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THE IMPACT OF BLOCKCHAIN TECHNOLOGY ON ECO-LABELLING SCHEMES:

A STUDY IN THE FISHING INDUSTRY

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Knowledge Field:
Management and Competitiveness in Global Companies

Adviser:
Prof. Renato J. Orsato

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Abstract

The food industry has an enormous global impact on the environment and our societies. With a broad variety of products available to us consumers, there is a rising demand for knowledge about the production of goods and their sustainability aspects. Eco-labels aim to provide credible information of where and how a food product was produced. Consumer confidence in eco-labels has decreased due to cases of inefficient auditing and fraudulent actors along the supply chain. New technologies such as blockchain could solve this issue.

Blockchain is a public digitalised ledger, where all transactions are saved in a sequence of blocks. With its decentralized, fully traceable, transparent and auditable characteristics, blockchain technology has been proposed as a potential solution to improve supply chain governance.

By analysing sustainable supply chain governance, eco-labelling schemes and implementation of blockchain technology in the fishing industry, this thesis addresses how blockchain technology may impact eco-labelling schemes. It uses an exploratory qualitative approach to further define the field of research on blockchain applications for supply chain management and eco-certification in the fishing industry. The research illustrates how key actors and processes may be affected by the introduction of blockchain technology. The paper concludes that blockchain technology alone does not create a substantial impact on certification processes in the fishing sector, as it does not prevent illegal, unregulated and unreported fishing, overexploitation of fish stock and mislabelling. This is mainly due to the physical link, which is needed to bridge physical and digital world. However, with a fully digitalized system in place, it can be a useful tool for managing supply chains effectively and provide increased transparency among supply chain actors.

This paper is structured into five major sections: introduction, literature review, methodology, empirical findings and discussion.

Key words: Sustainability, Eco-label, Supply chain governance, Blockchain, Fishing, Tracking, Traceability, MSC

Resumo

A indústria de alimentos tem um enorme impacto global no meio ambiente e em nossas sociedades. Com uma ampla variedade de produtos à disposição dos consumidores, há uma crescente demanda por conhecimento sobre a produção de bens e seus aspectos de sustentabilidade. Os rótulos ecológicos visam fornecer informações confiáveis de onde e como um produto alimentar foi produzido. A confiança do consumidor nos rótulos ecológicos diminuiu devido a casos de auditoria ineficiente e atores fraudulentos ao longo da cadeia de suprimentos. Novas tecnologias como blockchain podem resolver esse problema.

Blockchain é um livro público digitalizado, onde todas as transações são salvas em uma sequência de blocos. Com suas características descentralizadas, totalmente rastreáveis, transparentes e auditáveis, a tecnologia blockchain foi proposta como uma solução potencial para melhorar a governança da cadeia de suprimentos.

Ao analisar a governança sustentável da cadeia de suprimentos, esquemas de rotulagem ecológica e implementação da tecnologia blockchain no setor de pesca, esta tese aborda como a tecnologia blockchain pode impactar os esquemas de rotulagem ecológica. Ele usa uma abordagem qualitativa exploratória para definir melhor o campo de pesquisa em aplicativos blockchain para gerenciamento da cadeia de suprimentos e certificação ecológica no setor de pesca. A pesquisa ilustra como os principais atores e processos podem ser afetados pela introdução da tecnologia blockchain. O documento conclui que a tecnologia blockchain por si só não cria um impacto substancial nos processos de certificação no setor de pesca, pois não impede a pesca ilegal, não regulamentada e não declarada, a superexploração do estoque de peixes e a rotulagem incorreta. Isso se deve principalmente ao link físico, necessário para conectar o mundo físico e digital. No entanto, com um sistema totalmente digitalizado, ele pode ser uma ferramenta útil para gerenciar efetivamente as cadeias de suprimentos e proporcionar maior transparência entre os atores da cadeia de suprimentos.

Este artigo está estruturado em cinco seções principais: introdução, revisão de literatura, metodologia, resultados empíricos e discussão.

Palavras-Chave: Sustentabilidade, Rótulo Ecológico, Governança da cadeia de suprimentos, Blockchain, Pesca, Rastreamento, Rastreabilidade, MSC

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List of abbreviations

BC	Blockchain
BCT	Blockchain Technology
COC	Chain of Custody
CT	Contingency Theory
CSR	Corporate Social Responsibility
DLT	Distributed Ledger Technology
EMS	Environmental Management Systems
FAD	Fish Aggregating Devices
FAO	Food and Agricultural Organisation
FOS	Friend of the Sea
FSC	Forest Stewardship Council
GMO	Genetically Modified Organism
GPS	Global Positioning System
ISO	International Standard Organisation

IOT	Internet of Things
IT	Information Technology
IUU	Illegal, Unreported and Unregulated
MSC	Marine Stewardship Council
MTCB	MSC trip certificate batch
MSY	Maximum Sustainable Yield
OTIF	On Time In Full
PNA	Parties to the Nauru Agreement
POW	Proof of Work
QR	Quick Response
RBV	Resource Based View
RFID	Radio Frequency Identification
RV	Relational View
SAP	Strategic Alignment Perspective
SCM	Supply Chain Management
SSCM	Sustainable Supply Chain Management
SSCGM	Sustainable Supply Chain Governance Mechanism
TBL	Triple Bottom Line
TCE	Transaction-Cost Economics
TRU	Traceable Resource Units
UK	United Kingdom
UN	United Nations
USD	United States Dollar
VEI	Voluntary Environmental Initiatives
WHO	World Health Organisation
WWF	World Wide Fund for Nature

1 Introduction

1.1 Problem definition

Over the past decades, there has been an increasing trend towards environmentalism and a growing availability of globally sourced products. Consumers want to know more about the sustainability aspects of products before purchasing them. (Mason, 2013) In order to control information about the product, self-regulatory programs such as environmental labelling schemes emerged. Eco-labelling schemes provide information regarding the sustainability of production processes, and supply chain governance. (Mason, 2013) Famous examples are the German “Blue Angel” or the Swedish “Nordic Swan” program (Orsato, 2009). These ecolabels generally help consumers to understand the environmental friendliness of a product, including its production processes as well as other factors like biodegradability. There is evidence that consumers are willing to pay a price premium for products that are more environmentally friendly than their unlabelled substitutes. Altruism towards public good is among the reasons for such behaviour (Mason, 2013).

According to Mason (2011), certification processes are not perfect, as third-party certifiers use random monitoring, in which multiple errors along the supply chain can occur. The certifier cannot be sure that the monitoring scheme always perfectly detects all violations. (Mason, 2011) Eco-labels should provide accessible information to consumers that a product has more sustainable characteristics than its non-labelled alternatives and therefore distinguishes them. However, Daugbjerg et. al (2014) suggest that some consumers believe that companies use green claims only for charging a price premium and have a lack of trust towards eco-labels. (Daugbjerg, Smed, Andersen, & Schvartzman, 2014) To exemplify this problem, I have investigated the chain of custody certification in the fishing industry.

In the fishing industry, one of the most serious concerns is the circulation of illegal, unreported, and unregulated fishing (IUU), which could be accounted for almost 30% of global fish catch in the early 21st century. In 2001, the “International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing” was published by The United Nations Food and Agricultural Organisation (FAO). This initiative gives insights on voluntary actions for governments to prevent IUU fishing. They recommended to improve the transparency of

the market and the traceability of fish and its products. Traceability meaning the ability to track and trace the product by documenting its origin, the processing and handling of the product until the final purchase of the customer. Furthermore, these documentations must be interconnected so that it is possible to trace back the history, location, and application of the product and its components throughout the whole supply chain. Traceability should also provide information about sustainability aspects and the legality of the catch. (Borit & Olsen, 2012)

In practise, a traceability system can be implemented by using paper-based systems or a computer software that can include bar codes or radio frequency identification (RFID) tags, a more recent technology (Karlsen, Sørensen, & Forås, 2013). It must contain the following characteristics: (i) The units, which are referred to as Traceable Resource Units (TRU) (ingredients, components and products); (ii) A numbering or identification scheme that uses codes or numbers to identify each TRU; (iii) A method that can associate the TRU with the respective number or code; (iv) Functionality of recording the TRU's properties; (v) Functionality for having access to the numbers/codes and all associated recordings (Borit & Olsen, 2012).

The documentation, which displays the seizure, control, custody, transfer, disposition of evidence and analysis is referred to as chain of custody. In the fish industry, this term more specifically refers to the documentation that is required for eco-labels to certify their products. In many ways, the chain of custody for eco-labels is stricter than general traceability requirements, such as not allowing the mix of different suppliers for certain products. (Borit & Olsen, 2012)

IUU fishing is one of the biggest contributors to the overexploitation of fish, which is harming the sustainability of fish populations (Nielsen, et al., 2012). Eco-labels have the objective to counter overexploitation of fish stock by providing credible information about the chain of custody, which also includes the origin of their certified fish. Marko et al. (2011) investigated the integrity of MSC (Marine Stewardship Council) certified Chilean Seabass by genetically analysing retail samples of the certified fish. In their research they found that not all MSC labelled fish had their origin from the stated certified fishery. (Marko, Nance, & Guynn, 2011) Nielsen et al. (2012) provide additional examples of illegally caught and mislabelled fish such

as cod, herring and hake. Further studies of Helyar et. al (2014) have shown that an estimate of more than 200 million fish in the UK have been mislabelled. Moreover, their studies showed that, out of all samples labelled as Atlantic cod, a large amount of the mislabelled fish were Pacific cod, which implies that the mislabelling did not occur in the early stages of the supply chain, but at a later point. This amount of misinformation is becoming an increasing concern in terms of consumer protection and information. Furthermore, it poses a threat to sustainable fisheries and the credibility of eco-labels (Helyar, et al., 2014).

Blockchain technology has been proposed to solve such problems. Blockchain is widely known for its association with cryptocurrencies such as Bitcoin. However, cryptocurrencies are only one applicable field of usage for blockchain technology. Other areas include the public sector, transportation, infrastructure, banking industry etc. (Nofer, Gomber, Hinz, & Schiereck, 2017) With its characteristics of being a public and secure ledger system where recorded information cannot be altered or deleted after each transaction, it can be used as a tool for improving supply chain governance. (Sissman & Sharma, 2018) The integration of blockchain allows companies to provide more credible information by having direct access to transactional records along the supply chain. Furthermore, it provides exact timestamps of when and where the transaction has occurred (Apte & Petrovsky, 2016). A system that could connect all partners along the supply chain by tracking the product has always been talked about, but it has been too expensive and therefore not affordable until blockchain technology was introduced. Blockchain technology makes it possible to oversee when and where an item has passed a key point and which business, or worker handled the transaction. Alone, blockchain technology does not help companies to trace their products. First, they would need to digitalise their data collection method such as using QR or RFID codes, as mentioned before. An additional advantage is that blockchain technology makes it possible for companies to adopt a supply chain governance system without a broad expertise in IT. (Shilling, 2018) Furthermore, the blockchain system uses crowd-sourced information and no party has control over the data, which makes it more resistant to fraud (Bateman, 2015).

Several pilot projects adopting blockchain technology have been launched to track the supply chain of MSC certified fish. One is the *WWF initiative*, which tracks tuna from “bait to plate” (Visser & Hanich, 2017). Another initiative is conducted by *Provenance*, which aims to tackle a similar issue. Both initiatives have the potential to provide a solution for the supply chain

issues mentioned above. Additionally, the company *Gustav Gerig* is the first European wholesaler who uses blockchain technology to track its MSC certified tuna.

1.2 Research question

Blockchain technology is still at its early stages and besides cryptocurrencies, most people do not know about its application possibilities. As blockchain technology is a rather new technology and the application for eco-labelling schemes is even more recent, the present study aims at answering the following research question:

"How does blockchain technology impact eco-labelling schemes?"

The findings of the study will illustrate what benefits the use of blockchain technology has for eco-labelling schemes and what challenges remain.

1.3 Methods

To answer the research question, a qualitative analysis based on expert interviews was developed to uncover the intricacies involved in the fish industry. An exploratory approach was chosen due to the nature of the problem, which still requires the identification of the main variables involved (rather than testing the associations among variables).

The fish industry was chosen due to the availability and quantity of secondary data, as well as the possibility of collecting primary data from pilot studies. A deductive approach is utilised, meaning that the author first defines the scope of the question itself and then further answers with the specific characteristics of the selected case study. The research focuses on the core criteria for eco-labels within the fish industry, which is the sustainability of fish stock. As the sustainability of fish stock is certified by eco-labels such as the MSC, this thesis focuses on the credibility of their evaluation criteria. Furthermore, it explores if blockchain could improve supply chain governance for eco-labels.

This thesis solely focuses on the application of blockchain within the fish industry and therefore issues such as the quality of the fish have been disregarded. Furthermore, as the thesis focuses mainly on MSC's chain of custody certification, human rights issues have not been addressed.

This thesis investigates and provides empirical data in an exploratory research design from the *Pacifical* case.

1.4 Structure

The first chapter introduces the topic of the thesis. In the problem statement I explain the relevance of the research on this topic followed by the research question, aim of the thesis and its limitations. The fourth part of the introduction gives an overview of the chapter outline. In the second chapter the reader is introduced to the literature which is used to discuss the main topics of the thesis. The literature review is divided into supply chain governance, eco-labelling, and blockchain literature. The third chapter discusses the methodology, which is applied to answer the research question and introduces the case study by outlining the applications of blockchain technology in the fishing industry. The findings of the research are presented in the fourth chapter followed by the discussion. Lastly, the conclusion reviews the whole conducted study.

2 Literature Review

In order to discuss the case of *Pacifical*, which involves the application of blockchain technology for MSC certified tuna, the most relevant literature will be discussed beforehand.

2.1 Supply chain governance

Industrial organizations and trade have drastically changed during the past few decades. Globalization has fuelled the development of industrial capabilities. These developments have led to global value chains of integrated corporations and new governance patterns. Gereffi et al. (2005) argue that the form of global value chains depends on three variables: the ability to codify transactions, the complexity of transactions and the capabilities of the supplier. Through these variables five governance forms for network relationships can be outlined: modular, market based, relational, hierarchical structures and captive networks. (Gereffi, Humphrey, & Sturgeon, 2005)

"Supply chain management (SCM) is a process that controls, coordinates, and integrates the logistics and the flow of information and capital from original suppliers through a series of intermediaries to end customers in a timely manner to improve the performance of all parties involved." (Wang & Ran, 2018)**.** Through successful SCM, several benefits such as reduced costs, increased sales, higher market share, on time in full (OTIF) deliveries and enhanced customer relations can be achieved. The academic literature review illustrates that effective SCM is not possible without suitable governance mechanisms. Governance can be described as a set of regulations and the coordination of different activities through various formal or informal mechanisms based on the purpose of the supply chain. It may include guidelines, policies, rules, norms, laws, standards, verification and monitoring procedures, financial incentives and law enforcement. (Wang & Ran, 2018)

Complying with international standards is a benchmark for entering global supply chains. Standards transmit information to the end user and customers about the specifications of a product. The International Standards Organization (ISO) is an umbrella organisation for standard setting agencies. One of the most prominent standards for quality assurance is the ISO 9000 series certificate with around a million certificates issued. These standards are independently verified by auditors and compliance agencies. The ISO 9000 standard was often seen as too generic and insufficient from an environmental and labour point of view. Therefore,

the ISO 14000 series certifies environmental standards and the ISO 26000 has been adopted for social standards. Gereffi et al. (2005) argue that standards can ensure codifiability which can reduce transaction cost that is associated with the supply chain's governance. (Nadvi, 2008) Governance is critical to the solidity of buyer-supplier relationship. In these relationships, mechanisms occur by which both parties act. In interorganisational exchanges like the supplier-buyer dyad, governance can be realized through transactional and relational instruments. (Liu, Luo, & Liu, 2009) In the next paragraphs several governance theories will be discussed.

Transaction-cost economics is one of the main theoretical frameworks for analysing governance between organizations (Wang & Wei, 2007). Transactional mechanisms are realized in joint stipulated contractual agreements and bilateral transaction-precise investments. Transaction cost economics state that transactional mechanisms happen due to economic rationality, which emphasize the governance of relationships by monitoring and having incentive mechanisms. Formulating a well-defined contract is the main instrument that hinders opportunistic behaviour. Opportunism can be defined as "self-interest seeking with guile" or in simpler terms cheating, lying etc. A well-specified contract stipulates the obligations and rights of the parties through formal terms, rules and procedures and how future situations should be handled. This can help to realize hazards and mitigate potential problems from occurring in the future. Transaction-specific investments can take the form of tangible assets (e.g.: facilities, machines) or intangible (e.g.: technology, knowledge). It provides binding incentives to continue vertical relationships. (Liu, Luo, & Liu, 2009) TCE illustrates why companies form institutional structures, which do not correlate to the market driven view of neo-classical theory, where the main goal is maximising profit. TCE follows the principle of reducing transaction costs, which are all direct and indirect (e.g.: stress, time) costs that involve transactions. (Chen & Chen, 2003)

Relational governance can be seen as an important hybrid structure that allows flexibility for uncertainties in a partnership (Wang & Wei, 2007). Relational mechanisms include trust and relational norms. Relational norms are behavioural expectations of how different parties are supposed to behave and involve solidarity, information exchange and participation. Trust emphasizes the benevolent atmosphere of the exchange. It is defined as the belief or confidence that the partner has about the honesty and cooperative behaviour of the exchange partner. Developing solidarity helps to shift away from a self-centred approach to unity, arising from

common interests, responsibilities and goals. (Liu, Luo, & Liu, 2009) Relational governance includes the expectations of mutuality and continuity of the relationship (Wang & Wei, 2007). In general, transactional mechanisms provide the legal framework in which relational mechanisms exist to jointly reduce transaction cost and mitigate opportunism (Liu, Luo, & Liu, 2009).

The resource-based view argues that strategic inter-organizational alliances are formed because of the potential that resources can be pooled together for value-creation. This essentially gives them access to resources they do not own. It is argued that the structural profile of resource distribution transfers to the structure of contractual alliances. Resources can be distinguished in many ways: intangible resources and tangible resources; physical capital resources, organisational resources and human capital resources; financial, physical, technological and managerial; knowledge-based and property-based resources. Every strategic alliance such as a buyer-supplier alliance incorporates a 'give and take' aspect of their resources. Chen and Chen (2003) argue that resource complementarity indicate less exploitation or opportunism, as a high degree of interdependency prevails. While TCE highlights the benefits of contractual agreements to prevent opportunism, the RBV emphasizes the establishment of business relationships for resource sharing which contributes to the overarching goal of the organisational agreement. (Chen & Chen, 2003)

Alignment is regarded as the adjustment of a different components to achieve an optimal relationship of the components. (Wu, Wu, Chen, & Goh, 2014) In this regard, the strategic alignment perspective (SAP) highlights the alignment between corporate strategy and operations. Formenitini and Taticchi (2016) use the framework to explore governance mechanisms on a functional level and on a corporate level or in simpler terms achieving strategic fit of the company's strategy and processes. They found that the alignment of supply chain strategy and corporate environmental strategy improve the profitability of the firm. (Formentini & Taticchi, 2016)

Contingency theory is based on the principle that there is no unique structure which fits all companies. It argues that each organization builds its structure based on contingency factors. (Elgharbawy & Abdel-Kader, 2013) These structures may change to fit contingencies in order to reach higher performance (Formentini & Taticchi, 2016). Sousa and Voss (2008) established

four contingency factor categories: culture and national context, strategic context, firm size and other variables in the organisational context. Each company's contingency factors vary and therefore different governance mechanisms are put into place. (Sousa & Voss, 2008)

2.1.1 Sustainable supply chain governance

Sustainability within the supply chain is a topic that became of increasing importance after several incidents. One of those incidents was a Greenpeace report released in 2009, which alleged several brands, such as Adidas, Nike, Clarks, Timberland and Reebok to have sourced their leather from illegally deforested zones in Brazil. This resulted in media headlines around the world and called for enhanced environmental and social responsibility when sourcing products. All involved companies had to distance themselves from the illegal sourcing practices to keep stakeholder satisfaction intact. The ways in which companies monitored their supply chain became questioned and potential benefits of integrating social and environmental concerns in the supply chain have been discussed. A 2008 report of KPMG showed that nearly all Global 250 companies have a code of conduct for supply chain management for socially responsible and ethical practices. Only half of them disclose how their monitoring of codes is conducted. The burden to reduce costs has led to suppliers in less developed countries to act in an opportunistic behaviour, resulting in a loss of innovation and lower quality. This has led to reduced trust of stakeholders and value creation in the long run. The integration of sustainability practices along the supply chain has been discussed to counter misconduct along the supply chain. (Vurro, Russo, & Perrini, 2009)

The World Commission on Environment and Development's definition for sustainability is "development that meets the needs of the present without compromising the ability of future generations to meet their needs". Integrating environmental, social and ethical issues in the supply chain and purchasing is known as sustainable supply chain management. Gimenez and Sierra (2013) have analysed two different governance mechanisms from the buyer's perspective for improving environmental performance in the supply chain, namely supplier assessment and collaboration with suppliers. Any activity such as questionnaires or company visits, which evaluates suppliers is regarded as supplier assessment. Collaboration with suppliers includes having direct contact with them, giving support, training or other activities. Their research found that supplier assessment is crucial when deciding which supplier to develop and collaborate with and moreover, to enable the implementation of sustainability in

the supply chain. Supplier assessment helps the company to identify which activities should be focused on for supplier development. The higher the degree of supplier collaboration was, the more environmental performance could be derived. (Gimenez & Sierra, 2013)

Gimenez and Sierra (2013) found that supplier assessment helped companies to reduce opportunism of the supplier and improve the supplier's environmental performance which in return improves their own environmental performance and reputation. The resource-based view claims that rare, valuable and difficult to reproduce capabilities and resources can give a company a sustainable competitive advantage. Supplier and buyer's change of perception through education and greater knowledge can be regarded as an important asset. It can also be referred to as an intangible resource, a term which scrutinises products that are rare, valuable and difficult to reproduce. The sharing of knowledge in this form allows smaller footprints in their processes and increases trust and profitability of the company. (Gimenez & Sierra, 2013)

Following the framework of van Tulder et al. (2009) for sustainable supply chain strategies, which classified companies into inactive, reactive, active and proactive clusters, depending on their level of codes of conducts and CSR practices, Gimenez and Sierra found that groups with the highest form of proactive governance mechanisms, outperformed the other groups and have higher rates of collaboration with suppliers and supplier assessment. They advise companies to conduct supplier assessment in the initial phase and follow up with training the supplier and giving directions for improvement. (Gimenez & Sierra, 2013)

Formentini and Taticchi (2016) define "sustainable supply chain governance mechanisms (SSCGMs) as practices, initiatives and processes used by the focal firm to manage relationships with 1) internal functions and departments and 2) their supply chain members and stakeholders with the aim of successfully implementing their corporate sustainability approach." They proposed a framework which analyses the implementation of corporate sustainability approaches in connection with governance mechanisms for supply chain management and developed three different classifications regarding sustainable supply chain management (SSCM), namely traditionalists, sustainability practitioners and sustainability leaders. They differ in their engagement of the triple-bottom-line, which takes environmental, economic and social dimensions into account. Sustainability leaders are characterised by fully implementing the TBL approach, sustainable practitioners usually limit their focus on one or two of the

aspects, whereas traditionalists do not include explicit initiatives regarding the TBL or SSCM. These three categorisations could be made by analysing contingency factors, internal governance mechanisms, external governance mechanisms and available resources. Their research shows that companies engage with sustainability at different levels according to these factors. The SSCG literature indicates that there is a positive benefit of implementing formal and informal governance mechanisms as well as collaborating for SSCM initiatives. (Formentini & Taticchi, 2016)

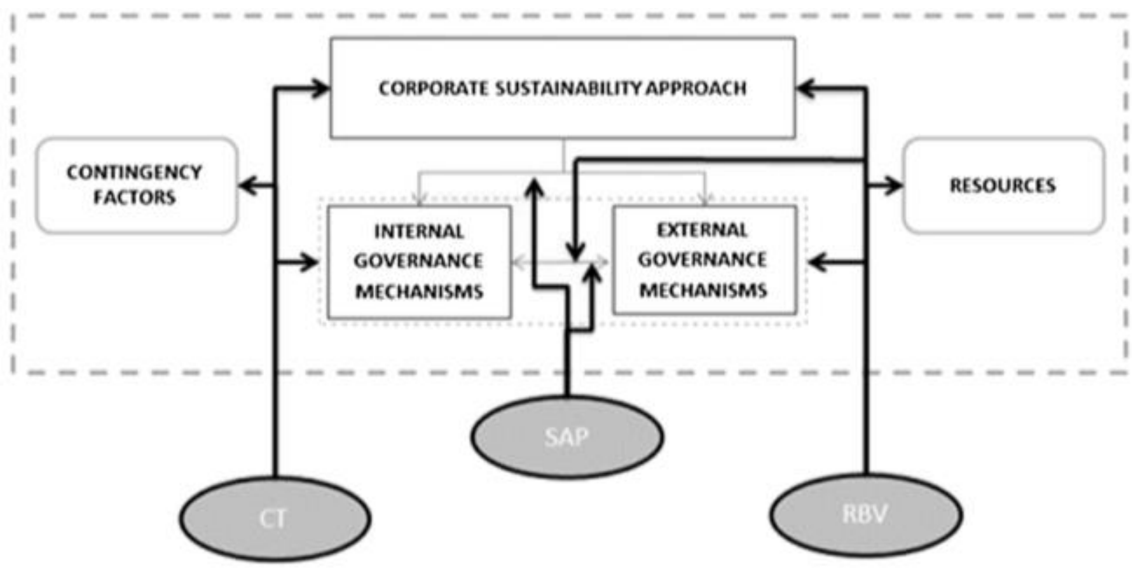

Figure 1: Corporate Sustainability Approach (Formentini & Taticchi, 2016)

Figure 1. illustrates the different factors that form the corporate sustainability approach of firms according to the framework of Formentini and Taticchi (2016) by taking CT, SAP and RBV into consideration. It demonstrates that all factors play a crucial role for a company's decision to choose a certain corporate sustainability approach.

2.1.2 Sustainable supply chain management (SSCM)

Over 80 percent of greenhouse gas emissions from consumer products occur within the supply chain. A large amount of literature has been dedicated to the development of sustainable supply chain management systems. Carter and Easton (2011) define sustainable supply chain management as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual company and its supply chains." (Carter, Hatton, Wu, & Chen, 2019)

According to Bowen et al. (2001) key factors for facilitating green supply chains are i) teams working cross-functional ii) collaboration with suppliers iii) purchasing staff that are aware of environmental issues iv) technical knowledge of the purchasing staff v) in-depth purchasing procedures and policies. Following the relational view and the resource-based view a sustainable supply chain heavily depends on inter and intrafirm capabilities which can facilitate the exchange of knowledge and enable strategic purchasing. As highlighted in Figure 2., Bowen et al. (2001) state that there are different ways of achieving a sustainable supply chain. (Gold, Seuring, & Beske, 2010) The following chapter will review the concept of environmental proactivity and going beyond basic compliance.

Category	Acronym	Description
Environmental proactivity	EP	Going beyond basic compliance with regulations, while management gives environmental issues a high priority; managing effectively environmental risks.
Strategic purchasing and supply	SPS	Written long-range plan of the purchasing function including the kinds of material or services purchased and the various types of relationships to be established with suppliers.
Supply management capabilities	SMC	Liaison between purchasing and other functions; detailed purchasing policies and procedures; partnership approach with suppliers; technical skills of purchasing professionals; advanced understanding of environmental issues and how they affect supply.
Product-based green supply	PGS	Recycling initiatives which require co-operation with a supplier; collaboration with a supplier to eliminate packaging; efforts with suppliers to reduce waste.
Greening the supply process	GSP	Environmental supplier questionnaire; supplier environmental award; scoring system to rank suppliers on their environmental performance; requirement on suppliers to have an environmental management system; integration of environmental criteria into vendor assessment system and the selection of strategic suppliers.

Figure 2: Categories of sustainable supply chains based on Bowen et. al (2001) (Gold, Seuring, & Beske, 2010)

2.2 Beyond compliance leadership and the emergence of green clubs

With an increasing awareness of how our consumerism affects the environment, companies started to go beyond just compliance in the early 1980s and implemented Environmental Management Systems (EMS) certification. These voluntary initiatives, including the establishment of codes of conducts or environmental programs, helped companies to mitigate reputational risk and bad stakeholder dialogue, which could potentially lead to eco-activism as highlighted by Orsato (2009). To enhance corporate reputation, Voluntary Environmental Initiatives' (VEI) or so-called green clubs emerged. By engaging with Green Clubs, companies could manage their environmental reputation more effectively. Green clubs often help companies to improve their reputation, which might have been damaged by environmental accidents such as oil leaks. The *UN Global Compact* or *Climate Leaders* are examples for those

Green Clubs. The main cost that occurs when joining a Green Club are not membership fees, but the costs that occur when adhering to the club's rules. Companies that joined the *UN Global Compact* enjoyed several benefits, such as increased trust, networking opportunities and addressing humanitarian concerns. In general, the adoption of Green Club guidelines and doctrines enhances the public opinion and the reputation of the company. (Orsato, 2009)

2.3 Eco-labelling

Eco-labelling provides a differentiation strategy that differs from traditional differentiation strategies. Instead of differentiating the product by its appearance or quality, the processes in which the product is produced is investigated and highlighted. Eco-labelling relies on the consumers' willingness to receive credible information about how the product was produced and to pay a price premium for this information. In order to trust the methods and the source of information, eco-labels were established. In essence, eco-labels are an additional example to Green Clubs, but instead of only focusing on upstream activity, meaning the processes, they also focus on downstream activities i.e. what happens to the product post-consumption. (Orsato, 2009)

Eco-labels were introduced to encourage companies to implement sustainable practises by providing them with their label and a potentially more rewarding and prestigious brand. The first eco-labels, such as the Nordic Swan, the German Blue Angel or the European Flower were introduced in the late 20th century by governments and covered a wide range of products. (Gulbrandsen, 2006)

In addition, various voluntary certification and eco-labelling programmes were developed by non-governmental organisations in response to social and environmental concerns in the fishing, farming, forestry industries and more. The Forest Stewardship Council (FSC) is the first eco-label that was established by a non-governmental organisation. It emerged due to a growing concern of global forest degradation, biodiversity loss, deforestation and the inability of governments to counter these problems. It was founded by the World Wide Fund for Nature (WWF) among other stakeholders. It is an open membership organisation with economic, environmental and social chambers. The FSC has established 10 principles and 56 criteria, which cover main issues such as use rights; tenure and responsibilities; workers' rights; indigenous people rights; maintaining biodiversity; use of forest services and products; forestry

monitoring; planning and assessment etc. These criteria and principles are adjusted to the regulations of different countries and aim to provide solutions for economic, ecological and social concerns. There is a chain of custody certificate for products that carry a specific percentage of fibre, wood or chip contained in those FSC certified products. (Gulbrandsen, 2006)

Contrary to the management of forests, which happens to be mainly done by private companies, marine fish stocks are commonly managed by governments. Resulting from the depletion of fish stock caused by overfishing and furthermore the loss of natural habitats, the WWF cofounded the Marine Stewardship Council (MSC) with Unilever. The MSC developed a global fishery standard for managing sustainability in compliance with national, local and international fishing standards and laws to protect the marine ecosystem. Similar to the FSC, the MSC has a chain of custody program which ensures that MSC products have their origin from a certified fishery. Both the MSC and FSC were established in response to the inability of governments to address habitat degradation or resource depletion. (Gulbrandsen, 2006)

In contrast to Type II certification where the manufacturer puts a self-proclaimed certificate on its products, eco-labels provide a further level of legitimacy. The International Organisation for Standards (ISO) considers Type I and Type III as eco-labels. (Orsato, 2009) These eco-labels are examples for voluntary certification schemes. Type I labels refer to third party certified products that provide a logo. Type I are the most common labels referred to as eco-labels in the literature. Type III labels further provide life cycle assessments on environmental data in a detailed report format. Figure 3. illustrates some of the most well-known labels and their classifications. (Horne, 2009)

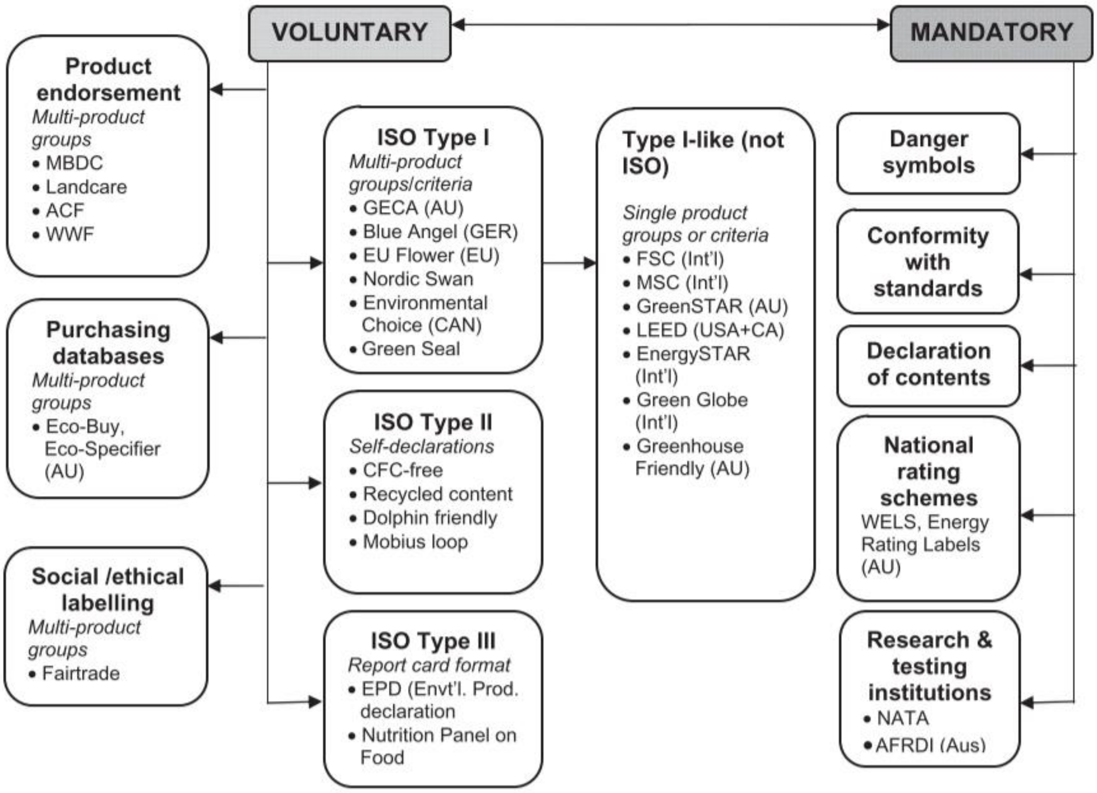

Figure 3: Classification of eco-labels (Horne, 2009)

Orsato (2009) found that eco-labels do not significantly improve competitive advantage but worked better in avoiding disadvantages. As the adoption of eco-labels gradually increases, eco-differentiation decreases as the product is less unique than before.

Carlson and Palmer (2016) have investigated the benefits of eco-labelling in developing countries. Firstly, they found that there are costs at all three stages (preparation, auditing and compliance) for producers to adopt to an eco-label. For FSC certification, the producers are subject to auditing costs, such as travel, fees and oversight costs. In many cases producers have to change their operations or equipment to obtain the certification where further costs occur. Other barriers include lack of knowledge about certification schemes and their complexity. Despite those barriers, there are several benefits that have been found for even developing countries such as increased access and differentiation to its competitors. (Carlson & Palmer, 2016)

The findings of Carlson and Palmer (2016) support the hypothesis that there are substantial benefits for producers when certifying their products, which can justify the costs of

certification. Besides the financial benefits that occurred for only two of 20 reviewed case studies (both FSC), certifying products gave producers more market access in the fishing and forestry industries, as many buyers made certification a prerequisite when choosing suppliers and therefore gave producers access to higher profit export markets. Even though there was limited support for eco labels providing private economic aids, all twenty cases showed satisfaction with their decision to certify their products. One of the key factors was the learning process that producers became aware of. In all case studies conducted by Carlson and Palmer (2016), the evidence showed that producers became more aware of environmental problems and the impact that their activities have on the environment and helped them to manage their resources more efficiently, which also enhanced data collection and monitoring. Stakeholder participation increased as well and benefitted the community by facilitating communication. A second theme which arose was government support and empowerment. It took the form of tax benefits, public good provision, regulatory relief, and preferential treatment for resource access. The third theme which emerged was enhanced reputation. Certification helped producers to differentiate their products against competitors and gain international recognition. (Carlson & Palmer, 2016)

2.3.1 Eco-labelling in the fishing industry

Global fishing has increased significantly from the 19th century until the 1990s to a level of 90,000 tons/year and above. Fishing is the largest human alteration in the sea-ecosystem and became subject to sustainability concerns. (Thrane, Ziegler, & Sonesson, 2009)

Seafood eco-labelling schemes claim to address issues such as the overexploitation of fish. The reference points for non-over-exploited and sustainable fish stocks are outlined in the *United Nations Convention on the Law of the Sea and the United Nations Fish Stock Agreement*. Following those agreements, fish stocks should be maintained at a level that can support the Maximum Sustainable Yield (MSY), which takes fishing patterns, interdependence of fish stocks and international minimum standards into account. However, there is no clear definition of how exactly overfishing and MSY are measured. Generally overfishing refers to the point where fishing from a stock is too high for it to naturally maintain its size. (Froese & Proelss, 2012)

There are around 50 ecolabels that relate to aquaculture and fisheries. Well known ecolabels include the Marine Stewardship Council, KRAV, Natureland and Friend of the Sea (FOS). These eco-labels reward producers, which use responsible fishing practices with their seals of approval. Deere (1999) has grouped ecolabelling schemes in the fishing industry into three groups. First party eco-labels are usually self-declared schemes by the producer or reseller itself based on an own set of criteria. Second party eco-labels are created by industry associations for products of its members and compliance is either internally to verified or by external certifiers. Third party eco-labels are established by organisations outside of the specific industry sector. These labels carry a certain level of independence. It is the owner of the label who sets the criteria, which is considered the most robust scheme for eco-labelling, because of the lower amount of commercial influence. (Srinivasa Gopal & Boopendranath, 2013)

Furthermore, three different categories of eco-labelling schemes can be identified. Single attribute schemes focus on the protection of a single species (e.g.: Dolphin Safe Tuna). Resource oriented multi attribute labels focus on countering overfishing and adverse effects on aquaculture, by enhancing the sustainability of the reproductive capacity of the stock (e.g.: MSC). Multiple aspect eco-labels focus on environmental aspects of the product’s whole life cycle (e.g.: KRAV). (Srinivasa Gopal & Boopendranath, 2013) “A recent study found that more than half of consumers are willing to pay more for certified sustainable seafood products.” (Furlong, 2016) One of the most prominent certifiers for sustainable fishing is the Marine Stewardship Council (MSC) (Gutierrez, et al., 2012).

2.3.2 The Marine Stewardship Council

Single species eco-labels were among the first to be established after a rising public concerns about the inadvertent capture of sea turtles and sea mammals. In 1990, the US government created the Dolphin-safe label. This label along with the sea-turtle safe label guaranteed that sea turtles and dolphins were not killed by the fishing method of the certified fisheries. It soon became apparent that the single-species approach did not address the main environmental problems in the fish industry. The success of the Forest Stewardship Council, as a sector wide certification scheme, served as predecessor for the World Wildlife Fund for Nature (WWF) to establish a similar certification program in the fishing industry. (Gulbrandsen, 2009) The Marine Stewardship Council (MSC) was founded in 1997, as a joint project between Unilever and the WWF (Srinivasa Gopal & Boopendranath, 2013). At that time Unilever was one of the

biggest frozen fish purchasers. Together, they aimed to improve fishing practises. To counter criticism that Unilever and the WWF controlled the MSC, the MSC became a fully independent non-profit organization in 1998. (Gulbrandsen, 2009)

The principles that guided the MSC were established by building on the UN Fish Stocks agreement, the FAO code of conduct for responsible fisheries and other international agreements for fisheries. There was an initial discussion if the MSC should cover social and developmental issues or focus on environmental issues and fishing practises. It was concluded that it would narrow its focus on environmental and fishing operations due the large scale of social aspects. (Gulbrandsen, 2009) One key attribute of the MSC eco-label is its chain of custody that ensures that MSC-certified fish originates in certified fisheries (Gutierrez, et al., 2012).

The mission and vision of the MSC are to ensure that ocean resources are safeguarded for future generations. Their certification standards and eco-labelling program are used to recognize and reward sustainable fishing practices at sea and to transform the seafood market into a more sustainable environment. The MSC is an international standard setter for chain of custody certification. They set up the chain of custody program, which essentially is a segregation based standard system, to ensure that certified fisheries and their products that enter the supply chain can be clearly segregated from unsustainable sources at all stages along the supply chain and are traceable from the final labelled product back to a certified sustainable source. Each link within the supply chain is part of the chain of custody certification. The MSC uses an independent and accredited third-party auditor to perform annual audits, where certified fisheries need to demonstrate conformity with MSC standards. (Liow, 2020) The MSC defines sustainable fishing as "leaving enough fish in the ocean, respecting habitats and ensuring people who depend on fishing can maintain their livelihoods." (MSC, 2020)

2.3.3 Chain of custody

One of the main problems in the fishing industry is illegal, unreported and unregulated (IUU) fishing. These issues could lead to damaging the fish stock by overfishing and economic losses to communities. To counter these problems, third party certifiers such as the MSC developed chain-of-custody certification programs that should ensure a supply chain that is free from illegally caught fish. To mitigate reputational risk, corporations which are at the top of the

supply chain such as retailers and processors are incentivised to prevent any IUU seafood from entering their stock. (Roheim, 2008) Chain of custody certification generally refers to documentation in chronological order tracking the "seizure, custody, control, transfer, analysis and disposition of evidence, physical or electronic." In the fishing industry however, chain of custody refers to the documentation that is required by eco-labels to certify their products. (Borit & Olsen, 2012)

2.3.4 Global seafood supply chain

To get a broader understanding of what is certified, I will give a short overview of the main players or stakeholders that are involved in the seafood supply chain. The seafood supply chain involves many different intermediaries between the fishing vessel and the final consumer. As Roheim (2008) outlined in Figure 4, there are several different ways of fish to take until it reaches the consumer. 1) It is directly exported after harvest. 2) It is primarily processed in the harvesting country and then exported. 3) Primary and secondary processing has been done in the harvesting country. 4) Or it is exported to a third country to process after the harvest.

Between almost every connection that can be seen on Figure 4. middlemen such as traders and brokers can be found, which is one of the reasons why tracing seafood can be so difficult and IUU fishing can occur.

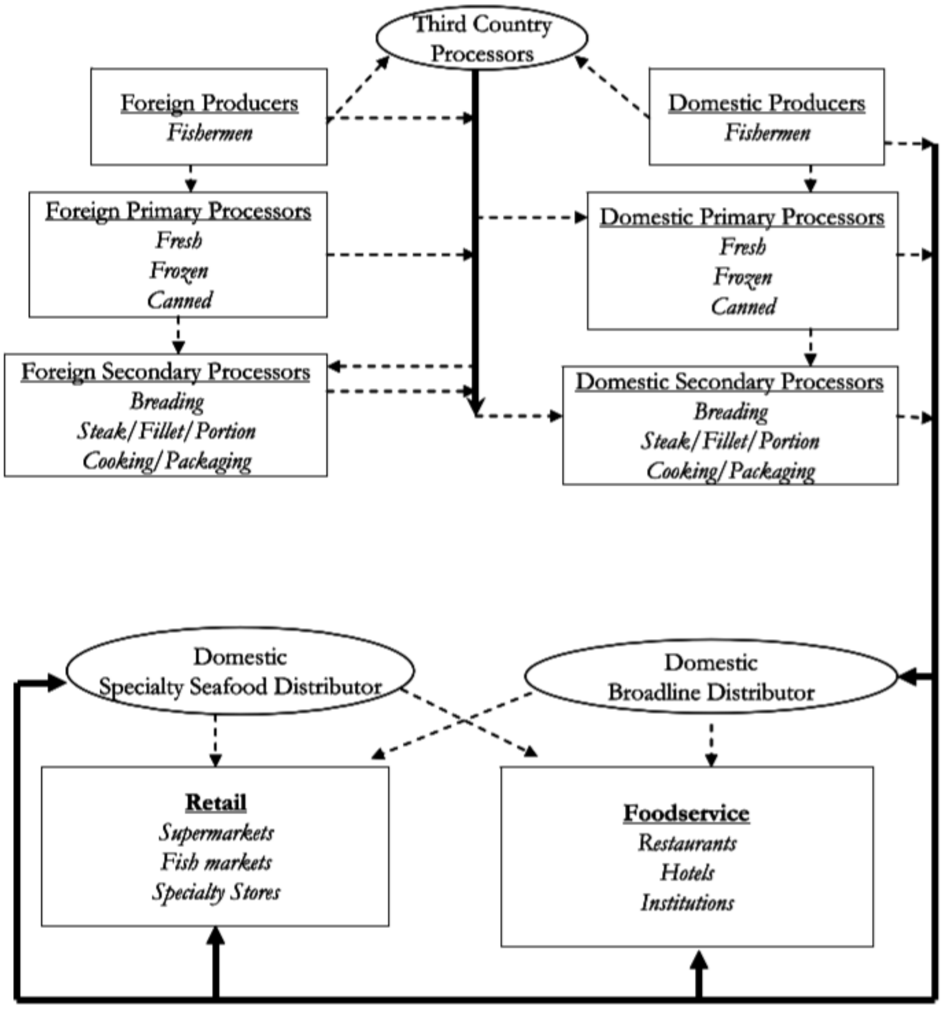

Figure 4: Simplified Seafood Supply Chain (Roheim, 2008)

2.3.5 Traceability

Traceability means the ability to track and trace the product by documenting its origin, the processing and handling of the product until the final purchase of the customer. Furthermore, these documentations must be interconnected so that it is possible to trace back the history, location, and application of the product and its components throughout the whole supply chain. Furthermore, traceability should also provide information about sustainability aspects and the legality of the catch. (Borit & Olsen, 2012) In the seafood industry, traceability has first occurred to counter food-borne illnesses and to recall products in a fast manner. (Roheim, 2008)

In practise, a traceability system can be implemented by using paper-based systems or a computer software which can include bar codes or radio frequency identification (RFID) tags, a more recent technology (Karlsen, Sørensen, & Forås, 2013). It must contain the following

characteristics: (i) The units, which are referred to as Traceable Resource Units (TRU) (ingredients, components and products); (ii) A numbering or identification scheme that uses codes or numbers to identify each TRU; (iii) A method that can associate the TRU with the respective number or code; (iv) Functionality of recording the TRU's properties; (v) Functionality for having access to the numbers/codes and all associated recordings (Borit & Olsen, 2012).

A traceability system has to cover all points along the supply chain such as in Figure 4, which includes all middlemen and the transportation involved (Roheim, 2008). Several pilot projects aim to use blockchain technology for their wild caught tuna to enhance governance, traceability and transparency.

2.4 Blockchain technology (BCT)

Blockchain technology is essentially a public ledger, or distributed database of records where all transactions are saved in a sequence of blocks and shared among all participating parties (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016). With its decentralized, persistent, anonymous and auditable characteristics, blockchain technology provides a system that can improve efficiency and save costs. A blockchain is immutable and blocks cannot be changed once they are inserted in the blockchain. (Zheng, Xie, Dai, Chen, & Wang, 2017) The main benefit of blockchain is that each transaction can only be verified by a consensus of the majority users, which allows all participants to know that an event happened. An immutable record is created on the public ledger which is broadcasted on the public ledger of all systems or so-called nodes. This information can never be deleted once it entered the system. (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016)

2.4.1 The block

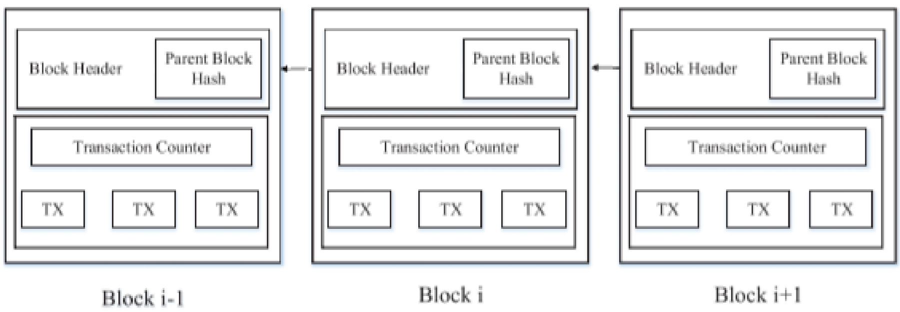

Figure 5: The Blockchain (Zheng, Xie, Dai, Chen, & Wang, 2017)

As can be seen in Figure 5, each block header contains a parent block hash from one previous parent block, whereas the first block is referred to as genesis block (Zheng, Xie, Dai, Chen, & Wang, 2017).

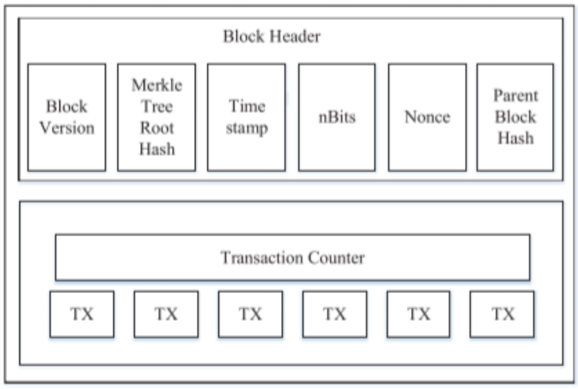

Figure 6: The Block (Zheng, Xie, Dai, Chen, & Wang, 2017)

Figure 6. explains how a block is built. A block can be divided into block header and block body. Each block header has a block version, which indicates the block validation set for the following blocks. The Merkle tree root displays the hash value of all transactions within the block. The timestamp holds current time information in seconds. The nBits display the target threshold of valid block hashs (references numbers of a block). The Nonce is a four-byte field, which increases in value with every hash calculation. The parent block hash is a 256-bit hash value, which directs to the previous block. (Zheng, Xie, Dai, Chen, & Wang, 2017)

The block body includes transactions and the transaction counter. There is a maximum number of transactions a block can contain, which depends on the size of the block and the transaction itself. (Zheng, Xie, Dai, Chen, & Wang, 2017)

2.4.2 Digital signature

Every blockchain user has a private key and a public key. A private key is used in confidentiality and signs the transaction. After signing a transaction, it is broadcasted throughout the entire network. The digital signature process involves two phases. Firstly, in the signing phase, User A encrypts the data with the private key and sends User B the original data and encrypted result. Secondly, in the verification phase, User B validates the data with the public key of User A. This allows User B to check if the data has been manipulated or not. The

algorithm used for digital signatures is called "elliptic curve digital signature algorithm" (ECDSA). (Zheng, Xie, Dai, Chen, & Wang, 2017)

2.4.3 Characteristics of blockchain

Blockchain technology fulfils four central characteristics: decentralisation, persistency, anonymity and auditability. In the following, the four terms will be explained:

Decentralization: With blockchain technology the need of a third-party trusted agency is eliminated through consensus algorithms that provide data consistency within the network.
Persistency: Blocks that include invalid information would be included immediately, as they would not be admitted by ethical correct miners. Therefore, it is nearly impossible to rollback or delete transactions.
Anonymity: The blockchain does not reveal the identity of its users as addresses are generated.
Auditability: Transactions can easily be verified as they are connected to previous transactions, which makes them easy to track.

There three different types of blockchains are compared in Figure 7. (Zheng, Xie, Dai, Chen, & Wang, 2017).

Property	Public blockchain	Consortium blockchain	Private blockchain
Consensus determination	All miners	Selected set of nodes	One organization
Read permission	Public	Could be public or restricted	Could be public or restricted
Immutability	Nearly impossible to tamper	Could be tampered	Could be tampered
Efficiency	Low	High	High
Centralized	No	Partial	Yes
Consensus process	Permissionless	Permissioned	Permissioned

Figure 7: Comparison of public, consortium and private blockchain (Zheng, Xie, Dai, Chen, & Wang, 2017)

2.4.4 Consensus algorithm

Consensus algorithms are based on the Byzantine Generals Problem. In this problem, a group of Generals surrounds a city that they plan to attack. If only a few Generals attack, instead of the whole group, their attack would most likely fail. Thus, only if a consensus is reached amongst the group, they would win. This example illustrates that it is difficult to reach an agreement in a distributed environment. In blockchain, there is also no superior node which

assures consensus. However, there have been protocols put into place which ensure that ledgers in different nodes are the same. (Zheng, Xie, Dai, Chen, & Wang, 2017)

PoW or Proof of Work is known for being the consensus strategy of Bitcoin. In PoW, calculations are being made by each node to calculate the block header's hash value, which is required to be smaller or equal than a given value. Once a node reaches the value, it will be broadcasted in the whole system to other nodes which have to confirm that the value is correct. If the value is validated it is added to the blockchain of all nodes. (Zheng, Xie, Dai, Chen, & Wang, 2017) This mathematical puzzle is not easy to solve and due to the complexity, it takes ten minutes on average to solve it. There is a slight chance that two blocks are produced at the same time, which leads to more than one branch. (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016) However, this is stabilized shortly as the block after is very unlikely to be produced at the same time and then the longer chain becomes the valid chain. There are several consensus algorithms in place among the different types of blockchain. (Zheng, Xie, Dai, Chen, & Wang, 2017) PoW was illustrated as an example, as it is the one most widely known.

2.4.5 Smart contracts

In simple terms, smart contracts are computer programs that can automize contractual terms. When a certain condition in a preconfigured environment has been met, an automatic payment can be made in a transparent way. (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016) Nofer et. al (2017) argue that smart contracts might replace banks and lawyers for contract execution. A prominent example for the execution of smart contracts, is Ethereum. Ethereum is designed in a way that it has more application areas than bitcoins. (Nofer, Gomber, Hinz, & Schiereck, 2017) Ethereum can be used as a programming language and platform to build and publish distributed applications. It is a Turing complete scripting system, meaning that it has the ability to run any script, coin or cryptocurrency. Ethereum is the underlying structure to develop applications like smart contracts that can call multiple protocols, blockchains and cryptocurrencies. (Swan, 2015) The world economic forum has stated that blockchain is among the six mega trends that will shape the computing world. (Kshetri, 2018) However, smart contracts can also be run by blockchains of TRON, EOS or DASH.

2.5 Implementation of BCT for supply chain management

Current supply chain systems pose several disadvantages, such as having little information about the origin and transport of the product for consumers and lack of communication among partners of the supply chain. Potential issues which can arise while transporting goods are lost orders, defaults and delays of the delivery. In order to counter these problems, organizations have digitalised the data of their supply chain. (Casado-Vara, Prieto, De la Prieta, & Corchado, 2018)

Supply chain management has seen an increasing implementation of Internet-of-Things (IoT). Among those are sensors, RFID tags, barcodes and GPS chips which can track the location of the product at every step and allow real-time tracking of the goods. Blockchain can be used as a fool proof method to determine who is handling what action at what time and in which location. Once the data is on the blockchain it cannot be altered or changed, while other suppliers can track the process of the shipments and deliveries, which increases their trust among each other. It can be determined if a good has been in a wrong location or if it remained at a place for too long, which can be crucial for refrigerated goods. As a result, blockchain solution can provide consumers with more confidence that the quality of a product can be trusted. Kshetry (2018) has found that blockchain can reduce opportunism of suppliers simply by pressuring partners to be more accountable and responsible for their actions. (Kshetri, 2018)

Benefits of implementing blockchain include that each user has an own trusted copy of the ledger and can immediately see when transactions occur (Kshetri, 2018) and allows improved connectivity among supply chain partners (Min, 2019). Sissman and Sharma (2018) further highlight the following benefits i) Maintainability across products. BCT makes managing stock easier, as it is possible to oversee the demand of goods in relation to production levels ii) Real-time production updates. With BCT, consumers are provided with updates regarding a change of production processes. For example, if there is a change of supplier. iii) Awareness of practices. Consumers often prefer labelled products which include sustainable, organic, humanely produced, non-GMO etc., but do not really know what exactly happens behind the label. With BCT they would be provided with a verifiable way if the production process meets their standards iv) Investment transparency. Not only consumers can benefit from increased transparency, but also investors when deciding in which company to invest in. (Sissman & Sharma, 2018)

However, Sissman and Sharma (2018) outline several concerns, which are i) that increased transparency can lead to unfair practices of competitors who can use the information to damage the relationship between a buyer and supplier ii) implementing blockchain requires further standards of documentation to be applicable on a larger scale; and iii) if the 51% or more of the blockchain is owned by an organisation it has the power to decide which data is verified and which is not verified. (Sissman & Sharma, 2018) This would speak against the original intention of a decentralised blockchain.

2.5.1 BCT in food traceability

It is critical for a food business to provide consumers with food that is safe to eat and not contaminated. Goal 2 of the UN Sustainable Development Goals emphasizes the importance of food security. Food traceability standards are defined by the "FAO and WHO Food Standards Programme". Its principles are defined in the CAC/GL 60-2006: "The traceability/product tracing tool should be able to identify at any specified stage of the food chain (from production to distribution) from where the food came (one step back) and to where the food went (one step forward), as appropriate to the objectives of the food inspection and certification system". As many products have multiple-step horizontal and vertical supply chains, the one up/one down approach leaves the supply chain vulnerable. As there still is a large amount of paper-based tracking in place, the complexity of these systems makes the supply chain an easy target for fraud. (Pearson, et al., 2019)

Distributed Ledger Technologies (DLT), which comprises blockchain is proposed as a solution to the above-mentioned problems, as it allows consumers, regulators and business to instantly access the data of the supply chain. All system users hold the same data and new data can only be added to the ledger by a consensus agreement. As an attempt to change the data would be transparent to all users, the DLT makes the data, in theory, immutable. The added transparency and consensus mechanism, where actors verify the quality of each other's data, enable increased trust. Twelve global food companies already have started to adopt BCT for tracking their food. Prominent companies which already adapted the food tracking system are Nestle, Walmart and Unilever. (Pearson, et al., 2019)

Even though BCT arguably increases trust, it does not eliminate the need of regulatory mechanisms such as audits, investigation etc. Global standards for blockchain are being developed by the ISO Blockchain (TC 307) initiative. Pearson et al. (2019) argue that the DLT still faces some issues such as the need for low cost global standards and DLT architecture and increased scalability which can be derived from technical challenges of computational power and data storing. However, DLT has the ability to immediately trace food along the entire supply chain which goes beyond "one up/one down" (Pearson, et al., 2019). Figure 8. illustrates how BCT would differ from traditional SCM. It shows that all the actors would be interconnected with each other's transaction data, while in the current supply chain the actors only receive information from the actor before them. (Casado-Vara, Prieto, De la Prieta, & Corchado, 2018)

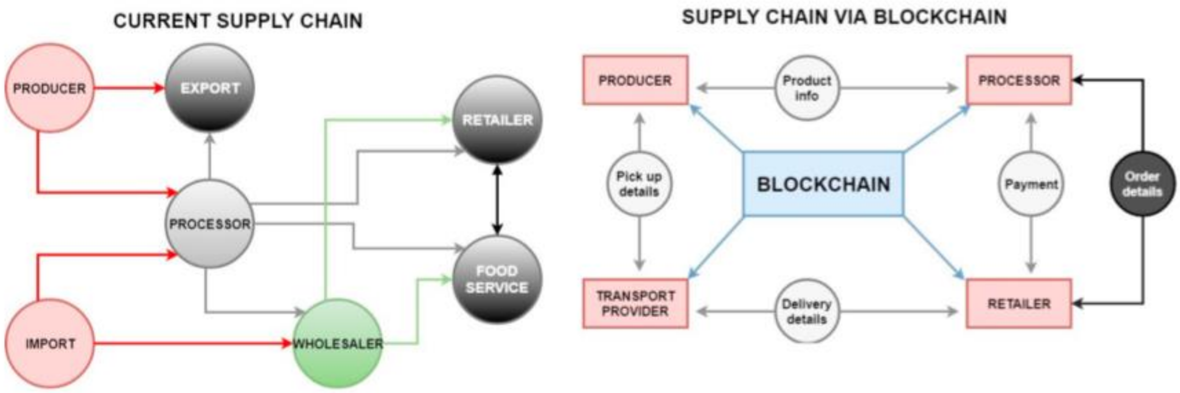

Figure 8: Current SC vs. SC via Blockchain (Casado-Vara, Prieto, De la Prieta, & Corchado, 2018)

2.6 Blockchain in the fishing industry

As mentioned in the previous chapter, blockchain technology is being used to counter illegal, unreported and unregulated fishing in the tuna industry. It is expected that blockchain technology will increase traceability and transparency while countering human rights abuses such as corruption and illegal trafficking while also regulating crew working conditions. The pilot project, which was initiated by the WWF uses a combination of RFID tags and QR codes, which are scanned along certain points of the tuna supply chain. Tracking starts when the tuna is caught and a RFID tag is attached to the vessel, which automatically uploads the information to the blockchain. The RFID tag is switched to a cheaper QR tag once the fish is processed, which will be on the product packaging and is also linked to the blockchain and traces the rest of the journey until the consumer. (Visser & Hanich, 2017)

Electronical tracking systems are not new as there are private companies such as “Trace Register” which provide full supply chain traceability. However, these services or systems rely on a centralised system of the managing authority, which would have to be trusted. Blockchain provides a decentralised system with inherent trust due to the nature of the blockchain system. (Cook & Zealand, 2018) The case of *Pacifical* will be investigated in Chapter 3.4.

3 Methodology

3.1 Research method

This master thesis analyses the research subject “the impact of blockchain technology on eco-labelling schemes within the fishing industry”. The fishing industry was chosen due to the quality and validity of secondary data. As the sustainability of fish stock is certified by eco-labels such as the MSC, this thesis focuses on the credibility of their evaluation criteria. Furthermore, it explores if blockchain could improve supply chain governance for eco-labels. The research aimed at answering the following research question: “How does blockchain technology impact eco-labelling schemes?”. Hence, this thesis focuses on the application of blockchain within the fishing industry. Narrowing its centre of attention on individual stakeholders’ supply chain operations in the context of eco-labelling makes this thesis tap into a unique research gap, which it aims to close at the end of its completion.

Based on this premise, an inductive reasoning approach was chosen. Inductive reasoning (Hair, 2015, p. 276) is a methodology “that involves identifying patterns in a data set to reach conclusions and build theories”. This means that this paper first conducted primary research to collect its own data set to then build its own theories. From a research strategy perspective, three potential modes could be taken into consideration: quantitative, qualitative and mixed-methods design. A quantitative analysis is best used if data already exists and the field is already adequately analysed. It enables a wide potential of analysis upon a chosen quantity of analysed variables. Qualitative research is an approach which enables an exploratory approach on a research area with yet limited data existing (Neergaard & Ulhøi, 2007, p. 256). A mixed-methods approach is itself a mixture of both quantitative and qualitative research which advantage is the two-step approach of data analysis via quantitative data and a further deeper insight by qualitative research methods, such as interviews, experiments or surveys (Bazeley, 2018).

In the case of this master thesis, the qualitative research approach fits best because it enables understanding processes, sentiments and incomparable data due to holistic thinking. The research is based upon an exploratory research design, which is in the majority of cases reliant on qualitative data. This approach provides a much deeper level of analysis, particularly in a small case setting (Erickson, 2017). Exploratory research is not conducted by building

hypotheses, therefore, creating freedom for the researcher to see information and data differently. Thus, it enables to build connections among individual variables to be built in a more convenient way. Lapan et al. (2011) describe qualitative researchers as "constructivists" that have the target to create a frame of the reality itself through their research (Lapan, Quartaroli, & Riemer, 2011). While critics of qualitative research state that quantitative methods are more objective, constructivists respond that, due to careful analysis of themselves and their understanding of their own biases, qualitative research has a higher level of self-reflection and a closer relationship between the researcher and the research matter. Consequently, a qualitative approach is directed towards the comprehension of individuals' view, awareness and judgment on a specific research field (Merriam & Grenier, 2019, p. 4). It is less depending on the factor of time; meanwhile focusing on the investigation of internal and external factors on the research area. Due to social interaction and communication with key stakeholders through interviews or in experiments, the qualitative researcher investigates observed reality in its full complexity and focuses its aim on the recreation of told reality (Cassell, Cunliffe, & Grandy, 2017, p. 490). Consequently, qualitative research is closing missing research gaps by the creation of data sets which resemble the reality. Alvesson and Sköldberg (2009) state that the qualitative researcher can be compared more with a "truth-finder", and less with a "reality narrator" (Cassell, Cunliffe, & Grandy, 2017).

Data was essential for developing this thesis: In the beginning, literature in the form of academic articles build the foundation of the data collection. The advantage of academic data is its availability, as well as its time and cost efficiency (Neelankavil, 2015). They are an integral part of the analysis as its analysis provides a holistic picture on existing research, meanwhile, enabling to raise new questions on the interconnectivity of data variables itself. A major disadvantage of secondary data, even in case of academic secondary data, is its limitations on comparability, verifiability as well as trustfulness – raw data can always be processed or edited (Saunders, Lewis, & Thornhill, 2009).

Method employed in the search of relevant literature

The literature review used databases like Google Scholar, EBSCO and JSTOR as the main sources. The literature includes papers published between 2000 and 2019. If publications fulfilled the criteria of two of three keywords "blockchain, tuna, MSC" they were included in

the list of publications. Overall 70+ papers were identified and subsequently read and analysed. Figure 9. illustrates the categorisation of papers by topics.

Topic	Number of publications
Blockchain (general)	5
Blockchain/supply chain	7
Blockchain/Fishing	5
Eco-labelling	11
Eco-labelling/Fishing	14
Supply chain governance	10
Supply chain governance/Blockchain	6
Supply chain/Fishing	6
Chain of Custody	3
Total	

Figure 9: Categorisation of papers by topics between 2009 and 2019 (Source: author)

Analysing the publication date illustrates that the topic of blockchain and fishing industry started to have some attention in 2009 but a trend only initiated in 2015, with 11 articles published in 2018, according to the search. It reached a peak of publications in 2018 (see Figure 10.).

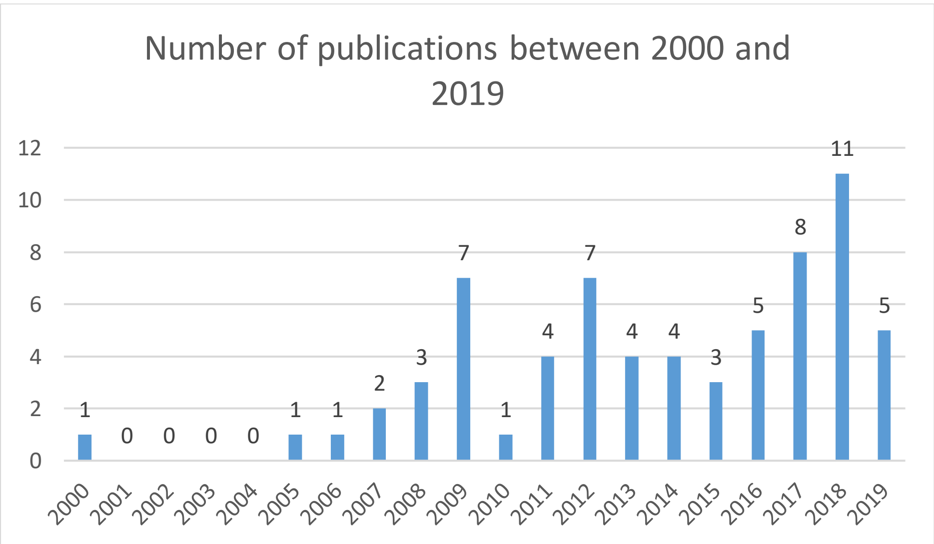

Figure 10: Publications per year (Source: author)

The literature review identified the use of several theories to understand and assess the study of blockchain implementation for sustainable fishing practices. The theories focused on eco-labelling literature and supply chain governance literature which comprised TCE, CT, RV, RBV and SAP. The outcomes of the review constitute the research gap for the assessment of blockchain technology on eco-labelling schemes. Within a transforming environment of the fishing industry, the master thesis aims to understand the holistic picture of the current circumstances in order to provide an in-depth analysis of the large number of variables which impact the chain of custody of eco-labelling schemes. Important variables include certification, regulation, operations, traceability, transparency and stakeholders' interests.

3.2 Sociological paradigm and research type

A qualitative research approach affects the perspective of analysis. In sociology, this is referred to as sociological paradigm which provide different perspectives of "social reality" (Burrell & Morgan, 1979). Four paradigms exist which are as the following: the functionalist paradigm, the interpretative paradigm, the radical humanist paradigm and the radical structuralist paradigm.

The functionalist paradigm is the most prominent and most referred structure of the four paradigms as it stresses the "objective" analysis of an issue. Functionalist perspectives incorporate a variety of perspectives which are associated to edge to the objectivist perspective, such as "realist, positivist, determinist and nomothetic" (ed. 1979, 26). It is considered as the view that aims to understand current status quos, changes in society and interrelations of factors. Meanwhile it tries to solve existing issues by providing potential solutions.

Due to individuals' subjectivism in understanding, connection and interpretation of information; the interpretative paradigm exists. Instead of observing the world like the functionalist, this paradigm argues that an individual actively needs to gain a meaning of actions surrounding the present world. Hereby, social consciousness and ontology gain their importance. A specific viewpoint for analysis is beneficial as it gives the analysis a comparability and validity (ibid).

The radical humanists put the subjectivist paradigm on a new level as their premise is that "ideological superstructures" exist in our society which make individuals act accordingly.

Superstructures decrease humans' ability to be free and reach full consciousness. Thus, this paradigm critics existing status quo and proposes an anti-organisation of structures so individuals can fully develop (ibid).

Focusing its view on the interrelation of factors the radical structuralist paradigm is a further expansion of the functionalist paradigm. Reviewing social and political conflicts radical structuralists see structures as the primary solution to overcome such crisis. Primary supporters of this theory were Max Weber and Karl Marx (ibid).

The current status quo of this paper analysis comes from a functional paradigm perspective, which entails observing the information from a "realist" perspective. As no hypotheses was created, there are no expectations for clear results. In reference to Durkheim (1964) functionalist perspective particularly focused on quantitative data. However, today it is also widely accepted among qualitative scholars (Durkheim, 1964). Flick et al. (2004) state that functionalism is suitable to understand processes and their actors, while being able to keep distance to the research matter (Flick, von Kardoff, & Steinke, 2004). Lapan et al. (2011) argue that a qualitative researcher is someone who reconstructs the reality through research (Lapan, Quartaroli, & Riemer, 2011). Critics like Hopper et al. (2007) may argue that the system is not a system and processes are not as stable as they appear; however, this is the premisethat was made and used for this paper and on which this it is built upon. Surely, due to my individual personality and background, there may be indirect or direct bias, where certain information and data may be seen as more relevant (Hopper, Northcott, & Scapens, 2007). Thus, subjectivism will also impact this paper to some extent, particularly, when it comes to interpreting the data and its impact for the future of eco-labelling schemes (Saunders, Lewis, & Thornhill, 2009, p. 121).

3.3 Research strategy

The assessment of eco-labelling schemes in the fishing industry was analysed via an empirical case study (Lee & Saunders, 2017). Case studies are used to analyse a particular industry to "understand complex social phenomena" (Yin, 2003, p. 2). The strategy suits the qualitative and exploratory research design perfectly as it is highly "useful for generating new hypotheses" (Gerring, 2006, p. 38). The case study design stresses necessity of deep and strong research, particularly as it stresses on one single case as in this thesis.

Creswell (2007) presents three types of qualitative case studies: “the single instrumental case study, the collective or multiple case study, and the intrinsic case study”. Firstly, the single instrumental case study focuses on one-single case while the collective case study focuses on a larger number of cases. The intrinsic case study stresses on exceptional case analysis through an in-depth target (Creswell, 2007, p. 74). This thesis uses a single instrumental case study of a blockchain implementation in the fishing industry. The advantage of the single case study is its suitability for generalisations, depth and focus of analysis (Marschan-Piekkari & Welch, 2011). Stuart et al. (2005) describe the processes of case study creation: case design creation, case execution and analysis of findings. A specific case of samples needs to be selected, goals clarified, and processes cleared before analysing the case (Stuart, George, Bennett, Lynn-Jones, & Miller, 2005). As this paper stresses the analysis of eco-labelling through the entire supply chain, sample size was reduced to a small sample size, while the time horizon was set for 2019 (Hwee Ang, 2014). In the following the case selection will be introduced.

3.4 Case selection

A mapping of blockchain applications within eco-labelling schemes was conducted from March 2019 to June 2019 through Google Scholar, EBSCO and JSTOR. The terms used in the filtering process were “blockchain”, “ecolabels” and “supply chain governance”. Subsequently, as most of the literature was found within the fishing industry, I narrowed the research down to the specific cases that existed at the time. *Provenance’s pilot project*, *WWF’s pilot project* and *Pacifical’s blockchain project* emerged from such process. *Pacifical* is the largest case of handling tuna fish in all a region 40% bigger than Europe, whereas others are relatively small-scale pilot projects.

3.5 Collection methods

Literature review in the form of academic articles and primary research were collected for this study. Primary data has been collected via face-to-face as well as Skype interviews with selected interview partners. Bernard (2000) proposes a number of advantages of face-to-face interviews: ability to answer questions related to interview questions to stress levels of comprehension, potential of increase of reliability of response (lying while looking into the eyes of an interviewer is difficult), ability to reach a 100% completion rate for questions and controlling function to know who answers to the questions (Bernard, 2000, p. 230). Major

disadvantages are the following: costs like timeliness, difficulty of anonymity as well as inability to not answer questions (Sreejesh, Mohapatra, & Anusree, 2013). Skype interviews meanwhile encourage cost savings as well as time flexibility while it creates a geographic distance between the interviewee and interviewer. It is dependent on technology and may create an environment which makes the interviewee keep certain information from the interviewer (Fielding, Lee, & Blank, 2016, p. 423).

The interview partners were chosen based on recommendations of past interviewees. To enhance a larger number of interviewees, it was furthermore decided to contact major stakeholders which are closely involved in the supply chain process of the fishing industry. The on average 20 to 45 minutes long interviews were made either in person, via Skype or telephone, dependent on the availability and accessibility of the interview partners.

In a structured interview standardised questions enable a comparability of analysis (Mann & Stewart, 2000). Following the structure makes the interviewer surely gain the information needed. However, the structure also prevents changes. Thus, non-standardized interviews are the key to gain a greater depth of analysis, freedom of follow-up questions and changes of brief structure during the interview (Creswell, 2007). In the case of this study "semi-structured interviews" were more adequate because they suited the exploratory research design better, allowing in-depth exploration of interviewees' perception of blockchain in its operations among the fishing supply chain (Ritchie, Lewis, Nicholls, & Ormston, 2013).

Figure 11. illustrates length, date, location of the interviews and positioning along the supply chain of the interviewees.

Role	**Interviewee**	**Location**	**Date**	**Time**
Blockchain provider	Atato	Bangkok (Face to face)	28.10.2019	20 min
Logistics and Tracing	Pacifical	Skype	05.12.2019	45 min
Eco-label	MSC	Skype	20.12.2019	40 min
Blockchain expert	former PWC IT auditor	Skype	11.1.2020	40 min

Wholesaler	Gustav Gerig	Phone call	15.1.2020	20 min

Figure 11: Interviewee table (Source: author)

In the following the case study of blockchain implementation in the fishing industry for MSC certified tuna will be introduced.

4 Empirical findings and discussion

4.1 Description of the case

Pacifical is a global marketing company and supply chain coordinator, which was set up in 2011 by the eight PNA (Parties to the Nauru Agreement) countries. They are trading MSC certified tuna products around the globe. In August of 2018, Pacifical started tracing tuna products via the Ethereum public blockchain ledger built by Atato, a Bangkok-based blockchain provider. Pacifical extended its MSC traceability certification system to the Ethereum blockchain. With this initiative, the company aimed to provide more transparency and better communication within the tuna supply chain. By publishing non-confidential and non-commercial data to the public ledger, consumer confidence and traceability have increased. The system is powered by IPFS (Interplanetary file system) decentralized storage and Ethereum's smart contracts, which are integrated in the traceability system of Pacifical. (Asaf, 2018)

This solution allows a collaborative network of sustainable certification by connecting fishermen, manufacturers, traders, distributors, wholesalers and retailers with each other. They are able to connect, upload and view relevant transaction and data records. Pacifical's tuna products are marked with the MSC and Pacifical logos. There is a unique tracking code on the packaging which can be scanned or manually entered to trace the tuna on Pacifical's tracking application. Pacifical is a pioneer in incorporating blockchain on a large-scale initiative within the 42-billion-dollar industry of tuna. Over 200 million consumers in more than 23 countries are able to trace and verify their tuna products. Everyone who uses the tracking code has immediate access to know how the tuna was caught and by which vessel and captain it was caught. Furthermore, the area, period and method are displayed and even where the tuna was processed and when it was processed. The integration of Atato's Ethereum-based blockchain system covers more than 220 fishing vessels and works through the entire chain of custody, which translates to around 35 million tuna fish that is annually caught on an area that is 40% bigger than Europe. The data is collected from the fishing vessel, through the production processing steps until the point of sale. (Asaf, 2018)

4.1.1 Parties to the Nauru Agreement (PNA)

The Nauru Agreement refers to the cooperation for managing fisheries with a common interest and comprises a sub-regional agreement which outlines the terms and conditions for tuna purse seine fishing within this region (Tuqiri & Turaganivalu, 2011). Purse seine is a fishing method that uses a fish net which circles around the fish and can be pulled together from the bottom to trap the fish (MSC, 2020). The PNA countries include Kiribati, Micronesia, Marshall Islands, Palau, Nauru, Solomon Islands, Papua New Guinea, Tuvalu and the territory of Tokelau. The exclusive economic zones of the PNA countries contribute to 25% of the global tuna catch and around 50% of skipjack tuna. Figure 12. illustrates the EEZs of the PNA countries. Their combined size is 14.3 million square kilometres and their annual tuna catch volume is 1.2 million metric tonnes which translate to more than 2 billion USD. (Tuqiri & Turaganivalu, 2011)

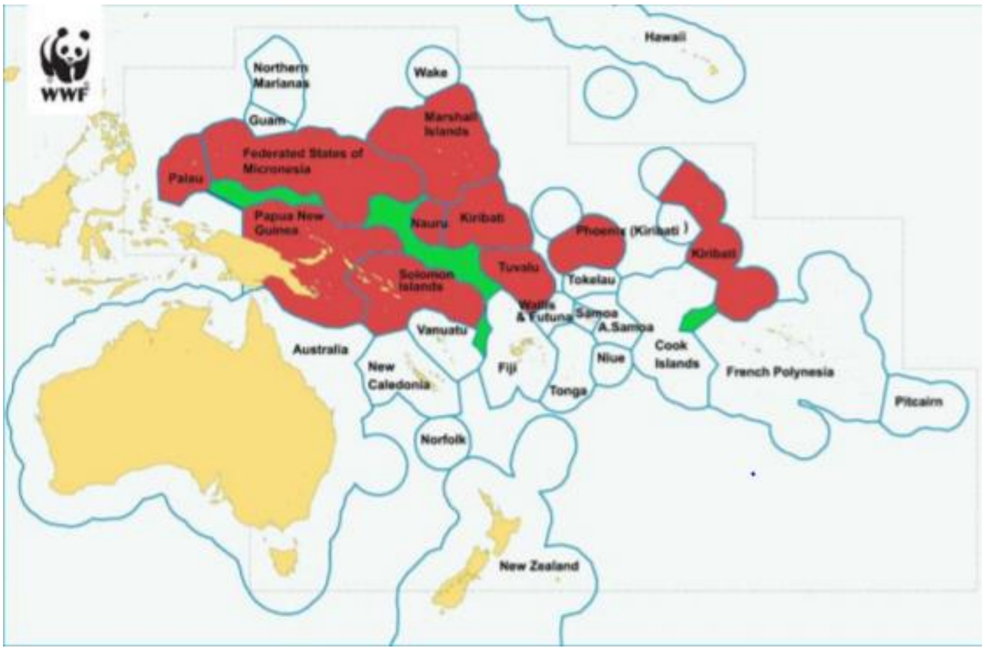

Figure 12: PNA area (Tuqiri & Turaganivalu, 2011)

The Nauru Agreement introduced three Implementing Arrangements in 1982, 1990 and 2008. The first arrangement introduced a regional register system for foreign fishing vessels and the implementation of vessel monitoring systems which made it mandatory to communicate the vessel's position, course and speed at any time. The second arrangement prohibited transhipment at sea and introduced catch reporting and logbook maintenance. It included placing an observer onboard as well as having an electronic data transfer device on the vessel. The third arrangement included a ban from operating in high sea areas which are highlighted

in green in Figure 12. Furthermore, it included the ban of Fish Aggregating Devices (FADs) and the retention of skipjack, yellowfin and big eye tuna catch in order to prevent bycatch and fish dumping. (Tuqiri & Turaganivalu, 2011)

4.1.2 Pacifical

Pacifical was jointly set up by the eight PNA countries in 2011. Pacifical's PNA fisheries have been certified by the MSC since 2012. Pacifical itself does not own any vessel, plants or brands. It solely establishes and oversees supply chains of all partners until the end customers. Their mission is: "Pacifical promotes, develops, and monitors the global supply chain of PNA's MSC certified skipjack and yellowfin tuna. We create efficient, fully traceable supply chain models using innovative technology and maintaining affordable prices. In close cooperation with our business partners, we create awareness of the key role our PNA people play in providing sustainable, and socially responsible Pacific tuna. Key to our success is our 100% dedication to the MSC standard and our Pacifical geographical indication." (Pacifical, 2020)

The fishing method that they use does not include fish aggregating devices or FADs. FADs are objects that float in the ocean to attract tuna. Using FADs has a higher risk of bycatch and catching young tuna that are not able to reproduce yet. PNA MSC-certified vessels solely catch free swimming adult tuna by scanning the sea for seabirds, which are a signal for tuna presence. This procedure is more challenging but results in bigger and qualitative better tuna. "Every vessel fishing PNA waters for MSC certified tuna must have an official MSC trained independent observer on board, checking that it's abiding by the regulations and by the MSC's chain of custody requirements." These requirements include limits in quantity, size restrictions, complete separation during the time on sea and during transhipment while not fishing in sensitive and restricted areas. Fishery authorities can oversee the vessel movements through a monitoring system to spot any signs of IUU fishing. (MSC, 2016) A total of 650 MSC trained observers are employed within the PNA countries which have more than 20 processing partners, 35+ distributors and 50+ retail brands which sell over 200 million products per year. (Brinxma, 2018) The following figure illustrated the PNA and Pacifical chain of custody.

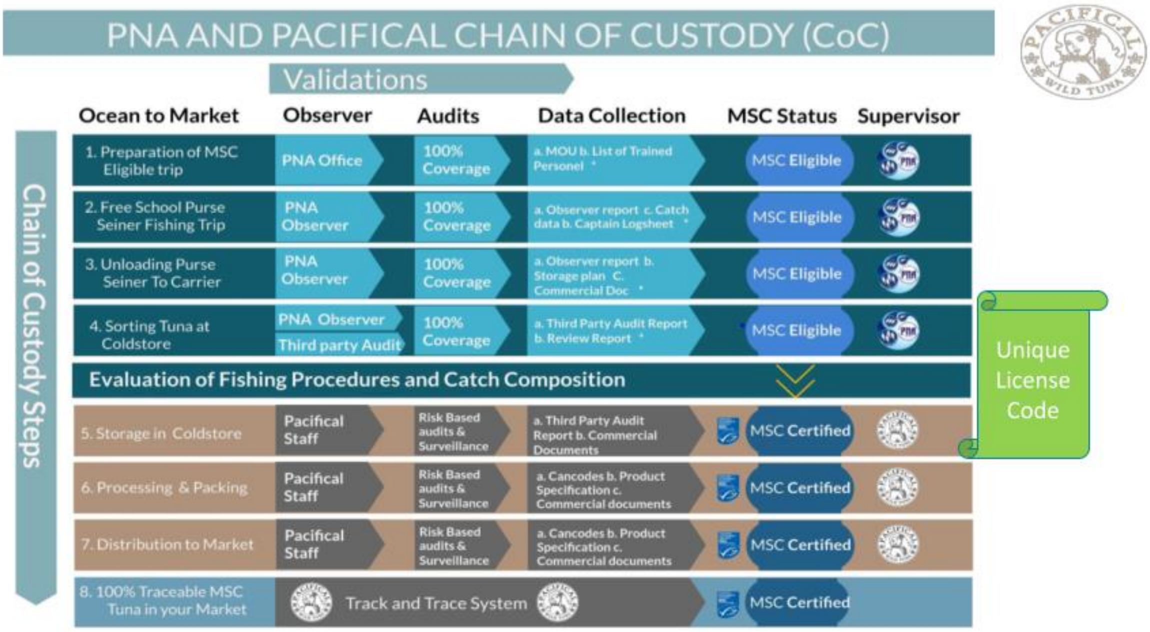

Figure 13: PNA and Pacifical CoC (Brinxma, 2018)

4.1.3 Gustav Gerig Co.

Gustav Gerig founded its company that goes under the same name in 1923. He focused on importing food products and wholesaling. Today they employ a total of 30 employees and are located in Zurich. (Gustav Gerig, 2020) Gustav Gerig is the first European wholesaler to sell a tuna line that is fully traceable with an Ethereum based protocol starting in April 2020. For this reason and because it is the only wholesaler who partners with Pacifical, the company was chosen to be interviewed for this research. Gustav Gerig is a marketing and sales company that supplies retailers and catering companies with non-perishable food. Since 1949 they offer their tuna brand "Raimond Freres" to its partners making the sale of tuna to one of their core businesses. They were one of the first to certify their tuna line with the MSC standard and are now the first European wholesaler to provide a fish range that is fully traceable via blockchain from catch until the end customer by cooperating with Pacifical. (PR Newswire, 2018) They employ a total of 30 employees and are located in Zurich (Gustav Gerig, 2020).

This following presents the findings of the conducted research by analysing the interviews of the selected use case and its blockchain implementation to answer the research question: "How does blockchain technology impact eco-labelling schemes?" In order to answer the research question from a holistic point of view implications on eco-labelling schemes will be elaborated first.

4.2 Impact of blockchain technology on eco-labels

Orsato (2009) states that eco-labels provide customers with credible information on the product's sustainability performance against set industry standards and were initially seen as a tool for differentiation and diversification against competition. However, as eco-labels became more established across industries, their purpose and significance transformed to being merely a benchmark to even operate in certain markets (Orsato, Eco-branding, 2009). Another reason for the establishment of eco-labels was the government's inability to address habitat degradation or resource depletion (Gulbrandsen, 2006). Furthermore, consumers want to know more about what the production processes behind the product are. (Mason, 2013) Many consumers do not feel that the information provided on product labels are sufficient. (Siegner, 2017) Daugbjerg et. al (2014) suggest that some consumers believe that companies use green claims only for charging a price premium and have a lack of trust towards eco-labels. Thus, the lack of trust in eco-labelling is an essential issue that blockchain aims to counter from a more holistic point of view.

Blockchain brings a novel technology to the consumer that provides immutability of supply chain data while providing instant access to the consumer by scanning a QR code on the product. Maxime Paul (Atato) claims that blockchain strengthens the trust for information within the eco-labelling schemes. This is important as it enables stakeholders to trust the exchange of data and shared confidential information throughout the supply chain process. The full recording of detailed steps along the supply chain process encourages greater level of control, meanwhile, eliminates the possibility of changing data within the supply chain, once it is entered. Blockchain technology raises the level of transparency and sustainability throughout farming, transport, packaging and redistribution. As the new technological advancement potentially raises existing standards, it also invites involved parties to start a multi-stakeholder dialogue to renegotiate agreements on a higher level (Orsato, Eco-branding, 2009). In 2018, a consumer study of the Food and Marketing Institute and Hartman Group concluded that 75% of the questioned consumers are willing to switch brands if they are provided with more in-depth information which goes beyond the label of the product. In 2016, only 39% gave that answer. This further emphasizes the growing demand consumers have for transparency and efforts of sustainability from eco-labels. (Avery Dennison, 2019) Blockchain technology will provide consumers with the opportunity to trace products along the supply chain, meanwhile, legitimizing eco-labelling. However, blockchain technology does not

eliminate the need for third-party auditors. Only they can assure that the first data uploaded on the ledger is accurate and truthful. Thus, blockchain technology will not make third-party certification redundant for eco-labels. This will be elaborated in the following chapter.

> *"I think it will give legitimacy to those labels."* (Maxime Paul, Atato)

In 2020, in the context of eco-labelling and fishing, the term blockchain technology is used mainly for marketing purposes one of the interviewees states. Blockchain technology is simply the key that could be used to improve transparency within the system but will most likely not reinvent the operation itself. In order to comprehend the reasons for that, I have investigated blockchain technology and its impact for MSC certified tuna. The MSC certifies chain of custody, thus, the effectiveness of blockchain technology on chain of custody certification will be addressed.

4.3 Impacts of blockchain technology on chain of custody certification

In the context of chain of custody certification, I have been asking one key question which investigates the essence of what problems it aims to counter: ***Does blockchain technology ensure a supply chain that is free from IUU fishing, overexploitation of fish stock and mislabelling?*** The reason this question is asked in particular, is to assess whether the new evolving technology of blockchain will positively contribute to fighting the issues mentioned, and improve the sustainability of fish stock.

> *"Blockchain does not change the quality of the data, so if the quality of the data is bad, it is going to stay bad on the blockchain. So, blockchain is not solving this issue. It is just giving another level of control, but if the captain of the vessel decides to enter bad data on the blockchain, blockchain is not going to change anything with the data, it is still going to be bad."* (Maxime Paul, Atato)

> *"Blockchain never does that exactly. It can never ensure that data is reliable."* (Margreet Brinxma, Pacifical)

> *"The problem with these kinds of solutions or implementations is that blockchain was invented and is primarily really suitable for digital assets. So, as soon as we*

are dealing with some physical assets, it is always necessary to have some sort of bridge between those two worlds and it is necessary to have a way of how we can feed the data from the physical world into the blockchain, into the digital world. This is a point where it always somehow gets complicated because blockchain is really good in minimising the trust needed and trust that is necessary for, let's say, verifying the data. But as soon as we are importing some data from the outside, there is always a level of trust needed for us." (David Stancel, Former PWC IT auditor)

According to the answers of the interviewees, blockchain technology does not ensure a supply chain that is free from IUU fishing, overexploitation of fish stock and mislabelling. As mentioned, one of the main reasons is that with physical assets such as tuna, there is always a link needed to connect the physical to the digital world. Even if we assume that the whole supply chain is fully digitalised with traceable tags such as RFID tags, the actors within the supply chain need to trust that the data inserted into the system is fully accurate. However, the data that is entered into the blockchain system can be tampered with. Fisheries could be collecting data from cameras and GPS tracking systems and still enter false data into the blockchain system about the origin of the fish or the used method of fishing. Furthermore, during the processing step, the fish is gutted, beheaded and then separated. During these steps the volume and the mass balance changes. When the volume changes, product substitution can occur, which means that the volume can be inflated by adding tuna from a different and potentially uncertified source into the supply chain. The physical link (e.g.: RFID tag) does not control these external factors.

Currently the PNA countries use their own Fisheries Information Management System (FIMS) where they collect all steps that are linked to fishery activity, from the trip application to the logbook of the observers. The PNA countries use MSC certified observers on board of these vessels as well as government authorities who produce a report of the critical events that occurred during the fishing trip. This report is summarised at the point of landing and its accuracy is inspected by a third-party auditor. The summary of the report is then uploaded onto the Pacifical contract system and only then uploaded to Atato's blockchain ledger. This information is linked to Pacifical's unique MTCB (MSC trip certificate batch) code, which is linked to all the supply chain activities thereafter until the final consumer, who can scan the

QR code on the product to see which partner, buyer, processor and fishery was involved in producing the final tuna product. All this information is stored on the blockchain ledger. As the information is only entered on to the ledger after the actual fishing event, blockchain technology can never verify that the data which is inserted is correct and does not replace the existence of third-party auditors.

4.4 Potential benefits of blockchain technology for chain of custody certification

In order to assess the full potential and impact of blockchain technology on eco-labelling schemes the following question is asked: ***What can blockchain technology do?*** The answer of this question will enable a more comprehensive understanding of the use case of blockchain technology and its opportunities despite the technological obstacles which were mentioned above.

> *"Alright, so when would blockchain technology be useful? I think, as you said with RFID tags that register also volume and also conversion rate. You know what is a conversion rate? If I have a raw fish for example, how many steaks do I get of a raw fish and how much do I throw away, what is the final product, how do I calculate if I have this fish and this much weight of this size, how much goes out or how much steaks can I make from it. So, for high value products with RFID tags or a very strong physical link to the product and then that information is used with every contract, yes, I think it can be useful.* (Margreet Brinxma, Pacifical)

> *"So, blockchain definitely can be helpful. So, it is immutable. Once we have the data on the blockchain it is much harder to tamper it and change it because of the immutability properties."* (David Stancel, Former PWC IT auditor)

Blockchain technology certainly does add a level of trust due to its immutability traits, which means that once information is stored on the blockchain it cannot be changed anymore. Gimenez and Sierra (2013) state that the higher the degree of supplier collaboration is, the more environmental performance can be derived. As illustrated in Figure 8, blockchain technology can facilitate information exchange between supply chain actors. In the conducted interviews, the benefits of smart contracts were highlighted, and the problem of volume inflation was

mentioned in the previous paragraph. In the interview with Pacifical, the interviewee stated that smart contracts could pose a solution for volume control, meaning that if the volume which goes in and goes out of a batch can be controlled, the exact fluctuations in volume can be monitored, which makes it more difficult for uncertified products to enter the supply chain.

4.5 Technical limitations of blockchain technology within the fishing industry

One of the main challenges for blockchain technology and any traceability system in the fishing industry is the difference between each fishery around the world. The MSC is an international institution and does not prescribe what methods must be used to demonstrate conformity with the sustainability criteria in each country. Each fishery uses a different method to demonstrate conformity with certification standards. Some fisheries might use camera and GPS tracking systems while others different methods. As a result, each supply chain and each traceability system is different. This makes it difficult for blockchain technology to ensure traceability of fish harvesting activities within different jurisdictions if there is no harmonised traceability system in place. Furthermore, blockchain technology has a deep association with cryptocurrencies. In the interview with former IT auditor of PWC, David Stancel, he stated that many governments still have an ambiguity and scepticism towards cryptocurrencies, which could be a further obstacle for blockchain technology to be applicable on a global scale.

> *"I think blockchain itself is not the solution for us in my point of view. We will have to utilise various tools and a lot of fishery sectors itself are also looking for innovative solutions to help countering this IUU challenge. Some of the tools already being tested or implemented include vessel monitoring devices, satellite GPS monitoring of catch location and even on-board cameras that are able to record videos and live stream and transmit to the management office."* (Shen Yan Liow – MSC)

Even though there still are a few obstacles for blockchain technology to be applicable on a larger scale, all interviewees agreed that there is potential if certain criteria are met. The first step would be for fisheries to fully digitalise their system in order for blockchain technology to operate. This allows a frictionless data transfer without the need of transferring data from paper-based records. The MSC mentioned that currently various tools are being tested, which

include vessel monitoring devices, satellite GPS tracking of catch location and on-board cameras that can record videos and transmit live streams to the management office. All these tools need to be in place to allow more trustable tracking and reporting of the actual harvesting activity. Pacifical mentioned that Atato's blockchain system currently does not focus on volume registration. The MSC suggests that there should be a weighing system in place which includes an algorithm to calculate volume against the size of the fish to be certain that the processed volume is accurate according to statistical standards and does not show any signs of inflation. The MSC concluded that at present, blockchain technology is only a useful tool for reporting activities and data transmission, but essentially does not substitute monitoring systems which have to be in place beforehand.

In all interviews it was mentioned that a control environment in the form of human auditing still has to be in place.

> *"Well, blockchain is not going to replace any control that has been put into place to tackle this issue. Blockchain is not a magical solution which can solve this problem of illegal fishing or illegal workers or something like this in the books. What blockchain can provide is just a record of what happened during all along on the supply chain and nobody can change these records."* (Maxime Paul, Atato)

> *"You always need an external party. Trust is not just transferred to blockchain."* (Margreet Brinxma, Pacifical)

> *"The point is, what I also want to say with the previous things, to a large extend it depends on the many other factors in the company, as I said the control environment and their IT systems, how it is set up, who has access to which system and how is it locked and how it is audited. I think these things provide much more guarantees against corruption and manipulation of data than having the blockchain itself."* (David Stancel, Former PWC IT auditor)

Blockchain can help in creating a certain level of trust within the supply chain but the major limitation is the verification of data which is utilised for eco-labelling. Referring to Carlson and Palmer (2016) and several interviewees, eco-labelling could be subject to manipulation

and used for marketing purposes, particularly if data is certified by blockchain. Thus, companies may ask their customers for a price premium in order to secure a larger profit share and success within the market. Blockchain technology is currently limited by uncertainty from government regulations and the resulting governance structures for chain of custody certification. The life cycle of blockchain technology is still in the early adopting stage and according to industry experts even developers do not know how it will evolve. For example, Ethereum currently has a transition process from Proof of Work consensus algorithm to Proof of Stake consensus algorithm. In conclusion, the limitation of blockchain technology is its dependency on the integrity of external parties that verify the process and its data (e.g. auditors).

4.6 Impact of blockchain technology on the MSC

Ms. Liow (MSC) stated that the MSC currently does not foresee the development of an own blockchain solution, as it is not a tool of immediate relevance to their certification processes. The MSC has a positive outlook for enterprise operation solutions to be developed that will help to bring conformity among different certification processes. Having these systems in place will allow blockchain technology to be used on a larger scale to verify and transmit data.

However, independently the MSC struggles to give customers an opportunity to have access over data when they want to know more about the processing steps of a fishing product. Blockchain based fisheries will fill in the gap as it will provide a new form of legitimising products. It intensifies the status and the importance of eco-labelling itself. According to Maxime Paul, it is a matter of time until the adoption of blockchain becomes the industry standard which therefore would follow the life cycle of current eco-labels of being an industry standard in certain markets. Third-party auditors that work with MSC certified companies will have an easier job accessing data that is published on the blockchain. Interviewees pointed out the limitation that current MSC certification and blockchain technology has: its focus on environmental and fishing operations, while not emphasizing on the raise of social standards. The measurability of data is one of the important criteria for both the MSC and blockchain technology, but as social factors are not easily measurable it stresses one of the limitations of blockchain technology regarding sustainability.

Currently, Gustav Gerig is the first European wholesaler who will sell MSC certified tuna that is traced by blockchain technology. When asked why they implemented blockchain technology their answer was that they were following a consumer trend of seeing blockchain technology as an innovative and trustable tool for traceability. Major concern of interviewees is that blockchain technology will be misused as a marketing tool to sell products to customers. The representative of Atato mentioned that blockchain technology can enhance the credibility of the MSC label, which is reflected in consumer behaviour. The problem with transparency in the supply chain was that it was time consuming for brands to gather all the documents along the supply chain and to make them accessible for the consumer. With blockchain technology everything is digitalised. All transactions are recorded on the public ledger and by scanning the QR code on the tuna can, consumers can have instant access regarding information of the product's supply chain. Consumers are willing to pay a price premium if they can access trustable information about the sustainability aspects of a product. Therefore, blockchain technology will most likely have a positive effect on consumer behaviour for MSC certified products that are traced by blockchain but will not make the eco-label redundant, as only third-party auditors can verify that the data inserted on blockchain is truthful.

> *"Blockchain can actually enhance that certificate to not just give the report on how the fish was caught, but how was it transported, transported to the factory, how was it packed and when was it packed. It can give an optional and additional agreement on the MSC label. It is not going to replace it, but it is going to give another option of transparency and sustainability."* (Maxime Paul, Atato)

4.7 Impact of blockchain technology on governance theories

Health and sustainability are two of the most prominent megatrends for the upcoming decades. The interview with Pacifical underlined that consumers increasingly demand sustainable fished tuna that fulfils MSC standards. The collection of data will be important to secure the sustainable future of tuna populations. From a resource-based view, a stable population is the best way to secure the supply chain to operate effectively. The United Nations Global Compact already affects interviewees operations at least indirectly as businesses are inspired to implement sustainable policies. It is most likely that new standards set by governments, the ISO or other types of standard setting agencies will affect the direction and timing that the MSC and other eco-labels will have for adopting to blockchain and traceability systems.

Gereffi et al. (2005) argue that standards can ensure codifiability which can reduce transaction cost that is associated with the supply chain's governance. If the ISO sets out criteria that enable a harmonised traceability system, blockchain technology certainly would reduce transaction cost by providing codified data.

In the interview with Pacifical, the interviewee stated that smart contracts could pose a solution for volume control, meaning that if you could control the volume which goes in and which goes out of the batch and meaning it would be possible to monitor the exact fluctuations in volume with blockchain technology, therefore, the likelihood of uncertified products entering the supply chain would decrease. This is supported by the theory of transaction cost economics. TCE highlights that well-stipulated contracts and transactional mechanisms hinder opportunistic behaviour. (Liu, Luo, & Liu, 2009) As stated by Liu, Luo and Liu (2009) transactional mechanisms such as smart contracts can provide a framework in which relational mechanisms can exist to jointly reduce transaction cost and opportunism. Relational mechanisms include trust and relational norms. Blockchain technology provides transactional mechanisms in which a trusted third-party auditor can operate. In this case it would hinder actors along the supply chain to engage in fraudulent and opportunistic behaviour. Nevertheless, it is impossible to eliminate human error. The relational view states that there is always a level of trust needed when dealing with different supply chain actors.

In contingency theory (Elgharbawy & Abdel-Kader, 2013) it was highlighted that each company's governance structures depend on various factors. Sousa and Voss (2008) established four contingency categories: culture and national context, strategic context, firm size and other variables in the organisational context. The adoption of blockchain implementation largely depends on digitalisation and size of the fishing operation. Margreet Brinxma (Pacifical) highlighted that RFID tags are mainly used for high quality products. Thus, it will take technological advancements and improved industry standards for companies to adopt blockchain technology.

There is a cost involved to implement blockchain technology on all three stages of eco-labelling (preparation, auditing and compliance). Nevertheless, the implementation of blockchain will decrease transaction cost by facilitating auditing processes and contractual agreements with

smart contracts. In conclusion, blockchain technology improves supply chain governance's performance, as it reduces transaction cost while reducing the risk of opportunism.

4.8 Future outlook

Critics argue that blockchain won't greatly affect the industry and eco-labelling. This is derived by a lack of digitalisation of supply chain procedures and its limited connection with eco-labelling schemes itself. Data sharing on one single platform does not exist yet or is still in the process of initiation such as the Streamr project. In mid-2020, WWF, UnionBank, TX and Streamr are planning to run a project which enables Philipino fishers to share their fishing data via a blockchain-technology app called Tracey. (Ronstedt, 2019) The app will be based on the Streamr protocol. Streamr, a Swiss start-up, created a blockchain-based decentralised platform that collects real-time data of traffic, pollution, transport and also fishing activities. All data can be accessed publicly and can even be purchased. In the focus of attention of the collaborative project is sustainable fishing and microfinance. As the collaborating parties state sharing knowledge on fishing habits, location and amount of fished food, this will help preserving the nature and the long-term future of fishers. Hereby, credit institutions will enable microloans to fishers who share their data through the blockchain-based app. The real-time data of fishers will be available for businesses, regulators and consumers through the Streamr platform. Data could potentially be used as foundation for certification of eco-labelling in developing countries.

In the future, IoT technology sensors will most likely communicate with each other through 5G infrastructure. The massive amount of data of the fishing industry could easily be kept by platforms like Streamr. Interviewees fear the chance of data manipulation by fishers; however, chances are medium that manipulated data will not be recognised. Thus, blockchain's auditability will bring with it, new forms of governance mechanisms. As within the blockchain, data needs to be verified, false data can be tracked and changed if no other block is created yet. Sissman and Shama (2018) emphasised that real-time production data increases investment transparency and furthermore raises awareness on practices. While, interviewed stakeholders within the fishing supply chain will not create their own blockchain technologies themselves they will wait for it to be developed through visionary start-ups like Streamr.

Blockchain-based protocols are the foundation and the infrastructure for Internet of Things (IoT) as well as 5G technology. Companies and other stakeholders know about the potential transparency and full documentation within that blockchain brings upon. For the interview partners full digitalisation of processes among the supply chain comes first. Thereafter, the implementation of smart contracts and new types of governance mechanisms is on top of the agenda. Dependent on suppliers, products will be observed via RFID tags, particularly high value products.

Data will be important for securing the sustainable future of tuna populations. A stable population is the best way to secure the supply chain to operate effectively. This argument is strongly supported by the resource-based theory presented in the literature part of the paper (Chen & Chen, 2003). To further elaborate this argument, the resource-based view stresses the potential of alliances for the distribution of products which does create new value for all stakeholders. Resource cooperation does preserve exploitation, opportunism and dependencies. If all stakeholders among the supply chain would adapt blockchain technology this could enable a new level of business relations and better good governance agreements between organisations.

Data is what is crucial in order to have a more profound overview of blockchain technology. As Gustav Gerig is launching its blockchain-based tuna line only in April of this year, the impact on consumers can only be fully explored afterwards. Blockchain technology is currently perceived as a potential tool for the long future, however, will not impact the supply chain in the short term.

5 Conclusion

The fishing industry is facing several issues, which includes illegal, unreported and unregulated fishing, overexploitation of fish stock and mislabelling of fish. To counter these problems, the MSC has developed a chain of custody certification program, where certified fisheries and actors along the supply chain must comply with certification standards. Opportunistic behaviour in the form of fraud and false reporting for private gain can damage the label's credibility. Due to its immutability aspects, blockchain technology is regarded as a useful tool for data gathering and data transmission among supply chain actors, which allows them to access the whole supply chain process from a more holistic point of view. However, it does not eliminate the need of a third-party auditor. Only the auditor can assure that the first data which is uploaded on the ledger is accurate and truthful.

Thus, there is always a certain level of trust needed between all actors along the supply chain with or without blockchain. For blockchain technology to be fully operational to its potential, a digital system needs to be in place. Fishing practices are still mainly recorded with paper-based methods. The MSC highlighted that digitalised monitoring methods, such as camera systems, real time GPS tracking systems and volume registration systems have to be in place to strengthen traceability systems first. The application of blockchain technology for food traceability is still in its early stages. Gustav Gerig is the first European wholesaler to sell a tuna line that is fully traceable with an Ethereum based protocol starting in April 2020. Their adoption was influenced by consumer trends which have a positive outlook for blockchain technology. For now, blockchain technology is a potential tool for the long future, however, will not impact eco-labelling schemes such as the MSC in the short future.

5.1 Contribution to Literature

This thesis evaluated and expanded on existing literature on eco-labelling and highlighted the potential of blockchain technology to overcome issues such as illegal, unregulated and unreported fishing or mislabelling. In reference to existing academic models like transaction cost theory, resource-based view and sustainable supply chain governance, this paper connected the literature to the future of the fishing and eco-labelling industry. As testing is currently in place, stakeholders' analysis was conservative and risk evaluating. It particularly scrutinises individual stakeholders' positions on the impact of blockchain technology along the fishing industries' supply chain. Practical knowledge through interviews with key stakeholders

resulted in a variety of insights on the transformation of the fishing industry, today and in the near future. This master thesis helped the reader to gain a holistic picture of the current circumstances of chain of custody schemes within the fishing industry and potential advantages and threats that lead stakeholders to wait until the experimentation phase is completed. The results of this thesis are highly valuable as they connect blockchain's impact with analysed variables such as certification, regulation, traceability, transparency and stakeholders' interests.

5.2 Contribution to Management Practices

From a management perspective, understanding blockchain's needs and positive impact on all steps within the supply chain is essential in order to create a holistic perspective of the entire process. Blockchain technology is a topic that attracts an increasing amount of attention. Nevertheless, managers within the fishing industry and other supply chain related sectors currently do not have adequate knowledge of blockchain's application areas. The general public is not aware of what blockchain technology is and tends to associate it with cryptocurrencies, therefore, there is a general misconception about the effectiveness of blockchain technology. This thesis highlights the tools that are needed for managers to implement blockchain as well as its technical limitations. The findings of the interviews show that implementing blockchain technology should be considered if certain criteria are met. Effective supply chain management heavily depends on different factors such as digitalisation and harmonised traceability standards. However, it depends on how those systems are in place based on the context of the organisation, as contingency theory suggests. By having digitalised systems available, blockchain technology can certainly increase efficiency as well as attract more consumers.

5.3 Contribution to Government Policies

Even though blockchain technology arguably increases trust in the brand and between actors in the supply chain, it does not eliminate the need of regulatory mechanisms such as audits and other types of controlling. Global standards for blockchain are being developed by the ISO Blockchain (TC 307) initiative. Blockchain technology still faces some issues such as the need for low cost global standards and the right technological architecture. Only by adopting international standards such as outlined by ISO TC 307 allow an increased scalability. Currently many different ledger systems exist and are developed with each being different to the other. Governments should set out clear standards and guidelines that can harmonise

different blockchain operating systems and reduce the market fragmentation. Only uniform standards such as the ISO 14000 series for environmental management systems provided companies clear set guidelines to operate. I believe that policy makers should stress the development of an international standard to bring conformity and structure to the blockchain industry.

5.4 Further Research

While the focus of this thesis is the impact of blockchain technology on eco-labelling schemes within the fishing industry, namely the MSC, it does not address social aspects. Social aspects are part of sustainable development and should be investigated further. As the fishing industry still largely depends on paper-based documentation, future research could investigate forestry practises in Scandinavia where GPS tags and digitalisation are already a standard in many traceability systems and currently new pilot studies emerge. Once enough qualitative research has been conducted, future studies should develop meta-analysis to summarise individual findings and establish coherence among different results by using quantitative research methods.

The existence of eco-labels is derived from consumer's willingness to pay a price premium for the sustainability aspects they provide. Once a broader availability of blockchain traced eco-labels exist on the market, a consumer study should be conducted to investigate their behaviour, knowledge and adoption.

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6 Annex

6.1 List of standardised interview questions

1. How does blockchain technology impact ecolabelling schemes, more specifically in the food industry?
2. Does blockchain technology improve sustainable fishing practises?
3. Does blockchain technology improve chain of custody certification?
4. Does blockchain technology ensure a supply chain that is free from IUU fishing, overexploitation of fish stock and mislabelling?
5. What potential do you see in blockchain technology for the future?
6. Do you think there will be a cooperation with eco-labels such as the MSC?
7. What are major challenges that remain for blockchain technology to be applicable on a broader scale?
8. What factors have to be in place that blockchain technology can be operational to its full potential?
9. What added value does the consumer have with blockchain technology compared to a conventional MSC certified product?