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The application of blockchain technology for supply chain visibility - A case study of the fish farming industry

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Abstract

The fish farming industry is one of the fastest growing industries in Norway, and is stated to be the “new oil” and one of the most important industries for the future. Blockchain is one of the biggest buzzwords in the business environment today and there have in the last years been more use areas towards logistics and supply chain management.

In this study, the authors were set to explore how blockchain technology could improve supply chain visibility. To reach the objective of answering the research question, the authors found it necessary to conduct a case study of a general supply chain. The authors, therefore, analysed the fish farming industry and investigated whether the industry as a whole could benefit from blockchain technology. Also, it was found necessary to examine key barriers for technology adoption. To do so, exploratory research was conducted based on semi-structured interviews with actors from the fish farming industry and blockchain experts. The theoretical background will consist of theory regarding supply chain visibility, the fish farming industry and lastly, various blockchain concepts to build up evidence and documentation for the discussion. The results are divided into two parts, where the authors first will include industry findings on the current situation. Further, will the second part display the findings related to blockchain technology and how it can affect the current situation in the fish farming supply chain.

The main conclusion that can be drawn from the results is that blockchain can enhance visibility in the industry with usefulness of the information, where better operational efficiency through better forecasting and planning through data anlaytics would increase business value. Further, would the quality of information and the documentation of information of the fish be more secure and reliable using blockchain technology. Lastly, will blockchain combined with other technologies improve how the fish farming supply chain capture information through autonomous solutions.

“It will take years to transform business, but the journey begins now”

- Iansiti & Lakhani

1.0 Introduction

In the era of globalization, there has been an emerging growth of complex supply chains which span over several actors and countries. As a result, the integration of digital supply chains has been increasingly important for businesses in the last decade. Today, most supply chains have multiple stages internationally involving several transactions. For each business transaction, it is more crucial for organizations to verify the identity of all potential partners to make a product, due to risks of frauds and scandals. Deloitte (2017) identified lack of end-to-end visibility as one of the main challenges and causes for risk. Is the potential second and third-tier supplier whom they say they are? Are the transporters properly handling the goods? Today, the demand for end-to-end visibility on products and supply deliveries in the supply chain by customers and other stakeholders is increasing.

To facilitate supply chain visibility, different enterprise systems like enterprise resource planning (ERP) systems have been vital. Even though ERP systems have been and still is very beneficial for businesses around the world, challenges to facilitate the coordination and collaboration among involved actors in the supply chain have increased due to the growth of digital footprints, information flow and maturity of cyber infrastructures (Infosys, 2018). As a result, more companies and industries have been exploring potential use cases for blockchain technology.

In 2008, an unknown person or group behind Bitcoin, called Nakamoto, described how blockchain technology could be used to solve the problem of maintaining the order of transactions and to avoid the double-spending problem (Nakamoto, 2008). Now, a decade later, supply chain professionals believe that blockchain technology will give a competitive advantage (Partida, 2018). According to Partida (2018), there will be a need for systems that can share information more accurate and faster, where the companies are transparent, which is essential to maintain relationships in complex supply chains. The transparent nature is what the blockchain provides, and the technology could be the new digital platform for managing these relationships. The supply chain of the future and the logistics industry can also benefit from a platform that can significantly reduce intermediaries, paperwork, and transaction costs. Lastly and most importantly, for this paper, will precise tracking of temperature, maintenance, and location of

goods help companies to record every step of their products and potentially improve the logistics efficiency of a shipment. Furthermore, would this lead to more transparency and more trustworthy relationships between parties in the emerging digital ecosystems.

1.1 Motivation

The fish farming business is an example of an industry with a complex supply chain with many intermediaries which can benefit from the attributes mentioned. According to Deloitte (2017) traceability breaches or frauds, is the most straightforward examples of corrupt practices in the food industry. With scandals and recalls of products impacting the industry, companies have a key challenge in making the supply chain information more reliable.

Commercial fish farming in Norway began in around 1970, and since that it has developed into a significant industry in coastal areas. Farming of salmon is the most crucial activity now and is accounting for around 80 percent of the total Norwegian aquaculture production (FAO, 2019a). Salmon are exported to all over the world and is now one of the leading export products from Norway. Fish farming and related industries contribute much to the country's economy, and there is still potential for future growth (FAO, 2019a)

The fish farming industry faces some significant challenges regarding factors such as cost, quality, and sustainability. There has been an increasing awareness within the end-consumers about sustainability. This awareness affects both fish farmers and the whole supply chain within the industry. The industry has been facing volume constraints due to regulations, biological challenges, and a need for technical development (EY, 2018).

Throughout 2017 and 2018, the fish farming industry has been gaining record-high revenue streams and export value. However, the industry has experienced a drop in profit because of the rise in operating costs due to increasing challenges with diseases and sea lice. There has been progressing made on farm operations towards the challenges of sustainability, but it is still a complicated case through the supply chain both upstream and downstream. There are challenges regarding sustainable sources of feed, and a lack of disclosure to the origins of the majority

of the feed. Other challenges are increased greenhouse gas emissions due to long-haul exports of fresh fish and a lack of visibility in the industry. (EY, 2018).

To be able to write the master thesis about blockchain with a case study of the fish farming industry, the authors have been introduced to a blockchain startup called Unisot, where Stephan Nilsson is the contact person. Unisot has developed an open blockchain platform that has the potential to change the dynamics of the entire supply chain. The authors are highly motivated to investigate blockchain technology which can provide the tools and services to deliver more efficiency, secure data sharing, global traceability, and process automation across the supply chain in the fish farming industry. The main motivation for collaborating with Unisot is the opportunity to get knowledge on blockchain technology and the benefits of the broad network the contact person have.

1.2 Problem statement and research question

The purpose of this master thesis will be to investigate how blockchain technology has the potential to influence the fish farming supply chains in Norway. To scrutinize the field of investigation, the scope of this paper will be to discuss how blockchain can improve supply chain visibility. The main research question will be as follow:

> *How can blockchain improve supply chain visibility in the fish farming industry?*

To answer the primary research question, a case study of the general fish farming supply chain was conducted. To answer the research question the investigation of the current situation in the industry in relation with the opportunities of blockchain influence on visibility was examined.

In addition, the authors have decided to implement one sub-question. Previous research shows that there are different barriers to implement blockchain technology in industries. An understanding of the specific issues of implementing blockchain technology in the fish farming industry is seen by the authors as

essential to include to answer the primary research question. The sub-question is, therefore:

Barriers for blockchain adoption in the fish farming industry?

1.3 Value of research

It is fair to say that blockchain as a research field is in the early stage and the adoption in industries is in the beginning of its era. Academic research on blockchain technology with the focus on supply chain visibility in food industries is regarded as limited, with minor publications.

The research provides a detailed theoretical framework, which will enable readers who are unfamiliar with blockchain to get an overview of how the technology works. Furthermore, the data was collected from the actors in the fish farming industry to map the current situation on visibility in the fish farming supply chain. With the data collected from the blockchain experts, the authors were able to get a broader knowledge of blockchain technology and how it could be beneficial for supply chains and the fish farming industry. Thereby, and by help of the case study, the authors could take the circumstances in the industry into consideration and discuss the opportunities of how blockchain affects supply chain visibility in a specific case. In this context, the authors will contribute to the literature on how blockchain can improve visibility in a fish farming supply chain.

The fish farming industry is curious on the potential use of the technology to improve their supply chain, and it is found that the actors wishes to understand the benefits and barriers of the technology for their situation. This research will in particular be valuable for the actors in the industry to better understand what blockchain really is and how it can improve their supply chain visibility. More specific, the study discuss how blockchain can be vital to improve the accessibility, quality, and usefulness of information. The fish farming actors have stated that the author's research will be read for insight on how disruptive technology, like blockchain, can have use areas in the industry.

The research will also be valuable for the blockchain experts as they will get a more in-depth understanding of the fish farming industry with their challenges

and thoughts and attitudes towards new technology like blockchain. The collaborating company, Unisot and other blockchain developers and implementers could use the research to map the situation in the fish farming industry and see how the technology suits a multi-stage food supply chain.

1.4 Thesis structure

The thesis started with a short introduction in the first chapter to discuss the background and motivation for the research. In the next chapter, will previous literature related to the research area be presented to provide a theoretical background. The theory will contribute to a more profound knowledge of the fish farming industry and blockchain technology, which in the end will support the discussion and conclusion. In chapter 3, the research methodology will be discussed, which includes the choice of research strategy and design, and how we collected and analysed the data. Further, will the quality and reliability of the research be accounted for. In the next chapter, the authors will present the results from the expert interviews. Furthermore, will the theoretical contribution in line with the findings be analysed and discussed. The last chapters will address the limitations, future research and the conclusion.

2.0 Theoretical background

In this chapter, the theoretical background will connect the research with existing theory and knowledge needed to answer the research question. Three main topics and concepts were identified from the literature to be crucial for the analysis, discussion and conclusion. Firstly, the authors present the components of supply chain visibility and how supply chain transparency and traceability affect the term. The second central part is consisting of the characteristics of the fish farming industry. More specifically, the understanding of supply chain visibility in the industry was found to be especially relevant and vital for the research. Lastly, a detailed literature review of blockchain will be essential to establish knowledge of the characteristics of the technology. Further, there will be a review of how blockchain can contribute to supply chain visibility and enterprise systems.

2.1 Supply chain visibility

In order to describe supply chain visibility, a brief introduction to supply chain terminology is required. Christopher (2016, p.3) describe a supply chain as "A network of connected and interdependent organisations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users"

"the management of upstream and downstream relationships with suppliers and customers in order to create enhanced value in the final marketplace at less cost to the supply chain as a whole." In other words, a supply chain is consisting of all actors who contribute to get the product from supplier to end-consumer in the most optimal way.

Most products today have a long history and a complicated route to the end-consumer. However, most of this history is presently obscured and not visible to the supply chain and its actors. Supply chain visibility is a critical business challenge for international companies, which have little or no information on second and third-tier suppliers (Abeyratne & Monfared, 2016). Supply chain visibility is recommended as one of the best ways to reduce the risk of supply chain failure and to improve supply chain analytics (KPMG, 2016). However, in most supply chains, visibility is far from being fully achieved (KPMG, 2016). Deloitte (2017) states that one of the biggest concerns related to the extended supply chain is due to visibility shortages and lack of reliable information over the entire supply chain. Lastly, it is important to mention that businesses today are heavily impacted when harmful practices are exposed, which can be financially devastating and harm the brand value (Francisco & Swanson, 2018).

Supply chain visibility refers to the extent to which actors within the supply chain have access to the timely and accurate information that they consider to be key or useful to their operations (Barratt & Barratt, 2011; Somapa, Cools, & Dullaert, 2018). How to make information available for end-consumers is also vital regarding supply chain visibility. The key to improved supply chain visibility is shared information among supply chain members (Christopher & Lee, 2004). The authors indicate this is because shared information reduces uncertainty and risk along the pipeline and thus reduces the need for safety stock. However, for this to

be feasible, access to customer demand needs to be shared effectively throughout the pipeline. According to Butner (2010), the most significant barriers to visibility is created by organizational factors rather than technological factors. These factors can be organizational data silos, unwillingness to share information, lack of time, lack of rewarding systems, and increased levels of work (Somapa et al., 2018).

Supply chain visibility characteristics

Somapa et al. (2018), examined the characteristics in their recent literature review on supply chain visibility, where the authors reveal three broad characteristics of supply chain visibility that relate to the accessibility, quality, and usefulness of the information. Their process-oriented approach allowed them to express the importance of information accessibility as an automational characteristic, the quality of information as an informational characteristic, and the usefulness of the information as a transformational aspect of supply chain visibility. Somapa et al. (2018) describe the three broad characteristics as following based on their literature review.

Automational characteristics

Automational characteristics refer to the ability to capture (Delen, Hardgrave, & Sharda, 2007; Francis, 2008; Griffiths, Phelan, Osman, & Furness, 2007; Musa, Gunasekaran, & Yusuf, 2014; Papert, Rimpler, & Pflaum, 2016; Rai, Pavlou, Im, & Du, 2012) and transfer the necessary information in a timely manner by using information communication technologies in diverse forms and (Barratt & Barratt, 2011; Bartlett, Julien, & Baines, 2007; Cherrett et al., 2015; Kim, Ryoo, & Jung, 2011). These technologies and systems objective is to capture information related to the flow of products along the supply chain and to coordinate the flow of information between partners in the supply chain efficiently. The characteristic also includes measuring the lead time associated with each movement, including the fill rate and stock quality and the capturing of demand information for product replenishment and production schedule.

Informational characteristics

The second characteristic of supply chain visibility underlines the crucial importance of the quality of information downstream and upstream in the supply chain. The quality of the information is reflected by three sub-characteristics such

as timeliness, accuracy, and completeness (Barratt & Barratt, 2011; Brandon-Jones, Squire, Autry, & Petersen, 2014; Caridi, Crippa, Perego, Sianesi, & Tumino, 2010; Saint McIntire, 2016; Williams, Roh, Tokar, & Swink, 2013). If the information should be shared every minute, hour, or day, changes based on the business case relates to the timeliness. Timeliness is also related to the automational characteristics, as technology allows the information to be communicated and processed on time. Another feature of informational characteristics is accuracy. With this feature, the authors mean how the shared information differs or is equal to its actual value (Caridi et al., 2010). Lastly, we can define information completeness to the amount and type of information that corresponds to the needs of the users or the consistency of the information (Francis, 2008). Here it is important to identify which information is sufficient and needed for each participant in the supply chain.

Transformational characteristics

The last characteristics refer to the "alignment of the accessed information with the business processes and the use of that information to create business value" (Somapa et al., 2018, p. 327). The transformational characteristics are classified into two subgroups. The first relates to operational efficiency, where information is considered useful if it creates supply chain visibility that leads to meaningful operational benefits and enhanced business activities (Barratt & Barratt, 2011). The second group relates to strategic competencies, where supply chain visibility is an important factor for supply chain competitiveness (Kim et al., 2011) and has the potential to create strategic competencies. For example, could the exchange of demand information throughout the supply chain reduce uncertainties in the inter-organizational relationship and, accordingly, enhances trust between the participants (Kim et al., 2011). Strengthening relationships is particularly essential in industries where products and supply chain operations are highly regulated by the government, or other regulatory bodies (Klueber & O'Keefe, 2013).

The characteristics mentioned above can work as parameters and metrics to evaluate a supply chain visibility project. In order to improve visibility, the supply chain needs to create a more transparent environment in the pipeline and enhance the traceability throughout the supply chain. Total end-to-end visibility will enable supply chains to be transparent, and the right information would be

available to the right member of the supply chain at the right time (Christopher et al., 2004). Furthermore, will traceability and transparency be discussed as the major drivers for providing visibility in a supply chain.

2.1.1 Supply chain transparency

Supply chain transparency refers to information available to companies involved in a supply network (Francisco & Swanson, 2018). Further, was transparency in a supply chain context defined by Hofstede (2004), to be the degree of shared understanding of and access to product-related information as requested by a supply chain stakeholders without loss, noise, delay, or distortion.

Consumers and governmental authorities demand an increased exchange of information about the characteristics of products, processes, and resources between stakeholders in a food supply chain (Trienekens, 2011). Through information exchange between actors, the origin and history of products can be made visible and, thus, more transparent. Transparency, in this case, implies openness and communication exchange. According to Abeyratne & Monfared (2016), supply chain transparency is one of the most critical and hardest areas to achieve improvement for logistics and supply chain management (SCM). To achieve optimal supply chain collaboration between actors, trust and information transparency is required.

Bastian & Zentes (2013) discuss how supply chain transparency has emerged as a key prerequisite for sustainable agri-food supply chain management in the modern world. They debate that quality and safety reasons through legal requirements were the main reasons for transparency efforts in the past decades. However, the last decade supply chain professionals have been more interested in how transparency could benefit operational optimization and performance within ethical and quality related products and process innovations, as well as supplier development (Bastian & Zentes, 2013).

Transparency and traceability are often mentioned in the same settings, but they have significantly different meanings. In a supply chain context will traceability set the framework for the functionality of transparency. Scholars have identified that optimizing transparency and traceability are correlated, while having more

information available and being transparent may lead to increased traceability (Francisco & Swanson, 2018). However, increased traceability may not lead to increased transparency if the supply chain is including actors with bad relationships.

2.1.2 Supply chain traceability

Traceability in supply chains has evolved to be an essential part of many industries. Today, businesses strive to enhance the visibility of product movement through different internal and external networks. In the last decades, agri-food supply chains have been focusing on getting more accurate and timely traceability of products and activities from suppliers to end-consumer (Francisco & Swanson, 2018).

With respect to a food product, Opara (2003, p.102) defined traceability as

> "the ability to identify the farm where it was grown and sources of input materials, as well as the ability to conduct full backward and forward tracking to determine the specific location and life history in the supply chain by means of records. It contributes to the demonstration of the transparency of the supply chain through the use of verifiable records and labelling."

To manage full visibility from materials to consumers, the integration of digital supply chains has been increasingly important for businesses (Korpela, Hallikas, & Dahlberg, 2017). Further, traceability systems have become more advanced with innovative technology to capture and share data more efficiently.

Traceability systems

In order to track any product or movement in the supply chain, the need for a traceability system will, in most cases, be useful. Before we discuss what this system should consist of, we need to define what a traceable resource unit (TRU). In traceability systems, a TRU can be "any traceable object, and typically it is a trade unit (e.g. a case, a bag, a bottle, or a box), a logistic unit (e.g. a pallet or a container) or a production unit (i.e. a lot or batch)." (Olsen & Borit, 2018, p. 144).

Olsen & Borit (2018) identified three components which any food traceability system should consist of.

Identification of TRUs

Firstly, the system needs a mechanism for identifying TRUs. To identify a product one will need to choose which identifier code type and structure which suits the product, make choices concerning granularity and uniqueness of the code, and lastly, find a way to associate the identifier with the TRU in question. In this component, you will need a barcode, quick response (QR) code, sensor technology, wireless network technologies or radio frequency identification device (RFID) to record the movement and history of a product. In order to capture and trace the movement and origin of a product, different types of technology are needed. Today, we have emerging technology as mentioned above, that can be called the internet of things (IoT) devices, which creates excellent opportunities for effective and efficient traceability system design. Implementation of identifier technology and IoT devices will result in automated data capture in every step of the supply chain, where traceability information can be obtained at significantly reduced labor costs and with minor changes in the enterprise's business processes (Kelepouris, Pramatari, & Doukidis, 2007).

Documentation of transformations

The second component in a traceability system is the mechanism for documenting transformations, i.e., connections between TRUs. With transformations, Olsen & Borit (2018) discuss the need to document what happens to the TRU as it moves through the supply chain. In this component, will food supply chains have the most significant challenges. The TRUs are split continuously up from their original batch, or put together with other TRUs. These transfers, splits, and joins are referred to as transformations and is the ability to document the sequence of transformations, which is one of the most vital functions of the traceability system (Derrick & Dillon, 2004; Olsen & Aschan, 2010; Olsen & Borit, 2018). The implementation consists of recording these splits either direct or indirect, and of weights and percentages and time-stamping of location and ownership transfer (Olsen & Borit, 2018).

Attributes of TRUs

Lastly, the traceability system needs a mechanism for recording TRU attributes. After the stakeholders in the food supply chain have chosen an identifier and established a connection with the TRU and made it possible to document transformations, the main interest for the stakeholders lies in the TRU attributes (Epelbaum & Martinez, 2014). All attributes and details that can be connected with the product is the information that travels from supplier to customer. In the fish farming industry, the attributes of the TRUs could be; Species information, feed information, location history, transporter and storage information, how the fish has been processed and packaged, etc.

In practice, all three components are part of the food industry traceability systems, and for each of the three components, there are several options related to practical implementation (See figure 1).

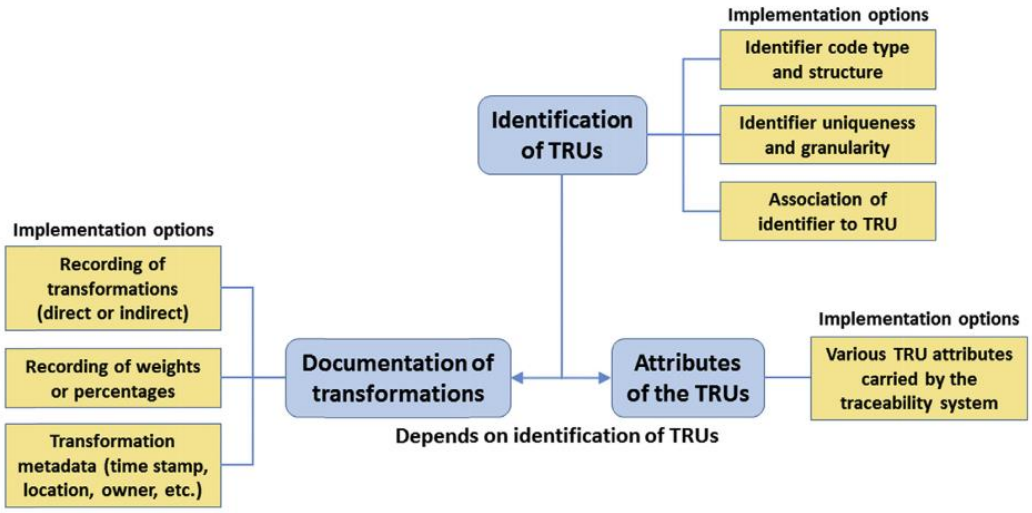

Figure 1 - Components of a traceability systems, (Olsen & Borit, 2018)

A reliable and effective traceability system will benefit both the downstream and upstream actors in a food pipeline. Regarding the consumers, traceability accommodates to build trust and increase confidence in the food system, through verification of all attributes and the journey of a product (Opara, 2003). Furthermore, as consumers have demanded more verifiable evidence of quality and safety, transparency has been in focus for the companies. For the upstream actors, traceability is part of an overall cost-effective quality management system. This will facilitate the work with continuous improvement along the pipeline and mitigate the risk of safety hazards through rapid determination and effective recall of products (Opara, 2003).

2.2 Supply chain of the fish farming industry

In this chapter, there will be a brief description of the fish farming industry with its characteristics, challenges, and supply chain. Furthermore, an examination of the visibility in the industry, traceability standards, benefits and challenges of the current traceability, and frauds in the fish farming industry will be done.

2.2.1 Current situation

The fish farming industry has been faced with different sustainability issues, which has raised concerns from consumers, non-government organizations, and regulatory agencies. The fish farming industry is going through a significant transition due to explosive growth, changing global demographics with growing demand from new markets and environmental concerns (Sterling & Chiasson, 2014). Some challenges the industry faces are concerning fish lice, fish escapes, antibiotic use, greenhouse gas emissions due to long-haul export, frauds, and visibility.

Norway is one of the biggest fish nations in the world, and the industry has been important for many centuries. Norway exports fish all over the world, where the EU market is the biggest. However, other markets are booming, such as the US, Japan, and China. In 2017, China lifted the restrictions on Norwegian salmon export, and as a result, the export to China increased by 595 % in the first half of 2018 (EY, 2018). Norway exported 2.7 million tonnes of seafood to a record high of NOK 99 billion in 2018, where 1.1 million tonnes with a value of NOK 71 billion comes from the fish farming industry (Norwegian Seafood Council, 2019). Exports account for 95 percent of the total Norwegian aquaculture production, and the fish is exported to more than 130 different countries (FAO, 2019a).

2.2.2 Supply chain structure

The fish farming business is an example of an industry with a complex supply chain with many actors. When discussing the fish farming industry, the focus is mostly on the end-product, the fish. However, there are many stages the fish goes through, including many actors in this industry. Global trade makes seafood moving long distances, in and out of multiple ports, and the seafood changes hands among different wholesalers, brokers, processors, and retailer before it ends up with the end-customer (Sterling & Chiasson, 2014).

Many companies, and especially the large fish farming companies in the supply chain offer products and services in more than one stage of the supply chain and some control the whole supply chain (Fully integrated), while others are only operating in one stage of the supply chain (EY, 2018). The supply chain, as we define it, includes feed, egg and spawn, smolt, sea farming, distribution, primary processing, secondary processing, transport, retail and restaurant, and consumer. (See figure 2)

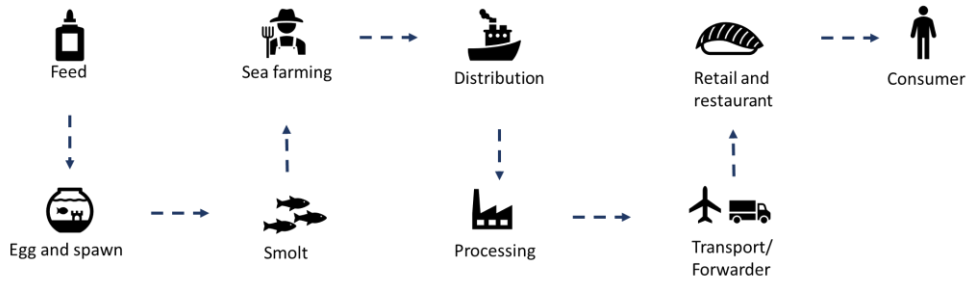

Figure 2 – Illustration of the fish farming supply chain

The production cycle and description of every stage in a supply chain can be found in appendix 10.1

2.2.3 Visibility in the fish farming industry

According to (EY, 2018), the salmon farming industry in Norway has been under pressure to increase its transparency. Food corporations recognize today that traceability and transparency is critical to food safety, risk mitigation, production optimization, brand enhancement and consumer confidence (Sterling & Chiasson, 2014).

Effective traceability in a fish farming supply chain is the ability to identify the origin of the fish and the sources of input materials. It is also to be able to conduct forward and backward tracking using recorded information to confirm the specific location and life history of the fish. Traceability in the fish farming industry is important for the following reasons (Hanner, Becker, Ivanova, & Steinke, 2011; Sterling & Chiasson, 2014; Thompson, Sylvia, & Morrissey, 2005):

- **Consumer attitudes:** There is growing pressure from consumers towards the producers to produce sustainable food. Consumers are interested in third-party certifications that verify that the products are sustainable.

- **Production/Management Tool:** The fish farming industry rely on traceability to improve management and production practices in order to respond to market demand. For these firms, the key driver is increased revenue or decrease costs.
- **Regulatory requirements:** Traceability systems allow fish farming companies to meet general export and production regulatory requirements.
- **Market requirements:** High volume buyers of fish products use rigorous standards for traceability in their business and demand the same from their suppliers.
- **Mislabelled products:** Mislabelling of fish products a common fraud and problem conducted by unethical actors.

2.2.4 Traceability standards and regulations

Today there are many different standards and regulations in the fish farming industry and also many different certifications the companies can have with regards to traceability. Borit & Olsen (2016) follow three main categories of standards: international standards and guidelines, regulatory standards, and non-regulatory standards. Further investigation of different traceability standards can be found in the appendix 10.2.

2.2.5 Benefits of traceability

Research is divided when it comes to determining which are the most significant benefits of improved traceability practices, where some are arguing for business benefits and others for public health and safety benefits. Different benefits of a traceability system are (McEntire, Bhatt, & Group, 2012; Nga, 2010; Sterling & Chiasson, 2014):

- **Recall scope:** Being able to reduce the number of recalled products through more precise data and product tracing practices. If the source of problem and precise batch affected is not able to identify, then the company has to destroy or withdraw all batches as it potentially could be affected (Goulding, 2016). With effective traceability, a company can reduce the costs of withdrawal.

- **Value capture and sustainability:** There can potentially be notable branding advantages by being able to trace products to an accurate source, where a company can validate that the product is sustainable. With better traceability, it will be easier for companies to have control over inventory, improve supply chain management, and have more accuracy, which will lead to increased revenue and reduced costs.

- **Quality management:** An effective traceability system strengthens the capabilities of managing food safety. Food safety problems often originate at other stages in the supply chain than the point where problems are detected (Goulding, 2016). In order to locate the problem, backward tracing going through each stage until the reason for the failure is located is necessary. There may also be necessary to trace forward to identify the actors who potentially have received unsafe products and then effectively report to them about the issue.

2.2.6 Current challenges with the traceability systems

Even though there are many practices and tools for fish traceability, there are still challenges. A gap analysis distinguish traceability related gaps in five different categories: awareness gaps, commitment gaps, technology gaps, standard gaps, and implementation gaps, where the paper will focus on the four first gaps (Olsen & Borit, 2018).

Awareness gaps

There is a lack of understanding of how traceability can streamline companies' internal processes to improve financial performance. There is a lack of understanding of the fact that the main obstacles of adopting traceability in the fish farming supply chain are organizational and cultural rather than technical. There is a lack of understanding that traceability needs to cover the whole supply chain rather than in a specific company alone.

Commitment gaps

While there are still some challenges related to standards, solutions, and technology, most companies have less traceability than they probably should have given their strategy. A sound traceability system can reduce operating costs and

can give a company competitive advantages through branding and marketing. Typically, companies that invest in traceability are required through legal or commercial requirements and are surprised over the positive effects they may not knew existed. The inexperience is a vital explanation of why the industry has a lack of commitment towards traceability systems.

Technology gap

Today there is a lack of procedures for verification, which is integrated in monitoring of products authenticity. This means that even a customer or company can follow a fish product back and forth through the supply chain, but they cannot be guaranteed that the fish is what it is claimed to be. The reason for this is that there has been a lack of cheap, robust, and functional RFID tags. This prevents the introduction of smaller granularity TRUs and makes it expensive to implement RFID. The trend is that prices are decreasing for this type of technology and it will be more accessible and convenient to implement it with time. There has also been a lack of cheap, robust, and functional technology for automatic data capture. A significant cost for running traceability is the manual data entry that is frequently performed, which lead to time-consuming processes and errors.

Standards gaps

There is a lack of standards and norms regarding traceability, and they differ a lot between different institutions. There is also a lack of common standards for information sharing and gathering through the supply chain, meaning that there is lack of interoperability between IT systems across different companies, which increase business risks and costs when adopting a certain traceability system. Another gap is that different countries use different names on seafood attributes, where, for example, different names can be used on the same species, which creates challenges.

2.2.7 Frauds in the fish farming industry

The global fish supply chain is vulnerable to fraud, mainly to mislabelling and species substitution (Reilly, 2018). Furthermore, most of studies are reported from developed countries, and much less is known about fraud happening in developing countries. Different fish frauds happen both in domestic and international fish

supply chains and the cause and motivation is often economic or financial gain, where the effect is a public health threat (Reilly, 2018).

Some of the most common frauds in the fish supply chain includes (Reilly, 2018):

- Species substitution, where a more expensive variety is replaced by a low-value variety for economic gain, or where a high-value variety is presented as a low-value variety to avoid taxes.
- Brand names are fraudulently used on counterfeit products.
- Use of food additives and water to increase the weight of products
- Illegal use of food additives to enhance the visual appearance of fish products.
- Mislabelling of ingredients, such as breadcrumbs and batter, to increase the weight of products that are processed.

The impact of food fraud leads to loss of consumer confidence in the fish farming industry, but also in the government food control programs. It can also damage national reputation with the focus on low safety, lousy quality, and authenticity of foods exported to the global market (Reilly, 2018).

Some significant findings from a major report from Oceana (2016) were that one in five of more than 25.000 samples of seafood tested worldwide was mislabelled and it was found in every stage of the supply chain. Seafood frauds were found on every continent except for Antarctica, and every study found frauds except for one. Around half of the samples substituted for other seafood products had a specific health risk to consumers with the possibility of becoming sick by eating it.

2.3 Blockchain technology

Blockchain was first introduced in 2008, where it was developed by a person or a group of persons called Satoshi Nakamoto as the technology behind the cryptocurrency, Bitcoin (Nakamoto, 2008). To most people, blockchain is known to be a peer-to-peer distributed ledger technology that underpins bitcoin. Blockchain can be regarded as a public and immutable ledger, where all transactions are stored in a chain of blocks, which continuously grow when new blocks are added to the chain (Zheng, Xie, Dai, & Wang, 2016). Definitions of

blockchain technology can be formulated in different ways. Tapscott & Tapscott (2016) define blockchain as "an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value". The most extensive definition of blockchain is (Seebacher & Schüritz, 2017, p. 14):

> *"A blockchain is a distributed database, which is shared among and agreed upon a peer-to-peer network. It consists of a linked sequence of blocks, holding time-stamped transactions that are secured by cryptography and verified by the network community. Once an element is appended to the blockchain, it cannot be altered, turning a blockchain into an immutable record of past activity."*

Blockchain technology goes under the shared term of distributed ledger technologies. A distributed ledger means that the collection of data is shared and not copied, which implies that everyone in the network can see and update the data. The cryptography of blockchain technology makes it possible to keep track of every transaction and offers transparency and accountability of information between parties (Foerstl, Schleper, & Henke, 2017). The tamper-proof system and immutability of blockchain are also one of its main properties, which will be discussed in the next section. These applications allow buyers and sellers to enter direct relationships with each other based on a mutually agreed set of rules and enables trust without having to go through a central authority.

2.3.1 Structure and architecture

To establish a basis, the authors will present a short introduction to the architecture and technical foundation of blockchain. Casino, Dasaklis, & Pasakis (2019) used figure 3, to describe how blockchain could be considered as a set of interconnected mechanisms which provide specific features to the infrastructure.

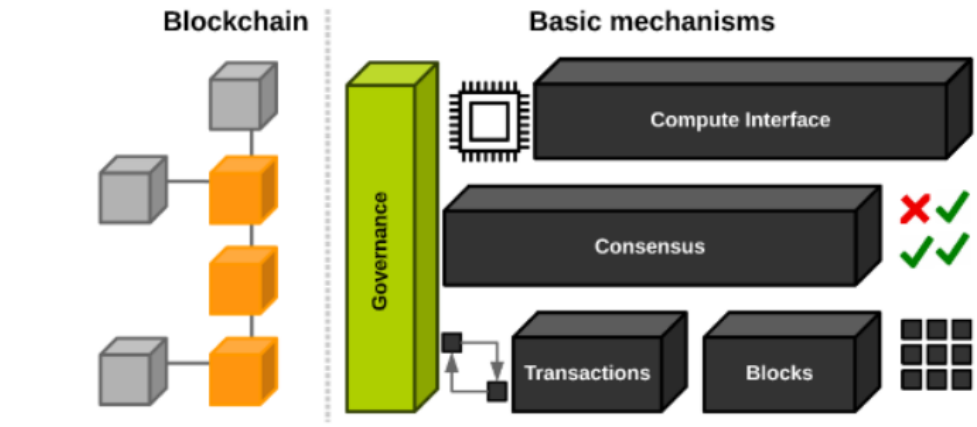

Figure 3 – An overview of blockchain architecture, (Casino et al., 2019)

Blocks and transactions

A blockchain contains a set of blocks, and every block contains a hash (input of letters and numbers into an encrypted output) of the previous block, which is creating a chain of blocks from the first, also called a genesis block, to the current block (Novo, 2018), where these blocks consist of transactions. A transaction in the blockchain is a "transfer of values between different entities that are broadcast to the network and collected into the blocks" (Novo, 2018, p. 2).

In the first layer, we have transactions between peers. These transactions mean that there is an agreement between two participants, where the value of transfer may be of physical or digital assets, or it could be the completion of a task. The requested transaction is broadcasted to a peer-to-peer network consisting of computers, known as nodes, which have to validate the transfer (Dasaklis, Casino, & Patsakis, 2019).

Consensus

The validation takes us to the next layer of the infrastructure, consensus, where nodes must reach an agreement on which transactions that must be kept and validated in the blockchain. We have different security measures which may be used to verify transactions within a blockchain system, the most known approaches to reach a consensus today is Proof-of-work and Proof-of-stake (Zheng, Xie, Dai, Chen, & Wang, 2017). Having a good consensus algorithm means better efficiency, safety, and convenience, nevertheless, which consensus an organization should choose is heavily dependent on the use case (Zheng et al., 2017).

The upper layer, compute interface, allows blockchains to offer more functionality to the system (Casino et al., 2019). In this part, blockchain stores information on all the transactions that have been made by the users. For more advanced applications, we need to store complex states which are dynamically changing, which means that the state shift from one to another once specific criteria are met (Casino et al., 2019). These applications have given rise to smart contracts.

Smart contracts are according to Iansiti & Lakhani (2017), maybe the most transformative blockchain application, which could dramatically change how organizations work. The authors state that smart contracts can automate the transfer of currency or other assets when the negotiated conditions are met, as for example when a shipment is delivered and verified, the contract will automatically enforce payments.

Lastly, we have the governance layer which extends the blockchain architecture to cover the human interactions taking place in the physical world. Blockchain protocols are affected by inputs from different people who integrate new methods, improve the blockchain protocols, and patch the system (Casino et al., 2019).

Tokenziation

In blockchain systems monetary values are called tokens and as stated by Nakamoto (2008), these are important building blocks for the technology. With the term tokenization we have a method to convert rights and value of an asset into a digital token. Blockchain technology turns assets into a digitally encoded tokens that can be registered, tracked, and traded with a private key (Francisco and Swanson, 2017). This means that everything of value can be uploaded as a digital object in the blockchain system.

2.3.2 Characteristics of blockchain technology

Blockchain is a relatively new technology which still has its limitations towards technical and governmental aspects to be fully adopted in industries. However, the underlying characteristics of the technology behind blockchain can be examined. The literature review by Seebacher & Schüritz (2017) identified several characteristics that describe how the technology function. They managed to

identify two major features, trust and decentralization, with three sub-characteristics within each. (See figure 4)

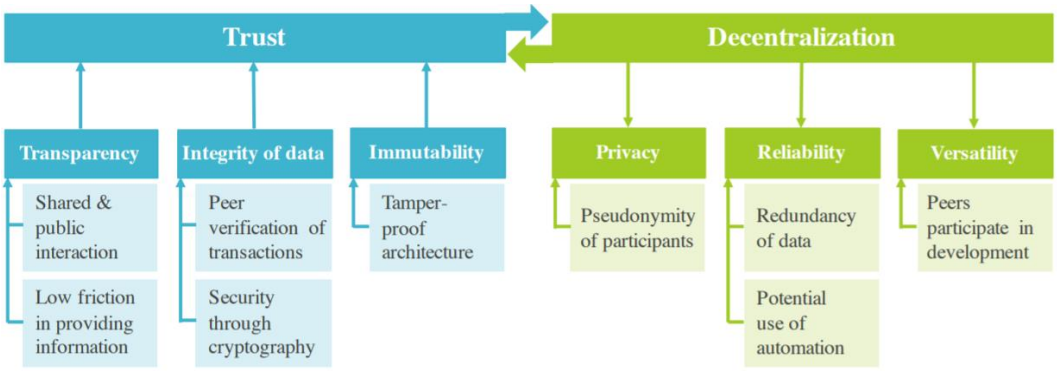

Figure 4 – An overview of blockchain characteristics, (Seebacher & Schüritz, 2017)

Decentralization

Decentralization means that in a blockchain transaction system, each transaction does not need to be validated through a central trusted agency, e.g., the central bank (See figure 5). This implies that third parties, which are resulting in higher costs and performance bottlenecks at the central servers, is no longer needed (Zheng et al., 2017). It is here consensus algorithms used to maintain data consistency in a distributed network (Zheng et al., 2017). For an entity to operate in a decentralized network, an organization would be issued a digital identity that it could use in all business interactions. The identity would have all relevant credentials attached to it, allowing the businesses to interact with other potential business partners freely (World Economic Forum, 2019). Blockchains decentralized structure can be discussed using the terms privacy, reliability, and versatility (Seebacher & Schüritz, 2017).

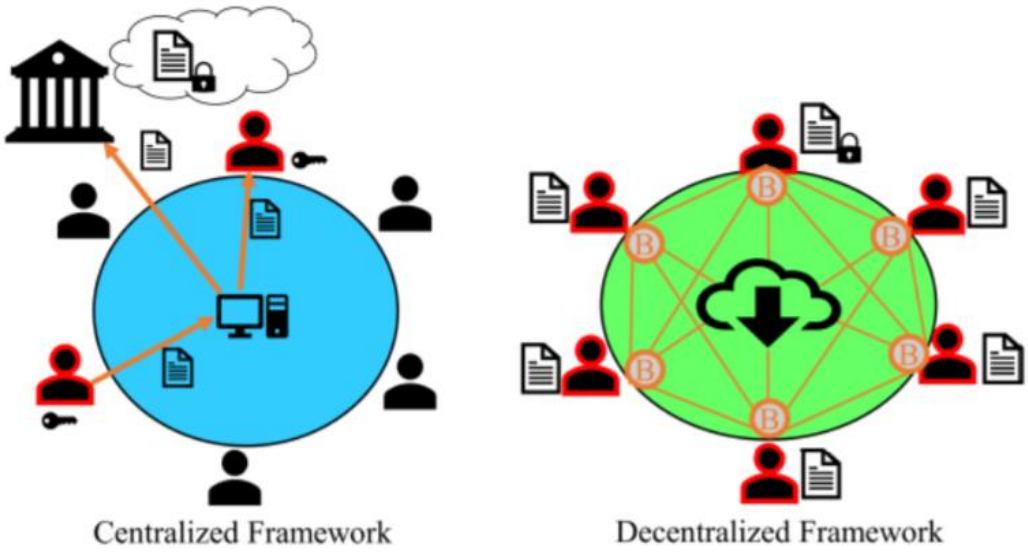

Figure 5 – Centralized versus decentralized framework, (Puthal et al., 2018)

Privacy

According to Zyskind & Nathan (2015), personal data and sensitive data should not be trusted in the hands of third-parties since they are susceptible to attacks and misuse. They suggest that users should own and control their data without compromising information security or limiting authorities' ability to provide personalized services. With a decentralized platform, laws, and regulations about collecting, storing, and sharing sensitive data could be programmed into the blockchain itself. Furthermore, could the blockchain ledger act as legal evidence for accessing data, since it is tamper-proof. Seebacher & Schüritz (2017) imply that the pseudonymity of the participants will increase the privacy of people, companies, and organizations.

Reliability

There were identified two different characteristics of reliability. Firstly, we have the redundancy of data, which means that information of transactions is shared and stored throughout the network (Sharples & Domingue, 2016). Secondly, will the potential use of automation provide reliability, which will reduce individual mistakes as there is little need for manual intervention (Guo & Liang, 2016). One of the most beneficial automated application of blockchain is its ability to provide a global computational infrastructure, which facilitates, smart contracts.

Versatility

The popularity of cryptocurrencies in recent time has highlighted the versatility, and applications of a decentralized system can involve peers to participate in the development of the blockchain structure. Blockchain technology facilitates the creation of an open and versatile system by enabling its participants to integrate their programs, develop and distribute their own code, thereby shaping their environment (Ølnes, 2016).

Trust

Blockchains other primary characteristic is the ability to provide trust in business environments (Seebacher & Schüritz, 2017). In the traditional business models participants who do not trust each other need to have a mediator or agree on a third party which can be trusted by all actors (Weber et al., 2016). Trust is a crucial element of blockchain technology, but not between the participants and companies involved, but of the information integrity contained within the blockchain (Francisco & Swanson, 2018). The enabled trust organizations get from blockchain will decrease the need for intermediaries and labor intensive audit, thus minimizing errors and unnecessary cost. Blockchain can replace this trusted third party, by its characteristics of transparency, the integrity of data, and immutability (Seebacher & Schüritz, 2017).

Transparency

The transparency of blockchain comes from the fact that the transactions and holdings of each public address are open to view from the whole network. Firstly, Seebacher & Schüritz (2017) discuss that blockchain technology enables its participants to establish a shared and public relation. The phenomenon where participants have full disclosure on activities and transactions in the database has not existed within financial systems before (Garman, Green, & Miers, 2014). Secondly, blockchain facilitates the process of checking creditworthiness, which results in reduced friction and increased transparency (Morabito, 2017; Seebacher & Schüritz, 2017).

Integrity of data

One of the main advantages of blockchain is that it guarantees the integrity and non-repudiability (the assurance that someone cannot deny the validity of something) of all the transactions registered without the need of a trusted entity

(Cucurull & Puiggalí, 2016). Seebacher & Schüritz (2017) found the characteristic of the integrity of data to facilitate trust through the technology's ability to store information on transactions in the database itself. This ability is because direct interaction is secured through public-key cryptography and that through its transparent nature, every user can verify broadcasted transactions based on predefined rules in the blockchain (Delmolino, Arnett, Kosba, Miller, & Shi, 2016). With cryptography, only those parties who have access and keys to specific information on the blockchain can see and verify the data.

Immutability

The transactions in blockchain are immutable, within a sequence of blocks and in a distributed manner by a set of nodes, meaning that once a transaction is added to a block, it cannot be altered (Cucurull & Puiggalí, 2016). Data information is immutable due to the need for validation by other nodes and the traceability of changes, which allows users to operate with a high degree of confidence that the data is accurate (Abeyratne & Monfared, 2016).

2.3.3 Differences between private and public blockchain

The differences between a private and a public blockchain is essential to define because they have different attributes and a distinction between. To illustrate the differences, six different perspectives developed by Zheng et al. (2016) will be used.

- **Consensus determination and read permission:** In a public blockchain, each node has the possibility to take part in the decision process, and the transactions are visible to the public. In a private blockchain, one entity are adequately controlling the decisions and governance, which determine the final consensus and read permissions for each participant.
- **Immutability:** One of the main principles of a public blockchain is the immutability of the recorded entries (Zīle & Strazdiņa, 2018). Since the transactions are stored in different nodes in the distributed network, it is nearly impossible to tamper or hack the blockchain. On the other hand, private blockchain could be reversed or tampered.
- **Efficiency:** Regarding transaction efficiency, it is more efficient for organizations to integrate existing enterprise systems with private blockchains rather than public blockchains, which concerning the number

of transactions it can process 3–20 transactions per second (Xu et al., 2016). It takes plenty of time to propagate transactions and blocks as there are a large number of nodes on a public blockchain network. With fewer validators, a private blockchain is more efficient (Morabito, 2017).

- **Centralized:** The main difference between the two types of blockchains is that public blockchain is decentralized, and private blockchain is centralized as a single group controls it.
- **Consensus process**: Everyone in the world could join the consensus process of a public blockchain. Different from a public blockchain, a private blockchain is permissioned, and one node needs to be certificated by the controlling group to join the consensus process.

Well-known implementations of public blockchains include Bitcoin, Ethereum, Litecoin and in general, most cryptocurrencies. One of their main advantages is the lack of infrastructure costs, where the network is capable of maintaining itself, which drastically reduce the management overheads (Dasaklis et al., 2019). It is vital to mention that public blockchains do not mean that all data is public, but the platform is open and free for everyone to join. In private blockchains, the main applications are database management, auditing, and performance demanding solutions (Zheng et al., 2016).

2.3.4 Blockchain and supply chain visibility

Blockchain use cases for logistics and supply chain management (SCM) have emerged in the last years. However, a study by Kersten et al. (2017) on trends in logistics and SCM, blockchain is only known to some logistics experts and even fewer pursue implementation plans. Furthermore, Hackius & Peterson (2017) found blockchain to be used in logistics and supply chains to decrease paper workload, identifying counterfeit products, facilitating origin tracking, and operate the IoT devices.

Blockchain alone will not support full visibility in supply chains. The control of an asset may be achieved using tracking technologies like RFID, sensors and other IoT devices (Francisco & Swanson, 2017), or human activities, to connect and gather secure information to all actors and stakeholders concerning a supply chain. Blockchain technology can turn assets into a digital token (Francisco and

Swanson, 2017), which is a crucial step to acquire end-to-end visibility in a supply chain through the technology.

Today, most of the information from each actor in the supply chain is gathered in data silos. According to Tian (2017), will the change from storing data in local silos to storing it in the blockchain network, where all the information of the products can be stored in a shared system for all the members along the supply chain.

Today customers demand more information about the products they purchase, including supply sources and complete history. According to Francisco & Swanson (2017), is this requirement often too challenging to meet, costly, and in some cases, impossible given traditional supply chain information technology. However, the authors state that blockchain technology could provide a level of supply chain transparency that allows supply chain executives to obtain the information consumers are demanding and thus contribute to their companies' competitive advantages. One example that could occur in the fish farming industry is how consumers often want guarantees that fish consumed are not farmed using illegal netting practices or from closed waters (Earley, 2013; Francisco & Swanson, 2018).

The characteristics of blockchains make them uniquely suited for traceability applications in the supply chain (Francisco & Swanson, 2018; Tian, 2017). Blockchain can provide trusted information in the entire food supply chain with full end-to-end traceability, which could effectively guarantee the food safety, by gathering, transferring and sharing the authentic data of food in production, processing, warehousing, distribution, and sellers (Tian, 2017).

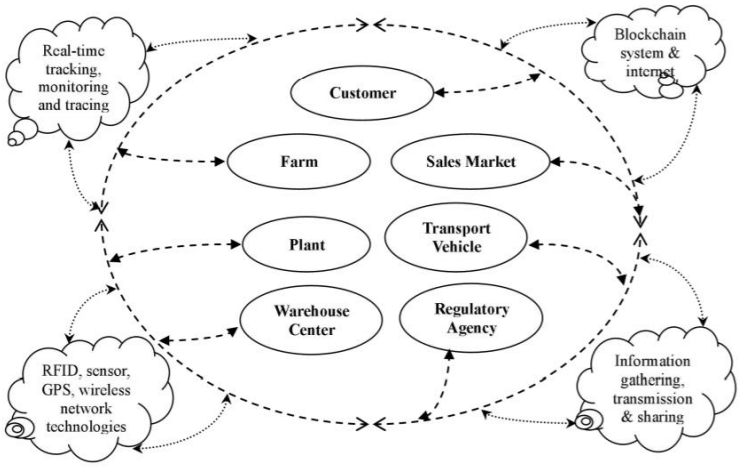

Figure 6 – Traceability system based on Blockchain, (Tian, 2017)

A traceability system based on blockchain technology could solve issues of a centralized system (See figure 6). In this system, governments, departments and regulators are only some normal nodes of the system, just like all the other members of the system. (Tian, 2017). However, they will have the responsibility to inspect the authenticity of the information uploaded by supply chain members. By using IoT devices & blockchain technology, this new decentralized traceability system could become a disruptive innovation which could increase the supply chain visibility (Tian, 2017). With real-time tracking with the possibility to strengthen the information credibility, and consequently enhance the safety assurance of the agri-food supply chain, the opportunities for a competitiveness is highly present.

Advantages of blockchain combined with traceability system

- **Tracking and traceability management:** Moreover, relying on the blockchain system, all the information of the agri-food in the supply chain is transparent and open. Thus, companies could implement real-time tracking for the agri-food product (Tian, 2017). A supervision regulator could execute traceability management and responsibility investigation for a defective product, and the consumer could obtain the full information of the products in the entire agri-food supply chain. Blockchains can also be used to record ownership transfers to be maintained for each asset in the pipeline (Abeyratne & Monfared, 2016).
- **Reduction of agri-food losses and logistics cost:** Integrate upstream and downstream enterprises and improve the information acquisition and sharing degree in the supply chain by establishing an agri-food supply

traceability system can enhance the agri-food logistics efficiency and remarkably reduce the loss and logistics cost (Tian, 2017)

- **Enhanced credibility of the agri-food safety information:** Supply chain traceability systems are all based on the idea of using a centralized system with the government department or a third-party organization to achieve information transparency along the supply chain (Tian, 2017). A new traceability system which contains blockchain technology removes the need for a trusted centralized organization and provides an information platform for all the members in it, with openness, transparency, neutrality, reliability, and security (Tian, 2017). End-users have more confidence in the information they receive since no entity can arbitrarily change the information contained within the blockchain (Francisco & Swanson, 2018).
- **Reduction of counterfeit and shoddy products:** Whenever goods and related documentation as bills of lading or ship notifications, transfer from one actor in the supply chain to another, items are subject to counterfeiting or theft. To protect from this, blockchain technology involves the creation of a digital "token," which is associated with physical items when they are created. The final recipient of the item can then authenticate the token, which can follow the history of the item to its point of origin (Francisco & Swanson, 2018). By using blockchain technology, all the members in this system are unable to manipulate food information, which further increases the safety and quality of the product.

Barriers for blockchain adoption in supply chains

Successful implementation of blockchain technology to manage supply chain processes and products through the pipeline begins with the identification of challenges and barriers (Saberi, Kouhizadeh, & Sarkis, 2018). Supply chain partners need to understand and plan for the listed barriers below for blockchain technology adoption. Saberi et al. (2018) found four main categories to examine barriers for blockchain adoption in supply chains; intra-organisational, inter-organizational, system-related, and external barriers.

- **Intra-organisational:** These set of barriers comes from internal activities of organizations. Lack of knowledge and limited technical expertise on how to use blockchain is key barriers that stems from this category (Saberi

et al., 2018). Although blockchain is one of the biggest buzzwords today and there is growing interest about blockchain in the technical market, the limited number of applications and technical developers of blockchain is an issue (Mougayar, 2016).

- **Inter-organisational:** This category mainly identifies supply chain partners' relationship barriers. Relationships between partners could be challenging, especially when it comes to integrating new information technology (Saberi et al., 2018). The hesitation to share information with some partners may hinder the successful implementation of blockchain. Because of the characteristic of transparency that comes with the technology, it is important to develop and define information sharing rules and policies within the supply chain network (Saberi et al., 2018). Another obstacle within this category is to get every actor in the supply chain to join the blockchain network, and implement other technologies which facilitate tracking and transparency.
- **System related:** This category implies barriers related to integrating blockchain technology, but also in order to implement the technology for supply chain purposes other and new IT tools are needed (Abeyratne & Monfared, 2016). Another barrier is the immaturity of the technology, where it is in the early development stages and considered an immature technology in terms of scalability and handling a large number of transactions (Saberi et al., 2018; Yli-Huumo, Ko, Choi, Park, & Smolander, 2016).
- **External barriers:** The last category includes challenges stemming from external stakeholders, industries, institutions, and governments. The biggest concern is governmental regulations and laws, which are still unclear on the usage of blockchain technology (Saberi et al., 2018). Saberi et al. (2018) suggest that governments, NGOs, industries, communities, and professional organizations should promote how blockchain technology can create value to make businesses more aware about the properties and use cases for the technology.

2.3.5 Enterprise systems and blockchain adoption

A study from Korpela, Hallikas, & Dahlberg (2017) investigated how the adoption of blockchain technology could accelerate B2B Digital supply chain

integration. They found that critical functionalities in today's enterprise systems with intermediaries and banks lacked "standards, timestamping of transactions, monitoring and tracking of information flows and secure end-to-end delivery of information," that could be solved by blockchain.

Morabito (2017, p.125) defines enterprise systems as "large-scale application software packages that support business processes, information flows, reporting, and data analytics in complex organizations." Enterprise systems have been vital for businesses in the area of globalization and digitalization and helped to bring more accessible data for analytics, planning, and maintenance. According to Shang and Seddon (2002), enterprise resource planning (ERP) is the most crucial class of enterprise systems. ERP software "integrates management information and processes, such as financial, manufacturing, distribution and human resources, to enable enterprise-wide management of resources" (Shang and Seddon, 2002; Morabito, 2017). However, according to a report on ERP systems by Panorama Consulting Solutions (2017), only 26 percent of the respondents were satisfied with the ERP vendors and their software. Furthermore, is warehouse management system (WMS), customer relationship management (CRM) and manufacturing execution systems (MES) essential enterprise applications. In general, enterprise systems have been bringing all business processes together to improve collaboration within the business units and the whole supply chain, where it has helped companies to make data-driven decisions and advance productivity.

Several organizational benefits can be identified to merge enterprise systems with blockchain technology.

- **Reduced errors in manual data entry:** More automated data entries, which will reduce human errors and staff will have more time to focus on customer needs.
- **Data archiving:** All enterprise systems mentioned above build, track, purchase and ship products. With the integration of blockchain, a copy of this information can be tracked and used for reference at any time (Infosys, 2017). Blockchain can be used as a data archive, which will allow any nodes to validate the authenticity of the archived data without relying on central authority (Morabito, 2017).

- **Consensus and better verification:** This implies business rules will be complied with, through the validation of business processes and transactions by applications and algorithms added to the blockchain network as well as the enterprise systems. If one application is not made correctly, the others will be notified, and without a consensus, the transaction will be cancelled (Morabito, 2017). The integration with ERP, WMS and MES systems will reduce disputes and bring transparency of the origin, movement, and possession of goods (Infosys, 2017)
- **Smart contracts for automatic procurement:** Adoption of blockchain technology has the advantage that it can release funds in transactions only when certain conditions are met (Morabito, 2017). This gives the opportunity of connections between procurement, accounts payable and payments, with the chance to discover inefficiencies, double-payments, and prevent frauds.
- **Decentralized B2B Auditing:** B2B exchange models are one of the core activities of modern trade, where the essential features are auditing, reconciliation processes, and transaction tracking. "Using the blockchain, each party at both endpoints in a B2B process could independently verify and track the events related to a B2B transaction without the need to rely on a centralized authority that might not be fully trusted" (Morabito, 2017, p. 137).

When implementing blockchain in any enterprise systems, the adoption should focus on disrupting the incumbent system as little as possible (Morabito, 2017). To facilitate this, one should harmonize the blockchain technology and the enterprise system to complement each other.

3.0 Research methodology

In this section, the authors will elaborate on the methods used, why they were used, and how the methods were conducted. The agenda will be to discuss the research strategy and design, the methods applied in order to collect data, and how the data was analysed. Lastly, will a review of the quality of data be addressed.

3.1 Research strategy

According to Bryman & Bell (2015), a research strategy is a general orientation to conduct business research. A qualitative method has been chosen and emphasizes words in the collection and analysis of data (Bryman & Bell, 2015).

The analysis based on the collected data were all of qualitative character where the authors sought to get viewpoints from different actors regarding the industry situation, technological solutions and information sharing on today's situation in the fish farming industry. Hence, the authors decided that a qualitative research strategy would be the most applicable to the research. Another argument for using qualitative methods for this subject is that there is not a broad usage of blockchain in industries yet, and it would be difficult to quantify the implications of using this technology.

The objective of the author's research has been to map the visibility in today's fish farming supply chain and find out which potential blockchain technology has to improve this visibility. To answer the research question and to reach the objective, it has been necessary for the authors to get an in-depth understanding of the research area. Therefore, it has been essential to conduct interviews with both actors in the fish farming supply chain and experts in the field of blockchain technology.

The theory distinguishes mainly between two theoretical approaches to research: deductive and inductive. A third approach that has become popular among qualitative researchers is an abductive approach (Bryman & Bell, 2015). Abductive reasoning seeks to turn surprising facts into a matter of course and identify conditions that make the phenomenon less puzzling (Mantere & Ketokivi, 2013). By having an abductive approach, the authors initiated the research by discovering the theoretical scope and reviewing different literature. As the authors continued with the data collection, more information and issues were found relevant, and the authors moved back and forth between theory and the findings to stay flexible.

3.2 Research design

Research design can be defined as "a framework for the collection and analysis of data" (Bryman & Bell, 2015, p. 49). In this research, it was necessary to conduct a detailed analysis of the supply chain visibility where the Norwegian fish farming industry is the scope, which is consistent with the characteristics of a case study. According to Bryman & Bell (2015), a case study is different from other studies because it has focused on a bounded system or situation, an entity with a purpose and functioning parts. This fits well with the author's in-depth focus on supply chain visibility in the fish farming industry. Furthermore, the research questions include words as "how" and why" which favors the use of a case study as a research design (Yin, 2014).

A case study of exploratory characteristics is used to explore situations where the intervention being evaluated has no clear, single set of outcomes (Yin, 2014). The nature of this research is exploratory where the authors are exploring how blockchain technology can improve supply chain visibility in the fish farming industry where the topic is uncertain to the authors as the maturity and adoption of the technology is low. Available academic literature on blockchain technology in the fish farming industry is lacking. Therefore, an exploratory case study is suited for the study.

The authors chose a single case study as the limited time to do the research implied that it would be hard to get an in-depth knowledge of multiple cases, each with its complexity. Therefore, the authors concentrated on the uniqueness of a single case with supply chain visibility in the Norwegian fish farming industry as a focus area. A general supply chain in the Norwegian fish farming industry was selected as the case and not a specific supply chain, as it would be difficult and time-consuming to locate all actors in a specific supply chain and to collect information from them. Since many of the challenges with visibility applies for most supply chains in the fish farming industry, the authors chose a general fish farming supply chain as the case. This approach provides the opportunity to analyse data from multiple perspectives, which will help to create a complete picture and make the results applicable to all actors.

Through contact persons, the authors got in touch with different actors in different parts of supply chains in the fish farming industry. The case was found interesting as the project participants were willing to share information and take time to participate in the interviews, which gave the authors good learning and understanding. The authors access to information from people in high positions, and relevant companies made it possible to represent the characteristics of a case presented by (Yin, 2014) such as critical and representative.

3.3 Sampling

Sampling is about identifying the people that need to be contacted to obtain relevant information and data for the study. Bryman & Bell (2015) propose purposive sampling (non-probability sampling) for qualitative research. This method does not seek to sample research participants on a random basis, but rather select strategic participants related to the research questions (Bryman & Bell, 2015). For the qualitative research, participants who had positions or knowledge on logistics and SCM in the fish farming industry was found to be the main target for selection. The second target group was to locate persons with expertise in blockchain technology, which could comment on the technology and the potential use in the fish farming industry.

Seven interviews with an average duration of 45 min were conducted, with five and two for the fish farming and blockchain experts, respectively. The authors see the sample size in the fish farming industry as adequate to get saturation and generate enough data through conducting interviews with the competent profiles in logistics and SCM in the industry. The authors see the restraints of only having two interviews regarding blockchain technology. However, the low number of interviews can somehow be defended due to the difficulty to find respondents with supply chain and blockchain knowledge or experience. It is fair to say that the authors were heavily dependent on their network to get in contact with the right persons, to gather relevant and useful data.

Identifier code	Expert level	Supply chain stage	Interview date
F1	Fish farming industry	Forwarder	09.05.2019
F2	Fish farming industry	Fish farmer	09.05.2019
F3	Fish farming industry	Interest organization	10.05.2019
F4	Fish farming industry	Forwarder	20.05.2019
F5	Fish farming industry	Fish farmer	27.05.2019
B1	Blockchain	NA	13.05.2019
B2	Blockchain	NA	13.05.2019

Figure 7 – Sampling overview of the interview objects

3.4 Data collection

In research projects, the key point is to collect data (Bryman & Bell, 2015). The literature distinguishes between primary and secondary data, where this paper is based on both. By using both primary and secondary data, the authors can test the findings of the primary research, by analysing secondary data and move back and forth between them in a discussion. Qualitative research methods were chosen in order to collect in-depth primary data.

Primary data

Primary data is when the researcher collecting the data is also conducting the analysis (Bryman & Bell, 2015). Expert interviews have been a central part of the data collection to gain data and information about the fish farming industry and blockchain technology. Primary data will be obtained by carrying out semi-structured interviews to actors in the fish farming supply chain and blockchain experts from the sampling.

A semi-structured interview is where the authors will have a list of questions, but the interviewee has a great deal of leeway in how to reply (Bryman & Bell 2015). The semi-structured form is useful for the paper's purpose, as it provides a framework that guides through the interview process, consisting of several key questions that help to define the areas to be explored. Further, will the form give the authors and the actors in the fish farming industry the opportunity to elaborate on valuable information that may emerge during the interview, or response in more detail. In this way, the authors can add more depth to the exploratory study

by using a semi-structured interview, where new questions can emerge from other questions, or elaboration is needed. The interview will be recorded during the process to ensure reliability, as well as it makes the analysis of the transcribed interviews more readily for the authors afterward.

The semi-structured interview guides are developed (see appendix 10.3) as a structured list of themes to be addressed and questions to be asked during the interview. The guide is determined by questions mainly related to the research topic while avoiding leading questions to give flexibility to the conversation. Two different guides were created to combine relevant questions to the respondent's knowledge area. The first guide was created for actors in the fish farming industry. The objective was to get insight and information on the situation today in the industry, their technological stand, and how the communication and data sharing through the supply chain was perceived, and lastly, a short section on blockchain. The second guide was developed for blockchain experts, where the majority of questions was related to the understanding of the technology, but also how blockchain technology potentially could function in the fish farming industry.

The language in the guide and interview is formulated in the native language of the participants, Norwegian, as it provides a more comprehensive understanding of the question and the subject. In exploratory studies, this will be particularly valuable as it allows the researcher to explain subjects the informant does not understand and ask follow-up questions if there is more to retrieve from the informant. Relatively open questions are used to get a broader aspect from the respondents and follow up questions concerning the topic is also created to ask about important aspects of the primary questions. Every interview was conducted by telephone rather than personal in-meeting interviews. The researchers found this to be the quickest method to administer all interviews based on the geographically spread of the respondents (Bryman & Bell, 2015). Bryman & Bell (2015) also state that the telephone interview is more straightforward to supervise than the personal interview. Further, can rephrasing of questions or elicit of further information from the interviewee when the response is inadequate, be more manageable over the telephone.

Secondary data

Secondary data was gathered from literature containing earlier findings and theories related to the author's research questions. Literature containing supply chain visibility such as supply chain traceability and transparency were gathered. Furthermore, to get an overview over the current situation in the Norwegian fish farming industry with its supply chain (see the appendix 10.1), resources were gathered from relevant institutions connected to the fish farming industry. Relevant information was gathered from Foods and Agriculture Organization of the United Nations (FAO), Norwegian Seafood Council, Marine Harvest's Salmon Farming Industry Handbook and EY's Norwegian aquaculture analysis 2018. The literature on traceability in the fish farming industry was gathered from researchers who had done comprehensive research on this topic. The participation on EY's conference in the aquaculture industry was another way to gather secondary data which provided valuable insight into the fish farming industry. Through the attendance, the researchers got a better understanding of what type of challenges the industry is facing today.

The literature on blockchain technology was gathered from different sources, where data on blockchain structure and architecture, blockchain in supply chain management and blockchain combined with supply chain visibility was collected. In addition to academic literature, project whitepapers and similar documents from blockchain start-ups and consultancy companies were used as resources regarding benefits and limitations of the technology. Further, by attending the Oslo Blockchain Day, it gave the authors valuable information on how companies are working individually with blockchain today, and the authors were able to gather secondary data regarding benefits and barriers of adopting blockchain technology.

3.5 Qualitative data analysis

The collected and analysed data in this study will consist of the interview transcript retrieved from actors in the fish farming industry and blockchain experts and the theoretical background. Choosing a qualitative strategy enables us to examine large volumes of information in the form of the expert interviews (Bryman & Bell, 2015), and then to move back-and-forth between the data collected and the theoretical framework. Hence, this strategy aligns with an

abductive approach. This helped the authors to stay flexible and to secure findings to be aligned with the theory. The abductive approach is also helpful when trying to discover new relationships and variables (Dubois & Gadde, 2002), in this case, the relationship between blockchain technology and the fish farming industry is explored and how it affects the variable of supply chain visibility.

After each interview, the authors interpreted the collected data individually and discussed it to reveal the key findings. When every interview was conducted the process of transcribing was initiated. Transcripts of the interviews will help the authors to do a more thorough examination of what was said in the interview and also to do a repeated analysis of the answers when exploring the findings (Bryman & Bell, 2015). After transcribing the interviews, the authors analysed each other's writings to get a clear picture of what was said in the interviews. Furthermore, the results were extracted from the raw material with the most relevant findings, and quotes regarding the current situation in the fish farming industry and the blockchain experts view on blockchain technology.

The exploratory case design is, according to Yin (2014) appropriate when the existing knowledge base of the "exploration" of the authors is in the early phase, and the available literature is limited. Even though there is limited literature on fish farming and blockchain technology, the theoretical background provided as secondary data is seen as sufficient enough and critical content for analysis and discussion. The exploratory analysis was also seen as a convenient approach for flexibility and make the authors capable of coping with such a sophisticated problem statement.

The general approach for analysing the case study was in line with relying on theoretical propositions (Yin, 2014). The research started with the proposition to investigate how every aspect of blockchain could benefit supply chains in the fish farming industry. However, after the authors had conducted an extensive review, every potential benefit was seen as too comprehensive to be examined. Therefore, the authors decided to narrow the scope of the research and focus on an in-depth analysis of how blockchain can benefit supply chain visibility. In the analysis and discussion, the objective was to gain more knowledge on the current situation in the fish farming industry regarding supply chain visibility. Further was data on the

blockchain and the theoretical background examined to see how it could affect the current situation in the industry.

3.6 Quality of research

Lincoln and Guba (1985) and Guba and Lincoln (1994) suggest an alternative method than reliability and validity to determine the quality of qualitative research. They propose two prominent criteria for evaluating the quality of qualitative research is suggested: trustworthiness and authenticity. Trustworthiness is made up of four different criteria: credibility, transferability, dependability, and confirmability.

Credibility entails the ensuring of good practice and the validation of the findings from the participants in the research (Lincoln & Guba, 1985). To use more than one source of data to study the phenomena to secure credibility, which is called triangulation was used (Bryman & Bell, 2015). The authors used a combination of literature, interviews, and attended conferences of blockchain and aquaculture as parts of the triangulation. The findings from the different sources were cross-checked, meaning the source of data, and each participant was checked against each other to increase the credibility (Bryman & bell, 2015). The interviews were audio recorded, and the participants could be reserved to answer specific questions. The interviewees were informed before the interview that it would be recorded, but that the recordings would be deleted after the research was finish, and all of them accepted to be recorded. They were also informed that their responses were anonymous and that the data collection was in compliance with the General Data Protection Regulation (GDPR). The interview objects were given the questions in advance so they could prepare, and it would limit the author's influence on the participants. This would increase the probability for an open response leading to more credible answers. Further, the authors explained the questions the participant did not understand and asked follow-up questions if there could be more answers to retrieve from the participant.

Transferability is related to whether the findings of the author's research can be used in another context or time (Bryman & Bell, 2015). The authors think that the in-depth analysis that is done with its findings can be useful for other actors and supply chains in different food industries. Even though the focus of the research

has been the specific case with its uniqueness to give new insight, the authors believe that many of the findings could be applicable in other complex food supply chains, as many of these supply chains have similar structures and also similar visibility challenges.

Dependability facilitates trustworthiness through the ensuring of complete records are kept in an accessible manner through all phases of the research process (Guba and Lincoln 1994). The selection of participants, interview recordings, transcripts, and data analysis decisions have been kept secure and anonymous through the whole process using folders with coded numbers. In the presentation of our findings, each interviewee who stated each quotation was given a sector and number code to establish consensus throughout the paper and give transparent research. The authors will argue that the findings in the thesis are consistent with the raw material and repeatable, and if other researchers were to look over the data, they would have come to similar findings and conclusions.

Confirmability is related to that the researchers have acted in good faith, meaning that personal values or theoretical subjectivism do not derive the objective of the study (Bryman & Bell, 2015). All of the interviews were transcribed before they were analysed. Confirmability is increased as the answers from the interviewees are quoted to what was answered through the interviews. However, as stated in Bryman & Bell (2015) is complete objectivity merely impossible in business research. Even though the authors are acting in good faith, without intention, the authors admit that some meanings and interest will somehow influence the study as any other studies. One reason for this is that the authors have a firmer belief in a public blockchain solution, rather than a private blockchain solution.

Lastly, Guba and Lincoln (1994) suggest the criteria of authenticity, which raise a widerset of issues concerning political impact on research such as fairness, ontological authenticity, educative authenticity, catalytic authenticity, and tactical authenticity. For the purpose of this thesis, the authors will describe how fairness and educative authenticity affect authenticity in general.

Fairness represents whether the researchers manage to provide different viewpoints among members of the social setting (Bryman & Bell, 2015). As the

data collection represent participants from different actors in the supply chain of the fish farming industry, interest organization, and blockchain experts, the authors are confident that the research is fair. By having viewpoints from every single actor in a fish farming supply chain, the research would be even more authentic. However, the authors believe that the answers they got represent the industry in a fair matter. Furthermore, the participants answered different questions about how visibility is perceived by the industry as a whole, which gives more authenticity. By interviewing actors with different roles in the fish farming industry, the authors are a better fit to unveil different views on the situation today. A different interview guide is given to the blockchain experts to answer the technical questions regarding the technology. Still, a significant number of questions is highly related to the industry.

Educative authenticity is involving how participants experience increased awareness and respect for the viewpoints of others (Guba & Lincoln, 1994). The author's research will help the actors in the fish farming industry to better understand blockchain technology and how it can improve supply chain visibility. For the blockchain experts and implementers of the technology, the research will give them an understanding of the current situation in the fish farming industry and the potential challenges of implementing the technology. The research provides an overview of the case, and the arguments from both the blockchain experts and the actors in the fish farming industry will give a better understanding of the viewpoint of each other.

4.0 Results

In this chapter, the results will be presented as the contribution from the expert interviews. The results are divided into two parts, where the authors first will include industry findings on the current situation regarding supply chain visibility, technological solutions, and information and data sharing. Further, will the second part display the findings related to blockchain technology in general, in supply chains and opportunities in the fish farming industry. To formulate the meanings derived from the interviews, the decision is to present the findings in a summarized text with associated quotes. The quotes have identifier code F for fish farming participants and B for Blockchain participants. The quotes are translated

from Swedish and Norwegian, which means that the wording of some sentences can be a little bit off.

4.1 Current situation

4.1.1 Supply chain visibility in the industry

In the theoretical background of this thesis, the authors started by introducing supply chain visibility, and since it is the scope of the research question, several questions are conducted to get an understanding of the visibility in the industry today. As mentioned before is increased transparency and traceability stated to be two key factors to improve visibility in supply chains, and answers related to these themes will be presented.

Transparency

When asking how the transparency was perceived in the industry today, many say that it is a two-folded answer. It is clear that everyone knows every player in their industry and supply chain. However, openness is dependent on sharing with either internal or external players. Transparency is argued to be good in the industry by all participants, and some even say it is prerequisite to be successful. However, the digital instruments to communicate and use the information is stated to be insufficient. On the other hand, some participants are arguing that too much transparency leads to decreased competitiveness, and that openness towards external companies such as air freight companies and transportation companies regarding prices, are too sensitive to share. Another finding was that there is a difference in transparency between transporters and air-freight companies in different markets.

> *"The transparency is total, but we lack tools to be able to take advantage of it... Above all, we are far behind in digitalization ... One thing that is very interesting in the overseas market and airfreight is that it is entirely different, there is zero transparency. For exporters in Norway, visibility compared to the transport market in Europe it is like night and day."*- F5

> *"In my opinion, it is relatively open and few secrets. However, when that is said, a supply chain concerning information flow, I do not know if I should say that we are in the Stone Age, but we work very much on*

different fronts, and so far there are very much systems that do not talk together."- F1

"You are open to what you feel you want to be open about, and you are not open to the areas that go directly into your opportunity to make money and competitiveness against other players."- F4

The best way to conclude how transparency in total is perceived by actors in the industry is by presenting a short quote from one respondent.

"It is closed in an open way, or it is open in a closed way, I can say" - F3

When asking how transparency can be beneficial for the industry, many respondents answer that more openness towards operational activities would be very beneficial for the industry. One good example derived from one participant is how to be more open on available transport capacity in the industry. It is stated that the capacity on air freight will decrease relatively to increased production capacity in the coming years, and better utilization of the capacity is needed. Some other participants are also mentioning that more transparency across the industry will give a better foundation for innovation in the future.

"But, it is quite clear that a little more openness will solve several challenges with more efficiency and new solutions. Openness is forming the basis for innovation. "- F3

Another vital topic derived from the interviews is how the participants consider the trust in the industry. Even though the perception of having a transparent supply chain is present, the belief and meaning of trust can be of another character. In this case, trust between actors was perceived to be very high and important in the industry. However, as mentioned in the previous section, some argue that there is a big difference in the European and the global market.

"I live of trust and live by the fact that customers and suppliers believe in what I say. It is clear that it is a small industry by the way, and if you are

busted with your pants down, you will be stamped as one who does not have credibility. So basically, it is pretty good."- F1

"If we cannot trust the people we cooperate with, we have a problem. But it is very simple. If we do not have trust, we find someone else we can trust."- F2

Traceability

Several questions were related to the traceability and conducted to get a clear picture of the total supply chain visibility. In order to present these findings, the dividing on meanings between the forwarders and fish farmers was seen appropriate.

The forwarders are never handling the fish, but store it before they send it with an airplane. These actors are discussing that they can track the fish until it has arrived at their location. They state to have sufficient traceability on their shipments, but that there is an improvement potential in use and adopting of new technology. Moreover, one actor is concluding that the developing of traceability projects are done in closed environments and not shared. Another finding of air freight is that only location of the cargo is traceable, and not the temperature.

"In principle, it is possible for us to track any shipment, assuming that it is confirmed on board an aircraft and that it is confirmed received at the arrival station."- F4

"No, could only trace where the flight was. Often the customers complained about the products have been too hot and stuff like that, then I could rarely tell where that problem was."- F3

The farmers have a different perception of their traceability in their supply chain. Both participants are arguing that they have almost full traceability of their products in their supply chain. However, they say that the tracking is complete on transporters on wheels, regarding the location. However, temperature and delivery time in air freight are still in the development phase. The rise of automation of

capturing tracking information is also confirmed, where most are manually set up today.

> *"We have full traceability of the products… We can follow the products. So that our customers in Spain, when they receive a delivery, they can enter the invoice and see where the fish comes from and what feed it has received, and which way it has taken, whom it has traveled with, what time it traveled, which terminals it was transferred to and such things. However, everything is manually set up."- F2*

> *"More and more is going to be automated, so you need a platform that can handle everything" - F5*

However, one participant is arguing that one of the biggest challenges in the fish farming industry is traceability. Even though you can track where the fish have been in the supply chain, a substantial improvement potential is recognized.

> *"But it is clear that it is traceability in a supply chain. One has to some extent an overview from A to Z, but here one could get much better. There are more and more projects where, for example, a customer who buys fish in a store can scan a QR code to bring up the whole life story of the fish. This is just in the beginning phase, but there you can get better, and it is a part of the supply chain that you have with the entire value chain from the fish is an egg until it becomes food."- F3*

At last, findings related to how the tracking was on the production cycle captured from one participant. The uncertainty on which weight the fish would have after being harvested could be a problem in some cases. For example, when a salesman have agreed on a certain amount of 4-5 kilo fish sizes, and the production batch has mostly 3-4 kilos fish, many challenges occur. It is also a challenge for the forwarder to know what is in the sea, and they can experience significant deviations from their forecast and planned operations. Both argue that new sensor technology could potentially solve the forecasting estimates. However, it could be difficult to implement it in the sea cages. Further, there is a visibility challenge for

the forwarders to know when the inbound transport from the fish farmer arrives at the airport terminal.

> *"It is very difficult to know how much fish there is in the sea cagse. You have had much mortality through the production period, and you may not have 100% correct numbers of what was in the cage when it started, and that it is a huge problem. Here technology can solve a lot."- F3*

> *"But we do not have any traceability on the in-transport. So we are often waiting for fish that is arriving late."- F1*

Lastly, is one finding related to how the companies in the industry do visibility projects in separate and closed environments.

> *"Many companies work on projects, but they work on their own projects. There are not many extensive projects that embrace everyone ... It is a challenge then, there are probably many who work with the same project, but they do not know about each other. "- F3*

4.1.2 Technical solutions and adoption of new technology

The findings argue that there are many different IT systems in use in the supply chain today. Both the fish farmers and the forwarders are using different and more than one type of IT systems today. It is stated that the system Maritech is a widely used ERP system by the fish farmers and a newer popular ERP system called Innova is both a competing and a complementary system. Another ERP system used by the fish farmers is Navision, and there are also many other small systems that interact with each other. There is a consensus from the actors that there are cumbersome IT systems in the industry today, and in some cases, there are also many different system solutions within each company that makes it more complicated. It is confirmed that actors are lagging behind on the technological level they desire to possess.

> *"... a company have many different system solutions that do not speak together"- F3*

"We share the same feeling (cumbersome systems)"- F5

"But what we see here at work is that we have to take 5-6 steps before we are where we want to be."- F5

IT Integration through the supply chain

Another essential topic derived from the interviews is how the participants consider the integration of IT through the supply chain, and it is confirmed that different actors in different stages use different systems, which makes the integration harder. It is stated that it is hard to get comprehensive IT solutions for the industry as it is global, and there are different levels of technological competencies around the world. Further, it is argued that entries are done manually, and the same information is typed many times from different actors in the supply chain. Furthermore, it is stated that Excel is the most used IT tool for collaboration in the supply chain.

"My customers and my suppliers and myself are punching the same information. Of course we want to avoid it."- F1

"It's so banal that we and our competitors use different article numbers on the same product."- F2

"The IT infrastructure in our industry, the industry as a whole, is fragmented. An update at one location does not automatically transfer data to another location, usually."- F4

Experiences and attitudes with implementing new technology

When asking about their previous experiences with implementing new technology, many had mostly positive experiences, but there were also some negative. The negative experiences were when for example coworkers who were used to work in a certain way and had to do things differently, which created a negative atmosphere and it was even worse when the system had different errors and did not work as it should. On the other hand, the positive experiences are when the implementing of IT systems leads to efficiency and function as it is supposed to. A forwarder experienced the technology implementation often as

more directed toward economic parameters rather than business parameters, and tended to give strong incentives to the top management.

> *"It has been exclusively positive and not at least necessary. We have to improve to keep up with technological development."- F1*

> *"The negative is, indeed, colleagues' attitudes or ability to change in ways of working ... Very important that new systems are well tested and work so that one gets a positive flow."- F2*

Previous experiences with technology and technology implementation often affect an actor's attitudes. The findings showed that participants were positive towards adopting new technology. Many want to be assertive and be the leading actors on digitalization, but there are some barriers with the cumbersome systems mentioned earlier. It is also revealed from the interviews that there is some scepticism in the industry as the knowledge is too low.

> *"Innovation has been a key word for us since day one, we are the leader on many fronts, and our ambition is to become a leading force in supply chain and digitization."- F5*

> *"It is straightforward, the sooner, the better and it is about to stay in there and preferably to lie a little ahead."- F1*

> *"We are very assertive about it. We want new technology. But of course, we have some bottlenecks in the system like everyone else."- F2*

> *"Sceptical, because the knowledge is too low. You need good salespeople to sell in a new system and the users have to know that it works."- F3*

Solutions for product tracking

The findings argue that there is a rise in technological solutions for product tracking in the industry today. The participants talk about sensor technologies, RFID, cooling labels, GPS-based systems, track and trace systems, and cameras.

"We are working with some freight forwarders to implement RFID, where we try to get the technology into the labels. At pallet level in the first place, because the cost is a little too high at the moment."- F5

"We do not have RFID, we do not use it. But we can follow the products."- F2

"From our biggest transporters, we have access to their track and trace system" - F2

"As of today, there is mostly online tracking. However, now, there has come up technology with tiny GPS trackers that also log temperature and humidity. There is also labels to mark the goods with the same opportunities and characteristics as the GPS trackers. It is working a lot on tracking, and version 2.0 is released as 1.0 has started to be put into use."- F1

4.1.3 Information flow and data sharing between actors within the supply chain

To facilitate supply chain visibility, you need good technological solutions, and a good information flow and data sharing between actors within the supply chain. The information flow is stated by almost all participants to be relatively good in the industry. The information is often visible in excel files and shared google docs documents, and some also said that telephone and mail were used for specific clients. However, some states that the systems could be improved and as mentioned before the system set-up is too cumbersome.

"So I choose to say that it is relatively good, but it will not be perfect before the systems interact and we can get rid of the manual punching."- F1

"It works, we make it happen, we deliver the goods. In that way, it works, but of course, there could have been better systems that solved it in a better way."- F2

Furthermore, was one participant, mainly stating that the information flow between transporters is chaotic. To solve some of the issues, they have started a project based on implementing a WMS system. With this system, they want all communication to be logged in one channel or system. With this system, the organization will be more efficient to track down and analyse deviations in the supply chain, instead of going through logs in various channels.

Even though the information flow and data sharing are seen as sufficient enough, it does not mean that the actors can analyse and use the data they have in their disposal. Asking if they could use the data to improve and maintain processes in the supply chain today, the answers are that someone can use some of the information, while other cannot use it for any value-added purposes. However, almost everyone argues that there is a vast potential in improving data analytics and how they use data today. Some actors also state they have initiated projects towards this subject and have some beneficial methods, especially to find deviations on processes.

> *"I think there is endless potential in streamlining and analysing and coming up with new methods on already existing data that you are not aware of."- F3*

> *"If we have problems with fish arriving at a given destination in a much poorer condition than usual, then we can use sensor technology to track if there are large temperature fluctuations at a given point in the chain up to that destination. It is a typical example of how we use data and IT solutions to solve problems and maintain product quality."- F4*

The last stage in the supply chain and probably the actor with the most power in the pipeline, the end-consumer, is getting more demanding. In the context of this study, it was essential to get information on whether the end-consumer would have interest of full visibility on how the fish was produced and handled from production to end-point. There is an agreement that this is important today, and will probably be even more widespread in the future. On the other hand, is one participant discussing that there is an expectation that products in Norway have good quality, and after running a project with QR-code on products, it was not

used frequently. However, it is also stated that the demand for this will vary between different parts of the world, where there are lower trust and more scepticism towards the food suppliers.

> *"You are not able to sell the fish without referring to traceability. You may not be able to sell a box of fish from a sea cage if you do not have traceability on that fish from hatchery to delivery."- F1*

> *"Authorities have already begun to impose strict requirements on Norwegian seafood products, and this also applies to other countries. There is much more awareness at the level of the authorities, but this will, over time, also reflect down to the consumer level." - F3*

> *"No, I do not think so. I think it has become more a requirement that it should be in order. An expectation of that everything is in order. If you go to the store and see a package of fish in the store, then you expect it to be safe."- F2*

Many good examples emerged through the previous question on why consumers and other stakeholders are starting to be more curious about what processes have been done to get the fish to the dinner table.

> *"Yes, I think it will be more important. What you see now is that fish goes to China, then they get stuffed full with salt water and other stuff, which is usually to get the weight of the fillet to be heavier, but there is no more fish meat, there is water. And then it is sent back to Europe. Thus, the quality of the fish is deteriorated. From an environmental perspective, it should be sustainable, and I believe that the general consumer is becoming more and more aware of what he eats and where it comes from. Especially when it comes to seafood because those who eat much seafood are also a more conscious consumer."- F3*

Lastly it is stated that it is important for the actors to be able to provide good quality products, and that the value of the fish product is connected to the ability of keeping it fresh and in align with cool chain compliance.

"We work mainly with quality, but it is clear that all markets consist of quality, price, service. You must have a competitive price, you must have a competitive service and most of all you must have quality. Because it is an area where we move quite large values. The kilo price of salmon is quite high. A large salmon shipment has quite a great value. The value in itself is related to the freshness and what they call "cool chain compliance" on the movement from fish from A to B. I would almost say that quality is the most important component of them all."- F4

In figure 8 the four most relevant findings within each topic is summarized to get an overview of the current situation in the fish farming industry.

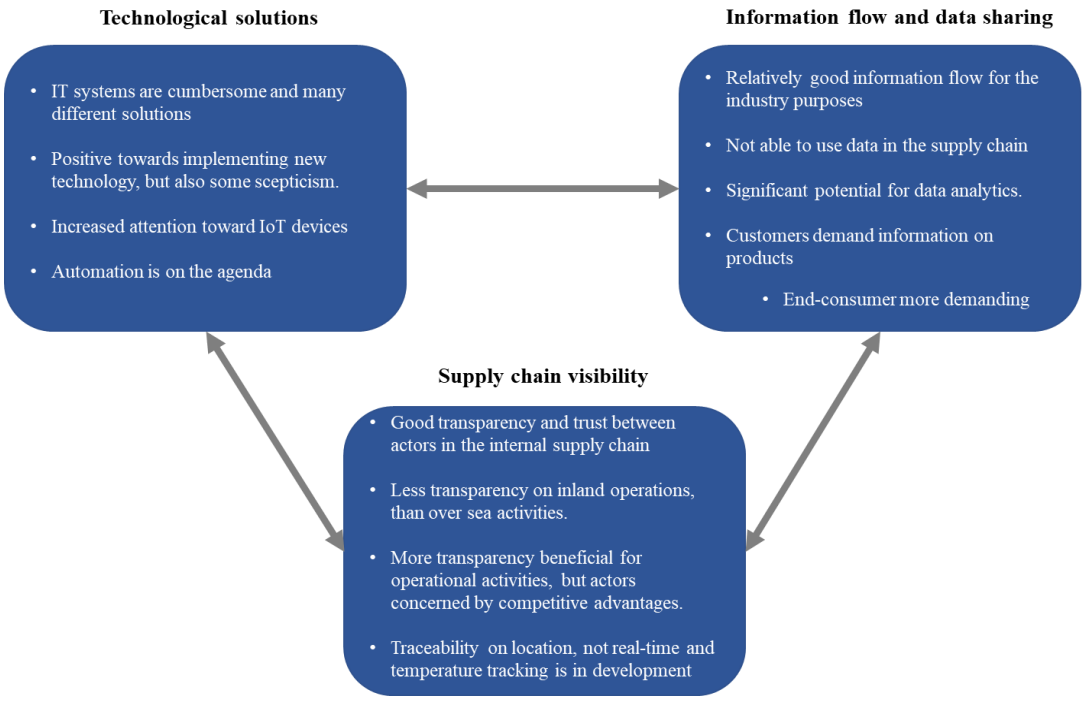

Figure 8 – Key findings retrieved from the current situation in the fish farming industry

4.2 Blockchain in supply chains and in the fish farming industry

In this part of the results, the presentation of relevant findings of blockchain is necessary for the understanding of the technology. The results demonstrated in these chapters will include experts view on blockchain in general and how it can be used in supply chains and industries today. Lastly, there will be findings on how blockchain could potentially change the dynamics of supply chain visibility

in the fish farming industry. In the last section, the authors have included viewpoints from both interview groups.

4.2.1 Blockchain experts view on blockchain technology

The blockchain experts have a similar description of what the definition of what blockchain is, and are using words as decentralization, immutability, and transparency to describe it.

> *"Blockchain technology is a decentralized and immutable database." - B1*

> *"Blockchain technology is easily told a globally distributed database that anyone can use, but no one owns. It is globally available to everyone, and no one owns it, and no one can tamper with the data. What is stored in the blockchain can be stored forever, and it has, therefore, many helpful use areas"- B2*

According to the blockchain experts, there is a misunderstanding today around the terminology of blockchain. One expert argues that it is essential to know that blockchain is part of and a sub-group of distributed ledger technologies, and in some use cases of blockchain in supply chains today, it is actually a distributed ledger technology and not blockchain. This creates a challenge across governments in Europe when regulators have different expressions of the blockchain terminology.

> *"But then they forget the part where everyone is talking about is the hype around a database, that is precisely the fact that all of the majority of so-called blockchain projects are in reality DLT projects ... one of the significant challenges the authorities are facing is when they for example work on a European level and Norwegian level where they get different reports from both sides."- B1*

Attractiveness of blockchain technology

The experts mention different aspects of blockchain that will be beneficial today and in the future. Both of the experts see the most significant potential in the transfer of value, where it is stated that it will have very positive consequences for

communities where anyone can transfer money quick, safe, and cheap. One expert also elaborates on the underestimation of setting up a database that will give access to different parties. The reason this is an attractive feature of blockchain is that databases today is not able to transfer objects of value between them.

> *"But, today there are no databases in the world that manages to transfer value objects from one database to another, without going through the usual money world and issuing an invoice. So the most significant potential lies in the properties of the blockchain to transfer a value ... it can be anything from a confirmation token to where a product is located, to ownership, to the transfer of value. And that is what is the advantage here and where the full potential is." - B1*

The experts also talk about the benefits of the immutable nature of blockchain and that the information in the blockchain can be used as proof that no one has changed or altered the information.

> *"It is the fact that the information we store in the blockchain network or database is immutable and cannot be changed so that we can use that information as evidence and we can prove when it was stored and prove that no one tampers with the information."- B2*

Both experts explain that there is a misunderstanding about transparency in blockchains, and particularly, in public blockchains. Many actors are sceptic of the transparent nature of blockchain and worried that sensitive information could be open to competitors. Nevertheless, both the blockchain experts are responding to those beliefs with the quotes below.

> *"When it is in the blockchain, it becomes globally traceable by anyone who has access to that information. These 100 kilobytes can also be encrypted, such that no one else can read it, except those you give keys to. So it is as secure as bank transactions on the internet where everything is encrypted so no other than the bank and I can see it. This is often misunderstood when talking about a public blockchain, and it is believed that everyone can see everything, but it is wrong. It is public just like the*

internet, but the information that one does not want others to see is encrypted." - B2

"In Ethereum it is run on an underlying public structure, but you can also limit it to a private access method so you can get someone to see and confirm that you have completed a transaction, but they will not see what is inside the transaction. In the same way that they will access your phone log and confirm that you have called Pettersen, but do not see what you have talked about."- B1

Public and private blockchain

The findings conducted on blockchain technology from the experts are mostly based on a public blockchain solution, as they mostly work on this kind of solution. According to the experts, there are specific differences in a public and private blockchain. It is stated that a group controls a private blockchain, and there could be an individual risk for the actors involved, and one should have high trust in the group that control the blockchain to join the ecosystem. Further, it is found that many actors are claiming to develop private blockchains which the experts claim to be just an advanced database. The experts argue that the distributed public blockchain is the real blockchain, but that in some cases there is a need to limit the access on specific information in the public blockchain.

"We have much more faith in public blockchains, open blockchains, but depending on which use case you must necessarily restrict access to something. So we say we are using public blockchains but on a hybrid structure. We do not use private"- B1

"Private blockchains... and the nodes that exist are then privately owned, so those who own the data have the possibility to tamper with it, this is not possible in a public blockchain since it is distributed all over the world."- B2

Blockchain implementation with current IT systems

The experts tell that there are different solutions on implementing blockchain with IT systems and that it depends on the structure and what you set up, but that they

have good experiences from earlier projects. It is possible to set up a stand-alone solution as a tracking mechanism for example. However, to get the best effect, and as companies often use ERP systems including different functions such as customs declarations and invoices there is a need of a link between the blockchain and the ERP system. One of the experts argues that it is crucial for the customers that they get products that solve their problems.

> *"... then we use a token to transfer values, which can do this in a much faster and efficient and less expensive way than today, and then take a final settlement in ordinary money eventually. This can be done in very simple solutions or in integrated ERP systems."- B1*

> *"It is very important to offer blockchain products that solve problems, and that customers and businesses do not need to become blockchain experts, but rather be good in their own core areas. They should be able to use blockchain technology to help solving their problems."- B2*

4.2.2 How can blockchain improve supply chain management?

Opportunities

The experts argue that there are enormous possibilities for supply chains regarding benefits of implementing blockchain technology. They argue that blockchain can lead to efficiencies like time and costs savings, and to get a better view of the flow of goods. It is stated that information sharing through the supply chain can be improved and actors can get information regarding the location of a product or a truck, and expected delivery time, which will lead to improved planning. They also argue that there are possibilities to create efficiencies by implementing smart contracts. Settlement mechanism will be more productive and will revolutionize supply chains which have a traditional structure with many intermediaries and multiple stages.

> *"So I think we are going to see far more effective settlement mechanisms in the future, for a system that is very cumbersome today, especially in the supply chain which use much shipping which has a traditional structure, with brokers, middlemen, and things need to be stamped. It is going to be*

streamlined in a completely different and revolutionary way that one cannot even imagine today."- B1

"We can also use blockchain technology by using smart contracts, where we can create insurance solutions, we can assure ourselves of different occurrences and secure the economy. There are many opportunities in the supply chain."- B2

Blockchain can also contribute to more efficient data sharing across companies within a supply chain. It will not only transfer the information but also contribute to better planning and forecasting opportunities.

"The big problem today with the supply chain is that it is shared too little information, and companies do not share information if they are not forced to do so. For example, sending of orders and invoices is often done with an EDI today. But there is so much other information that could have been used for other parties in the supply chain, like knowing the planning, knowing the times, knowing which obstacles that can hit. So if my supplier's supplier has problems with something, then I do not know when the delivery is sent to me by the truck, but with blockchain technology my supplier's supplier can sell this information. I could then find out where the truck is, what delivery time is expected, etc. Then I can plan my production much better and become more efficient and save money." - B2

The findings argue that blockchain can facilitate tracking in a supply chain and that the tracking of a product will be more effective than how it is today. Further, the findings argue that to get a more satisfying tracking in a supply chain, blockchain needs to be combined with other technology. Other IoT devices have emerged as technologies that can capture the traceability more efficiently. However, these solutions can not either be trusted completely, where devices can have downtime and system failure.

"But I think that some of the most relevant are and yes in the short time it solves very much, is when Walmart says that it before took them two weeks to track back where a mango came from, but now they can do it in a

couple seconds or minutes. So internal it saves internal working years... but it is not just that easy as saying: yes we put on a sensor because you can rely on a sensor all the time ... a sensor could suddenly not be connected, and then you risk getting a backlog on your blockchain structure."- B1

"It is the piece of information that one can store in blockchain and use for tracking. One can add temperatures or locations or links to more information in a bitcoin transaction. When it is in the blockchain, it becomes globally traceable, by anyone who has access to that information ... You do not need to have other technologies, but of course, it does help. You have to automate as much as possible, and then these IoT devices, machine learning, and big data analytics will be useful. There are no requirements, but it will help to streamline the companies and the supply chain."- B2

Moreover, are one of the experts also arguing that there is nothing that can be verified 100 % as long as humans and machines are involved in the process. Therefore, will the auditing of blockchains be crucial to examine the processes and standards that are done prior to traceability and information capturing.

"It is clearly much more effective than what we use today, but there is nothing that can be verified 100% as long as people or machines are involved. But it can be verified easier and better."- B1

"The auditing of the blockchains is going to be essential in the future, where you can verify that the inserted information is correct or not."- B1

The findings argue that blockchain can create trust between actors as the information in the blockchain is immutable, and no one can change the information. This makes it possible to trust the information in the blockchain and enable the trust to actors you do not know and actors further away in the supply chain. Today the trust issue is solved by involving a third party such as a lawyer or banker and with a blockchain network, there may not be a need for these middlemen.

> *"Then the blockchain technology will be a significant impact on something that can give greater transparency into systems, and in industries where there has been very little transparency."- B1*

> *"It does mean that one can have trust in a supply chain with different players that one does not know, and they can be several steps apart, but one can still rely on the information that lies in the blockchain." - B2*

Barriers for adopting blockchain in supply chain today

The main barrier for adoption of blockchain today is according to both blockchain experts, knowledge from decision makers. They often understand the use-case, cost and time savings, and the market effects, but they do not grasp what blockchain is and which decisions that need to be undertaken. It is also a belief that many actors from different industries are focusing on what their competitors do and takes action subsequently, because of the risk and investment cost. Further, is many uncertain of implications of IT integration, especially regarding time and costs, but both blockchain experts argue that the implementation itself is not difficult and everything is relative to the project area.

> *"I think one of the biggest challenges today is that decision makers do not fully understand what they are going to make decisions for ... That is the most significant barrier now, together with the confusion about private and public blockchains. What is it really, and how does this work? ... technical implementation in itself is not difficult. But everything is relative, and it depends on how much of an ERP system it should be integrated with."- B1*

> *"Simply, the knowledge and incorrect information." - B2*

Another barrier is how the extreme hype from consultants and media, which has driven the expectations of blockchain to transform industries and generate significant results immediately. This barrier is also creating challenges for governments, which also get confused and struggle to create more predictability for industries when developing standards and regulations.

> *"And then there are far too many in the industry that is going around using too many buzzwords and talking about this in a way that does not make it understandable, neither for governments to create any predictability about this. That is one of the reasons why they fail to understand what this is all about, and down to those people who do not really understand what to take a stand for."- B1*

In supply chains in particular, will one crucial barrier be to get members in the pipeline to join the blockchain network, to be able to get full advantage of the benefits that blockchain provides.

> *"In the supply chain part, one is entirely dependent on having a whole network of actors, from freight forwarders, freight authorities, to the Customs and the whole part of the freight companies also, that one has a combination of transparency in there." - B1*

> *"I think it will be to include actors and make them understand how easy it is and the enormous benefits that can come from it." -B2*

4.2.3 Opportunities and challenges of adopting blockchain technology in the fish farming industry

Opportunities

The findings from the blockchain experts argue that there are potential for significant benefits of applying blockchain in the fish farming industry. The blockchain experts argue that many of the opportunities are applicable for most supply chains and industries, but especially for the fish farming industry where the supply chains are complex, with many intermediaries and risks of frauds.

They argue that the fish farming industry is one of the most relevant industries where it would be beneficial with more transparency and a better system and process efficiency. One of the experts argue that it would be cheap to integrate a public solution with IT systems for the fish farming companies, and it does not need to be integrated with an ERP system, it could also be integrated with single systems and make them more efficient. The opportunities already mentioned in

the industry and supply chain section, will also be applicable for the fish farming industry.

> *"It is clear that the aquaculture industry is one of the most relevant industries to be able to achieve better transparency and get a more efficient system and process improvement." - B1*

> *"It does not have to be an entire ERP system, as most companies in the fish farming industry today use very much individual systems, such as Excel and Microsoft. But even in excel and Microsoft, we can easily connect directly to the public blockchain with APIs. And make the systems they have today more effective. A lot of good things can be done there." - B2*

The actors in the fish farming industry have less knowledge of blockchain, therefore, it is interesting to get different views on the potential benefits of blockchain. Findings argue that the industry is new and there are many processes today which could be more efficient with a blockchain solution to be able to be more transparent and open towards relevant actors. Some actors in the industry are more sceptical about applying blockchain technology, but they also see some potential benefits. They argue that safe document handling and safe transactions could be beneficial. One argues that blockchain technology will be attractive on an operational basis with tracking of fish, including information on temperature, where it is located, how old the fish is, and when the fish arrives.

> *"I believe that blockchain is the future in many areas of the fishing farming industry and to develop the industry."- F3*

Further, some actors argue that visibility is a good argument for adopting blockchain. It will be easier to verify which actors that are working sustainable and correctly, and those actors that are not. This will benefit sustainable actors by getting a good reputation and force the actors that are not performing well to do better or disappear.

> *"Visibility in what is happening. Then it will become visible on who is a good actor and who is a less good actor. Those who are less qualified will do what they can to get better. It is the visibility side, and if you can live in the shade of someone, then you will be able to do a lot of strange things. But if you are in the daylight and everyone can see what you are doing, you must do things properly and keep your path clean." - F2*

The blockchain experts are both acknowledging that blockchain could benefit well performing actors in the fish farming industry.

> *"If you are a producer today that produces a sustainable product, then it is tough to prove this to the end-consumers. This is where you can store information about which carriers, how they have their processes, you can store evidence that employees have the right salary, and you can use technology that is popularly called zero-knowledge-proof, which means that you can prove matters without talking about the exact information, where one should prove that the employees have the right level of salary, without saying how much salary they have." - B2*

> *"As long as you manage to get a transparency structure on everything, which people actually trust and are verifiable, it is clear that it is good for corporate governance and business in general. There is no doubt about that."- B1*

One of the main reasons that blockchain will benefit well performing actors is because of the pressing demand from customers and end-consumers to get verifiable and traceable information on the fish they buy. Both experts believe that this will be an exciting field. However, some scepticism is noted towards the statement about customers demand after traceable information.

> *"First, I think we will see a real hype where everyone wants to scan, and then they lose their interest and then the hype goes down again ... But then I think we will see that it is adapted a little better, and then it comes back again to the part where it is get adapted to pure products and get a better track."-B1*

> *"Yes, I believe that. We have no data on it, but if you look in the general public, consumers are becoming more and more interested and demanding ... In a country like Norway, which is a high-cost country, it is important to be able to prove that the products are better, so it is important."- B2*

More visibility and better tracking solutions with blockchain technology will also have the opportunity to increase operational efficiency and give more business value. Both are mentioning how blockchain with other tracking and sensor technology can reduce the waste, frauds, and recalls of fish.

> *"And when you do a TV scan of the fish, you also scan the shell structure of the fish, which means that when you slice up the fish and make fillets, then it starts to be quite interesting when you can scan the fillet and look at the structure of the shells based on the perimeter, which takes a match against the other fillets and sees that the total weight of all these 8 fillets becomes the fish plus the cut, which is enable us to confirm where it comes from, and then down to whether it is a farce product or not."- B1*

> *"This is another great advantage of blockchain, that one can have digital twins and what we call a digital thread, which gives a backlink ... you can transfer that information back to the producer very fast, which gives the producer feedback on the changes they make. So that the producers can streamline and optimize their processes significantly cheaper and more accessible than they do today." - B2*

> *"These digital twins and digital threads will become important, as one can trace the batch exactly back. If a producer should find a fault in a product or a batch, then one can track in real time where the products are located, and directly be able to pick out the exact packages that there is something wrong with, and it is big money to save from this." -B2*

One actor in the industry argues that there is missing visibility on flight freight visibility and that blockchain could enable a better platform with an overview

over all available capacity, and make it easier to book and fully exploit the capacity.

> *"The biggest challenge we want to solve is the visibility on air freight."- F5*

Barriers

The findings argue that there could be some barriers by adopting blockchain in the fish farming industry. Both interview groups argue that lack of knowledge is the most significant barrier against blockchain adoption, which was already mentioned in the previous section. When talking to the actors in the industry, it is stated that blockchain is a broad concept, which has been hyped up for a long time, and it is hard to understand it. Blockchain needs to be explained in a way that people can understand and relate to for comprehension.

> *"I have been to multiple blockchain lectures, and I have gone out of the room many times without being any wiser. Blockchain is difficult, but it is very exciting, much digitization and many platforms are evolving." - F5*

> *"I think there is a lack of knowledge, by not seeing the use of it right away or not having the competencies to see the benefits of it ... People think blockchain is bitcoin, and then you have specific knowledge and information flow that needs to be improved." - F3*

Furthermore, challenges regarding the costs with technology adoption is a concern. To get proper implementation between systems, there is a need for dedication, and costs are a problem that stops development. Especially costs regarding tracking, and that it becomes more expensive the more detailed the tracking is.

> *"If you want to track each unit when it is in the store, then you have to have a sensor on each consumer package, and it will be expensive. If you want to have sensors on a distribution package or a pallet then it will be much cheaper, however, then you will lose the tracing on the entirety and only get track until the pallet that was split."- F2*

Two other impediments towards blockchain are that the technology only will be beneficial for some actors in the supply chain. They argue that the importance of intermediaries could be less influential, while producer and consumer will benefit the most. Another point is that there are different interests and self-interest between the actors, which makes it challenging to implement blockchain technology. Further on, the blockchain experts argue that there has been and are different types of frauds in the fish farming industry today, which some actors want to hide, and therefore it could be challenging to implement blockchain technology as it is against their interest.

> *"Many actors in the various value chain stages have their own interests and want to make money from this. Some would prefer to have time savings and earn money on it, while others would lose money on it."- B1*

> *"Since there are many frauds, and of course they (actors involved) will not show this, the pressure must come from the consumers. If you do not have the right product, you will not be able to sell it either. Today there is very much money to earn on frauds, so it is very often done."- B2*

> *"I think that as an owner of the product, there can be some benefits ... The problem is who is supposed to be a natural participant in that blockchain because an original blockchain should include the producer, the freight forwarder, the aircraft controller, and the buyer as a minimum. It should also include some levels from the government such as VAT and health and that kind of thing."- F4*

The blockchain experts respond to the statement of that the new ecosystem will not be beneficial for every actor in the supply chain.

> *"In a way, is it an ecosystem and the actors will in each their way have an extremely significant benefit from this. But it requires that the entire ecosystems manage to set up a structure for it. So that it is not only the fish farmer that scans the fish, and then the freight forwarder does not care to*

confirm what has happened on the trip down to Asia where the fish is supposed to be filleted."- B1

"There will be even distribution. But, one should start with it and where it is most interesting is about the consumers and supermarket chains ...the pressure will come from them and from the suppliers/producers who have quality products and want to prove that they have it."- B2

There need to be set some standards from either the government or powerful actors with significant impact and influence on the market, to lead the supply chain in the right direction.

"... it should be required from the fish farming industry, that not only the boats should have sensors, but that there should be sensor technology in every stage from the fish farmer to the carrier and in everything that takes place in Norway. Then it will put much pressure on the rest of the industry"- B1

Lastly, the findings from the actors in the fish farming industry argue that there is scepticism towards new technology and many actors are comfortable with the way they are doing their operations today and at the same time are having a good profit. They do not see the value of implementing this type of technology. It is also stated that there could be too much transparency, which could hurt the competitive advantage of companies.

"Many people are generally sceptical about trying new things. But, very many are very comfortable with what they do today and have a good profit on it. Why should they implement something uncertain? It can be a barrier."- F3

"But, how to use a blockchain with that transparency it has as a methodology and at the same time protect your business secrets and specialties ... The problem is that by sharing information freely throughout the chain, you will create financial problems for the players, for everyone, I believe." - F4

To conclude the results, the authors have included the final words one blockchain expert argued for the blockchain implementation in the fish farming industry.

> *"Absolutely, I think blockchain will be important... Clearly, because as how it is today I have understood it from what I have heard from the authorities and other stakeholders, that there is too little transparency throughout the supply chain, and there is significant complexity, and there are substantial inefficiencies in the industry in general, and specifically down to this industry which is food that requires in the vast majority of cases rapid processing in the sense that we are talking about fresh fish. It is dependent on high-speed processing to get the best possible price, and therefore I see it as a top-level area with all the attributes that we can add to this we already talked about with transparency, micro-payments, verifications, and confirmations. But then it is not blockchain alone but in combination with other technology that allows you to get optimal savings and cost efficiency in that area."- B1*

In figure 9, the authors have included the key results that was conducted from the blockchain experts. From these findings three interesting topics on opportunities and barriers were identified for a general supply chain, which thereafter were used to illustrate how they would affect the fish farming industry.

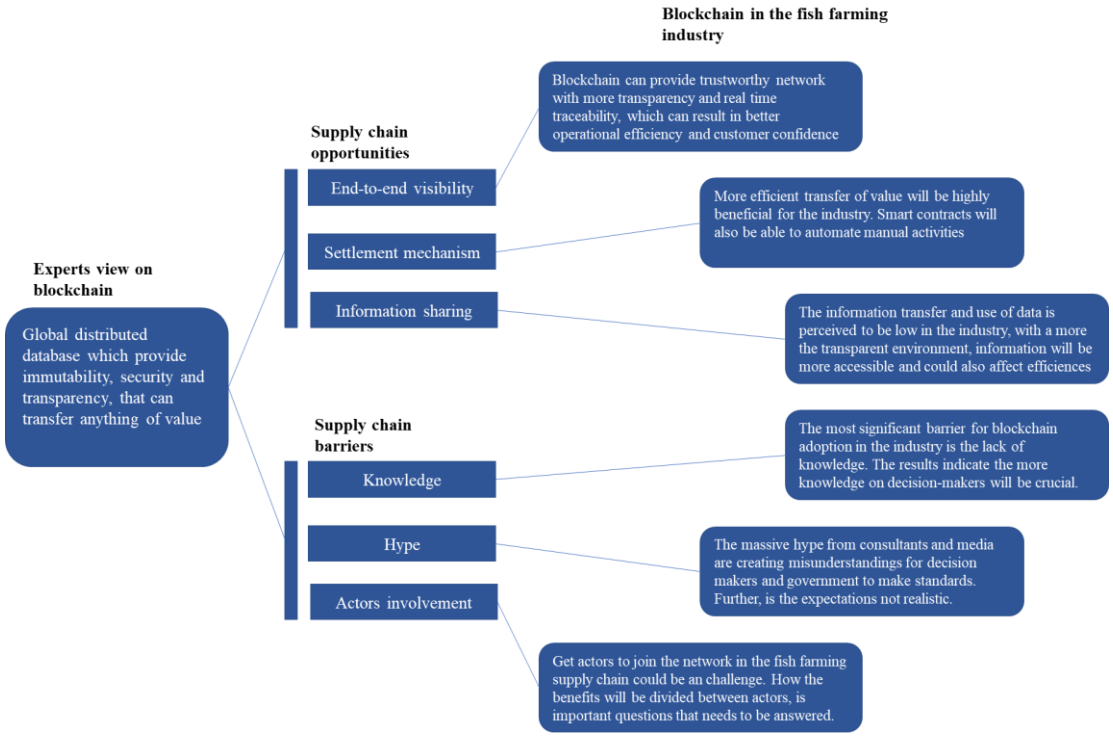

Figure 9 – Key findings on blockchain in supply chains and the fish farming industry

5.0 Analysis and discussion

In this chapter, the analysis and discussion of the results from chapter 4 in relation to the theoretical background from chapter 2 will be presented. Combining the most relevant findings and results from these chapters will help the authors to answer the research question, *"How can blockchain improve supply chain visibility in the fish farming industry?".* The results will be processed and analysed, where the authors will discuss if the findings on blockchain technology from interviews and the theoretical background can improve the current situation in the fish farming industry. To evaluate how blockchain technology can improve supply chain visibility, the characteristics on visibility from Somapa et al. (2018) is used as parameters and metrics to evaluate the findings. Moreover, the last section will be in relation to the subqustion: *"Barriers for blockchain adoption in fish farming industry?".*

5.1 Blockchain benefits on supply chain visibility

5.1.2 Automational characteristics

How actors in the fish farming industry capture and transfer data and information are found to be somehow good but are also seen by the authors and participants to

have the potential for improvement, especially regarding the digital tools to communicate the information.

The mission to track and capture every stage a fish product has gone through is perceived to be very important in the literature, and something that the actors in the industry strive to accomplish. This is also in line with the demand from the consumers and customers in the industry, which seek sustainable food and producers who can account for it (Hanner et al., 2011; Thompson et al., 2005).

The research confirms that the actors have traceable records on every stage the fish have been. However, in line with the results of traceability in the industry, it can be concluded that most of these entries are done manually and the same information is typed many times from different actors in the supply chain. Furthermore, the actors in the industry are only capable of tracking location, and not temperature on air freight in most circumstances. Nevertheless, is it also discussed that traceability is the biggest challenge in the industry when talking about logistics and supply chain topics, which is seen as a statement because of the importance of traceability. The results show that visibility is perceived different depending on which supply chain stage the actor is located.

Furthermore, is the transfer and sharing of information perceived to be two-folded in the industry. The actors communicate well between them, but the data and information are currently not being shared efficiently throughout the supply chain. The current systems and integration between systems is one primary reason for the poor quality on the transfer of information between actors in the industry. The industry participants and the authors are perceiving the systems to be too cumbersome, and the IT integration is not facilitating the distribution of information. This can create inefficiencies when, for example, updates downstream in the supply chain is not captured by the actors upstream. Still, it is important to mention that the results indicate that the actors are working on solutions today for channelling the information more appropriately.

First of all, blockchain and its principle of being a distributed ledger enable each party in the supply chain, which has access, to verify the entire database and the complete history of the fish. This is seen as an attractive feature of blockchain, as

there is not possible to transfer a value object from database to database today. As argued in the findings and theoretical background (Francisco & Swanson, 2017) can everything of value be uploaded as a digital token on blockchain networks. Moreover, will the fish have digital twins in the network which have links to its history and every information related to how the fish was produced, handled, and transported. When a fish farmer, for example, transfer the fish from the sea, process it and it is transported, these transactions will be updated for everyone in the supply chain network, in real-time, with full traceability back to the point of origin.

The results demonstrated that it could take weeks to track down the source of failure and restore consumers' confidence in food safety when a food disease or operational deviation occurs. With blockchain, the supply chain actors will get a quick overview of where the fish came from and which other products or batches also are affected and must be removed from the stores (Hackius & Peterson, 2017; Tian, 2017). This means that a producer can effectively optimize more straightforward than they do today, where much amount of time goes to localize the source of failure. The finding ties well with previous studies wherein challenges in the documentation of transformations in traceability systems (Olsen & Borit, 2018). In relation to the theoretical background will food supply chains have most challenges in this area, where TRUs are split continuously up from their original batch, and one area the authors see a considerable use area for blockchain implemented with other technologies. According to the result, most of the tracking is based on pallet level and large batches, mostly because of the high cost of implementing tracking on the fish level.

The rise of IoT devices with, RFID, GPS, sensor, and wireless network technologies is seen as crucial to automate these processes. Given a large amount of possible IoT objects in the future, a platform to facilitate these devices might be one of the most promising applications for Blockchain (Zheng et al. 2017). More and more logistics objects are equipped with sensors that generate data along the supply chain, for example about the status of a shipment (Hackius & Peterson, 2017), and there is a rising demand from authorities to have sensors in multiple stages in the industry according to the results.

In this case, blockchain could enable actors in the fish farming industry to interact autonomously with other actors, and through smart contracts IoT actions will trigger payment actions by themselves. Iansit and Lakhani (2017) provide one interesting example combining IoT devices and smart contract to benefit from the settlement mechanism of blockchain. A forwarder in the fish farmer could signal via blockchain that a particular product or batch have been received-or the product could have GPS functionality, which would automatically log a location update in the network. Moreover, resulting in trigger mechanisms in the smart contract which enforce payment to the inland transporter or fish farmer. Temperature tracking is also something that could be solved with IoT devices, which is under development already, with GPS trackers in the industry. In a blockchain ledger will the information on temperature be available information could be stored on the blockchain ledger for everyone in the network to see and resolve disputes faster.

It is found that automational visibility could get improved by applying blockchain technology. The shift from manual to autonomous data capturing and sharing will be a critical objective in the fish farming industry, which could make the supply chain transparency and traceability significant better. The combination with other technology will be even more beneficial for data capturing, but the results provide evidence that blockchain alone will be valuable for transferring of information.

The authors perceive the visibility in terms of location tracking to be sufficient, where the actors can show the origin and history of the fish. In contrast, the results lead to a different conclusion regarding temperature visibility. The answers argued that it is insufficient, but under development. One interesting obstacle for temperature tracking was found to be the sharing of this information with actors they do not trust. A specific situation where temperature variations could occur, mentioned by some industry actors is when fish is in transit before or after the transport departure. Further, it was mentioned that this temperature variation would not decrease the quality of the products and that it is impossible to transport fish products globally without any temperature variations. The dilemma is if this information should be shared in a blockchain with untrusted actors that could use this information to claim economic compensation for the fish products? The authors see this problem, but believe that this information should be shared with

all actors in the industry, and according to the literature it is strict laws on how temperature should be under transport.

One important finding in the understanding of the digital asset transferring, is the digital twins. With digital twins, blockchain can trace in which exact batch or product in real-time that has the failure, which could potentially save the fish farming industry for tonnes of thrown fish when they are not sure which products that are affected. Further, will this help the documentation of transformations in the industry, which assumed to be a complicated procedure today in a multi-stage supply chain. It is important to note that every system will rely on some verification error on the traceability due to human and machine failure. On the other hand, will blockchain in combination with other IoT devices significantly reduce the error and enable more efficient data and tracking capture.

5.1.3 Informational characteristics

High quality on the information in fish farming supply chain is vital to verify the history of the products. Further, the degree of this quality and what type of information will depend on where in the stage the actor is located. For a fish farmer, it would be essential to provide verifiable information on sustainable production practices and have the correct quality. For the downstream actors, it would be of great value to have access to high-quality information by being able to verify that the fish they handle and distribute has the correct quality.

According to the literature (Hanner et al., 2011; Thompson et al., 2005) and results, the consumers want more reliable information on the product they buy and consume. The results argue that it is perceived to be high quality of fish products from Norway. However, there are still cases with lack of product information, where an example was the disclosure of the Norwegian cod that was pumped with water and chemicals in China and was not labelled with that type of information (NRK, 2019). Today there is a challenge with the quality of the product information that is served the consumers, where most information is text on labels on the products, which does not give enough reliability.

According to the technology gap, there is a lack of procedures for verification integrated with monitoring of products authenticity, such as a fully developed

ecosystem (Borit & Olsen, 2016), which means that a customer or a company may be able to track products, but not be able to verify the quality of the fish. However, the findings argue that the government and consumers are demanding better traceability of Norwegian seafood, which will potentially influence or force the actors to provide higher quality on the information of the products. Data entry may lead to errors that potentially may weaken the quality of the information (Boris & Olsen, 2016). Further, by not having an ecosystem with the ability to verify the quality on the products and provide high-quality information there will be more significant risks for frauds, such as the substitution of species, use of food additives to increase the weight or change the visual appearance of the product or mislabelling of products. In line with previous literature (Oceana, 2016), it is argued from the blockchain experts that many frauds are happening worldwide in the aquaculture industry today.

The results argue that the fish farming supply chain as an ecosystem will have the potential of obtaining higher quality on the information facilitated by blockchain. As argued in the results and theoretical background is immutability, one of the most important attributes of the blockchain (Seebacher & Schüritz, 2017).

Trust is stated as a critical element of blockchain technology, but not between the participants and companies involved, but of the information integrity contained within the blockchain (Francisco & Swanson, 2018). Also argued in the results is the information stored in the blockchain nearly impossible to tamper or hack, therefore can the information be used as evidence for accountability, which makes the quality of the information high. It is further argued that also, other technologies like sensors need to be implemented, to strengthen the verification and provide that the information is equal with its actual value. Despite improved verification of information, the findings argue that nothing can be verified 100% as long as humans and machines are running it, where sensors may stop working or due to human errors. However, uncertainty will be reduced, and information will be of higher quality with a blockchain solution.

Quality of information is also connected to the frequency of information shared, and the theory state that real-time information is not necessarily needed, but depends on the business and industry (Somapa et al., 2018). Real-time tracking

will have the possibility to strengthen information credibility (Tian, 2017). From the findings, it is argued that real-time information would be beneficial in many situations in the fish farming industry. In fish farming, there is much mortality, and it is difficult to estimate the correct amount of fish in the cages. When the well-boats arrive with the fish to the processing plants, it could suddenly be much less fish than forecasted, which creates challenges to meet the demand. By possible future technology, where sensor technology in used in the sea cages, which is connected to a blockchain, it could give better control over the amount of fish that is available to sell. Furthermore, it would be easier to forecast, and actors in the whole supply chain would have access to real-time information about the situation in sea cages.

By using blockchain technology there will be great potential for providing high quality on the information to the end-consumers in the fish farming industry. The immutable nature of blockchain technology will facilitate trust in the information that is inside the blocks in the chain and makes it easier to cooperate with unknown actors further away in the fish farming supply chain.

The level of trust is high in Norwegian society today, and consumers in Norway are confident that the food they buy in the store is of high quality and is produced sustainably. In some of the markets abroad where 95% of the Norwegian fish is exported, there is less trust among the consumers towards the food industry. However, as long as the food looks fresh and the price is reasonable, would anybody care to have full information on the product? The authors believe that customers in countries that have less trust to the food industry are especially interested to be provided with information on the fish they consume. Furthermore, in Asia for example, most people are eating the fish raw and would have great interest of verified information on the fish Over the years, there has been a greater focus on sustainable issues, both from consumers, government, and media. There has, for example, newly been raised significant concerns in the fish farming industry where fish is pumped with chemicals and water, and the products were not labelled with correct information. News like this will further make the consumers more engaged in demanding visibility from the supply chains.

Furthermore, the question is if the high quality of information will be beneficial for not only consumers but also for other actors in the supply chain? It is argued from one of the actors that quality, price, and service is their primary focus, but that quality is the most important focus area and which they work very hard to maintain. A salmon delivery has a relatively high value and it is connected to the freshness and the cool chain compliance on the movement of the fish from A to B. A blockchain solution would facilitate to prove this information about high quality on products to the consumers, which would be beneficial for the actors in the supply chain as it would benefit their reputation, since they can be more accountable for their business. Furthermore, actors that are not operating sustainably and are committing frauds will be forced to improve. Blockchain technology has the potential to give more transparency and provide real-time information to all actors in the supply chain, which will increase the quality of information and have an impact on the transformational visibility discussed in the next chapter.

There is also a considerable difference in trust between actors in the European market compared to other markets. Some actors are, therefore, sceptical about sharing information with other actors, as there is a risk of frauds and tampering with data. The information in the blockchain is immutable, and with a blockchain with a zero-knowledge proof, the actors do not need to share all of the information and can still hide sensitive information. This makes it possible to trust the information in the blockchain and enable the trust to actors you do not know and actors further away in the supply chain.

5.1.4 Transformational characteristics

How businesses in the industry share information to improve business operations, internally and externally to improve operational efficiency is seen as medium to low. Further, the information is used to strengthen strategic relationships or to gain insight into the markets perceived to have potential for improvement.

The fish farming industry will rely on improved practices and operational efficiency in order to respond to the increased market demand and expected production growth in the future (Hanner et al., 2011; Thompson et al., 2005). Contrary to this finding, a commitment gap has been identified where companies

often provide traceability to meet the minimum standards set by governments and for commercial purposes (Borit & Olsen, 2016), and not to improve business value. However, the results confirm that companies understand that improved visibility can give a more effective supply chain regarding cost, quality, and sustainability.

It is essential to state that with every actor in the supply chain connected to the blockchain network, will give the ecosystem more transparency. To achieve optimal transformational visibility, it is important to have transparency to that extent, that it will not affect the competitiveness between companies in an industry. However, from the theory (Delmolino et al., 2016) and results, only those parties, which have access to data, can see the information. The research does, however, reveal that some of the actors in the industry believe that the attractiveness of transparency could provide a too open environment, which would harm competitiveness. Nonetheless, the authors believe that it is well justified to the barrier of knowledge, which they have mentioned themselves as a barrier. Therefore, it is worth discussing the results that relate to the consensus of zero-proof-knowledge. This consensus will make authorities and other parties see that a transaction or delivery has been undertaken, but not the value or information on prices.

The integration of blockchain technology will reduce much of the manual labor done by middlemen today, such as stamping and clarification of documents. Forecasting is difficult in industries like fish farming, where you have short product life cycles and very long production lead times. Then, according to Nakasumi (2017, p. 140), “supply chains face the risk of either excess capacity due to low demand realization or lack of product availability.” This result highlights that little is known from downstream actors about how much fish is going to be harvested from farms, due to mortality. Hence, if the seller, trader, or distributor had more precise data, it could make the whole supply chain achieve better planning and operational efficiency. The authors also assume that the actors longer down the pipeline, like a retailer or a restaurant also have little information on the production volume. With better information sharing based on blockchain technology, would make these actors adapt their orders and promotions towards customers accordingly.

Another good example where blockchain can improve operational efficiency, which was found to be a key challenge from the results, was air freight capacity. With blockchain technology, the actors in the industry could have full information on the available capacity in the market in real-time, moreover, could a party choose the best-suited air company based on the customer data as well, which could automate the procurement process of choosing air freight (Morabito, 2017). Further, it is mentioned in the results that the forwarders have little to none visibility when the fish arrive at their locations. With better traceability between these two stages, the forwarders could plan and forecast better the air freight departures.

More transparency in the industry with external parties could potentially, as stated in the results, be the foundation for innovation and better solutions in the industry. The results and theory argue that asset tracking is one of the main attributes of the technology for supply chain and logistics (Abeyratne and Monfared, 2016). From the results, it is stated that most actors in the fish farming industry are having their visibility projects regarding traceability in closed environments. The industry could, instead of having suboptimal solutions in each entity, one single platform with restricted access to each organization to handle real-time tracking from broodstock to end-consumer (Tian, 2017).

When discussing transformational visibility, it is also vital to make use of the data you already have or may not know that you have (Somapa et al., 2018), and visibility in this context will improve supply chain analytics (KPMG, 2016). In order to share and transfer information it will also depend on the issues discussed in the automational section.

The results show that some actors can use and analyse some data, but the consensus is that everyone could improve in this area. One important reason for this is that each entity in the supply chain is gathering internal data silos, and not effectively sharing these throughout the pipeline. Another reason is the interoperability of the current systems today, which is mentioned before. With a blockchain platform integrated with all major enterprise systems, the actors can store all communication and data in one channel which will make it more feasible

to find deviations on the product flow or work on analysis for continuous improvement.

The results and theoretical framework also show that better visibility could improve the competitiveness of organizations through better brand enhancement and consumer confidence (Sterling & Chiasson, 2014), and good traceability is seen as a market requirement in the industry (Thompson et al., 2005, Hanner et al., 2011). The actors who can provide evidence that the fish is produced with sustainable practices and handled the right way under transportation could achieve a higher demand for their products, and the results argue they also could take a premium price.

The analysis and results found evidence for blockchain technology to have the potential to improve transformational visibility in several ways. To make use of the information through better data sharing and more transparency, will be essential factors blockchain technology which could benefit the fish farming supply chain. Better planning, forecasting, and operational efficiency are possible with better visibility with internal and external actors in the supply chain. One dilemma towards the benefit of operational efficiency was identified to be how the potential gains would be distributed through the supply chain. When implementing new technologies in a supply chain, there will always be some actors that benefit more from the integrated solutions than other, therefore is it essential to locate which actors who will benefit most, and then divide the investment cost accordingly. The producers are seen to gain the most from a blockchain solution, however, is every actor somehow going to take advantage of more visibility through blockchain. The results indicate that a more incentivized program would get more actors like forwarders and transporters in the industry to distribute and share more information. If the transporters, for example, receive micropayments every time someone in the supply chain network used the information they had stored in their system, more actors would have better incentives to track and share information.

Furthermore, would the enabling of a technology which creates more transparency towards customers and end-consumers be an action to create a strategic relationship with increased consumer confidence. There is insufficient data on the

end-consumers demand after more reliable information on products, nevertheless, do the authors believe that with the recent adverse media reports on the fish farming industry, that end-to-end visibility could potentially give actors a competitive advantage.

As stated by Christopher (2016), we have in the past gone from company versus company, to supply chain vs. supply chain on a competitive level. Interestingly, is the future prediction that we will extend this level, to an ecosystem versus ecosystem. In a blockchain ecosystem, the creation of partnerships with competitors in Norway could contribute to develop and improve the global supply chain in the Norwegian fish farming industry. The authors believe that the competitive environment will lean towards the ecosystem against ecosystem, rather than the traditional supply chain against supply chain. The risk of sharing sensitive information is going to be one of the main barriers for companies to join a digital ecosystem like blockchain. One important action for blockchain integration will be to agree on what information that should be shared, to not affect competitiveness. Furthermore, this can create a new dilemma where they may share too much sensitive information regarding prices, which could lead to illegal cooperative pricing strategies.

5.2 Barriers to blockchain implementation

To successfully implement blockchain technology for supply chain purposes, it is necessary to identify the challenges and barriers that need to be managed. Saberi et al. (2018) found four main categories to examine barriers for blockchain adoption in a supply chain, which the authors want to discuss up against the findings, and with a further look at the opportunities.

Intra-organisational

The lack of knowledge is seen as the most significant barrier by the interviewees and is confirmed by the theory (Saberi et al., 2018) to be one crucial intra-organizational barrier. It is stated that blockchain is a broad concept, which has been hyped up for a long time, and which is hard to understand. It is essential that the providers of blockchain technology offer blockchain solutions that solve problems and that the actors do not need to be experts on blockchain technology themselves, but rather be able to use the technology to strengthen their core areas.

However, it is important that the decision makers in the industry is capable of understanding some key areas of blockchain technology. The majority of the actors claimed that they had a positive attitude towards adopting new technology, but it was also admitted that some did not understand why they should implement new technology as the old system worked. This is in line with the awareness gaps by (Borit & Olsen, 2016), where companies not fully understand how traceability systems can improve their business processes. The authors see that there are great attitudes towards adopting new technology in the fish farming industry, however there is a great potential for improvements. The blockchain experts argue that some actors want to hide their business activities and is therefore not interested in a blockchain solution that can potentially disclosure unsustainable behaviour, and therefore, it will be against their interests as they may be involved with frauds.

Inter-organisational

The findings argue that the trust between actors in the industry is perceived to be very high. However, it is mentioned that there is a difference in the European market and other markets. Some actors state that they are reluctant to share too much information with other actors as it may reduce their competitive advantage and fear that the information may be abused or used against them. The hesitation to share information with supply chain partners may hinder a successful implementation of blockchain (Saberi et al., 2018). However, the blockchain experts argue that it is possible to limit the access to specific information in the blockchain such that sensitive information and secrets are not shared.

A challenge is to get every actor to join a blockchain network and to implement other necessary technology (Saberi et al., 2018). The findings argue that actors with immense market power such as the big supermarket chains, or the consumers with their influence need to make pressure on the supply chain network to increase its visibility. The findings argue that there are too many private ecosystems that are not scalable beyond their businesses today. The blockchain experts further argue that a challenge with a private blockchain network is that a certain actor has the power and is the decision maker, which will make the other actors hesitating to join. It is argued that a private blockchain solution is more like a database, while the distributed public blockchain is the real blockchain and is immutable and decentralized.

From some of the answers from the actors that work as middlemen in the industry, there was an uncertainty for losing jobs by implementing blockchain technology and were therefore reluctant to the technology. However, in line with the ideas from the blockchain experts about that new jobs will be made from the adoption of blockchain, the authors will argue that intermediaries need to adjust to the technological development to still stay competitive in the future.

System related

From the actors in the industry, it is confirmed that costs are a barrier of integrating blockchain and other new technology. Especially costs regarding tracking and that it becomes more expensive, the more detailed the tracking is. This is highly related to the cost of RFID, sensor technology and other data capture technologies which is seen as too costly today. However, the actors discuss that cheaper prices is expected and that they follow the market trend. It is hard to integrate comprehensive IT solutions for the supply chain as it is global, and there are different levels of competencies within technology around the world. Another barrier is that the blockchain technology is immature in terms of scalability (Yli-Huumo et al., 2016; Saberi et al., 2018). The scalability of public blockchain is getting better, and the transactions speed is considered to be much more efficient with Blockchain SV, which is also mentioned in the interviews. The experts further argue that is not very difficult to implement a blockchain solution in terms of the technical part where they argue to have good experiences from earlier projects, where it is possible to set up a stand-alone solution or blockchain integrated with the ERP systems.

External barriers

External barriers come from external stakeholders, such as industries, institutions, NGOs, and governments. Saberi et al. (2018) argue that the biggest concern is governmental laws and regulations in this category. The findings from the blockchain experts confirm this, because of the hype of blockchain with many different terminologies, which makes it harder for the government to understand the technology and to set laws and regulations regarding blockchain technology. It is further discussed in the standards gaps (Borit & Olsen, 2016), that there is lack of standards and norms regarding traceability systems and information sharing through the supply chain and that it differs a lot between institutions. The

blockchain experts argue that there must be developed far better standards and regulations from the government and for example, new ISO standards. The regulatory standards today with the General Food Law in focus, is seen as insufficient to require full traceability through in the supply chain, as it has a "one step back-one step forward" approach (Borit & Olsen, 2016). The authors believe that if it comes certain demands from the government towards actors to show full visibility, and standards are made, it will make the supply chains more likely to adapt to a blockchain ecosystem.

6.0 Conclusion

The authors of this master thesis have investigated how blockchain technology could improve supply chain visibility in the fish farming industry through a exploratory case study. It has been argued that more visibility in supply chains will lead to better operational efficiency, less fraud and scandals, and improved risk mitigation throughout the pipeline (Barrat and Barrat, 2011, Reilly 2018, KPMG, 2016). Further, has blockchain arisen as a technology which will enhance supply chain visibility in the future (Francisco and Swanson, 2017). As the authors have discussed through this thesis, blockchain may be considered a promising facilitator of supply chain visibility. Furthermore, the authors discuss the potential of applying blockchain in the fish farming industry, as the supply chains are complex, with many intermediaries and have risks of frauds.

The results of the research indicate that information accessibility in the industry is sufficient in terms of tracking of location, however real-time tracking and temperature tracking have potential of improvement. Importantly, the results provide evidence for how blockchain combined with other technologies will benefit the capturing of information along the supply chain. The results show that various IoT devices are emerging in the fish farming industry, and this is an important finding in the understanding of how blockchain could work as a platform to operate sensor technologies (Hackius and Peterson, 2017). Lastly, will blockchain combined with other technologies benefit how the fish farming supply chain capture information through autonomous solutions, where most is done manually today.

The immutable nature of blockchain contribute to higher quality and more reliable information in the supply chain network (Abeyratne and Monfared, 2016). The results show that transparency and trust are perceived to be lower towards actors which are geographically spread than close actors in the internal chain. Further, the literature confirms that fraud is a critical challenge in the fish industry (Reilly, 2018). With higher visibility and verification demands on fish products from authorities, customers and end-consumers, blockchain could provide as a new IT infrastructure which will benefit sustainable and well performing actors.

Supply chain efficiency is found to be critical because of the perishable nature of the products transferred globally. More visibility on the flow and available freight capacity would enable better operational efficiency and planning. These findings illustrate that blockchain could work as a platform to get actors to share more information between them to increase overall business value. The authors also see the potential to create a digital ecosystem in the Norwegian fish farming industry to enhance innovation on traceability projects and cooperate on transport to the global market.

Today, we are moving towards supply chain 5.0, which is the revolution where machines, men and technology are reconciled and find ways to work together to improve the efficiency of the supply chain flow. The fish farming industry is according to the results, positive towards implementing new technology, and are interested in how solutions like blockchain could automate operations and provide a more secure and transparent environment. The current situation in the fish farming industry is seen as an interesting use case for blockchain technology, which could give value in terms of supply chain visibility.

All participants discussed the lack of knowledge as the most significant barrier against blockchain adoption. The authors perceive this factor to be a short-term barrier for implementation, where the actors need to be better informed to be able to see the real potential and use case for their situation, which this thesis intend to do. The long-term barriers will include the involvement of all actors in the supply chain to join the the blockchain network, create regulations and standards, and find solutions of how blockchain benefits and costs could be shared fairly among them

It is difficult to conclude rather blockchain should be implemented or not, as this thesis only examine the visibility aspect of the fish farming supply chain. However, the benefits from this study on supply chain visibility in the industry is seen as substantial. As with all other technology, it will take time before the majority adopts blockchain technology. Nevertheless, as long as the consumers, government, or actors with high market power, demands higher visibility in the supply chain, the authors believe that there will be great opportunities for blockchain adoption in the fish farming industry in the near future.

To conclude, this paper argues that a more in-depth exploration should be initiated on blockchain technology by the industry actors. The development of use cases for supply chains has increased over the last years, and the examination of blockchain should be on the agenda for the fish farming industry, as blockchain could have the potential to revolutionise the way business is done today.

7.0 Limitations

Before starting the work on the master thesis, the authors knew that there would be some limitations within the research and research area. A limitation is the limited amount of previous research and literature regarding the author's research scope. There is a lack of research on blockchain technology in the fish farming industry. Further, there was not much literature on supply chain visibility in the fish farming industry. However, previous research is considered sufficient. However, the authors found the previous research on supply chain visibility, blockchain technology, and the fish farming industry as sufficient. Another limitation is the lack of opportunities to quantify the costs and benefits of adopting blockchain in the fish farming industry as there are limited practical examples in the literature and in the real life. Furthermore, the author's research on the technological implementation of blockchain is not fully comprehensive as the authors have limited knowledge on the technical part of it.

After the research was done, the authors address some implications. The research is a qualitative study and is to a large extent based on answers from actors in the fish farming industry and blockchain experts. The different answers from the participants will, to some extent, be affected by their own subjective opinions that

help provide information about the current situation in the fish farming industry. However, some of the answers from the blockchain experts could be biased to a certain degree because of their job positions. The blockchain experts are arguing for a public blockchain over a private blockchain as they are working with public solutions in their daily life.

The authors have not been able to interview all of the actors in a fish farming supply chain and therefore, may have missed out on essential findings. This limitation is concerning the limited time of a master thesis. There were conducted five qualitative interviews with actors in the fish farming industry, and the author's findings could be seen as challenging to be generalized for all the actors in the industry. This is also in line with the theory of case studies that it is difficult that a specific case has the possibility to represent all similar groups or situations. However, the participants answered with regards to the whole industry and not only their businesses.

Furthermore, some of the findings in the research were contradictory, where blockchain technology would have a different value for different actors. In other words, some actors would benefit more from blockchain than others. The authors see some implications of presenting the whole industry as a case when it includes different actors with different needs. However, the authors try to argue for all parts, and the findings are analysed and discussed thoroughly in the thesis.

8.0 Future research

In light of the research and its limitations, we recommend researchers to conduct further studies of blockchain technology in the fish farming industry or other food industries. Future research should consider the potential effects of blockchain more carefully, where especially quantification of the benefits and costs would be interesting. For example, could cooperative game theory could be used to be able to distribute costs and savings among the actors who implement blockchain technology. Comprehensive research on IoT technology in the fish farming industry with its interaction with blockchain is a field that needs more exploration. It would be beneficial for the decision makers in the industry to understand what kind of IoT devices should be used in every stage of the supply chain and how IoT devices connect with a blockchain platform the use should be. At last, we believe

that apart from looking on blockchain, future research should look for how food supply chain visibility will be more important in the future, due to pressing demands from customers on sustainability.

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10. Appendix

10.1 Additional information on the fish farming production cycle and supply chain

Production cycle

The production of salmon takes about three years. During the first year, eggs are, and the fish is grown in freshwater to around 100-150 grams. Then the fish is moved to seawater where it grows over 12-24 months to around 4-5 kg. The growth of the fish is dependent on the temperatures of the seawater, which varies by the time of the year. The optimal temperature is 8-14 degrees Celsius. When the fish is ready to harvest, it is transported with well-boats to processing plants where it is slaughtered and gutted (Marine Harvest, 2018). The well-boats can carry loads between 20 to 200 tonnes of fish, and the harvesting stations have operating practices to ensure a high level of animal welfare. The offal that is produced during the process is used as fish meal production (FAO, 2019a).

It is a trend that Norwegian seafood often comes to another country for processing before it ends up with the consumer. Typical transit or processing markets for Norwegian seafood are Poland, Denmark, and the Netherlands. Salmon is mainly exported unprocessed, 84 percent exported as whole fish gutted with head-on, while 16 percent of the raw material is processed in a variety of ways (smoked salmon, fillets, etc.) before export (FAO, 2019).

The fish farming supply chain

Feed

The feed is standing for half of the total production costs of salmonids, and having the correct ingredients are essential for providing the quality and the health of the farmed fish (EY, 2018). About 70 percent of the feed consists of vegetable ingredients, while about 30 percent comes from marine raw materials such as fish meal and fish oil (laksefakta.no, 2018a). Because of the shortage of marine ingredients and increased price, there has been a shift toward vegetable ingredients. This leads to a decrease in the omega-3 fatty acid in the fish, which is a motivating factor for the industry to explore new sources of ingredients in feed (EY, 2018).

The feed usually has a shelf life up to maximum one year and is seen as a perishable product. Since the turnover of feed usually is high, there are no concerns regarding shelf life in large operations. (Marine harvest). Farmers will use that feed, which they perceive gives a weak growth on the fish, quickly change their suppliers. Those fish farmers that use feed from suppliers are less likely to know how they should design their feeding strategies, as they may have an absence of information. Feeding strategies is about growing a healthy fish fast at the lowest possible cost (Marine Harvest, 2018). It is therefore vital for feed companies to produce good quality feed, being able to document it and share information with the fish farming companies.

Egg and spawn production

The companies within this stage of the supply chain are specialized in spawning and egg production. The primary product they offer is fertilized fry, but often sell other products such as fry, smolt, and broodstock. Many of these companies also do smolt production and even sea farming on a smaller scale. Some companies are owned wholly or partly by sea farmers or are operating on a stand-alone basis (EY, 2018). Egg suppliers can by obtaining more or less fish for breeding tailor their production to demand during the season, and production can easily be scaled. The market for salmon eggs is international (Marine Harvest, 2018).

Smolt production

The producers of smolt cover the process from egg fertilization to when the mature fish is ready to be set to sea. Smoltification is the biological process where young fish is ready for the transition to seawater from freshwater, and a fish that has been through a smoltification is called a smolt (EY, 2018). Most of the smolt are produced by vertically integrated fish farmers, in-house. The production is generally for the company's use, but some smolt is also sold to third parties. A smolt is produced over 6-12 months, where a mature smolt weights 60-100 grams. There has been a trend that smolts are produced larger from 100-1000 grams, to shorten the time in the sea, where the fish are exposed to the highest risk in the production cycle (Marine Harvest, 2018).

Sea farming

Sea farming is where the fish is put into seawater and grown until it is around 4-5 kg and ready to be harvested, which is a process that takes 12-24 months. This is the most significant stage in the supply chain of fish farming. This stage of the supply chain has been experiencing record-high profitability with an EBITDA margin of over 35 % in the last two years. The reasons for the profits are increased demand combined with increased harvest volume and an increased annual average price for farmed salmon by over 50 % from 2013 to 2017 (EY, 2018).

Transportation on sea/Distribution

This stage of the supply chain consists of well-boat companies that are transporting smolt to sea farms and living salmon to processing plants from farming cages. Many of these companies also offer treatment against sea lice onboard the well-boats and services such as counting of fish and sorting. This stage of the supply chain is a high-margin business, and there are rapid investments in more technological and larger vessels (EY, 2018).

Well-boats are specialized vessels used for transporting alive fish over long distances. It can go with open or closed well - it depends on pathogenic organisms in the water the boat is driving or the disease of the fish being transported. Closed well ensures that one avoids infection from fish to water or vice versa. Regulations on the transport of aquaculture animals regulate the transport of farmed salmon. The Norwegian Food Safety Authority approves the means of transport, and personnel with expertise in fish welfare and salmon needs should always be available. The carriers must document that they have the necessary practical and theoretical knowledge (Laksefakta.no, 2018b)

Primary processing

Primary processing is slaughtering and gutting. This is the point in the supply chain at which standard price indexes for farmed salmon are set. Companies in this stage offer slaughtering services. There are different methods applied for slaughtering, and it is either done by machines applying electric stunning and then cutting the main artery or done by hand (Ólafsdóttir et al., 2013). After the fish has been packaged in EPS boxes, the package is labeled and weighted and finally gets loaded on pallets (Ólafsdóttir et al., 2013). Both independent suppliers and

salmon producers offer to slaughter as an integrated part of their supply chain. (EY, 2018)

Secondary Processing

Secondary processing is filleting, portioning, fillet trimming, smoking, producing different cuts like cutlets, etc. Products that are going through secondary processing are called value-added products (VAP) (Marine harvest, 2018). Secondary processing is costly in Norway and is relatively labor-intensive. It is also difficult to automate all processes sufficiently to cut off the labor costs. In 2017 only 10 % of the Norwegian salmon was processed in Norway. (EY, 2018).

Forwarder and transport

The forwarders work with the export of fish and seafood and are working closely with freight companies where they are booking the transport for the fish products. There are requirements for the transport of seafood that is transported to consumers worldwide. The seafood must not be subjected to temperature fluctuations or other conditions that reduce the quality of the products. The salmon is packed in boxes that keep it cold, and ice is wrapped around the salmon so that the temperature should not exceed 4 degrees during transport (Laksefakta.no, 2018b). The cold chain distribution system is complex and involves different stakeholders which sometimes have a limited understanding of the importance of chilling of the products (Ólafsdóttir et al., 2013)

Retailer/Restaurant

According to Marine harvest (2018), around 70% of the salmon supply went to retailers, and 70% was sold fresh in the EU in 2017. The remaining 30 % went to hotels, restaurant, and café (HORECA). The supermarkets have increased their retail power over the years and are now the key players in the global food-retail sector (Richards, Bjørkhaug, Lawrence, & Hickman, 2013). The supermarket chains make demands to the fish farmers regarding quality, animal welfare, and the environment.

10.2 Traceability standards in the fish farming industry

International traceability standards and guidelines

The Codex Alimentarius: established by the World Health Organization and Food and Agriculture of the United Nations (FAO) to develop international food standards to protect the health of the consumer and promote fair food trading practices (FAO, 2019b)

The FAO Technical guidelines: guides the implementation of aquaculture certification schemes. The guidelines address how issues such as animal health, food safety, socio-economic aspects, and environmental aspects should be certificated in the fish farming industry (FAO, 2019c). The guidelines state that the certification schemes should include procedures to maintain traceability and Chain of Custody (CoC). CoC is defined by FAO as the set of measures that verify that a product that is certified originates from a certified fish farming production chain (FAO, 2019c).

Aquatic code: established by The World Organisation for Animal Health (OIE) and provides standards for the welfare of farmed fish worldwide (OIE, 2019).

Regulatory standards

In the European Commission Regulation 178/2002, which is often referred to as the "General Food Law," article 18 the legal aspects of traceability of food business is presented. The legal aspects are that a food business shall be able to identify the person who they have been supplied from and what the food contains, and shall also have systems or procedures in place to identify the other businesses their products have been supplied to (European Commission, 2002). This is seen as a "one step back- one step forward" approach according to Borit & Olsen (2016), instead of total transparency through the supply chain.

Non-regulatory standards

Non-governmental organizations (NGO's), International Organization for Standardization (ISO) and other industry associations have delivered commercial standards to set requirements for traceability, adapt product identification standards and facilitate information sharing (Borit & Olsen 2016).

Non-regulatory standards overview (Borit and Olsen, 2016)

International Organization for Standardization	Industry associations	Non-governmental organizations
ISO 9000:2000 Quality management systems	US National Fisheries Institute	World Wildlife Fund Smart Fishing Initiative
ISO 22000:2005 Food safety management systems	EU Fish Processors Association	National Marine Fisheries Service Dolphin Safe
ISO 22005:2007 Traceability in the feed and food chain	EU Federation of National Organisations of Importers and Exporters of Fish	Marine Stewardship Council
ISO 12875/12877:2011 Traceability of finfish products – Specification on the information to be recorded in captured/farmed finfish distribution chains	British Retail Consortium Global Standard for Food Safety Issue 6	

10.3 interview guides

Interviewguide: Fish farming industry

Forskningsspørsmål: *How can blockchain improve supply chain visibility in the fish farming industry?*
Introduksjon til intervju og masteroppgave:

Vi er to masterstudenter ved Handelshøyskolen BI som tar fordypning innenfor logistikk og supply chain management og skriver vår avsluttende masteroppgave dette semesteret. Vår oppgave handler om hvordan blockchain-teknologi kan forbedre supply chains, og med et spesielt fokus på fiskeoppdrettsnæringen. Vi har en formening om at blockchain-teknologi kan gjøre supply chains mer effektive, åpne og bærekraftige enn dagens systemer. Fremtidenes supply chains kan dra store fordeler av en plattform som kan kutte mellommenn, spore varer, forenkle handelstransaksjoner og føre til mer åpenhet og gjensidighet mellom aktører i supply chain.

Vi ønsker derav å undersøke om teknologien kan gi positive ringvirkninger i fiskeoppdrettsnæringen på bakgrunn av økt åpenhet og sporbarhet.

Vi ønsker gjennom dette intervjuet å kartlegge hvordan situasjonen er i dagens fiskeoppdrettsnæring.

Begreper:

Supply chain - er et system av organisasjoner, personer, aktiviteter, informasjon og ressurser involvert i å flytte et produkt eller en tjeneste fra leverandør til sluttkunde.

Blockchain - er en «distribuert hovedbok» hvor man har en utvidet oversikt over kryptografisk signerte, ugjenkallelige transaksjoner som deles av alle deltakere i et nettverk. Tenk deg at du for eksempel har en loggbok der du holder oversikt over hvert salg du gjør. Hver gang du gjør et nytt salg registrerer du transaksjonen i hovedboken din. Blockchain tillater bedrifter å spore en transaksjon og utveksle transaksjoner med partnere.

Tema	**Spørsmål**
Bakgrunn	I hvilken del av fiskeoppdrettsnæringen jobber du i?.
Industrirelatert	Hvordan er åpenheten mellom aktørene innad i supply chain i dag? Hvordan kan åpenhet mellom aktører være fordelaktig for dagens supply chain? Hvordan vil du beskrive tilliten mellom aktørene i supply chain i dag? - *Oppfølging:* *Hvilke tiltak kan gjøres for å forbedre åpenhet og tillit?* Hvilke utfordringer møter dere i dagens supply chain? - *Oppfølgning* *Hvordan jobber dere i dag for å løse disse utfordringene?*

Dagens teknologiløsninger og ERP	Bruker du ERP-systemer i din stilling? Og i så fall hvilke? Dersom ikke, hvilke andre IT-systemer benyttes? - *Oppfølging:* *Hvordan er integrasjonen av IT-løsninger på tvers av supply chain? Hvordan er samhandlingen mellom de forskjellige aktørenes løsninger?* Er IT-infrastrukturen i industrien tilrettelagt for å enkelt kunne oppgradere nåværende systemer? Hva kan du si om tidligere erfaring med implementering av IT-løsninger, og hva var de positive og negative effektene? Hvordan er holdningene deres til å implementere ny teknologi? Skal være i første rekke. Hvilke løsninger har dere i dag for å spore produktene? Brukes sensorteknologi? RFID? IoT?
Informasjons- og datadeling	Hvordan vil du beskrive informasjonsflyten mellom aktører i supply chain i dag? - *Oppfølgning* *Hvilke verktøy bruker dere for å samarbeide og kommunisere?* Hvordan er sporingen av produkter i dagens supply chain? Spørre om sporingssytemer??? Hvor effektivt klarer dere å håndtere og analysere data for å forbedre og vedlikeholde prosesser i dag? (Produktkvalitet og bærekraft) Er sporing av fisk fra opprinnelse til butikk noe konsumenter og kunder i dag vil etterspørre når de handler? Hvordan blir produktinformasjon om fisk gjort tilgjengelig for sluttbruker? - *Oppfølgning:* *Hvordan verifiseres denne produktinformasjonen?*
Blockchain	- *Introduksjon* *Blockchain har egenskapene til å kunne spore hvert steg i supply chain et produkt går gjennom med tanke på lokasjon, temperatur og kvalitet, (med andre*

	teknologier) og å skape åpenhet mellom aktører i supply chain og skape en sikker informasjonsflyt. Hvordan kan ovennevnte egenskaper ved blockchain-teknologi være attraktivt for industrien?. Hva er de største barrierene for å implementere ny teknologi som for eksempel blockchain?

Interviewguide: Blockchain

Forskningsspørsmål:

How can an blockchain improve supply chain visibility in the fish farming industry?

Introduksjon til intervju og masteroppgave:

Vi er to masterstudenter ved Handelshøyskolen BI som tar fordypning innenfor logistikk og supply chain management og skriver vår avsluttende masteroppgave dette semesteret. Vår oppgave handler om hvordan blockchain-teknologi kan forbedre supply chains, og med et spesielt fokus på fiskeoppdrettsnæringen. Vi har en formening om at blockchain-teknologi kan gjøre supply chains mer effektive, åpne og bærekraftige enn dagens systemer. Fremtidenes supply chains kan dra store fordeler av en plattform som kan kutte mellommenn, spore varer, forenkle handelstransaksjoner og føre til mer åpenhet og gjensidighet mellom aktører i supply chain.

Vi ønsker derav å undersøke om teknologien kan gi positive ringvirkninger i fiskeoppdrettsnæringen på bakgrunn av økt åpenhet og sporbarhet.

Vi ønsker gjennom dette intervjuet å kartlegge hvordan blockchain potensielt kan være fordelaktig for fiskeoppdrettsnæringen.

Begreper:

Supply chain management - er samordningen av alle prosesser og aktiviteter både opp- og nedstrøms i verdikjeden

Supply chain - er et system av organisasjoner, personer, aktiviteter, informasjon og ressurser involvert i å flytte et produkt eller en tjeneste fra leverandør til sluttkunde.

Tema	Spørsmål
Blockchain	Kan du kort forklare hva blockchain-teknologi er? Hvilke egenskaper ved teknologien er det som gjør at den vil være attraktiv i dag/fremtiden?

	Hva er forskjellen på private og public blockchains og hvilke har du mest tro på? - *Oppfølgning:* *Vil bruksområde eller industri ha noe virkning på hva som er best* *egnet av public eller private?* Hvordan vil det være mulig å spore produkter med bruk av blockchain-teknologi? Hvordan kan blockchain endre måten tillit fungerer mellom aktører? Hvordan implementeres blockchain-teknologi med dagens IT- og ERP-løsninger? - *Oppfølgning* *Hvordan kan industrier utvikle standarder, som gjør at alle systemene snakker samme språk?* Hvilke er de største barrierene til implementering av blockchain i forskjellige industrier i dag? - *Oppfølgning* *Hva er hovedutfordringene ved å implementere teknologien i supply chains?* Hvilke andre teknologiske løsninger må implementeres for å kunne utnytte fordelene av blockchain best mulig med tanke på åpenhet og sporbarhet? Hvilke positive endringer kan supply chains forvente ved integrasjon av blockchain teknologi?
Blockchain i Fiskeoppdrettsnæringen	Fiskeoppdrettsnæringen i dag er preget av komplekse supply chains og ineffektiv deling av data mellom aktører, tror du at blockchain integrert i dagens ERP-systemer vil være fordelaktig for industrien? - *Oppfølgning* *Hvilke fordeler bringer blockchain med seg som dagens ERP-systemer ikke dekker?* *Hvordan vil blockchain bidra positivt for seriøse aktører i fiskeoppdrettsnæringen?*

	Er sporing av fisk fra opprinnelse til butikk noe konsumenter og kunder i dag vil etterspørre når de handler? Hvordan kan blockchain forhindre svinn og tilbakekallinger av dårlige produkter i fiskeoppdrettsnæringen? I hvilke deler av supply chain vil blockchain være mest fordelaktig i fiskeoppdrettsnæringen, og hvorfor? Hvorfor vil aktører i fiskeoppdrettsnæringen potensielt være skeptiske til blockchain-teknologi? Har du tro på implementering av blockchain i fiskeoppdrettsnæringen?