What are the key barriers for increased automation in the seafood industry?

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What are the key barriers for increased automation in the seafood industry?

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Abstract

This thesis aims to examine and explain the key barriers to increased use of automation in the Norwegian seafood industry. Increased use of automation is empowering technologies in the seafood industry where the ambition is to expand product quality, enhance working environment, improve hygiene criterions, bring down production cost and reduce food waste. Even though automation augments opportunities to increase productivity, efficiency and quality, the degree of automation is still low in the seafood industry. The seafood industry uses some technologies for its advantages, but there is still potential for more.

To understand these technologies better it is essential to see how firms wants to innovate and plan to tackle difficulties to come. There are different barriers preventing firms to fully commit to enhance the implementation of automation in their daily business activities.

The analysis is based on a dataset focusing on firms in the seafood industry. By using a logit regression model to investigate the barriers; lack of internal funds, lack of external funds, lack of qualified personnel, difficulties to get public support, lack of external partners, uncertain demand for innovation ideas and too high competition at the market. Furthermore, its influence on four different innovation outcomes. Which is total product innovation, radical product innovation, total process innovation, and radical process innovation.

The empirical literature identifies the most common barriers as; high costs, lack of financial resources, lack of qualified personnel and the ability for a firm to adapt to new technologies as these are major obstacles preventing firms to innovate.

The overall result show that there are not any key barriers preventing firms in the Norwegian seafood industry to innovate. None of the barriers shows a significant value with a decreased likelihood of innovating.

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1 Introduction

1.1 Background to the Research

Approximately one-third of the food produced for human consumption throughout the world gets lost or wasted, about 1.3 billion tons. (FAO, 2018) Too much raw materials are wasted, and we can recognize this huge problem in Norway. Food waste was calculated to at least 355 000 tons in 2015, which denoted an economic loss of more than NOK 20 billion per year. (Hanssen & Stensgård, 2016) Food waste is defined as the food that could have been eaten by humans but did not turn into human food. (EU Fusions, 2016)

Not only based on all these numbers but on our own experience and knowledge, we should recognize that there is a need for a change in order to reduce the growth of increased food waste. The Norwegian Government has united with the food industry and together, they have agreed to cut food waste in Norway by 50% by 2030. (Government, 2017)
To face this challenge, firms need to be adaptable to new ways of thinking. With the purpose of reducing food waste, firms need to incentivize innovation and creativity, especially in production and supply chains where it is more frequently with a higher degree of food losses. Most of the food wasted happen at each stage of the supply chain and in the processing process, not all come from the consumer level. (FAO, 2011)

The degree of automation is low, especially in Norway. (Teknologirådet, 2014) Within manufacturing processing industries, there is a big need and great potential for increased application of automation. By adding more robotics to daily process activities, it will add opportunities and benefits to supplement a more proficient performance rate than could have been achieved with only regular human labor activities. Automation augments opportunities to increase productivity and quality. (IrisGroup, 2015)

1.2 Problem Identification and Research Objectives

This thesis intends to investigate and recognize key barriers for increased automation in the seafood industry. By using a quantitative research approach, the objective is to discover and interpret the barriers when implementing automation by studying and establishing a relationship between the variables.

1.2.1 The Research Question

This thesis will study the following research question:

What are the key barriers for increased automation in the seafood industry?

The barriers variables investigated for this thesis are based on technical, operational and organizational barriers. With the main focus on lack of internal and external resources, difficulties to attain qualified personnel, lack of external partners, uncertain demands for innovative ideas and too high competition at the firm's market. These barriers were studied and discussed by using questionnaire survey, regression analysis and supplemented with appropriate literature findings.

1.2.2 The Objectives of the Research

The purpose of this thesis is to show awareness of elements of automation as relevant to the seafood industry and how implementing automation in daily activities can boost the productivity of firms in sense of increasing efficiency, reducing production cost and providing higher quality products. Additionally, exploring potential barriers suggested in order to investigate and interpret how these factors hinder firms to implement automation and innovation and its advantages.

1.3 Research Design

This section gives an overview of how I will elaborate on the research question. The overall plan is to use measurements such as questionnaire survey, empirical literature, and statistical analysis in order to address the research question in the best possible way.

1.3.1 Literature Review

The Information and knowledge acquired on automation, innovation and technological developments are primarily gathered by reviewing academic and industry literature, and online search within the research area. The purpose is to establish a broad understanding of knowledge concerning the use of automation in the seafood industry. In addition, the literature review aid in developing the research question, its goal, and purpose, and its methodology by selecting appropriate research tools to enhance the quality of data collection and analysis. Furthermore, for the literature review to be reliable, it is based on several former types of researches, delivering general outline on automation, innovation, and barriers to overcome in the seafood industry.

1.3.2 Data Collection Methods

This thesis uses primary data as a foundation of the research but is supplemented with secondary terms in form of online research to provide extra knowledge within the research area. The primary data consist of a questionnaire survey used to gain valuable intelligence on the industry with special focus on firms' barriers toward innovation and automation.
The dataset used was not obtained specifically for this thesis. It was retrieved for another purpose, by other researchers. For this thesis, only parts of the data set were used.

1.3.3 Data Analysis

This thesis uses regression analysis with the purpose of establishing and examining the relationship between the dependent and independent variables. Focusing on four different models representing four different dependent variables; total product innovation, radical product innovation, total process innovation, and radical process innovation.
By integrating the data into Stata, I will interpret the result and its relationship and evaluate the result collected in order to develop reasonable conclusions and recommendations for further research.

1.4 Outline of Thesis and Structure of Chapters

Chapter 2 provide the background of the concepts used in this thesis in order to stipulate awareness through the research. Further, an overview of the seafood industry in Norway with the main focus on the four different industries this thesis is based upon; fishing, fish farming, fish processing and suppliers.

Chapter 3 aims to provide a literature review on the principles of the research question in this thesis. By using existing literature, we get a clear overview regarding automation in Norway with a specific interest in the seafood industry, and the barriers when innovating and particular when implementing automation in daily performance activities.

Chapter 4 provides an overview of the research design and methodology of this research. I aim to outline the data collection methods, variables, and explain the regression analysis used in order to investigate the research question.

Chapter 5 contains discussions on the result from the regression analysis. Specifically, indications on each of the regressions models and its outcome with the main focus on what variables affect the dependent variable.

Lastly, in chapter 6, the conclusion is presented together with limitation and recommendations.

2 Background

This chapter explores suitable academic and industry literature concerning innovation, automation and robotics technology in order to achieve a better understanding of the different concepts. Further, this chapter aims to provide an overview of the seafood industry in Norway, with the main focus on providing a theoretical foundation of the four industries represented in this thesis.

2.1 Innovation

Innovation is all about making a change. Joe Tidd and John Bessant (2014) define innovation as “the process of creating value from ideas”. By all means, the variations in the novelty of the changes being introduced are spread. From minor incremental improvements through radical enhancement that change the way, we increment them.
The tiniest change or the biggest improvement on the market have one thing in common. It is all about making a change in order to create value which others can find useful and profitable. This is one of the reasons why we innovate. The change is unpredictable making the future unclear. In order to face the change or make a change, we need to innovate to stay equated.

Technologies keep advancing, consumers’ preferences keep enhancing, competitors are stronger than ever, and markets are not stable. The change is rapidly growing and to be able to stay ahead of these changes, there is a need for an innovative solution to stay up to date. Firms’ needs to take innovation actions to be best prepared for the changes and gain long-term benefits. Innovation is all about meeting consumers’ demands. It is crucial for firms to make sure they are picking up on these trends.

According to Oslo Manual 3rd edition (2005), an innovation is the “implementation of a new or significantly improved product, or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations.”
As seen in the manual, innovation is affiliated to the market through implementation, which can be described as the process of putting a decision or plan into effect. Likewise, it is stated that "a common feature of an innovation is that it must have been implemented." It also mentions that "a new or improved product is implemented when it is introduced on the

market.” Based on these descriptions, we cannot call it an innovation until a new or improved product or process is put into practice on the market.

In the Oxford Handbook of Innovation (2005), the authors point out how innovation has existed for decades, where essentially humans started to believe in new and more efficient ways of doing things and carry them out in practice. The world would not look the same without any innovation. One of the finest advancements in firms is innovation, as it allows firms to be competitive and to succeed in the business world.

Pursuant to Joseph Schumpeter (2005), innovations are arranged into five different types: new products, new methods of production, new sources of supply, the exploitation of new markets and new ways to organize a business. Schumpeter defined innovation by naming these five different types as "new combinations" of existing resources. Later on, the main focus began particularly on the first two types; new products and new methods of production. Which later were classified as "product innovation" and "process innovation."
OECD (2002) define product innovation as carrying out new or improved product to provide enhanced service to the consumer. Accordingly, process innovation focuses on the adoption of new delivery methods.

With rising demand, innovation is the main idea of maintaining the productivity growth. Innovation also aids the food systems that merge sustainable good production, distribution, utilization and waste management. Innovation is the key to technology adoption. Those who innovate tend to have a greater productivity and income rate. It is a leading factor behind competitive advantages and making a difference between firms when it comes to performance. Empirical studies show how firms do not innovate under closed doors but rely on considerable influence from external sources and its environment. By adopting open innovations strategies and external sources, firms tend to not only improve their innovations activities but also stay attractive at the market, as firms are able to embrace new ways of thinking. There are greater opportunities by working in collaboration and proximity with each other. The role of networking and openness to external sources are becoming increasingly important as firms face the emergence of rapidly growing technology advancement.
Powell et al (1996) discovered how essential network relationships are in order to stay attractive in a fast-paced industry. There is a higher chance of innovation to happen when firms can draw knowledge and information from a diverse pool of resources and experiences.

Baldwin and von Hippel (2015) identified the advantages by interacting with the environment. Trusting external sources to bring perfection to a product or process. Further, Henry Chesbrough (2003) points out how firms should combine their internal ideas with external sources in order to advance their own technological capability.

2.2 Automation

The International Society of Automation (2018) defines automation as the utilization of technology to observe and influence the manufacturing and distribution of products and services.

The Oxford English Dictionary (2018) illustrates automation as "the action or process of introducing automatic equipment or devices into a manufacturing or other process or facility." In other words, building a system or a device more adaptable and compliance for an automatic process.

According to Encyclopaedia Britannica (2018), automation is the use of machines and technologies to perform demanding tasks that have previously been attained by humans or even been impossible. In their opinion, automation has helped to modernize all areas where it has been applied. In general, the integration of machines and robotics into manufacturing process denotes a more self-governing system with increased use of software and digitalization. By adding automation into the daily process, it would change the way of how the system will operate with less human intervention. It will increase efficiency, and instead of human interaction, it will now be programmed with computer commands to make sure of the right execution of the instruction.

Lately, the progress of new technology has rapidly grown and has become progressively dependent on computer-related technicalities. One of the reasons behind a more advanced and complex automated system, as they denote high-level of skill and performance that exceed the capabilities of humans to complete the same task. Utilizing hardware and software automation increases productivity, safety and profitability. Automation brings many advantages when incorporated properly, especially in the seafood industry were daily activities can easily be substituted with automatic computer demands. Automation reduces production cost as tasks can be performed automatically, it will improve quality and reliability, as tasks are performed repeatable and more precise. As the automation technology keeps maturing, other technologies have developed from it and grown their own identification and significance. Robotics is one of these examples as it represents computerized devices with humanlike input. (RobotWorx, 2018)

2.3 Digitalization

Digitalization can be defined as "the use of digital technologies and of data in order to create revenue, improve business and create a digital culture whereby digital information is at the core." (i-SCOOP, 2016) Transforming to a more digitalized firm means being more adjusted to new types of creativity and innovation. It opens up new paths of creating value-based opportunities and improvements within the business activities. Reducing cost and specifically the need for manual labor.

According to Gartner (2018), digitalization is "the use of digital technologies in order to change or convert something into a digital form." In other words, it is the process of transforming into a digital advanced business, by changing the operating procedures and creating better opportunities.

Digitalization is based on the idea of upgrading its business procedures, functions and methods with digital technologies by addressing higher rate of innovation activities and idea solving into daily activity processes. In the future, it will be beneficial for those who implement this “smart” approach, as it would add multiple benefits. Being able to handle the excessive pace of innovation today will not only give your firm a competitive advantage but also make the firm more likely to make profits out of these digitalized revenue methods. (CIO Whitepapers Review, 2018)

2.4 Robotics

"Robotics is the branch of technology that deals with the design, construction, operation, and application of robots.” (Oxford Dictionaries , 2018) Industries involving simple repetitive tasks and harsh environment are experiencing the increased use of robotics technologies. Some of the most common characteristics of robotics implicate artificial intelligence, which means being able to work and respond like humans, with the ability to think and learn.

(Techopedia, 2018) Characteristics that contribute robotics with human intelligence are the vision, touch, and the ability to sense temperature. (Encyclopaedia Britannica, 2018)

Robotics today is not the same as what we used to think of when we hear the word robotics. Traditionally, robotics represents a one-armed or two-armed machine that moves something. Today it is more complicated. Robotics can be a software, working as the brain of a robot. Applying a software program empower a robot to execute its assignments with higher frequency, accuracy and higher quality. Robotics can easily substitute humans. (RobotWorx, 2018)

For instance, the powered mechanical arm is a typical example of a robot filled with human intelligence. This robot arm can be programmed to carry out suitable tasks, such as cutting, sorting, loading and unloading parts to boost the performance rate. Further, a robot can be designed to execute fixed working activities that are applied regularly in every part of the seafood industry such as within fisheries, processing, fishing, and distribution. As time progresses, robots are becoming more and more reliable, accurate and repeatable to deliver higher quality products due to technological enhancements. Innovation such as new visions sensors makes them more flexible and safer, so they can work more efficiently parallel with people. (Teknologirådet, 2014)

In the 1940s, Isaac Asimov, a famous science fiction author was the first person to coin the term robotics. He investigated the fundamentals of robotics behavior as he concluded them in his work:

Asimov`s Three Laws of Robotics: (2018)

1. Robots must never harm human beings
2. Robots must follow instructions from humans without violating rule 1.
3. Robots must protect themselves without violating the other rules.

With the aim of following the technological enhancement, it is the firms who adjust their abilities to correspond to rapidly growing industry demands that will thrive in altering into the "future workforce." Applying control systems and information technologies in their daily activities to substitute human workforce, allows firms to follow the trend and grow as developing firm.

On the other hand, there are some concerns with implementing robotics. For instance, there are some limitations in making it less attractive for some industries to implement them as they do not fit in. The robots are not emotional, they do not have feelings like humans. This is a concern as they can never enhance its working result exterior of their programmed software design. This damper interference with people as they do not think for themselves. For instance, within the health sector, it is more difficult to use them as it is hard to program robots to interact with people. Hence, the seafood industry is an industry that can benefit from increased use of robotics as it can improve quality and reduce labor cost. (Soffar, 2016)

2.5 Seafood Industry in Norway

Seafood is any edible marine fish and shellfish. (Mirriam-Webster, 2018) In other words, it is anything living from the sea that humans eat. Consumers are replacing meat with fish as it is a healthier option, with a higher rate of proteins compared to meat. There is a global need for more protein filled food which seafood covers and some of the health benefits of fish are related to rich sources of omega 3. (Henchion, Hayes, Mullen, Fenelon, & Tiwari, 2017)

Norway is known for its seafood production around the world as the country is rated the world's second largest seafood exporter. In 2017, Norway distributed about 95% of the fish caught and produced at the value of 94.5 billion NOK, a rise of 3% from 2016. (Sjømatnasjonen, 2018) Over the years the seafood industry has been increasing and has become the second largest industry in Norway, after oil and gas industry. (FAO, 2011)

Norway is already ahead of other countries in developing new, proficient, and environmental seafood production. With higher demand from consumers, it is becoming more important for Norway to offer attractive products that can meet those demand. This involves endlessly altering of new ways of doing things suchlike how to transport the products, how to keep it fresh throughout the whole process, and always looking for improvements in order to offer best possible products at a minimal price. Consumers want the option of choosing from numerous product based on the price, quality and its origin. (FHL, 2013)

2.5.1 Traditional Fishing

The fishing industry has been important to Norway for more than 1000 years and has proved themselves to be a leader of fishing technology. (Norwegian Seafood Council, 2018)
With the different oceans surrounding Norway, it governors some of the richest fishing grounds, making the fishing industry an important distributor. Some of the most common fish species for Norway are cod, herring, capelin and mackerel, also known as white fish. (Eurofish, 2016) These species were exported with a total value of 13.8 billion NOK in 2016, and approximately 90% of the fish produced get exported out. (SjømatNorge, 2016)

In the last few years, the traditional fishing industry has experienced different changes, due to new technological enhancements, new equipment, restructuring, and quotas. All of these influences have had a positive correlation on the industry as the production has increased, as well as the number of job vacancies has substantially deflated. (NAV, 2015)
SINTEF (2013) sees possibilities for automation as it would be more beneficial for products, workers and firms in the fishing industry. SINTEF view automation onboard as very influential in terms of creating a better environment for the workers onboard. New machines can remove heavy workloads for the fishermen's, providing better health and safety, create more workspace, condense the duration from catch to processing and most important, boost productivity.

2.5.2 Aquaculture

Aquaculture refers to the farming of fish under controlled circumstances. The beginning of aquaculture in Norway dates back to the 70`s and have ever since been an industry in development. (FAO, 2018) Approximately 80% of the industry consist of farming of salmon. A typical Norwegian salmon farm holds up to 200,000 salmon in deep nets. (Lybæk, 2016)

Norway is known for its rich ocean resources that have created a firm base for local communities along the entire Norwegian coast. The aquaculture industry is considered one of the most important industries in Norway, with its remarkable export opportunities throughout more than 150 countries. The industry will continue to have a tremendous effect on Norway as it continues to provide not only quality products but also boost the working opportunities in the country. Each job in the aquaculture produces 2 jobs in another industry, which is good for the economy. (Aquaculture In Norway, 2011) The Norwegian expertise is becoming increasingly appreciated as Norway continues to further develop in the future. More advanced technologies and substantial expenditure in R&D have resulted in a lot of new innovations and made it feasible to produce food in proximity to the coast and in the open ocean. (NOAA, 2018)

On the other side, as a forerunner and an innovator, the aquaculture is also considered to be one of the most substantial responses to the problem the world is facing today: to substantially produce healthy food selections for an emerging population. Looking in the future, entering new markets or developing new products are not solely what will make Norway attractive as the forefront of innovation and development. Norway needs to discover new ways of thinking, in order to keep cultivating the sea in an environmental and resourceful way. With this in mind, Norwegians fish farms are dependent on increased advancement within the biological and technological development. (Norwegian Seafood Federation , 2011)

2.5.3 Fish Processing

The fish processing industry consist of processing raw materials from both fisheries and farmed fish. Because of the high labor cost in Norway, most of the fish are exported out of the country to be processed in a low-cost country. As a result of this, Norway loses a lot of the value creation within this sector. (SINTEF, 2013)

Norway has experienced a strong decline in fish processing lately. According to SINTEF, (2013) this decline is a result of a highly labor-intensive processing industry. There is a need for automated processing equipment as there is room for improvements. Statistics show only 10-25% processed products are being exported out of the country. The majority of fish is exported without being processed. With the right skills and development, there is a great opportunity to improve the fish processing capacity.

Recently, the processing of fish has been emerged from the labor-based work environment to now more machines, filled with automation and new technological solutions. Even though this industry sector is still reliant on manual labor, suchlike feeding of specific purpose machines manually, inspections and controlling the procedures, it is on a rise again as automation can make the daily activities more efficient, providing a better quality of the product and boost the export level. This rapidly growing enhancement within automation can carry Norway to a higher stage of export of processed fish. There are countless opportunities for the future as most of today's product shipped out are put through minimal processing. (Addy, 2013)

Buljo and Gjerstad (2013) considered some of the reasons behind the slow response regarding the exploitation of new automatic solutions within this industry sector. Firstly, they discover low-profit margin and the majority of processing firms facing lack of skills as most of the employees had little or no technical skills. Another problem faced resulting in low automation involvement are that seafood product is more like "one of a kind." This means they are extremely changeable when it comes to size, structure, and the shape of each object. Making it really hard and time-consuming to develop appropriate systems and equipment's specific for each object. For instance, the industry is facing lack of gripping solutions that are flexible, suitable and specialized that can manage these non-rigid objects like prepared fish or whole fishes.

On the other hand, increasing automation in the fish processing industry can be beneficial in terms of reducing physical stress on the object and diminish the amount of food waste on each object. Within an automated procedure, the object is only grabbed once, as opposed to during manual process where the object can be touched numerous times throughout the different stages prior to being laid in a fixed position. By applying machine-driven equipment to the procedures, the physical stress on each object will be decreased, while preserving a higher quality of the finished product.

2.5.4 Suppliers

Firms within the supplier industry contribute to make other firms in other sectors more productive and beneficial as a result of distribution of higher quality products and advanced services. Suppliers offer technological solutions, construction, consulting, and service to help supplement a firm's performance. (Kvistad, 2017)

As the Norwegian fishing industry still has room for a lot of potential with its rich fishing grounds, suppliers can keep researching and create novelties specific for this industry and benefit them in terms of keep developing stronger equipment and solutions to improve the

industry. For instance, suppliers can offer new equipment for fishing trawlers and vessels which can improve fishers' productivity and performance.
Towards contributing to the aquaculture, suppliers can provide new technical solutions and service in terms of new software, high-tech cameras, underwater lights, higher quality cages and nets. (AKVA, 2015)

The company EY[1] (2017) classify three groups of suppliers; technical solution suppliers, biotechnology suppliers, and distributors.
The technical solutions suppliers are essential to the stages of the value chain. The biotechnology suppliers ensure that a variety of products are delivered including feed, vaccines, medicines and cleaner fish. This sector has faced continual progress recently, due to better volumes and higher demand for new sophisticated quality and resourceful products.
The distribution sector is also very important and complex. Sea transportation is necessary when transferring smolt from freshwater into fish farms, and in the distribution of harvestable fish to the processing plants. Additionally, there are traders and exporters that get the fish from the fish farmers and prepare it for customers.

2.6 Summary

Innovation has become widespread throughout the world. It affects many aspects of the economy, including the seafood industry. Innovation not only feeds the world at the same time it is trying to reduce food waste and provide quality, which is a huge challenge. Innovation is a big catalyst in fixing this challenge.

As a result of increased efficiency and minimized manual labor, automation is supplementing a greater value to firms and industry. With the help of automation and robotics, a firm will not only improve performance but also increase efficiency and quality of their service and product. It will keep enhancing the competitiveness of the industry, encouraging nearby firms to adjust their involvements in order to thrive into a more automated industry.

With rising demands from consumers, it is essential for the seafood industry to increase its use of automation in order to meet these demands and for the industry to stay attractive on a

[1] EY = Ernst & Young

global level. The seafood industry is one of the most important industry for Norway, with its remarkable export opportunities. In order to continue to have a tremendous effect on Norway, it needs to adjust to the rapidly growing technological trends and increase its implementation, so it will lift the industry to another level.

3 Literature Review

This chapter aims to provide a theoretical background on the concept of automation and its impact on the seafood industry in Norway. Further, the goal is to provide an overview of the barriers to innovation and the implementation of automation by reviewing academic and industry literature, former researches and online search within the research area.

3.1 Automation in Norway

Automation has had an enormous impact on the modern shift of the Norwegian market. The implementation of digital technologies is a necessity in today's market as it empowers the possibilities of firms to develop new and valuable business models. By implementing automation and new technologies, there is a greater chance of internal and external improvements. Robotics and digital technologies enable a firm to be more efficient, offer higher quality, diminish unit cost and stay more competitive. For instance, using new technologies in the processing or packaging process enables firms to reduce manual labor and stay competitive with low-cost countries. In other words, the reduction in labor cost lowers the percentage of total production cost. Indicating that there is no need to move the production process to a cheaper country as there is nothing to gain. It could be simpler to keep production and manufacturing in Norway despite being a high-cost country. (Teknologirådet, 2014)

In time to come, automation will proceed to provide superior business opportunities. All new improvements suchlike, new digital technologies, new software, and digitalization, can make a difference, as it opens up new ways of doing business. It increases the likelihood of developing novel and more intelligent solutions that add greater value to firms. It also modifies desired capabilities within manufacturing, as it will be a must too conquer employees with technological skills such as programming and monitoring new computers. (Teknologirådet, 2013)

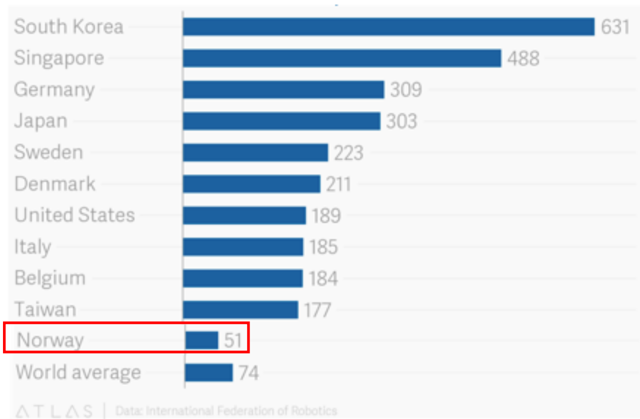

Figure 1: List of Countries with Most Industrial Robots per 10,000 Employees

Source: International Federation of Robotics (2018)

Based on Figure 1, we can see Norway is ranked 26th with 51 robots per 10,000 employees, that is below the global average of 74. We can also notice how Norway is drastically behind the other Nordic countries.

The Iris Group (2015) elaborated on explanations of the low density of industrial robots in Norway based on the structure of industries. In their view, a lot of the manufacturing industries are relatively small, compared globally. In terms of lack of interest and knowledge, Norway is falling behind when global manufacturers are developing new automated technologies solutions. With lack of knowledge, it will be more time-consuming and costly to implement automated technologies developed globally.

3.2 Automation in Seafood Industry

According to Buljo and Gjerstad (2013), increased use of automation and robotics are empowering technologies in the seafood industry when the ambition is to expand product quality, enhance working environment, improve hygiene criterions, bring down production cost and reduce food waste. In general, the industry represents a small portion compared to other industries and should expand this involvement even though it faces difficulties with the robotics involvement of fresh food and its cleanliness necessities.

Because of the advantages that come with automation and the use of robotics, it is becoming a necessity to ensure future success at the market. Seafood business is going up globally. In today's society, people want to eat seafood that is easily available and easily prepared for them at a good price. Some examples of automated solutions benefitting the industry are;

Marel, an Icelandic company collaborated with SINTEF and Norway Seafoods on the APRICOT[2] project. They realized how manual filleting of fish was very costly, time-consuming and three to seven percent of the best part of the fish being thrown away for no reason. To find a more efficient solution to this problem, they created an automated robot that can discover pin-bones in the fish with the help of x-ray technologies. By instantly and with higher accuracy, cut the bones away, ensuing in less waste than manually doing it. (Quick, 2014)

Nofima (2016) used imaging spectroscopy to speed up the processing of fish. This camera was established to inspect blood content and nematodes in fish fillets. By using this development, firms are able to see what lies underneath the skin of a fish. Implementing computer vision in daily activities enhance production as it is labor saving, increases performance rate and consistency. Most important, by using this technology, it is easier to defect detection as well as assessing the fish with no contact.

Another innovative solution benefitting the processing industry is the new automated processing line. This process begins with fish fillets entering a cooling tank before obtaining direct contact with the cooling surface. In this phase, the raw materials are cooled down to under 0°C without freezing the fish. The next phase consists of skinning the fillets, cutting the tail and separately freezing the fish. This whole process has advanced the industry, providing higher qualified products and extended storage longevity. (Green, 2013)

The seafood industry uses many technologies for its advantages, but there is still potential for more. To understand these technologies better, it is essential to see how the firms want to innovate and plans on tackling obstacles to come.

[2] Automated Pinbone Removal in Cod and Whitefish

3.3 Barriers to Implementation

This thesis examines the barriers when there is a rise in the need for automation in the seafood industry. In other words, enhanced use of digitalization and robotics technology to help advance production quality and reduce cost and food wasted in daily business activities.
We can define barriers as an internal or external factor that prevents or hinder something and makes it more difficult to carry out the desired result. It can consist of laws, rules, problems, human behaviors or other issues related to factors where barriers exist. (Merriam-Webster, 2018)

There are many different barriers preventing firms to fully commit to enhance the implementation of automation, specifically robotics in their daily business activities. SINTEF (2015) classifies barriers to technical, organizational and operational barriers. The technical barriers consist of equipment and system that hinders firms to innovate. Operational barriers focus on the performance and activities of the personnel, their ability to change and adapt new methods, while organizational barriers signify the hindrance of information exchange between employees. Occasionally, the main barrier to innovation is the way a firm operates, how they interact, controls, and make decisions.

3.3.1 Technical Barriers

Despite the enhancements within seafood automation within recent years, the industry is still facing a technical problem issue, as it is hard to copy the normal biological disparity in a product that humans add to the process. With all the different types of fish, size, and texture, it is necessary with adaptable strategies and flexible processing techniques for each specific item. For instance, this involves sensing systems with features for improved interaction with the fish such as grippers and cutting tools. As fish are quite delicate, there is a risk for each firm whether or not applying technology, as inappropriate handling can damage the fish. The unevenness in the dissection of each fish is one of the reasons why the preparation of the fish still continues the use of manual labor. (Government of Canada, 2014)

Another technical challenge to consider is the equipment longevity and suitability for food production environments. (Purnell, 2013) Usually, conventional robots are not convenient for the seafood industry. There are issues concerning high focus on hygiene as some of the robots are not intended to survive surroundings with high humidity or being washed with sterilizer. (Arnarson & Khodabandehloo, 1993) Additionally, it is very expensive to adopt robots, so they are capable to resist this high-pressure wash down, and condensation. A cost that firm needs to reflect before implementing automation. Finding the right equipment can be very difficult as they are scheduled to work in harsh environment.

As the trend of more advanced technologies keeps improving, it is becoming increasingly costly to keep up with the trend. There is a need for new software programs, higher skilled personnel, higher focus on R&D, upgraded equipment, and it all comes at a cost. A cost that can and will decide if a firm`s destiny in a positive and challenging way. It is improbable for all firms to engage in this technology-driven way filled with automation and robots' integration, as there is a lack of proper sources of finance. The high cost of innovation and lack of financial sources, both internal funds and access to external funds are typically seen as barriers that hinder firms to follow this trend. (IrisGroup, 2015)

Another issue concerning particularly the smaller firms rather than bigger firms is the proximity of processing operations. The firms in the seafood industry tend to be closer to the coast rather than bigger cities, which mean reduced access to obtainable resources. It is unusual for smaller firms to have access to an engineer in place who can instantaneously repair and maintenance of an automated machine. The scarce availability of easily accessible resources can affect how adaptable the automation and robotics for firms can be that are distant from the main processing centers. This can be a challenge for firms, as automation and robotics can be unavailable locally or hard to acquire.

The availability of automation and robotic technologies, in general, are very low in the seafood industry related to other industries such as automotive industries and electronics industries. Specifically, we can see how low the estimated annual supply of robotics is in the food sector compared to all other sectors worldwide. The food industry is already behind when it comes to implementing automation, indicating an even lower use of automation in the seafood industry. (IFR, 2017)

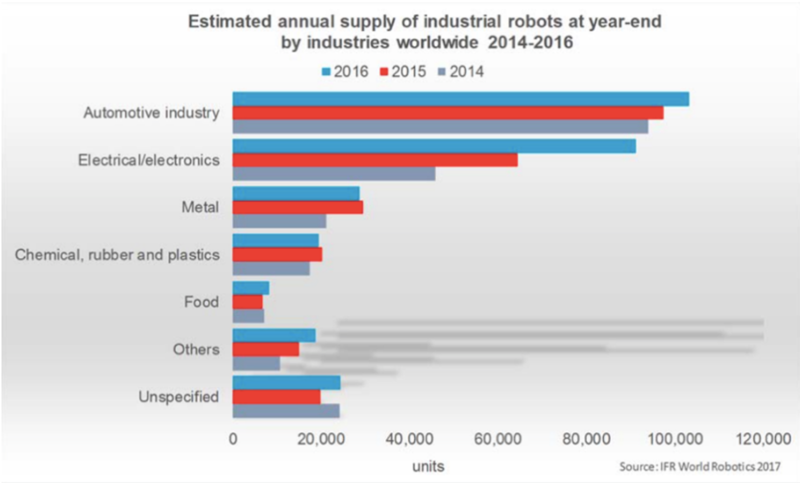

Figure 2: Estimated Annual Supply of Industrial Robots. *Source: (IFR, 2018)*

Because of the nature of the seafood industry work processes itself, it is more challenging to develop and create a robot specific for this industry. The unavailability for implementing robotics is seen as a hindrance for firms. As an option, firms can decide to acquire cheaper from other industries, but in order for the robotics and technology to work, the developed devices and equipment need to be robust, adaptable, movability and versatility so it will fit the harsh environment. (Caldwell, 2003)

3.3.2 Operational Barriers

When it comes to the operational barriers, one of the most common barriers is the human belief and behavior towards new technologies. Today, there are numerous firms that steer clear of incorporating innovation as they are frightened of change. Employees may be terrified of the technological advancements and the idea of changing something. By bringing in new technological equipment, employees with long routine experience, are not always passionate and excited about implementing innovation that modifies the fundamental of their daily activities. They are used to do everything in their own way, exactly how it has been year after year. They are not resistant to learning new things, it is more the concern of modifications, especially the changes that can be seen as a caution to the security of their jobs. (Pontius, 2017)

Calestous Juma (2016) argues in his book; Innovation and Its Enemies: “Why People Resist New Technologies” that society choices to stay away from new technologies when they take over our humanity. Further, Juma points out that resistance to new technologies is heightened when the public perceives that the benefits of new technologies will only accrue to the small section of society, while the risks are likely to be widespread. This is why technologies promoted by large corporations often face stiff opposition from the public. Similarly, new technologies face great opposition when the public perceives that the risks are likely to be felt in the short run and the benefits will only accrue in the long run.

EY (2018) points out increased operational risk as a challenge being faced as technology reliance increases. Operational innovation can make a significant distinction between a failure and success of a firm.

3.3.3 Organizational Barriers

Sileshi Talegeta (2014) points out different barriers when introducing or developing technological innovations, such as lack of skilled personnel, organizational culture, lack of technological and market information. These are all factors that damper increased use of automation. With all the new technologies and procedures, there is a higher necessity for in-house skills and a higher level of training. Not only does this come with a higher cost, it is also hard to find the right people with the right knowledge.

Many managers of SMEs[3] find it hard to recognize and access certain need for updated investments in automation technologies due to lack of ICT-skills. Some managers of smaller firms do not have the knowledge to keep up with the market and automated technology. It takes too much time and effort for small firms to find the right technological solutions that would work in harmony with its requirement. Imposing scare management resources as an obstacle for innovation activities. (IrisGroup, 2015)

As mentioned, the seafood industry today is still very reliant on manual labor. One of the reasons why increased use of automation is necessary and could be beneficial but faces some challenges when it comes to seasonality and the unpredictability of size and texture of the raw materials.

Quality and quantity of fish available vary throughout the season. Automation and robotics specific to each species process is very pricey and it is hard to adopt technologies for each process. Additionally, the high consumer demand for fresh food poses a concern for firms. The time it takes from the product is captured to it hit the shelves in the grocery store shrink

[3] Small Medium-sized Enterprises

the possibility of fresh produce.
Seasonality means that the working conditions differ along the year as some periods consist of operations at full capacity, while other periods operate at moderate capacity. Norwegians are in generally not satisfied with seasonality contract, as they cannot rely on these working conditions. With this in mind, it is hard to attract Norwegian workers as some areas/sectors cannot offer full-time job. Processing firms struggle to source factory-floor workers as these are only needed in certain number of months in harsh and physically demanding working environments. One of the reasons why there a rise in migrants working in the industry. This can be an obstacle as firms depend on migrants to satisfy consumers need. Implying the chance of language barriers, misunderstandings or refusal of firms to devote money to teaching these employees new skills so they can effortlessly adapt to different types of work. Finding labor is a major challenge. For instance, the average age in the fishing industry is rapidly growing. Working on a fishing boat is a demanding job as it requires hard work. With this in mind, as the fishers get older it will be even harder to substitute them. (Fiskeridirektoratet, 2018) Nofima´s report (2017) suggest the industry is highly dependent on local workforce, indicating it is difficult to keep and acquire employees. The seafood industry is also very reliant on family businesses, which denote concerns as fewer younger people are interested in a career that in some cases has been the family business for generations.

3.4 Reducing the Barriers and Opportunities for Implementation

In general, for all industries, the main driver of adopting and utilize new technologies is the perspective of securing a competitive advantage from the benefits that comes with automation. The eagerness for seafood firms to initiate R&D and continuously carry out new technologies will only occur if firms recognize that by using these novel solutions, it will be more efficient and add monetary incentives. Some of the advantages that come with the implementation of automation involve higher productivity in terms of automatic machines enhance the efficiency and reduce production cost. Firms will see improvements in both process and product development as the work will have a higher performance rate as the consistency is better. Overall, these advantages will enhance the competitiveness of firms, increasing the willingness to expose themselves to higher cost and financial obligations in order to follow the technological development. (Sandey, Qureshi, Meshram, Agrawal, & Uprit, 2017)

The seafood industry varies between all kind of activities, everything from fish feed to distribute a finished product to consumers. In light of this, there are massive implementation opportunities. Automation can not only be applied but also make a difference in all different areas within the industry such as, dealing properly with the fish onboard, using novel equipment to handle the fish in the best possible way, and in new ways of quickly getting the finished product out in business. Most of the products produced are incomparable to other industries because of the texture, shape, and size of each object. Making room for automation and new technologies to be more appropriate.

Developing suitable robots are also complicated because of the harsh environment and the work process itself. For the robots to be efficient, they need to be strong, adaptable, and have mobility. Tasks are usually done repeatedly, in which case it is essential to monitor the performance closely. Technology is a huge part of the structure. One of the reasons why robotics will be more present in areas representing repetition such as in the processing stage. (Nayik, Muzaffar, & Gull, 2015)

The toughest barrier to conquer presumably be the human beliefs. Employees representing lifelong careers are not always open-minded of new ways of doing things. Employee resistance can form a strong obstruction of automation as they can be unwilling to let their work skills be replaced by machines. This can be prevented by changing the way people think and assure that new machines will not threaten the job but instead join forces to efficiently enhance performance. For labor-intensive firms, it can be less costly to hire a person instead of investing in a robot.

3.5 Summary

Norway is a forerunner when it comes to developing new, proficient, and environmental seafood production. But there is still a need for increased implementation of automation and innovative solution to enhance performance. Reviewing the academic literature provided in this chapter, we can underline high cost, the unavailability of robots, employee’s resistance to change, lack of qualified personnel, seasonality and variability as major barriers firms in the seafood industry faces.

4 Methodology

This chapter aims to express the strategy and research design implemented in this thesis in order to investigate and study the relationship of firms' innovation activities and what kind of obstacles hinder firms to take innovation actions.
To carry out this research, quantitative research approach will be used for the purpose of studying the different relationships with the help of logit regression approach in order to study the effect of each variance and its impact on the dependent variable.

4.1 Quantitative Data Analysis

Research can be identified as the act of gathering, evaluating and interpreting data with the intention of an open perception of a phenomenon.(Leedy & Ormrod, 2010) The research process as a whole is about being capable to interpret the result and express the findings within the frameworks and the guidelines given. (Williams, 2007)

When conducting a research, the most frequently used approaches to organize a study, collecting data and evaluating the information acquired that is suited specifically for the objective of the research are quantitative, qualitative and mixed methods. What approach to use depends upon the data needed to answer the research question and develop evidence. Each approach has its own distinctive impact on the analysis and has its own pros and cons. In general, the researchers chose the quantitative methods when dealing with numerical data, the qualitative method when dealing with textual data and the mixed methods when it is necessary with a combination of both data.

In this thesis, the best way of answering the research question is based on numerical data and the quantitative approach. Quantitative methods aim to generate findings and results that are accurate and generalizable. (Rubin & Babbie, 2001) It is an efficient approach when looking to support whether a cause has or have not an impact on the result.

We can identify quantitative approaches by their controlled methods when obtaining information. It is a systematic process, meaning the researcher go through reasonable steps consistent with an individual plan of action. Starting with defining the problem of interest, to solving the problem. Some helpful tools researchers can take advantage of including arranged/planned instruments to control the study, hence it can disturb the effects of the research, thereby keep biases minimized and maximize precision and validity. (Polit & Tatano Beck, 2006) The methodology of a quantitative research preserves the theory of an empiricist paradigm. (Creswell, 2003) The purpose is to develop and utilize statistical figures, ideas, and hypothesis that are relevant to phenomena.(Bhawna & Gobind, 2015)

To understand the research question more deeply, it is efficient to use quantitative analysis. Implementing automation in daily activity process are constantly increasing, and the approach will give a better way of showing the barriers to see what obstacles firm faces when deciding to pursue this trend. (Green, 2013)

4.2 Research Design

The intention of research design is to give an overview or an overall plan for how to convey a research question, along with definitions for strengthening the research`s integrity. Trochim (2002) implies that research design is what holds the research together. Without the research design, there would be nothing holding the research in place. Generally speaking, it is a plan for how to conduct the research from starting point throughout the finish line. It is a step-by-step plan revealing how sections of the study embrace each other in order to address the research question.

For this thesis, the overall plan is to use measurements such as questionnaire survey, empirical literature, and statistical analysis in order to address the research question in the best possible way.

4.2.1 Purpose of Research

According to Kothari (2004) the purpose of research is to find answers that reply to questions through the implementation of scientific procedures. Particularly, the objective is to find the truth of the research, which usually has not been discovered yet. Usually, the purpose of each research study is personal, in their own specific way. Following Kothari’s perspective, the research objectives can be divided into four different types; exploratory-, descriptive-, diagnostics-, and hypothesis-testing research.

The exploratory research is to become familiar with a phenomenon. Descriptive research is to sketch the features of an event or situation. The diagnostic research concludes the occurrence of something happening or is connected with something else. This is important because you want to know what is causing something to flourish and what might be causing something to go downhill. Lastly, hypothesis-testing research analyses a hypothesis of a regular correlation between variables. This research will be based on hypothesis-testing

4.2.2 Hypothesis Testing

Hypothesis testing contains stating a null and an alternative hypothesis, where H_0 denotes the null hypothesis, and H_1 represents the alternative hypothesis.

$$H_0: \beta = 0$$
$$H_1: \beta \neq 0$$

H_0: The hypotheses exhibit no significant reference between the variables measured.
H_1: The hypothesis exhibits a significant reference between the variables measured. (Stock & Watson, 2015)

Hypothesis testing has been essential to this thesis with the purpose of studying if the data acquired specifies an appropriate establishment to whether reject or accept the hypothesis. This involves the model to show evidence for either supporting the hypothesis or reject it.

Further, the p-test is functioned in terms of studying the statistical significance of variables on the dependent variable. The most frequently used p-values are when alpha is either a 1%, 5%, or 10% significant level. For instance, if we have a p-value greater than our chosen significant level, we have no indication of a certain independent variable being statistically significant for enlightening the dependent variable. Which means that we can reject H_0. With this in mind, the level of statistical significance can be relevant when deciding whether or not to accept a hypothesis depending on whether it provides a significant explanation of the dependent variable. (Stock & Watson, 2015)

Overall, the hypothesis test assembled with the p-value will give a suggestion of the level of significance, to outline an assumption on the hypothesis based on the result achieved in the analysis.

4.3 Data

The data analyzed in this thesis consist of 206 Norwegian firms within the seafood industry and their innovation activities. The questionnaire consists of questions related to firms' innovations activities, collaboration partners, both external and internal, barriers and drivers of innovation, educational level, and demographic information. The data collected specifically for this thesis are taken from a questionnaire intended for an earlier research provided by Nofima (2016).

The participants represented leading positions with great knowledge for representing their firm. Over 50% represented CEO positions and 33% other management positions. Only 11% represented the category others, which represented positions such as fabric manager, technical manager, research developer etc. Overall, these percentage numbers indicate the high quality of the answers collected providing a more reliable dataset.

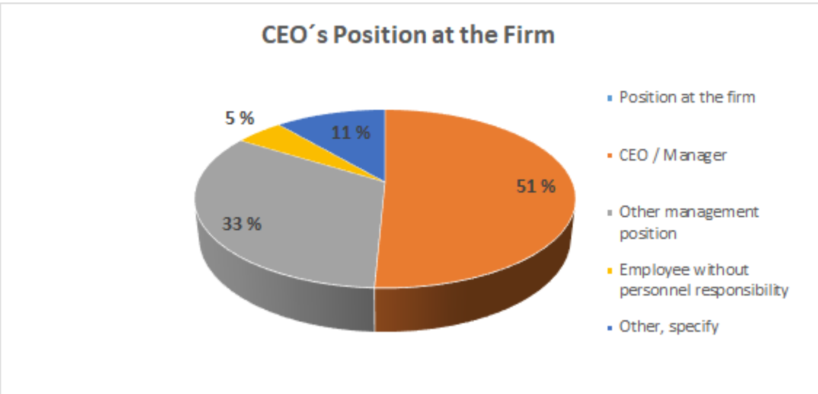

Figure 3 CEO`s Position at the Firm

The main goal of using this survey was to attain knowledge regarding industry perception, innovation activities, demographic information such as the educational level for both CEOs and employees, size, and region; barriers of innovation activities, product– and process innovation in the seafood industry. The primary answers of interest were withdrawal from the questionnaire and divided into various data set.

The questionnaire used is typically described as a closed-ended question, which means that the respondents were given a set of answer. The benefit of this kind is that these types of questions are easy to code. In essence, it makes the findings more helpful as it is easier to check for statistical significance of the final result. Additionally, researchers can easily label respondents into various groups based on their preferred answers and make predictions and analysis within each group.

In order to make a significant analysis, I have conducted different adoptions to the survey. I have divided the firms based on the number of employees into either small, medium or large. Based on these statistics, the majority of the respondents are representing smaller firms.

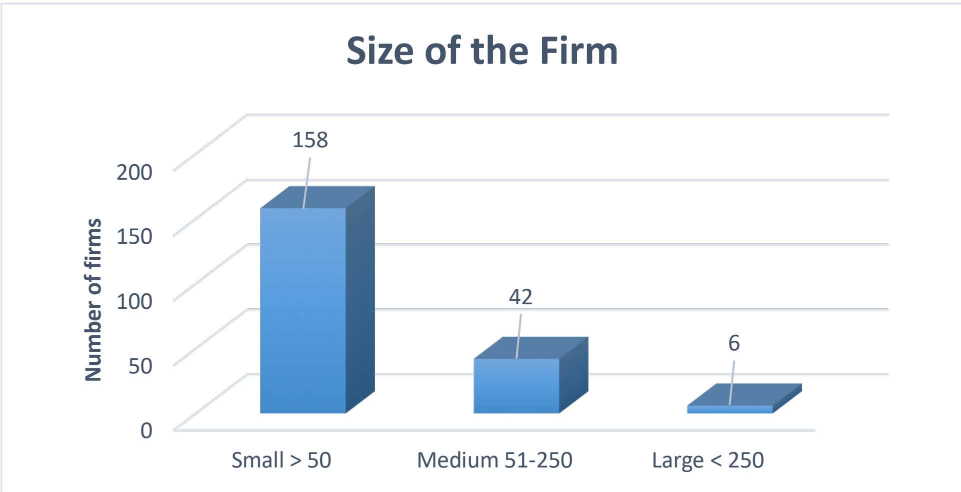

Figure 4: Size of the Firm

In total, the dataset represented eight different industries; fisheries, farming, fish processing, feed/medicine/R&D, maritime services and equipment suppliers. In order to get a more significant effect, I decided to group them into four different industry sectors. Farming, fisheries and fish processing represented their own industry, while suppliers represented firms labeled as maritime services, equipment suppliers, BioMarin industries, and R&D services.

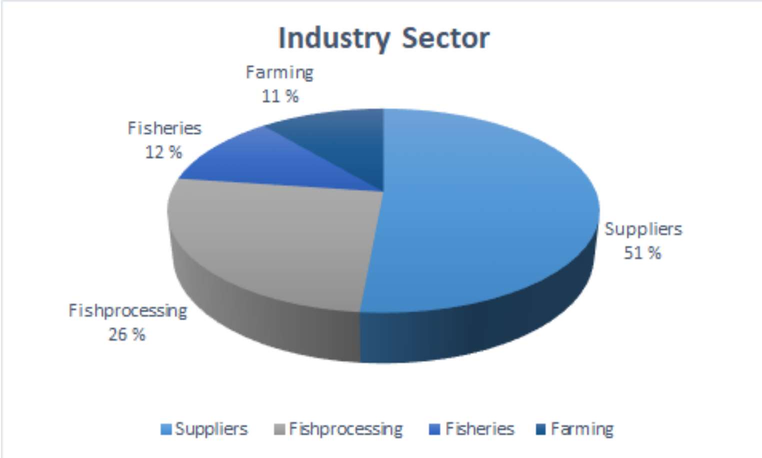

Figure 5: Industry Sector

In addition, regions were compromised to make the effects more influential. Sør-Trøndelag and Nord-Trøndelag were assembled to Trøndelag as of January 1st, 2018. (Regjeringen, 2016) Rogaland, Aust-Agder, and Vest-Agder were combined to Rogaland-Agder. Lastly, I compromised all the regions in east into Østlandet. This was a combination of Vestfold, Akershus, Oppland, Oslo, and Østfold. These specific regions were merged based on the location and that each area represents similar industries and firms. All of these combinations were helpful to make the result more significant and accurate.

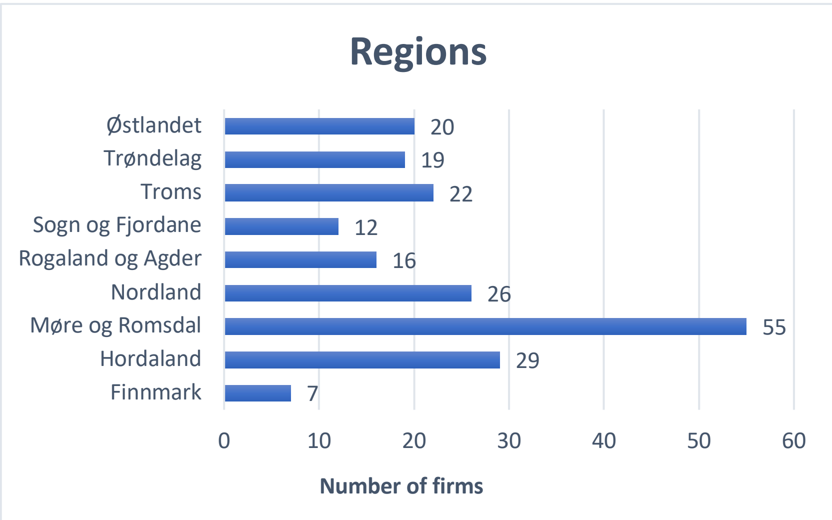

Figure 6: Regions

Figure 7 illustrates the firms’ response towards innovation activities.

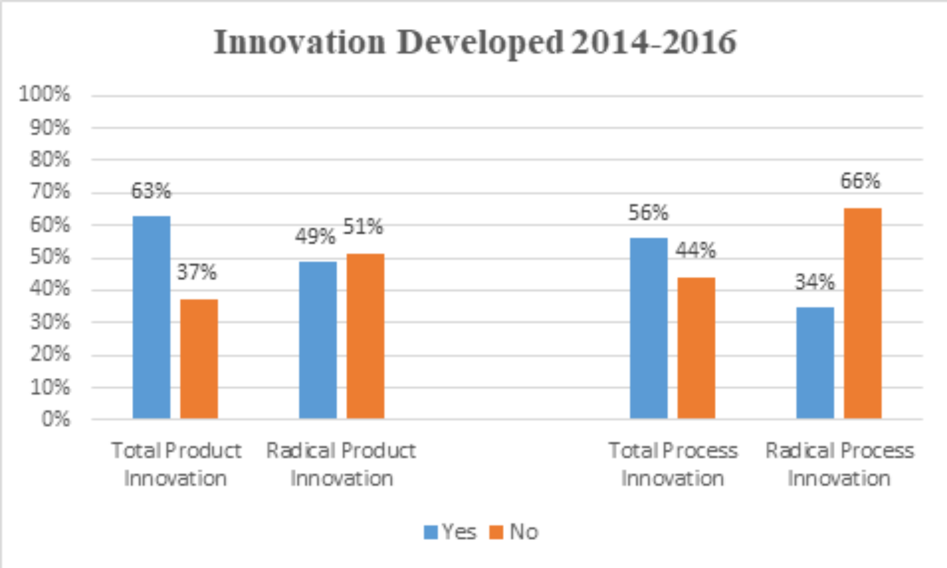

Figure 7: Innovation Developed during 2014-2016

To continue elaborating on the responses of what firms view as barriers, I conducted pivot tables in Excel to quickly summarize the data and view the data with a different perspective and different effects.

4.4 Descriptive of Barriers

Figure 8 show all the different variables in terms of barriers that are included in the data. The first column represents "very important," the next; "slightly important," and lastly; "not relevant." These columns are calculated in terms of the respondent's answers in the questionnaire survey. To further investigate the effect on each of the barrier, I have reorganized and summarized the data to get a broader understanding and to take an extra look at interesting columns for the specific barriers.

As we can see from Figure 8, lack of internal funds, lack of qualified personnel and difficulties to get public support all stand out as firms view these factors as a very important factor that hinders firms in their innovation activities. The next section will cover discussion on all of the barriers compared to the different industry sectors with the main focus on the circled columns. For figure 9 – figure 15, The left axis shows the value of the importance where 0 represents not important and 6 represents very important.

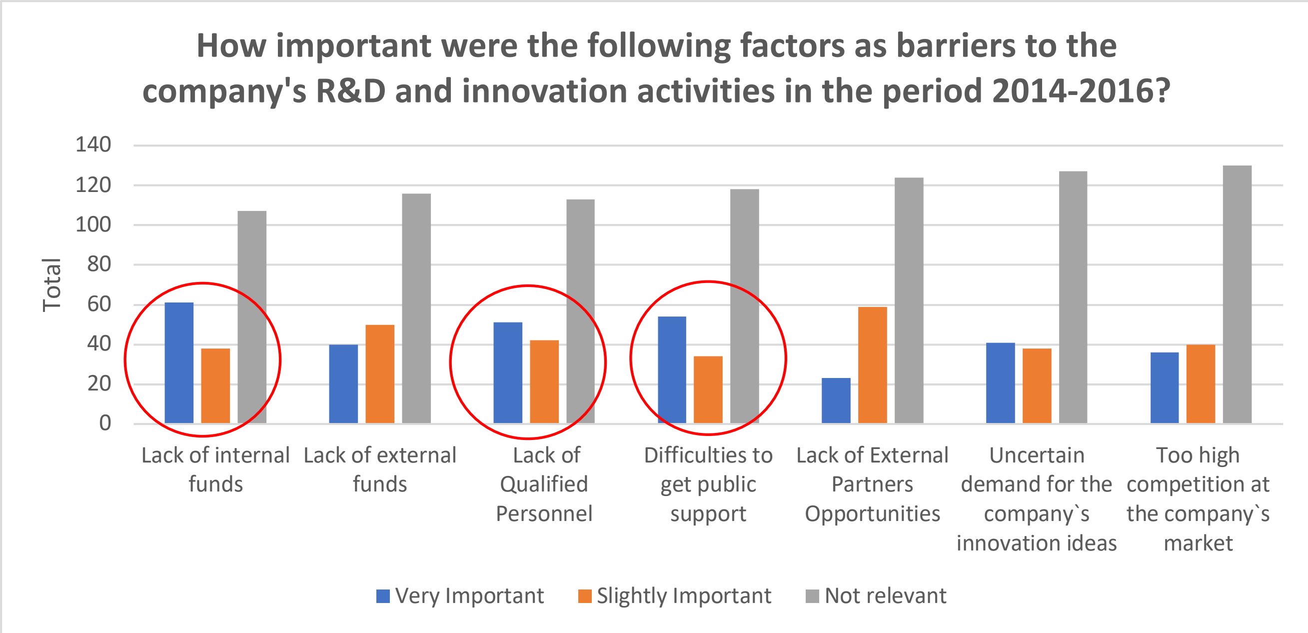

Figure 8: Barriers to Innovation

1) Lack of Internal funds

Figure 9 show the respondents average answer rate based on the barrier; lack of internal funds. With help from pivot tables, I have arranged it so I could see the correlation between this barrier and the different industry sectors.

Internal funds are crucial for firms that intent to innovate. In order to stay ahead of the market, or follow the growing technological enhancement, it is necessary with equity and good financial resources. Innovation does not come cheap. Some of the innovation expenditure includes; R&D, acquisition of technological knowledge, machinery, equipment, and training employees to carry out the activities. In regard to this analysis, lack of internal funds is viewed as the most important barrier the majority face that hinders innovation activities.

Based on the industry sectors, firms in the farming industry tend to struggle more with internal founds than the others. Fish farms form the foundation in many local communities. With this in mind, it is more likely for the majority of firms to be small rather than large. As smaller the firms are, as harder it is to conquer extra money or equity to spend on innovation. As a small firm, you do not have the same access to a resource pool as the bigger firms. You do not have the same amount of money to work with. The limited amount of money and resources internally diminish the likelihood of innovation activities.

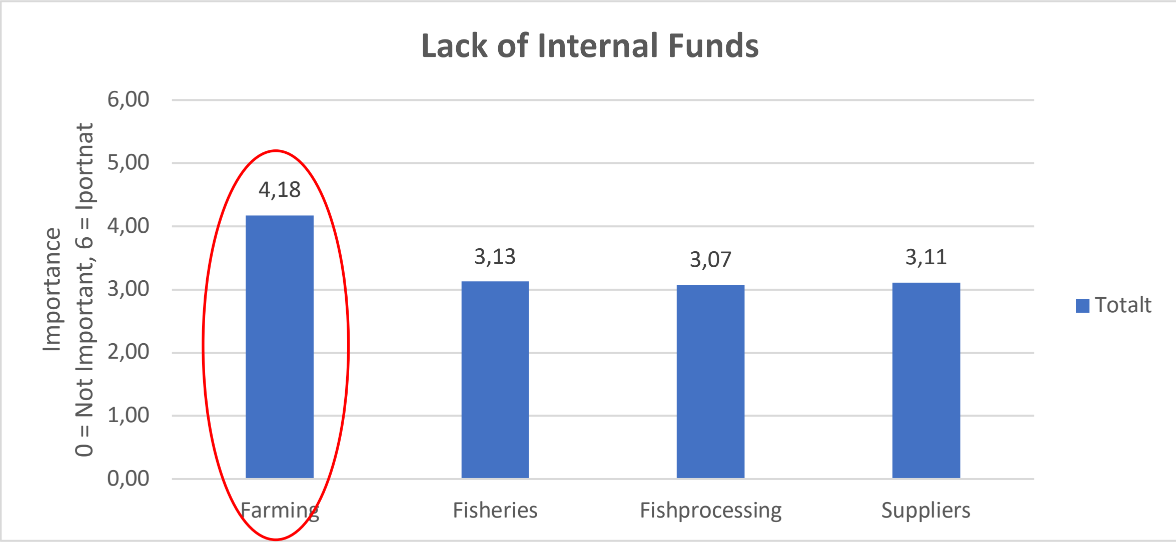

Figure 9: Lack of Internal Funds

2) Lack of Access to Credit or Other External Source of Finance

Figure 10 outline lack of external funds in comparison with the different industry sectors. All firms need money in order to do business. We can define sources of finance as where the money comes from. When we talk about external sources, we mean finances from outside the firm. If a firm needs to generate more capital and cannot do this internally, they may apply for a loan. Usually, for firms struggling with internal capital, it is essential with external sources to finance innovation activities. The chart displays lack of external funds compared to the industry sector. As we can see, the farming industry tend to struggle with access to external resources. This makes sense in regard to be an expensive industry. Fish farming also referred to aquaculture is one of Norway's most important industry. It is a developing industry that continuously needs to improve itself in order to meet market demands. It is an industry with lots of potential R&D developments, which means it is an expensive industry for firms to operate in.

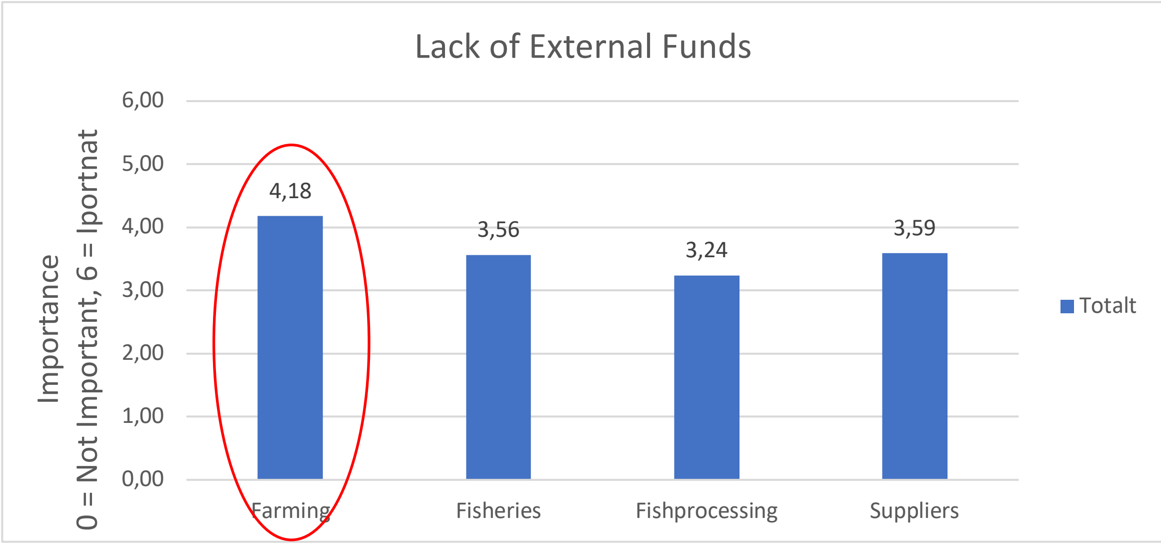

Figure 10: Lack of External Funds

3) Lack of Qualified Personnel

Figure 11 displays the relationship between each industry sector and how the respondent views lack of qualified personnel as an obstacle for the firm. We can see how firms within the fisheries industry tend to struggle the most with attaining qualified personnel. This can have something to do with the job requirements in fisheries. Usually, you stay out in the ocean for weeks and it is a physically demanding job making the job less attractive and harder to attain personnel. It is hard to attract younger workers as there is not very much appealing to this type of work. For instance, as younger generations are more interested in technology and use of advanced equipment's, it would be more attractive if fisheries could appeal the juvenile with sophisticated equipment's.
Another explanation can be based on the educational level of the firms. For instance, firms with a low educational level among the employers face higher challenges to attain qualified personnel. Smaller firms tend to have a majority of primary/certificate education, while medium firms tend to represent employees with a university background. This indicates that as bigger the firm is, it is more likely to have good financial resources and higher standards to hire highly educated employees. The more educated they are, the more success they can bring to the firm, in terms of knowledge, experience, and resources. All that leads to more sales, production and enhanced performance.

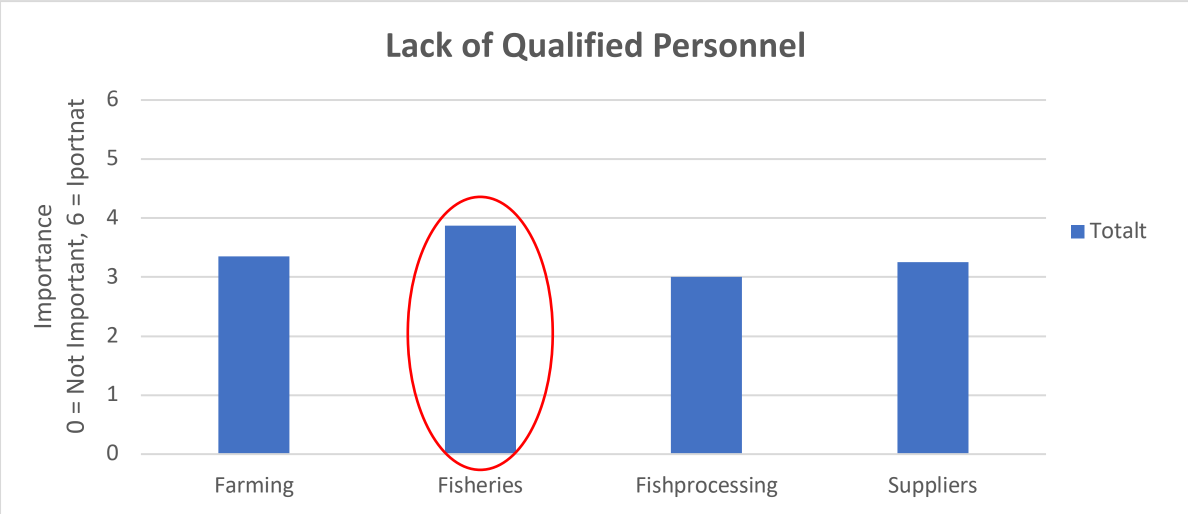

Figure 11: Lack of Qualified Personnel

4) Difficulties to Get Public Support from Innovations Organizations

Figure 12 exhibits the barrier difficulties to get public support and its average rate based on the industry sectors. Firms getting support from innovation organization can have a significant effect on the firms' performance when it comes to innovation. Innovation Norway is one of the most important organizations for Norwegian enterprises and industries. This organization support firms and entrepreneurs in advancing their competitive advantage and to strengthen their innovation abilities. There are different requirements to reach in order to receive funding which can halt firms to receive the support. Either your firm is a start-up or already successful firm, the requirements are still strict. As pointed out in the in the first table of all the barriers, this factor is seen as a very important barrier that hinders firms in their innovation activities.

Reading off the chart, this barrier indicates it is harder for firms in the fisheries industry to acquire support form innovation organizations opposed to firms in the fish processing industry for instance. An explanation to this may be that the fisheries sector represents the majority of smaller firms. According to Innovation Norway`s Annual Report (2016), the organization prefers to support high-risk innovation projects. This can be another explanation why this barrier is seen as a very important obstacle. It is not easy to introduce sufficiently big innovation projects, in terms of needing a lot of funding, experience, and knowledge. Additionally, the project needs to be profitability, doable and there needs to be some sort of value creation. With this in mind, it is hard for smaller firms to fund high-risk innovation project due to lack of funding and in most cases lack of appropriate skills and knowledge.

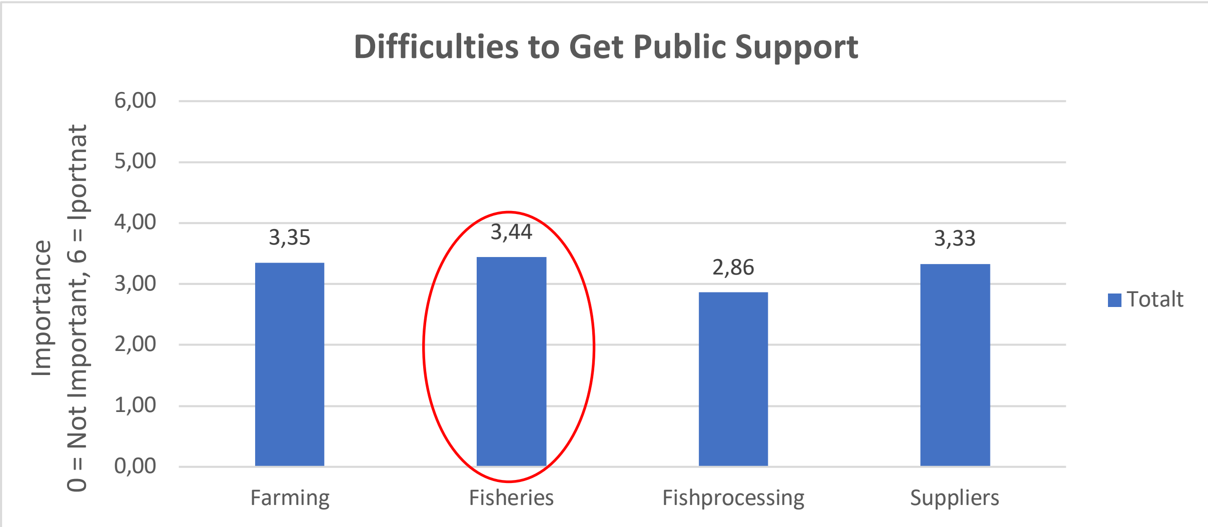

Figure 12: Difficulties to Get Public Support

5) Lack of External Partners Opportunities

Figure 13 shows similar interest in importance for firms viewing this barrier as slightly important. There is no drastic difference between the industries. This barrier is seen as the least important restriction of innovation. I believe one of the reasons behind this is that there is no requirement for external partners in order to innovate. A firm can innovate solely by themselves, and do not need to be dependent on others.

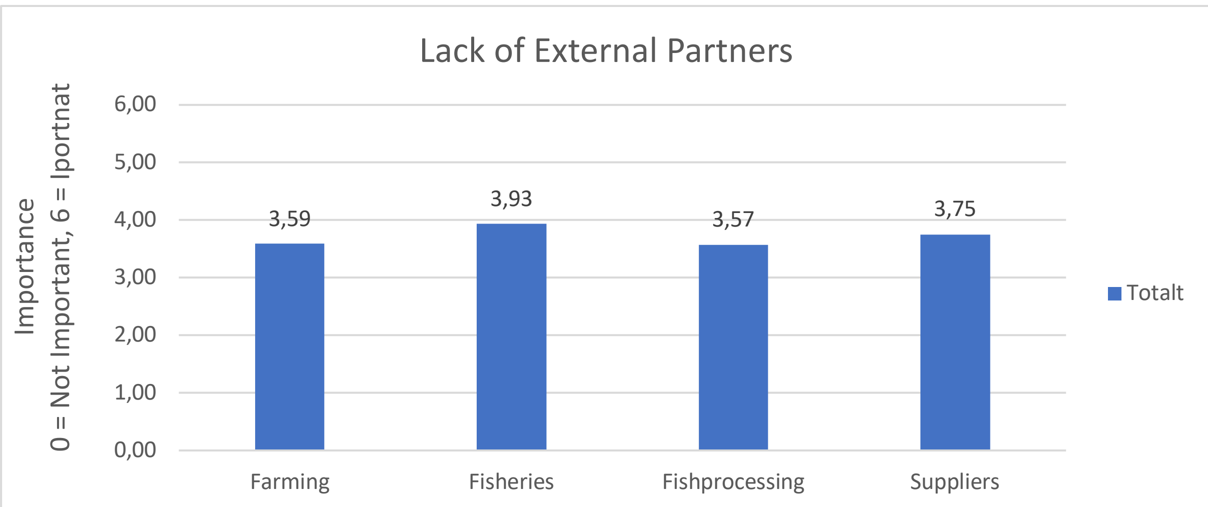

Figure 13: Lack of External Partners

6) Uncertain Demand for the Firm´s Innovation Ideas

Figure 14 shows the rate of importance for the barrier; uncertain demand for innovation ideas. This barrier is divided quite evenly with a slightly higher very important rate. The seafood industry one of the most important industries for the Norwegian market. As mentioned earlier, it is necessary with new ways of thinking to further explore the opportunities to keep enhancing the industry. It is an industry filled with manual labor with a potential of improving areas with automation to improve quality and efficiency and reduce waste. Some of the working areas include harsh environments were robotics can introduce safer and faster performance. By doing so, there is a need for innovation and new ideas. As people are often labeled as resistant to change and abstaining new ideas, there is a lot of uncertainty about what to do and how to move forward.

The fisheries industry has a higher percentage of uncertain demand for innovation within their market compared to the other industries. This industry represents the majority of the time worked on a boat, with a lot of human labor. It is hard to replace all human workforce with machinery and robotics. One of my reasons behind the uncertain demand for new ideas.

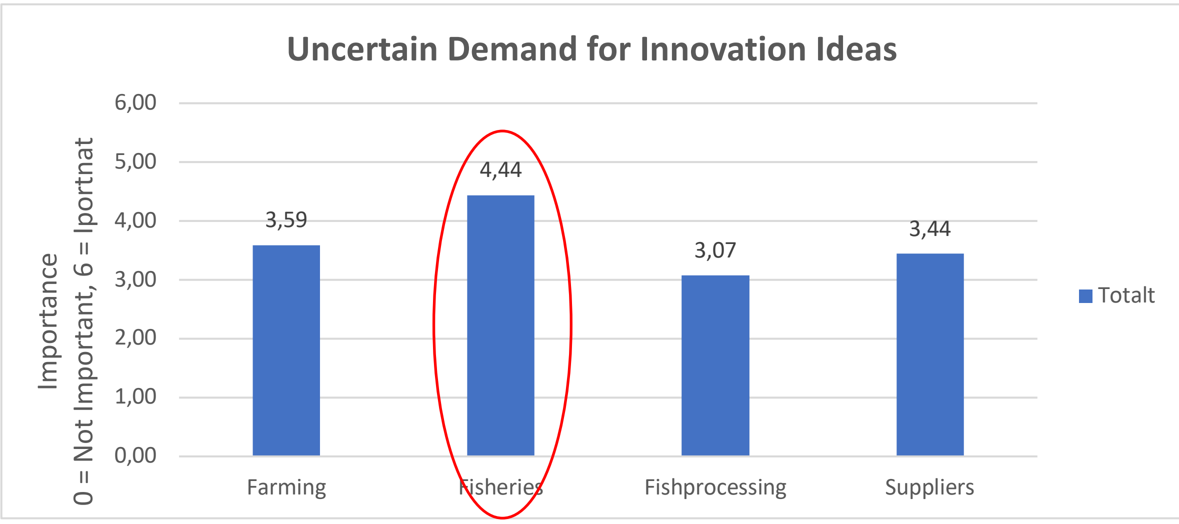

Figure 14: Uncertain Demand for Innovation Ideas

7) Too High Competition at the Firm´s Market

Figure 15 displays the barrier concerning competition at the market and outline the different sectors view on its importance as an obstacle. The seafood industry is like everyone else, filled with competition to secure a spot on the market. The chart suggests that fisheries tend to view this barrier as an obstacle for innovation. Competition can also have a crucial impact whether your firm is small or big. Smaller firms tend to face a lot of competition which puts innovation activities on hold. In order to stay competitive and in front of your competitors, there is a need for innovation to follow the technological development and be attractive in the market. In general, it is easier for a larger firm to stand out and handle competition. They are more resourceful, experienced and have better access to requirements.

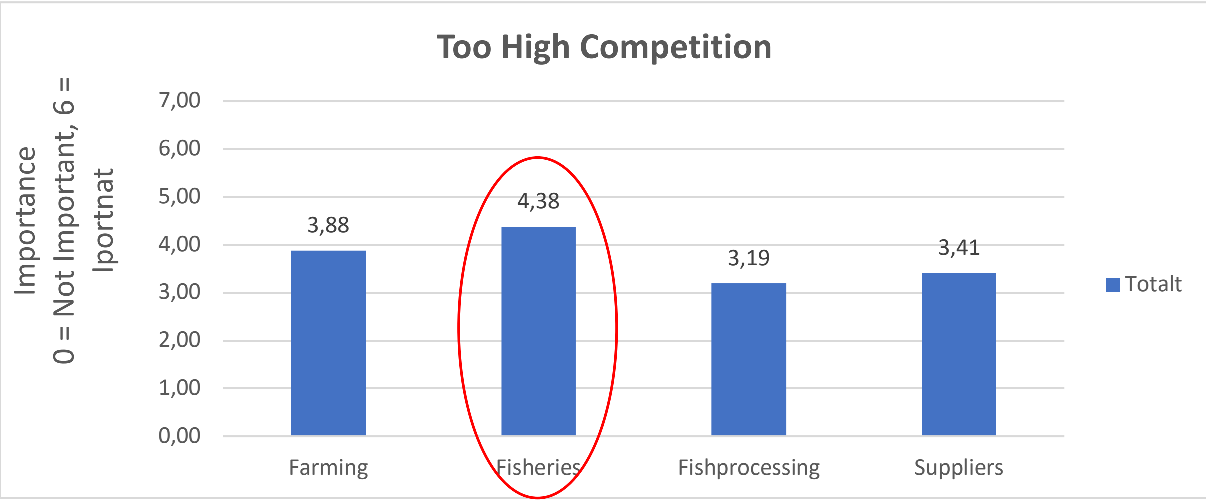

Figure 15: Too High Competition at the Market

4.5 Logit Regression Analysis

The descriptive statistics gives a good overview of the barriers, but it does not give us any impression on how the barriers are related to innovation. This is why a regression analysis is necessary. When conduction a regression model, it is essential to understand the variables applied in forming theories, as the aim is to study the relationship between these variables. A variable can be labeled as an aspect of the research study that does not stay consistent and can change values. (CIRT, 2018)

The two most common types of variables are dependent and independent variables. The dependent variables are recognized as the product of the independent variable, while the independent variables are identified as those who either cause, influence or affect the outcomes. Another important variable to consider is the control variable. These are used as a constant variable and are often included as they are a certain type of independent variable and can shape the dependent variable. They are taken into account because demographic variables may need to be monitored so that the impacts of the independent variable on the dependent variable can be shown. (Creswell, 2009)

For the purpose of looking at the relationship between the dependent variable and the independent variables and what effect what, I have designed eight different regressions models, two for each of the innovation outcomes. One original model, and one revised model. The reason for this is to be able to further elaborate on the result, by removing the independent variables that do not have any significant impact in order to get a more accurate result. To get a clear understanding of what the data represent, I decided to use logistic regression analysis method. This is because the dependent variable represent innovation or no innovation, and it is an efficient approach as I want to study the relationship between the dependent variable and the independent variables. (Creswell, 2009)

If the value of the dependent variable indicates 1, it means that innovation will occur, which is also the target group, and 0 if no innovation occurs.

The probability for a firm *i* innovation activity is:

$$Log = \left[\frac{Prob\ (Innovation\ i)}{1 - Prob\ (Innovation\ i)}\right] = \beta 0 + \beta 1X1 + \beta 2X2 + \cdots + \beta kXk$$

Can also be presented as:

$$Prob(Innovation\ i) = \frac{Exp\ (Xi\beta)}{1 + Exp\ (Xi\beta)}$$

where Prob (innovation *i*) is the probability that firm *i* innovates. β_0 is the intercept, and βs are the coefficients related to each independent variable.

A positive sign for the coefficient implies that a one unit increase in the independent variable will raise the likelihood of innovation to occur. On the contrary, a negative sign will have a negative impact, signifying a decrease in the dependent variable. For the dummy variables, the variables coded equal to 1 will have a higher likelihood to innovate with a positive value, as opposed to a negative sign, which decreases the likelihood.

4.5.1 Ordinary Least Squares (OLS)

OLS regression can be defined as a statistical method used to evaluate correlations between one or more independent and dependent variables. (Encyclopedia, 2016) This approach attempts to detect the best-estimated regression line that minimizes the sum of squared residuals. The deviation between the anticipated and the perceived value. OLS is usually known as either simple or multiple linear regression, depending on how many independent variables are included in the analysis.

In order for OLS to be reliable, it needs to encounter with six different assumptions, known as the Gauss-Markov assumptions. If assumptions 1 to 5 hold, then the OLS estimator is Best Linear Unbiased Estimator (BLUE). (Albert, 2016)

4.5.2 Multicollinearity

Multicollinearity can be identified as a problem in multiple regression models. Usually, this problem takes place when there is a linear correlation between the independent variables. (Pedace, 2013) High multicollinearity is frequently recognized and can produce consequential difficulties for the regression analysis. This emerges from a linear correlation of the independent variables that have a high extent of correlation but do not have a perfect relationship. A common theory is that multicollinearity exist when the correlation coefficient is approaching nearly 1. (Wooldridge, 2016)

4.5.3 Model Specification

In regard to the research question, I have conducted a logit regression model for each innovation outcome; total product innovation, radical product innovation, total process innovation and radical process innovation. Including dummy variables for each barrier as independent variables. The logit regression model is as follows:

$$\textbf{Logit } (\pi_i) = \quad \alpha + \beta_1 \textit{Barriers}_i + \delta_2 \textit{Region}_i + \delta_3 \textit{Education}_i + \delta_4 \textit{Value chain}_i + \delta_4 \textit{Size of Firm}_i + \varepsilon_i$$

The dependent variable, π, is the likelihood of firm i initiating an innovation. This variable was labeled as either 1 or 0, which represented yes or no answering if the firm had introduced an innovation within the last three years. The independent variables represent seven different types of barriers which I divided in two, getting a total of 14 binary variables.

Table 1: Dividing the variables into new variables groups

Variables:	**New Variables**
InternalFunds	InternalFunds_1Important InternalFunds_2NotImportant
ExternalFunds	ExternalFunds_1Important ExternalFunds_2NotImportant
QualifiedPersonnel	QualifiedPersonnel_1Important QualifiedPersonnel_2NotImportant
PublicSupport	PublicSupport_1Important PublicSupport_2NotImportant
ExternalPartners	ExternalPartners_1Important ExternalPartners_2NotImportant
LowDemand	LowDemand_1Important LowDemand_2NotImportant
HighCompetition	HighCompetition_1Important HighCompetition_2NotImportant

Those who were divided in "_1Important" were labeled 1 if the firms respond in the survey referred to important or very important, 0 otherwise. This was opposite in the "_2NotImportant" groups. Here, 1 represented firms who viewed the barrier as slightly important or not at all important, and 0 otherwise. This was done in order to give a more accurate result with clearer statistical significance if any.

To control for variability, I will include factors that are relevant to both; innovation and the barriers. Regions will be included with the purpose of studying if there will be any distinctions amongst the regions when considering other variables. Regions are divided into 8 regions with binary values representing each region in the survey. Østlandet represents the base group and therefore omitted in the model. I also included the educational level with the value of 1 if they had university background, and 0 otherwise. This variable will be included in the original models but omitted in the revised models if the factor is not significant. The industry sectors include fisheries, fish processing, farming, and suppliers. These were assorted into binary numbers with suppliers being omitted as they represent the base group. Size of the firm was divided into small, medium, and large, all in binary numbers where I will omit the large firms because they are the base group. ε represents the error term.

Model 1: Total Product Innovation + Revised Total Product Innovation

Model 2: Radical Product Innovation + Revised Radical Product Innovation

Model 3: Total Process Innovation + Revised Total Process Innovation

Model 4: Radical Process Innovation + Revised Radical Process Innovation

4.5.4 Variables

This section describes all the variables used in this thesis.

Table 2: List of Variables

Dependent Variables	**Description**
Radical Product Innovation	Firm i introducing an innovation = 1, 0 if not.
Incremental Product Innovation	Firm i introducing an innovation = 1, 0 if not.
Radical Process Innovation	Firm i introducing an innovation = 1, 0 if not.
Incremental Process Innovation	Firm i introducing an innovation = 1, 0 if not.
Total Product Innovation	Radical Product Innovation = 0 + Incremental Product Innovation =1, 0 otherwise
Total Process Innovation	Radical Process Innovation = 0 + Incremental Process Innovation =1, 0 otherwise
Independent Variables	
Lack of Internal Funds_1Important	Firms who answered this barrier as very important/important =1, 0 otherwise.
Lack of Internal Funds_2NotImportant	Firms who answered this barrier as slightly important/not at all important =1, 0 otherwise.
Lack of External Funds_1Important	Firms who answered this barrier as very important/important =1, 0 otherwise.
Lack of External Funds_2NotImportant	Firms who answered this barrier as slightly important/not at all important =1, 0 otherwise.
Lack of Qualified Personnel_1Important	Firms who answered this barrier as very important/important =1, 0 otherwise.
Lack of Qualified Personnel_2NotImportant	Firms who answered this barrier as slightly important/not at all important =1, 0 otherwise.

Difficulties to get Public Support_1Important	Firms who answered this barrier as very important/important =1, 0 otherwise.
Difficulties to get Public Support_2Not Important	Firms who answered this barrier as slightly important/not at all important =1, 0 otherwise.
Lack of External Partners_1Important	Firms who answered this barrier as very important/important =1, 0 otherwise.
Lack of External Partners_2NotImportant	Firms who answered this barrier as slightly important/not at all important =1, 0 otherwise.
Uncertain Demand for the Firms Innovation Ideas_1Important	Firms who answered this barrier as very important/important =1, 0 otherwise.
Uncertain Demand for the Firms Innovation Ideas_2NotImportant	Firms who answered this barrier as slightly important/not at all important =1, 0 otherwise.
Too High Competition at the Firms Market_1Important	Firms who answered this barrier as very important/important =1, 0 otherwise.
Too High Competition at the Firms Market_2NotImportant	Firms who answered this barrier as slightly important/not at all important =1, 0 otherwise.
Control Variables	
Region	Where the firm is located.
Region *i* (dummy variable for all regions)	Firm *i* located =1, 0 otherwise
Education	University degree =1, 0 otherwise
Value chain	Fish processing, Fisheries, Farming and Suppliers
Value chain *i* (dummy variable)	Industry sector *i* =1, 0 otherwise
Size of Firm	Small < 50, Medium 51-251, Large > 250
Size of Firm *i* (dummy variable)	Size of Firm *i* =1, 0 otherwise

4.6 Reliability and Validity of Data

It is inevitable, in any dataset, to some extent of error to occur. To provide more precise deliberation of the truth, it is necessary with some extent of error as it is essential to diminish for the data.

The aim of this thesis is for the findings to demonstrate the truth. With the focus on providing evidence of finest quality, it is in my best interest to evaluate the quality of the proof provided in this thesis by analyzing the theoretical and principle-based decisions researchers made. Using scientific merit is useful within quantitative research methods. By doing so, the researchers have various benchmarks to evaluate the quality of the study. For instance, through the use of the two most important evaluation criteria, reliability and validity. (Polit & Beck, 2006)

Reliability denotes how reliable the findings are. If this research would be done by the second time, would the result yield the same as the first time? To be specific, how accurate and consistent are the information that has been gathered in order for the study to be dependable?

Validity, on the other hand, insinuates to the trustworthiness of the research. Whether or not the findings are authentic, influential, convincing, and reasonable. In order to attain both reliability and validity throughout this thesis, there has been a high focus on the quality of the literature, along with suitable technique to maintain an accurate research.

However, anytime you base your research on existing data, you are automatically restricted to what exists. This is because, in most situation, the data you are using do not always cover precisely what you are interested in. With this in mind, the analysis and measurements you want to achieve from the data may not quite be a reasonable illustration of the variable and the theory you wanted to draw a conclusion from. (Polit & Beck, 2006)

4.7 Summary

This chapter describe the methodology and the research design for this thesis.
The descriptive statistical analysis conducted from the questionnaire survey gives an impression of the importance of the barriers. The analysis highlights lack of internal funds, lack of qualified personnel and difficulties to get public support as the major barriers for innovation. In order to further investigate the barriers effect on the four different innovation outcomes, linear regression analysis have been used to study the relationship between the dependent and independent variable.

5 Analysis and Finding

This chapter deliberates on the findings and the result of the regression model applied. The aim of this chapter is to outline the relationship of the independent variables and its influence on the dependent variable.

5.1 Data Integration

Table 3 shows the result of all the innovation outcomes, while Table 4 displays the result of the revised models. Both models show different level of significance and different sign of coefficients. A positive sign of the coefficient indicates a positive relationship towards innovation, while a negative sign indicates a negative relationship. I have tested for multicollinearity (appendix) for all models, indicating no problems. Based on Psuedo R^2, we can see that the barriers are related differently towards different innovation outcomes.

5.1.1 Logit Regression Results of Each Innovation Outcome

The result exhibited in Table 3 show different levels of significance for different barriers, regions and industry sectors. Further, it shows either a positive correlation or a negative correlation on the dependent variable.

InternalFunds_1Important is much correlated to the likelihood of total product innovation and less connected but still important to total process innovation. However, it does not appear to disturb the likelihood of radical product innovation and radical process innovation. The likelihood of total product innovation is exp(2.49) = 1106%[4] higher, and of total process innovation exp(1.84) = 529% higher, for firms who view this barrier as very important.
As firms tend to innovate more despite the fact they view this obstacle as very important, suggest that innovation can be conducted with use of other monetary options. In order to innovate, a firm needs money. As they do not have internal funding available, firms can search externally in terms of loan, investors or funding from innovation organizations. These explanations can all help to escalate the likelihood of innovation.

[4] *Calculations: exp(2.49) = $e^{(2.49)}$ =12.06 – 1=11.06*100 = 1106%*

InternalFunds_2NotImportant indicates that the likelihood of radical product innovation is exp(-1.72) = 82% lower for firms who do not view this barrier as important, considering it is not significant within the other models. For radical product innovation, as firms tend to innovate less, it can imply that firms who run a successful business with good financial resources buy a finished product rather than spending money on R&D and looking for new solutions.

ExternalFunds_1Important, **ExternalFunds_2NotImportant**, **QualifiedPersonnel_1Important**, **PublicSupport_1Important**, and **LowDemand_1Important** have no significant relevance on the dependent variable in either one of the models.

Firms who do not view the skills and knowledge of its employees as an obstacle tend to have a negative correlation on total product innovation. **QualifiedPersonnel_2NotImportant** indicates the likelihood of product innovation to be exp(-1.25) = 71% lower for these firms. Whereas it does not appear to have an influence on the other innovation approaches. The coefficient suggests that there can be other reasons for not innovating. It may not be the employee's knowledge or technical skills that hinder firms to innovate, but rather something else such as lack of financial resources to support innovation projects.

Firms who view the importance of achieving public support as not important or with low relevance in order to carry out innovation projects indicates a negative impact on all of the innovation outcomes. The likelihood for total product innovation for **PublicSupport_2NotImportant** is exp(-2.54) = 92% lower, while the likelihood for radical product innovation is exp(-2.06) = 87% lower. Whereas the likelihood of process and radical process innovation decreases by exp(-1.32) = 73% and exp(-2.30) = 89%.
Radical innovation means innovations that are representing something new. Usually, it is easier and cheaper to enhance or improve already existing products rather than creating something new novel solutions that can integrate into the market. This can suggest that firms who receive innovation funding choose not to innovate for other reasons as it is hard and expensive to create something new that will fulfill market’s needs. Additionally, access to public support is not always enough to carry out an entire innovation project. In order to fulfil requirements of innovation, you need motivated employees to handle new technical solutions,

financial resources, and the project needs to improve existing products. Carrying out an innovation project takes time as it need to be planned or well organized in order to gain best possible potential out of the project. Just because you received support and funding from an innovation organization does not mean you need to innovate right this moment as developing something new can take years.

Powell et al (1996) point out how the majority of successful innovation will be established within cooperation and with a mix of external and internal knowledge instead of by a single firm. In their view, internal capabilities are not enough to carry out new innovative solutions in the rapidly growing technological advancements. As the industry is complex and still in development, there is a higher chance of successful innovation solution when knowledge and experiences are drawn from external sources combined with internal capabilities. For instance, Laursen and Salter (2006) arguments how the use of external knowledge is beneficial in realizing and supporting innovation. Firms who voluntarily participate in open innovation approaches increase the likelihood of being able to adjust to any changes and enhance innovation performance.

Based on this result, we can see some relevance to total process innovation. The likelihood of process innovation for firms representing **ExternalPartners_1Important** is exp(-1.55) = 78% lower. Hence, it appears that it does not have an effect on the probability of other innovation outcomes. Firms without external partners are less likely to innovate. For smaller firms, it is expensive to carry out innovation project solely by themselves. In which case it is better with collaboration, so they can split any risk or cost they would eventually face, in order to increase innovation activities. On the contrary, firm who do not view lack of external partners as an obstacle for innovation tend to have a positive correlation on radical product innovation. The likelihood of radical product innovation for **ExternalPartners_2NotImportant** is exp(1.67) = 431% higher, while it does not seems to have an effect on the other innovation outcomes. **ExternalPartners_2NotImportant** suggest that it is not important for collaboration in order to innovate. Firms can solely innovate by themselves and can use their own internal capabilities to increase their radical product innovation activities.

Typically, firms tend to innovate in order to meet consumers' needs and wants. **LowDemand_2NotImportant** implies that uncertain demand for firm's innovation ideas is not seen as an important barrier to innovation. The result shows that the likelihood of total process innovation is exp(-1.06) = 65% lower for this factor. Even without focusing on customer needs and their demand for qualified products, the likelihood of innovating is diminishing.

Too high competition at the market is viewed as a very important obstacle that hinders firm from innovating. **HighCompetition_1Important** implies that even though firms operate in a highly competitive market, they still tend to find reasons to innovate. Again, we can see both independent variables focusing on the level of competition are both significant and have a positive correlation to enhanced product innovation. Indicating that firm innovates even though there is no competition. This can suggest that firms tend to innovate because of the advantages that come from it. In fact, usually, competition brings out the best in each other. If one firm actively pushes for innovation, other firms in the industry have to follow in order to stay competitive. Additionally, innovation can give a competitive advantage to others, this is why innovation essential and important. The likelihood of total product innovation is exp(2.02) = 653% higher for firms who see this as an important obstacle for innovation.

In a non-competitive environment this hindrance is correlated to the possibility of radical process innovation, yet less related, but still noteworthy to product innovation and radical product innovation. Consequently, it does not have an influence on the possibility of total process innovation. The likelihood of radical process innovation representing **HighCompetition_2NotImportant** is exp(2.30) = 897% higher, for total product innovation it is exp(1.38) = 297% higher, and the likelihood of radical product innovation is exp(1.90) = 568% higher for firms who do not see this barrier as an important obstacle hindering innovation.

HighCompetition_2NotImportant indicates that firm can still innovate without feeling pressure by competitors. Novel innovation within the seafood industry is needed, and in general, not every firm have the abilities to support a new invention. This diminishes the likelihood of competition, as the majority of firms are not competing to be first at the market with their solution. A non-competitive market is not a hinder for increasing innovation activities.

Firms located in SognogFjordane tend to have a higher tendency of innovating than those located in other areas as it has a positive correlation on total process innovation. Finmark is significantly related to total product innovation, but as we can see, it has a negative correlation. All other regions have no impact on the likelihood of any innovation activities.

The likelihood of innovation varies within industry sectors. Fisheries, fish processing, and farming are all significant towards total product innovation but has a negative effect. When it comes to radical product innovation, it is only fisheries and fish processing industry that are significant, but the likelihood of innovating is diminishing for firms within these industries. We can see that firms within the farming industry have a positive correlation on total process innovation as it is significant. The likelihood of total process innovation is exp(1.14) = 212% higher for firms in this industry.

Size of the firm has no significant impression on either of the innovation outcomes.

Table 3: Logit Regression Result of Each Innovation Outcome

	Model 1 Total Product Innovation	**Model 2 Radical Product Innovation**	**Model 3 Total Process Innovation**	**Model 4 Radical Process Innovation**
Barriers				
InternalFunds_1Important	2.49** (1.11)	0.53 (0.69)	1.84** (0.79)	0.82 (0.64)
InternalFunds_2NotImportant	-1.07 (1.14)	-1.72* (0.98)	1.10 (0.95)	-1.25 (0.88)
ExternalFunds_1Important	-1.80 (1.25)	-0.37 (0.79)	1.11 (0.95)	0.26 (0.73)
ExternalFunds_2NotImportant	1.46 (1.25)	-0.03 (0.93)	0.95 (0.92)	-0.30 (0.82)
QualifiedPersonnel_1Important	0.37 (0.66)	0.09 (0.56)	0.75 (0.61)	0.04 (0.57)
QualifiedPersonnel_2NotImportant	-1.25* (0.72)	-0.37 (0.64)	0.65 (0.63)	1.04 (0.71)
PublicSupport_1Important	1.08 (0.67)	0.79 (0.55)	0.82 (0.59)	0.18 (0.53)
PublicSupport_2NotImportant	-2.54*** (0.83)	-2.06*** (0.72)	-1.32* (0.68)	-2.30*** (0.78)
ExternalPartners_1Important	-0.64 (0.94)	0.13 (0.80)	-1.55* (0.88)	0.27 (0.76)
ExternalPartners_2NotImportant	1.29 (0.80)	1.67** (0.68)	-0.17 (0.65)	-0.41 (0.63)
LowDemand_1Important	0.64 (0.72)	0.49 (0.62)	0.12 (0.65)	-0.51 (0.66)
LowDemand_2NotImportant	0.41 (0.76)	0.09 (0.63)	-1.06* (0.63)	0.03 (0.68)
HighCompetition_1Important	2.02** (0.86)	0.63 (0.58)	-0.21 (0.62)	0.31 (0.60)
HighCompetition_2NotImportant	1.38* (0.74)	1.90*** (0.71)	0.01 (0.61)	2.30*** (0.71)
Control Variables				

Trøndelag	*-0.69 (0.90)*	-0.12 (0.83)	*-0.89 (0.84)*	-0.22 (0.71)
Troms	*-0.25 (0.90)*	-0.96 (0.87)	*0.85 (0.81)*	0.47 (0.96)
SognogFjordane	-0.75 (0.99)	-0.82 (0.94)	1.62* (0.95)	0.47 (0.96)
RogalandogAgder	-0.12 (1.00)	-0.10 (0.89)	0.46 (0.88)	1.27 (0.92)
Nordland	-0.32 (0.83)	-1.13 (0.77)	1.16 (0.77)	1.29 (0.82)
MøreogRomsdal	0.17 (0.74)	-0.37 (0.68)	0.14 (0.67)	0.30 (0.77)
Hordaland	0.12 (0.80)	-0.45 (0.77)	1.20 (0.76)	0.60 (0.84)
Finnmark	-2.32* (1.35)	-1.94 (1.18)	0.40 (1.18)	-0.52 (1.27)
Education	0.59 (0.49)	0.04 (0.48)	0.49 (0.48)	0.34 (0.52)
Fisheries	-1.38** (0.65)	-1.48** (0.71)	-0.80 (0.65)	-0.87 (0.73)
FishProcessing	-1.01** (0.50)	-1.07** (0.48)	0.28 (0.47)	-0.15 (0.49)
Farming	-1.33** (0.61)	-0.66 (0.57)	1.14* (0.563)	-0.35 (0.64)
Small	-0.41 (1.41)	0.01 (1.11)	-0.58 (1.13)	0.16 (1.22)
Medium	0.09 (1.46)	1.01 (1.17)	-0.55 (1.18)	0.01 (1.28)
Constant	0.73 (1.60)	0.19 (1.26)	-0.80 (1.28)	-1.61 (1.39)
N	**206**	**206**	**206**	**206**
Pseudo R^2	**0.31**	**0.27**	**0.28**	**0.28**

*Note: First number in every cell represent the coefficient, with the standard error behind in parentheses. * P < 0.10 , ** P < 0.05 , *** P < 0.01 ,*

Overall, Table 3 shows that for *Model 1*: Total Product Innovation, the most important barriers that are significant are **InternalFunds_1Important** and **HighCompetition_1Important**. What is interesting is the fact that even though firms view these barriers as a very important obstacle for innovation, this analysis indicates that firms tend to innovate more despite their hindrance. In my point of view, this suggest that firms in the Norwegian seafood industry do not have any major barriers for Total Product Innovation. We can also notice how the three industry sectors; Fisheries, FishProcessing and Farming has an influence on Total Product Innovation but tends to innovate less. This indicates there is a higher likelihood of innovation within the Suppliers industry.

Model 2: Radical Product Innovation show none very important barriers with a significant influence. The analysis also show there is a relationship between firms in the fisheries and fish processing industry on radical product innovation, but it implies a negative likelihood towards innovation.

Model 3: Total Process Innovation show **InternalFunds_1Important** as the only important barrier with a significant influence on Total Process Innovation. This barrier implies a higher likelihood of innovation despite the barrier being seen as a hindrance. This imply that lack of internal funds is not a key barrier towards total process innovation. Firms located in

SognogFjordane show a higher likelihood of innovating than firms in other regions, as well as firms operating in the farming industry tend to innovate more than firms in other industries.
Model 4: Radical Process Innovation show none important barriers having an impact on Radical Process Innovation.

In sum, for all the four different innovation outcomes in Table 3, there is none very important barriers that are both significant and show a negative impact on innovation. This indicates that for firms in the Norwegian seafood industry, there is no major barriers to point out that are preventing them to innovate.

5.1.2 Logit Regression Result of Revised Models of Each Innovation Outcome

Table 4 shows the result from each revised model where only significant independent variables are included. Focusing on the *Revised Model 1*, we can see some interesting notations. We only have three independent variables transported over from the original model. By excluding the non-significant ones, we can see that even though **InternalFunds_1Important** is very significant and has a positive correlation on total product innovation, it is still lower than the original one. Here, the likelihood of product innovation is exp(1.43) = 317%, which is drastically less than the original model where the likelihood probability equalled 1106%.
Another interesting notation is the fact that **QualifiedPersonnel_2NotImportant** has no longer a significant influence on product innovation. While **PublicSupport_2NotImportant** have changed from a negative to a positive correlation on innovation. Now, in the revised model, the likelihood for total product innovation is exp(1.79) = 498% higher, for firms who do not see this factor as an important barrier. All of the industry sectors have a negative association with total product innovation

For *Revised Model 2*, the significant independent variables have the same influence on radical product innovation as they had in the original model. Fisheries and Fishprocessing are both significant, but the likelihood of radical product innovation for firms within these industries are respectively exp(-1.60) = 79% lower and exp(-0.80) =55% lower.

From Table 4, *Revised Model 3* indicates a positive correlation on total process innovation for firms that view **InternalFunds_1Important** as an important hindrance. The likelihood of product innovation is exp(2.11) = 724% for firms facing this barrier. Approximately 200% higher than the original model indicating higher significant when removing the non-relevant ones. **PublicSupport_2NotImportant** and **ExternalPartners_1Important** have less of a negative impact in the revised model compared to the original model within this innovation type.

In this model, we can see how the different regions have obtained a higher influential correlation on process innovation. Firms located in SognogFjordane, Nordland, and Hordaland tend to innovate more than firms outside of these regions. The likelihood of total process innovation for firms within the farming industry is exp(1.25)= 249% higher than firms within other industry sectors.

Lastly, the result for *Revised Model 4* indicates a higher negative influence when excluding the non-significant variables. The likelihood of radical process innovation is exp(-3.04) = 95% lower for firms who do not consider this barrier as a factor. Further, innovating in a non-competitive market still have a positive influence on radical process innovation. The control variables show now significant influence on radical process innovation.

Table 4: Logit Regression Result of Revised Models of Each Innovation Outcome

	Revised Model 1 Total Product Innovation	**Revised Model 2 Radical Product Innovation**	**Revised Model 3 Total Process Innovation**	**Revised Model 4 Radical Process Innovation**
Barriers				
InternalFunds_1Important	1.43*** (0.50)		2.11**** (0.47)	
InternalFunds_2NotImportant		-1.96**** (0.54)		
ExternalFunds_1Important				
ExternalFunds_2NotImportant				
QualifiedPersonnel_1Important				
QualifiedPersonnel_2NotImportant	-0.63 (0.51)			
PublicSupport_1Important				
PublicSupport_2NotImportant	1.79** (0.70)	-2.13*** (0.66)	-0.70 (0.44)	-3.04**** (0.59)
ExternalPartners_1Important			-0.63 (0.61)	
ExternalPartners_2NotImportant		1.35** (0.58)		

LowDemand_1Important				
LowDemand_2NotImportant			-0.43 (0.43)	
HighCompetition_1Important				
HighCompetition_2NotImportant		1.50*** (0.53)		1.94**** (0.55)
Control Variables				
Trøndelag	-0.35 (0.83)	-0.16 (0.79)	-0.65 (0.79)	-0.05 (0.86)
Troms	-0.30 (0.82)	-1.01 (0.80)	0.62 (0.75)	0.31 (0.83)
SognogFjordane	-0.82 (0.92)	-0.70 (0.91)	1.79* (0.92)	0.34 (0.99)
RogalandogAgder	-0.33 (0.93)	-0.23 (0.83)	0.45 (0.80)	1.26 (0.80)
Nordland	-0.33 (0.77)	-1.07 (0.73)	1.23* (0.73)	0.97 (0.75)
MøreogRomsdal	0.05 (0.70)	-0.44 (0.65)	0.29 (0.62)	0.35 (0.68)
Hordaland	-0.04 (0.76)	-0.61 (0.71)	1.31* (0.72)	0.60 (0.76)
Finnmark	-1.76** (0.61)	-1.74 (1.10)	0.01 (1.09)	-0.10 (1.15)
Education				
Fisheries	-1.41** (0.61)	-1.60** (0.67)	-0.53 (0.59)	-0.55 (0.65)
FishProcessing	-1.02** (0.46)	-0.80* (0.41)	0.30 (0.43)	-0.05 (0.42)
Farming	-1.37** (0.58)	-0.70 (0.56)	1.25** (0.60)	-0.60 (0.61)
Small	-1.22 (1.23)	-0.20 (1.04)	-0.13 (1.04)	-0.09 (1.07)
Medium	-0.62 (1.27)	0.73 (1.09)	0.30 (1.08)	-0.30 (1.12)
Constant	2.34* (1.34)	1.27 (1.09)	-0.41 (1.12)	-0.64 (1.15)
N	**206**	**206**	**206**	**206**
Pseudo R^2	**0.26**	**0.23**	**0.23**	**0.20**

*Note: First number in every cell represent the coefficient, with the standard error behind in parentheses. * P < 0.10 , ** P < 0.05 , *** P < 0.01 , **** P < 0.001*

Overall, Table 4 show the result of each models when we exclude all the non-significant barriers.

Revised Model 1: Total Product Innovation highlights **InternalFunds_1Important** as very significant but with a positive correlation indicating that firms tend to innovate more despite this being a very important barrier. The coefficient representing firms located in Finmark show a negative influence towards innovation despite its significant value. Fisheries, Fishprocessing, and Farming industries are all significant but have a tendency to innovate less.

Revised Model 2: Radical Product Innovation have none very important barriers included as none of them had any impact in the original *Model 2:* Radical Product Innovation. Fisheries and FishProcessing are both significant but less likely to innovate.

Revised Model 3: Total Process Innovation outline **InternalFunds_1Important** as very significant. But it has a positive coefficient indicating a higher chance of innovation. This suggest that lack of internal funds is not an important barrier preventing firms to innovate as it increases the likelihood of innovation. Further, firms located in SognogFjordane, Nordland, and Hordaland have a higher chance of introducing a process innovation. Firms within the farming industry tend to innovate more.

Revised Model 4: Radical Process Innovation show none very important barrier with a significant value.

In summary, for the Revised Models, there is no evidence of this result indicating any major barriers preventing firms in the Norwegian seafood industry to innovate.

5.2 Linking Data Integration with Literature Review Findings

From the descriptive analysis of the barriers, we have lack of internal funds, lack of qualified personnel and difficulties to get public support ranked highest as the three most important barriers to innovation. These are all barriers that the firm view as obstacles preventing them to innovate. But we cannot study its effect on innovation activities until we further investigate the factors by running a regression analysis.

For the literature review findings, we recognize high cost and funding as a threat to firms for not to innovate. Other important obstacles are built upon humans' belief and the operational part of a firm. How lack of technical skills and employee’s resistance to change have a negative influence on a firms innovation activity.

From the result of the analysis, we find no evidence of any key barriers preventing firms to innovate. Instead we find that barriers that were supposed to be very important barriers increased the likelihood of innovation, while the barriers who were view not important tend to diminish the likelihood of innovation.

5.3 Summary

The analysis conducted show no evidence proving any major barriers preventing firms to innovate in the Norwegian seafood industry, instead it shows the opposite. Very important barriers tend to increase the chance of innovation.

6 Conclusions and Recommendations

6.1 Conclusion

The goal of this thesis is to identify key barriers of increased implementation of automation for firms in the Norwegian seafood industry. The seafood industry is still very reliant on human labor, which damper the productivity and quality of the products produced. Automation brings many advantages when incorporated properly. It reduces production cost, enhance quality, accuracy and reliability. With its consistency and accuracy, the number of raw materials used can be concentrated, which reduces waste. Both empirical studies and the research provided in this thesis gives an impression that barriers exist at different levels and reduces the likelihood of integrating new innovative solutions.

Based on the literature given, the key barriers of innovation and increased use of automation are the high cost associated with either buying new equipment, investing in R&D, or the high cost of maintaining the new technological solutions provided. Further, we have seen how Norway is lacking on integrating the use of robots within different industries, providing the unavailability of robotics as an obstacle, which again is associated to expenditures as it is expensive to buy high-tech solutions outside of the country.
Another main barrier focuses on the way a firm operates, how they interact, controls, and make decisions. Together with employee's resistance to change, this is considered as a strong obstacle preventing a firm from enhancing innovation activities. Technologies that substitute, rather than augment employees are placing a threat on each firm. Internal capabilities with the focus on the technical skills and knowledge of the employees and managers are seen as an avoidance, as the implementation of automation requires high technical skills and knowledge in order to maintain and control new machinery and equipment.
Lastly, seasonality and variability of the raw materials are seen as a big threat of implementing new automated solutions based on the academic review. Within the seafood industry, raw materials come in different shape, texture and size. All this requires customized equipment in order to handle each object in the right way.

The quantitative research provided in this thesis focuses primarily on the barriers; lack of internal and external funds, lack of qualified personnel, difficulties to get public support, lack of external partners, uncertain demands for innovative ideas, and too high competition at the market. The survey indicates lack of internal funds, lack of qualifies personnel and difficulties to get public support as very important obstacles for innovation. Additionally, it outlined lack of external partners as a slightly important barrier.

The findings of the regression analysis indicate no evidence for any of the barriers to be a major obstacle preventing firms in the Norwegian seafood industry to innovate. Instead, it shows that the barriers who are seen as very important and significant have a higher tendency to innovate.

6.2 Limitations

The survey used was originally conducted for other purposes, where I drew questions of interest in to my analysis. With this in mind, the questionnaire used was not solely giving me the answers I was looking for in terms of barrier variables. The sample size of 206 responding firms can also be considered relatively small to draw a conclusion from.

Missing values was another challenge faced as the questionnaire represented a lot of missing values. For instance, a lot of the questions was either left blank or answered, "don't know". With this in mind, I had to make some adjustment, when firm answered whether or not they had introduced an innovation; missing values and "don't know" answers was adjusted to "no". Another adjustment I made for the questions concerning barriers, was that a lot of respondents left the answers blank. In order to get these missing values representative, I had to adjust them to "not that important". Furthermore, approximately 75% of the respondents represent smaller firms which can suggest less innovation activities as some of the firms only represents a few employees.

6.3 Recommendations for Future Research

For further research, I recommend conducting a survey with the intention of looking at the barriers of innovation and increased use of automation. As the technology is rapidly growing, and the importance of the seafood industry is growing, there is a need for the implementation of automation in order for Norwegian firms to stay competitive in the global market.

This analysis did not indicate any key barriers to innovation in the Norwegian seafood industry. The results suggest that there are other factors preventing firms from innovation as the seafood industry today is still lacking automated systems and machinery. The seafood industry is one of the most important industries for the Norwegian economy. One of the reasons why I believe this subject of interest is worth investigating on a higher scale.

References

Addy, R. (2013, April 7). *Researchers tackle Norway´s fish processing decline*. Hentet fra Fish Processing: https://www.bakeryandsnacks.com/Article/2013/04/08/Researchers-tackle-Norway-s-fish-processing-decline

AKVA. (2015, January 1). *AKVA Group*. Hentet fra Your Aquaculture Technology and Service Partner : http://www.akvagroup.com/home

Albert. (2016, November 26). *Albert.io*. Hentet fra Key Assumptions of OLS: Econometrics Review: https://www.albert.io/blog/key-assumptions-of-ols-econometrics-review/

Anfara, V. A., & Mertz, N. (2014). *Theoretical Frameworks in Qualitative Research* . U.K: SAGE Publications Inc.

(2011). *Aquaculture In Norway.* Oslo: the Norwegian Seafood Federation (FHL) and the Norwegian Seafood Council (NSC).

Arnarson, H., & Khodabandehloo, K. (1993). Fish processing using computer vision and robots. I K. Khodabandehloo, *Robotics in Meat, Fish, and Poultry Processing* (ss. 26-47). London: Sprincer Science+Business Media Dordrecht.

Baldwin, C., & von Hippel, E. (2015, August 7). Modeling a Paradigm Shift: From Producer Innovation to User and Open Collaborative Innovation . *Organization Science , 22*(6), 1399-1417.

Bhawna, & Gobind. (2015). Research Methodology and Approaches. *IOSR Journal of Research & Method in Education (IOSR-JRME), 5*(3), 48-51.

Buljo, J., & Gjerstad, T. (2013). Robotics and Automation in Seafood Processing. I D. G. Caldwell, *Robotics and Automation in the Food Industry: Current and Future Technologies* (ss. 354-384). Norway: Woodhead Publishing Limited.

Caldwell, D. G. (2003). *Robotics and Automation in the Food Industry: Current and Future Technologies.* Cambridge: Woodhead Publishing Limited.

Chesbrough, H. W. (2003, April 15). *MIT Sloan Management Review* . Hentet May 1, 2018 fra The Era of Open Innovation: https://sloanreview.mit.edu/article/the-era-of-open-innovation/

CIO Whitepapers Review. (2018, January 1). *CIO Whitepapers Review*. Hentet March 5, 2018 fra What is Digitalization?: https://whatis.ciowhitepapersreview.com/definition/digitalization/

CIRT. (2018, January 1). *Center for Innovation in Research and Teaching*. Hentet May 3, 2018 fra Variables and Operational Definitions: https://cirt.gcu.edu/research/developmentresources/research_ready/quantresearch/variables_def

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches - 2nd Edition.* Thousand Oaks: SAGE Publications.

Creswell, J. W. (2009). *Research Design - Qualitative, Quantiative, and Mixed Methods Approaches* (3rd Edition. utg.). California: SAGE Publications Inc.

Creswell, J. W. (2009). *Research Design - Qualitative, Quantiative, and Mixed Methods Approaches.* California: SAGE Publications.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches - 4th Edition.* California: SAGE Publications Inc.

Encyclopaedia Britannica. (2018, March 16). *Automation*. Hentet April 3, 2018 fra Automation: https://www.britannica.com/technology/automation

Encyclopaedia Britannica. (2018, January 1). *Robotics*. Hentet April 3, 2018 fra Technology: https://www.britannica.com/technology/robotics

Encyclopedia. (2016). *Encyclopedia.com*. Hentet fra Ordinary Least Squares Regression: https://www.encyclopedia.com/social-sciences/applied-and-social-sciences-magazines/ordinary-least-squares-regression

EU Fusions. (2016, January 1). *EU FUSIONS* . Hentet fra Food Waste Definition: https://www.eu-fusions.org/index.php/about-food-waste/280-food-waste-definition

Eurofish. (2016, January 1). *Eurofish*. Hentet fra Overview of the Norwegian fisheries and aquaculture sector : http://www.eurofish.dk/norway

EY. (2017). *The Norwegian Aquaculture Analysis 2016.* Norway: EYGM Limited.

EY. (2018). *The Norwegian Aquaculture Analysis 2017.* Norway: EYGM Limited .

Fagerberg, J. (2005). Innovation - A Guide to the Litterature. I J. Fagerberg, D. C. Mowery, & R. R. Nelson, *The Oxford Handbook of Innovation* (ss. 1-23). Oxford: Oxford University Press.

FAO. (2011, January 1). *Fishery and Aquaculture Country Profiles* . Hentet fra The Kingdom of Norway: http://www.fao.org/fishery/facp/NOR/en

FAO. (2011, May 16). *Global Food Losses and Food Waste* . Hentet fra Extent of food losses and waste: http://www.fao.org/docrep/014/mb060e/mb060e02.pdf

FAO. (2018, January 1). *Food and Agriculture Organization of the United Nations*. Hentet March 18, 2018 fra Save Food: Global Initiative on Food Loss and Waste Reduction: www.fao.org/save-food/resources/keyfindings/en

FAO. (2018, January 1). *National Aquaculture Sector Overview Norway*. Hentet fra Characteristics, structure and resources of the sector: http://www.fao.org/fishery/countrysector/naso_norway/en

FHL. (2013). *ENVIRONMENTAL REPORT Norwegian Seafood Industry.* Oslo: the Norwegian Seafood Federation.

Fiskeridirektoratet. (2018, March 20). *Fiskeridirektoratet.* Hentet fra Fiskere fra fiskermanntallet: https://www.fiskeridir.no/Yrkesfiske/Statistikk-yrkesfiske/Fiskere-fartoey-og-tillatelser/Fiskere-fra-fiskermanntallet

Gartner Inc. (2018, January 1). *Gartner*. Hentet March 5, 2018 fra IT Glossary: https://www.gartner.com/it-glossary/digitalization/

Government. (2017, June 28). *Agreement to reduce food waste*. Hentet April 6, 2018 fra Government.no: https://www.regjeringen.no/en/aktuelt/agreement-to-reduce-food-waste/id2558931/

Government of Canada. (2014, August 30). *Technology readiness assessment of automation and robotics in the food and beverage processing sector in Canada*. Hentet April 17, 2018 fra Food and Beverage Processing: https://www.ic.gc.ca/eic/site/026.nsf/eng/00126.html

Green, D. (2013). Automation in Seafood Processing. *Journal of Aquatic Food Product Technology, 22*(4), 337-338.

Green, D. (2013, February 28). *New Food*. Hentet fra Emerging technologies with automation: https://www.newfoodmagazine.com/article/10082/emerging-technologies-with-automation/

Hanssen, O. J., & Stensgård, A. (2016). *Food Waste in Norway 2010-2015.* Østfold: Østfolforskning.

Henchion, M., Hayes, M., Mullen, A., Fenelon, M., & Tiwari, B. (2017). *Future Protein Supply and Demand: Strategies and Factors Influencing a Sustainable Equilibrium.* MDPI: Foods.

IFR. (2017). *IFR World Robotics.* Hentet fra Executive Summary World Robotics 2017 Industrial Robots: https://ifr.org/downloads/press/Executive_Summary_WR_2017_Industrial_Robots.pdf

IFR. (2018). *Executive Summary World Robotics 2017 Industrial Robots.* Germany: International Federation of Robotics .

IFR. (2018, March 1). *The Atlas* . Hentet fra Robot Density Report: https://www.theatlas.com/i/atlas_H1Lx-4_Kz@2x.png

Innovation Norway. (2016). *Innovasjon Norge.* Hentet fra Annual Report: https://www.innovasjonnorge.no/contentassets/65b4f155f38244ef8a35192c668f7de7/in-annual-accounts-2016.pdf

Iris Group. (2015). *Digitalisation and automation in the Nordic manufacturing sector.* Copenhagen: Nordic Council of Ministers .

IrisGroup. (2015). *Digitalisation and Automation in Nordic Manufacturing Sector.* Denmark: Nordic Council of Ministers .

IrisGroup. (2015). *Digitalisation and Automation in the Nordic manucaturing sector.* Denmark: Nordic Council of Ministers .

i-SCOOP. (2016, January 1). *i-SCOOP*. Hentet April 24, 2018 fra Moving from digitization to digitalization: https://www.i-scoop.eu/information-management/moving-digitization-digitalization/

Jack, L., & Read, B. (2008). Raw Material Selection: Fish. *Woodhead Publishing Series in Food Science, Technology and Nutrition*, ss. 83-108.

Juma, C. (2016, July 6). *Why do people resist new technologies? History might provide the answer*. Hentet April 10, 2018 fra World Economic Forum: https://www.weforum.org/agenda/2016/07/why-do-people-resist-new-technologies-history-has-answer/

Kothari, C. R. (2004). *Research Methodology: Methods adn Techniques* (2nd Revised Edition. utg.). New Delhi: New Age International (P) Limited, Publishers.

Kvistad, A. (2017, April 6). *SjømatNorge*. Hentet fra Leverandørene til sjømatbedriftene vokser: Suppliers offer technological solutions, construction, consulting, and service to help supplement a firms performance.

Laursen, K., & Salter, A. (2006, June 13). OPEN FOR INNOVATION: THE ROLE OF OPENNESS IN EXPLAINING INNOVATION PERFORMANCE AMONG U.K. MANUFACTURING FIRMS. *Strategic Management Journal*, ss. 131-150.

Leedy, P. D., & Ormrod, J. E. (2010). *Practical Research: Planning and Design* (9th. utg.). New Jersey: Pearson Education Inc.

Lybæk, S. (2016, May 25). *Dyrevernalliansen*. Hentet fra Fish farming in Norway: https://www.dyrevern.no/english/fish-farming-in-norway

Merriam-Webster. (2018, May 20). *Merriam-Webster Dictionary.* Hentet fra Barrier: https://www.merriam-webster.com/dictionary/barrier

Mirriam-Webster. (2018, May 30). *Dictionary* . Hentet fra Definition of Seafood: https://www.merriam-webster.com/dictionary/seafood

NAV. (2015). *WORKING IN THE SEAFOOD AND FISH INDUSTRY IN NORWAY.* Norway: NAV.

Nayik, G. A., Muzaffar, K., & Gull, A. (2015). Robotics and Food Technology: A Mini Review. *Journal of Nutrition & Food Sciences*, s. 4.

NOAA. (2018, February 21). *National Oceanic and Atmospheric Administration*. Hentet fra What is Aquaculture?: https://oceanservice.noaa.gov/facts/aquaculture.html

Nofima. (2016, January 28). *Nofima*. Hentet fra Looking into fish: https://nofima.no/en/nyhet/2016/01/looking-into-fish/?lang=en

Nofima. (2016, January 30). *Nofima*. Hentet fra Fra virkemiddel til verdi: https://nofima.no/nyhet/2016/01/fra-virkemiddel-til-verdi/

Nofima. (2017, September 19). *Nofima.* Hentet fra Under halvparten av arbeidstakerne i fiskeforedling er norske: https://nofima.no/nyhet/2017/09/under-halvparten-av-arbeidstakerne-i-fiskeforedling-er-norske/

Norwegian Seafood Council. (2018, January 1). *Seafood From Norway*. Hentet fra https://herring.fromnorway.com/norway/history/

Norwegian Seafood Federation . (2011). *Aquaculture in Norway.* Norway: Gunnarshaug Trykkeri AS. Hentet fra Aquaculture in Norway: https://sjomatnorge.no/wp-content/uploads/importedfiles/Aquaculture%2520in%2520Norway%25202011.pdf

OECD. (2002, January 1). *OECD.* Hentet April 30, 2018 fra Oslo Manual - THE MEASUREMENT OF SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES : https://www.oecd.org/sti/inno/2367580.pdf

OECD. (2005). *Oslo Manual - GUIDELINES FOR COLLECTING AND INTERPRETING INNOVATION DATA* . Oslo: A joint publication of OECD and Eurostat .

Oxford Dictionaries . (2018, January 1). *Robotics*. Hentet April 24, 2018 fra Robotics: https://en.oxforddictionaries.com/definition/robotics

Pedace, R. (2013). *Econometrics For Dummies.* USA: For Dummies.

Polit, D. F., & Beck, C. T. (2006). *Essentials of Nursing Research - Methods, Appraisal, and Utilization* (6th. utg.). Philadelphia: Lippincott Williams & Wilkins.

Polit, D. F., & Beck, C. T. (2010). *Essentials of Nursing Research.* USA: Wolters Kluwer.

Polit, D. F., & Tatano Beck, C. (2006). *Essentials of Nursing Resarch.* Philadelphia: Lippincott Williams and Wilkins.

Pontius, N. (2017, February 22). *Business.com.* Hentet fra Operational Innovation: Barriers, Benefits and a Roadmap for Success: https://www.business.com/articles/nicole-pontius-innovation-operations-roadmap/

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). *Interorganizational Collaboration and the Locus of Innovation: Networks of Learning Biotechnology.* Arizona: Cornell University.

Powell, W. W., Koput, K., & Smith-Doerr, L. (1996). Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. *Administrative Science Quarterly* , ss. 116-145.

Purnell, G. (2013). Robotics and automaiton in meat processing. I D. G. Caldwell, *Robotics and Automation in the Food Industry: Current and Future Technologies.* Oxford: Woodhead Publishing Limited.

Quick, D. (2014, January 29). *New Atlas*. Hentet fra Something fishy about new robotic filleting machine: https://newatlas.com/apricot-project-robotic-fish-filleting/30644/

Regjeringen. (2016, September 9). *Regjeringen.no*. Hentet fra Alt klart for nye Trøndelag: https://www.regjeringen.no/no/aktuelt/nye-trondelag/id2513205/

RobotWorx. (2018, January 1). *Robotic Industry News*. Hentet April 3, 2018 fra Advantages of Automation: https://www.robots.com/articles/advantages-of-automation

Rubin, A., & Babbie, E. (2001). *Research Methods for Social Work* (4th Edition. utg.). Belmont: Wadsworth.

Sandey, K. K., Qureshi, M. A., Meshram, B. D., Agrawal, A., & Uprit, S. (2017, January 1). Robotics – An Emerging Technology in Dairy Industry. *International Journal of Engineering Trends and Technology (IJETT)*, ss. 58-62.

Schumpeter, J. (2005). The Innovation theorist Joseph Schumpeter. I J. Fagerberg, D. C. Mowery, & R. R. Nelson, *The Oxford Handbook of Innovation* (s. 6). Oxford: Oxford University Press.

SINTEF. (2013). *Automatic fish handling system onboard.* Bergen: SINTEF.

SINTEF. (2013, January 9). *SINTEF.* Hentet fra Still good hope for the Norwegian fish-processing industry: https://www.sintef.no/en/latest-news/still-good-hope-for-the-norwegian-fish-processing-industry/

SINTEF. (2015). *Towards a holistic approach for barrier management in the petroleum industry.* Trondheim: SINTEF.

Sjømatnasjonen. (2018, January 1). Hentet fra Sjømatnasjonen Norge 2018: https://sjomatnasjonen.seafood.no

SjømatNorge. (2016). *SjømatNorge Årsmelding 2016.* Norge: SjømatNorge.

Soffar, H. (2016, May 20). *Online Sciences*. Hentet fra Advantages and disadvantages of using robots in our life: https://www.online-sciences.com/robotics/advantages-and-disadvantages-of-using-robots-in-our-life/

Stock, J. H., & Watson, M. W. (2015). *Introduction to Econometrics.* Essex: Pearson Education Limited .

Suresh, S. (2014). *Nursing Research and Statistics* . India: Elsevier.

Talegeta, S. (2014, March). Innovation and Barriers to Innovation: Small and Medium Enterprises in Addis Ababa. *Journal of Small Business and Entrepreneurship Development, 2*(6), 83-106.

Techopedia. (2018, January 1). *Techopedia*. Hentet May 1, 2018 fra Artificial Intelligence (AI): https://www.techopedia.com/definition/190/artificial-intelligence-ai

Techopedia Inc. (2018, January 1). *Techopedia*. Hentet May 1, 2018 fra Isaac Asimov: https://www.techopedia.com/definition/32134/isaac-asimov

Teknologirådet. (2013). *Made in Norway?* Oslo: ILAS Grafisk.

Teknologirådet. (2014). *Made in Norway?* Oslo: ILAS Grafisk.

Teknologirådet. (2014). *Made in Norway? How Robots, 3D Printers and Digitalization Can Open Up New Opportunities for Norwegian Manufacturing.* Oslo: ILAS Grafisk.

The International Soceity of Automation. (2018, January 1). *ISA*. Hentet March 5, 2018 fra What is Automation?: https://www.isa.org/about-isa/what-is-automation/

The Oxford English Dictionary . (2018, January 1). *The Oxford English Dictionary* . Hentet May 1, 2018 fra Automation: https://en.oxforddictionaries.com/definition/automation

Tidd, J., & Bessant, J. (2014). *Strategic Innovation Management.* London, United Kingdom: Wiley.

Trochim, W. M. (2002). *What is the Research Methods Knowledge Base?* USA: William M.K. Trochim. Hentet fra http://anatomyfacts.com/Research/ResearchMethodsKnowledgeBase.pdf

Williams, C. (2007, March). Research Methods. *Journal of Business & Economic Research, 5*(3), 65-71.

Wooldridge, J. M. (2016). *Introductory Ecenometrics: A Modern Approach.* Australia: Cengage Learning.

7 Appendix A – Logit Models Stata Results

Model 1: Total Product Innovation

```
Iteration 0:   log likelihood = -136.15367
Iteration 1:   log likelihood = -97.306727
Iteration 2:   log likelihood = -93.631818
Iteration 3:   log likelihood = -93.450759
Iteration 4:   log likelihood = -93.450392
Iteration 5:   log likelihood = -93.450392

Logistic regression                               Number of obs     =        206
                                                  LR chi2(28)       =      85.41
                                                  Prob > chi2       =     0.0000
Log likelihood = -93.450392                       Pseudo R2         =     0.3136
```

TotalProduc~n	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
InternalFun~1	2.485502	1.114737	2.23	0.026	.3006585	4.670345
InternalFun~2	-1.070246	1.137456	-0.94	0.347	-3.299619	1.159127
ExternalFun~1	-1.801513	1.251458	-1.44	0.150	-4.254326	.6513
ExternalFun~2	1.463489	1.245312	1.18	0.240	-.9772786	3.904256
QualifiedPe~1	.3739504	.6612361	0.57	0.572	-.9220485	1.669949
QualifiedPe~2	-1.250692	.7211734	-1.73	0.083	-2.664166	.1627819
PublicSuppo~1	1.076131	.6688956	1.61	0.108	-.2348804	2.387142
PublicSuppo~2	-2.541234	.8262579	-3.08	0.002	-4.16067	-.9217984
ExternalPar~1	-.6433968	.9411584	-0.68	0.494	-2.488033	1.20124
ExternalPar~2	1.29412	.7986757	1.62	0.105	-.2712556	2.859496
LowDemand_1	.6413	.7153121	0.90	0.370	-.760686	2.043286
LowDemand_2	.4085891	.7594694	0.54	0.591	-1.079944	1.897122
HighCompeti~1	2.022981	.8574383	2.36	0.018	.342433	3.703529
HighCompeti~2	1.383815	.7375139	1.88	0.061	-.061686	2.829315
Trøndelag	-.6887666	.8966102	-0.77	0.442	-2.44609	1.068557
Troms	-.2511439	.896651	-0.28	0.779	-2.008548	1.50626
SognogFjord~e	-.7549713	.9867169	-0.77	0.444	-2.688901	1.178958
RogalandogA~r	-.1219337	1.000418	-0.12	0.903	-2.082718	1.83885
Nordland	-.3150363	.8263612	-0.38	0.703	-1.934674	1.304602
MøreogRomsdal	.1693959	.7356541	0.23	0.818	-1.27246	1.611251
Hordaland	.1200652	.8014432	0.15	0.881	-1.450735	1.690865
Finnmark	-2.319403	1.348297	-1.72	0.085	-4.962017	.3232096
Education	.0591213	.4914463	0.12	0.904	-.9040957	1.022338
Fisheries	-1.378544	.6459319	-2.13	0.033	-2.644547	-.1125405
FishProcess~g	-1.013243	.4986442	-2.03	0.042	-1.990568	-.0359185
Farming	-1.33239	.6109262	-2.18	0.029	-2.529783	-.1349963
Small	-.4104414	1.409879	-0.29	0.771	-3.173753	2.35287
Medium	.0875682	1.458706	0.06	0.952	-2.771444	2.94658
_cons	.7293635	1.599454	0.46	0.648	-2.405509	3.864236

Revised Model 1: Total Product Innovation

```
Iteration 0:   log likelihood = -136.15367
Iteration 1:   log likelihood = -101.83122
Iteration 2:   log likelihood = -100.21313
Iteration 3:   log likelihood =  -100.1894
Iteration 4:   log likelihood = -100.18939

Logistic regression                               Number of obs     =        206
                                                  LR chi2(18)       =      71.93
                                                  Prob > chi2       =     0.0000
Log likelihood = -100.18939                       Pseudo R2         =     0.2641
```

TotalProductionInnovation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
InternalFunds_1	1.430697	.5011383	2.85	0.004	.4484836	2.41291
QualifiedPersonnel_2	-.6347379	.5078765	-1.25	0.211	-1.630158	.3606817
PublicSupport_2	-1.718284	.5494485	-3.13	0.002	-2.795184	-.6413851
HighCompetition_1	1.78904	.7024096	2.55	0.011	.4123421	3.165737
HighCompetition_2	1.386727	.5694069	2.44	0.015	.2707098	2.502744
Trøndelag	-.3502887	.8345319	-0.42	0.675	-1.985941	1.285364
Troms	-.2984888	.8212545	-0.36	0.716	-1.908118	1.311141
SognogFjordane	-.8155445	.9236104	-0.88	0.377	-2.625788	.9946986
RogalandogAgder	-.3251834	.9254619	-0.35	0.725	-2.139055	1.488689
Nordland	-.3281498	.770768	-0.43	0.670	-1.838827	1.182528
MøreogRomsdal	.0522045	.6962388	0.07	0.940	-1.312399	1.416808
Hordaland	-.0383118	.7613524	-0.05	0.960	-1.530535	1.453912
Finnmark	-1.758409	1.155443	-1.52	0.128	-4.023035	.5062178
Fisheries	-1.405565	.6132761	-2.29	0.022	-2.607564	-.2035657
FishProcessing	-1.02201	.4609541	-2.22	0.027	-1.925463	-.118556
Farming	-1.366373	.576276	-2.37	0.018	-2.495853	-.2368931
Small	-1.220585	1.234882	-0.99	0.323	-3.64091	1.19974
Medium	-.6201192	1.273001	-0.49	0.626	-3.115155	1.874917
_cons	2.341074	1.340104	1.75	0.081	-.2854811	4.967629

Model 2: Radical Product Innovation

```
Iteration 0:   log likelihood = -142.70093
Iteration 1:   log likelihood = -104.82849
Iteration 2:   log likelihood = -103.95082
Iteration 3:   log likelihood = -103.94712
Iteration 4:   log likelihood = -103.94712

Logistic regression                               Number of obs     =        206
                                                  LR chi2(28)       =      77.51
                                                  Prob > chi2       =     0.0000
Log likelihood = -103.94712                       Pseudo R2         =     0.2716
```

RadicalProd~n	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
InternalFun~1	.5299386	.6874259	0.77	0.441	-.8173914	1.877269
InternalFun~2	-1.713254	.97578	-1.76	0.079	-3.625747	.1992401
ExternalFun~1	-.3722229	.7829044	-0.48	0.634	-1.906687	1.162242
ExternalFun~2	-.0296889	.9303771	-0.03	0.975	-1.853194	1.793817
QualifiedPe~1	.0851481	.5626965	0.15	0.880	-1.017717	1.188013
QualifiedPe~2	-.3723417	.6437699	-0.58	0.563	-1.634107	.889424
PublicSuppo~1	.7898484	.5464725	1.45	0.148	-.2812179	1.860915
PublicSuppo~2	-2.055745	.7182342	-2.86	0.004	-3.463459	-.6480322
ExternalPar~1	.1269003	.8026255	0.16	0.874	-1.446217	1.700017
ExternalPar~2	1.673181	.6768586	2.47	0.013	.3465626	2.9998
LowDemand_1	.4880746	.6125876	0.80	0.426	-.712575	1.688724
LowDemand_2	.0862597	.6311149	0.14	0.891	-1.150703	1.323222
HighCompeti~1	.6319714	.5803571	1.09	0.276	-.5055076	1.76945
HighCompeti~2	1.896696	.7080339	2.68	0.007	.5089752	3.284417
Trøndelag	-.1221467	.8259822	-0.15	0.882	-1.741042	1.496749
Troms	-.9581811	.8697432	-1.10	0.271	-2.662846	.7464842
SognogFjord~e	-.8163297	.9436723	-0.87	0.387	-2.665893	1.033234
RogalandogA~r	-.0959067	.8909365	-0.11	0.914	-1.84211	1.650297
Nordland	-1.132389	.7662822	-1.48	0.139	-2.634275	.3694966
MøreogRomsdal	-.3726488	.6833486	-0.55	0.586	-1.711988	.9666899
Hordaland	-.45481	.742252	-0.61	0.540	-1.909597	.9999771
Finnmark	-1.933712	1.184601	-1.63	0.103	-4.255487	.3880633
Education	.0427728	.4813438	0.09	0.929	-.9006437	.9861894
Fisheries	-1.481971	.7086814	-2.09	0.037	-2.870961	-.0929812
FishProcess~g	-1.068658	.4720038	-2.26	0.024	-1.993768	-.143547
Farming	-.6558264	.5738456	-1.14	0.253	-1.780543	.4688904
Small	.0169018	1.113831	0.02	0.988	-2.166168	2.199971
Medium	1.009167	1.171246	0.86	0.389	-1.286433	3.304767
_cons	.191991	1.262474	0.15	0.879	-2.282412	2.666394

Revised Model 2: Radical Product Innovation

```
Iteration 0:   log likelihood = -142.70093
Iteration 1:   log likelihood =   -109.882
Iteration 2:   log likelihood = -109.24745
Iteration 3:   log likelihood = -109.24378
Iteration 4:   log likelihood = -109.24378

Logistic regression                               Number of obs     =        206
                                                  LR chi2(17)       =      66.91
                                                  Prob > chi2       =     0.0000
Log likelihood = -109.24378                       Pseudo R2         =     0.2345
```

RadicalProductInnovation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
InternalFunds_2	-1.958056	.5402298	-3.62	0.000	-3.016887	-.8992248
PublicSupport_2	-2.133994	.6553709	-3.26	0.001	-3.418497	-.8494906
ExternalPartners_2	1.349294	.5817674	2.32	0.020	.2090509	2.489537
HighCompetition_2	1.488352	.533173	2.79	0.005	.4433523	2.533352
Trøndelag	-.1627697	.7816697	-0.21	0.835	-1.694814	1.369275
Troms	-1.009898	.8041415	-1.26	0.209	-2.585986	.5661907
SognogFjordane	-.6992827	.9197336	-0.76	0.447	-2.501927	1.103362
RogalandogAgder	-.226674	.8334924	-0.27	0.786	-1.860289	1.406941
Nordland	-1.072177	.7300673	-1.47	0.142	-2.503083	.3587285
MøreogRomsdal	-.4402099	.6544619	-0.67	0.501	-1.722932	.8425118
Hordaland	-.610253	.7129983	-0.86	0.392	-2.007704	.7871979
Finnmark	-1.738531	1.093146	-1.59	0.112	-3.881057	.4039957
Fisheries	-1.585783	.6677404	-2.37	0.018	-2.89453	-.2770356
FishProcessing	-.7840819	.416887	-1.88	0.060	-1.601165	.0330015
Farming	-.6986029	.5586505	-1.25	0.211	-1.793538	.396332
Small	-.1901105	1.035559	-0.18	0.854	-2.219769	1.839548
Medium	.7318115	1.089181	0.67	0.502	-1.402944	2.866567
_cons	1.27419	1.087544	1.17	0.241	-.8573572	3.405737

Model 3: Total Process Innovation

```
Iteration 0:   log likelihood = -141.38708
Iteration 1:   log likelihood = -103.35721
Iteration 2:   log likelihood = -102.42071
Iteration 3:   log likelihood = -102.41308
Iteration 4:   log likelihood = -102.41308

Logistic regression                               Number of obs     =        206
                                                  LR chi2(28)       =      77.95
                                                  Prob > chi2       =     0.0000
Log likelihood = -102.41308                       Pseudo R2         =     0.2757
```

TotalProcessInnovation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
InternalFunds_1	1.841792	.7781479	2.37	0.018	.3166499	3.366934
InternalFunds_2	1.105792	.9494626	1.16	0.244	-.7551209	2.966704
ExternalFunds_1	.9596063	.9182205	1.05	0.296	-.8400728	2.759285
ExternalFunds_2	.1392109	.897874	0.16	0.877	-1.62059	1.899012
QualifiedPersonnel_1	.7509255	.6069112	1.24	0.216	-.4385987	1.94045
QualifiedPersonnel_2	.6466026	.6287324	1.03	0.304	-.5856902	1.878895
PublicSupport_1	.8203135	.5927935	1.38	0.166	-.3415404	1.982167
PublicSupport_2	-1.321092	.6837232	-1.93	0.053	-2.661165	.0189807
ExternalPartners_1	-1.553946	.8733573	-1.78	0.075	-3.265695	.157803
ExternalPartners_2	.166446	.6499573	0.26	0.798	-1.107447	1.440339
LowDemand_1	.1206123	.6455748	0.19	0.852	-1.144691	1.385916
LowDemand_2	-1.064793	.6282158	-1.69	0.090	-2.296073	.1664872
HighCompetition_1	-.21302	.6168812	-0.35	0.730	-1.422085	.996045
HighCompetition_2	.0142725	.6263883	0.02	0.982	-1.213426	1.241971
Trøndelag	-.8927308	.8379724	-1.07	0.287	-2.535127	.749665
Troms	.845219	.8071224	1.05	0.295	-.7367119	2.42715
SognogFjordane	1.621654	.954367	1.70	0.089	-.2488707	3.492179
RogalandogAgder	.4649053	.8755695	0.53	0.595	-1.251179	2.18099
Nordland	1.15596	.7715863	1.50	0.134	-.356321	2.668242
MøreogRomsdal	.1386177	.6678241	0.21	0.836	-1.170294	1.447529
Hordaland	1.197372	.7624289	1.57	0.116	-.296961	2.691705
Finnmark	.4026063	1.179882	0.34	0.733	-1.909919	2.715132
Education	.488706	.474882	1.03	0.303	-.4420457	1.419458
Fisheries	-.8002652	.645722	-1.24	0.215	-2.065857	.4653266
FishProcessing	.0276002	.467181	0.06	0.953	-.8880578	.9432581
Farming	1.139377	.6284666	1.81	0.070	-.092395	2.371149
Small	-.5759359	1.131032	-0.51	0.611	-2.792718	1.640846
Medium	-.5520976	1.184494	-0.47	0.641	-2.873663	1.769468
_cons	-.7994292	1.281411	-0.62	0.533	-3.310948	1.71209

Revised Model 3: Total Process Innovation

```
Iteration 0:   log likelihood = -141.38708
Iteration 1:   log likelihood =  -109.0191
Iteration 2:   log likelihood = -108.56228
Iteration 3:   log likelihood = -108.56114
Iteration 4:   log likelihood = -108.56114

Logistic regression                               Number of obs     =        206
                                                  LR chi2(17)       =      65.65
                                                  Prob > chi2       =     0.0000
Log likelihood = -108.56114                       Pseudo R2         =     0.2322
```

TotalProcessInnovation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
InternalFunds_1	2.114526	.4694851	4.50	0.000	1.194352	3.0347
PublicSupport_2	-.6949221	.4368133	-1.59	0.112	-1.55106	.1612161
ExternalPartners_1	-.6313704	.6126518	-1.03	0.303	-1.832146	.569405
LowDemand_2	-.4260841	.4285881	-0.99	0.320	-1.266101	.413933
Trøndelag	-.6549847	.7906852	-0.83	0.407	-2.204699	.8947298
Troms	.621848	.7541362	0.82	0.410	-.8562319	2.099928
SognogFjordane	1.793423	.9166276	1.96	0.050	-.0031346	3.58998
RogalandogAgder	.4458929	.8006505	0.56	0.578	-1.123353	2.015139
Nordland	1.226332	.7229354	1.70	0.090	-.1905949	2.64326
MøreogRomsdal	.2801954	.6245443	0.45	0.654	-.943889	1.50428
Hordaland	1.305921	.7216504	1.81	0.070	-.1084882	2.720329
Finnmark	.0044169	1.086844	0.00	0.997	-2.125759	2.134593
Fisheries	-.5301064	.5900921	-0.90	0.369	-1.686666	.626453
FishProcessing	.3018337	.4323777	0.70	0.485	-.5456109	1.149278
Farming	1.252139	.6034563	2.07	0.038	.0693863	2.434891
Small	-.1257926	1.037654	-0.12	0.904	-2.159557	1.907971
Medium	.2941958	1.08255	0.27	0.786	-1.827563	2.415954
_cons	-.410481	1.121822	-0.37	0.714	-2.609211	1.788249

Model 4: Radical Process Innovation

```
Iteration 0:   log likelihood = -132.68012
Iteration 1:   log likelihood = -98.298985
Iteration 2:   log likelihood = -96.146184
Iteration 3:   log likelihood = -96.110462
Iteration 4:   log likelihood = -96.110417
Iteration 5:   log likelihood = -96.110417

Logistic regression                               Number of obs     =        206
                                                  LR chi2(28)       =      73.14
                                                  Prob > chi2       =     0.0000
Log likelihood = -96.110417                       Pseudo R2         =     0.2756
```

RadicalProc~n	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
InternalFun~1	.8172354	.6435488	1.27	0.204	-.4440971	2.078568
InternalFun~2	-1.249133	.8770936	-1.42	0.154	-2.968204	.4699392
ExternalFun~1	.2630011	.7259732	0.36	0.717	-1.15988	1.685882
ExternalFun~2	-.3016612	.8241198	-0.37	0.714	-1.916906	1.313584
QualifiedPe~1	.0437577	.5669068	0.08	0.938	-1.067359	1.154875
QualifiedPe~2	1.035811	.7067629	1.47	0.143	-.3494185	2.421041
PublicSuppo~1	.1801105	.53045	0.34	0.734	-.8595524	1.219773
PublicSuppo~2	-2.300895	.7818035	-2.94	0.003	-3.833201	-.768588
ExternalPar~1	.2661973	.7648413	0.35	0.728	-1.232864	1.765259
ExternalPar~2	-.4101464	.6334932	-0.65	0.517	-1.65177	.8314774
LowDemand_1	-.5057766	.6628914	-0.76	0.445	-1.80502	.7934667
LowDemand_2	.0331746	.6792244	0.05	0.961	-1.298081	1.36443
HighCompeti~1	.3121621	.5997471	0.52	0.603	-.8633206	1.487645
HighCompeti~2	2.30249	.706148	3.26	0.001	.9184654	3.686515
Trøndelag	-.2181042	.9659322	-0.23	0.821	-2.111296	1.675088
Troms	.467334	.9545906	0.49	0.624	-1.403629	2.338297
SognogFjord~e	.7251817	1.06905	0.68	0.498	-1.370118	2.820481
RogalandogA~r	1.27269	.9184301	1.39	0.166	-.5273996	3.07278
Nordland	1.2892	.8170522	1.58	0.115	-.3121929	2.890593
MøreogRomsdal	.2936652	.7747649	0.38	0.705	-1.224846	1.812176
Hordaland	.6042696	.8432972	0.72	0.474	-1.048563	2.257102
Finnmark	-.5212157	1.268012	-0.41	0.681	-3.006473	1.964041
Education	.3395752	.5209627	0.65	0.515	-.681493	1.360643
Fisheries	-.8734761	.7279533	-1.20	0.230	-2.300238	.5532861
FishProcess~g	-.1479935	.4881465	-0.30	0.762	-1.104743	.808756
Farming	-.3503816	.6419477	-0.55	0.585	-1.608576	.9078128
Small	.1634059	1.219689	0.13	0.893	-2.22714	2.553952
Medium	.0045223	1.280542	0.00	0.997	-2.505295	2.51434
_cons	-1.619038	1.393763	-1.16	0.245	-4.350764	1.112688

Revised Model 4: Radical Process Innovation

```
Iteration 0:   log likelihood = -132.68012
Iteration 1:   log likelihood = -107.76328
Iteration 2:   log likelihood = -106.64196
Iteration 3:   log likelihood =  -106.6389
Iteration 4:   log likelihood =  -106.6389

Logistic regression                               Number of obs     =        206
                                                  LR chi2(15)       =      52.08
                                                  Prob > chi2       =     0.0000
Log likelihood =  -106.6389                       Pseudo R2         =     0.1963
```

RadicalProcessInnovation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
PublicSupport_2	-3.041624	.587617	-5.18	0.000	-4.193332	-1.889916
HighCompetition_2	1.937316	.546626	3.54	0.000	.8659489	3.008683
Trøndelag	-.0512183	.8597341	-0.06	0.952	-1.736266	1.63383
Troms	.3067723	.8303984	0.37	0.712	-1.320779	1.934323
SognogFjordane	.3396275	.9931576	0.34	0.732	-1.606926	2.286181
RogalandogAgder	1.256308	.8032058	1.56	0.118	-.3179468	2.830562
Nordland	.9716672	.7485889	1.30	0.194	-.4955399	2.438874
MøreogRomsdal	.3526331	.6827004	0.52	0.605	-.9854351	1.690701
Hordaland	.5969926	.7584543	0.79	0.431	-.8895505	2.083536
Finnmark	-.1009783	1.145709	-0.09	0.930	-2.346527	2.14457
Fisheries	-.5453453	.6482307	-0.84	0.400	-1.815854	.7251636
FishProcessing	-.0508827	.4224297	-0.12	0.904	-.8788296	.7770643
Farming	-.6016421	.6049347	-0.99	0.320	-1.787292	.5840081
Small	-.0906058	1.069022	-0.08	0.932	-2.185851	2.00464
Medium	-.2991897	1.119931	-0.27	0.789	-2.494213	1.895834
_cons	-.6354774	1.152903	-0.55	0.581	-2.895126	1.624171

8 Appendix B – Correlation Matrix of all Variables

	T~duct~n	Radica..	T~cess~n	Radica..	Intern~1	Intern~2	Ext~ds_1	Ext~ds_2	Qualif~1	Qualif~2	Public~1	Public~2	Ext~rs_1	Ext~rs_2	LowDem~1	LowDem~2	HighCo~1	HighCo~2	Østlan~t	Trønde~g
TotalProdu~n	1.0000																			
RadicalProd~	0.7504	1.0000																		
TotalProce~n	0.4240	0.3164	1.0000																	
RadicalProc~	0.3703	0.4197	0.6451	1.0000																
InternalFu~1	0.3253	0.2848	0.3629	0.3574	1.0000															
InternalFu~2	-0.2942	-0.3192	-0.2289	-0.3512	-0.5546	1.0000														
ExternalFu~1	0.2017	0.2107	0.3131	0.3154	0.7299	-0.4197	1.0000													
ExternalFu~2	-0.2258	-0.2531	-0.2226	-0.3230	-0.4447	0.8718	-0.4814	1.0000												
QualifiedP~1	0.2572	0.1630	0.2158	0.1520	0.3917	-0.3083	0.3155	-0.2926	1.0000											
QualifiedP~2	-0.2545	-0.1497	-0.2037	-0.1584	-0.2832	0.5762	-0.2188	0.5839	-0.5153	1.0000										
PublicSupp~1	0.2780	0.2603	0.2857	0.2877	0.4112	-0.3756	0.3492	-0.3638	0.2975	-0.2912	1.0000									
PublicSupp~2	-0.3390	-0.2921	-0.3161	-0.3523	-0.3435	0.6905	-0.2825	0.6682	-0.3158	0.6058	-0.4946	1.0000								
ExternalPa~1	0.1146	0.0874	0.0981	0.0997	0.2765	-0.1783	0.2936	-0.1935	0.4038	-0.2565	0.4546	-0.2628	1.0000							
ExternalPa~2	-0.1437	-0.0657	-0.2065	-0.2379	-0.2810	0.5663	-0.2155	0.5866	-0.3326	0.6270	-0.4068	0.6808	-0.3870	1.0000						
LowDemand_1	0.1590	0.0997	0.1496	0.0222	0.2626	-0.2293	0.2471	-0.2214	0.3620	-0.3255	0.2005	-0.1662	0.4410	-0.2512	1.0000					
LowDemand_2	-0.1489	-0.0918	-0.2216	-0.1240	-0.2069	0.5150	-0.1355	0.4870	-0.2785	0.6261	-0.2802	0.6035	-0.2812	0.6301	-0.4391	1.0000				
HighCompet~1	0.2498	0.1157	0.1005	0.0428	0.2335	-0.1864	0.1619	-0.2212	0.3876	-0.2848	0.2198	-0.1998	0.2833	-0.2457	0.4429	-0.2765	1.0000			
HighCompet~2	-0.1613	-0.0621	-0.1536	-0.0075	-0.1916	0.5060	-0.0907	0.4964	-0.2385	0.5576	-0.2635	0.5946	-0.2533	0.5206	-0.3210	0.6749	-0.4094	1.0000		
Østlandet	0.0839	0.1080	-0.1045	-0.0653	-0.0331	0.0516	-0.1195	0.0720	-0.0741	0.0352	-0.0463	0.0615	0.0399	0.1029	-0.0403	0.0087	0.0650	0.0054	1.0000	
Trøndelag	-0.0658	0.0261	-0.1556	-0.0900	-0.0230	0.0331	-0.0292	0.0901	0.0115	0.1186	0.0389	0.0428	0.0468	0.0562	-0.0328	0.0236	-0.0142	0.0205	-0.1045	1.0000
Troms	-0.0902	-0.1157	-0.0089	-0.0854	-0.0521	0.0226	0.0289	0.0382	-0.1255	-0.0577	-0.0989	0.0969	-0.0727	0.0328	0.0638	0.0757	-0.0350	0.0722	-0.1134	-0.1102
SognogFjor~e	-0.0649	-0.0342	0.0960	-0.0059	-0.0251	0.0811	0.0351	0.0463	0.0974	-0.0150	0.0403	0.0467	0.1093	-0.0634	0.0318	-0.0519	-0.0599	0.0709	-0.0816	-0.0793
Rogalandog~r	0.0742	0.1173	0.0390	0.1330	0.1296	-0.0645	0.1327	-0.0669	0.0016	-0.0053	0.0332	-0.0563	0.0123	0.0110	-0.0084	0.0004	0.0097	-0.0025	-0.0952	-0.0925
Nordland	-0.0085	-0.0767	0.1026	0.0935	-0.0544	0.0006	-0.0757	-0.0219	-0.0148	-0.0768	0.1058	-0.0774	0.0045	-0.0627	0.0302	-0.0695	0.0176	-0.0732	-0.1246	-0.1211
MøreogRoms~l	0.0580	0.0286	-0.0818	-0.0221	0.0172	-0.0051	0.0366	-0.0432	-0.0157	0.0538	-0.0354	-0.0095	-0.0746	0.0242	0.0015	-0.0006	0.0401	-0.0728	-0.1979	-0.1924
Hordaland	0.0242	-0.0022	0.1352	0.0589	-0.0180	-0.0353	-0.0223	-0.0340	0.0912	-0.0267	-0.0508	-0.0518	-0.0105	-0.0495	-0.0619	0.0093	-0.0393	0.0334	-0.1327	-0.1290
Finnmark	-0.0766	-0.0749	0.0050	-0.0233	0.1131	-0.1061	0.0434	-0.0768	0.0787	-0.0607	0.0710	-0.0466	0.0186	-0.0971	0.0407	-0.0031	-0.0158	-0.0050	-0.0615	-0.0598
Education	0.0672	0.0463	0.1442	0.0289	0.0836	-0.0415	0.0295	-0.0218	0.0606	-0.0658	0.1036	-0.0564	-0.0549	0.1047	-0.0256	-0.0021	0.0053	-0.0707	0.0813	-0.0092
Fisheries	-0.2198	-0.2013	-0.1340	-0.1042	-0.0035	0.0877	0.0130	0.0979	-0.0681	0.1303	-0.0788	0.1297	0.0154	0.0593	-0.1431	0.0462	-0.1671	0.0426	-0.1191	0.0411
FishProces~g	-0.0503	-0.1273	0.0763	0.0171	0.0561	-0.0536	0.1041	-0.1107	0.1513	-0.1490	0.1289	-0.0364	0.0382	-0.1520	0.2072	-0.1154	0.1678	-0.0316	-0.0805	-0.0341
Farming	-0.1403	-0.0668	0.1291	-0.0301	-0.1624	0.0714	-0.0961	0.0223	-0.0605	0.0226	-0.0361	-0.0119	0.0211	-0.0156	-0.0223	0.0606	-0.0820	0.0571	-0.1163	0.0468
Suppliers	0.2735	0.2826	-0.0621	0.0708	0.0556	-0.0544	-0.0389	0.0200	-0.0505	0.0324	-0.0395	-0.0439	-0.0566	0.1047	-0.0753	0.0331	0.0122	-0.0357	0.2201	-0.0261
Small	-0.0936	-0.1539	-0.0510	0.0615	0.0305	-0.0634	0.0093	-0.0796	-0.0031	-0.0823	-0.0892	-0.0333	0.0496	-0.1130	-0.0991	-0.0701	-0.0185	0.0510	-0.1683	0.0170
Medium	0.0672	0.1353	0.0377	-0.0628	-0.0643	0.1040	0.0257	0.0821	0.0168	0.0786	0.0819	0.0214	-0.0264	0.0766	0.1099	0.0401	0.0209	-0.0377	0.1189	0.0053
Large	0.0741	0.0628	0.0378	-0.0041	0.0774	-0.0897	-0.0850	0.0034	-0.0325	0.0186	0.0280	0.0325	-0.0614	0.1007	-0.0140	0.0802	-0.0037	-0.0378	0.1382	-0.0552

	Troms	Sognog~e	Rogala~r	Nordland	Møreog~l	Hordal~d	Finnmark	Educat~n	Fisher~s	FishPr~g	Farming	Suppli~s	Small	Medium	Large
Troms	1.0000														
SognogFjor~e	-0.0860	1.0000													
Rogalandog~r	-0.1003	-0.0722	1.0000												
Nordland	-0.1314	-0.0945	-0.1103	1.0000											
MøreogRoms~l	-0.2087	-0.1501	-0.1751	-0.2294	1.0000										
Hordaland	-0.1400	-0.1007	-0.1175	-0.1538	-0.2443	1.0000									
Finnmark	-0.0649	-0.0466	-0.0544	-0.0713	-0.1132	-0.0759	1.0000								
Education	-0.0638	-0.0837	-0.1733	0.0430	-0.0564	0.1668	0.0935	1.0000							
Fisheries	0.1194	0.0389	-0.1054	-0.0469	0.0545	-0.0600	0.0989	-0.0464	1.0000						
FishProces~g	0.1201	-0.0041	-0.1293	0.1107	-0.0289	-0.0467	0.1348	0.0709	-0.2137	1.0000					
Farming	0.0770	0.0434	-0.0453	0.0045	-0.1443	0.2111	-0.0665	0.0223	-0.1287	-0.2087	1.0000				
Suppliers	-0.2302	-0.0487	0.2093	-0.0696	0.0812	-0.0537	-0.1395	-0.0463	-0.3739	-0.6060	-0.3650	1.0000			
Small	0.0047	-0.0590	-0.0546	0.0366	0.0731	0.0910	-0.0234	-0.1022	0.2002	0.0354	0.0131	-0.1677	1.0000		
Medium	0.0201	0.0799	0.0332	-0.0109	-0.0603	-0.1356	0.0381	0.1014	-0.1838	-0.0222	-0.0264	0.1540	-0.9181	1.0000	
Large	-0.0599	-0.0431	0.0576	-0.0658	-0.0393	0.0959	-0.0325	0.0140	-0.0629	-0.0359	0.0303	0.0527	-0.3142	-0.0877	1.0000

9 Appendix C – Descriptive Statistics of Variables Stata

Variable	Obs	Mean	Std. Dev.	Min	Max
TotalProdu~n	206	.6262136	.4849865	0	1
RadicalProd~	206	.4854369	.5010054	0	1
TotalProce~n	206	.5582524	.4978048	0	1
RadicalProc~	206	.3446602	.4764151	0	1
InternalFu~1	206	.2961165	.4576552	0	1
InternalFu~2	206	.4223301	.4951338	0	1
ExternalFu~1	206	.1941748	.3965277	0	1
ExternalFu~2	206	.4902913	.5011235	0	1
QualifiedP~1	206	.2475728	.4326537	0	1
QualifiedP~2	206	.4466019	.4983515	0	1
PublicSupp~1	206	.2621359	.4408675	0	1
PublicSupp~2	206	.407767	.4926166	0	1
ExternalPa~1	206	.1116505	.3157032	0	1
ExternalPa~2	206	.5436893	.499301	0	1
LowDemand_1	206	.1990291	.4002426	0	1
LowDemand_2	206	.4368932	.4972098	0	1
HighCompet~1	206	.1747573	.3806845	0	1
HighCompet~2	206	.4417476	.4978048	0	1
Østlandet	206	.0970874	.296798	0	1
Trøndelag	206	.092233	.2900595	0	1
Troms	206	.1067961	.3096062	0	1
SognogFjor~e	206	.0582524	.2347907	0	1
Rogalandog~r	206	.0776699	.2683034	0	1
Nordland	206	.1262136	.3328989	0	1
MøreogRoms~l	206	.2669903	.4434649	0	1
Hordaland	206	.1407767	.3486383	0	1
Finnmark	206	.0339806	.1816206	0	1
Education	206	.8009709	.4002426	0	1
Fisheries	206	.1165049	.3216109	0	1
FishProces~g	206	.2572816	.4382007	0	1
Farming	206	.1116505	.3157032	0	1
Suppliers	206	.5145631	.5010054	0	1
Small	206	.7669903	.4237782	0	1
Medium	206	.2038835	.4038648	0	1
Large	206	.0291262	.1685699	0	1