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Preconditions to Start and Scale Digital Ecosystems

A study of AquaCloud in the Norwegian seafood industry

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Executive Summary

Digital transformation characterizes a vast number of companies, and increasingly as the technological advancements with artificial intelligence (AI), internet of things, and 5G mobile network technology expands the possibilities. One digitalization strategy is to create digital ecosystems, which companies are increasingly pursuing to deliver complex value propositions and to develop structures for inter-organizational collaboration that facilitates open innovation. How digital ecosystems can be started and later scaled is not well understood, and this study focuses on the digital ecosystem AquaCloud to expand the knowledge on this subject. AquaCloud is an emerging ecosystem started by a seafood cluster organization together with Norway's largest salmon producers. Their first goal is to predict sea lice outbreaks by applying AI to large data sets, and in the future, AquaCloud could become something far greater as the ecosystem structure facilitates open innovation.

Findings show that data standardization and data security are fundamental to allow heterogeneous and complementary technologies operate together towards a joint value proposition while securing sensitive data. However, without fully understanding how to design this system, findings suggest digital ecosystems have to start with trust and simplified contracts among the involved parties, allowing experimentation toward a functional design. Also, findings suggest starting with large industry players helps to root the ecosystem in the industry and attract external contributors through its signaling effect. Then, as standardization and security are established, the ecosystem becomes scalable as technologies can easily connect and disconnect while efficiently preserving interests as trust shifts from primarily humans to systems. Furthermore, findings suggest establishing a structure e.g., an organization which adjusts standards and security measures according to changing business environments is fundamental for long-term success. These findings represent considerable barriers to overcome, but for digital ecosystems like AquaCloud, the incentives to succeed far outweigh the costs. Overall, creating a digital ecosystem shows signs of being a beneficial strategy if one can manage to establish these preconditions. Through the investigations and analysis performed, AquaCloud is on the right track to becoming a successful digital ecosystem, and an excellent case for inspiration.

Keywords – digitalization, life cycle, trust, data, standardization, security

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1 Introduction

1.1 Background

Artificial intelligence (AI), internet of things devices (IoT-devices), and 5G mobile network are transforming industries with their combined capabilities, enabling a new era of digital solutions. AI has become a buzzword with its capabilities to interpret enormous amounts of data, data which now can come from the real world from increasingly cheaper and more advanced IoT-devices (Wikipedia contributors, 2020b). 5G supports this with its capabilities for one millisecond latency, 10 GB per second throughput per connection, support for one million connections per km^2, data transfers in the infrastructure at 500 km/h, and network slicing which makes it possible to for example split consumer and business users into layers which do not disturb each other. When combined, this creates what Telenor calls "the perfect storm" for new solutions and a digital transformation (Wilhelmsen, 2018).

One of the most disruptive opportunities companies is trying to leverage, is the opportunity to create digital ecosystems because not only does it combine technologies, but it also creates an ecosystem that can foster more open innovation (Jacobides, 2019). However, the term digital ecosystem is unclear and widely used to describe various solutions, both in the industry and academia. Uncertainty, many researchers have tried to define for clarification (Bogers et al., 2019). Closest to the digital ecosystems which use the digital storm is the understanding from Jacobides et al. (2018) and Adner (2017), who notes this as an ecosystem of independent actors with heterogeneous and complementary technologies that work together for some complex co-value creation. As one is just starting to understand the definition of a digital ecosystem, there is much research to be done in order to get a proper understanding of what it is and how it evolves.

AquaCloud is a digital ecosystem in the Norwegian seafood industry developed by large salmon producing companies and a seafood cluster organization. The first goal is to predict sea lice outbreaks by conducting big data analytics. However, AquaCloud could become much more in the future, as the team could develop new tools or let external companies use AquaCloud's infrastructure and large data sets to build new tools for the industry (AquaCloud, 2020). Sea lice infections represent NOK 5 billions in annual costs and a threat to the fish welfare, where predictions can support data-driven decisions to ensure companies take actions accordingly to the specific situation (Iversen et al., 2017). AquaCloud is now emerging on the basis of AI, IoT-devices, and 5G. Previously, fixed infrastructure and the 4G mobile network have been a limiting factor because the former is not flexible to fish farms being moved and the latter, which does not provide enough power for enormous and high-speed data flow (Digital21, 2018). Today, AquaCloud has connected more than 3000 fish farms, 6000 sensors, and 140 000 data points along the coast of Norway, funneled into IBM's software called Watson, for big data analytics (Hávarðsson, 2020). This means the infrastructure will support large digital ecosystems, but for AquaCloud, which has many different actors and components coming together, it is a challenge to develop. Thus, a great example to learn more about how digital ecosystems can start and scale.

1.2 Research Questions

This study seeks to expand our understanding of how a digital ecosystem starts and scale by examining the development process of AquaCloud and seeking an answer to the research question:

- What are the preconditions start and scale digital ecosystems, and how do they drive the development?

In order to answer this research question, there are two major aspects to consider. First, as digital ecosystems represent an inter-organizational collaboration between multiple stakeholders, it might lead to a conflict of interests. Conflicts could slow down or, at worst, stop the progression. Therefore, it's essential to understand how these interests are balanced throughout the early stages. Second, as digital ecosystems combine heterogeneous and complementary technologies toward some complex value proposition, there is an issue with making ensuring inter-connectivity between devices and securing information being transferred throughout a more extensive system. By understanding how data is being shared, one can better understand how value is created in digital ecosystems. These aspects are researched through the following sub-research questions:

- How are interests balanced in an inter-organizational collaboration?

- How do we assure data sharing in the early stages of digital ecosystems?

By understanding AquaCloud and answering these questions, the study aims to contribute more knowledge to the fragmented literature and provide insights to practitioners planning or developing digital ecosystems.

1.3 Outline

As introduced, the thesis focuses on the emergence of a digital ecosystem called AquaCloud and aims to examine preconditions to start and scale successfully, to enrich our general understanding of digital ecosystems further. Chapter 2 presents the theory which will be used to understand the phenomenons. Then, to study the research questions, the research design is outlined in Chapter 3. Followed by how data was collected and treated, and which weaknesses that represent. Chapter 4 describes empirical findings, which are further analyzed in Chapter 5 by applying the theoretical framework. Lastly, in Chapter 6, strings are pulled together for a conclusion to the research questions along with implications and suggestions for further work.

2 Theoretical Background

Chapter 2 outlines the theoretical aspects of the research questions presented in Chapter 1. This is used to frame the case in the empirical setting and create a theoretical framework that guides the empirical analysis.

Answering the research questions requires diverse being applied to the early stages of the ecosystem development. Therefore, in order to get an understanding of digital ecosystems and create a theoretical framework, the chapter elaborates the following; what is a digital ecosystem, how does it emerges, what are the life cycles of a digital ecosystem, and what elements go into the early stages.

The chapter is structured with each subsection referring to the mentioned topics and finishes with a theoretical framework that synthesizes the elaborated theory.

2.1 Defining Digital Ecosystems

Researching digital ecosystems requires a firm understanding of what it is, and what goes into it, but what is a digital ecosystem? Both practitioners and academics have been using the term widely for the past 20 years and "digital ecosystems" are often mixed with terms such as business models, platforms, coopetition, multi-sided markets, networks, technology systems, supply chains, and value networks, where some concepts are overlapping, while others are complementary (Adner, 2017; Bogers et al., 2019; Boley and Chang, 2007; Cennamo, 2019; Jacobides et al., 2018; Peltoniemi, 2006). This confusion is easily understood as all terms involve collaboration to some degree across organizations or between different actors.

This study focuses on the definition from Adner (2017) because the elements align well with the structure of the AquaCloud case. Adner (2017) defines 'ecosystems' as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize." Jacobides et al. (2018) supports this definition by specifying that the multilateral dependencies of complementarities determine the ecosystem's created value, in a sense where one might have unique co-specialization where "A doesn't function without B" or supermodularity where "more of A makes B more valuable," where A and B are two different assets or activities. Further adding that for a study on this topic, one must consider the modularity required for different types of complementarities to co-exist, and to which nature it is aligned and how intense is the relation, as this determines the value created. One must also look at how firms influence these complementarities and thus shape the ecosystem structure. An exciting relationship as the value created depends on how modularities are mixed and matched to create a focal product or service for final customers. By understanding what goes into a digital ecosystem, we can explain its distinct value created and capture the dynamics within the ecosystem and between the inter-organizational relations.

Figure 2.1 illustrates how these elements play together and form a digital ecosystem. Starting at the bottom, there is a complex value proposition to be created which all parties involved agree upon. In order to create this value, heterogeneous and complementary technologies must be aligned for joint value creation, which means there has to be some system that enables modularity to mix and match interdependent technological components produced by different producers. At the top, there is the interdependent organizations with each has the autonomy to design, price, and operate their business as wanted, but agree upon the ecosystem value and interconnect with other firms to more or less extent to develop this digital ecosystem.

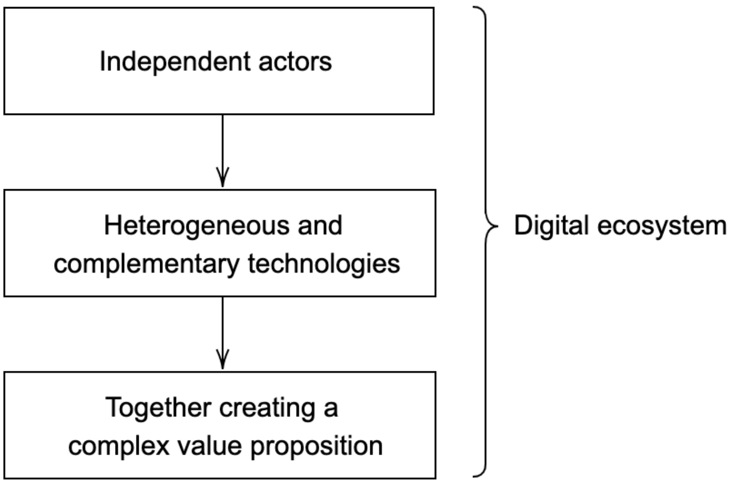

Figure 2.1: Components of the Digital Ecosystem Definition

Having this definition, one can further elaborate theory on the elements within and the contextual theory for digital ecosystems, and later use this understanding to frame the AquaCloud case and guide the empirical analysis.

2.2 Digital Ecosystem Emergence

The definition in Figure 2.1 shows a high degree of complexity. Complexity which is likely different when starting and scaling a digital ecosystem. As mentioned before, a system that enables modularity between complementary technologies to create a joint value proposition, a system where some technologies are required, and others enhance the value created, a system where actors enter and exit at their independent will for full modularity. This system requires an architectural design which standardizes entry and exit, but a meaningful system cannot be built before someone understands what and how the system should govern it. Implying there must be an earlier stage, where independent actors share their interest in the complex value proposition, doesn't have a complete ecosystem structure, but agree on trying to build a digital ecosystem together.

Studying this distinction between starting and growing an ecosystem can be done by integrating theory on organizational life cycles. Carraher et al. (2003) describes five stages of existence, survival, success, renewal, and decline. *Existence* being known as the entrepreneurial birth stage, with characteristics such as informal structure, centralized decision-making for trials, and errors. *Survival* is the stage where organizations try to grow and find a sustainable market position, by formalizing structure and building distinctive competencies. *Success* also referred to as maturity, where an organization is more focused on protecting its market shares rather than targeting new territory. *Renewal* refers to larger organizations seeking to return to times where collaboration and teamwork foster innovation and creativity. This might be facilitated through divisions and decentralized decision-making. *Decline* with no growth. Organizations may exit at any stage, but this stage is characterized by politics and power, where one or few members become more concerned with personal goals than with organizational goals and puts it in front of organizational performance.

The digital ecosystem AquaCloud, which is later introduced to its full extent, is still in its earliest years and is starting to become more formalized and prepared for growth. We can understand the ecosystem during its emerging stages by adopting Carraher et al. (2003) theory on stages for existence and survival. Having this clear differentiation, one can focus the study on underlying elements and challenges with each stage, and later have a better framework to analyze and discuss the transition from one stage to another.

On the note of the existence stage and contextual understanding required to build an empirical setting and understand the emergence of AquaCloud; Digital ecosystems do not emerge without the deliberate, organization-driven agency or deliberate decisions and actions. It is at least in part the result of deliberate experimentation and engineering from different actors trying to create some complex joint value proposition, because given the complexity with making heterogeneous and complementary technologies work together one must build some sort of system around it which is not always possible to design by foresight, it must be experimented with (Gawer and Cusumano, 2014). Thus, emergence is a phenomenon that arises from inter-organizational motives for a joint value proposition. As it is not easy to design a complete system beforehand, one must experiment, and based on experiences, create a system that makes up for the digital ecosystem, which means that the result emerges bottom-up (Peltoniemi, 2006).

Holistically, digital ecosystems are a complex phenomenon where its growth can be categorized into different life cycles with multiple topics within to study; *Stakeholder theory* for a framework to understand the interdependent, heterogeneous, and complementary actors who experiment together for a bottom-up emergence. *Inter-organizational trust* to understand how they come together before a complete ecosystem structure is built. *Data standardization* because digital ecosystems require some sort of system to connect lots of heterogeneous and complementary technologies in a self-regulating system where actors can enter and exit, and further understand how this supports inter-organizational trust. *Data security* to understand the importance in digital ecosystems where information flows, and each component might have exploitable weaknesses, also, how policies for data exchange and security supports inter-organizational trust. This helps us understand AquaCloud and build a *theoretical framework* to study how these multiple topics affect each other during the emerging stages of existence and survival.

2.3 Stakeholder Management

Digital ecosystems, in its definition, requires numerous interdependent organizations to collaborate in some way towards a common goal, some organizations being more critical than others. Jacobides (2019) distinguish between the roles of being a chief architect or complementor, in which the former refers to one having a strong and relevant portfolio of intellectual properties, large user base, and a strong brand that enables them to build an ecosystem and attract independent firms for joint value creation towards some end users. When an ecosystem doesn't have this foundation within one organization, it has to emerge from a collaboration with a group of organizations, which together can take on the role of chief architects. However, to attract external contributors, some actions can be done to send a signal for others to act upon. Baddeley (2010) defines this phenomenon as herding, where individuals decide to follow others and imitate behaviors rather than deciding independently on the basis of their own private information. Xu et al. (2012) looks at this herd behavior and the patterns of firms adopting new technology, finding that it is positively associated with the adoptions by its competitors and business partners. In which, companies which are looked up to are likely to influence the choices of external companies considering to join the ecosystem or not. Overall, for the companies who become involved, this inter-organizational collaboration creates an environment for potentially conflicting views on how the ecosystem should be designed.

Stakeholder theory enables a closer look at each type of actor in this inter-organizational collaboration, which helps to frame the empirical case of AquaCloud and understand relations between actors in the analysis. As for the literature, it has evolved as organizational structures have become more complex. For the traditional firms, Freeman (1984) categorized stakeholders into four main categories; corporation, resource base, industry structure, and social-political arena. In more recent times, the inter-organizational complexity becomes clearer as Fassin (2009) expands the traditional stakeholder theory by specifying different types within; Corporation being in the center, surrounded by a resource base of employees, business partners, shareholders, customers, and communities that help to build the corporation. Outside one has the industry structure with unions, competitors, investor funds, customer organizations, and special interest groups that creates the industry structure which the ecosystem operates in. In the boundaries of the social-political arena, one has the state, government, media, civil society, and others which sets the boundaries for which the ecosystem has to be built in.

In the context of digital ecosystems, this helps us structure our understanding of stakeholders by adopting Fassin (2009) theory and place the digital ecosystem in the center, which the resource base helps to build, the industry structure influences, and boundaries which are created in the social-political arena. Figure 2.2 illustrates this adopted model with the digital ecosystem being in the center.

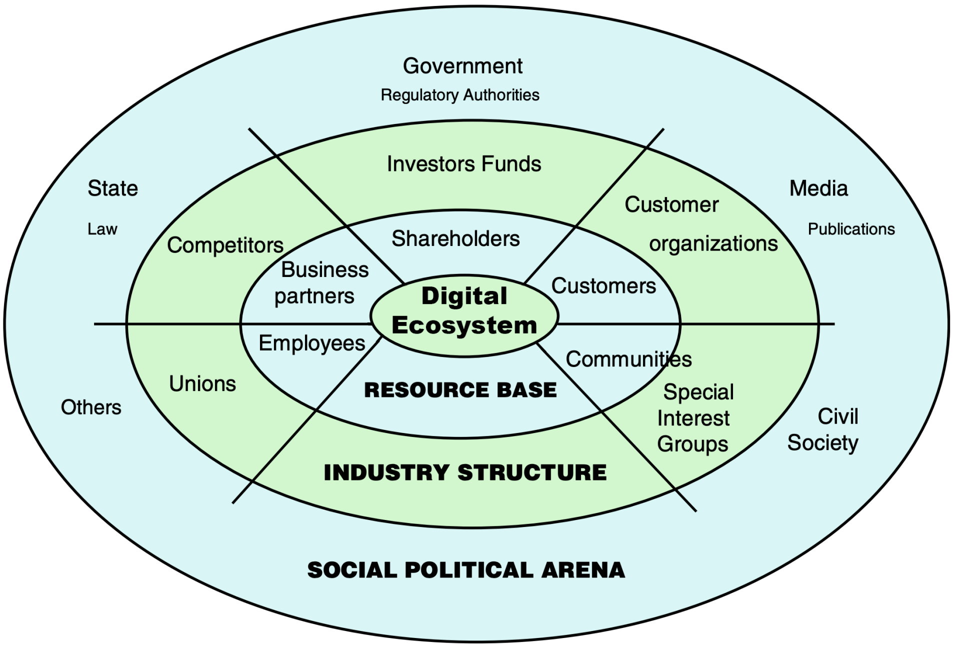

Figure 2.2: Adapted Stakeholder Model

Important to digital ecosystems is the sheer number of different stakeholders, which to different degrees, influences its emerging stages. Something the ecosystem designers may or may not consider when trying to experiment and build a system for joint value creation, nonetheless, this creates an environment where the process of building a digital ecosystem and the outcome is not predictable.

Darking et al. (2007) suggests ecosystem designers trying to manage stakeholders should consider the six dimensions of governance; balance of interests, culture of communication, credibility, synchronization, technological dimension, and licensing and regulation. Balancing interests is about making the ecosystem share values, vision, participation, and constitutional documents such as a bill of rights. Culture for communication refers to forming transparency, inclusion, procedures, and accountability. Credibility and trust come from forming alliances with diverse memberships. Synchronization is about having a distributed template that aligns infrastructure development. The technological dimension refers to the choice of software, which sets directions and standards for development. Licensing and regulation which relates to controlling the interactions relevant to entities in the ecosystem. It is easier said than done because the digital ecosystem has multiple stakeholders in a network with inter-organizational dependencies, which creates an environment with a low possibility of structurality and, therefore, a higher possibility for conflicts.

Kumar and Van Dissel (1996) suggests using mechanisms such as standards, rules, schedules, plans and mutual adjustment to facilitate coordination to reduce risk. Tools that ecosystem designers not only can use to reduce risk in-between but also mechanisms that can be used to self-regulate entry and exit of a digital ecosystem, this is later elaborated under data standardization and data security. For stakeholder management, it is favorable to digital ecosystems such as AquaCloud that is within the geographical area of one nation, as seen in the study of Lim (2014) working transnational has high complexity when combining governmental laws and regulations. Ecosystems limited to a country may still meet conflicts, such as conflicts with local societies or policy-makers, but too much less degree than international ecosystems (Daniels et al., 1994).

Looking back at the theory from Jacobides (2019) and discussion on having a group of chief architects coming together to build an ecosystem, it becomes a challenging task of managing interests. Especially because the digital ecosystem relies on contributions from external actors which one to a lesser extent can influence, therefore, trust becomes a crucial component for early stage development, which is later discussed (Schreieck et al., 2017). Furthermore, as it takes time to develop digital ecosystems because heterogeneous and complementary technologies are coming together, this also means the governance structure in this group should be flexible enough to support contributors enter and exit, as well as business environments changing (Ruokolainen et al., 2011). Gawer and Cusumano (2014) suggests facilitating interests by developing a shared vision and promote it among potential key players in the present and the future, and carefully manage relationships that are mutually beneficial for participants in the ecosystem.

Considering all these factors, managing a vast number of different stakeholders becomes a large task, and something to carefully manage. Good relations are especially important during the digital ecosystem's earliest stages because stakeholders must trust each other to a greater degree in the absence of formal mechanisms and contracts. The next sections focus on the topics of trust, data standardization, and data security, which again is essential if one wants to develop a vibrant and self-sustaining digital ecosystem.

2.4 Inter-Organizational Trust

Trust is an important driver for effective and efficient inter-organizational collaboration as it reduces transaction costs and allows greater flexibility to changing circumstances (Gibbs, 2003). However, trust becomes a prerequisite for the ecosystem when relying on third party contributions (Schreieck et al., 2017). Besides, trust is also highly beneficial to the ecosystem as a growing spiral of trust between stakeholders can evolve a unifying purpose and help to sustain a culture of shared decision-making, which then fosters greater value co-creation (Manring, 2007; Taillard et al., 2016).

According to Ganesan (1994), trust consists of two elements; credibility and benevolence. Credibility being the belief about another's trustworthiness based on competencies, reliability, and dependability. Benevolence is based on the intentions and motives seen in another. For collaborations where stakeholder doesn't know each other, trustworthy recommendations can create a fertile starting point (Isherwood and Coetzee, 2011).

Abrams et al. (2003) suggests nurturing interpersonal trust by being transparent, engaging, clear, and consistent in communication, which helps people get a clear behavioral picture. On an organizational level, they suggest establishing a shared vision and language, as well as holding people accountable for trust by having measurements of trustworthiness in performance evaluations, even if its a subjective evaluation as it sends a strong signal that trust is critical. For relational factors, managers are suggested to create arenas where one also builds personal connections. On an individual level, one should promote people disclosing expertise and limitations to build confidence in which competency they can trust. Hawlitschek et al. (2016) continues by suggesting that by understanding the perspectives of different user types, one can select measurements that increase trust for that specific user type in a digital ecosystem. An example can be seen in Sweden; Ecomuseum Kristianstats Vattenrike gained broad support and legitimacy in handling a diverse set of actors by creating arenas for trust-building in a case where a local actor was skeptical towards authorities until interests were discussed and understood as being in the same boat (Hahn et al., 2006).

Part of ensuring trust is handling information carefully. Sabouri et al. (2014) suggests identifying trust relationships by understanding "who needs to trust whom on what?" and that if there are created controlling mechanisms, parties must trust the issuer for it to have an effect. Supported by Fachrunnisa and Hussain (2011) suggesting trust in virtual environments should be handled by a trusted third party agent monitoring compliance levels based on outcomes, checkpoints, and weighted-based approaches.

2.5 Data Standardization

McKnight and Chervany (2001) argues trust in digital ecosystems is similar to trust in human interactions, but the object of trust moves from people to specific technology, which one trusts to handle interactions. In that sense, the ecosystem becomes more scalable as trust moves from people to designed systems. However, for digital ecosystems using big data, the volume of data collected reaches enormous proportions, which implies data standardization becomes a precondition for operating cross-firm or cross-industry (Gal and Rubinfeld, 2019).

Standardization brings many benefits to big data analytic projects such as securing more and better data, which again implies better predictions and algorithms (Gal and Rubinfeld, 2019). Standardization may also play a key role in facilitating innovation when facilitating market access into a domain filled with regulations. It also ensures inter-operability and thus, a modular ecosystem design that is flexible enough to let new technology integrate with existing technologies. Further, standardization means establishing a trust in which all compete on the same standards in the ecosystem (Friedrich, 2011; Lee, 2001). On the other side, creating standards might trap an industry when better alternatives become available, Farrell and Saloner (1985) sees that when this occurs, it instead becomes inertia to overcome.

When having an ecosystem with standards, Viljainen and Kauppinen (2011) suggests the management team should scout for fitting technology, orchestrate its value in the ecosystem, influence the supply network to ensure underlying components integrates into the ecosystem, and facilitate for reusing of technology by ensuring solutions are built flexible and modular or changing proprietary solutions with more common ones or open source solutions if possible.

2.6 Data Security

While big data represents a huge opportunity, it also represents a significant risk for many users, especially data owners sharing data with varying degrees of sensitivity. Digital ecosystems deploying large amounts of IoT-devices collects large amounts of valuable data, which again increases the likelihood of cyberattacks (Badr et al., 2010). Van den Dam (2017) sees digital trust as a critical factor because with breaches, clients and customers lose trust in the system, which results in momentum impossible to regain.

Cyberattacks can be redirected towards all vulnerable services in a network at the same time, which makes a digital ecosystem highly vulnerable. Protecting sensitive information thus requires a comprehensive solution to prevent and detect attacks (Tan et al., 2014). However, the heterogeneity with various IoT-devices provided by inter-organizational companies makes it challenging to find one solution applicable to all of them (Izquierdo et al., 2007).

Thus, creating balanced solutions between security and analytics usability is difficult. Gahi et al. (2016) suggests selecting the location of data storage accordingly to country laws and regulations and encrypting data storage, computations, and communications. Authentication of users and systems accessing resources. Tagging data according to the importance and if possible, include a specific data treatment accordingly. Unstructurally distributes information in case one malicious party accesses one or some clusters, to prevent everything from being leaked, and anonymization of data if possible. Tracing activity where logs can be used to audit malicious attacks. Izquierdo et al. (2007) takes encryption further suggesting adaptive encryption for a flexible yet secure means of protecting information, where each component can encrypt information making it more flexible for changing circumstances.

Overall, data security must be established for data to be used at its full power. Bertino (2016) suggests users should be able to express their preferences when sharing information into a larger system.

2.7 Synthesizing Theories

Figure 2.3 shows an overview of the theory put into a theoretical framework that is used when analyzing the AquaCloud case. Holistically, the ecosystem life cycles help to separate events into stages which we can analyze in a structured manner. Then, within these stages, it becomes possible to study the importance of trust, data standardization, and data security. Lastly, by clarifying the stages AquaCloud goes through during emergence, the theoretical framework can also help us understand the transition when the digital ecosystem shifts from an experimental existence stage to a more commercial survival stage.

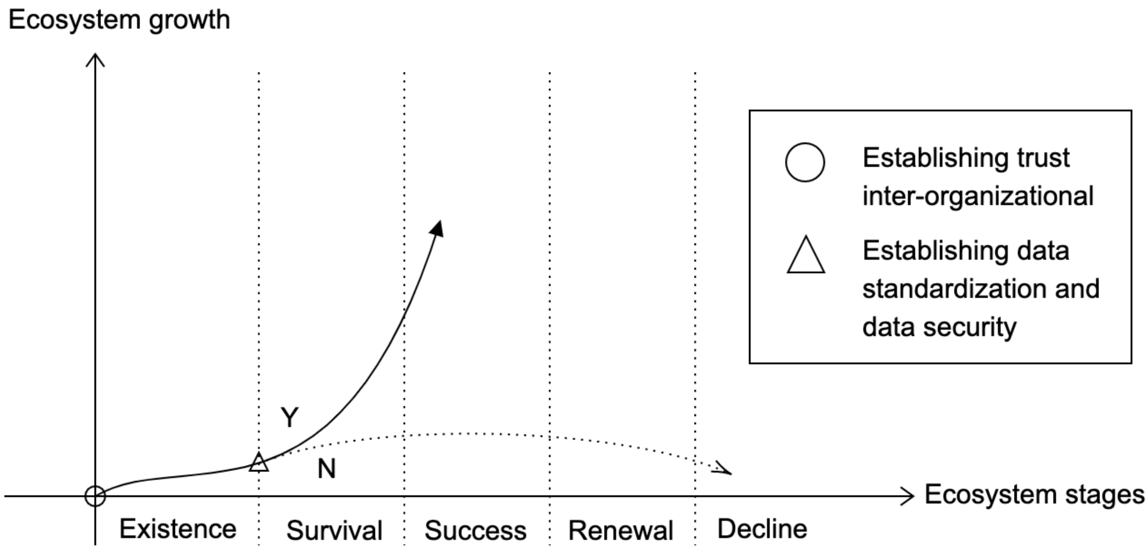

Figure 2.3: Theoretical Framework

3 Methodology

Chapter 3 starts by elaborating why case study is an adequate research design. Then the AquaCloud case is introduced for an empirical setting and a reference point to keep in mind during the intertwined relations, which unveils in the empirical findings and analysis. The data collection section explains the researcher's relevant background for collecting data in this case, the sampling strategy, what data was collected, how it was collected and managed, and which weaknesses this represents. The last section, data analysis, explains the process used to apply the theoretical framework onto the empirical findings for analysis.

3.1 Single-Case Study Design

In the introduction, open research questions for the emergence of AquaCloud were presented, a situation where the researcher has no control over events and seeks to understand historical and contemporary events of AquaCloud within its real-life context. Furthermore, these chosen research questions require in-depth knowledge about a digital ecosystem. Knowledge that must be explored and described to understand situations with multiple variables and few data points. For this matter, a single-case study with an embedded design is a rationale choice when trying to gain a complete understanding. Because when combining multiple sources of evidence, it is possible to group information and better understand how the digital ecosystem evolves and what casual links exist, within the limited scope of a master thesis. With case study designs, exact replication becomes difficult. Still, with the theoretical and methodological background, it is possible to replicate the setting to a larger degree should other researchers want to study this or another digital ecosystem further (Yin, 2018).

3.2 Empirical Setting: AquaCloud

AquaCloud is a big data project in the Norwegian seafood industry. The first goal is to solve the industry's need for better tools to predict and manage sea lice outbreaks because the parasite is an enormous cost and burden to the fish welfare. However, AquaCloud might become something much more significant if the team continues to develop new tools or lets external companies use AquaCloud's infrastructure and large data sets to build new tools. The idea for addressing sea lice came late 2016 when leading salmon farming companies came together in a workshop with NCE Seafood Innovation, and since 2017 IBM and many other technology companies have been involved to source the required technology (AquaCloud, 2020; Øvergaard, 2018). By adopting the digital ecosystem definition outlined in Figure 2.1 into the following Figure 3.1, we understand that AquaCloud is a project set out to become a digital ecosystem. This figure also includes the research topics for which a research design will be outlined, later in this chapter.

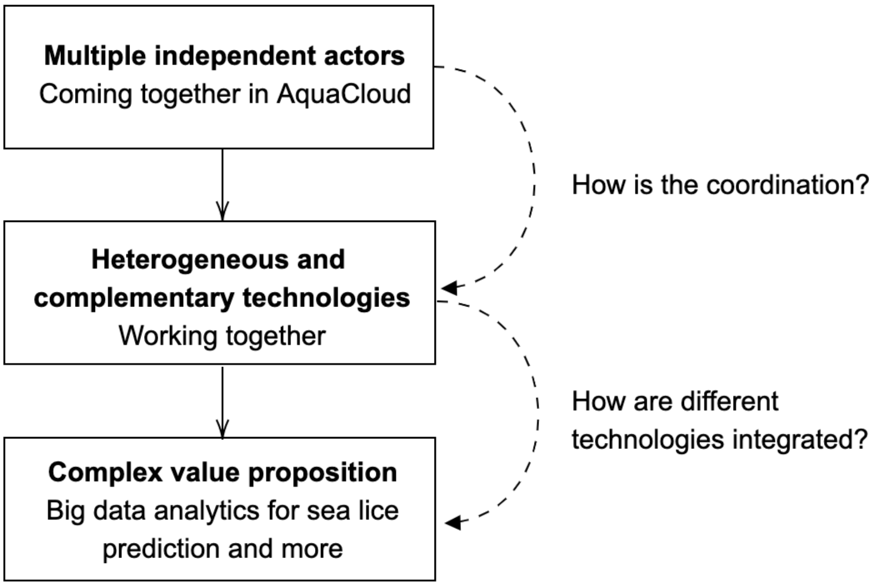

Figure 3.1: Components of the Digital Ecosystem AquaCloud

3.2.1 Stakeholders

AquaCloud operates in a heavily regulated industry in Norway and includes a vast number of different stakeholders. By placing AquaCloud in the middle of Figure 2.2, one can get a picture of how many actors are involved; At the resource base, one has salmon farmers, technology providers, and a steering group as business partners. Shareholders in NCE Seafood Innovation influencing AquaCloud, which up till 2019, has been the industry companies in the steering group, but now it is expanded. Employees working in the AquaCloud project. Beyond this, in the industry structure, we have special interest groups interested in preserving fish welfare and the ocean. Competitors developing their own digital ecosystems or proprietary IoT services. In the social-political arena, many forces are influencing AquaCloud. The Norwegian government has a digital ocean strategy and through its departments, heavily regulates the seafood industry. Media and customers also influence AquaCloud as they want to see changes in the industry to the large sea lice problem, and there are also other influencers.

As of December 2019, 61 members were directly involved in AquaCloud at different levels. To name some companies, these were present at the kick-off for AquaCloud 2.0's new workflows; Aanderaa/Xylem, Åkerblå, AKVA group, Anteo, Aquabyte, Atea, Attentec, BarentsWatch, Benchmark Genetics Norway, Cageeye, Cargill, Datafolk, Eide Fjordbruk, Embicon, FI, Fiizk, Fishency Innovation, Framo Innovation, Funn, Grieg Seafood, GS1 Norway, Hesbynett, Innovasea, Institute of Marine Research, Norwegian, Marine Datacentre, JM Hansen, Kontali Analyse, Krüger Kaldnes - Veolia, Lerøy Seafood Group, Lingalaks, Marel, Maritech, Mekatronikk, Microsoft, Mowi, MSD Animal Health Norge, NORCE, NTNU and Eltorque, Optoscale, OTAQ Group, OxyGuard Internationali, Panoptes, Piscada, Prediktor, SalMar, Salt Pixel, SBS Teknikk, ScaleAQ, Seafood Innovation Cluster, Searis, Seasmart, SINTEF Ocean, TIALTA, Triple-S, Vard, Webstep, and WSense (Finnøy, 2019).

Informants used for this study are seen in Table 3.1. Their source, which is primary or secondary, is later seen under the section, data collection.

Informant	**Role(s)**
Björgólfur Hávardsson	Innovation Manager at NCE Seafood Innovation, and Project Manager in AquaCloud since 2017 for Environmental data
Einar Wathne	Chairman of NCE Seafood Innovation, Member of AquaCloud steering group and the overall Project Manager for AquaCloud since its beginning and up till June 2020.
Helge Stubberud	Solution Architect / Project Manager at IBM and has been working with the AquaCloud architecture since2017
Trond Kathenes	Chief Digital Officer at Grieg Seafood, a large salmon producer and Kathenes has been involved since the beginning of AquaCloud as data supplier and member of the steering group.
Tomas Finnøy	Project Manager at Lerøy Seafood and AquaCloudsince the beginning.
Andreas Morland	Chief Executive Officer at SeaSmart, a startup company providing sensor technology to the seafood industry and AquaCloud.
Rune Wilhelmsen and Jan-Fredrik Larsen	For Telenor, Wilhelmsen has been Business Manager for their aquaculture strategy, and Jan Fredrik Larsen is partner manager for IoT solutions
Sondre Eide	General Manager at Eide Fjordbruk, a smaller salmon producer involved in the AquaCloud project
Erlend Haugarvoll	General Manager at Lingalaks, a smaller salmon producer involved in the AquaCloud project.

Table 3.1: Informants in this Study

3.2.2 Technologies

Innovation Manager at NCE Seafood Innovation, Björgólfur Hávarðsson (2020) informed that AquaCloud has received data from 3250 fish cages covering 12 out of 13 production areas in Norway, of which 1100 delivered every week. This represents approximately 6370 sensors and 140 000 data points. In 2020, the number of data suppliers is increasing from 7 to 8, which implies even more data from an enormous amount of heterogeneous sensors. Besides the technology providers directly involved in AquaCloud, there is a need for dependable infrastructure. Norway has a varied landscape, and fish farms change their physical location to reduce environmental impact on areas; this means it is difficult and costly to both build and maintain a fixed infrastructure. A big part of why the timing of AquaCloud is excellent, is the development of 5G, which gives the benefits of high speed, low latency, separate network layers to remove disturbance, and flexibility through it being a mobile technology. Holistically, this creates represents a large number of heterogeneous and complementary technologies that come together for AquaCloud. Figure 3.2 excludes the general industry infrastructure and gives a simplified overview of technologies used directly in AquaCloud for its complex value proposition.

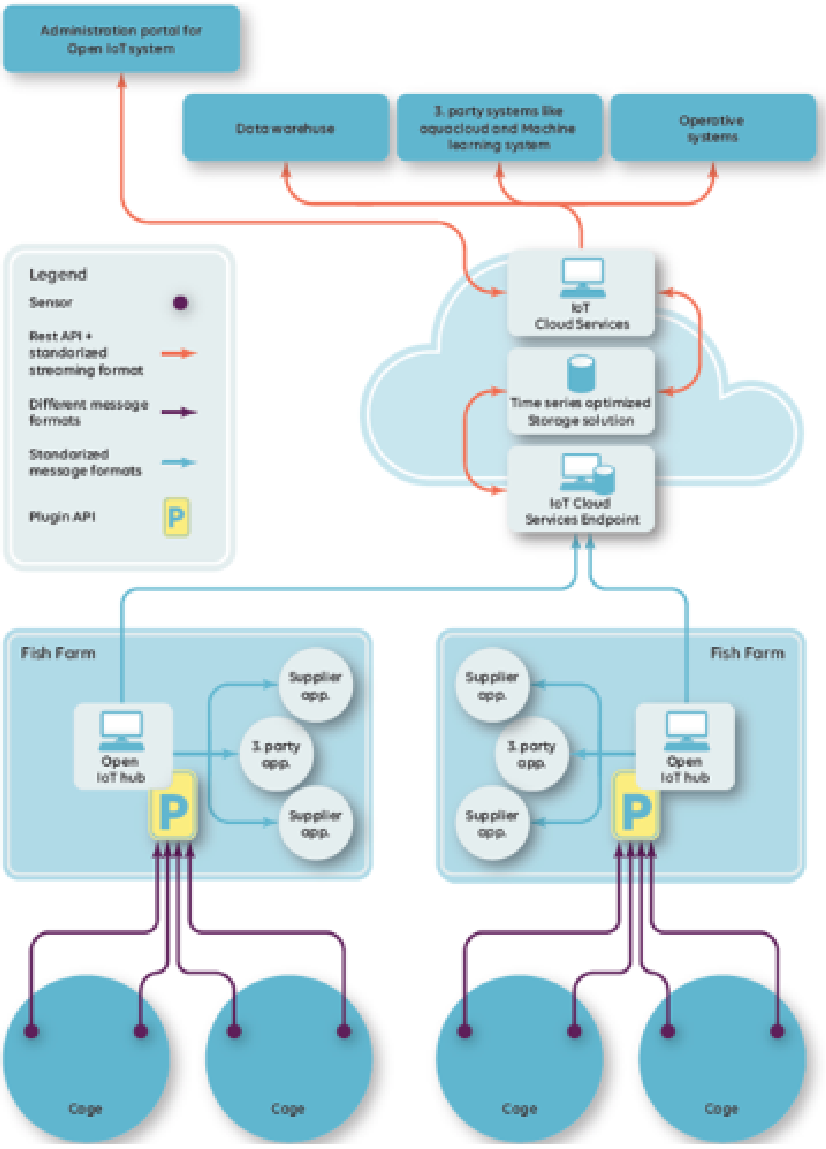

Figure 3.2: Simplified Overview of Technologies used Directly in AquaCloud (Finnøy, 2020a)

3.2.3 Value Proposition

The AquaCloud system is first aimed at predicting and managing sea lice outbreaks. In the future, AquaCloud might become something even greater for the industry if new tools are built on the AquaCloud infrastructure and data sets. However, the first problem is huge, and solving it means transforming one of the biggest problems the industry has. Iversen et al. (2017) estimates the sea lice problem costs the seafood industry NOK 5 billion annually, and it challenges the fish welfare. Sea lice are parasites that can kill juvenile salmon and reduce disease resistance in both juvenile and adult salmon. Since the 1980s with the introduction of farming equipment, the infection rates have been increasing.

To combat this, salmon farmers currently use biopesticides, but the efficacy has declined as the sea lice have increased its resistance (Guidi et al., 2020). Other combat techniques include cleaner fish in the farm, quickly removing dead and sick fish, breeding salmon for a better genetic variation, freshwater treatment, drugs and vaccines, bath treatments with different chemicals, in-feed treatments, and more (Wikipedia contributors, 2020c).

To solve the sea lice problem, one must be able to predict when outbreaks are about to happen and respond promptly with appropriate actions depending on the situation. Deep in the water with limited light, it is challenging to see the small sea lice before it is too late. Sea lice stick to the salmon, causing both physical and enzymatic damage to the fish. Furthermore, they can lay strings with eggs where two strings may contain 500 to 1000 eggs, which hatches after 17 to 72 days (Wikipedia contributors, 2020c).

Figure 3.3: Sea Lice Infection on a Salmon (NaturOgUngdom, 2016)

AquaCloud's first goal of predicting sea lice outbreak has been reached, but only with 70% accuracy two weeks ahead, which is not good enough for making costly decisions. Therefore, the project has entered its 2.0 phase, where one major workflow focuses on standardization to improve data for better analytics. The other two workflows address which health and environmental data to measure in an industry where there currently is nothing sufficient (Hávarðsson, 2020).

Overall, the Norwegian seafood industry is facing massive challenges, where AquaCloud can play a crucial role in data-driven decision-making. However, bringing data together for analysis becomes a complex value proposition, as data is supplied from different companies with varying formats and quality.

3.3 Data Collection

The researcher's background is favorable to the data collection process. First, because with previous technical education and personal interests, he has a firm grasp of the IoT, AI, and big data technologies, which helps to understand what's going on and ask better questions. Second, the researcher has over the past three years been working with technology-based business development within the seafood industry and amassed a solid foundation for understanding the industry in which AquaCloud operate in, who the central actors are, what the trends are, and in general a focal point to build good interviews around. Third, the researcher is currently working in NCE Seafood Innovation, the same company which organizes the AquaCloud project. While this thesis is conducted as an independent thesis and the researcher's job responsibilities are outside AquaCloud, the researcher cannot exclude preconceived notions about how the ecosystem has been developing and possibility of having gained business-sensitive information about AquaCloud, which is not to be publicized. To minimize the risk with business-sensitive information, the researcher has deliberately engaged in as few AquaCloud discussions as possible to build this thesis on publicly available data and the interviews conducted, but nonetheless, this affects the subjective analysis. Overall, the background and current job position are seen as favorable as it helps to understand the case and better connect with the interviewees (Yin, 2018).

3.3.1 Stratified Purposeful Sampling

AquaCloud has a vast number of stakeholders and with research questions requiring information-rich cases. Because of this, a stratified purposeful sampling strategy is chosen to find useful information within the limited scope. This includes focusing on the stakeholders who are directly responsible for the emergence of AquaCloud; salmon farmers, steering group, and technology providers. As introduced in Section 3.2.1, these stakeholders represent the variation needed to gain multiple perspectives on how AquaCloud is being developed (Patton, 2014).

Both primary and secondary data collection focuses on these selected stakeholder types. Whereas for secondary data, it is easy to find and select the relevant data, the primary data collection focuses on selecting individuals with significant responsibility, knowledge or experience about the AquaCloud development (Creswell and Clark, 2017). This implies focusing on busy people, many who are business leaders, which raises the challenge of getting willingness and availability to be interviewed (Palinkas et al., 2015). Positive to this challenge was the leader at NCE Seafood Innovation, who gave an introduction towards business leaders if the researcher's personal network was out of reach.

In total, this study builds upon nine interviews with different stakeholders in the digital ecosystem and 16 publicly available documents of various kinds. Following sections details the collection and handling process for primary and secondary data.

3.3.2 Secondary Data

News articles, reports, presentations, and podcasts publicly available were used to gain a contextual understanding. This helps to understand the digital ecosystem's boundaries and focus interviews on relevant details, rather than spending interviewee's limited time on surface information. Furthermore, the secondary data is used to build the empirical setting and support the empirical findings and analysis through its contextual value. As news articles, podcasts, and to some extent reports are published by journalists or people with similar functions, the reality might be slightly modified. To counterbalance this effect, key information was cross-checked during the conducted interviews. For presentations used, it is seen as trustworthy because the source is the AquaCloud team members. Thereby, this helps the researcher gain a firm understanding and increase the chances of conducting good interviews. All secondary data used are listed in Table 3.2.

Title (Source)
· About AquaCloud 2.0 (AquaCloud, 2020)
· AquaCloud's technological architecture (Finnøy, 2020a)
· Big Data in Marine Science (Guidi et al., 2020)
· Connecting farms – Challenges and opportunities (Wilhelmsen, 2019)
· Digitalisering av havbruksnæringen skal gi stor verdi (Øvergaard, 2018)
· Et hav av big data (Tekna, 2019)
· Hva er problemet med lakselus? (NaturOgUngdom, 2016)
· Kostnadsutvikling i lakseoppdrett–med fokus på fôr-og lusekostnader (Iversen et al., 2017)
· Oppdrettere skulle samarbeide om lusevarsling, men oppdaget at dataene var for dårlige (Aadland, 2019)
· Progress despite difficult circumstances (Finnøy, 2020b)
· Sea louse (Wikipedia contributors, 2020c)
· Slik jobber oppdretterne med digitalisering (Tekfisk, 2018)
· Verdien av tillit (Hávarðsson, 2019)
· Vi greier ikke å få til digitalisering uten god datakvalitet (Furuset, 2019)
· Wide industry support for Sensor Data Standard (Finnøy, 2019)
· Without standardization we will never overcome the problems with fish disease (Hávarðsson, 2020)

Table 3.2: Secondary Data in this Study

3.3.3 Primary Data

Primary data focused on the stakeholder types directly involved in building the digital ecosystem Aquacloud, within these types, candidates where interviewed in a stratified purposeful manner. The ones who indirectly influence the boundaries are seen as less relevant and thus kept out. This means the study focuses on; Norway's largest salmon farmers, technology providers, and the steering group. Representatives for these stakeholders types, which were interviewed, are listed in Table 3.3.

Name	**Role(s)**	**Interview(s)**	**Duration**
Björgólfur Hávardsson	Innovation Manager at NCE Seafood Innovation and Project Manager in AquaCloud since 2017 for Environmental data	Semi-structured	1hr, 30min, and 15min
Einar Wathne	Chairman of NCE Seafood Innovation, Member of AquaCloud steering group and the overall Project Manager for AquaCloud since its beginning and up till June 2020	Semi-structured	1hr
Helge Stubberud	Solution Architect / Project Manager at IBM and has been working with the AquaCloud architecture since 2017	Semi-structured	1hr
Trond Kathenes	Chief Digital Officer at Grieg Seafood, a large salmon producer and Kathenes has been involved since the beginning of AquaCloud as data supplier and member of the steering group.	Semi-structured	30min
Tomas Finnøy	Project Manager at Lerøy Seafood and AquaCloud since the beginning	Semi-structured	1hr
Andreas Morland	Chief Executive Officer at SeaSmart, a startup company providing sensor technology to the seafood industry and AquaCloud	Semi-structured	1hr
Rune Wilhelmsen and Jan Fredrik Larsen	For Telenor, Wilhelmsen has been Business Manager for their aquaculture strategy, and Jan Fredrik Larsen is partner manager for IoT solutions	Semi-structured	1hr 15min

Table 3.3: Interviewees in this Study

Interviews were conducted over four months, which is useful because when processing the data, it was possible to later cross-check uncertainty in upcoming interviews since all the selected stakeholders knew about the general development of the ecosystem. Scheduling the interviews were varied, for the people working in NCE Seafood Innovation, the researcher just asked for a meeting while meeting them at the office, for stakeholders representing a smaller firm they were contacted by phone or email by the researcher. For larger firms, an introduction was given by the CEO of NCE Seafood Innovation to ease the process of scheduling a meeting with persons who have lots of other demanding requests. The interviews were conducted semi-structured based on the interview guide seen in Appendix A2, and interviewees were notified about themes on at least a week beforehand to let them have time to prepare, an example is seen in Appendix A1. During the interviews, the researcher focused on listening carefully and adjusting the interview accordingly to gain as rich data as possible (Yin, 2018). While the researcher's background has been previously argued as beneficial to the case, one weakness to conducting the interviews is the researcher's motive to nurture his personal network due to his seafood related job, in-which asking certain sensitive questions might come across poorly for both parties. However, during the interviews, this didn't become a real issue.

All interviews were conducted solely by the researcher, which naturally splits the individual capacity to be a good interviewer and taking rich notes for later analysis. With access to multiple note-taking tools and the option to prepare various questions for the same themes beforehand in the interview guide, the single researcher focused primarily on being a good interviewer with the intention of trying to explore underlying mechanisms inside a digital ecosystem by listening carefully and asking the right questions (Yin, 2018). To collect adequate notes for analysis, the researcher prepared beforehand with secondary data to ensure a good understanding, actively took as many notes as possible, recorded the interviews with consent, and cross-checked information in the following interviews if something was uncertain. While this situation is not optimal, it is seen as sufficient as the analysis unveiled interesting links within the ecosystem emergence.

In order to triangulate data from various sources and analyze them in a meaningful way, all data was stored in a single database and tagged for date, topic, and stakeholder name. Through this evidence base, it was possible to reread notes and find links before a systematic analysis, and this helped to cross-check information during the on-going process (Yin, 2018).

3.4 Data Analysis

Data analysis started in parallel with the data collection as everything was examined during the process, and most data re-examined before finishing the last interview. Then by using NVivo, all data was imported into the tool, reread, and marked based on which topic it belonged to. By marking sentences and paragraphs to their according theme, NVivo creates a systematized data display that filters to the selected theme. By grouping data into themes, the links connected to the theoretical framework and initial research questions become clearer, and thus it becomes possible to combine insights for answers(Yin, 2018).

When trying to understand how the ecosystem emerges, the researcher uses the theoretical framework to guide the analysis, understand and find patterns, logical links, and build explanations based on a series of collected data. With this exploratory mode, it implies the risk of drifting away. However, this was done in an iterative way of multiple cycles with the support from supervisors early on to ensure the thesis is focused on relevant insight. A potential two-edged blade to the analysis is the researcher's job position in NCE Seafood Innovation, which organizes AquaCloud. On one side, this bias could frame AquaCloud in a better light or draw conclusions based on information gained outside the thesis. On the other side, the background also strengthens the quality of the study by being in the industry and close to AquaCloud. Furthermore, the analysis is done in an iterative way with multiple cycles on collected data, and with feedback rounds from the supervisors to reduce bias related to the collected data (Yin, 2018).

To present the findings and analysis, mixed data is categorized into themes corresponding with the research questions for an organized overview. Within each theme, theory and data are grouped in ways that help unveil patterns, logical links, and build arguments based on a series of data (Yin, 2018).

4 Empirical Findings

In Chapter 4, empirical findings from primary and secondary data are presented in a grouped manner, which later lets us analyze each phenomenon with the corresponding theory for a deeper understanding.

4.1 Ecosystem Governance in the Early Stages

Starting out

In the big picture, the industry corporation Telenor has a good overview as infrastructure suppliers to a wide range of industries across the globe. When looking at the Norwegian seafood industry, there was not a plug and play scenario. In an interview, Rune Wilhelmsen said: "We (Telenor) understand that we have a long way to go, they (salmon farmers) understand things must be done differently, and they are interested in inviting us out to let us understand what they are doing, but they're looking after their own money." On the question if he thinks the industry is prepared for digitalization, "Many wants to, but not all the local leaders have come that far on this journey, this requires that the leadership from the top states it will be digitalized" and that "When Eide Fjordbruk, Einar Wathne, Grieg Seafood publicly states they are going to digitalize this puts pressure on others."

The Norwegian seafood industry is spread along the coast, with some companies sharing a fjord while others do not; this creates a somewhat fragmented industry. However, with the enormous challenges presented in Section 3.2.3, there is a significant interest to come together as Einar Wathne commented, "Sea lice are so damaging that they are willing to try anything, the problem is so huge that companies are willing to see past competition." Early 2016 a diverse group was invited to a workshop about the seafood future, and the interest was evident. "There was an overall enthusiasm at the big data workshop that year. When someone started talking about the fact that we could use big data in relation to sea lice, people thought it was new and then with the CEO of MOWI, Principal in Bergen, and other enthusiasts it fell naturally in place. It was networking collaboration, which was a yes-case!" said Wathne. Adding to this, Björgólfur Hávardsson said, "When we came up with AquaCloud as a solution, everyone did not agree on everything, but they agree that this was a solution they were willing to start, and then we began a pre-project."

Chief Digital Officer at Grieg Seafood, Trond Kathenes, adds to this with "The project was rooted in the fact that all farmers face the same challenges and sea lice problems, and then contact was taken in many forms across. We were invited into a meeting with NCE Seafood Innovation and was invited into a shared project. We work more together than we compete, and when we have a shared problem we should get to the bottom and build the industry further." and that "As long as we are in the same fjord, its just a matter of time before (farm) number 2 is exposed (...) primarily this is about fish health and sustainability, fish in this context are animals. Living animals we are to take good care of, which the farmers independently from the companies have a close relation to. It may be weird, but when they send out one smolt (small fish), they have a relation to the individuals".

From here on, the shared enthusiasm started AquaCloud 1.0 in 2017 to explore what predictions IBM Watson could do if they fed it with industry data. In this project setup, NCE Seafood Innovation is the central actor with Chairman Wathne being the overall project manager for AquaCloud; however, he answers to a steering group which includes the three of the largest salmon producers in Norway; Grieg Seafood, Lerøy Seafood, and Mowi, each represented by one IT and one production-oriented person. "We are an extended tool for the industry, and we are 100% owned by the industry. We have our views and suggests, but it is the steering group who controls what we are doing and not doing" says Wathne. This means three large industry actors controlled the progression from the start, and quickly Cermaq joined, which is another large salmon producer. Hávardsson commented this by "I think it is important that we are neutral. Here we are working together for something much larger than ourselves."

Looking back at the first years

"From the start, everyone thought it would go faster to a product because they had heard about the Watson magic" said Wathne. During AquaCloud 1.0, data was gathered from a large number of farms. As the data was being fed the analytics software, IBM Watson, the challenges became more evident as the data quality resulted in 70% accuracy for predicting sea lice outbreaks two weeks in advance, which was not good enough for many taking costly decisions. Wathne comments the motivated, which fell a period "We forgot quick wins, if we have a long term goal without quick wins people lose some of the energy. It was a letdown when the prediction was not good enough. While we have had some significant setbacks, we have managed to keep the harmony and adjust us". Now the AquaCloud has entered their phase 2.0 which aims to solve many of the issues seen in 1.0, and for the motivation, Wathne comments "If I didn't take 2.0 as a project manager it is not certain we would have come further, it has to be a solid anchoring in the industry". 2.0 is under development regardless of the COVID-19 crisis, as Tomas Finnøy stated there is progress despite difficult circumstances, and they aim to present a standardization proposal in Q2 2020 (Finnøy, 2020b). Regardless, Kathenes added to this with, "We must get the focus back. The owners and drivers have to, in many ways, say and confirm that they want to develop AquaCloud to a new concept for the industry, and then we must agree to put resources on this; if not, it will just live as an initiative". While AquaCloud has a steering group represented by the largest salmon farmers, Wathne did comment, "We sit in an informal cluster structure, where the loudest might control the direction." Besides this, there are many stakeholders to consider, Wathne explained that they had created a map to categorize which stakeholders they have, their importance, and thereby which are the primary interests for AquaCloud.

In one interview with Helge Stubberud, he suggested that perhaps it would have been developed faster with venture capital. To which Håvardsson later commented that it is not about the money, this is about the salmon farmers and the issues we must overcome. In the interview with Wathne, he commented that "we have been smart with their physical location for network and collaboration. The farmers deliver data, and everything we do is financially supported through OINC and SIVA. It is very little being supplemented from the cluster's membership fee", which means the other members in NCE Seafood Innovation supports other cluster activities with their fee.

Regarding smaller companies' participation in AquaCloud

After starting AquaCloud 1.0, the smaller companies came after 8-9 months, said Håvardsson, and that "they knew the data quality was not good enough at that point, but they wanted a cluster collaboration." The smaller companies haven't got anything back from AquaCloud, but they are not tired of it. Håvardsson said, "they think it is moving a bit slow, but there are industry challenges, so they understand it. They gather data every day because they are required to by the government, then its easy to gather for AquaCloud simultaneously". On the question if they felt governance was skewed by the larger firms, Hávardsson further added: "They know there are big decisions which are not taken in a vacuum but taken together with the large which struggles with the same as the small ones do, and they might even have less prerequisite to solve it themselves."

TK has a different view with the agility, which comes with smaller firms, stating, "From the smaller, I would like them to raise their hand more and make themselves accessible to test and be an actor in that context which evaluates its operational value. It is easier for a small actor than a global actor to evaluate that, I have 150 farms, and another might have two, and then its easier to take an evaluation on the operational effect". Wathne stated he wants to change this "Lingalaks, Bremnes and Bolaks (smaller firms) have delivered data through this app which uploads data to AquaCloud daily (...) it has been little used, and it will be revitalized".

AquaCloud in the future

For the future, it seems clear that the steering group wants to make AquaCloud independent from NCE Seafood Innovation. Hávardsson says, "the cluster should not operate firms. It is a coordinator and inspirer we should be," which Finnøy adds to "I wish it becomes an official AquaCloud company who does this, and becomes a point of contact for the industry, which suppliers we have, how one can adjust, etc.". While these salmon farmers are competing in the same market, the competition is on another arena, as Kathenes said, "The first dimension is about how we feed the fish, when we set it out, geographical circumstances, and markets we can deliver to. The next level is more internal and in-between internal farms on who can produce most effectively with safe biological frames. The third layer is what I get in the market in price, which contracts I can get, and value-added products like smoked salmon". Overall, companies come together to solve industry-wide challenges, and with big data systems, there are many possibilities, for example, reporting metrics to the government, which Kathenes said he looked forward to automating.

AquaCloud has excellent potential for data-driven decision-making, but there are hurdles to overcome. As Kathenes said, "we are still at the most tiring and time consuming with the manual registration. At the moment we automate it, yes, then we can talk because you suddenly get a different regime". Furthermore, he has stated that "Data security, that's a given if we are to put our data, which is business sensitive in the same database with Lerøy, Mowi, and competitors. We are also listed on the stock market, and then there are some measurements we must take care of".

4.2 Importance of Trust

"NCE Seafood Innovation is a membership cluster and doesn't have more legitimacy than us doing something productive," says Wathne, and that "we built legitimacy by doing." As introduced, NCE Seafood Innovation is owned by the industry. Similar to AquaCloud, the steering group is also the industry, which makes the cluster an extended collaboration tool for the industry. Stubberud says, "trust is extremely important if AquaCloud is to become something more with an ecosystem around. The competitive advantage is the connection to governance and data, which creates a massive data house". Combined, this means NCE Seafood Innovation works on behalf of the industry. If the companies are to join on a digitalization project with this immense value, there has to be an underlying trust in the management. As Wathne said, "If I didn't take 2.0 as a project manager, it is not certain we would have come further", whom again is influenced by the steering group where Mowi, Lerøy Seafood, Grieg Seafood, and Cermaq sits.

While trust in human relations seems to be in focus for AquaCloud. Arne Norheim, CEO of IBM Norway, has stated that "it is not the case that sharing data means everyone can access all information. IBM ensures data is masked, such that one company cannot dig in information from competitors. Everyone shares data with IBM's Watson, and everyone gets access to relevant analyses. But no one gets access to stock market-sensitive information or other business-sensitive information from competitors. Data security is fundamental in a project like this" (Hávarðsson, 2019). This means companies can trust their sensitive data, but as seen in AquaCloud 1.0, this data isn't adequate for good predictions. More has to be established around data standardization and data security to ensure benefits and security.

4.3 Importance of Data Standardization

Why it matters

In a podcast session, Kathenes and Erlend Haugarvoll from Lingalaks discuss why standardization is so important and its challenges. "What's in many ways was a challenge was that we are a company with many subsidiaries in regions, often over country borders in terms of culture, and when you have also been allowed to develop own systems, domains, etc. over the years. Then there have to be some pointy elbows and some clear messages to make people walk together. It begins by gathering someone to walk in the approximately same direction, but the key which made Grieg go from 5 potential data systems to one data warehouse, was the board accepting an IT strategy which said one had to do the standardization track to prepare the organization for a digitalization wave, which would come at some point, this was back in 2011-2012.".

On the question, if it might be easier for Lingalaks to turn around for digitalization. Haugarvoll answers, "Of course it will be. We have 10-12 farms, and you probably have ten times that and maybe more (...), so we have a smaller job to get it fully integrated, but it is the same challenges we have. We need to make people register data, and its the same people we must try to change daily habits for." Kathenes adds, "Pretty sure we have the exact same challenges, just that the scale is different in many ways. It is probably the same with Marvin and Marine Harvest (now Mowi), similarly, I have a simple everyday life, as when he looks, he sees Jotun's color map". Later in this podcast, Kathenes adds, "we are still at the most tiring and time consuming with the manual registration. At the moment we automate it, yes, then we can talk because you suddenly get a different regime".

Standardization process

With the big potential value and lacking data, AquaCloud had to take another round to improve data quality in 2.0. Standardization becomes highly important in two ways. First, salmon farmers will report data in the same formats. Secondly, it becomes an innovation hub as knowledge providers can enter and use the data for research and development. Sintef Researcher Leif Magne Sunde is clear, "If we are unable to achieve standardization, then we will also not be able to get digitalization." Sunde continues by telling he was engaged in a standardization project in 2007 with Norwegian Seafood Research Fund and The Norwegian Seafood Federation. That standard was completed in 2012, but never implemented, and is the same standard which is now getting interest again (Furuset, 2019). On the bright side, Wathne commented in another article that "I feel it is a change of attitude going on. It is an understanding of the necessity and benefit of standardization" (Aadland, 2019). It would be easier if it were just a few firms involved, but establishing an industry-wide standard is a big project. Finnøy comments that when it is being established in Norway with Norsk Standard, the steering group has signaled that they want to take it globally and use the Norwegian standard as a platform to later get into the ISO-system.

Complexity of a good standard

Sunde says standardization must be on a reasonable level and built for the future of the seafood industry, estimating it will take a minimum of three years. "It has to be something the industry finds reasonable, but it cannot be at the minimum baseline either" and that "We cannot build a system that is controlled by one organization. The industry must be included, and we must look at how we can coordinate the efforts for standardization. It is important that the ownership in this work is at the companies" (Furuset, 2019). Finnøy tells that he was working on standardization for Lerøy, but when he realized that if they did it alone, they would not get the desired effect, after proposing it for their steering group they got more actors in the industry. Simultaneously, AquaCloud got the message that they had to focus on standardizing data, and then it naturally for Finnøy to move it into this setting for even better industry relations through the seafood cluster.

Value of standardization

The value is two-sided. On one side, Kathenes tells us the salmon farmers has experienced its importance when seeing all the internal variety, and that just standardizing basis data means one has taken a big step "Then we will all report apples, apples, and apples," which is vital for meaningful data sets. On the other side, standardization in this context also makes it simpler for external parties who might want to develop new sensors tailored to the standard and thus more options to choose from for the salmon producers.

Meaningful data sets are not only useful to IBM's Watson software, but also for external parties who want to develop new services to the industry. Andreas Morland, CEO of Seasmart, explains that they have not had any close relation to AquaCloud, but it is on their map as a way of sharing data.

"We talked with IBM, and the API they needed became too tedious that time, where we had to push data to them instead of them gathering it from us. It was this way IBM wanted us to provide them data, and that's a problem because it requires a custom solution at us (and other firms) (...) A standardized way of sharing data, but at the same time flexible enough to combine data sets in all ways, will be interesting in a sense where we can work with more data. (...) The ones who will lose on this are those who today integrate results in deliveries they would like to protect. (...) Good data sets and a simple way to discuss partnerships with another firm who wants to do something with our data, etc., and if we want to combine with others, this is interesting - a catalyst for collaboration.".

Finnøy has commented on this aspect, as smaller firms lack the financial muscles to tailor their systems to the needs of one firm. The integration becomes so costly and time-consuming that they spend a lot of time adjusting the system and creating little value. "The solution is to create an open industry standard, free to use. One doesn't have to adjust the systems if everyone collaborates. We could use one camera for multiple applications; we could use a feeding camera to track fish, estimate biomass, etc., and the same goes for sensors," says Finnøy. On this note, fewer sensors mean less equipment, causing less stress on the fish, and less maintenance, which reduces HSE risk. Having a standard makes the integration cost predictable and stable; it also reduces the barriers to entry. "For the small firms to enter in a reasonable way, we need to make them not dependent on the big companies. One must be able to build systems that fit the market. A lamp fits your home, and one doesn't have to consider if it fits the home. This will make it easier for R&D to think about value creation," says Finnøy.

4.4 Importance of Data Security

There are many factors to salmon production, and within each company, salmon farmers tweak these factors to optimize their production capacity and obtain the largest margins. Factors that are highly business sensitive to not only share with competitors but also the stock market as data about fish welfare or feeding habits could say something about expected economic performance. Still, companies want to share data with AquaCloud because the value from data-driven decision-making is tremendously high. This means companies want the solution, but they also see data security as a requirement for AquaCloud's success.

For the seafood industry in general, this means having robust infrastructure which can transfer the massive amounts of data from a salmon farm to a data warehouse. These salmon farms are moved after an extended period in one place. Infrastructure is something Telenor is working on, and in a presentation from Rune Wilhelmsen he states, "A shift from legacy to standardized and ultra-reliable networks in rural and harsh environments in the ocean space is required. 5G combined with smart software, and edge computing is an opportunity we investigate". and that "Cooperation, trust and a framework for data exchange are required to make use of new enabling technologies in the aquaculture industry" (Wilhelmsen, 2019). Finnøy supports its importance "A lot of the data streams over IP addresses. If we have one bad component in the system, it could tap information. The database is often stored in one place with open passwords. Then one non-verified supplier could easily extract all information. (...) No way of tracking data back to the source without encryption or certificates (...) For the smaller farms, there might be cases where one could stand on the parking lot outside a fleet and log straight onto their WiFi because it is an open channel. This is bad security standards".

This makes data security something that must be considered in multiple layers; industry infrastructure and technologies used in the AquaCloud ecosystem. Håvardsson states the "data security is established, and they know data is not shared, the work package is about formalizing everything related to more data and better formatting. Now its also such large amounts of data that it is important to formalize it and avoid distortion of competition". In that sense, Håvardsson has referred their views on this matter by referring to Lawyer Kristian Foss "The starting point must be that the person who creates something must be closest to disposing of what is created" (Tekna, 2019). This means establishing APIs for others to extract data from and create services on top of it must be built in a way where the data owner can control what data is shared and when it is shared and with whom. As an example, Sunde said, "In a crisis situation, such as during algae blooms, it could be useful if everyone shared data about current measurements, temperature, and so on. Data must be shareable at different levels" (Furuset, 2019).

Adding to this complexity, Morland says, "We want the that the customer gives data to AquaCloud without asking us. Its the customer who has to share data. This is something they have become much more aware of (...) Bremnes Seashore has told us they must have it like that or they cannot use us at all, if it is only the result, then it is not interesting" and later adding "they should demand compliance from all their suppliers, it would be an effective catalyst for easy integration with many data sets." Finnøy states they want to build a solution flexible to the organization and roles within.

On the other side, value creation cannot be completely closed as Wathne mentions they also have to consider the competition law and ensure this doesn't become a competitive advantage for some in the industry. "That's why we have our work package with Thomessen on governance, which will give us a framework to ensure the competition law," says Wathne, later followed by "DNV GL has recently made a report on blue-green data, it provides legal guidance to a common understanding of who should own the data, so it becomes a solid document which creates some clarifications." DNV GL is the world's largest classification society and a trusted source for contributing to this intricate security puzzle (Wikipedia contributors, 2020a).

5 Analysis

5.1 Effective Project and Stakeholder Management

The focus on one nation

AquaCloud is a big data project, gathering diverse sensor data from 3250 fish cages, which is transferred to IBM's Watson technology for big data analytics. The first goal is to predict sea lice outbreak and help salmon companies take preventive measures to eliminate this risk while ensuring fish welfare. The project team has global ambitions for AquaCloud, but they are currently only focusing on Norway's seafood industry, an industry that is regarded as one of the most high-tech industries within the world of seafood. This is beneficial because the industry is likely more willing to experiment with new technology. Furthermore, by being in the Norwegian context, the industry structure and socio-political arena are well established with little corruption, which on the one hand, makes the environment stable and predictable to develop a concept within. On the other hand, being well established and heavily regulated could also become a big hurdle to overcome. Lim (2014) adds to this notion by showing how transnational projects create a high degree of complexity in terms of governmental laws and regulations, all of which could have been the end for global ambitions. As Daniels et al. (1994) finds, ecosystems limited to a nation may still meet conflicts, such as conflicts with local societies or policy-makers, but too much less degree than international ecosystems.

Managing interests in a industry project

Within Norway, the project is well anchored in the seafood industry through its project managers and steering group who all work in the industry. Wathne, the overall project manager, said they had spent a lot of time mapping out other stakeholders and their importance, regardless, the AquaCloud team still comprises people from salmon farming companies and the cluster organization, NCE Seafood innovation. On one side, this could be a disadvantage for an industry-wide project as possibly relevant stakeholders are left out. On the other side, this is seemingly the better choice because in a smaller group it is easier to have an overview and manage relations, and as the team consists of the larger salmon companies they already represent what makes up for the major part of the Norwegian seafood industry, furthermore the salmon companies are also the customers of the first planned analytical service. Wathne mentioned he wished it was only two actors involved in the project as it would be easier to manage, but that they had to involve multiple salmon companies and make this into something industry-wide for long-term success. Overall, this core team includes various persons from large salmon farming companies, which arguably give the necessary industry understanding, which is required to conceptualize a digital ecosystem that the industry can adopt. Looking back at the theory, Jacobides (2019) also finds that by having a large project group, it becomes a challenging task of managing interests. Management includes many dimensions to consider, Darking et al. (2007) finds that the project group has to consider the balance of interests, culture of communication, credibility, synchronization, technological dimension, and licensing and regulation. Behind closed doors, it is likely to assume the AquaCloud team must have discussed topics such as which problem should first be addressed, if a digital ecosystem the right organizational structure, if it should be open to the entire industry, or if it should be restricted to Norway. For example, the latter might be sensitive to the large salmon producers with global operations, which could lead to harmful conflicts. If the interests were unbalanced, the solution might not become something the industry wants to adopt. Even worse, a big collision in interests could lead to conflicts large enough to make one or more actors pull out of the collaboration, which for AquaCloud might be devastating. Because it not only removes data sets that IBM Watson uses for machine learning, it might also create a snowball effect where the signal makes other actors reevaluate their participation.

Sharing a problem and vision

Another key to AquaCloud's progress is arguably balanced project management. Salmon farmers compete typically compete in the same markets with similar products, where everyone is trying to maximize their margins by tweaking their operations, which creates a highly competitive landscape. Still, there is a huge incentive to build a digital ecosystem because it not only lets technologies work together for a complex value proposition but also creates an ecosystem that fosters open innovation. However, as seen in Section 3.2.3, there are considerable challenges which the industry naturally shares because they are operating in the same waters, where the disease might flow from one company to another. Thus, there are common areas which all the industry see as critical to solving, and for specifically sea lice, the industry has tried to solve it for decades. With AquaCloud established, the promise is that one should be able to make data-driven decisions for preventive measures, which often are very costly, and therefore improving the operations for all companies. The flip-side to this is that as the companies often share waters, making it devastating if one company was not predicting outbreaks, taking preventive measures, and preventing spread. Overall, this makes the value proposition something all industry companies see as highly valuable and worth funding research and development for. Gawer and Cusumano (2014) supports this as to facilitate interests in a group; one has to focus on a shared vision and promote it among the group —something which lies at the core of founding the AquaCloud project.

Neutral project management in a competitive landscape

AquaCloud was conceptualized in a workshop with business leaders in the industry. By having the starting point, multiple interviewees stated there was a sense of enthusiasm and natural to begin a collaboration around. A group, where the cluster organization, NCE Seafood Innovation is the central actor who owns the project and drives it on behalf of the industry. Wathne, the overall project manager, states that while they have the project, they are controlled by the industry through its steering group, which has two representatives for each company. Thus, creating a project group with the right conditions for balancing interests among the competing companies to ensure a good solution for the industry. Some of the interviewees stated there had been other big data projects, but all stranded, which they said might be because of its lack of anchoring in salmon companies who are the end-users of such projects. Having a neutral project management team is arguably favorable because AquaCloud represents a digital transformation if it succeeds, and then the development should be balanced in a way, where the result is fair and doesn't distort the competition among companies. The conceptualization from this workshop is supported by Ganesan (1994), which clarifies that trust consists of credibility and benevolence in each other, and by starting in an environment such as this workshop, where actors know each other, on has a fertile starting point for inter-organizational collaboration. Furthermore, Abrams et al. (2003) argues interpersonal trust can be nurtured by sharing a vision and being transparent and clear in the communication, which is important because trust is an important driver for inter-organizational collaboration because it reduces the transaction costs and allows greater flexibility to changing circumstances (Gibbs, 2003).

Herd behavior and benefits of starting with large industry actors

AquaCloud has received good responses from actors such as the European Marine Board, acknowledging AquaCloud as an example on the track to transform the industry successfully. And as some informants stated, other digital ecosystems in the seafood industry might have stranded because of a lack of anchoring in the industry. In a way, this highlights the importance of AquaCloud starting with the largest salmon producers as it puts it on their agenda. Furthermore, by having the largest actors involved, one gets the signaling effect and herd behavior, where other companies more likely to join because the largest actors are doing it (Baddeley, 2010). Xu et al. (2012) further adds that technology is more likely to be adopted if competitors and business partners do. As a result, this herd behavior helps to attract external contributors, which could strengthen the emergence, establishment in the industry, and overall ecosystem growth.

5.2 The Role of Trust, Data Standardization and Data Security

Trust in the project team during a stage with experimentation

Wathne states they knew the data were terrible from the beginning, but they wanted to see how the AI could interpret it to understand the potential better. Looking back at the workshop, which sparked enthusiasm and kick-started the AquaCloud project, all interviewees pinpoint the value and sensitivity of their data for predictions. Having the numbers on feeding routines, size and number of the fish, sea lice outbreaks, and more, are sensitive to share with competitors and highly sensitive for companies on the stock market as these numbers can be linked to economic performance. Therefore, while there is enthusiasm for the AquaCloud project, data security becomes essential, and it is not easy to establish a complete framework in an early and experimental stage. This means the salmon companies have to trust the project team and IBM, which analyzes the sensitive information. Multiple project managers pinpoint that, for the first stage, AquaCloud 1.0, data were not only received in different formats, but it was also secured in a way where companies even struggled to get their data out. Overall, this is seen as beneficial because it ensures sensitive information and maintains trust in a project which is still experimental. Van den Dam (2017) highlights this importance, as breaches and data leakages cause the involved parties to lose trust in the system, which could result in a momentum impossible to regain. Schreieck et al. (2017) adds to this importance as trust, and good relations are fundamental for projects relying on inter-organizational contributions, where the withdrawal from one key actor is likely to reduce chances of establishing an industry-wide solution. Lastly, by having a safe foundation, it also becomes the foundation of growing a spiral of trust between the project group, which can help to sustain the culture of shared decision-making and through that, foster a better industry solution (Manring, 2007; Taillard et al., 2016). Overall, trust is seen as fundamental in the starting phase because there are many interests to please and business-sensitive information being processed. However, the big problem with trust in humans and strict data measurements is that they are not scalable and hard to build good solutions around, as discussed in the next paragraphs.

Benefits and challenges with standardization

Throughout all interviews conducted and all secondary data collected, data standardization is a focal point mentioned again and again for many reasons. Kathenes and Finnøy both highlight three significant benefits. First, ensuring sensors report data to the central hub in a similar format, which will enable better insights and good enough results for data-driven decision-making. Second, ensuring flexibility in technology providers, such as all sensor suppliers, would be interchangeable because they function within the standard. Third, having a standardized data integration makes it easy for startups to understand how they need to build their software in order to have something that's not only applicable to one salmon company but an entire industry using the same standards. This means standardization may also play a key role in facilitating further innovation as companies can understand what's necessary for market access into a domain filled with strict regulations. Morland in the sensor startup SeaSmart, echos this, not only because it becomes easy to understand how to develop their products for integration, but also because it would let them find new partnerships within the standard when thinking about new data-driven services. Overall, these three benefits make standardization a precondition for digital ecosystems to be functional, vibrant, and active. Because it lets the involved parties develop the planned services, which is the prediction of sea lice outbreak in the first round, and establish a system that quickly grows with new inter-organizational relations, thereby making the ecosystem highly scalable. The theory recognizes the value of standardization, Gal and Rubinfeld (2019), finding that ensuring more and better data improves the predictions and algorithms that can be made. Friedrich (2011); Lee (2001) adding that standardization means establishing trust in that everyone competes on the same terms in a regulated ecosystem.

From this, we can conclude that standardization enables the development of data-driven decision-making tools and creates a foundation for high growth scaling. But establishing standards is difficult, as Figure 3.2 shows there is a vast amount of different technologies coming together, and creating the final standard is hard when one doesn't know what it should include. Therefore, having a standard from the beginning is practically impossible for ecosystems starting on scratch. As the AquaCloud team experiments and gains an understanding of the complexity of all heterogeneous and complementary technologies coming together, they understand more of what needs to be included in the standard. Then by establishing a standard one creates a focal point for all actors to gather around. However, changing business environments is something the AquaCloud team is concerned about because with the speed technology is developing, the standards have to be updated for changing environments at some point. The team is already thinking about this, where making AquaCloud into its independent non-profit entity is one solution because it would give the industry a contact point and an organization which doesn't focus on maximizing the margins from involved parties, but instead concentrate on ensuring updated standards which can facilitate for the development of new data-driven tools. This approach is supported by Ruokolainen et al. (2011), which finds that the governance structure should be flexible enough to let contributors enter and exit as business environments change. Viljainen and Kauppinen (2011) adds to this notion as the AquaCloud team could then scout for fitting technology and efficiently orchestrate its value into the digital ecosystem for increased value creation. The downside to standardization is naturally the problem of locking the industry into a structure, but as Farrell and Saloner (1985) sees Farrell and Saloner (1985), the problem rather becomes inertia to overcome by further developing the standard. In total, data standardization provides immense value and is critical if the digital ecosystem is to transition into a flexible growth stage. If the team manages to establish AquaCloud in Norway, it will provide a good foundation for their ambitions of developing an ISO-standard and scaling internationally.

Data security

Throughout the AquaCloud case, it is apparent that the data is sensitive and highly valuable to salmon farmers, the stock market, and the software companies developing services based on the data. Thus, making it an intricate relation to balance in terms of security and accessibility. As the technology map in Section 3.2 shows, even this simplified figure involved a vast number of technologies to create AquaCloud, and beyond this is the industry infrastructure that must be secure. A vast ecosystem of many digital components, where every component is a potential threat, says Finnøy as one compromised component in the system can give leakages, or one could have an illegal partner in the ecosystem tapping sensitive data from the system. It is an intricate relation, and the AquaCloud team agrees that the data has to be shareable, but at different levels for different purposes, and that each company needs to choose how much to share. Similarly to standardization, this is critical, but challenging to establish completely before one knows what to protect, to what degree, and how. Thus, data security has to evolve throughout an experimental stage if one starts on scratch as the AquaCloud team and is essential to establish if the digital ecosystem is to enter a more commercial stage. For its crucial function and complexity, the AquaCloud team has involved external specialists in creating functioning governance, which is flexible change as the business environment changes. Overall, the data represents a massive opportunity for AquaCloud. As Badr et al. (2010) echoes, it is also a significant risk because the data owners are sharing large amounts of data into a system with many devices. A risk which Tan et al. (2014) argues will increase with scaling digital ecosystems, because cyberattacks can be redirected towards all vulnerable services in a network at the same time. There are many ways of protecting data. Izquierdo et al. (2007) suggests each component in the system should be able to encrypt information, and how AquaCloud's security measures finally become is still a work-in-progress. However, in theory, the team has a balanced approach to develop reliable and functioning data security, as Bertino (2016) suggests users should be able to express their preferences when sharing information into a larger system. Something Izquierdo et al. (2007) sees as difficult to protect because security measurements have to be developed for a large number of heterogeneous technologies. Fachrunnisa and Hussain (2011) states it also has to be monitored by a trusted third party agent. On this notion, the AquaCloud team seems inclined to establish its own entity for updating the standard, and likely the same organization would ensure that security protocols are developed according to the business environment. Considering its crucial role and complexity, data security becomes a precondition for establishing a digital ecosystem and something that has to be established before entering a commercial stage.

The relation between trust, data standardization and data security

Overall, this makes an interesting pattern for handling information carefully. In the experimental stage, there are few systems to rely on, which makes trust among the diverse team key to letting data flow into IBM Watson's software for experimentation with the data. As the ecosystem establishes data standardization and security for a commercial stage, stakeholder's interests are protected by a system. This relation is what McKnight and Chervany (2001) sees as a shift in trust, where trustworthy human interaction is moved to specific technologies. A shift which is vital to growing a digital ecosystem, because high growth implies external companies who might not know the core team should be able to connect with AquaCloud as a contributor or customer. A case where the external party should recognize its value and trust the standards and security protocols to protect their sensitive information, this relation is further discussed in the next section.

5.3 Life Cycles: From Trust in Humans to Systems

As Peltoniemi (2006) states, ecosystems emerge bottom-up, which fits well with AquaCloud as there is a clear emerging phase characterized by a small and diverse group experimenting with data to predict sea lice outbreaks. This is natural, as Gawer and Cusumano (2014) states because when trying to create a complex value proposition without being able to design everything by foresight, one has to experiment.

When looking back at Carraher et al. (2003) five stages of ecosystem development; existence, survival, success, renewal, and decline. The first stage fits well into the theory for existence, as the team has central decision-making and informal structure with a lot of trust in human interactions. As the team experiments to find a functioning structure, it fits well with the survival stage. Because the team is focused on formalizing structure through data standardization and security, which then the current and future stakeholders can trust their sensitive information with, this is fundamental to building the distinctive competencies AquaCloud is envisioning and thereby fits well with this ecosystem theory. What became apparent in the analysis is the importance of changing business environments. Initially, Norway is seen as a favorable starting point because the environment is stable and predictable to develop AquaCloud in. However, it becomes apparent when multiple informants highlight the importance of having an organization, which can be a focal point, and both keep the standards and security up to date. Because while Norwegian regulations might be evolving relatively predictable, the increasing digital transformation is evolving rapidly, and AquaCloud has to adjust accordingly if it is to stay relevant. Establishing an independent entity for AquaCloud isn't in focus right now, but it is being discussed in the steering group as a crucial element to establish. This fits well into Carraher et al. (2003) theory for the stage Success, which is described as a focus on protecting its market share rather than targeting new territory similar to the effect of having an AquaCloud entity that keeps the system up to date.

In summary, trust, data standardization, data security, and an entity that adjusts AquaCloud to changing business environments are all preconditions for a thriving digital ecosystem. Furthermore, AquaCloud shows these conditions has to be developed sequentially. First, the data standards and security protocols are impossible to design without understanding what goes into it, and thereby the ecosystem starts with trustworthy actors experimenting together towards a well functioning design. Second, as the analysis shows, trust in humans can become less important if trustworthy data standards and security protocols fulfill the minimum criteria current and future stakeholders have for sensitive information. Furthermore, having this established, the digital ecosystem is prepared for scaling as actors can quickly enter and exit. Third, we see that the team involves multiple specialists to ensure the ecosystem is developed to fit the business environment, but they are also planning on how to keep AquaCloud updated where an independent entity is a possible solution. Everything fits well into Carraher et al. (2003) first three stages, and by that we can expand the theoretical framework into a new conceptual model, Figure 5.1

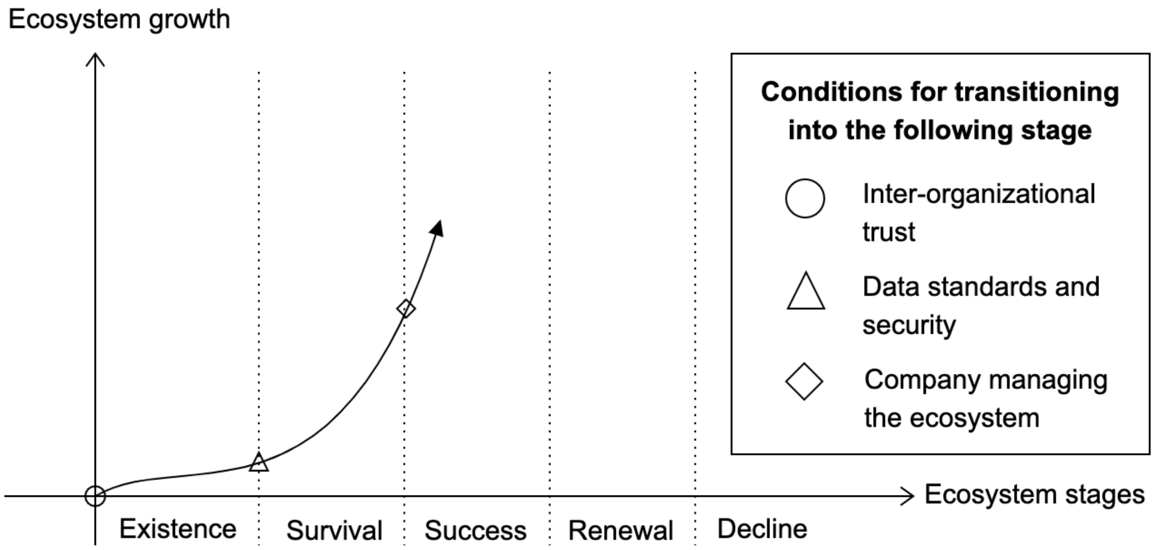

Figure 5.1: Conceptual Framework

6 Concluding Remarks

6.1 Conclusion

This thesis aims to provide insights into how digital ecosystems start and scale by studying AquaCloud, a case in the Norwegian seafood industry. AquaCloud leverages the perfect storm of AI, IoT-devices, and 5G to create a complex value proposition. However, as findings show, there had been several challenges necessary to overcome to design an ecosystem that lets independent actors and technologies collaborate towards a common goal. As the seafood industry is being digitally transformed, AquaCloud enriches our understanding of how digital ecosystems start and scale. Then to answer the research question, the underlying sub research questions are first elaborated before returning to the main one.

Sub-research question 1:

How are interests balanced in an inter-organizational collaboration?

Digital ecosystems being developed in an inter-organizational collaboration of competitors, rises many potential conflicts. Key to AquaCloud's harmony is the overall project management, which is neutral through the cluster NCE Seafood Innovation. Chairman of NCE Seafood Innovation, who has been the overall project manager, balances their interests in the process by having control, while simultaneously taking the directions laid out by the steering group in consensus. The steering group consists of large competeting salmon farmers, where they share an equal amount of representatives for a more balanced influence. Furthermore, the AquaCloud team mapped the importance of other stakeholders and found solid anchoring in the industry actors were the crucial ones. Thus, continuing the development in a relatively small group helps maintain close relations and a flexible structure for experimentation.

Sub-research question 2:

How do we assure data sharing in the early stages of digital ecosystems?

Developing a digital ecosystem from scratch where it is impossible to design a complete structure in foresight, one has to experiment towards a configuration. For this, inter-organizational trust is found to be a precondition for the emerging stage because no final ecosystem design established, and the actors have too some degree open up to let experimental learning occur. Data standardization is fundamental. It enables connectivity between heterogeneous and complementary technologies, as well as ensures all components send data in the same format, which lets the system function together towards the joint value proposition. Furthermore, data security is another essential component to digital ecosystems like AquaCloud as sensitive information is being transferred. Then, by having established both standards and security, existing and new actors don't necessarily need to have complete trust in the persons developing the ecosystem, because the system regulates entry and exit while protecting interests. Factors that enable not only good conditions to conduct sea lice predictions, but also enables other companies to relatively easily develop other tools on AquaCloud's infrastructure and data sets because the system gives clarity and development speed is not slowed down by human interactions. Thus, resulting in a shift from trust in humans to systems which is fundamental to enable scalability.

Overall, trust is found to be a precondition to emerging digital ecosystems, whereas data standardization and data security are preconditions transition into a more operational survival stage. Furthermore, findings suggest that changing business environments requires an organization to adjust the standards and security accordingly, which then results in a precondition for long-term sustainability in the success stage. Notably, is the order these preconditions must be established, which is further discussed in the main research question.

Research question :

What are the preconditions start and scale digital ecosystems, and how do they drive the development?

For the emerging stage, inter-organizational trust is found as a precondition because experimentation with sensitive data and various approaches is necessary to find an adequate ecosystem design. To transition into the survival stage where a digital ecosystem tries to find its market position, standardization, and data security is found to be a precondition because it lets heterogeneous and complementary technologies connect and disconnect in the ecosystem while securing sensitive data. Enabling both the planned analytics for sea lice prediction but also creating an infrastructure, which new tools can be built on top of for even greater ecosystem growth. Furthermore, as time evolves and business environments change, findings suggest a central organization must be established for long-term sustainability because the standards and security must be developed accordingly. Put together, these are substantial barriers to overcome, but as seen in the case of AquaCloud, the incentives to succeed far outweigh the cost because it might help to solve one of the industry's largest problems and create an ecosystem that fosters even more open innovation. Lastly, as AquaCloud started with the largest salmon producers, it creates a signaling effect that drives a herd behavior, attracting external contributors throughout the stages, which helps to overcome barriers.

In conclusion, this gives a set of preconditions that must be established at certain stages if the digital ecosystem is to continue thriving. Following Figure 6.1 shows these preconditions with their associated life cycle stage.

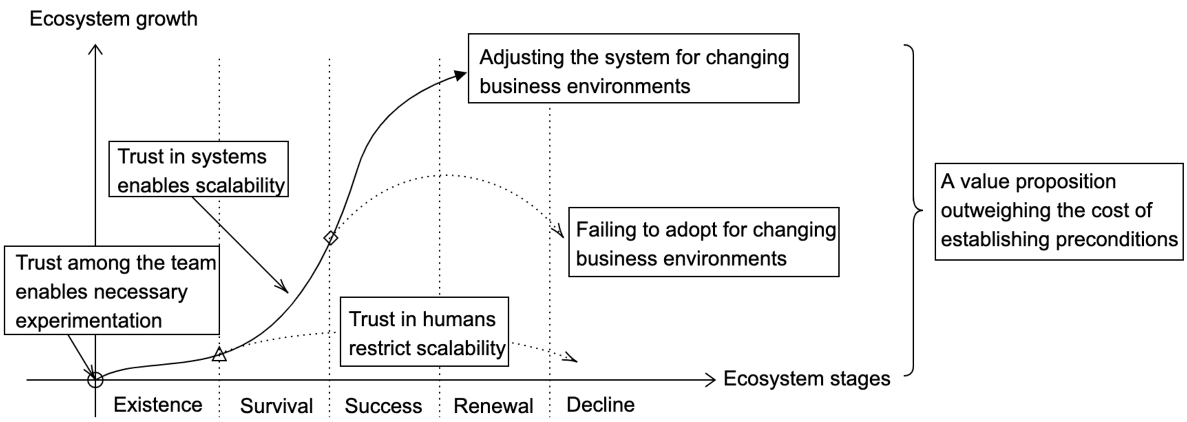

Figure 6.1: Preconditions for Transitioning Between Life Cycle Stages

6.2 Implications

The literature on digital ecosystems is limited and these findings provides academics with structured insight into the life cycle of a digital ecosystem, and what preconditions that must be established in order to start and later transition into a commercial stage.

For practitioners, four implications stand out. First, for those interested in digital transformation, the strategy of building a digital ecosystem is interesting to consider given the right circumstances. Digital ecosystems are found to be complicated start and scale due to the preconditions, but when considering the upside, it might be the better choice or, in some cases like AquaCloud a necessity. When the goal is to facilitate digitalization and open innovation for a whole ecosystem, then digital ecosystems provide a magnificent structure, and for cases where one has to experiment in a dynamic setting with inter-organizational collaborations toward a common goal, then the flexibility from a digital ecosystem is likely a necessity. As seen in this case, the AquaCloud team aims first to predict sea lice outbreaks, and they need a dynamic structure to find the right model. Furthermore, when succeeding, AquaCloud can quickly become something much greater because it provides developers with infrastructure to build tools to a broad ecosystem audience, and more easily integrate solutions with companies who are already in the ecosystem.

Second, practitioners should consider gathering large and established industry players in the beginning. As it helps to establish the ecosystem in the market as a larger portion is involved, and from the signaling effect, one drives herd behavior. Resulting in higher attractiveness to attract external companies which might represent necessary capabilities in the emerging stage, and later boost growth as actors chose this ecosystem over a competing one.

Third, for practitioners who are developing digital ecosystems, the study provides structured insights into preconditions that must be considered. When starting, the governance must be flexible to allow experimentation, which is necessary to design an adequate design for standardization and data security. However, practitioners might be able to speed this process by finding replicable designs which can be adjusted for the specific context. On the notion of governance, this study shows how potential conflicting interests can be balanced by having a neutral actor who serves a steering group with multiple stakeholders.

Fourth, to make digital ecosystems sustainable in the long run, findings suggest that the original governance structure for experimentation should be replaced by a more organized structure, which adjusts standards and data security according to changing business environments and ensures a functioning ecosystem.

6.3 Further Work

Considering the limitations, this study provides insight into the process of developing a digital ecosystem for value creation. However, it does not cover the process of creating a system that can capture value. Therefore, to get a better understanding of digital ecosystems, the first recommendation is to study further how value can be captured. Furthermore, as this single-case study focus on the earliest life cycles of a digital ecosystem, the next recommendations are to study both additional cases and examine the later life cycles to provide a more complete understanding.

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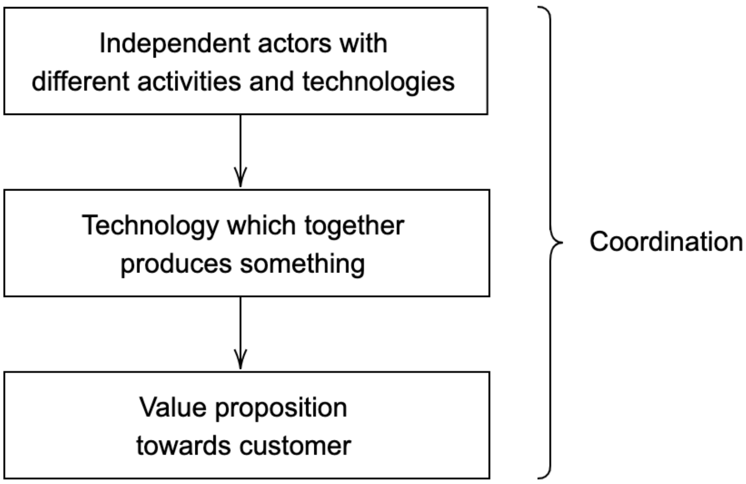
Appendix

A1 Interview Topics Attached to Email Invitations

Master thesis *(slightly adjusted for each interview)*

The purpose of this study is to understand how an ecosystem evolves and through that contribute to the understanding of digital ecosystems.

Theoretical model



Focus in this thesis is to study coordination and incentives between actors in the ecosystem AquaCloud during its emerging stage.

Themes for discussion

- How has it been to gather stakeholders in the beginning and along with the development?
- Why are you now focusing on data standardization and data security?
- Principles for development, a lot seems to be prepared for internationalization
- Who is relevant for me to talk with afterward?

In general, I have some insight into these topics, and I would appreciate a discussion to get a better understanding and documentation for the master thesis.

A2 Semi-Structured Interview Guide

Interview guide *(adjusted for each interview)*

Framing the interview

- Small talk about mine and other's role, what do they associate with the term digital ecosystem etc.
- Information
  - Purpose of this master thesis
  - Clarify context between NCE Seafood hat and NHH hat for this thesis
  - Ok to record?

Confirmation about data previously gathered and read

- If I understand it correctly, Telenor and "Smart HavBruk" facilitate other projects like AquaCloud and AI LAB?
- Telenor has all the core technology for infrastructure? external actors?
- Besides infrastructure, do all required technology exist for digitalization or is there a missing sensor supply, etc.?

Experiences as warm-up and bridge

- How are your experiences with the "Smart Havbruk" initiative in Telenor?
  - How has the sale process been towards seafood companies?
  - What does seafood companies do today for digitalization? a lot by themselves?
  - How does AquaCloud fit into "Smart Havbruk"?
- What's your experience with AquaCloud?

Key questions around AquaCloud *(multiple on same topics to select the most fitting during the interview)*

- Roles and coordination

  - In a slide, the term "partner ecosystem" pops up, what roles do you see in AquaCloud?
  - How have all the actors been gathered?
  - How has it been to collaborate with other companies? contracts or loosely?
  - What do other companies say about collaborating with Telenor?
  - How does the coordination with NCE Seafood? what's good/bad?
  - How is the communication flow in the project?
  - How has it been for Telenor to enter the seafood industry, which is very closed?
  - Is there pressure from other infrastructure suppliers, or are you in a dialogue to provide an optimal and shared solution for the industry?
  - What do you think the project's largest challenge is with coordination?
- Incentives
  - In a slide, the term "partner ecosystem" pops up, what roles do you see in AquaCloud?
  - The investment cost seems to be small for CoastHub, is it larger for some firms?
  - What do companies say about the cost in the context of Telenor's infrastructure role in a greater perspective with a large value for digitalization?
  - What's Telenor's greatest value in terms of AquaCloud?
- Progress
  - Are you satisfied with the progress in AquaCloud?
  - Are you satisfied with the direction the project is developing?
  - What are the biggest risks you see in this project?
  - What's Telenor's greatest challenges with the AquaCloud project?

Looking back

- Summarizing key findings - have I understood you correctly?
- Is there something you would like to add?
- To understand AquaCloud better, who do you think it is smart for me to talk with?