain rather than a hybrid or private blockchain. One could argue that the benefits of a public blockchain is also greater than the hybrid or private. Complete transparency, more participants equals more decentralization and thus more security versus cyberattacks. It all comes down to the purposes of the subject where one is trying to implement blockchain.

On a platform for commodity trading, there would naturally be requirements for privacy of company data. It is not supposed to be transparent to every participant in the network. This is the reason why a hybrid blockchain is probably the best fit for the purposes of blockchain in the commodity transaction life-cycle.

The main problem or challenge for blockchain to prove successful in the commodity industry seems to be widespread adoption across the industry.

6.2 Case-study analysis - VAKT

The blockchain-based company VAKT is the product of these nine companies in the consortium's idea to build a blockchain platform that will be involved through the entire commodity transaction life-cycle.

According to the expert the problems and challenges within the commodity trade life cycle have been addressed before but without success. Blockchain technology provides this opportunity on an entirely different level than any technology has done before.

One key factor that points to this is that the planned launch of the platform; the first and second beta, as well as the platform itself has been pushed forward by several months. This indicates that expectations have been met and that there has been less obstacles than expected and/or that the work has been less substantial than expected.

Another factor that points to the successfulness of the company is that the consortium consists of so many major companies across different industries, the competence within this consortium is impeccable and if the technology works out, there should be no problem for the consortium to implement it.

There are similar projects that addresses certain problems within the commodity transaction life-cycle but what makes VAKT unique is that;

1. The blockchain platform VAKT is creating, incorporates the entire commodity transaction life-cycle.
2. The company has broad backing from giants within their respective industries and also across various industries, energy companies, trading houses, and banks.

When it comes to what VAKT's blockchain platform actually will do for an energy company, is that first of all it will eliminate all costs associated with the "Bill of Lading". For post-trade, back-office operations like verification and reconciliation, the expert says that Equinor estimates a triple-digit number of FTEs will be streamlined. The expert emphasizes that these FTEs will not necessarily dissapear, but that most of the labor can be reallocated to more value adding activities rather than cumbersome routine-heavy back-office jobs.

When it comes to challenges associated with the technology, it seems like widespread adoption is the main one. Even though blockchain technology has been around for a while and in recent years has gotten more attention for its use-cases outside of cryptocurrencies, the technology is still in an early stage. People and companies tend to be skeptical towards new technology and risk averse when it comes to putting resources into untested territories. As long as there keep coming indications of the technology's successfulness and there are front-runners in the industry that are willing to pave the way, widespread adoption can be overcome.

6.3 Answers to the research questions

6.3.1 Research question 1

What are the characteristic problems and challenges in commodity trading today?

- What are the underlying reasons that makes Equinor and others to put their resources into blockchain?
- Which intermediaries will be redundant if blockchain proves to be successful in commodity trading?

This question is split into three parts, so for the case of structure the answer will be presented in three parts.

1. **What are the characteristic problems and challenges in commodity trading today?**

The empirical data obtained, and the data obtained from the expert interviews has been very similar. This indicates that there is a clear understanding about the role of blockchain in commodity trading. The author has identified four characteristic problems and challenges throughout the commodity transaction life-cycle.

Tracking Ownership of cargos

Physical paper contract "the Bill of Lading" is sent together with cargos. This is time consuming and requires substantial costs. There incur huge complications if the document is lost, and the system is exposed to fraudulent activity.

Cumbersome paper-heavy back-office operations

Ownership of commodities can change several times without even the underlying commodities moving. The paperwork associated with the back-office operations of post trade verification and reconciliation are often very heavy on paperwork, time consuming and highly inefficient.

Human errors

Human errors are a consequence of the two previous problems. Both systems require substantial manual labor, and these are heavily exposed to mistakes.

Intermediaries and transaction cost

The first order of business is to make money. Transaction costs eats up margins and slims down profits. Reducing transaction costs are important and a great challenge to every business across industries. Transaction costs are both internal and external. In a long and complex transaction life cycle, external transaction costs are a product of intermediary services provided to add value to the end-product.

2. What are the underlying reasons that makes Equinor and others to put their resources into blockchain?

Throughout the course of the research, two underlying reasons stands out to why Equinor and others decide to put resources into blockchain technology.

The characteristic problems and challenges within the commodity industry

The primary reason is that blockchain gives the opportunity to digitalize commodity trading through the entire trade lifecycle. The industry acknowledges that blockchain gives the opportunity to solve problems and address challenges identified in the previous research question. This will result in cost reduction, and elimination of inefficiencies where more labor can be streamlined and reallocated to more value adding activities rather than back-office operations, and a reduction in human errors associated with these operations.

The technology is maturing

The second reason is that the technology is maturing. Blockchain technology is still in an early stage, and the technology is constantly evolving, but it is getting increasingly more attention and recognition in the media and among people inside the industry and across other industries. The technology has been tested in real-life transactions and trades outside of cryptocurrencies.

3. **Which intermediaries will be redundant if blockchain proves to be successful in commodity trading?**

There is little doubt that implementation of blockchain technology will have consequences for several intermediaries involved in the commodity transaction life-cycle. The question asks which intermediaries will be redundant, and to that the author has been able to identify two.

Intermediaries associated with establishing trust and facilitating trade – brokers, price discovery systems and centralized trading platforms / exchanges.

Intermediaries issuing the Bill of Lading. The Bill of Lading is transported together with their respective cargoes, and the shipment process will naturally not be redundant. The author refers to the intermediaries that takes fees for issuing the document and transporting it to the carrier/ship.

6.3.2 Research question 2

Which transaction costs can be eliminated for a commodity supplier, by implementing blockchain technology in physical commodity trading between businesses?

Blockchain technology allows for trust between counterparties without an intermediary to facilitate trade. Hence, all transaction cost related to broker relationship or price discovery systems.

Costs related to centralized trading platforms, as a consequence of seller and purchaser being able to directly trade with each other.

By digitalizing the way ownership of commodities are tracked and determined, all costs related to issuing, transporting, signing and verifying the Bill of Lading will be eliminated.

Through enhanced transparency of transaction data, greater visibility of logistics data, and by counterparties sharing one single source of truth, on a digital ledger that allows for self-enforcing smart contracts. Enables the possibility of streamlining labor associated with back-office post trade verification and reconciliation. Will result in several FTEs being reallocated from back-office operations to more value adding activities and hence reducing transaction costs.

By documentation being digitized on a shared ledger, and more direct visibility of relevant trade data. Banks can optimize their own operations, resulting in reduced transaction costs for commodity suppliers in the form of lower premiums.

6.4 Discussion and implications for further research on blockchain in commodity trading

These two topics below is not directly relevant to the questions of research, and it has not been covered earlier in the thesis. It is two features within blockchain in commodity trading that has come to the authors attention towards the very end of this project. These two features of blockchain technology in commodity trading could be interesting topics for further research.

6.4.1 New trade models for trade finance in the commodity industry?

In the second expert interview, the expert mentioned the possibility of blockchain disrupting the current business models for trade financing. Tracking ownership of commodities digitally on a blockchain rather than by physical paper contracts, can open up for the possibilities of several, hundreds, and even thousands of owners of one single cargo. Working kind of like stocks, allowing businesses and individuals to invest in just “shares of the cargo”. Creating opportunities for diverse and easier access to trade finance in commodity trading.

6.4.2 A commodity-based cryptocurrency?

In an article published on Society of Petroleum Engineers, on the 10th of June 2018. A Venezuelan blockchain application called “petromoneda” was presented.

Petromoneda, or petro, is a cryptocurrency, and it is unique because it is launched and controlled by the government, and each coin represents a barrel of Venezuelan oil and valued at the same price (Dixit & Blaney, 2018).

Backing a cryptocurrency with a commodity may help resource-rich nations borrow against their as of yet untapped natural resources (petroleum reserves or otherwise). More interestingly, if reserves-backed cryptocurrencies catch on, their decentralized nature means there is no reason their use would be limited to governments. Reserves-holding companies may find it more convenient to run to petro-like tokens to raise funding against their reserves instead of more traditional financial markets. This could be in the form of a company-specific token or a more generic, industrywide token (Dixit & Blaney, 2018).

This last paragraph quoted from the article corresponds heavily with what the expert said in the interview about potential new business models for trade financing.

7 Conclusion

This thesis has focused on the role of blockchain in commodity trading and the solutions blockchain can provide to problems and challenges within the commodity industry. Also, what will happen to intermediaries involved in the commodity trade lifecycle and which transaction costs that can be eliminated as a consequence of blockchain technology implementation throughout the commodity transaction life-cycle.

Based upon a case study of the consortium company VAKT, that is creating a blockchain platform to cover the entire commodity trade life-cycle and owned equally between the nine consortium members. The thesis has explored the underlying reasons for companies in the consortium to put resources into blockchain technology.

There are only a handful, if that, of actual real-life results that indicates anything about blockchain's success or failure in commodity trading. All the findings of this thesis are therefore based on expert interviews, the case study of VAKT, and empirical data obtained from studies, articles, blogs and blockchain learning platforms. Conducted by people and companies that has knowledge about blockchain and/or commodity trading.

One observation that stands out is that the information and data obtained has been almost exclusively positive about blockchain in commodity trading. There seems to be a common understanding about what blockchain can do for the commodity trading industry and the trade lifecycle of commodities. The two points that stands out is the digitalization of ownership tracking (The Bill of Lading), and elimination of inefficiencies connected to back-office post trade paperwork-heavy verification and reconciliation processes. The author has tried to make this reflect throughout the thesis.

Widespread adoption is paramount, but if this can be achieved. It seems clear that blockchain will play an important role in commodity trading in the years to come. If the technology proves as successful in practice as it does in theory, and you have frontrunners like VAKT and others paving the way. Widespread adoption does not necessarily have to be too substantial of an issue.

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