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"Investment analysis under uncertainty: a case study of investment in fish farming technology"

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Investment analysis under uncertainty: a case study of investment in fish farming technology

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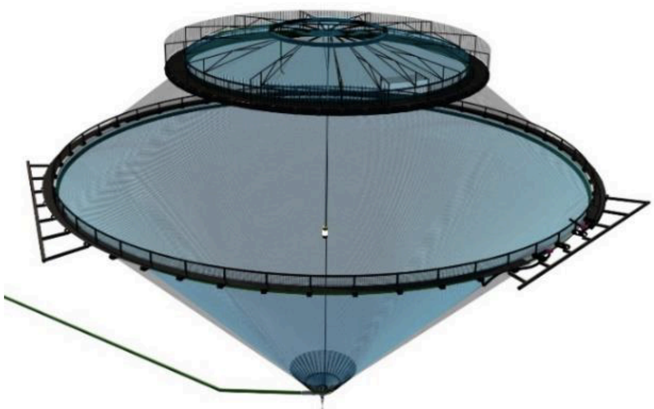

Master thesis in Applied Finance
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Supervisors: Bård Misund & Egil Steinberg

Abstract

The Norwegian Aquaculture industry is facing great environmental problems, where the Norwegian Government have limited the production potential in the industry until these challenges can be resolved. New technology and innovations are central for the industry to grow and for the suppliers to meet the high demand for fresh Atlantic salmon. However, for new technologies to be successful, the investments need to be profitable and more lucrative than the assets used by the industry today.

This thesis is written on behalf of Roxel Aqua, a possible new supplier in the aquaculture industry. With the “Brilliant™” fish pen, the company is seeking to change the industry trend of constant production volumes and stagnant growth. By investing in a submersible fish pen, incidents of sea lice can be limited, as the pen can avoid the higher temperatures and occurrences of lice found at the sea surface. “Brilliant™” is also constructed to be more robust and have other innovative components than fish pens in use today, that can benefit and profit the industry.

A fundamental valuation, more specifically; a net present value approach, is applied as the appropriate model to value and compare “Brilliant™” to a conventional open fish pen. Roxel Aqua is facing an investment decision of which fish pen would be the most profitable alternative when investing in an offshore salmon farming facility. The forecasted cash flows in the valuation model is based on a detailed strategic analysis of the Norwegian aquaculture industry. Because investing in “Brilliant™” includes new and untried technology, and therefore results in high uncertainty of estimated variables, simulations of uncertain factors and sensitivity analyzes are included in the results.

The outcome of the fundamental valuation indicates that “Brilliant™” will be a profitable investment, where the net present value model results in a value of 57.95 NOK/kg, compared to a present value of 22.32 NOK/kg for a conventional pen. The analyzes imply that the innovative fish pen may be a solution to the environmental problems in the aquaculture industry, and that it is a profitable alternative to today’s technology.

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Malin Lindløv Hogstad

List of abbreviations

APV	Adjusted Present Value
CAPEX	Capital Expenditures
CFE	Cash Flow to Equity
CFF	Cash Flow to Firm
COGS	Cost Of Goods Sold
DCF	Discounted Cash Flow
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
FCFF	Free Cash Flow to Firm
FTE	Full-Time Equivalent
GDP	Gross Domestic Product
IRR	Internal Rate of Return
ISA	Infectious Salmon Anemia
MAB	Max Allowed Biomass
NPV	Net Present Value
OPEX	Operating Expenditures
P/B	Price / Book
P/E	Price / Earnings
PE	Polyethylene
PESTEL	Political, Economic, Socio-cultural, Technological, Environmental, Legal (factors, strategic macroeconomic model)
PP&E	Property, Plant and Equipment
TV	Terminal Value
WACC	Weighted Average Cost of Capital

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1. Introduction

1.1 Introduction and motivation

The Norwegian aquaculture industry is facing great environmental problems, and the Norwegian Government has introduced regulations in the industry based on these challenges. A licensing system limits the production potential of farmed salmon, which halters the profitability and growth in the aquaculture industry. Aquaculture is one of Norway's most important export industries. With an increasing demand for salmon, solutions to the environmental problems must be found in order for the industry and economy to experience future growth. Development permits invites new, potential ideas and suppliers to take part in the challenge against the industry complications. But for new technology and concepts to be considered, they need to be profitable. Furthermore, the investment in new technology must be a more lucrative alternative than the existing facilities.

This thesis is written in collaboration with Roxel Aqua AS, a division of the Roxel Group. Roxel Aqua wish to become a new supplier in the aquaculture industry, to focus on new and innovative solutions within the field. By the possible development of a new submersible fish pen, the need for an investment analysis approached. Will this new investment in new technology be profitable for the company and should Roxel Aqua endow in the manufacturing of the fish pen? As the project includes new, untested technology and high investment costs, the project presents with high risk and uncertainty. With great environmental problems, limited concessions and new policies in the aquaculture industry, it may be difficult for a new supplier to succeed, even with new technology. This thesis will focus on the possible development of new technology within the aquaculture industry, and whether the investment in a submersible fish pen will be profitable for Roxel Aqua, or another fish farming facility, or if today's conventional open pens are the better choice.

1.2 Research question

The objective of the thesis is to assess if the investment in an innovative fish farming pen will be profitable for Roxel Aqua, or if it is more profitable to invest in a conventional open pen used by the aquaculture industry today. Although this thesis will focus on Roxel Aqua as the investor, the thesis and research question are not limited to Roxel as the only possible investing company. The "Brilliant™" fish pen and investment decision may also be of interest for other salmon farming companies, if the investment turns out to be a more profitable alternative than the conventional technology.

The main research question is described as:

Will the investment in new technology of a submersible fish pen

be profitable and should the investment be undertaken?

Based on financial valuation and strategic, uncertainty-focused analyzes of the investment, this paper will conclude on whether or not Roxel Aqua's "Brilliant™" fish pen is a profitable investment that ought to be accepted. Selected variables that are considered to be particularly uncertain and with great impact on the valuation outcome will be assessed under simulation and possible scenarios in order to look at how uncertainty may affect the valuation result. The valuation outcome will be compared to a similar valuation of a conventional open pen in use today. By comparing the results, a conclusion on whether or not investment in this new technology is a more profitable alternative can be made.

The analysis and conclusions from this thesis will not only be of interest for Roxel Aqua's further decision-making on the investment alternative, but also for other companies in the aquaculture industry seeking solutions to the environmental problems and more profitable substitutes for the conventional pen.

1.2.1 Appraisal

Roxel Aqua's innovative open fish pen, hereby referred to as "Brilliant™", is intended to take part in a salmon farming technology development project, called the "Octopus" project. The project includes investment in a whole aquaculture facility, including several fish pens surrounding a jack-up rig and numerous other components, like a feeding module, sensors and delousing units. Previous investment analyzes done by Roxel Aqua has proven the project to be profitable. There is, however, a possibility to buy pre-manufactured, conventional fish pens instead of investing in the new sub-surface technology fish pen Roxel has proposed. While the conventional open pen in use by competitors in the industry today is not constructed to operate in offshore conditions, it is currently still considered the best alternative on the market. To look at the innovative advantages the "Brilliant™" fish pen is assumed to hold, the thesis will include a valuation of a conventional pen in addition, in order to compare the two alternatives and make a conclusion on whether or not "Brilliant™" will be the most profitable solution for the project. Since a conventional pen is not robust enough to meet the conditions in exposed sea, it can be discussed if the pen can be seen as an alternative in the project at all. However, as it is currently the best alternative available on the market, it will be included as an alternative in the "Brilliant™" project.

Although "Brilliant™" is part of a larger investment project, this thesis will look at undertaking an investment in a fish pen only. Figure 1 illustrates the decision tree of the "Octopus" project and specifies which branch this thesis will focus on and analyze. The investment in a fish pen is here treated as an independent project. This means that this thesis will presuppose that the "Octopus" project will be commenced and will analyze if Roxel should undertake investment in the "Brilliant™" pen or if it is more profitable to invest in a conventional pen.

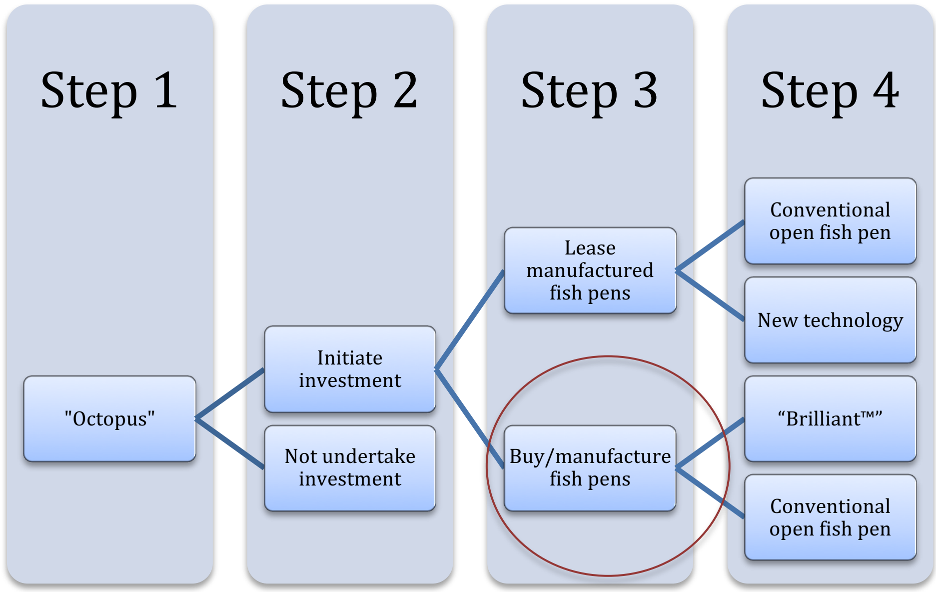

Figure 1: Decision tree of the "Octopus" project

The "Octopus" project includes a number of fish pens, but as the revenue, production costs and investment costs are dependent on the number of fish pens in the facility, the thesis is limited to the investment of one single fish pen. Constant production and investment assume that, ceteris paribus, investing in two fish pens will double the revenue and costs. Further, all costs related to the "Octopus" project as a whole, such as anchoring systems, transportation and other production and administration costs are neglected in this thesis, as the costs does not directly relate to a fish pen. Investment and production costs are limited to the "Brilliant™" fish pen and conventional fish pen only. The change in net working capital will also be excluded from the cash flow calculations. Working capital will be problematic to estimate correctly for this project, as it includes investment from a newly established company. Besides, as the change in working capital is expected to have little impact on the valuation results, it is neglected from the estimations.

Because the research problem is based on the fact that the "Octupus" project will be initiated, the thesis presupposes further that the initiator, here Roxel Aqua, will be granted with a farming license or development permit that can be converted to a license for salmon farming.

The investment is assumed to take place in year 0, which is stated in 2019-values. It is possible to undertake the investment in any year by adjusting for inflation and relative prices. Further, it is assumed that both pens are manufactured and ready for operation in year 0, and that total investments costs in the same year includes costs related to installation and preparation of the pen and all components.

"The project" or "the "Brilliant™" project" is hereby referred to as the investment project of the decision between the "Brilliant™" fish pen and a conventional open pen.

1.3 Structure of the thesis

The thesis starts with an introductory presentation of the Norwegian aquaculture industry. The production of salmon, historic market development and projected outcomes of the industry is included in this section. Possible new technological solutions will be discussed, before a presentation of the conventional open pen in use today. Roxel Aqua, the "Octopus" project and the specifications of the "Brilliant™" fish pen is presented next. The specifications of "Brilliant™" looks at the innovative characteristics the fish pen holds, and why it might be a solution to some of the environmental problems in the industry.

The "theory and method" section includes an evaluation of different valuation models and how they are performed. Which valuation method to be applied in this thesis will be assessed and concluded on. A discussion of how to assess uncertainty in a valuation model is to follow, together with a presentation of a possible solution; a Monte Carlo simulation.

Chapter 4 consists of different analyzes, where a comprehensive strategic analysis comprises the largest share. A macroeconomic analysis (PESTEL) is performed in order to get an overview of issues regarding the outlooks of the Norwegian aquaculture industry for future development. The strategic analysis will be used as the basis when forecasting the variables and cash flows in the valuations and will thus be of great importance and help. Accordingly, an assessment of the uncertain factors in the industry is included. This section will finally look at a brief comparison of "Brilliant™" and the conventional pen, and how "Brilliant's™" capabilities may impact the factors in a cash flow.

The investment analysis is the heart of the thesis. This part will first model the equations used for calculating the cash flows. Then we will estimate the variables and forecast the future cash flows expected to be generated by "Brilliant™" and the conventional pen, as well as estimating an appropriate discount rate. Selected variables will be discussed and simulated under a Monte Carlo simulation.

The final results are presented in an own segment. Chapter 6 includes the output from the valuations and Monte Carlo simulations, along with comments and brief summary conclusions. Variables considered to be uncertain and with great impact on the valuation outcome will be selected for a sensitivity analysis of how sensitive the results are of changes. Finally, an alternative approach for valuing “Brilliant™” and the conventional pen is included.

The final chapter of the thesis includes the final conclusion on the presented research question and a discussion of the results from the analyzes.

2. Industry and case

This chapter will first focus on the Norwegian aquaculture industry and present the specific product and production of salmon, together with a description of the Norwegian salmon market and future development. Then, a presentation of the typical conventional open pen used in the Norwegian aquaculture industry today will follow. Roxel Aqua's project and vision is briefly discussed, and finally, the innovative "Brilliant™" fish pen is presented.

2.1 The Norwegian aquaculture industry

The Norwegian aquaculture industry is one of the most profitable industries in the country, with fast growing revenues, high export numbers and an increasing demand for the product of salmon (EY, 2019). Today, Norway is the world's largest exporter of salmon and the export of seafood is Norway's biggest export industry after oil and gas (Norwegian Directorate of Fisheries and Food Safety Authority, 2010), and the Norwegian Parliament calls the aquaculture industry "an economic success story" (Stortinget, 2017). SINTEF, a Norwegian research institute, believes that the production of farmed salmon will fivefold within 2050 (SINTEF, 2012a). But the industry is facing stagnation and challenges within supply due to the licensing system for regulation of environmental sustainability and predictable growth. The following section will focus on the Norwegian salmon farming industry with its product and give a brief outlook on the market today.

2.1.1 Product and production

When discussing salmon in this thesis, the term refers to the Atlantic salmon, *Salmo salar.* The red-meat fish lives wild in the North Atlantic Ocean, western and eastern Atlantic, as well as in sea basins through northeastern Europe (FAO, 2005). The initial phases in the Atlantic salmon's life cycle is spent in freshwater. Most of the salmon migrate to the sea, in which it is called *anadromous* (SNL, 2018). The wild fish spawn in cool rivers entering the Atlantic Ocean, where the eggs are hatched during the spring. New-hatched fish are called *alevins* and are exposed to several predators in the "swim-up" period when they rise to the surface of the streams to gulp air. Once they swim freely, they are called *fry*. During the summer months, the fry feed and grow, while they are sensitive to changes in the climate, habitat and water quality. They develop into *parr* over the autumn where they feed on bigger invertebrates and grow for 1-3 years in the stream before adapting to life in seawater. *Smolt* is the final phase before adulthood and refers to the phase where the fish migrate along rivers from fresh- to seawater. The adult salmon has lived at sea for 3 or more years to mature and weighs between 3 to 15 kg.

The use of fish pens, as we know it today, for farming of Atlantic salmon got its breakthrough in Norway in the 1970s (The Norwegian Directorate of Fisheries, 2010). The farming of salmon resembles the natural life cycle of the specie. Eggs are extracted and hatched in indoor facilities to become alevins. The alevins are grown in freshwater silos or trays until the fry phase. Then they are moved to bigger tanks or chambers, with the possibility to manipulate light and temperature for optimal growth conditions. After 8-16 months, the fry undergoes smoltification and is characterized as smolt. Smolt are then transferred to fish pens in seawater where they will continue to grow to adult size for between 14 to 22 months. When harvested, the farmed salmon weight may range between 3-4 kg for smaller salmon and up to 6 kg (FAO, 2019). Once the salmon are ready for harvesting, they are pumped from the fish pens to tanks on a well-boat for transportation to a slaughter and production site.

The Atlantic salmon is sensitive to various changes in its environment and is subject to several diseases. Changes in sea temperature, light, pH, density of fish in net, sea currents, access and constitution of food, oxygen level in water and general health and wellbeing are conditions and factors to consider when farming the biological product (Salmonfacts, 2018).

2.1.2 Market and development

The salmon farming industry has, historically, had an increase in the production volume from start in the 1970s until 2007. From 2007, the production level has been more volatile, and it has been stagnating from 2013 until today. This seems like a paradox as the industry has experienced a high demand for the salmon product, increasing value and profits. Thus, 2 questions rise: what is this production stagnation caused by? And what must be done in order to increase todays levels and meet the high demand?

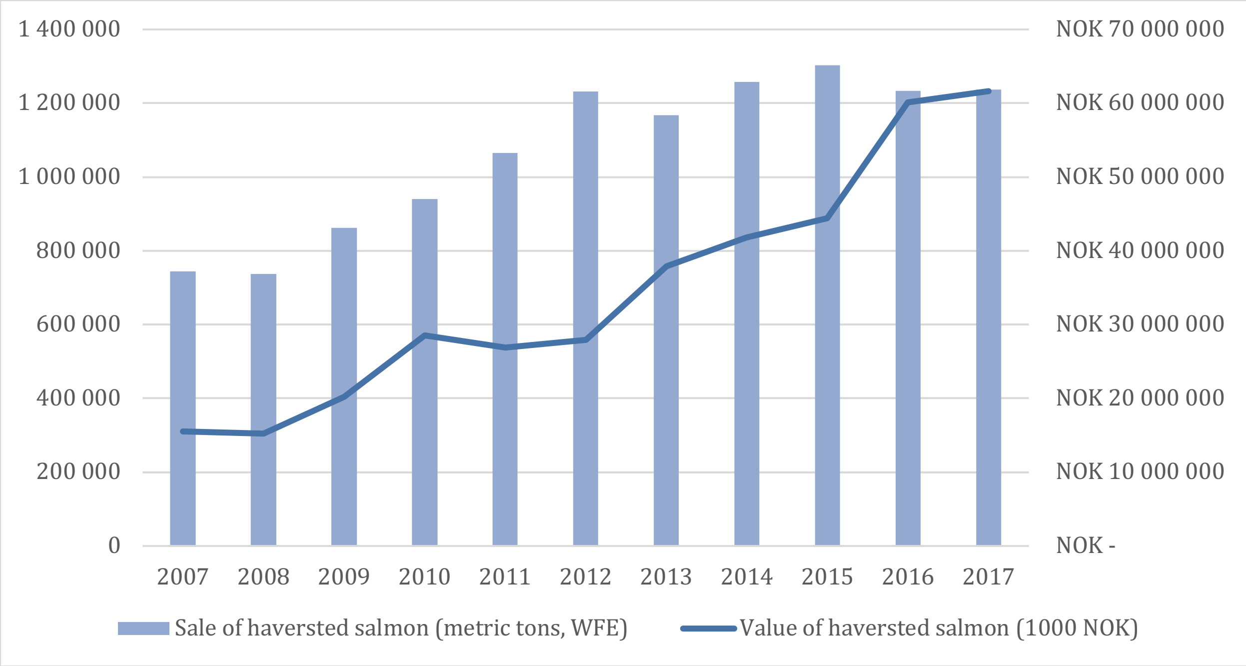

Figure 2: Volume of sale and value of slaughtered salmon in real prices, 2007-2017 (Statistics Norway, 2019b)

Figure 2 presents the development in the sale and value of harvested salmon in Norway from 2007 to 2017. The value of harvested fish is measured in 1000 NOK and the sale is measured in metric tons, whole fish equivalent (WFE). As mentioned, the value of produced salmon has been increasing throughout the last decade, presenting a value over 3 times higher in 2017 compared to 2007. The increase in value is simply caused by a high demand for the product as well as a low supply growth, pushing the salmon prices up. Although the industry is challenged with increasing production costs, the demand and prices are increasing at a higher pace. Simultaneously, the production volume reached a top in 2012, before stagnating until today. Several important environmental problems are faced by the industry, where the main problems include sea lice and infectious disease and escapes of farmed salmon from the pens. The Norwegian Aquaculture Act of 1985, amended in 2003, applies regulations and so-called capability licenses for salmon farming installations. The measures are implied in order to try and limit the number of escapes, and to help combat the salmon lice problem in the industry. The Act advises the Norwegian Government to control the production of salmon until the environmental issues are solved (The Aquaculture Act, 2003). The introduction of the MAB-regime (where MAB is max allowed biomass of live fish in pens (Barentswatch, 2013)) in 2005 resulted in a high growth in the production capacity in Norwegian salmon farming companies the first 6-7 years, before reaching the ceiling of the max allowed biomass in 2011/2012. Further, the Office of the Auditor General of Norway published an article in 2012, criticizing the environmental effects of the aquaculture industry and pointing at the challenges with the escaping of farmed salmon and high mortalities caused by diseases. The report raised questions about regional regulations in the industry and resulted in the Competence Reform Report No. 16 (2014-2015) for a better environmental adaption of the industry, which was the background for the "traffic light" licensing system in 2017. Thus, the main reason for the stagnation is the regulations and requirements for the technical and environmental standard of fish farming installations issued by the fisheries authorities. With an increasing demand for fresh salmon, the production stagnation and supply are a challenge for the industry. Still, speculators believe in continued growth in the aquaculture industry with innovative investments to change the structure of today's facilities and capabilities (EY, 2018).

In 2017, the average Norwegian salmon farming company presented an ordinary result of 215 million NOK (Norwegian Directorate of Fisheries, 2018a) with average EBITDA-margins (percentage of EBITDA over total revenue) over 15 % (EY, 2018). An increasing demand for salmon, and challenges with supplying and meeting the demand, the prices for harvested salmon are pushed up and the farming companies have experienced high profits.

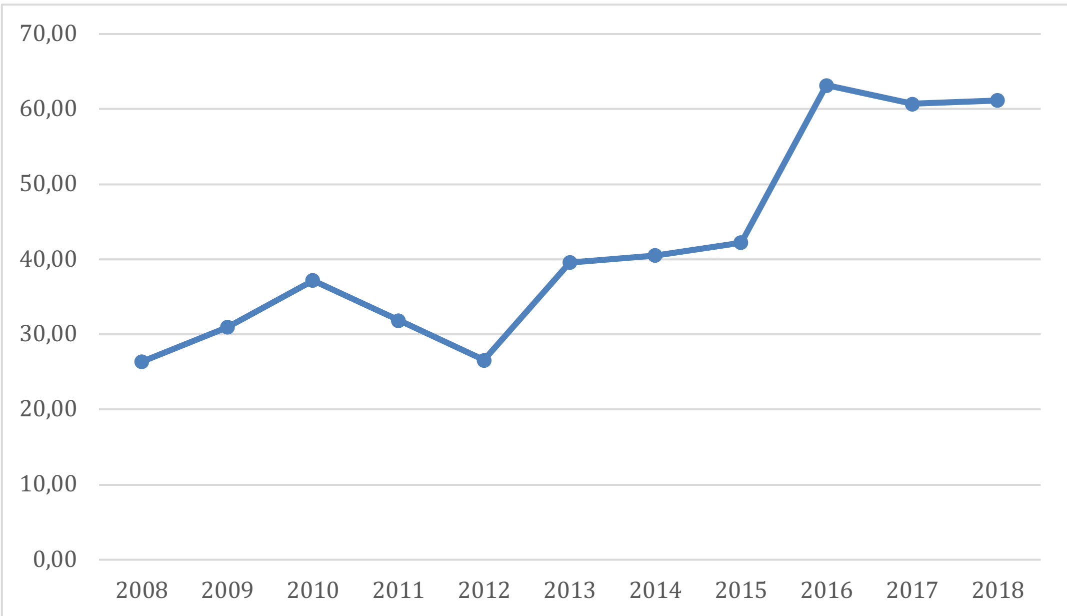

Figure 3: Salmon price history in NOK/kg, 2008-2018 (Fish Pool, 2019a)

Figure 3 presents the historic salmon prices during the last decade, measured as the average annual price in Norwegian kroner per kilo sold gutted salmon. As the figure illustrates, salmon prices were varying but increasing during the last 10-year period, and more than doubling the average price since 2008. After three years of stable average prices around 40 NOK/kg from 2013, the demand for salmon made a sudden jump, resulting in a price of over 60 NOK/kg in 2016. In May 2018, the highest recorded salmon price was measured at 80.22 NOK/kg. The salmon prices are fluctuating during a year, presenting an average standard deviation of 7 % annually during the past 5 years. From January to May 2019, the average salmon price has been 63.90 NOK/kg. Analysts at Nordea Bank, MOWI and EY all believe in a marginal growth in the harvested volume, and thus increased salmon prices in the rest of 2019.

Production costs in the salmon farming industry includes costs related to smolt, feed, health costs related to sea lice and other diseases, vaccination and cleaning, insurance, repair and maintenance of installations and other operating costs. The average production costs are highly varying between companies, where the total average costs reported by industry suppliers to the Directorate of Fisheries in 2017 were about 31 NOK per kilo harvested salmon (Norwegian Directorate of Fisheries, 2018a).

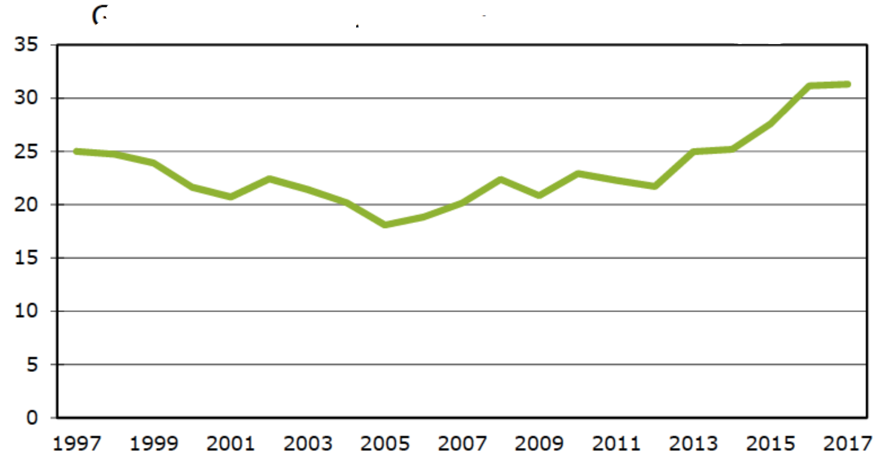

Figure 4: Average production costs in NOK/kg, in real 2017-values (Directorate of Fisheries, 2018a)

Figure 4, retrieved from the Directorate of Fisheries' profitability survey of 2017, illustrates the historical development of average production costs in the aquaculture industry in NOK/kg round weight, stated in real 2017-prices (Directorate of Fisheries, 2018a). As the figure shows, the production costs have mostly decreased in an 8-year period from 1997 to 2005. In fact, the industry presented the lowest average production costs in 2005. From 2005 to 2012 the costs have been slightly varying before increasing from 2012 until today. The cost of feed makes up almost half of the total production costs per kilo harvested fish and has thus a great impact on the total production costs. The increase in the production costs from 2005 is mainly caused by increasing input prices of feed. Further, costs related to fish health and environment presents a great share of the costs, which have also increased the last years.

The Norwegian Government has limited the production capabilities in order to control the biological challenges in open net pens. Biological challenges include sea lice and other diseases that limits the biological growth of salmon, resulting in high health costs and wastage of fish. The industry is also facing a problem with escaping salmon from fish pens. This is not only a problem for the farming companies, which experience less revenue due to escaped fish, but also an environmental problem due to the mixing of bred with wild salmon, and the possibility of spreading infectious diseases (Barentswatch, 2018). Scarcity of coastal areas suitable for salmon farming and the preservation of localities are other problems of supply in the aquaculture industry (The Ministry of Fisheries, 2014). The Norwegian Government has developed different strategies to control the number of companies in the industry, the number of live fishes allowed in the pens and per company, and how much is produced on different localities. Licenses and development permits are all regulated by the government and may be challenging and expensive for farming companies to receive. Furthermore, the licenses may limit future growth for existing companies. Development permits are initiated as a measure to facilitate new technology to solve the environmental problems in the industry, where also new suppliers get a chance to enter the industry. However, the permits demand significant innovations in the production of salmon and the allocation of a permit is challenging.

2.1.3 Regulations

Salmon farming companies in Norway are required to hold a license in order to legally farm salmon, with legal basis in the Aquaculture Act. The latest Aquaculture Act entered into force on January 1st, 2006. The Act focus on a licensing system that ensures aquaculture activities to be established and performed in a responsible manner (Norwegian Ministry of Fisheries and Coastal Affairs, 2005). The government wants to control the industry growth for the sake of the environment and market. The background for the act is to protect the environment and coastal zone, food safety, health and fish welfare, as well as innovation and growth in the industry, efficiency and public administration. By issuing a limited number of licenses that are allocated on a geographical distribution, the government can control for regional differences and make the industry more adaptable to meeting future challenges (Norwegian Ministry of Fisheries and Coastal Affairs, 2005).

In October 2017, the government introduced a new, temporary system for production capacity adjustment in the salmon farming industry. The system looks at the environmental impact from the industry on different localities and is based on an assessment of sea lice on wild salmon found in the area. The "traffic light system", which the regulation is often called, divides the coastal areas and aquaculture locations in Norway into 13 different areas with corresponding colors: green, yellow and red. Green areas represent locations with an acceptable environmental impact with regards to sea lice, where companies are offered growth of up to 6 % (2 % growth per license and 4 % with auction). Yellow areas present locations with moderate environmental impact which are frozen on current capacity levels, whereas red areas must downsize production due to an unacceptable environmental impact of lice. Reviews of the localities are adjusted every other year.

The given maximum allowed biomass (MAB) decides how much biomass of live fish a farming company can hold at any given time, measured in kilos or tons (Directorate of Fisheries, 2016). MAB is regulated on two levels: per locality and per company, where a standard permit for food production of salmon is 780 tons (North of Troms and Finnmark excluded). As of 31.12.18, the Norwegian Ministry of fisheries has allocated a total of 1041 licenses for farming of Atlantic salmon, rainbow trout and trout (Directorate of Fisheries, 2019a). The allocation of licenses for salmon farming are carried through applications and auctions. Applicants are screened based on location, current level of MAB and licenses and general suitability to determine who will be granted a license. The licensing system include only a limited number of salmon farming licenses, which contains a set of rights and obligations for the holder. The interest and demand for the licenses are great and the competition is tough. Allocated licenses usually have a fixed price, whereas remaining licenses not allocated by the Norwegian Ministry can be auctioned out to suitable companies, as of 2018. The aquaculture license auction in June 2018 resulted in 2.9 billion NOK worth of growth permissions bought from 14 different companies (Directorate of Fisheries, 2018e). The following surplus auction of remaining licenses held September 2019 resulted in a value of 81 million NOK (Directorate of Fisheries, 2018f), making up a total of about 2.7 billion NOK worth of farming licenses. However, 80 % of the income from the sale of new permits are distributed to municipalities and counties through the Aquaculture Fund. The Fund was established in 2016 and the income from the salmon farming licenses are distributed and payed out to the municipal sector, where the municipalities with the highest locality capacity for salmon farming will receive the biggest share of the income (Directorate of Fisheries, 2017a). In that way, the Directorate of Fisheries ensures that the high license costs benefit the aquaculture industry in return.

Development permits is a parallel system and temporary solution for allowing projects of considerable innovations and investments to be granted salmon farming permissions. The purpose of the permits is to facilitate new development of technology that can help solve the challenges of the environment and area that the industry face (Directorate of Fisheries, 2018b). The technology developed in the projects must be shared within the whole industry. The Directorate of Fisheries allocate the development permits, which can be difficult to be granted. Documentation of the project must be solid, and the innovations must be of significant character with the goal of combating escapes and sea lice. Companies that are granted development permits will hold the permit for a specific project period but can apply to the Directorate to convert the permit to an ordinary license after period-end.

2.1.4 New technology and innovation

The Norwegian aquaculture industry has a long history. With Norway's long coastline, colder climate and access to the biological products, the conditions were optimal to breed fresh salmon for harvesting. Since then, the experience and technology have evolved remarkably. The world's first salmon farming facility, as we know it today, was established on Hitra in 1970, when two pioneers put out 200.000 smolt in a floating fish net (Berge, A. 2014). The fish nets were octagonal constructions made of wood, with a diameter of 8-10 meters and volume of about 2.000 m^3. A few years later, the floating rings were produced in plastic and the more robust fish nets were used in the industry until the mid 80's. Conventional open fish pens in use today typically have a volume of 25.000 m^3, are located further from the coast and have floating rings with circumferences ranging up to 200 m (Bjørndal, T. & Tusvik, A., 2018). Seaborne, open pens typically consist of 130-meter circumference pens, equipped with net, lighting, sensors and feeding hoses. They have an estimated lifetime usage of 8 years and can on average hold about 550 tons of salmon per pen (Bjørndal, T. & Tusvik, A., 2018).

As an answer and possible solution to the environmental and production problems, new innovations have been brought to life. First, the idea of land-based fish pens for salmon farming was introduced. Land-based farming has existed for several decades but was previously only used on hatcheries. The past 10-15 years, big investments in land-based smolt production have made it possible to produce more and bigger post-smolt to be released in a traditional farming pen. This reduces the time for the development into adult salmon at sea, accelerates the replacement of adult fish ready for harvesting and may increase production. There is also a lower risk for diseases, as the facility has the possibility to process the water in the tank, which reduces the possibility of parasites, disease, sea lice and viruses. However, land-based farming is associated with great costs, high consumption of energy and fresh water, and problems related to the disposal of sludge such as stools and feed remains (Hilmarsen, Ø., 2019).

Coastal salmon farming installations are localized further from the coast than previously and in more exposed areas. Exposed farming, or exposed areas, are by SINTEF described as "farming localities more exposed for waves, currents and/or wind than most localities are today" (Sandberg, M.G, et al., 2012). The NYTEK Regulations of standard design, sizing, installation and operation of aquaculture facilities classifies "high exposure" as currents up to 1.5 m/s (meters per second) and waves up to 3 m/H_s (significant wave height, from trough to crest). For offshore exposure, the waves can reach a height of up to 15 m/H_s, which is a technical challenge for today's conventional open pens. The idea of exposed, or offshore, salmon farming has been discussed since before 2009, but is followed by several issues. First, the suppliers in the industry need to develop new solutions in terms of fish pens robust enough to deal with the environment in the open water. SINTEF, amongst others, performed a study in 2012, where 18 salmon farming companies that produce at more exposed localities stated the biggest challenges of exposed farming. These included docking of the boat to pen, safety and equipment, technology and surveillance of the fish and components, and buoyancy-based submerging of the pens (Sandberg, Lien et. all, 2012). For companies in the aquaculture industry, technological innovations that can cope with these challenges may result in more area available for production and better production capabilities in relation to fish health. Not only may production increase because of new localities, but the salmon has better living conditions further from the coast in terms of ecotoxicity (quality of the water), and a colder climate may reduce the occurrence of sea lice. Hence, exposed aquaculture facilities may be a good solution to the environmental problems causing the restrictions and limitations of licenses implemented by the Norwegian Government.

Salmon farming in exposed areas has, however, several pros and cons. The upsides include new and larger areas available as a solution to the scarcity of suitable coastal areas for farming, which may lead to an increase in the value creation in the industry. Further, exposed areas have better production capabilities in terms of living conditions for the salmon, with more optimal currents and temperature. Developing new areas also fosters the demand for new and innovative solutions in equipment and services, which in turn may increase the production and supply in the industry. Challenges with farming in exposed areas include mainly problems related to the robustness of the fish pen. Safety of the installment and boat approach to the pen, technology of the net in terms of deforming and surveillance of the fish and components are stated as the main challenges faced by companies farming in exposed areas (Sandberg, M.G, et al., 2012). Weighing down the net, challenges during reparation and maintenance and the protection against escapes are other factors.

Roxel Aqua has several competitors in the aquaculture industry regarding submersible fish pens and farming in exposed, open waters. The strict regimes in obtaining a development permit for salmon farming has resulted with only a few of the applying companies to have been granted with one. In fact, since 2016, only 11 concepts of applicants for development permits have been accepted, whereas 85 concepts have been rejected. Most of the approved concepts include closed or semi-closed fish pens, while other projects include the use of submersible pens in offshore farming. The information in table 1 is retrieved from the Norwegian Directorate of Fisheries in the end of May 2019 and presents firms and concepts that have newly been granted development permits.

Applicant	**Decision date**	**Development permits (tons of fish, MBA)**	**Concept**
Ocean Farming AS (SalMar)	26.02.2016	8 permits (6240 tons)	Offshore technology-based farming
Nordlaks Oppdrett AS	07.09.2017	21 permits (16.380 tons)	Farming in exposed sea
MNH Produksjon AS	28.04.2017	4 permits (3120 tons)	Semi-closed fish pen
AkvaDesign AS	05.06.2018	2 permits (1560 tons)	Closed fish pen
Marine Harvest Norway AS	01.03.2018	6 permits (3120 tons)	"The egg" – closed fish tank
Atlantis Subsea Farming AS	22.02.2018	1 permit (780 tons)	Submersible fish pens
NRS ASA / Aker ASA	09.03.2018	8 permits (5990 tons)	Semi-submersible farming constructions
Hydra Salmon Company AS	06.04.2018	4 permits (3120 tons)	Farming in closed tanks
Mariculture AS	22.02.2019	8 permits (6240 tons)	«Smart Fishfarm» - comprehensive solution for exposed sea
Cermaq Norway AS	01.03.2019	4 permits (3120 tons)	"iFarm" – technology for individually based farming
Mowi Norway AS	05.04.2019	2 permits (1100 tons)	"Marine Donut" – solid, closed units

Table 1: List of recently granted development permits, as of April 2019 (Norwegian Directorate of Fisheries, 2019a)

2.1.5 Conventional open fish pen

The typical open fish pen used in Norwegian aquaculture facilities consists of a 130-meter circumference pen with a volume capacity of about 25.000 m^3 per pen. The largest pens can have a circumference of up to 250 meters. The maximum number of fishes contained in a pen is strictly limited to 200.000 in order to give the salmon enough space for optimal living conditions (Norwegian Seafood Council, 2017). This results in a content of fish of approximately 2.5 % in each pen, which is the max allowed density of fish (The Ministry of Trade and Fisheries, 2008). Figure 5 illustrates a characteristic conventional open fish pen, with a cylinder-shaped net.

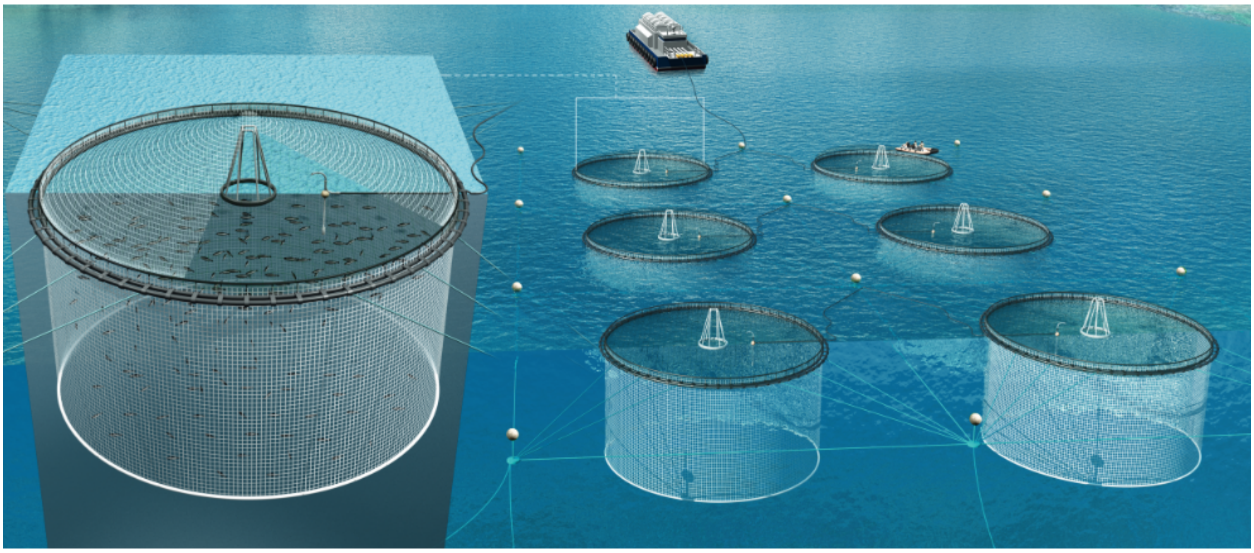

Figure 5: Conventional open fish pens (The Norwegian Seafood Council, 2014)

The Norwegian Directorate of Fisheries regulates requirements for technical standard for floating aquaculture constructions (the NYTEK Regulation). Norwegian Standard, NS 9415 from 2003, regulates the requirements for design, dimensioning, production, installation and operation of marine fish farms (NSF, 2003). Conventional open pens consist of ring constructions, or floating collars, made of steel or plastic (polyethylene, PE). The main function of the collars is to keep the top structure of the pen floating for easy access and maintenance, and as a base for attachment of the net. Open pens include a top net over the ring to protect from escapes and from other creatures, such as birds. The immersed nets are constructed and sized after empirical data in order to be robust enough to hold the fish inside the net and prevent escapes during all environmental conditions. Most nets are made of nylon, which is a flexible material resistant to gnawing. Sea currents and waves may compress and shrink the net out of shape, reducing the volume available for the fish. This may especially be a problem for pens on exposed localities, and NS 9415 sets special demands for nets used on localities with waves higher than 2.5 m/Hs and currents above 0.75 m/s. The net pens are anchored to the ocean floor and pulled down with heavy weights attached to the net to decrease deformation during high currents. A typical net is cylinder shaped and is between 20 and 50 meters deep. The installations also include advanced systems for surveillance and measuring of data related to waves and currents, temperature, salinity and oxygen in the sea.

2.2 Roxel Aqua AS

The vision and objective of Roxel Aqua is presented in this section, in addition to a description of the "Brilliant™" fish pen and the "Octopus" project it is intended to be a part of. Roxel Aqua's objective and innovative solution to environmental problems in the aquaculture industry support the motivation of the thesis.

2.2.1 Vision and objective

Roxel Aqua AS was founded in 2017 and is a new company applying to be a supplier within the Norwegian aquaculture industry. Roxel AS is the parent company, where Roxel Aqua is a part of the Roxel Group. However, the company has a complex owner structure, where part of the company is owned by Skretting, a leading distributor of feed in the aquaculture industry, through options.

The Roxel Group has several companies within the offshore and construction sector, and established Roxel Aqua to focus on a new branch for future development. They saw potential in the aquaculture industry, not only because of the historical high profits and the future outlook of the industry, but because of the possible groundbreaking new technology they could offer the sector in order to reduce the biological issues faced by the industry. Roxel Aqua's offshore facility within aquaculture, the "Octupus" project, together with the submersible "Brilliant™" fish pen, will be presented under.

2.2.2 “Octopus” project

The “Octopus” project refers to Roxel Aqua’s investment in an offshore salmon farming facility. The project consists of several components and includes a jack-up rig to serve as a hub, or base, to submersible fish pens. The concept is innovative because it makes it possible for salmon farming in exposed sea, further from the coast, and because of new technology in the project. The rig consists of different units, including a feeding unit, lice removal unit and a module for fish processing. Robust, submersible fish pens will be attached to the rig, adapting to the environment in exposed sea. The idea may help increase the production of salmon, not only because of the scarcity of coastal areas, but because of possible environmental benefits that can reduce sea lice and fish wastage and increase the well-being of the salmon. The environmental benefits in more exposed sea include better temperatures and climate, optimal flow and currents to oxygenate and circulate nutrients in the water. Over time, the project is also assumed to be more profitable in relation to conventional aquaculture facilities, in terms of expected increase in the survival rate of salmon and thus production volume, and reduced costs related to fish health.

The “Octopus” project is a patented concept. However, the concept is yet to receive a development permit from the Norwegian Directorate of Fisheries. The permit is a necessary prerequisite to commence the project. Initially, “Octopus” was rejected a development permit in November 2018, a decision which Roxel Aqua has appealed (Directorate of Fisheries, 2019c). The Ministry of Trade and Fisheries is currently reviewing the complaint.

The idea of salmon farming in exposed sea is not new. Some of the industry leaders; Nordlaks, Nova Sea and SalMar, are on track in offshore salmon farming with the use of rig-technology and submersible fish pens. However, there are still few competitors and the concept of offshore farming is relatively new and untried, giving room for new suppliers. Further, Roxel’s «Brilliant™» fish pen introduces new technology to help reduce the environmental and biological issues that need to be resolved.

2.2.3 The “Brilliant™” fish pen

The submersible “Brilliant™” fish pen is named after its shape; the brilliant cut shape of a diamond, with a sharp pointed tip. It is designed to be a robust fish pen which can meet the at times difficult environmental changes at exposed sea, with the possibility to be submersed if the conditions at sea surface is not optimal. It is constructed to hold up to the limited number of 200.000 adult salmon, with an estimated average weight of 5.0-5.5 kg. This presents a biomass of up to 1100 ton per fish pen. The total volume in the pen is 44.000 m^3, distributed over three levels. The bottom part consists of a point-shaped base with a closed container for dead fish. The middle component is the fish net with a middle ring, whereas the top structure consists of a ring with a closed walkway under a 6-meter-high net. These three layers make up the main components of the fish pen structure.

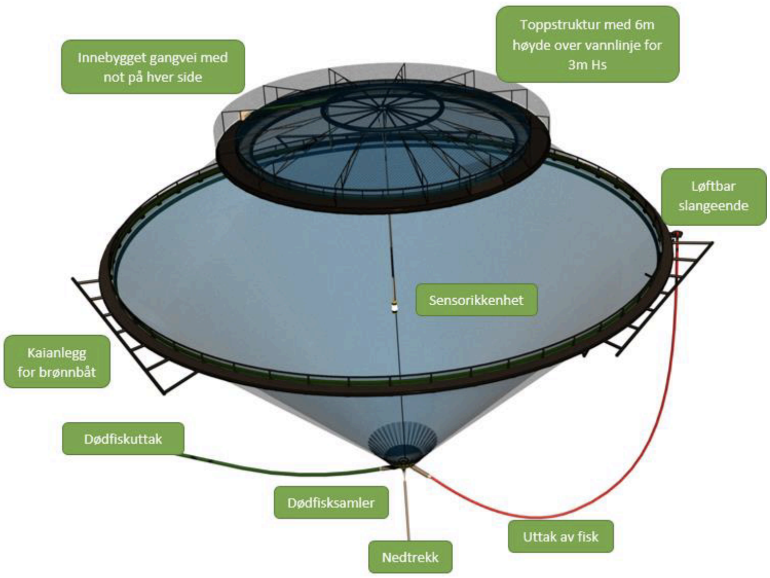

Figure 6: The "Brilliant™" fish pen

The top ring will be constructed of polyethylene (PE) with perforated middle rings. Hoses attached to the ring simplifies the extraction and pumping of salmon to a well-boat, reducing the need for personnel on the actual construction and minimizing the possibility of escapes during extraction. The hoses also simplify the process of releasing the smolt in the pen. Quays attached to the top ring will absorb shock from docking of the well-boat and make it safer and easier to dock and extract salmon ready for harvesting.

Pull-down technology

The flexibility of the pull-down function of the fish pen may compensate for buoyancy more than a ballasted submersible fish net. The technology of "Brilliant™" pulls the fish pen down by using winches, which gives it a continuous pull-down force to keep it in place. This also results in limited deformation of the net during high currents, maintaining the volume in the net to improve the health and welfare of the fish. Immersing the net is possible during times with difficult or extreme conditions at sea surface, such as high waves and currents. Submersing the pen to deeper water maintain stable living conditions for the salmon and may limit the contact with sea lice.

The pull-down flexibility has also the opposite effect; the possibility to retract and collapse the fish net to a flat structure, which makes it easier to transport, install, remove, clean and etc. Retracting will happen semi-automatically by reducing the pull-down force and is usually done in advance before pumping and extracting the salmon for harvesting. This feature is also helpful during reparation and maintenance of the net and may reduce the time and costs related to pumping, extracting and general maintenance.

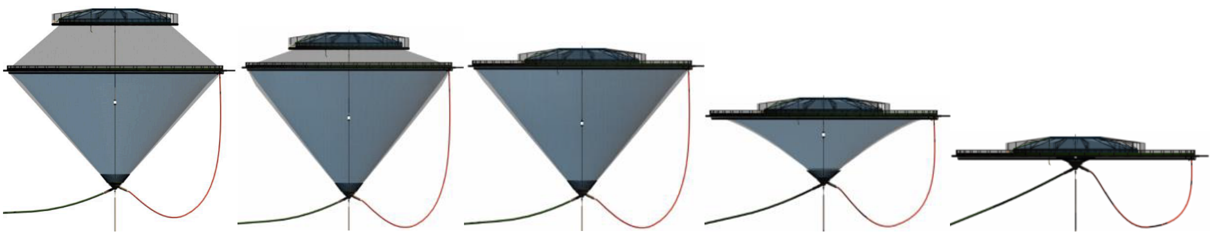

Figure 7: Retraction of the "Brilliant™" fish pen

Pointed shape

The pointed shape of the net is assumed to have better flow-characteristics, in which currents will pass the fish net more than in a cylinder-shaped net. The 3-level floating rings will present with high stability, which is especially important at the surface, with the highest currents. Conventional fish nets may decrease its volume by 80 % even at moderate currents of 0.5 m/s (Gansel, Oppedal et. al, 2018). A simulation done of "Brilliant™" proved that the net had almost no change in volume, even with currents of 1 m/s and waves at 4 m/H_s. The shape-stability and robustness of the net is expected to increase the durable life of the net in relation to a conventional net, reducing the need to replace components. Further, the well-being of the fish may be improved as living conditions and volume in the net are stable.

Sensor unit

A sensor unit will be located at the center of the fish net. This will include all typical sensors and cameras in one single unit. In today's conventional fish nets, the sensors are usually installed at different locations and must be manually removed before retracting the net. By gathering all sensors in one unit, the inclusion of winches makes it easier and safer to transfer and remove the sensors without the use of divers. The sensors will gather information on the fish count, lice count, environmental- and living-conditions in the net, as well as functioning as a light source and camera.

Dead fish collector

A dead fish collector at the bottom of the pointed fish net function as a barrier for deceased fish to float to the surface. This will reduce the potential spread of infections and pathogens to healthy fish. A hose in the collector will extract the dead fish from the net.

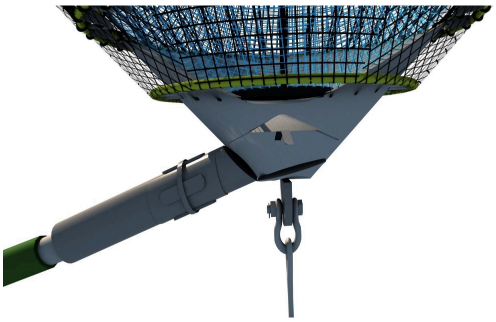

Figure 8: Dead fish collector of "Brilliant™"

"Brilliant™" also includes several other characteristics which will be too technical to explain for the purpose of this thesis. Features include resistance characteristics in the rings, hydrodynamic characteristics, windpipes for oxygenation and feed spreaders.

"Brilliant™" is patented and approved for testing in a pilot project partly funded by the government initiative Innovation Norway.

3. Theory and method

To analyze an investment opportunity, several methods can be used, ranging from simple models to more sophisticated calculations. Different valuation models will be described further, focusing on the fundamental valuation model, relative valuation and option-based valuation. A comparison and conclusion on which method this thesis will apply will follow. Finally, we will look at the Monte Carlo simulation model as a tool for assessing uncertainty in a valuation.

3.1 Valuation models

Investment analysis is a process of evaluating a possible investment for profitability and risk. If an investment appears to be profitable in the future, the investment could or should be commenced. Most estimates end up in an "accept or reject" conclusion, where the investment is accepted if it is estimated to yield a profit for the investor and rejected if it is not. The concept may be easy to implement and understand, but the result can vary highly regarding which method is chosen.

Most valuation models take time and the time-value of money into consideration, and is used to value both investments, projects, firms and assets. Generally, there are three different valuation methods; fundamental valuation, relative valuation and option-based valuation. Common analysis calculations also include *ad hoc* variants, like evaluating the internal rate of return, IRR, with the required discount rate, the net present value (NPV) approach or analyzing the payback period of an investment (Graham & Harvey, 2001). These three *ad hoc* variants use discounted cash flows to analyze the financial information and are based under fundamental valuation. Other approaches for concluding on investment decisions are sensitivity analysis (finding "good", "fair" or "bad" possible outcomes), multiple approaches or incorporating the real options of a project.

3.1.1 Fundamental valuation

Fundamental valuation includes a fundamental assessment of an asset's future cash flows and discounts them over a return to reflect the present value. By this means, fundamental valuation is often also called discounted cash flow valuation. According to Damodaran (2012), thousands of discounted cash flow (DCF) models exist, varying only in a few dimensions. The three paths to DCF valuation include equity valuation, firm valuation and adjusted present value (APV) valuation. These paths, or methods, applies different discount rates and different approaches to calculate the cashflows, but will all yield the same consistent estimate of value as long as the set of assumptions used in the model are held constant (Damodaran, A., 2012a).

The net present value model is a discounted cash flow method of fundamental valuation and will be presented under.

3.1.1.1 The net present value model

The net present value model, or NPV model, is a highly used model within decision-making and investment analysis. Even 25 years ago, Dixit & Pindyck called it "the orthodox theory" (1994). While the model comes with numerous assumptions and issues, it is still taught widely in business schools world over and is the most used valuation method. In fact, according to Graham & Harvey's studies, 75 % of CFOs use the NPV model "always or almost always" as the valuation technique of choice when deciding on project investment (2001). Similarly, studies performed by Horn, A. et al. (2015) in Scandinavia showed that 74 % of the CFOs of large companies use the net present value model as their technique of choice in a capital budgeting process.

The NPV model estimates an investment project's opportunity to generate future cash flows and discounts them to present value at a discount rate, or required rate of return. If the value of the sum of discounted cash-flows is positive, the model imply that the investment should be undertaken. The model is relatively simple to project and understand, but does not take uncertainty into account and is based on several assumptions.

There are generally two ways two estimate the current incomes and cash flows from an asset or project, based on an estimation of cash flows to equity (CFE) or cash flows to firm (CFF). CFE estimate the cash flows to equity investors and use the cost of equity as the discount rate. CFF values the cash flows to all claimholders, or the whole firm, and discounts over a cost of capital. When valuing an asset or a project, it is important to choose the right DCF model and discount rate, and not mismatching the two. Calculating errors or mismatching the cash flows and discount rates will lead to an upward or downward biased result. For the remaining of this thesis, the free cash flows to firm, FCFF, method will be enclosed further.

The model of calculating the NPV of free cash flows to firm, FCFF is considered the most appropriate method to be used in this thesis. Equation 1 illustrates the final calculation in an NPV calculation when valuing a firm or project on a total capital level (Damodaran, A., 2012a).

(1)

$$NPV_0 = \sum_{t=0}^{\infty} \frac{FCFF_t}{(1+WACC)^t} + TV_T$$

Where NPV_0 is the net present value in year 0 of the sum of free cash flows to firm, $FCFF_t$. *WACC* is the weighted average cost of capital, or discount rate. *t* represents the current period, or year, of the FCFF. TV_T is the terminal value in the final year, *T*.

The net or free cash flows to firm, FCFF, is the net inflow and outflow of cash in a project or investment, or the cash produced through operations after subtracting the cost of expenditures. Equation 2 presents a simple calculation of the free cash flows to firm (Damodaran, A., 2012a).

(2)

$$FCFF = (EBIT) \times (1 - T) - (CAPEX - D_t) +/- \Delta WC$$

Where *EBIT* represent the earnings before interest and taxes and *T* nominates the corporate tax rate. *CAPEX* are the capital expenditures. Depreciation, D_t, is an expense that allocates the cost of an asset or investment over its useful life and is used to account for the decline in asset value. Hence, the depreciation expense is a non-cash transaction. The change in working capital, ΔWC, is normally the most complex calculation in a FCFF calculation and is neglected in this thesis, as argued for in the appraisal. *t* represents the current period, or year.

The first step in an NPV calculation is usually to estimate the duration of the projected cash flows, or lifetime of the project. The project life time is normally decided upon the expected usage time of the asset or the project, in terms of expiration and obsolescence. There are generally two ways to assess the lifetime of a project. One way is to base the project's period on the lifetime of an asset to be valued or is expected to generate revenue in the cash flows. At the end of the asset lifetime, the asset will be obsolete and useless, the project will be over and an investment in a new asset must be undertaken in order to generate further cash flows. If an asset does not have a specific lifetime and improvements makes it possible for the asset to last until perpetuity, the project can be divided into different stages. The initial phase consists of the investment and development of the project until the investment level reflects the maintenance level, and the project is assumed to be in equilibrium. This first phase may be referred to as the development phase. When the project reaches the steady state, the second phase, the cash flows are expected to continue at a constant rate forever and a terminal value can be calculated. It is important to evaluate when the project will reach a "stable growth", or steady state, and what characteristics it will have when it does (Damodaran, A., 2012a).

If a project is expected to continue until perpetuity, the cash flow value calculated in the terminal year is divided by the discount rate minus the expected stable growth rate, as illustrates in equation 3 (Damodaran, A., 2012a). The terminal year is normally considered the period when the project reaches an equilibrium stage, or steady state, and constant cash flows are expected until perpetuity.

(3)

$$TV_T = \frac{FCFF_{T+1}}{(WACC - g_T)}$$

Where TV_T is the terminal value calculated in the terminal year, *T*, where the development phase is over, and the steady state has begun. $FCFF_{T+1}$. is the free cash flow to firm in the year after the terminal year, *T*, and g_T is the expected perpetual, stable growth rate.

The perpetual, or terminal growth rate is the constant rate the FCFFs are projected to grow at until perpetuity. After the forecasting period of the development phase, there is no need to project the annual cash flows in the steady state at equilibrium until perpetuity. The stable growth rate makes it possible to calculate the expected terminal value in the future. A growth rate in a mature stage is normally calculated between the inflation rate and the average GDP growth rate in the economy. A company can never grow at a rate higher than the growth rate in the economy forever (Damodaran, A., 2012a). It is impossible to outperform the economy in the perpetual future, which means that the constant growth rate cannot be greater than the overall growth rate of the economy. According to Damodaran (2012); "of all the inputs into a discounted cash flow valuation model, none can affect the value more than the stable growth rate". Estimating an exact growth rate may be difficult and the rate may have big impacts on the terminal value and the final NPV calculation. By asserting a too high growth rate, the total discount factor will be low, and the terminal value will be overstated. A too low growth rate will oppositely understate the TV and yield a downward biased NPV.

Finally, the cash flows and terminal value are discounted over an estimated discount rate and summed to reflect the net present value of the asset or project. The discount rate may be in nominal or real terms but needs to be consistent with the cash flows. The discount rate may also vary over time. By discounting the cash flows to present time, the value in year 0 is estimated, and the time value of money has been reflected. The time value of money provides a compensation for the delayed income and expected inflation and reflects the level of risk of the investment (Wahlen et al., 2012). Hence, the investment decision to be made today can be undertaken with basis in the calculated NPV of the project, as it reflects all future assumptions. The project is estimated to be profitable if the NPV > 0. In other words, if the NPV is calculated to be a positive number, the project will in theory be profitable and the investment should be accepted. The NPV will only be positive if the required rate of return is greater than the internal rate of return, IRR, for the project.

3.1.1.1.1 The discount rate

There are different ways to calculate a company's required rate of return, regarding which valuation model is being used, what is to be estimated and how the project is structured or financed. If a project is financed by debt, capital or both, there are different methods for calculating the discount rate. Further, it depends on whether one is valuing the cash flows to equity or to firm. How and which method is used to find the discount rate may have a big impact on the outcome of the NPV model. As mentioned, mismatching the chosen cash flow model with the wrong discount rate will result in serious biases. Further, small changes in the rate may yield a completely different result and conclusion. It may be difficult to calculate the required rate of return, as there is no "correct" answer and the final calculation is based on many sub-computations.

The appropriate discount rate used in a valuation of cash flows to firm is the cost of capital. The weighted average cost of capital, WACC, takes both the cost of equity and cost of capital into consideration and weights them over the share of equity and debt to the total capital. To estimate the WACC, the cost of equity and cost of debt needs to be calculated. The cost of equity can be estimated through the capital asset pricing model, CAPM.

The capital asset pricing model

The CAPM model is used in equity investing and is dependent on inputs as the risk-free rate, the expected return of the market and the beta (risk, or deviation from the market). In fact, this risk and return model is used as a standard in most real world analyzes (Damodaran, A., 2012b). The model assumes that a project is influenced by diversifiable and non-diversifiable risk, where the risk-free rate reflects the non-diversifiable risk and the beta presents a diversifiable risk that the individual asset adds to the market portfolio (Damodaran, A., 2012b).

The standard approach to estimating the cost of equity through the CAPM is defined as (Damodaran 2012b):

(4)

$$r_E = r_f + \beta_E\left[E(r_m) - r_f\right]$$

Where r_E is the cost of equity, r_f is the risk-free rate, β_E is the equity beta relative to the market and $E(r_m)$ is the expected market return. $[E(r_m) - r_f]$ make up the equity risk premium, which is the expected gain from undertaking a risky investment. Historical risk premiums are generally used for the risk premium (Damodaran, A.,, 2012b).

In practice, government security rates are mostly used as risk free rates. In Norway, the annual average 10-year government bond calculated by Bank of Norway, is normally applied (PwC, 2019). Risk free rates vary across countries and currencies, and it is important to use the correct real or nominal rate for the company being valued.

There are several ways to find an approach for estimating the equity beta. The standard procedure according to Damodaran (2012b) is to estimate the beta through a regression of stock returns against market returns. However, the regression beta has a high standard error and does not reflect the current situation as it takes historical averages of business mix and financial leverage into account (Damodaran, A., 2012b). The equity beta can also be found through a calculation of the covariance between the expected cost of equity and the market portfolio, and the variance of the expected market return. The equity beta can be calculated by:

$$\beta_E = \frac{Cov(r_E, r_m)}{Var(r_m)}$$

Where β_E is the equity beta, $Cov(r_E, r_m)$ is the covariance between the cost of equity and the market return, and $Var(r_m)$ is the variance of the market return.

Equity betas can also be calculated from the beta of the business or industry that the firm is operating in. It may be difficult to estimate the beta of a specific project correctly, which is why it is often normal to use the equity beta of the company managing the project (Graham & Harvey, 1999). According to Damodaran (2012b), a project equity beta can be found by adjusting the business beta for operating leverage of the firm to arrive at the unlevered beta. The unlevered beta is further adjusted for financial leverage to estimate the equity beta of the firm. The levered, equity beta can thus be calculated through:

$$\beta_L = \beta_U \,(1 + (1 - T)\left(\frac{D}{E}\right))$$

Where β_L *is* the levered beta, β_U is the unlevered beta, T is the corporate tax rate and (D/E) is the debt/equity ratio of the firm.

The weighted average cost of capital

The method for estimating the cost of equity has been discussed and the cost of capital can be calculated. This is done through the equation of WACC, or weighted average cost of capital. The equation takes both the cost of equity and cost of debt into consideration and weighs the different costs over their share of the total capital. The cost of debt is considered the borrowing rate in year 0 and reflects the default risk and the level of interest rates in the market (Damodaran, A., 2012a). Estimating the cost of debt can be done through two widely used approaches: through the yield to maturity on a straight bond that is outstanding from the firm or use the rating for the firm to estimate a default spread (yield between a corporate bond and risk-free bond). For a company with no ratings or multiple ratings, other methods can be used. In project investment, where the investment is partly financed with debt, it is possible to simply calculate the c borrowing rate, or weighted borrowing rate, to reflect the cost of debt.

WACC is then calculated as a weighted average of the cost of equity and the cost of debt, as presented in equation 5 (Damodaran, A., 2012b).

(5)

$$WACC = r_E \times \frac{E}{(E+D)} + r_D(1-T) \times \frac{D}{(E+D)}$$

where r_E is the cost of equity, r_D is the cost of debt, *E* is the market value of equity, *D* is the market value of debt and *T* is the tax rate. (*E*+*D*) make up the total capital of the firm, and (E/(E+D)) equals the equity ratio, whereas (D/(E+D)) is the debt ratio.

The uncertainty and difficulty related to estimating a "correct" or appropriate cost of capital is normally controlled for by raising the discount rate. Yang and Blyth (2007) argues that using a single discount rate to represent many sources of risk aggravates the difficulty of choosing the appropriate rate, particularly where risk premiums are not well established. It is still hard to determine by which degree the discount rate should be increased to justify all future risks. Further, Damodaran (2012) argues that the cost of equity should be higher for riskier investments and lower for safer investments. As the cost of debt is difficult to interfere, a higher cost of equity will result in a higher cost of capital.

3.1.1.1.2 Evaluation of the NPV model

Challenges with the NPV model is that it may be difficult to estimate the exact life time of the project and may therefore yield an uncertain estimate. Further, the calculation of the appropriate discount rate can be characterized by discretionary errors, where only a small uncertainty or change in the rate may have a big impact on the valuation result. In economic theory, the discount rate may be a measure of uncertainty of the project. High uncertainty or risk is considered less attractive, hence results in a higher discount rate.

Further, it may be difficult to estimate the equity beta, or risk, of the project. The typical approach of using the equity beta of the company managing the project can be considered inadequate, as it does not necessarily conform with the project risk.

Finally, the growth rate in the different cash flow components may be difficult to estimate correctly, as one do not know what will happen in the future and the future predictions and estimations comes with great uncertainty.

The positive side of the NPV model is that it is relatively easy to understand and implement and will give a good stance on the investment analysis. By somewhat controlling for the uncertainty in the model, the present value model may yield an adequate result.

3.1.2 Relative valuation

Relative valuation is a market-based approach that looks at standardized calculations and compare the numbers with a selection of relatively similar assets currently priced in the market. This is an indirect way to estimate the net present value of a company or project, as the method takes the industry market into consideration. There are two components to relative valuation. The first component is to standardize prices into multiples in order to value the asset on a relative basis. The second is to find comparable firms and control for the differences in regard to risk, growth and cash flows. Relative valuation is then thought of as a simple and quick method, based on the calculation and comparison of multiples. The method is easy to understand and present further, and as it not based on assumptions and forecasts, it may reflect the current market better than a DCF valuation (Damodaran, A., 2012a).

However, the methods' strengths are also its weaknesses. When controlling for company differences in terms of risk, growth and cash flows, these key variables are neglected and may result in inconsistent estimates of the final valuation (Damodaran, A., 2012a). Further, when not including for future predictions, the current market price may be too high or too low regarding how the market values the firm or the asset today. Finally, relative valuation is highly vulnerable for manipulation, as the lack of clearness in the underlying assumptions can result in bias when choosing which multiple to make comparison with.

Standardized values, or multiples, used in relative valuation include earnings multiples, book value or replacement value multiples, revenue multiples and sector-specific multiples. The earnings multiples are amongst the most popular used, including the price/earnings ratio (PE), price to book ratio (PB) and enterprise value to EBITDA ratio (EV/EBITDA).

3.1.3 Option-based valuation

3.1.3.1 The real options model

The real options model has previously been sparsely used as a valuation method in corporate financing. New insight has however brought real options to become a "cross-disciplinary area of research" (Triantis, 2005), with a great potential to improve the evaluation of investment opportunities and decision-making. It may especially be a helpful tool when investors have a flexibility when making investments, as the model accounts for flexibility under different conditions. The model is also advantageous when it comes to assessing possible outcomes and the probabilities for each scenario.

By thinking of investment opportunities as real options, new insight has been provided in modern corporate resource allocation. The real options method treats the investment as a flexibility, where the opportunity to "wait and see" or stage the uncertain investment can help a company in making the right decisions (Trigeorgis, 2002). In uncertain or volatile markets and investments, real options may help gain from opportunities or limit downside losses in the flexibility to continue with the project or not.

The owner of a real option has the right, but not the obligation, to undertake an investment in a real asset, rather than a financial contract. When uncertainty in the investment exist, the holder may wait to exercise at some time in the future when the uncertainty has been resolved or reduced. If the risk is too high and no future profit from the project is asserted, the owner may choose not to exercise the option (undertake the investment) and abandon the project. If the intrinsic value is positive, however, it will, in theory, be profitable to exercise the option and invest in the project.

3.2 Comparison and choice of method

Valuing a project with new technology, high uncertainty and no assets that are similar enough for comparison, the relative valuation method will be difficult to apply to this thesis. In regard to assumptions and expectations for future development, relative valuation is not considered an appropriate approach for this matter. The model neglects risk and growth and is only based on the current market situation. Hence, this method will not be assessed further.

The real options model is an interesting tool that accounts for the flexibility that many investments hold. For the investment decision in this thesis, however, it is difficult to determine the possible flexibility of the investment. As discussed in the appraisal of the research problem, investing in a fish pen presupposes that the project already will be initiated, and the flexibility is therefore limited. By this means, the real options model will not be an appropriate valuation method to conclude on the problem.

The NPV model is considered the model of choice for this investment analysis. First, the model is relatively easy to understand and apply, and will give a good basis on concluding on the research question on whether or not to invest in the new technology. Second, it is considered the most appropriate method for analyzing this exact investment project, as other models are more advanced or have other impacts than what is relevant for this problem. Studies also show that this is the most used technique within capital budgeting of companies in Scandinavia (Horn, A. et al., 2015).

Although the NPV model has several implications, like the discount rate, assessing the lifetime of the investment and when the steady state is approached, and the variables included in calculating the net cash flows, the uncertainties will be accounted for in the implementation of the estimations. Further, a probability simulation of selected risk factors and sensitivity analysis will be included to strengthen the result of the calculations. By accounting for uncertainty in the NPV model, it is considered the most appropriate method to address the investment decision Roxel Aqua face.

3.3 Investment under uncertainty

In economic theory, an investment is described as undertaking a cost in the expectation of future rewards (Dixit & Pindyck, 1994). Investments are universal for all firms, and investment decisions considered risky and uncertain. According to Dixit and Pindyck (1994), investment decisions share three important characteristics; they are *irreversible*, there is *uncertainty* over the future rewards and the investor have some *flexibility* in the timing of the investment. The initial investment cost is partially or completely sunk, and an irreversible act if the investment is undertaken. Further, one can never predict the future and therefore, future rewards are filled with uncertainty. The best an investor can do is try to assess the outcomes and probabilities of the potential future rewards before making the investment decision. Finally, the action to invest can be postponed until the investor has more information about, or a better assessment of the future. Together, these implications interact to help make investors take difficult decisions in investment.

Risk is referred to a situation where the dimensions and probabilities of possible future outcomes are known in advance. In contrary, uncertainty refers to the situation where the probabilities cannot be objectively specified in advance (Porterfield, 1965). Based on this concept, risk is then described as something that can be measured and explains a situation where uncertainty is probabilistically quantified (Wells, 1976).

To deal with the level of uncertainty in an investment decision, it is possible to perform a sensitivity analysis of fluctuations or simulation methodology of the uncertain parameters in the project. A simulation of selected uncertain inputs will result in a probability distribution of the data, providing probabilities for each scenario and thus try to assess the possible outcomes in the future. In other words, the uncertain parameters can be measured and explained as levels of risk. Such a distribution of probabilities will give a better view of the calculated net present value of a project, hence contribute to a better understanding and insight of the uncertainty in an investment decision. Monte Carlo simulation is a widely used simulation technique for this purpose and will be explained further.

3.3.1 Monte Carlo Simulation

An investment with uncertainty has an unlimited number of possible outcomes based on the plausible combinations of variables. A sensitivity analysis allows the user to consider these effects by changing one variable at a time and looking at alternative scenarios. A Monte Carlo simulation, however, looks at all possible combinations at the same time and results in an entire distribution of project outcomes. Brealey, Myers and Allen (2011) explain the Monte Carlo simulation as a "roulette wheel with a model of the world in which the project operates", which is a suitable description of the gambling-named model.

Many companies perform a Monte Carlo simulation as an important tool in their decision-making process. Simulations can be used to estimate the exposure to different kinds of risk, helping companies forecasting variables such as net income, costs, interest rate changes and average return. Finally, these simulations may result in a better understanding of the possible outcomes in an investment project and calculate a more precise valuation.

When estimating the possible outcomes in a Monte Carlo simulation, several steps are taken. First, the project is modelled into variables that precisely affect possible outcomes of the project. Examples of such variables are factors in the cash flows, tax rate and discount rate. Cash flows consists of revenues and costs, which further consists of several variables such as price, amount, market size, market share and forecasted expectations. It is possible to break the different parts of the project model down to numerous variables which all affect the final outcome. However, it is not enough to just define the variables, as one must also consider how the variables are interrelated. For example, if the market price of a product is uncertain and determined by the market, then the amount sold will depend on the price because of demand. Vice versa, the amount produced may influence the market price due to supply. Further, what is expected or forecasted to happen to one variable in year 1 affects the expectations also for year 2, and so on. In other words, the modelling of the project allows for interdependence between variables *and* periods (Brealey, Myers & Allen, 2011). As the variables are linked through the periods, the probability of forecast errors accumulates over time. Consequently, the uncertainty increases with time and the further one forecast from year 0, the more the estimate may differ from the original.

The second step includes specifying the probability for forecasting errors made in step 1. These probabilities need to be calculated for all forecasted variables in the model. For example, if the market price is estimated to be X, within in a range of plus or minus 10 %, the forecasted error will have an expected value of 0 +/- 10%.

The final step is to simulate the possible outcomes of a project. A simulation program takes samples from the distribution of forecasted errors and calculates the resulting cash flows. This is executed for all time periods and after several repetitions, the program can estimate probability distributions of the different outcomes.

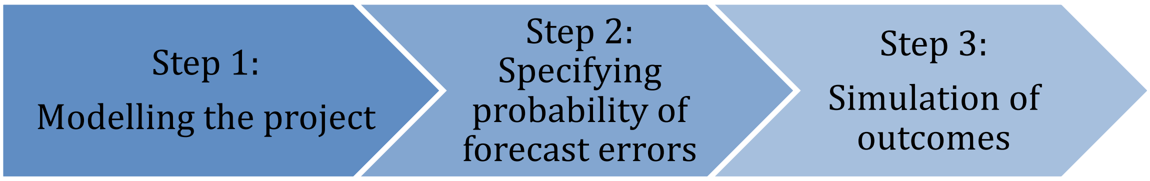

Figure 9: Process of Monte Carlo simulation

By simulating the different variables over time and estimating the probability of each outcome, it is possible to estimate the expected outcomes of a project more accurately. The mean of the distribution outputs can be considered the expected value of the project (Damodaran, A., 2012a). Simulations take uncertainty and interdependencies into account, making the final outcome more realistic. It may also be interesting for the decision maker to see the different possible outcomes of the project and explore possible modifications to get a different result. All in all, a simulation may help decreasing the uncertainty in a calculation, but as it may be difficult to define the model and estimate interrelationships between the variables and probability distributions, even the simulated outcome can be biased.

A Monte Carlo simulation will be used to assess selected uncertain variables in the specific NPV model for the investment in order to control for some uncertainty in the estimations, and to reflect on how the simulation impacts the result.

4. Analyzes

The following section will look at three different analyzes; a strategic, macroeconomic analysis of the Norwegian aquaculture industry, an assessment of uncertain factors in variables affecting the investment project and an analysis of the innovative components of the "Brilliant™" fish pen.

4.1 Strategic analysis

A strategic analysis is included in the thesis for a better understanding of the internal and external factors affecting the investment project, the possible outcomes and the final valuation and decision. It is essential to perform a strategic assessment of the market and industry the investment project is in, especially when the project owner is new in the industry. A strategic analysis sets the basis for forecasting estimates in the investment analysis, as a ground for possible future development.

Several strategic tools are available to help assess the specific factors related to market, industry or firm. This thesis will focus on macroeconomic factors the Norwegian aquaculture industry is facing, which will be analyzed in a PESTEL framework.

4.1.1 Macroeconomic analysis - PESTEL

A PESTEL analysis is a tool or framework to identify external macro factors facing an industry, or a company within a specific industry. PESTEL is short for Political, Economic, Social, Technological, Environmental and Legal, and refers to the different areas where macro forces are located. A macroeconomic analysis is essential for organizations within marketing, new projects or developments, investment decisions and as a tool for understanding the underlying market factors in forecasting and valuation. By constructing a solid PESTEL, the macro-environment can be used as a basis for understanding the current market and help estimating the future market factors in an industry. A PESTEL analysis is included in this thesis as a supplement when estimating the forecasted cash flows the fish pens are expected to generate. The analysis is undertaken on the Norwegian aquaculture industry and will be used to examine factors that may affect the investment decision, and as a basis for forecasting the variables in the cash flows and NPV calculations.

4.1.1.1 Political factors

Political factors explain policies implemented by the government which may have an impact on the company or specific industry. The factors include political policies, trade, fiscal and taxation policies. In the aquaculture industry, political market factors include licenses, development permits, the corporate tax rate in Norway and the possible implementation of resource rent taxation in the industry.

Licenses

The licensing system applied by the Norwegian Government is of duplex importance; it limits the growth for existing companies and makes it tough for new competitors to enter the market. But it is necessary for the environment, for the living specie and the Norwegian coastal areas. The Norwegian Ministry commend the limited number of licenses, the geographic distribution, the timing of allocation of the licenses, the prioritization criteria, the selection of qualified applicants within the prioritization criteria and the license fees (FAO, 2019b). In other words, the government sets all the conditions of the licenses and a single company has limited influence on the system. There is a great demand for salmon farming licenses, which are allocated by the Norwegian Directorate of Fisheries. Licenses not allocated by the Directorate of Fisheries are auctioned in rounds until all are distributed. Licenses may however be transferred under the Aquaculture Act (2005), and although leasing of licenses is not permitted, the Ministry may grant exemptions for this in exceptional cases. The allocation of licenses applies both to new licenses and to the increase of MAB on existing licenses.

There are primarily three ways to receive a salmon license; through direct allocation from the Directorate or auction of remaining not-allocated licenses, transfer of license from another owner or through the conversion of an already received development permit. New companies trying to enter the market and salmon farming industry rarely receives licenses from the Directorate, as these are mainly allocated to existing companies for future growth. The high demand for farming licenses ought to make it challenging for Roxel Aqua to receive a farming license through direct allocation. License auctions are also reserved for companies who have already met the criteria set by the Directorate and is considered a difficult approach. Development permits are only allocated to projects that can document "considerable innovation and considerable investments", in terms of new technology as a solution to one or more of the environmental challenges in the industry (Norwegian Directorate of Fisheries, 2018b). On this basis, it is assumed that Roxel Aqua's "Brilliant™" pen must rely on a development permit that can be converted to a license after project end, as the project brings new technology and innovation. If the "Octopus" project is to go for the alternative option of a conventional open pen, it is still assumed that the company must depend on receiving a development permit for conversion. As regular licenses mostly apply to existing companies in the aquaculture industry, Roxel Aqua ought not to base its's new investment project on a regular license. Although a conventional pen may not meet the criteria for considerable innovation, the total "Octopus" project may however still be innovative enough for a development permit allocation.

Once a company has been granted a salmon license, it is unclear if it is subject to a time limit, as this is not set in the individual license (Stortinget, 2018). However, it is supposed that the license has an infinite lifetime and does not expire. It can, however, be withdrawn from the government if the content of the license is violated, or the MAB can be reduced. The Norwegian Labor Party, among others, has proposed to implement time limits on the salmon farming licenses, in order to contribute to a more even development of revenues between larger cities and districts, and between the industry leaders and new suppliers (Stortinget, 2018). The proposal was to introduce a time limit similar to the structural quotas in fisheries, which is between 20 to 25 years with an option for extension. The proposal was up for consultation in April 2019, but did not get majority (Stortinget, 2019).

With a great demand for the salmon licenses in the Norwegian industry of aquaculture, the prices are pushed up through the auction rounds. In the allocation round of licenses in 2018, 47 different farming companies applied for 2 % growth through the licensing system, with a set price of 120.000 NOK per extended ton MAB. This resulted in over 947 million NOK in remuneration in the first allocation round. Through the first auction, the average price of 1 ton MAB resulted in over 186.000 NOK, whereas the second auction had an average price of 203.000 NOK (The Norwegian Government, 2018b and 2018c). Note that there are geographical differences in the prices offered for a ton MAB, where the average prices were higher in the coast of Helgeland, in Vestfjorden and Vesterålen in Northern Norway. Auction prices thus depend on location, but average around 194.800 NOK per ton MAB.

Summary:

Companies in the Norwegian aquaculture industry are required to hold a license for salmon farming in order to legally produce salmon. Licenses and prices of these will not be considered further in this thesis, as the "Brilliant™" project is assumed to rely on the allocation of a development permit as regular licenses applies mostly to existing companies in the industry.

Development permits

Development permits are a temporary arrangement by the Directorate of Fisheries that makes it possible for new companies to establish in the aquaculture industry. As the permits are dependent upon new and innovative technology in aquaculture in order to solve the environmental challenges of the industry, the allocation of a permit may be difficult. The criteria are strict; however, it is still necessary to protect the industry and foresee that technological innovations are safe for the environment and the biological product of salmon. The development permits are thus of duplex importance, as with the licensing system. The Directorate of Fisheries allocates the permits for salmon farming for development purposes. The temporary arrangement was open for application from November 2015 to November 2017.

Unlike salmon licenses, development permits are set with a specific time duration for expiration. When the duration is considered, the time perspective of the manufacturing and development activity is emphasized. Amongst the development permits allocated to projects with open fish pens, that is – closed pen concepts excluded, the permits have a duration of between 4-15 years with an average extent of 7 years (Bjørndal, T. & Tusvik, A., 2018). The maximum duration of a development permit is up to 15 years but can be extended by application (The Ministry of Trade and Fisheries, 2004). When the duration is over, the development permit can be converted to an ordinary license, but only if the project criteria granting the holder the permit in the first place, is fulfilled. By conversion, the permit holder must pay a remuneration of 10 million NOK, adjusted by the consumer price index (Norwegian Directorate of Fisheries, 2018b).

As Roxel Aqua's "Brilliant™" fish pen is of new technology that can help solve the environmental problems of the industry, the production of the pen and permit to salmon farming ought to be based on a development permit, as previously discussed. As long as Roxel Aqua is a new supplier in the industry and the "Octopus" project is of technological innovation, it is assumed that also a conventional pen will be based on the allocation of a development permit.

Summary:

New technology in the aquaculture industry is dependent upon the allocation of a development permit, in which can be converted to an ordinary license within an expected average of 7 years. The remuneration cost for converting the permit in 2019 is 10 million NOK and will be assumed further. Both fish pen alternatives for the "Brilliant™" project is expected to be dependent on a development permit that is to be granted in year 0 and thus converted in year 8 with a cost of 10 million NOK, adjusted by inflation. It will further be assumed that criteria specified for the project is fulfilled.

Corporate tax rate

The corporate tax rate is an important factor for a company, as it determines what share of the net revenues must be paid to the government and what is earned and withheld by the company. A higher tax rate is therefore negative for the company's revenues, as a larger share must be paid in tax. The tax rate is also a variable in the calculation of the weighted average cost of capital, where the cost of debt is calculated after tax. Tax deductions available on the interest rates paid on the company's debt are a benefit, as they are subtracted from the amount of interest and thus lowers the net cost of debt. Hence, a higher corporate tax rate increases the tax deductions on interest rates, which is positive for the net financing costs.

Since the early 90's, the corporate tax rate in Norway was at 28 %. With the appointment of the Solberg government in 2013, changes in the state budget followed from 2014, including changes in the corporate tax rate. From 2013 to 2014, the corporate tax rate was dropped with one percentage point from 28 % to 27 %. A further decrease followed with the Tax Settlement of 2016, where a percentage point decrease in 2016, 2017 and 2019 resulted in a corporate tax rate of 22 % in 2019 (The Norwegian Government, 2018a). Altogether, the Solberg government has decreased the tax rate by 6 % since the accession. The reason for the tax cuts is to stimulate savings and investments in the industries, long-term predictability in the economy and to make the Norwegian economy more expansive (The Norwegian Government, 2018a). Low tax rates and equal tax treatment between industries and businesses are supposed to make investments more attractive and obtain a better utilization of resources (The Royal Finance Department, 2019).

The next Parliamentary election in Norway is in 2021, and the elected party will sit until 2025. Which National Assembly will be elected may have impacts on the corporate tax rate, and may be impossible to predict. However, most parties agreed on the Tax Settlement in 2016, with a proposed final corporate tax rate of 23 % by 2018, and many parties still stand by the settlement today. The corporate tax rate in Norway in 2019 is 22 % (The Norwegian Government, 2019).

Summary:

As it may be impossible to project the future government tax rate, a constant corporate tax rate of 22 % in 2019 will be assumed further in this thesis. The assumption is based on the agreement on the Tax Settlement and a prerequisite that a possible change of government will not raise corporate taxes in the future.

Tax proposal (resource rent tax on aquaculture)

Salmon farming licenses allocated by the government are not time-limited, and they give the right to a protected profitable industry that can cause extraordinary returns. Extraordinary returns are possible when there are shortages in input factors in a production. In many industries, this is characterized as a limited access to natural resources and is referred to as ground or resource rent (The Norwegian Government, 2018d). The government means that a share of the resource rent should accrue to the Norwegian community. The income from license auctions are distributed back to the aquaculture industry, but the revenue from the allocation rounds in 2018 amounted only 2-3 % of the total amount of licenses in the sector. Until 2002 farming licenses were allocated to companies for free, and in the period of 2002 to 2012, license costs only amounted a modest remuneration. Hence, for older, already allocated licenses with perpetual duration, the resource rent is only minimally collected and distributed to the public.

In 2017, members of the Norwegian Parliament submitted a proposal to introduce a production fee per kilo unprocessed farmed fish produced in Norway. The Parliament has asked the government to implement the proposal for the State budget of 2019, but the formulation has been a challenge. In the fall of 2018, the government appointed the Aquaculture Tax Committee, consisting of key members within economics and organizations in the aquaculture industry (The Norwegian Government, 2018e). The proposal is expected to be finalized in the Parliament by spring 2020, with a view to entry into force medio 2020. The goal of the possible implementation is to ensure stable and predictable annual income for host communities of the aquaculture industry, for predictable use of areas and to facilitate new areas for salmon farming, even when there is no growth in the industry (The Norwegian Government, 2018d).

The Ministry of Finance have first based the progress of the model for resource rent taxation in aquaculture on the existing tax in hydropower. The ground rent tax in the hydropower industry makes up 37 % of the ground rent income and is in addition to the corporate tax of 22 %. This means that the effective, total revenue is taxed by 59 % (KPMG, 2019). The government states that other tax models based on ground rent taxation may be considered and that the Parliament can reach another conclusion when promoting the bill in 2020. Further, the deputy of the Aquaculture Tax Committee currently states that a taxation based on the system of the power industry do not have majority in the Parliament and that the committee is now "back to square one" (Witzøe, A. 2019). However, there is apparently still political majority to implement royalties on part of the production of salmon, but the model and rate is still highly uncertain.

Summary:

Based on the high uncertainty about the implementation and model of a resource rent taxation in the aquaculture industry, this tax will not be taken into consideration further in the NPV valuation in this thesis. One should not disregard the possibility of a resource rent tax in the future, but as of 2019, the Norwegian Government is still to decide whether or not to apply the tax and how it should be calculated and deducted.

4.1.1.2 Economic factors

Economic factors affect the performance of the economy, which in turn directly impacts the company in the industry and its profitability (Oxford College of Marketing, 2016). Such factors include interest rates, costs of raw materials and input factors and foreign exchange rates.

Salmon price

The price of fresh, gutted Atlantic salmon has more than doubled in a ten-year period from 2008 to 2018. From a weighted average price of 26.36 NOK per kilo in 2008, the average price reached 61.16 NOK/kg in 2018 (Fish Pool, 2019a). The high price increase has a simple explanation; high demand for fresh salmon products, where the production and supply have difficulties meeting the growth in demand. Based on macroeconomic theory, the demand and supply are in disequilibrium and the uncovered demand pushes the price up. Price increases enables all companies, effective and less effective, to profit from production in the industry. As salmon is marketed and sold fresh, all production in one period needs to be disbursed in the same period. The production level is difficult to adjust in the short term, not only because of the licenses and MAB, but also because of a long planning and production cycle of salmon. Hence, the supply is very inelastic in the short term. Additionally, the demand for salmon have been increasing, as has the input production factor prices and general food prices. This results in a high price volatility for salmon in the market (FHF, 2015).

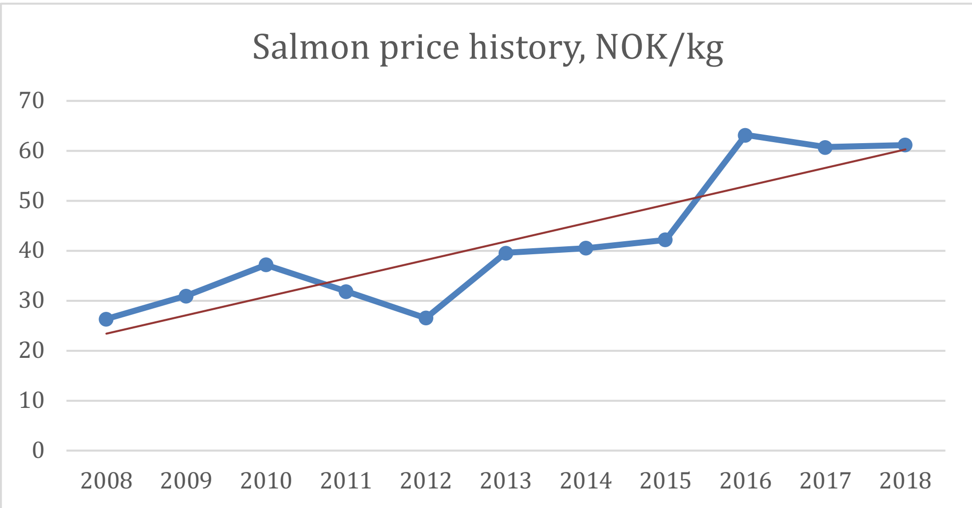

Figure 10: Annual average salmon prices, 2008-2018 (Fish Pool, 2019a)

Figure 10 is rendered from section 2.1.2 and presents the salmon price history from Fish Pool during the last decade, with a trend line. The Fish Pool Index (FPI) is recorded weekly, and the weekly average spot prices are calculated and visualized as an annual average. The trendline shows a great price increase of salmon in the period, with an evident price drop in 2012 and high inclines in 2013 and 2015. The price drop in 2012 is explained by a significantly higher supply level, due to higher production activities and harvested volume of slamon. With increasing salmon prices due to the introduction of the MAB system in 2005, the farming companies increased production to reap the high prices. The production volume peaked in 2012 and the supply were able to meet the demand, which resulted in a price decline the same year. The prices increased the following year and remained relatively stable from 2013 to 2015. In 2015, the Aquaculture Report no. 16 (2014-2015) was released and resulted in the introduction of the new “traffic light” licensing system. As the report criticized a predictable and environmentally sustainable growth in the aquaculture industry (The Ministry of Trade and Fisheries, 2015), the production capacity stagnated. The high demand lead to an all-time high for the salmon prices, with an average price of 63.19 NOK/kg in 2015.

The average annual price growth throughout the last decade has been 5.70 %. However, for the past 2 years from 2017 until the first five months of 2019, which presents more stable prices, the growth rate has been -0.20 %. The current annual growth rate of average prices from 2018 to end of May 2019 is at a 3.0 % increase. However, salmon prices are somewhat cyclical. Cyclical price changes of 2018 are illustrated in figure 11. The figure illustrates a price increase until April/May, a decline in the price during the summer months, relatively flat but varying prices during the fall and an increase in the winter. The annual standard deviation of salmon prices the last two years was plus/minus 8.17 and 8.88 NOK/kg in 2018 and 2017, respectively. This results in a percentage standard deviation from the annual average price of 13 % and 15 % the same years. The average annual standard deviation through the last 5-year period has been plus/minus 6.94 NOK/kg, or 13 %. The relatively high standard deviation throughout a year shows volatile prices due to changes in demand and changes in supply when the salmon is harvested.

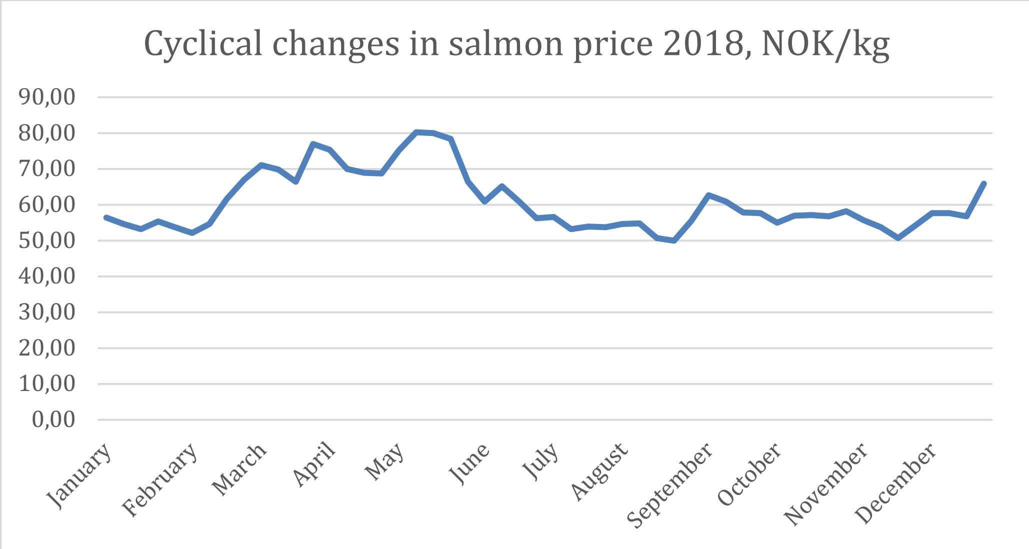

Figure 11: Cyclical changes in salmon prices, 2018 (Fish Pool)

Some of the biggest suppliers in the aquaculture industry, banks, investment companies and consulting agencies publish analytical reports on the aquaculture industry, where analysts forecast the market and salmon prices in the year to come. Contributors include Mowi, formerly known as Marine Harvest – one of the industry leaders, Nordea Markets, DnB Markets, Sparebank1 Markets, Pareto Securites, EY and PwC. Common for all mentioned analysts is that they predict and forecast an increase in the salmon price for 2019, with an average annual price of between 60 and 64 NOK/kg. They all explain the forecasted price increase with stable or even an estimated lower volume of harvested salmon, caused by the limitations of the licensing system in Norway. Further, there has been an increase in demand from European and American markets, and the analysts also sees potential of increased demand in other markets. Nordea Markets believes the average salmon price will reach 64 NOK/kg in 2019 (Giskeødegaard, K. (2018)). Pareto Securities believe in a price of 62 NOK/kg (Witzøe, A., 2018), whereas EY also forecast the price to “stay at the low NOK 60s” (EY, 2019). Further, the mentioned analysts all assume that new technology within the aquaculture industry, such as land-based farming and offshore farming, will increase the production and supply of salmon in the years to come. However, it is not expected to have an impact on the salmon price for at least 3 years due to the long planning and production phase of technological innovations and new facilities.

Fish Pool ASA, part of the Norwegian Oslo Børs, was introduced in 2006 as an authorized marketplace for trading of derivatives of fish and seafood, and also offer financial salmon contracts. A forward contract is a financial agreement between two parties to buy or sell a predetermined quantity of a product in the future, where the price is agreed upon today. In theory, the forward prices cannot systematically deviate from the realized spot prices, in order to satisfy both the seller and the buyer. In practice, however, the future spot price is uncertain which yields a possible risk premium for the buyer or the seller. Because the future price today is uncertain, the forward price represents the markets expected spot price for the given future delivery period. This means that the forward price is determined from the changing market expectations, and forward prices can thus be looked upon as forecasted future spot prices. The forward salmon prices are assessed monthly and forward contracts are signed for up to 3 years. Monthly forward prices in NOK/kg are presented in figure 12, which are extracted from Fish Pool from April 2019 to December 2021. Note that all numbers extracted from Fish Pool are based on salmon of sizes 3-6 kg, superior quality, head-on gutted (Fish Pool, 2019c).

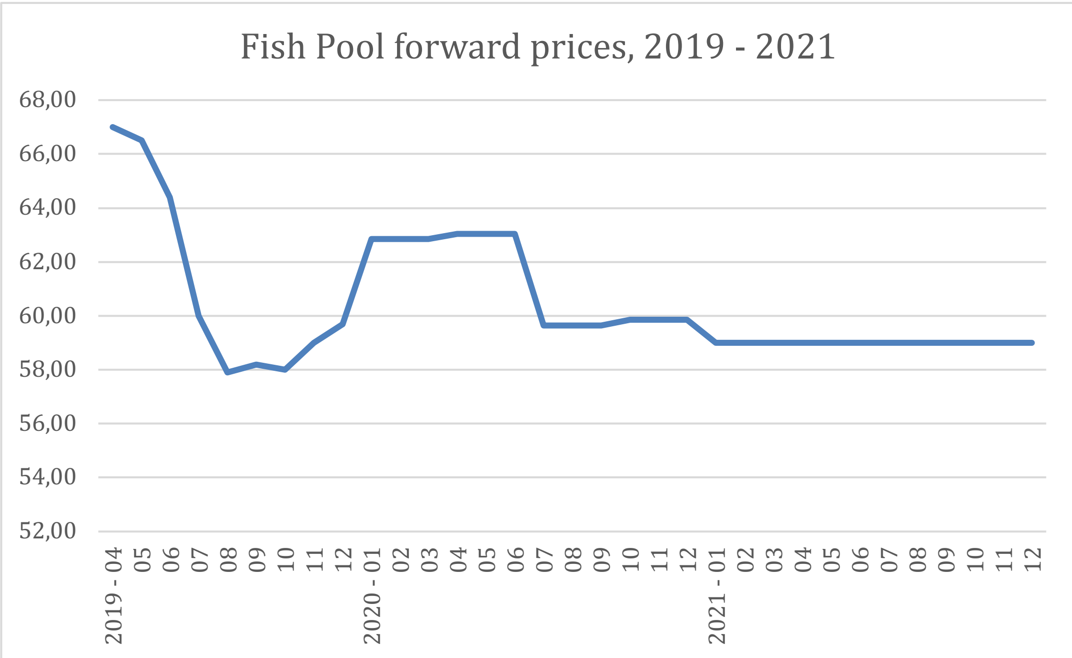

Figure 12: Forward salmon prices, 2019 – 2021 (Fish Pool)

The forward salmon prices from Fish Pool estimates a cyclical price drop during the summer and fall months before increasing until the beginning of 2020. Then the price is expected to follow the same cyclical pattern as previous years until reaching stabilized prices of 59.65 NOK/kg in August 2020 and predicted flat prices of 59.00 NOK/kg from 2021 on. The forward salmon prices thus imply a price decline of 1.0 % in 2020 and a 0.3 % decline in 2021. The average Fish Pool forward price from April to December 2019 is 61.19 NOk/kg. Including the realized spot prices from January throughout March the same year, the average price of 2019 is estimated to be 61.99 NOK/kg. This average of the realized prices and forward prices of 2019 is equal to the forecasted price from analysts at Pareto Securities and DnB Markets, and also consistent with price forecasts from other analysts.

Summary:

The average annual growth in salmon prices the last decade has been over 5.0 % annually, which was explained by a high demand for fresh, gutted salmon together with an industry challange of meeting the demand because of environmental problems and limits in the production. The annual average salmon price has been relatively constant for the last three years. Forward prices extracted from Fish Pool are assumed to represent future spot prices of salmon, and thus serves as a reliable source for estimating forecasted prices. The forecasted salmon prices in the FCFF estimations will therefore be based on the relatively flat forward salmon prices extracted from Fish Pool in 2019. Forecasted price estimations will be adjusted by the inflation rate.

Smolt costs

The Directorate of Fisheries' published a profitability survey amongst Norwegian farming companies in 2018, reporting the average numbers of costs and revenue from the industry. According to the survey, cost of smolt amounted 11 % of the total production costs, on average (The Directorate of Fisheries, 2018a). The cost of smolt is measured in NOK per kilo gutted salmon (round weight) and is a result of two main factors: the cost per smolt (unit price) and the yield from harvest per produced unit of salmon or amount of smolt released. These factors are again a result of many cost drivers. The cost or price per smolt is affected by the price and availability of roe, feed and vaccines, in addition to the actual production costs of smolt. Further, there are different sizes of the smolt to be purchased and released in the pen, with an average weight ranging between 100-150 gram. Larger smolt, or post-smolt, are more expensive due to longer production time and costs. The smolt yield is dependent on the weight of the adult, harvested salmon and wastage of fish due to escapes and dead fish.

The cost of smolt per kilo produced fish in round weight is shown in table 2. The 3-year history presents increasing costs related to smolt. The numbers are extracted from the Directorate of Fisheries profitability report of 2018, where the author specifies that the costs are average costs presented by the selection of companies and that the spread of reported costs is great.

Year	2015	2016	2017
Cost of smolt, NOK/kg	2.72	3.18	3.43

Table 2: Cost of smolt, NOK/kg produced fish, round weight (SNF, 2018)

Figure 13 illustrates the development in smolt prices in the decade from 2007 to 2017. The price of smolt has had an annual average increase in average prices of 4.7 % in the last decade. In 2017, the price of smolt was 12.64 NOK per smolt (The Directorate of Fisheries, 2018d).

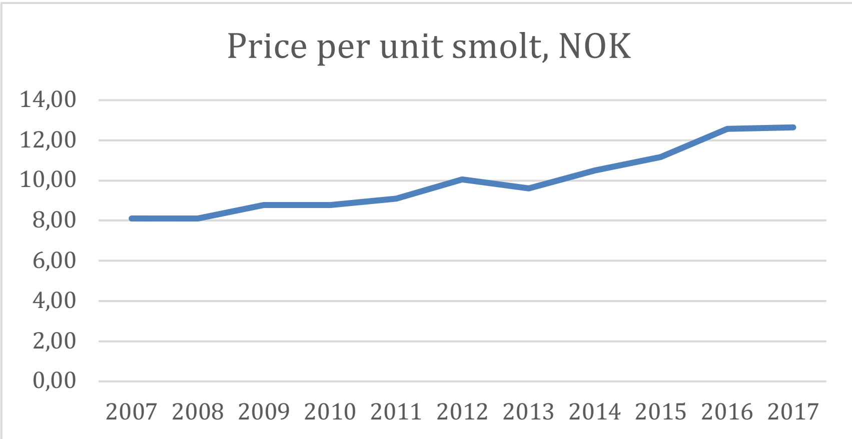

Figure 13: Prices of smolt, 2007-2017 (The Directorate of Fisheries, 2018d)

The smolt price illustrates the value of a unit of an average smolt, with sizes varying between companies. As mentioned, the most common smolt sizes in Norway are between 100-150 grams, with an average weight of 135 grams (Nofima, 2018). However, the average standard size is increasing due to a higher demand for larger post-smolt. As a result, smolt prices are increasing and the production of bigger post-smolt is aggregating. Due to the shift in the industry to release bigger post-smolt, the average price of smolt is expected to increase further in the future. Analyzes performed by Nofima and Kontali from 2018 estimate a unit cost per smolt to be 11.50 for a 100 grams smolt (Nofima, 2018).

Summary:

Smolt prices have historically increased by 4.7 % annually and are expected to increase further due to production of bigger smolt and high demand for bigger post-smolt.

Feed costs

Atlantic salmon has specific requirements for nutrients, especially for amino acids and fatty acids naturally found in raw materials of animal origin. Because of this, the two most important ingredients in fish feed have previously been fish meal and fish oil (Marine Harvest, 2018). However, the availability of the two have been limited and today they are often substituted with other ingredients, such as soy, sunflower, wheat, corn and rapeseed oil. With shortage of marine ingredients and significant price increases in the raw material due to the high demand from the aquaculture industry, the industry shifted to vegetable materials. The salmon feeds must provide enough proteins and energy for high muscle growth, and the technology today makes it possible to feed salmon with non-marine protein sources and still ensure sufficient protein and fat for optimal growth and good health. In other words, recent development and technology has made it possible to produce satisfactory salmon feeds at cost optimizing levels with the limited availability of fish meal and is also more sustainable. Today, about 30 % of the average fish feed in Norway consists of marine materials.

The cost of feed makes up almost half of the average total production costs for salmon (The Directorate of Fisheries, 2018a). For companies in the aquaculture industry, it is thus an important production factor in which the companies want to minimize. Prices of feed vary depending on the supplier, the content and the composition. Figure 14 illustrates the development of the average feed prices in NOK per kilo feed from 2008 to 2017, retrieved from the Directorate of Fisheries' profitability survey.

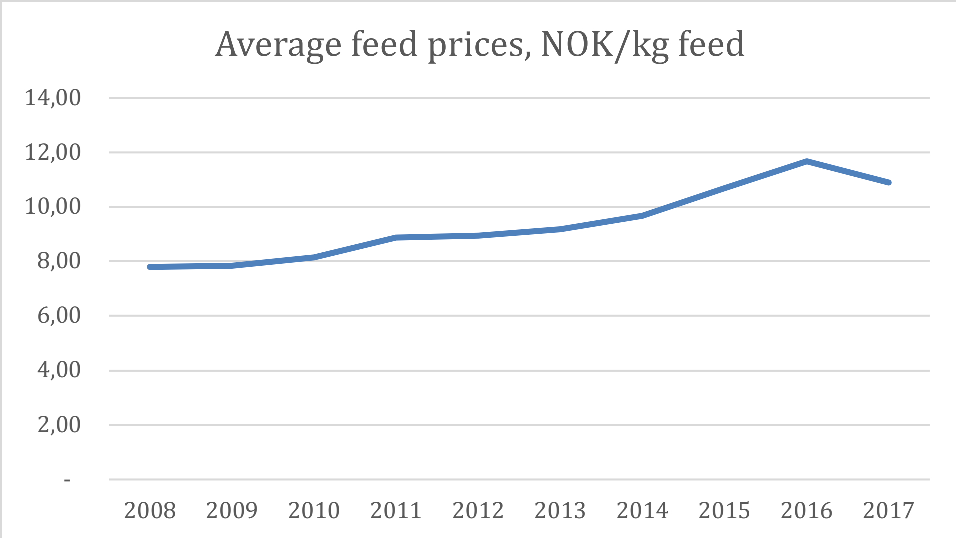

Figure 14: Average feed prices 2008-2017, NOK/kg feed (The Norwegian Directorate of Fisheries)

The graph illustrates increasing feed prices during the 10-year period, with a top in 2016. The extracted feed prices are based on feed costs divided on the difference of inventory of feed from January 1st to December 31st, and the total purchase of feed in the survey year. The average historical price increase in the period has been 3.92 % annually, including a price drop of 7.0 % in 2017. The average price for salmon feed in 2017 was 10.90 NOK/kg feed. The feed price is highly affected by the exchange rate of the Norwegian krone, as most input factors in the feed are imported. With a weak NOK, the price for the import factors are high, as is the price for feed. EY believes that the feed prices will continue at the 2017 levels for 2019 due to a weak NOK (EY, 2019).

The economic feed conversion rate is a calculation method used to estimate how many kilos of feed a fish needs to grow one kilo. The Directorate of Fisheries suggests that an aquaculture facility should have a feed conversion rate around 1, with a potential to decrease the rate to under 1 (The Directorate of Fisheries, 2018a). The economic feed conversion rate is calculated as the feed consumption divided by the produced amount of fish in a year. The annual feed consumption is further calculated as:

$$\textit{Feed consumption} = \textit{feed storage 01.01} + \textit{feed purchase} - \textit{feed storage 31.12}$$

The produced amount of fish is calculated as the sum of sold amount and change in biomass during the year. Table 3 presents the calculated average economic feed conversion rates, in kg feed per kg fish, in gutted weight.

Year	2015	2016	2017
Feed conversion rate	1.23	1.25	1.32

Table 3: Feed conversion rates, 2015-2017 (The Directorate of Fisheries, 2018e)

Summary:

The annual average historical growth in feed prices have been at almost 4.0 % during the last decade. However, analysts believe that the feed prices will continue at the historically low 2017-levels, caused by a weak NOK exchange rate. With respect to this, flat prices based on the 2017-prices will be assumed further in the FCFF estimations, adjusted annually by inflation.

Cost of slaughter

Cost of slaughter consist of the cost directly related to the harvesting of salmon and costs of freight. According to the Directorate of Fisheries' profitability survey (2018a), the average cost of slaughter reported from Norwegian farming companies were 3.09 NOK/kg in 2017 and 3.26 NOK/kg in 2016. This presented a decrease of 5.2 %. However, from 2014 to 2017, the reported cost of slaughter increased by 26 % during a 3-year period, which results in an average annual increase of 8.6 %. This is considered a high increase, which also may have a great impact on the total costs and cost allocation for companies in the aquaculture industry. The cost of slaughter usually makes up about 10 % of the total production costs that accrues to the company (Directorate of Fisheries, 2018a).

Analysts from EY's Norwegian Aquaculture Analysis (2018) report of a high revenue growth for harvesting companies in 2018, where the prices for slaughtering continue to rise despite a constant, or even decreasing, harvested volume of salmon in the same period. Further, analysts believe that all production costs for farming companies will continue with the historic growth in the years to come. With the possibility of increasing harvested volumes of salmon due to new technology, the price for harvesting may rise significantly if harvesting companies does not expand or facilitate the processing.

Summary:

An assumed growth of 8 % in the cost of slaughter is assumed and forecasted further in this thesis. This is based on the historic 3-year average increase in the expenditure, as well as analytical assumptions.

Interest rates

The interest rates in the economy will have an impact on the discounted cash flows to total capital based on its influence on the discount rate. Companies in the aquaculture industry is in a capital-intensive industry, where large and costly investments increase the need for bank loans. In other words, the borrowing rate in the Norwegian market is of high interest and impact. Also, the risk-free rate is an important factor in the calculation of the cost of equity, where small changes in the rate may have a significant impact on the calculated outcome in a valuation. To estimate the lending rate by Norwegian banks, several approaches can be used. First, it is possible to calculate the average lending rate issued by credit institutions and use the average as the borrowing rate in the cost of debt. It also possible to look at the key policy rate, or sight deposit rate, which is the interest rate on banks' reserves up to a specified quota in the Bank of Norway. The key policy rate will normally have a high impact on the money market rates in the short term, and the banks' lending rate (Bank of Norway, 2019a). Most credit institutions finance loans by issuing bonds to investors, where the price is split in two parts. One part consists of the changing 3-month NIBOR rate, which is varying. The other part is a fixed margin, called the risk premium. The latter approach will be discussed further, as this approach will be applied in the thesis.

NIBOR is short for the Norwegian Interbank Offered Rate and is often referred to as the money market rate. It is used as the rate the Norwegian banks and credit institutions are willing to borrow to each other for a specific time period, with maturities from one week to one year (Johnsen, T., 2018). The rate is based on currency swap rates and varies widely due to the structure and the difference in exchange rates in NOK and USD. Loans issued by institutions are, as mentioned, reflected on a rate consisting of the 3-month NIBOR rate plus a margin. Figure 15 presents the historic 3-month NIBOR rate from 2013 to 2018. The average rate in 2018 was 1.06 %, which is still historically low and can be explained by a weak NOK. A low NIBOR interest rate means that it may be "cheaper" for companies to take up loans, but this also depends on the additional margin. Further, an increase in or higher NIBOR rate results in an increased borrowing rate and thus higher interest rates on the issued loan. Hence, a low NIBOR rate is to prefer for a company.

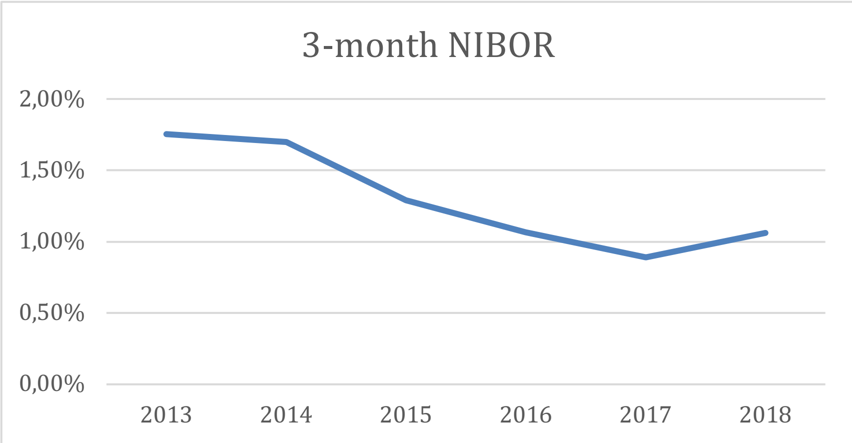

Figure 15: 3-month NIBOR rate, 2013-2018 (Oslo Stock Exchange, 2019)

The risk-free rate used in calculations is thought of as the rate on an investment without interest payments, i.e. there is no interest rate risk. It is common to use securities issued by the government in which the investment takes place as the risk-free rate. In Norway, the 5-year and 10-year government bonds are widely used, where the latter is the most popular (EY, 2014 and PwC, 2019). The Bank of Norway issues the government bonds, and the annual average of daily quotes from the past 5 years are illustrated in figure 16.

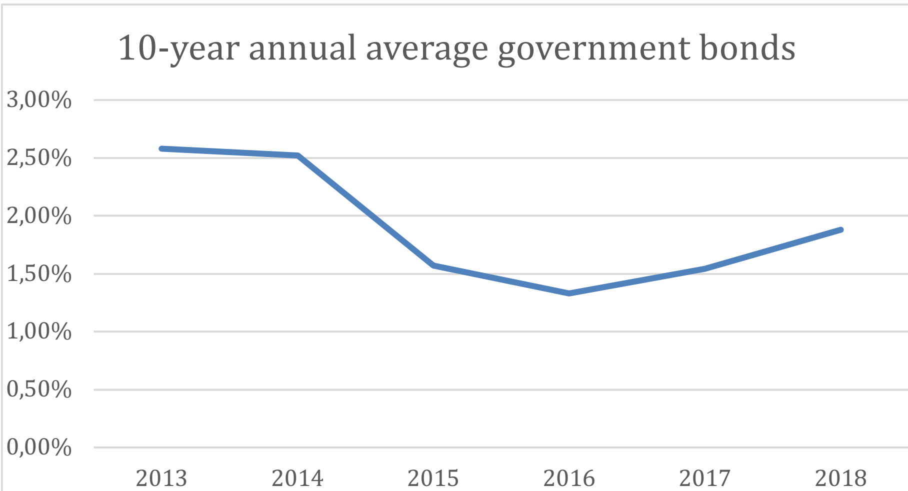

Figure 16: 10-year annual average government bonds (Bank of Norway, 2019b)

The annual average of the 10-year government bonds is also historically low, but the average has now been increasing since 2016. The 6-year average from 2013 to 2018 was 1.90 %. From 2008 until today, the government bond yields have presented with high volatility.

Volatility in the risk-free rate leads further to volatile costs of capital and difficulties estimating an appropriate value (EY, 2014). EY (2014) suggests using an average yield as a proxy for the risk-free rate when calculating the cost of equity through the CAPM to be used in a DCF approach. According to studies performed by the accounting and assurance company, normalizing the risk-free rate will lead to a more stable valuation result.

<u>Summary:</u>

Based on discussion and historical analysis of the 3-month NIBOR rate, the average rate from 2018 of 1.06 % will be assumed further in this thesis. The assumption is based on an expectation of continuance of the historically low rate, influenced by an expectation of a further weak NOK. The 6-year average of the 10-year annual average government bonds was 1.90 %, which is also equal to the yield in 2018. Based on EYs suggestion of using an average yield as a proxy, a 10-year government bond rate of 1.90 % should be used as the risk-free rate.

Inflation

Inflation is a persistent growth in the general price level, or the development in the monetary value of the Norwegian krone (Stoltz, G. 2018). The development of the value follows the relationship between the money supply and the society's ability to produce goods and services. The generation of money is subordinate to the money and credit policy, where the political system aims to a low and stable inflation to contribute to economic growth. In Norway, inflation is measured by the percentage yearly change in the consumer price index (CPI). The CPI is an index showing changes in the prices of goods and services bought by households and compared to a base year.

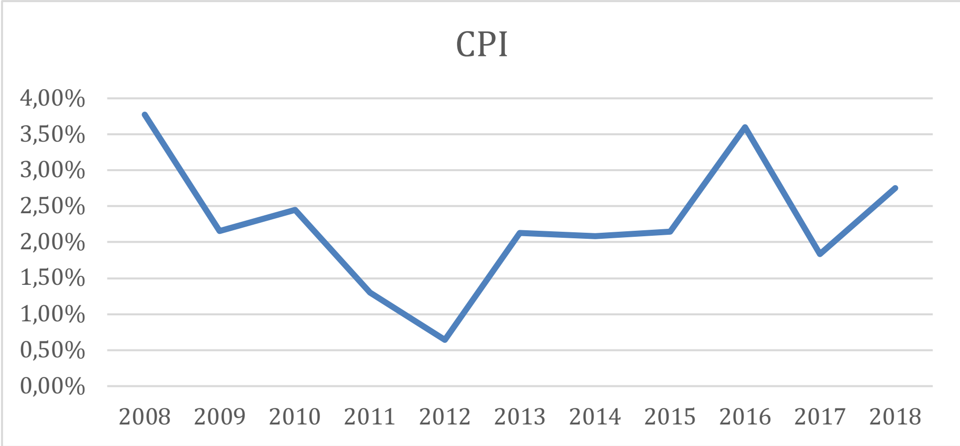

Figure 17: Consumer price index, annual percentage change, 2008 - 2018 (Statistics Norway, 2019a)

Figure 17 presents the historical inflation, or percentage annual change in the CPI, in Norway the last decade. The inflation rate presents high annual variations, with an annual average of 2.26 % throughout the presented 10-year period (Statistics Norway, 2019a). High inflation is associated with a low-key policy rate and weakens the purchasing power of the krone. By keeping an interest rate floor for the key policy rate, the Bank of Norway can somewhat control the inflation rate and avoid that the inflation is too high. The Norwegian government has set a target for the inflation rate, where the monetary policy is oriented towards an approximate growth of 2 % annually in the consumer price inflation, to ensure a high and stable production (Bank of Norway, 2018). In real life, it will be difficult to determine the price movements and the effects on the CPI. The Monetary Policy report projects the inflation rate for the coming years, which is presented in figure 18. The projections illustrate an estimated decreasing rate in 2019 and 2020, before approaching 2 % in 2022.

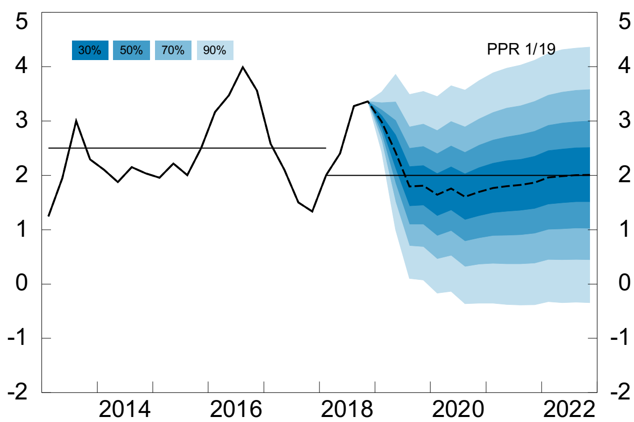

Figure 18: CPI projections from Monetary Policy Report (Bank of Norway, 2018)

Summary:

Based on the historical average, but most importantly the CPI projections from the Monetary Policy Report, the assumed inflation rate is estimated to be 2.0 % and will illustrate the expected growth in the economy and variables further in this thesis.

Exchange rates

Interest rates and inflation have a mutual influence on the Norwegian exchange rates. In a ceteris paribus state, high interest rates and inflation in a nation's economy increases, or strengthens, that country's currency against other currencies with lower interest rates. However, there are many other factors affecting the exchange rates in an interrelated relationship. Foreign investment is accelerated by higher interest rates, which will increase the demand and in turn the value of the home nation's currency. Oppositely will lower interest rates decrease a currency as foreign investment is seen as unprofitable. Looking at the annual average of the 10-year government bonds from the previous section, the bond yield was historically low in 2016, with a rate of 1.33 %. The yield has increased slightly since and averaged in 1.88 % in 2018. The same pattern can be seen in the historical offered lending rate, NIBOR, or money market rate. The rate decreased from 2014 until a historically low rate in 2017, before presenting an average of 1.06 % in 2018. Now looking at the Norwegian exchange rates on the world's two most common currencies; the Euro and the US Dollar, the opposite pattern is discovered. Figure 19 presents the EUR and USD exchange rates to NOK during the last decade.

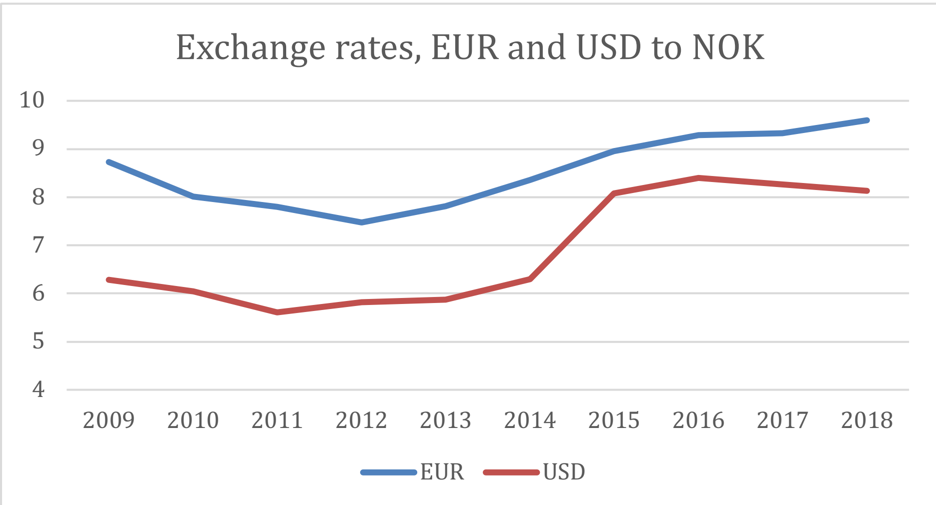

Figure 19: Exchange rates to EUR and USD, in NOK (Bank of Norway, 2019c)

As figure 19 illustrates, when Norway's money market rate and government bond yield are low, the Norwegian krone is weakened. A weakening of the krone reduces the NOK exchange rate and strengthens the opposing currency. Opposite from the NIBOR rate and bond yield, the Norwegian currency decreased from 2014 and reached a historical high in 2016/2017. Exchange rates are important in an economy because of import and export and the trade with other currencies. For the investment in the "Brilliant™" project, the Norwegian exchange rate is important because it affects the salmon prices and feed costs, among others. Most of the ingredients in salmon feed produced in Norway are exported from other countries, and a weak NOK exchange rate thus influences the production costs and sales price of feed. Further, the salmon prices are affected by the exchange rate as a weak NOK increases the demand for exported salmon and the salmon price. EY predicts in its Norwegian Aquaculture Analysis from 2018 that the weak NOK will continue for the coming years and affect the feed and salmon prices (EY, 2019).

Summary:

The Norwegian exchange rate is affected by the interest rate in the economy, and with today's historically low NIBOR rate and government bond yield, the Norwegian krone is weak. It is predicted that the weak NOK, or high exchange rate, will continue from 2019 and may influence the aquaculture industry with high feed and salmon prices.

Labor costs

According to Statistics Norway (2019c), the average monthly salary for a worker in the aquaculture industry was 49,030 NOK in 2018. This make up an annual industry pay of 588,360 NOK, which is slightly higher than the average of 547,320 NOK for all sectors.

Annual labor costs reported from a company does not merely include the costs related to salaries. Payroll taxes, holiday pays, National Insurance contributions and social costs make up the total labor costs together with the paid salaries. The reported annual cost of labor is thus somewhat higher than simply the annual salary of a worker. The Directorate of Fisheries reported annual average labor costs of 808,079 NOK per FTE (full-time equivalent). FTE is a ratio referring to number of employees working full-time, where one FTE equals one full-time employer (BusinessDictionary, 2019).

The growth in labor costs are assumed to equal the historic annual average increase in salaries or labor costs per FTE from 2017 to 2018. The increase in annual salaries from the aquaculture industry retrieved from Statistics Norway (2019c) was 2.4 %, whereas the inflation rate in the same period was 2.7 % (Statistics Norway, 2019a). This means that there was actually a real wage decrease in the same period of 0.3 %. From 2015-2017, the Directorate of Fisheries (2018a) reports an annual average increase of 4.1 % in labor costs from the aquaculture industry. Based on these aspects, a growth rate in labor costs of 3.0 % are assumed further.

<u>Summary:</u>

Labor costs in the aquaculture industry has historically had an increase of 4.1 % in average. However, statistics show that there was a reduction in the real annual salaries reported from the industry of 2017-2018, as the inflation rate was higher than growth in salaries. An annual increase of 3.0 % are thus assumed further.

4.1.1.3 Socio-cultural factors

Social or socio-cultural factors of a PESTEL-analysis focus on emerging trends in the social environment and may help assess the demand for specific products in the industry. Social factors include cultural trends, attitude changes, lifestyle changes, demographics and education levels. Socio-cultural factors that may affect the aquaculture industry includes population growth, general health of the population, environmental status and trends.

Socio-cultural factors are important aspects to consider when making assumptions about the future demand for salmon. However, the demand is affected by a sum of several variables. As demand for salmon is not to be estimated solitary in this thesis, socio-cultural factors will only be mentioned briefly, and a summary will be included at the end of a presentation of the factors.

Population growth

Figure 20 is retrieved from Statistics Norway and illustrates the projected population in Norway towards year 2020 (Statistics Norway, 2019d). The yellow line presents the historic population from 2000 to 2018 and the green line illustrates the main assumption in forecasted growth.

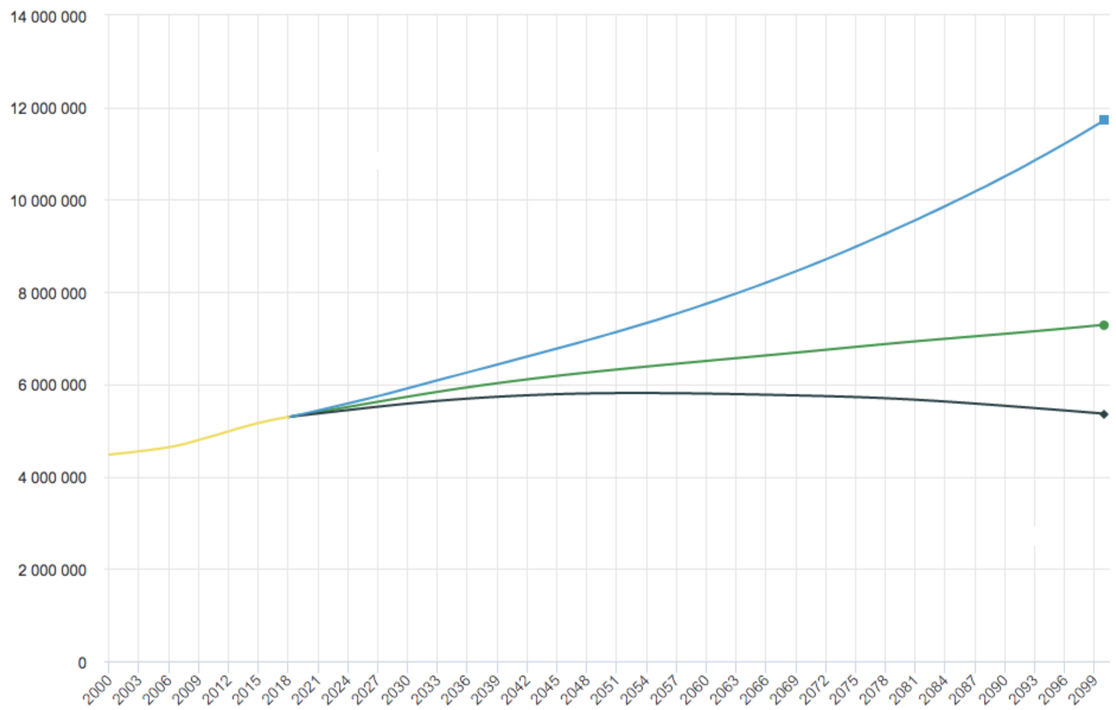

Figure 20: Population projections in Norway, in number of people (Statistics Norway, 2019d)

The black and blue line shows the highest and lowest projections, respectively. The graph clearly illustrates a historical growth in the Norwegian population, from 4.48 million in 2000 to 5.3 million in 2018. This increase is not only caused by surplus of births versus deaths, but also by higher immigration into Norway than emigration.

With an increasing population, and estimated future growth, the demand for food and nutrition are expected to increase. The Norwegian Directorate for Civil Protection (DSB) published an analysis in 2017, looking at the possible risks and vulnerability of the Norwegian food supply. In 2018, the degree of self-sufficiency of food in Norway was at 40 % (Norwegian Agricultural Cooperation, 2018). DSB estimates challenges within the self-sufficient supply in the long-term, explained by the forecasted population growth, uncertainty in the food market and climate changes, as well as limited areas for own production of food (2017). Hence, the demand for food, including salmon, and especially local food, are assumed to increase in Norway for the coming years.

Health and food trends

In most Norwegian online newspapers, one can daily find articles regarding health and food trends. In 2019, the focus on food involves healthy diets consisting of less meat and unsaturated fats and more plant-based and leaner food products. The Norwegian Directorate of Health publishes dietary advices for the Norwegian healthy population. Advices include 2-3 dinners containing fish during a week, and to limit the amount of processed and red meat (The Directorate of Health, 2019). Following the advices and the trends related to food and health may result in a higher demand for salmon, as it is considered a healthier alternative than meat (NHI, 2016).

Another trend expected to increase the demand for salmon is the variety and innovation related to products and dishes containing salmon. The Japanese dish "sushi", consisting basically of sushi rice and raw fish, have existed for nearly two centuries, but made its entry into Norway around 2006 (Norwegian Seafood Council, 2017). Many sushi dishes contain raw salmon, demanding a fresh and high-quality product. The growth in the demand for sushi in Norway has increased by 341 % from 2006 to 2017. Furthermore, the trend is not only limited to Norway. Norwegian salmon was introduced for Japanese chefs 30 years ago, and in 2017, the export of Norwegian salmon to Japan resulted in over 114,000 tons (Norwegian Seafood Council, 2018).

In 2019, the Hawaiian dish "poke" or "poke bowl" is trending the food market in Norway. "Poke bowl" is a raw salad often served in a bowl with rice, and the main ingredient; raw salmon (Lerøy, 2019).

Norway as a leading salmon farming country

In 2012, SINTEF released its newest report on the aquaculture industry, enclosing the status of the industry goals towards 2050. The report was a follow-up from a similar report from 1999. A workgroup of different scientists, managers, founders and workers from the industry have analyzed the industry and set aims for year 2050 (SINTEF, 2012a). The analysts believe that the general demand for food will increase in the coming years, and especially the demand for salmon. The high demand is expected to increase the value creation in the aquaculture industry greatly, and the analysts predict that the total return from the Norwegian marine industry can reach 550 billion NOK in 2050 (SINTEF, 2012a). The ambition is that Norway will become the leading salmon farming supplier in the world. In order to meet these objectives, the industry must find solutions to the environmental challenges to increase the production volume and hold the production costs down.

Summary of socio-cultural factors:

Population growth, food trends and a high focus on health are socio-cultural factors that are assumed to have an increased effect on the demand for salmon. The "SINTEF 2050" report believes in an increased value creation in the aquaculture industry and that Norway will be a leading global supplier of salmon within 2050.

4.1.1.4 Technological factors

Technological factors look at the rate of technological innovation and development that affects the market and industry. Development of methods of distribution, manufacturing and logistics are considered technological factors, as well as digital technology, automation and research. In the aquaculture industry, innovative competition between companies and the Norwegian government's support of innovation are technological factors to consider.

Innovation in the industry

Technological innovation is essential in the aquaculture industry. The Norwegian government wants to emphasize and support research and development in the aquaculture industry, to find solutions to the environmental problems that can further develop and increase the production of salmon. First, the government has limited the number of licenses available, in order to limit production levels until innovative solutions can help reduce sea lice. This means that new technology is crucial for new competitors to enter the industry, and for existing companies to grow. New technology is supported by the government by allocation of development permits, where receiving companies are allowed to produce salmon in order to test out innovative solutions. New technological innovations are usually costly for a company. Therefore, development permits only present a cost if the permit is to be converted to a regular license after the duration of the permit. This is an advantage for the company, as regular farming licenses are expensive.

The Norwegian Government further supports aquaculture innovation through the Aquaculture Fund and Innovation Norway. Eighty percent of the income from sale of farming licenses are distributed through the Aquaculture Fund to municipalities involved in salmon farming. The goal of the Fund and the payouts is to highlight that the aquaculture industry gives back to the community, and to stimulate municipalities to invest in innovation within salmon farming (The Norwegian Government, 2018f). Innovation Norway is an organization owned partly by the Ministry of Trade, Industry and Fisheries and county authorities, and is the Government's "most important instrument for innovation and development of Norwegian enterprises and industry" (Innovation Norway, 2015). The organization supports and facilitates innovation through sharing of industry knowledge, support systems and services, international networking and, most importantly, by offering financial aid.

Summary:

Technological innovation is necessary for the aquaculture industry to grow and is supported by the Norwegian Government through development permits, payouts from the Aquaculture Fund and aid from Innovation Norway.

4.1.1.5 Environmental factors

Supply and demand of salmon consist of several underlying factors affecting the market price of salmon. Underlying factors include the quality of the salmon product, outbreaks of diseases, loss due to escaping salmon and the general welfare of the biological product. All these are environmental factors that not only affect the environment and sustainability, but also the market supply and demand in the aquaculture industry.

Sea lice and diseases (ISA)

Sea lice and diseases was responsible for a 19 % mortality rate of salmon in conventional fish pens in 2017, a 3 % increase from the previous year (EY, 2018). Loss caused by sea lice amounted the largest reason for mortality, which explained over 49 % of the total wastage (Norwegian Directorate of Fisheries, 2018). Destruction of salmon due to infiltration of infectious salmon anemia (ISA) made up the second largest reason, contributing to almost 45 % of the salmon mortality reasons. Other diseases causing a health risk to salmon includes pancreas disease (PD), infectious pancreatic necrosis (IPN), heart and skeletal muscle inflammation (HSMI) and gill disease.

Sea lice, *Lepeophtheirus salmonis,* is the most common parasite on salmon and can be a challenge not only for the farmed salmon, but also for wild fish (Lusedata, 2019). Although the parasite is found naturally in all northern seas, high incidences of lice increases the number attached to the fish. Sea lice causes cuts and wounds on the salmon host, which may result in infections and problems with the fish's salt balance (Lusedata, 2019). Eventually, it may result in death. The aquaculture industry and farming of salmon increase the count of fish in the sea considerably. This means that there are more hosts for the sea lice to attach on, and the levels of lice increase simultaneously. It is crucial to keep the sea lice levels low and maintain control of the levels in the farming facilities, in order to avoid excess infections and spread to wildlife. According to the Scientific council for salmon management, it is proven that the increase in sea lice from salmon farming has reduced the number of spawning salmons in the most farmed intensive areas in Norway (VRL, 2012). The Ministry of Trade and Fisheries developed a regulation for preventing sea lice in 2013, which includes requirements for counting of sea lice levels for Norwegian aquaculture companies (The Ministry of Trade and Fisheries, 2016).

Treatment measures for sea lice includes medical and non-medical treatment. Medical treatment includes adding medicinal products in the water or in the fish feed (KLV, 2019). Both medical methods have led to hereditary resistance amongst sea lice at several facilities, and new non-medical treatment methods are now applied or under development (KLV, 2019). Non-medical measures include the use of cleaning fish, mechanical delousing by the use of spraying with water or use of laser, and different ways of shielding and preventing infiltration of lice in the pen. According to the Scientific council for salmon management, the current measures are not sufficient enough to reduce the number of sea lice to a sustainable level (VRL, 2012).

The second main reason for farmed salmon mortality is the viral disease of infectious salmon anemia, or ISA. ISA is a highly contagious disease, with a cumulative mortality rate of 90 %, if the disease is unchecked and untreated (CFSPH, 2011). The ISA virus has a complex epidemiology, where individuals can carry the virus without symptoms. It may therefore be difficult to detect and diagnose before an increased mortality rate in the pen has already occurred. Clinical signs include anemia (lack of red blood cells), fatigue, ascites (fluid in the abdominal cavity), darkened skin or pale gills (CFSPH, 2011). The ISA virus spreads readily in a fish pen within 7 to 15 days and can also spread between pens. High cleanliness in the pens are assumed to decrease transmission of the virus (CFSPH, 2011). However, there is currently no treatment of ISA and detection of the virus will normally result in harvesting of all fish in the relevant pen (FoMAS, 2019). Vaccines are available and in use where ISA is considered to be a high risk (Marine Harvest, 2018).

EY forecasts that biological problems and diseases will continue to be an industry challenge in the future. 2018 presented with several cases of ISA and PD in Norway and increase in outburst compared to 2017. With no new control measurements in sight, it is estimated that the diseases will continue to stagnate the production of salmon. The statistics of sea lice levels in Norway in 2018 were still high and EY further estimates that the levels will be constant until new, sustainable solutions for lice removal and prevention are found.

<u>Summary:</u>

In 2017, the mortality rate in conventional pens caused by sea lice and diseases was 19 %. There are currently no new measures to reduce the levels of sea lice and infections, and based on EY's future estimates, the mortality rate is assumed to be constant. A similar rate will be assumed for the conventional pen, whereas "Brilliant™" is expected to have a decreased rate due to its capabilities.

Escaping salmon

Escaping of salmon may have a big environmental impact even with the escaping of a single fish. A farmed and bred individual made for a life in the pen have different genes and capabilities than the wild salmon. If farmed salmon is mixed with the wild population, the biology of the bred specie will spread with the "original" gene composition, which is unfortunate for the nature and wild salmon for several reasons. In addition, escaping salmon is an economic loss for the supplier and affects the industry conditions.

Salmon may escape the fish pen for different reasons. The most common escapes occur during the release of smolt into the pen or through handling of the net by the sorting and harvesting of fish, sea lice removal or change of net (Barentswatch, 2019). Escaping may also follow because of technical errors, holes in the net or caused by storms.

Fortunately, the share of escaped salmon has decreased significantly during the last two decades (The Directorate of Fisheries, 2019b). According to the statistical report of the aquaculture industry in 2017 by the Norwegian Directorate of Fisheries, none of the contributors had escaped salmon in 2017 (Norwegian Directorate of Fisheries, 2018e). However, the Directorate of Fisheries received 44 reports regarding escaping incidences in 2018, including a total number of 160.000 salmon (The Directorate of Fisheries, 2019b). Although escaping of salmon is an environmental challenge for the aquaculture industry, it does not affect the total wastage rate significantly. In 2017, the number of escaping salmons was at an historical low. During the years of 2014-2016, escaping fish only accounted for an average of 0.35 % of the total wastage of fish (Norwegian Directorate of Fisheries, 2018e).

Summary:

Escaping of farmed salmon is an environmental problem for the aquaculture industry. Because of the low numbers of escaping fish in the last couple of years and the minimal impact on the total rate of wastage, escaping salmon will not be assessed further in this thesis.

Salmon welfare

Salmon welfare is an important prerequisite for a general good health, low mortality and good quality of the fish, as well as a positive reputation and profitability of the industry suppliers (Mattilsynet, 2019). Regulations in the Animal Welfare Act and the Aquaculture Act provides legal requirements in order to obtain good fish welfare, which include both the handling and slaughter of farmed fish.

Farmed salmon cannot choose the environment it lives in, as wild species can. Therefore, the environment in aquaculture facilities must be optimal for the farmed salmon throughout the whole life cycle. Factors that affect the salmon welfare includes primarily environmental conditions, nutrition, social relations, correct handling, transportation, and prevention and treatment of diseases (Salmonfacts, 2018). Environmental conditions are numerous, and involves water quality in regard to oxygen level, temperature, circulation and currents, salinity and pH level, as well as light and other physiological needs (Salmonfacts, 2018). Salmon lives wildly in the northern Atlantic Sea, and recent studies proves that wild Norwegian and Russian salmon also thrives in the Barents Sea and the surrounding waters of Svalbard (SNL, 2018). The studies imply that the wild fish is fleeing to more exposed waters. Exposed sea may improve the salmon health and welfare, because of colder sea temperatures and higher currents. According to the National Institution of Nutrition and Seafood research, NIFES, the salmon increase its feed intake and growth at temperatures of 13 degrees Celsius, which is lower than previously assumed (NIFES, 2013). The study also imply that the optimal temperature may be even lower. Global warming increases the sea temperatures, especially at coastal areas, and the temperature sensitive salmon may be affected by these climate changes in today’s farming facility locations (NIFES, 2013). Further, studies performed by Nofima proves that increased current velocities have a positive effect on growth and feed efficiency (FHF, 2012). Farming in exposed sea may therefore improve the salmon robustness, health and welfare.

A robust and healthy salmon is also resistant against stress. The attachment of sea lice reduces the salmon welfare in the pens. The lice attach to the salmon's skin surface, creating ulcers and wounds that may result in infections. When handling the salmon for treatment of lice, the fish is put under stress. Stress may also be experienced by the fish under pumping of the pen before harvesting, during transportation and cleaning (Nofima, 2019). Stress is associated with a higher chance of attachment of sea lice, higher infectious risks and decreased feed intake and growth.

Summary:

Optimal environmental conditions are important factors affecting the welfare of the salmon. New studies prove that salmon thrive in colder sea temperatures and higher currents than assumed today, and further estimates will assume benefits regarding salmon welfare when farming in exposed sea.

Global warming and climate changes

Global warming and climate changes are trending words in 2019. Norway has experienced higher temperatures at land and sea, more and frequenter precipitation, and melting of snow and sea ice the last years (The Norwegian Environment Agency, 2019). Increasing temperatures at sea, and especially at coastal areas, is negative for the aquaculture industry. According to NIFES, salmon thrives at temperatures of 13 degrees Celsius, which is expected to have an impact on feed intake, growth and size of the product. According to the Norwegian Environment Agency, temperatures at sea surface are expected to increase between 0.5 and 2.5 degrees Celsius by the end of this century (The Norwegian Environment Agency, 2013). Even small changes in the temperatures can have great consequences on the aquaculture industry, and the Environment Agency (2013) expect wild salmon to travel further north to find colder climates. Ocean acidification, an increase in the carbon dioxide (CO_2) levels and decrease in the pH level, caused by heavy precipitations changes the environment in the sea (The Norwegian Environment Agency, 2019). Furthermore, extreme weathers and high changes in the climate and environment impacts the living conditions for the salmon even further.

Sea lice are affected by sea temperatures, and multiply more rapidly in higher temperatures (Dalvin, S. et al., 2019). The sea temperature along coastal areas in Norway vary greatly due to seasonal changes and geographical location. Higher temperatures are found to increase not only the development of sea lice, but also faster reproduction and a higher rate of infections when attached to the salmon (Dalvin, S. et al., 2019). Hence, increasing sea temperatures have a negative impact on the challenge of sea lice in the aquaculture industry.

Summary:

Climate changes and higher sea temperatures are presumed to have a negative impact on the aquaculture industry and the challenge of battling sea lice on salmon.

4.1.1.6 Legal factors

Legal factors are similar to political factors but differ in that political factors are led by government policy, whereas legal factors must be complied with (Oxford College of Marketing, 2016). Legal factors include consumer laws, health and safety, and trade regulations and restrictions. In the aquaculture industry, the proposal of resource rent taxation is a legal factor affecting the industry. See section 4.1.1.1 Political factors, under "tax proposal" for a discussion of this.

4.1.1.7 Summary of PESTEL

Political, economic, socio-cultural, technological, environmental and legal factors affecting the aquaculture industry have been discussed. The most important factors for the remaining of this thesis are undoubtedly the economic factors, including the price of salmon and the prices of feed, smolt and harvesting of the salmon. The rate of inflation is also an important factor and assumption for future forecasts. The discussions and conclusions on future estimates from the PESTEL analysis of macroeconomic factors will be used further in the investment analysis to follow in the next chapter.

4.2 Assessment of uncertainty

The demand for salmon is affected by the availability of the product, the price of salmon, the price of comparable protein products, the quality of the product, macro trends referring to health and climate and several other factors. The demand can change rapidly due to a change in one of the factors and may have a big impact on the industry suppliers.

The supply of salmon is difficult to change in the short run. Not only does it take time to plan for and produce the biological product, but legal and political restrictions put a roof on the production level in Norway. The supply of salmon is affected by such legislations, in addition to the availability of area suitable for salmon farming, the mortality rate of salmon, health and welfare, and weight and quality of the harvested product, amongst others.

With many factors affecting the supply and demand for salmon, the aquaculture industry faces many inputs that are assessed as uncertain variables. A summary of the different macroeconomic factors that impact the aquaculture industry and uncertain inputs to be used in a valuation analysis will be discussed in this section.

4.2.1 Price uncertainty

Uncertainty in the prices of salmon, smolt and feed affects the aquaculture industry and the net revenue and profitability of the industry suppliers.

Salmon price

The price of salmon is expected to be the variable of highest impact on the net revenue of a salmon farming company. The operating revenue is simply calculated from the harvested volume of salmon times the market sales price. If the harvested volume is somewhat constant, revenue is merely dependent upon the price of salmon. In other words, small changes in the salmon price will have big impacts on the generated income for a supplier of salmon. Supply and demand for salmon determines the market price, which again is dependent on many sub-factors. With high estimation uncertainty for the sub-variables, the uncertainty accumulates for the price of salmon. In today's market, there is especially great uncertainty in the total production level of salmon. If the environmental status in the industry is not changed, the production of salmon will be constant and the demand for and price of salmon can increase significantly. However, is a solution found and production increases, salmon prices may experience a drop. Consequently, the market price of salmon is expected to a be a highly uncertain variable that have a great impact on the calculated revenue.

Smolt price

The sales price of smolt is set by the smolt producers or suppliers in the aquaculture industry. The price is again determined by the demand for smolt, the size of the smolt and the input prices of production costs related to the hatchery and production. The historic smolt prices presented small fluctuations during the last decade. It is, however, possible that the prices will rise significantly in the future, if the demand for bigger sized post-smolt increases. Although the price of smolt is dependent upon several variables and factors, it is not considered an input with great uncertainty.

Feed price

Feed prices have been increasing at a constant and relatively low rate throughout the last decade. The price of salmon feed is greatly dependent on the input prices of raw materials used in the feed production, which is mainly imported. Feed prices are thus further dependent on exchange rates and custom fees, amongst others. If the production level of salmon is to expand, feed prices may rise due to increased demand. It is further assumed that the cost of feed is the main expense item in the total production and operating costs of a farming facility, and feed prices therefore have a great impact on the net cash flows.

4.2.2 Production uncertainty

Harvested volume

The volume of harvested salmon is calculated from the amount, or number, of salmon ready to be harvested and the average weight of the harvested salmon. The amount is primarily dependent on the number of smolt released in the pen, the survival rate of smolt and the volume of wastage. The average weight may vary based on the salmon feed composition and intake and the health and welfare of the salmon. The harvested volume may differentiate over the use of fish pens but will also depend on the location of the installation and on environmental changes during seasons and between years. Biological or environmental variations in the sea include currents and waves, temperatures and light, pH and oxygen level. Further, the infection risk profile and wastage rate are other important factors, where wastage not only include escaping fish lost from the production volume, but also the mortality rate caused by infections and sea lice. The level of harvested salmon has a big impact on the revenue. With new and untried production facilities, the uncertain estimation of production volume increases further, and the harvested volume is considered a variable with great uncertainty.

4.2.3 Cost uncertainty

Investment costs

Investment costs are expected to be uncertain for “Brilliant™”, as the construction is new, and the pen has not been manufactured before. The applied investment costs from the manufacturer of the pen are only estimations and the real expenditures are therefore prone to variations. Initial investment costs are considered one-time costs in the production facility, but small changes in the estimated values may still have a big impact on the NPV outcome. “Brilliant™” is expected to be more expensive to produce than a conventional open, as it is constructed to be more robust for the exposed environment and with a submersible feature. Because of the estimated investment cost difference, and the fact that “Brilliant™” is a new, untested construction, investment costs related to “Brilliant™” is assumed to be highly uncertain.

The conventional open pen has existed and been in use in the industry for several years, but to be valued as an alternative for exposed farming, it is assumed that the pen must be adapted and improved in terms of robustness. Hence, the investment costs are considered to be revised upwards and will consequently suggest uncertainty.

Operating costs

Uncertainty related to operation expenses include expense items such as slaughter costs, health costs, insurance and labor costs, and other operating expenses related to administration and maintenance. Where the first two expenses related to slaughter and health are considered variable costs, the other expense items are assessed as more or less fixed. In other words, costs of slaughter and health costs are assumed to be more uncertain than the relatively fixed costs. Most salmon farming companies outsource the gutting of the fish, and the cost of slaughter is thus affected by the number of abattoirs and the supply of harvested salmon. Health costs are dependent on the general salmon health and the status of sea lice, infections and diseases. Health costs may include medicines, vaccines, delousing and cleaning of fish, which all are determined from several variables. Health costs and costs of slaughter are considered fairly uncertain expenses.

4.2.4 Technological uncertainty

Technological uncertainty includes uncertainty related to the investment costs of the manufacturing and production of new technology, but also in regard to the durability and estimated useful lives of the innovation. As the "Brilliant™" fish pen has never been produced before, investment costs are estimates based on material input prices, manufacturing costs and construction drawings and plans, and are prone to changes. Moreover, the estimated lifetime depends on the environment, wear and tear, and on the development of other new technologies in the industry that may increase or reduce the estimated extent of usage. Consequently, uncertainty with new technology may have a great impact on both investment costs and replacement costs of components and assets, as well as the total useful life of the fish pen. For a conventional open pen, however, the technology is not new and untried, and there is little uncertainty related to durability and costs. Nevertheless, if a conventional pen is to be operating in a new environment, as in more exposed sea, technological uncertainty will arise.

4.3 “Brilliant™” analysis

An analysis of “Brilliant’s™” innovative components and how they may affect production costs and revenue, fish health and possible environmental effects in contrast with a conventional open pen is to follow. The innovative components of “Brilliant™” was explained in section 2.2.3 and included pull-down technology, a pointed shape of the net, the sensor unit and dead fish collector.

First, the pull-down technology of the pen makes it possible to submerse the net in order to escape possible storms, high waves and currents and increased temperatures at the sea surface. This feature results in a more stable external environment for the salmon to live in, which may increase the general health and wellbeing of the fish. Moreover, sea lice reproduce at a slower rate in colder temperatures, which is possible to obtain when submersing the pen. Improved living conditions and fish health is assumed to affect the survival rate of smolt, the average harvested weight and, consequently, the harvested volume positively. Further will increased health reduce the costs related to fish health and the wastage of dead fish.

The pointed shape of the net has many of the same features and outcomes as the pull-down technology. The diamond shape of “Brilliant™” increase the flow of currents through the net, which moderate the collapsing of the net and help maintain a constant volume. This is again assumed to increase fish health and welfare, in which enlarges the expected outcomes related to this. The construction of the net makes it more robust and durable. This is expected to reduce the need for and total costs of replacement for a new component.

The sensor unit is considered innovative in terms of collecting all sensor devices into one single unit. The unit is easier to remove and replace, and it improves the observation and control of the fishes. Primarily, the sensor unit is assumed to have a greater useful lifetime than the units of a conventional pen, which is expected to reduce the need for replacement. It is also possible that the sensor unit may improve fish health, as the improved observation may detect sea lice and possible infections at an earlier stage.

Finally, the dead fish collector is assumed to improve fish health even greater by avoiding the spread of sea lice and infections from dead fish to the living organisms. The collector separates the deceased fishes and eases the removal of dead fish. The consequences of this innovative component are assumed reduction of sea lice, decreased costs of fish health, and a decreased volume of deadweight fish in which increases the harvested volume of salmon.

Table 4 sums up the effects on the technologic innovations of “Brilliant™”.

Innovation	**Effect**	**Comment**
Pull-down technology	Submersible construction, can avoid changing environments	Expected to increase survival rate of smolt, average harvest weight and salmon health. Further expected to increase the harvested volume, decrease costs related to fish health and decrease wastage of fish.
Pointed shape of net	Constant volume in net, more robust and less prone to replacements	Expected to increase fish health further. Assumed to marginally decrease fish health costs and replacement costs.
Sensor unit	One single unit to ease and reduce replacements, better observational control of the salmon	Expected to decrease the frequency of component replacement and may somewhat increase fish health.
Dead fish collector	Reduces the spread of infections from dead fish	Expected to further increase general fish health, decrease sea lice and fish health costs and decrease volume of deadweight fish.

Table 4: Estimated innovative effects of “Brilliant™"

5. Investment analysis

The investment analysis to follow includes the data and assessment of all components included in a net present valuation, together with estimated numbers and forecasted values, where applicable. Further, selected variables concerned with a higher degree of uncertainty and impact on the NPV calculations will be simulated under a Monte Carlo simulation to detect the impact of uncertainty in the estimations.

For a better understanding of the variables in the projected cash flows and how they are connected, a modelling of the project, as described in section 3.3.1 as the first step in a Monte Carlo simulation, will be assessed first. The two final steps in the Monte Carlo simulation will then follow after the investment analysis of the NPV model.

5.1 Modelling the project

The first step when simulating possible outcomes in a Monte Carlo simulation is to model the project. As we are performing a fundamental valuation on the project, the net present value calculation is used as the final equation to determine the project value. To model the project, we will revert back from the NPV equation and assess all initial variables that are included in the cash flow model. One section will be discussed at a time, where we will start with the projected lifetime of the project, *t.* Then we will look at the variables in the free cash flows to firm, FCFF, the terminal value and the stable growth rate, before decomposing the discount rate, or WACC.

5.1.1 Project lifetime

Estimating the lifetime of the project is critical and have a great impact in the NPV calculation. The longer the lifetime of the project, the better chance and longer time it has to generate positive cash flows and result in a positive NPV. In this thesis, the approach of dividing the project lifetime into two phases will be applied. The development phase represents the stage where investment and development take place, whereas the steady state phase characterizes a state of constant growth where the terminal value can be calculated to denote the expected perpetual cash flows of the project.

5.1.2 FCFF

The equation for calculating the free cash flows to firm is broken down further into initial variables that make up the different components of the FCFF, and the EBIT will be presented first.

5.1.2.1 EBIT

The earnings before interest and taxes, EBIT, or net profit from operations, is made up of the operating revenue from sales minus the operating expenditures, or OPEX, and depreciation. Operating revenue is further comprised of the revenue from sales minus the cost of goods sold, or COGS. In other words, EBIT can be broken down to the following equation

$$EBIT = \underbrace{(sales\ revenue - COGS)}_{Operating\ revenue} - OPEX - D_t$$

Operating revenue

<u>Sales revenue</u>

The sales revenue from the net operating revenue consists of all variables generating income from the project. The sales revenue from a fish pen is generated from sale of the salmon and is thus dependent on the harvested volume and sales price, as modelled below, where R equals the sales revenue, is the harvested volume, or weight in tons, and is the sales price of salmon in NOK/kg WFE.

$$R = w^{harvest} \times p^{salmon}$$

The production volume, or harvested volume from a fish pen, is dependent on the amount of smolt released in the pen and the survival rate of the fish. Together, these variables make up the estimated produced number of adult salmons to be harvested. Multiplying the number with the average weight of a harvested adult salmon, the harvested volume can be calculated.

$$w^{harvest} = \left(\left(x^{smolt} \times r^{survival}\right) \times w^{adult}\right)$$

Where $w^{harvest}$ is the harvested volume of salmon measured in tons, x^{smolt} is the amount of smolt released in the pen, $r^{survival}$ is the survival rate of salmon and w^{adult} is the average weight of an adult salmon.

COGS

The cost of goods sold, or COGS, are subtracted from the sales revenue to make up the net operating revenue. COGS include all costs directly related to the release, maintenance and growing of the smolt into full grown salmon ready for harvesting. Production costs related to the production from smolt to adult salmon includes the cost of smolt and cost of feed. The cost of slaughter is also included in the COGS.

$$COGS = c^{smolt} + c^{feed} + c^{slaughter}$$

Two different approaches could be undertaken to calculate and estimate the future cost of smolt in the fish pens to be valued. The estimations could simply be based on the industry average cost of smolt, with data based and retrieved from the profitability survey from the Directorate of Fisheries. However, the cost of smolt will be estimated through the price of smolt and the amount of smolt released in the pens. The smolt costs equation is

$$c^{smolt} = \frac{(p^{smolt} \times x^{smolt})}{(w^{harvest})}$$

where p^{smolt} is the unit price of smolt.

The feed conversion rate is calculated as the total feed costs during a year per kg produced salmon, and is calculated as following:

$$Feed\ conversion\ rate = \frac{(Feed\ storage\ 01.01 + feed\ purchase - feed\ storage\ 31.12)}{(Sold\ amount + \Delta biomass)}$$

The numerator represents the feed consumption during a year, whereas the denominator makes up the total annual production of salmon. Note that both variables are stated in kilos. The feed conversion rate thus makes up the amount of feed needed for the growth of 1 kg of salmon. It is possible to calculate the total cost of feed by using an industry average feed conversion rate and average annual feed prices and multiplying the consumption with the harvested volume of salmon. The total cost of feed can also simply be calculated from the industry average feed cost times the estimated harvested volume of salmon.

$$c^{feed} = c^{feed}_{average} \times w^{harvest}$$

The cost of slaughter is not necessarily an expenditure that is directly related to the production of salmon. However, it is included in the costs of goods sold because the expenditure is related to the final product of the sold salmon stated in WFE after gutting, as reflected by the salmon price. The cost of slaughter is dependent on the volume of harvested adult salmon and is also a variable expenditure. Total costs of slaughter are calculated from the average cost of slaughter in NOK/kg times the estimated harvested volume of live adult salmon for each pen.

$$c^{slaughter} = c^{slaughter}_{average} \times w^{harvest}$$

OPEX

Operating expenses comprise of all ongoing costs in the operation of a product or business, in this case the fish pen. OPEX refers to costs related to the sale of the product and administration expenses. The operating expenses in this project include costs related to fish health, insurance costs, labor costs and other operating expenses, and will also include the costs for farming licenses.

License costs, or $c^{license}$, reflects the costs related to the allocation and purchase of a salmon farming license, or costs related to the conversion of a development permit to a regular license. This expense item may be difficult to classify. Licenses are considered significant investments, but license costs are not activated and are thus not depreciated over time. Farming licenses are instead characterized as intangible assets and does not fall under capital expenditures. According to Damodaran (2012), intangible assets categorized as operating expenses. This thesis will follow the same process and include license costs in the OPEX.

The value of health costs is calculated from the growth in kilos from smolt to harvested salmon, and on the amount of delousing and cleaning necessary on the population. This is indeed an uncertain variable, as it is difficult to break down and predict and may fluctuate significantly from year to year. Health expenses are determined from the population and are variable costs that will change regarding to the climate, marine environment, amount of sea lice and general fish health and welfare. Because of the difficulty of estimating the necessary amount of delousing, vaccines, medicines and cleaning, health costs will be based and calculated from the historical industry average.

Insurance costs, labor costs and other operating expenses are not directly dependent on the harvested weight of salmon and are considered fixed costs that are somewhat constant throughout the project lifetime. Insurance costs are net payments and premiums on insuring the installment and the biological product in the pens. Insurance costs and other operating expenses are calculated from the industry averages. Labor costs will be calculated from the average annual labor cost per FTE times the estimated number of FTEs.

$$c^{labor} = c^{labor}_{average} \times x^{FTEs}$$

Total OPEX can then be calculated by:

$$OPEX = c^{health} + c^{slaughter} + c^{insurance} + c^{labor} + c^{other} + c^{license}$$

Where c^x denotes the costs related to fish health, insurance, labor and other operating expenses, and license costs.

Depreciation

Depreciation is a non-cash expense used to deduct the value of an investment asset as its value is decreasing over time. The deductions can be depreciated over the useful life of the asset and are calculated by two different methods; linear depreciation or balance depreciation (Altinn, 2019). The first method, linear depreciation, is based on equal deductions distributed over the asset lifetime. The latter method takes balance depreciation into account, where a given percentage of the remaining asset value is deducted every year. This method results in higher depreciation expenses the first years, which is declining with the remaining lifetime years (Altinn, 2019). For internal purposes, a company can choose freely in which method they want to apply. When the end of an asset's lifetime is reached, the sum of depreciation will equal the value of the asset in year 0, regardless of which method is applied. Based on this statement and for a simpler calculation, the linear depreciation method will be applied further.

Annual linear depreciation expenses are calculated by

$$D_t = \frac{I}{n}$$

Where D_t represents the deprecation expense in year t, I represent the investment cost, or value of asset or component in the year of investment, and n is the asset or component lifetime. Note that the investment costs in this thesis only refer to expenses that are directly related to the physical asset of the fish pen, and that are legitimate to deduct. The depreciation expense will vary with the different components, based on their different estimated lifetimes.

It is assumed that all assets or components are purchased and applied 01.01 in the year of investment or replacement, and that the first, annual depreciation will be expensed in the same year.

5.1.2.2 Corporate tax rate

The corporate tax rate is not dependent on other variables and should thus be easy to estimate. However, the tax rate is set by the Norwegian government and has decreased significantly the past 6 years. Selecting an appropriate corporate tax rate to use in the calculation may thus be difficult.

5.1.2.3 CAPEX

Capital expenditures are costs related to the change in property, plant and equipment, or PP&E. In other words, the expenditures are related to the costs a company spends to invest in, maintain or improve fixed assets. In this project, the capital expenditures consist of all initial costs that are associated with the investment and replacement costs for expired components. The initial investment costs include all costs related to the manufacturing and installment of the fish pen in order for it to be a complete asset that can house smolt and start the growing and production of adult salmon. Eventually, different components in the pens will need to be upgraded or replaced due to insolence. Costs related to this is included as capital expenditures. The equation for calculating the capital expenditures for the fish pens is

$$CAPEX = I_0 + c^{PPE}$$

where I_0 reflects all initial investment costs, c^{PPE} refers to all costs related to maintenance, improvement and replacement of assets.

As the "Brilliant™" pen differs from other conventional open pen in terms of innovative components, initial investment costs related to "Brilliant™" are expected to be higher and the investment cost equation containing more variables than for a conventional pen. However, these variables are not necessarily asserted with high risk. The initial investment costs for "Brilliant™" is split into four main components and is calculated as

$$I_0 = p^{pen} + p^{net} + p^{sensory} + p^{deadfish}$$

Where p^{pen} includes all costs related to the actual pen, such as perforated floating collar, quays, walkways, top-structure and anchoring. p^{net} reflects all costs related to the net, $p^{sensory}$ includes costs related to the sensor unit, such as camera, lights, sensors and hoses. $p^{deadfish}$ reflects the cost of the dead fish collector with hoses. This latter component is only included in the "Brilliant™" fish pen.

For the conventional open pen, the initial investment costs are merely related to the pen, net and a sensor unit.

5.1.3 Terminal value

The terminal value will be calculated after year 8, when the project's development phase is over, and the steady state begins. The terminal value reflects the project's cash flows at equilibrium, where investment and PPE costs are reflected by the total depreciations. This means that the total capital expenditures will equal the total depreciations in the cash flows in the terminal value. One-time license costs are neglected from the terminal value.

Residual value

The free cash flows in the terminal year will include the estimated residual value of the pens after the last year of the development phase. Residual values are included to represent the remaining value from investments in the development phase, to make the pens comparable from the equilibrium state. The residual value, or liquidation value, emerges if we assume that the firm will sell the remaining values of the project after the estimated asset lifetime is over.

That is, the residual value is the value of any assets or investments that is left after the end of project lifetime and that can be expected to be sold at book value. The expected residual value can be calculated as the book value of assets in the terminal year, times the expected inflation rate of the average life of the assets (Damodaran, A., 2012a).

$$RV_T = BV_T * (1 + r_i)^{residual\ asset\ life}$$

where RV_T denotes the residual value in the terminal year, BV_T the book value of assets and r_i is the inflation rate.

However, inflation will not be considered when assessing the residual value of the assets. Damodaran's calculations are based on a liquidation value from sale of remaining asset values to highest bidders, whereas this thesis will focus on the residual value as the book value of the remaining assets for continued operation. The residual value will then be calculated as the total of applied book values assets in the year of purchase minus the sum of annual depreciations until the terminal year:

$$RV_T = BV_{applied\ year} - \sum D_t$$

where RV_T is the total residual value in the terminal year, $BV_{applied\ year}$ is the book value of an asset in the applied year and ΣD_t is the sum of depreciations on the assets.

The terminal value in the end of year 8 will then be calculated as

$$TV_T = \frac{FCFF_{T+1}}{(WACC - g_T)} + RV_T$$

where $FCFF_{T+1}$ is the forecasted free cash flows in year 9.

5.1.4 Discount rate

As discussed, the calculation of the discount rate includes several assumptions and is essentially prone to bias. Estimating a correct discount rate may be difficult and only a small change in the rate may have a severe impact on the valuation result. The WACC estimated for this project will be based on the WACC for the total "Octopus" project, as well industry averages and assumptions.

5.2 The NPV model

In the following sections, the different variables making up the cash flows and final NPV calculations will be evaluated with data and estimated forecasts. The data will model the project variables, which will be assessed under uncertainty in the next segment. The strategic analysis with the historic variables and future assumptions, together with the assessment of uncertainty in the project make up the basis for the decision of future growth and forecasted values.

Investment costs and asset lifetime for the "Brilliant™" submersible pen are estimates based on discussions between Roxel Aqua and the senior vice president of technology and development in Akva Group ASA. Akva Group is a leading supplier of equipment and installations in the aquaculture industry, and a possible manufacturer of Roxel's fish pen. As the supplier is independent of the project and has more knowledge in the manufacturing in the industry, the investment cost estimates from the discussions is considered reliable and will be applied in the assessment.

Investment costs and asset lifetime for conventional open pens are based on the Norwegian SNF report nr. 07/18: "Economic analysis of alternative production forms within farming" (Bjørndal, T. & Tusvik, A., 2018). Production costs and all other costs for the conventional pen are retrieved from the report "Profitability survey on the production of Atlantic salmon and rainbow trout 2017", from the Norwegian Directorate of Fisheries, published in 2018 (Directorate of Fisheries, 2018e). The numbers reported in the survey are average values retrieved from several Norwegian farming companies within production of salmon and rainbow trout. Note that the production of trout is included in the survey and cannot be eliminated from the numbers. Hence, the cost basis will be somewhat biased. The survey is still considered a reliable and sophisticated source for information with a solid foundation for estimating costs.

All numbers extracted from the profitability report and other sources are stated in or translated to round weight, or whole fish equivalent (WFE). WFE is a standard weight designator for round bled weight of the harvested salmon, and is standard denomination used by the Norwegian Directorate of Fisheries. A standard weight is necessary in order to avoid integrating different weight types in the calculations, in which the outcome would be biased.

The conversion factor from the Directorate of Fisheries, from gutted to round weight (WFE), is 0.889 (The Directorate of Fisheries, 2019d).

The values used in the FCFF are stated in total numbers of 1000 NOK and are annual values per fish pen. It is normal for farming companies and the Directorate of Fisheries to state all numbers in NOK per kg harvested salmon, but as the two pens to be valued have different production capabilities and volumes, the numbers in this valuation will be stated in total value. Consequently, the outcome of the NPV will also be stated in total numbers, but the final calculation will take production volume into account to make the results comparable.

Finally, the analysis is based on a new establishment of an aquaculture facility, which means that the company does not have any assets or biological products in year 0. The initial investments in the actual facility will occur in year 0. Year 0 will be based on 2019 prices and all prices will be adjusted for inflation in the following project years. The average growth period from the release of smolt to harvestable weight is between 16-18 months (Nofima, 2018). That means that if we assume that the investment facility is ready for production in year 0, the initial release will be effectuated in year 0 and will be harvested in year 1. Further, the cost of slaughter will first accrue in year 1, and revenues will be generated from year 1.

5.2.1 Project lifetime

The lifetime of a project is often thought of as the life span of the investment asset until it is considered useless, outdated or inoperative. The investment asset in this project is the "Brilliant™" fish pen, which consist of several components made of different materials and with a different degree of usage and durability. In other words, the components comprising the fish pen may all have different life spans or usage durations. The components in a conventional open fish pen also have different lifetimes, where the pen itself is considered a lifetime of 8 years (Bjørndal, T. & Tusvik, A., 2018). The smaller components; the net and the electronic devices such as lighting, sensor modules and the feeding hoses, have a lifespan of only 3 years before considered expired.

According to Roxel Aqua, the usage lifetime of the float collar and the pen construction of "Brilliant™" is estimated to be between 15-25 years, whilst the net and innovative components is estimated for 4-7 years. However, the collar is likely to be obsolete due to new technology years before actual expiration. With regards to this and the lifetime of a conventional pen, the lifetime of the "Brilliant™" pen is estimated to be 15 years, which is located in the lowest part estimated for the fish pen. The other components, the net and dead fish collector, are estimated with a lifetime of 5 years, whereas the sensor unit is expected to have a duration of 8 years.

Because of the different estimated lifetimes of a conventional pen and "Brilliant™", a new project lifetime must be determined in order to make the outputs of the valuations comparable. As discussed, the "Brilliant™" project will be separated into two phases; the development phase and the stable, or steady state, phase. An innovative facility can hold the development permit for an average of 7 years before converting to a regular license. With regards to this, the development phase is set to 8 years and the steady state will continue from year 8 until perpetuity. After 8 years, both pens are expected to operate on a regular farming license and has produced several litters of salmon for the production to be stable and expectations more reliable. The project phases will hold for both pens. Further, the steady state is projected to continue until perpetuity. Although the fish pens have estimated usable lifetimes, new investments and improvements at the end of the lifetime may extend the usable time and make them operable for many years. Continual development could make the project have an infinite lifetime. The steady state is still considered stable in regard to new investments, as the investments costs and depreciation are evened out throughout the years. Additionally, the farming licenses, which are essentially the project's most costly financial investment, does not have limited lifetimes and can be held forever. Based on these arguments, the project is expected to have an infinite lifetime. The terminal value of the project will be calculated after year 8. The residual value from initial investments in the development phase will be included in terminal value calculation to include the differences in value of the pens.

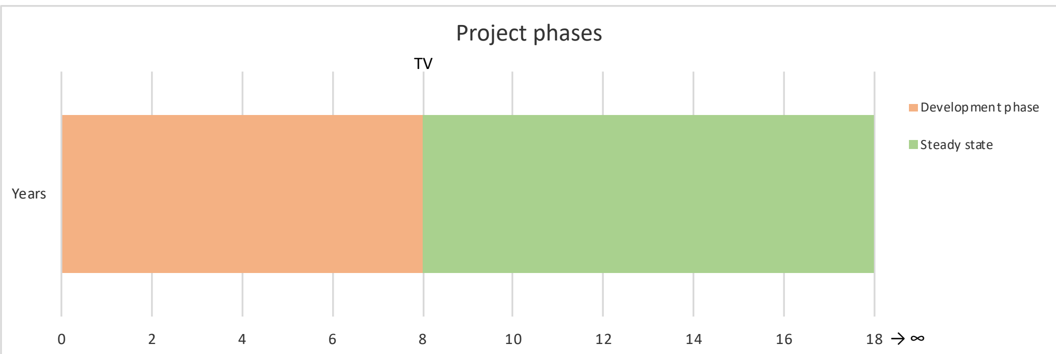

Figure 21: Project phases during the project lifetime

Figure 21 illustrates the two expected phases of the project, divided into the development phase from year 0 to year 8 and the steady state phase from year 8 and until perpetuity. The terminal value will be calculated after year 8, expecting the steady state to continue until perpetuity. Year 8 is thus set as *T*.

5.2.2 FCFF

The forecasting of the free cash flows to firm will follow in the next section, where the EBIT, corporate tax rate and capital expenditures are the individual variables that will be assessed in own subsections.

5.2.2.1 EBIT

5.2.2.1.1 Operating revenue

Sales revenue

Sales revenue from the "Brilliant™" pen and the conventional pen is calculated from the estimated harvested volume of adult salmon times the estimated sales price of salmon in the specific year.

<u>Harvested volume</u>

The harvested volume is assumed to be the amount of live, adult salmon ready to be slaughtered and sold, and is thus expected to equal the quantity sold. The relative distribution of wastage due to rejection from the abattoir was only 5 % of the total production wastage in 2017 (Norwegian Directorate of Fisheries, 2018e). The total loss and wastage in the production of farmed salmon in 2017 was 13.88 %. This means that abattoir rejection only accounted for a 0.7 % loss on the total production level and is therefore neglected. Thus, the harvested volume can be assessed as the sold quantity.

According to the Norwegian Seafood Council, the maximum number of fishes allowed in a pen is 200.000 individuals. "Brilliant™" is constructed to hold up to this amount of adult fish, which means that the limited number will be held and the smolt released in the pen will be 200.000. For consistency, the limited amount is assumed to be released also in the conventional pen.

The survival rate of salmon refers in this thesis to the percentage share of smolt released in the pen remaining as an adult salmon ready for harvesting, including both the survival rate of smolt and the percentage of wastage caused by death and escapes. The survival rate of salmon is estimated to be higher for "Brilliant™" than a conventional open pen, referring to the arguments in section 4.3. First, the release of smolt from a well boat to the pen through a pipe reduces the possibility of escaping smolt. As does the density of the meshes in the net and the double layered net in the bottom of the pen. Retractability of the pen makes it possible to maintain optimal conditions for the salmon at all times. The optimal environment is expected to improve the general health of the salmon and increase its rate of survival. The dead fish collector prevents sea lice and diseases to spread rapidly to healthy fish, which again may decrease the wastage rate. According to the report on salmon farming cost drivers from Nofima and Kontali from 2018, the average total rate of wastage from the past two years, caused by all forms of mortality, was approximately 21 %. However, as these numbers include destructed fish after sorting from the abattoir, the averages are considered upward biased. The Norwegian Directorate of Fisheries have estimated the percentage annual loss based on the average inventory of live fish, which in 2017 was 11.1 % (Norwegian Directorate of Fisheries, 2018a). This number seems to be slightly downward biased as it includes the percentage loss of rainbow trout, which is significantly lower than for salmon. In regard to these arguments, the wastage rate of salmon in a conventional open pen is set to 18 %. For "Brilliant™", the advantages of the pen are assumed to improve the salmon health and decrease the wastage rate by 3 percentage points from a conventional pen. This means that the survival rate of salmon for the conventional pen and "Brilliant™" is estimated to 82 % and 85 %, respectively.

The average weight of a harvested adult salmon depends on the time of smolt release, the time of harvesting from the pen, the age of the salmon, the general health and well-being and ratio of sea lice and diseases. The size of the smolt released in the pen may also have an impact, where bigger post-smolt may result in the salmon reaching an optimal weight for harvesting faster and be more resistant to sea lice (Berget, Å., 2016). According to Seafood Norway, the average harvest weight of salmon in round weight is highest from February through April, with an average weight of around 5.00 kilos during these months (Seafood Norway, 2019). The annual average weight in 2017 and 2018 was between 4.5 and 4.7 kilos. Salmon farming in exposed sea and the use of bigger post-smolt are expected to increase the average weight of the adult salmon for both pens. An average weight of 5.0 kilos is thus estimated for the population harvested from "Brilliant™". The conventional pen will base the average weight slightly lower, with an estimate of 4.7 kilos. The reasons for this 0.3-kilo difference in average weight between the pens are that the conventional pen is not submersible and cannot avoid the at times difficult environmental changes at sea surface. The "Brilliant™" pen can somewhat avoid these changes and maintain a stable environment, which is estimated to generate an improved health of the salmon and further assumed to increase the average weight during the same period and harvest time. Additionally, "Brilliant™" can avoid possible higher temperatures at the sea surface, which is expected to decrease the level of sea lice and diseases. All things considered, "Brilliant™" is estimated to produce salmon with a higher weight when harvested.

The initial investments will take place in year 0, including the release of smolt in the pen. The average production time for smolt after release in the sea is between 14 and 18 months (Nofima & Kontali, 2018). The time until the smolt is harvestable as an adult salmon depends on when the smolt is released and the size of the smolt at release. Release of smolt is usually done two times a year; either at spring or fall. Spring release have historically been most used, where the smolt is released in the period of February to July. However, the last couple of years, fall release from July to November/December has increased and is almost as frequently used as release period (Nofima & Kontali, 2018). According to Berget (2016), spring release may be preferable over a fall release, and with an increased smolt size of up to 650 grams, it may be possible to reach harvestable weight within 10 months. However, only 10 % of the release of smolt in 2018 were over 250 grams at the time of release (Nofima & Kontali, 2018). For this offshore aquaculture facility project, a post smolt size of 400 grams is assumed to be used. It is highly likely that bigger smolt sizes will be used more frequently in the future, to cut the production time from smolt to harvestable adult salmon. The production time for the 400 grams post-smolt is estimated to be around 14 months, which is in the lower part of the annual average obtained from Nofima and Kontali's analyzes (2018). This means that the first generation of released smolt in year 0 will be harvested in year 1. In other words, the project will not generate revenue in year 0.

The harvested volumes are assumed to be stable over the project lifetime, as the limited amount of smolt allowed in the pen is not contemplated to change in the near future.

The estimated annual average harvested volume for "Brilliant™" is calculated to

$$w_{Brilliant}^{harvest} = \left((200{,}000 \times 0.85) \times 5.0\ kg\right) = 850\ 000\ kg$$

For the conventional open pen, the estimated annual average of harvested volume is estimated to

$$w_{conventional}^{harvest} = \left((200{,}000 \times 0.82) \times 4.7\ kg\right) = 770\ 800\ kg$$

The harvested volumes equal 850 and 771 tons for "Brilliant™" and the conventional pen, respectively. This further represents 1.09 and 0.99 MAB for each pen.

<u>Price of salmon</u>

The estimated future salmon prices will be based on the Fish Pool forward prices as of April 2019. The forward prices are estimated for the first three years, after that, flat prices are assumed. Disregarding any possible risk premiums in the forward prices, the Fish Pool forwards should reflect the market's prognosis for future spot prices and can thus be included as the estimated future salmon prices. Yet, the forward prices cannot be used directly. The Fish Pool salmon prices are stated in gutted, head-on premium quality weight between 3-6 kilos. However, the price estimate includes costs for transportation, quality adjustment and size adjustment, and an export margin that needs to be subtracted to express the netback price. The estimated average Fish Pool forward price for the year of 2019 (including the monthly average of the three realized spot prices) is 61.99 NOK/kg, rounded to 62 NOK/kg. According to Folkvord, B., et al. (2019), the netback price can be calculated as following:

NOK/kg, gutted weight	**2019**
Fish Pool estimate	62.00
- transportation	- 0.70
- quality adjustment	- 0.55
- size adjustment	- 0.25
- export margin	- 1.00
= netback price	59.50

Table 5: Netback Fish Pool salmon price, 2019 (Folkvord, B., et al (2019)

The subtracted additional charges that scale up the Fish Pool forward prices thus constitutes of 2.50 NOK/kg and will be subtracted from all future prices. Further, the prices will be adjusted from gutted weight to represent round weight in WFE with the conversion factor of 0.889. Finally, 2019 price estimates represent expected salmon prices in year 0. As the average annual growth in the last decade has been 2 %, future price estimations will be based on the foregoing growth rate. However, a 2 % growth rate equals the expected rate of inflation. Therefore, all prices from year 1 and onwards are adjusted with an inflation rate of 2 %, which represents the expected future growth in salmon prices. The Fish Pool forward prices estimates a slightly decreased average price from year 0 to 1 and year 1 to 2, before assuming flat prices from year 2 on. Table 6 presents the estimated inflation-adjusted salmon prices in NOK/kg WFE.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Estimated salmon price, NOK/kg	52.90	53.37	51.23	52.26	53.30	54.37	55.46	56.56	57.70

Table 6: Estimated future salmon prices, in NOK/kg round weight (WFE)

COGS

Cost of smolt

According to studies performed by Roxel Aqua, post-smolt of 400 grams are predicted to be optimal for release in offshore conditions in the "Brilliant™" pen. Smolt of the same size is also assumed to be chosen for the conventional pen. The rough environmental conditions predict that post-smolt of a minimum weight of 250 grams are necessary in order for the small fish to survive in the environments. In addition, indications show that smolt of bigger size have economic advantages for the company in relation to better survival rate, less infections of lice and reaching slaughter weight faster (Berget, Å., 2016). The bigger post-smolt sizes have a higher price than the normal size of averaged 135 grams. According to estimates from Nofima and Kontali (2018), 250 grams smolt have a unit cost of 17.90 NOK, whereas 500 grams smolt have a unit cost of 28.50 NOK. The median calculated unit cost of 23.20 NOK would equal the estimated unit cost to a 375 grams smolt. With a 9 % profitability rate, as calculated in section 4.1.1.2 under "smolt costs", the unit price for a 375-grams post-smolt would be estimated to 25.29 NOK per unit smolt. This price will be used as the basis for estimating the future price of a 400-grams smolt. The unit costs estimated for bigger post-smolt are high in 2018, but as the smolt sizes are expected to increase on a general basis and sizes of at least 500 grams are assumed to be normal in the future, the unit costs may decrease due to future technology and improvements in the smolt production. However, as bigger smolt is assumed to have an increase in demand, the smolt price will, ceteris paribus, increase. The historical average annual increase of 4.7 % in smolt prices, based on the prices of 100-150 grams post-smolt in the last decade, could be used as a basis for future growth in smolt prices. The future growth rate in smolt prices are estimated to be 3 % annually, plus an inflation adjustment of 2 %. This equals a total price increase of 5 % annually.

Table 7 presents the estimated unit price of smolt in NOK per unit from year 0 to year 8. The estimated smolt prices are relevant for both fish pens.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Estimated smolt price, NOK per unit	25.29	26.55	27.88	29.28	30.74	32.28	33.89	35.59	37.36

Table 7: Estimated smolt prices in NOK per unit, for 375-grams post-smolt

The number of smolt released in the pens are set as the limited amount of 200.000 units. As the pens are reliant upon the same amount of smolt, the cost of smolt for the two pens will be equal. The estimated total cost of smolt for *both* fish pens is presented in table 8.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cost of smolt, in 1000 NOK	5,058	5,311	5,576	5,855	6,148	6,455	6,778	7,117	7,473

Table 8: Estimated total cost of smolt, for "Brilliant™" and conventional pen, in 1000 NOK

<u>Cost of feed</u>

The cost of feed will be based on the industry average cost of feed in NOK per kilo produced salmon, extracted from the profitability survey from the Directorate of Fisheries (2018a). The annual average cost of feed was 14.38 NOK/kg in 2017. The cost is calculated from an average feed price of 10.90 NOK/kg in 2017, times the average feed conversion rate of 1.32

in the same year. It is assumed that the prices will continue at the 2017-level due to an estimated future weak NOK. The feed conversion rate of 1.32 is also assumed further. Because the project will use post-smolt of bigger size than average, the total feed costs are likely to be slightly lower than the average reported to the Directorate of Fisheries. This is caused by the shorter production time from smolt to adult salmon, and growth in feed costs is therefore not expected. Because of these arguments, the future estimates on the cost of feed for the conventional pen will be based on the 2017-costs, only adjusted by inflation annually. The cost of feed for the conventional pen in year 0 is thus estimated to 14.96 NOK/kg.

It is assumed that the harvested salmon from “Brilliant™” will have a higher average weight of 0.3 kilo than harvested salmon from a conventional pen. It could then be implied that the total cost of feed should be higher for “Brilliant™”. However, the higher growth of the harvested “Brilliant™” salmon can be explained by a lower feed conversion rate. The average feed conversion rate extracted from the profitability survey from the Directorate in 2017 was 1.32, however the reported conversion rates vary between 0.9 and 1.9 (Norwegian Directorate of Fisheries, 2018b). For “Brilliant™”, a conversion rate of 1.1 will be assumed because of the estimated improved health and welfare of the salmon. The costs will be calculated on the basis of the feed prices from 2017, which was 10.90 NOK/kg. Assuming flat prices, the inflation adjusted cost of feed for “Brilliant™” is estimated to 11.34 NOK/kg in year 0.

The estimated cost of feed in NOK/kg for both pens are presented in table 9.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
"Brilliant™"	12.47	12.72	12.98	13.24	13.50	13.77	14.05	14.33	14.62
Conventinal pen	14.96	15.26	15.57	15.88	16.19	16.52	16.85	17.19	17.53

Table 9: Estimated cost of feed, NOK/kg

Multiplying the estimated cost of feed in NOK per kilo produced salmon with the estimated harvested volume for “Brilliant™” and the conventional pen yields the following total cost numbers in 1000 NOK, presented in table 10.

Year	0	1	2	3	4	5	6	7	8
"Brilliant™"	10,603	10,815	11,032	11,252	11,477	11,707	11,941	12,180	12,423
Conventional pen	11,532	11,763	11,998	12,238	12,483	12,732	12,987	13,247	13,511

Table 10: Estimated total cost of feed, in 1000 NOK

Cost of slaughter

The cost of slaughter will be based on the industry average 2017-numbers reported to the Directorate of Fisheries. The cost of slaughter includes cost of freight from the farming facility to the abattoir. Costs in NOK per kilo are assumed equal for both pens, whereas total costs are calculated with the estimated harvested volume of each pen. Based on the discussion from the strategic analysis, an annual growth of 8 % is estimated for the cost of slaughter. The growth rate is assumed to include annual inflation. Because of the production time from smolt to adult salmon, the first generation of harvestable salmon will be harvested in the middle of year 1. Accordingly, no cost of slaughter will accrue in year 0. Table 11 presents the estimated cost of slaughter for both pens in NOK/kg.

Year	0	1	2	3	4	5	6	7	8
Estimated cost of slaughter, NOK/kg	-	3.78	4.09	4.41	4.77	5.15	5.56	6.01	6.49

Table 11: Estimated cost of slaughter, in NOK/kg

The total cost of slaughter for “Brilliant™” and the conventional pen is listed in table 12.

Year	0	1	2	3	4	5	6	7	8
"Brilliant™"	-	3,217	3,474	3,752	4,052	4,376	4,726	5,105	5,513
Conventional pen	-	2,917	3,150	3,402	3,675	3,969	4,286	4,629	4,999

Table 12: Estimated total cost of slaughter, in 1000 NOK

Summary of operating revenue

The sales revenue is expected to be moderately higher for “Brilliant™” than for a conventional open pen. Salmon prices will clearly be the same for both pens but “Brilliant™” is estimated to generate a higher harvested volume of salmon. This is related to a higher estimated average weight at the time of harvest, caused by better welfare and living conditions for the salmon, and a higher survival rate due to decreased salmon lice and other diseases. Together, these variables are expected to increase the volume of harvested salmon in “Brilliant™”, both in amount and in weight.

For the COGS, the cost of smolt is expected to be equal for both pens due to the restricted amount of fish allowed in one pen. However, smolt costs are estimated to be higher than the costs reported from the industry companies to the Directorate of Fisheries in 2017, because of the project’s use of bigger-sized post-smolt.
The price of feed is estimated to stay constant at reported average 2017-levels for both pens, only adjusted by inflation. However, the cost of feed will be based on different feed conversion rates. Because of “Brilliant™”‘s assumed higher growth weight, welfare and living conditions of the salmon, it is estimated to have a lower feed conversion rate. Hence will the cost of feed be lower than for a conventional pen, which is based on the industry average conversion rate.
Costs of slaughter make up the smallest share of the total COGS. The costs will first accrue in year 1, because of the production time of the harvestable salmon. Slaughter costs are assumed to grow at a constant annual rate of 8 % and be equal for both pens.

Summarized, “Brilliant™” is expected to earn a higher sales revenue, present with a slightly lower level of COGS and is thus expected to generate higher operating revenue than a conventional pen. Table 13 and 14 presents the forecasted operating revenues of “Brilliant™” and the conventional pen, respectively.

Year	0	1	2	3	4	5	6	7	8
Sales revenue	-	45,365	43,546	44,421	45,305	46,215	47,141	48,076	49,045
- COGS	15,661	19,343	20,082	20,859	21,677	22,539	23,446	24,401	25,409
Operating revenue	- 15,661	26,022	23,463	23,562	23,628	23,676	23,695	23,675	23,636

Table 13: Forecasted operating revenue for "Brilliant™", in 1000 NOK

Year	0	1	2	3	4	5	6	7	8
Sales revenue	-	41,138	39,488	40,282	41,084	41,908	42,749	43,596	44,475
- COGS	16,590	19,990	20,725	21,495	22,305	23,156	24,051	24,993	25,984
Operating revenue	- 16,590	21,147	18,763	18,787	18,779	18,752	18,698	18,604	18,491

Table 14: Forecasted operating revenue for conventional pen, in 1000 NOK

5.2.2.1.2 OPEX

Health costs

Health costs reflects costs related to the health of the fish, and includes costs for vaccines and medicines, delousing, cleaning of the fish, etc.

The expense item of health costs is assumed to be the most differentiating cost between the "Brilliant™" and conventional fish pen. Based on the innovative characteristics of "Brilliant™", this fish pen is expected to have big advantages related to environmental issues of diseases, sea lice and other health-related problems. The dead fish collector prevents possible parasites to spread throughout the pen. The submergibility of the pen makes it possible to avoid the toughest climate and higher temperatures at sea surface, which is expected to slow or prevent the reproduction and attachment of sea lice. Because of this, the costs of health are expected to be lower for "Brilliant™" than for a conventional open pen, which is assumed to face the specific biologic problems in the industry today.

According to the Directorate of Fisheries' profitability survey, the cost of fish health was 2.25 NOK per kilo in 2017. This was an 11 % increase in health costs from the year before, and a 23 % increase from 2015. Information on costs related to fish health was first gathered by the Directorate of Fisheries in 2015, which means that there are few data to rely on. An annual increase of 11 % in health costs is high and with only three years of data, it can be argued if the average increase is representative for the past and can be expected for the future. The strategic analysis concluded that sea lice and other diseases will continue to be a problem for the future and that no new treatment measures are currently available. With a great focus and pressure on the environmental issues of the industry, it is important to maintain good fish health and hygiene, and to treat possible outbreaks of disease and sea lice. By these means, the high annual growth rate of health costs is expected to continue in the future, and an annual growth rate of 10 %, including inflation, is assumed further.

The conventional pen will rely on the average 2017 costs reported to the Directorate of Fisheries of 2.25 NOK/kg. Adjusted by the assumed annual 10 % growth rate, the costs estimated in year 0 is 2.72 NOK/kg. For "Brilliant™" however, the benefits of the fish pen are assumed to increase fish health and decrease costs related to sea lice and disease. "Brilliant™" is therefore estimated to expense health costs of 10 % less than a conventional pen. In year 0, the costs in NOK/kg is thus estimates to be 2.45. The estimated annual health costs in NOK per kg for each pen is presented in table 15.

Year	0	1	2	3	4	5	6	7	8
"Brilliant™"	2.45	2.70	2.96	3.26	3.59	3.95	4.34	4.77	5.25
Conventional pen	2.72	2.99	3.29	3.62	3.99	4.38	4.82	5.31	5.84

Table 15: Estimated health costs, in NOK/kg

Table 16 presents the estimated total annual costs related to fish health during the development phase for both pens.

Year	0	1	2	3	4	5	6	7	8
"Brilliant™"	2,083	2,291	2,520	2,772	3,049	3,354	3,690	4,059	4,464
Conventional pen	2,099	2,308	2,539	2,793	3,072	3,380	3,718	4,089	4,498

Table 16: Estimated total health costs, in 1000 NOK

Insurance costs

The costs on insurance make up only a small portion of the total production costs and changes in this expense item influence thus the total production costs marginally. Total insurance costs include pure costs of insurance and insurance payments paid due to loss of fish. In 2017, the insurance costs made up under 1 % of the value of biological products (Norwegian Directorate of Fisheries, 2018a). According to the profitability survey from the Directorate of Fisheries, total insurance costs per kilo was 0.13 NOK in 2017. The survey presented unchanged costs from 2016 to 2017. Average, constant insurance costs reported to the Directorate of Fisheries will thus be assumed further for both pens. Inflation adjusted insurance costs estimated for year 0 is estimated to 0.14 NOK/kg. Table 17 presents the estimated insurance costs in NOK/kg for both pens, whereas the calculated total insurance costs in 1000 NOK are presented in table 18.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Insurance costs, NOK/kg	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16

Table 17: Estimated future insurance costs, in NOK/kg

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
"Brilliant™"	115	117	120	122	124	127	129	132	135
Conventional pen	104	106	108	111	113	115	117	120	122

Table 18: Estimated total insurance costs, in 1000 NOK

Labor costs

Labor costs will be based on the reported average labor costs from the aquaculture industry, obtained by the Directorate of Fisheries (2018e). Average labor cost values reported in the profitability survey are gross costs that contains all expenses related to wages and labor. These include payroll taxes, holiday pay, social security contributions and social costs. The gross labor costs per FTE from 2017 was 808.097 NOK. An assumed average growth rate of 3 % will be applied for the forecasts of labor costs, based on the discussion from the strategic analysis.

Statistics Norway reported an average of 5.1 employed persons per license in the aquaculture industry of salmon and trout farming in 2017 (Statistics Norway, 2019b). These 5 employees include all personnel from operations, management and administration in the production, and is considered a greater number than for the operations of the individual pen. Because of this, the assumed number of workers per license for this project is set to 3. As both "Brilliant™" and the conventional pen are estimated to produce a harvested volume of about 1 MAB, both pens are assumed to employ 3 workers FTE. Table 19 presents the corresponding total labor costs for both pens.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Labor costs, in 1000 NOK	2,572	2,649	2,729	2,810	2,895	2,982	3,071	3,163	3,258

Table 19: Estimated total labor costs, in 1000 NOK

Other operating expenses

The expense item of other operating expenses includes residual costs related to reparations, maintenance and administration of the pen. According to the profitability survey from the Directorate of Fisheries, other operating costs make up about 20 % of the total operating costs related to a farming facility. The expense item in the profitability survey includes the same costs assumed in this thesis, and the reported average number from the survey will thus be used as a basis. However, the maintenance and administration costs extracted from the survey represent costs for the whole facility and therefore include costs which are not directly related to the production of salmon (Norwegian Directorate of Fisheries, 2018b). Because of this, other operating costs are expected to be somewhat lower for the "Brilliant™" and conventional fish pen than the costs reported from the survey. Further, it is assumed that other operating expenses will be lower for "Brilliant™" than for a conventional pen. This is explained by the more robust and durable construction of the "Brilliant™" pen and its components, which is expected to require fewer replacements and reparations.

The profitability survey of 2017 presented other operating costs with a total of 5.88 NOK/kg in the same year. This was a decrease of -12 % from 2016. However, other operating expenses had an increase of almost 50 % from 2015 to 2016, which implies that the expense item can present with great fluctuations. The Directorate of Fisheries does not specify what the other expenses related to maintenance, reparations and administration consists of, or what caused the variations. Because of this, it may be optimal to split the costs related to replacements or reparations from the other operating expenses. Inflation adjusted other operating expenses based on the reported 2017-numbers will be used as a basis. It will be assumed that replacement costs represent 30 % of the total of other operating expenses. Replacement costs will only incur in years where investment and replacement of expired components are taken place for both pens, respectively. This means that years of replacement will have investment costs related to the replacement of a component, and a 30 % increase in other operating expenses for the given year. Investment costs related to replacements for both pens will follow in section 5.2.2.3 under "PPE costs".

An illustration, or timeline, of when replacements for each pen is undertaken is presented in figure 22 and 23.

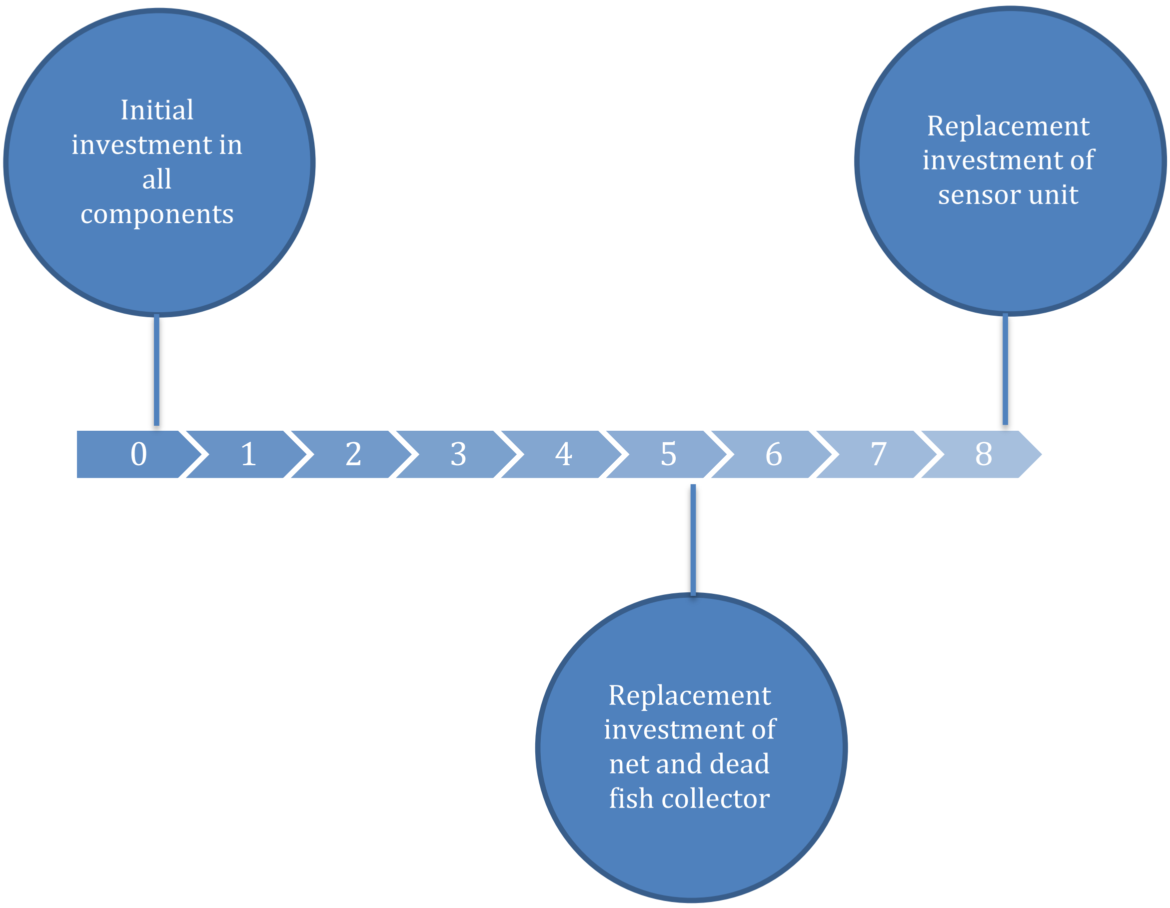

Figure 22: Timeline of investments and replacements of "Brilliant™"

Figure 22 illustrates the timeline of investments in "Brilliant™", where the initial investment in the total fish pen with all components is made in year 0. Replacement of the net and dead fish collector, with estimated usage lives of 5 years, will happen in year 5. The sensor unit with a durability of estimated 8 years will be replaced in year 8.

Correspondingly, figure 23 presents the investment and replacements of components for the conventional open pen. Initial investment in year 0 includes all components making up the total fish pen. Replacement investments in year 3 and 6 refers to the replacement of the sensor unit and net, which both have estimated lifetimes of 3 years. In year 8, the fish pen construction itself is considered expired and must thus be replaced.

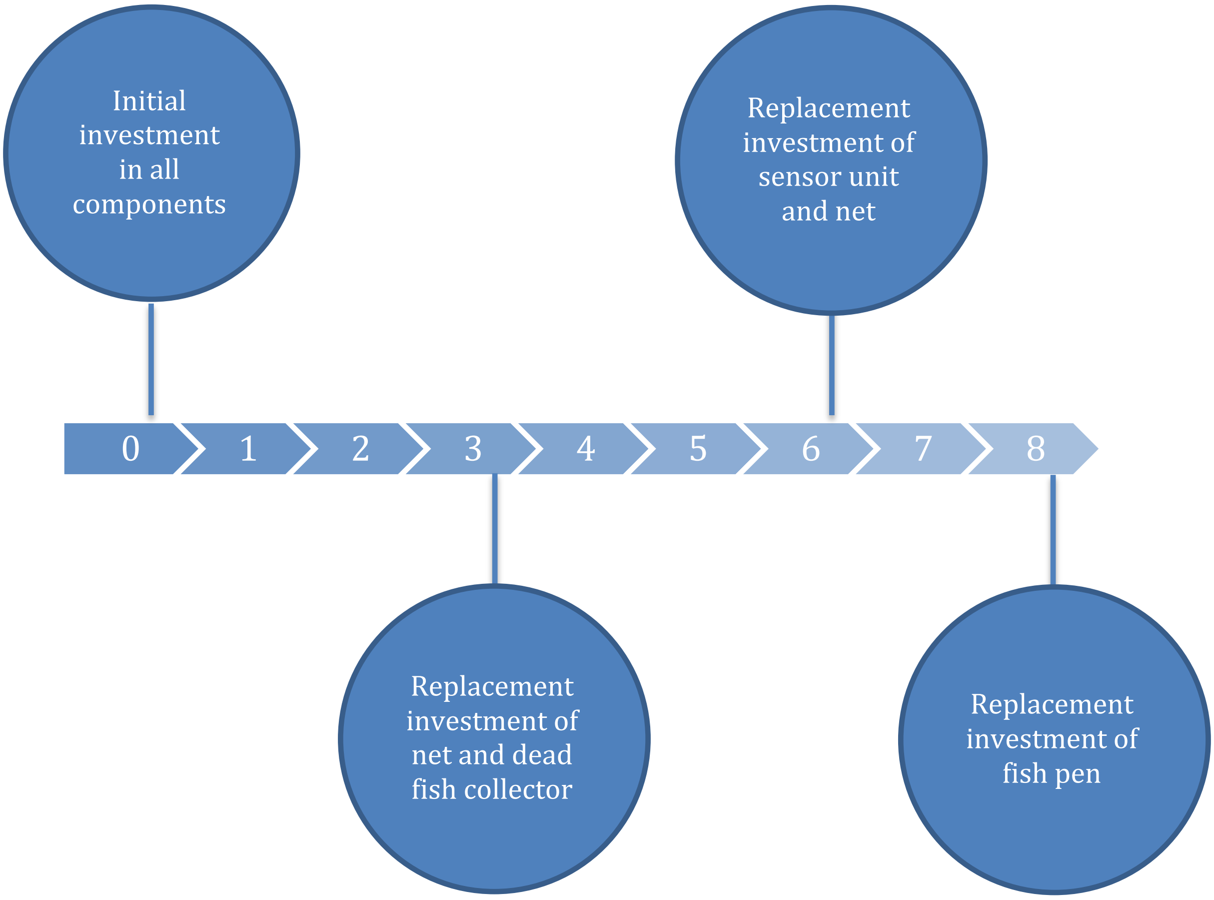

Figure 23: Timeline of investments and replacements of conventional pen

Costs related to replacement of investment are presented in table 20 and stated in NOK/kg. All costs related to the initial installment of the fish pens are assumed included in the initial investment costs, estimated under section 5.2.2.3. 30 % of the total other operating expenses reported to the Directorate of Fisheries in 2017 is inflation adjusted for the given year that the costs accrue. For the conventional pen, the main fish pen construction is replaced in year 8. As this is considered a bigger operation than the replacement of other assets, in terms of time, use of equipment and workforces, the replacement costs for the conventional pen is assumed to make up 60 % in year 8.

Year	0	1	2	3	4	5	6	7	8
"Brilliant™"	-	-	-	-	-	2.03	-	-	2.15
Conventional pen	-	-	-	1.95	-	-	2.07	-	4.30

Table 20: Estimated replacement costs of other operating expenses, in NOK/kg

The remaining other operating costs are inflation-adjusted values based on the reported industry average from 2017, extracted from the profitability survey of the Directorate of Fisheries. The remaining costs include expenses related to maintenance and administration. Because replacement costs of components are separated from other operating expenses, flat prices are assumed for the remaining operating costs and the industry fluctuations are somewhat taken into account. Table 21 presents the remaining other operating expenses for both pens, in NOK/kg. Other operating expenses are assumed to be equal for the two pens.

Year	0	1	2	3	4	5	6	7	8
Remaining other operating expenses, NOK/kg	6.12	6.24	6.36	6.49	6.62	6.75	6.89	7.03	7.17

Table 21: Estimated remaining other operating expenses, in NOK/kg

Total other operating expenses, the sum of replacement costs and the remaining other operating expenses, is calculated and presented in table 22. The values are stated in total numbers of 1000 NOK.

Year	0	1	2	3	4	5	6	7	8
"Brilliant™"	5,200	5,304	5,410	5,518	5,629	7,463	5,856	5,973	7,920
Conventional pen	4,715	4,810	4,906	6,505	5,104	5,206	6,903	5,417	8,840

Table 22: Estimated total other operating costs, in 1000 NOK

License costs

As discussed and concluded in the strategic analysis, both the conventional pen and "Brilliant™" will be based on the allocation of a development permit to legally farm salmon. The development permit is estimated to have a duration close to the industry average of 7 years and is thus expected to be converted to a regular farming license in year 8. Hence, costs related to licenses will accrue in year 8. Converting the license requires a remuneration of 10 million NOK in 2018 (Norwegian Directorate of Fisheries, 2018b), and must be inflation adjusted. The cost of converting a development permit to a license in year 8 is calculated to 11,951 in 1000 NOK, referring to table 23. The same expense is assumed to apply for both fish pens.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Conversion cost of development permit to license	-	-	-	-	-	-	-	-	11,951

Table 23: Estimated license costs for both pens, in 1000 NOK

Summary of OPEX

Costs related to conversion of a development permit to a license is by far the largest operating expense item. License costs are assumed to be equal for both pens and held outside the other operating expenses in this summary, as the expenditure is considered a one-time cost for an intangible asset.

Table 24 presents the total forecasted OPEX for "Brilliant™", whereas table 25 present the OPEX for the conventional pen, in 1000 NOK.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Health costs	2,083	2,291	2,520	2,772	3,049	3,354	3,690	4,059	4,464
Insurance costs	114.96	117.26	119.61	122.00	124.44	126.93	129.47	132.06	134.70
Labor costs	2,572	2,649	2,729	2,810	2,895	2,982	3,071	3,163	3,258
Total other operating costs	5,200	5,304	5,410	5,518	5,629	7,463	5,856	5,973	7,920
Total OPEX	9,969	10,361	10,778	11,223	11,697	13,926	12,746	13,327	15,777

Table 24: Forecasted total OPEX for "Brilliant™", in 1000 NOK

Year	0	1	2	3	4	5	6	7	8
Health costs	2,099	2,308	2,539	2,793	3,072	3,380	3,718	4,089	4,498
Insurance costs	104.25	106.34	108.46	110.63	112.85	115.10	117.40	119.75	122.15
Labor costs	2,572	2,649	2,729	2,810	2,895	2,982	3,071	3,163	3,258
Total other operating costs	4,715	4,810	4,906	6,505	5,104	5,206	6,903	5,417	8,840
Total OPEX	9,490	9,873	10,282	12,219	11,184	11,682	13,809	12,789	16,718

Table 25: Forecasted total OPEX for conventional pen, in 1000 NOK

Operating expenses related to labor and insurance are expected to be identical for both pens. Health costs are, however, estimated to be lower for “Brilliant™” than the conventional pen. This is explained by estimated fewer infections, sea lice and better general fish health, and accordingly lower costs related to this. Costs related to the replacement of expired components in selected years will influence the total other operating costs. Consequently, total operating expenditures of both pens will fluctuate during the development phase.

An illustration of the shares of the different operating expenditure items is presented in the appendix.

Depreciation

The investment costs of the “Brilliant™” fish pen consists of several components. As mentioned in 5.1.3, these components are expected to have different lives of usage, which means that the depreciation expense must be split over the different components. The main part, the actual pen, is estimated to have a lifetime of 15 years, the sensor unit a lifetime of 8 years, whereas the net and the dead fish collector are estimated to last 5 years. Hence, the latter parts will be replaced during the development phase of the project. Because of inflation-adjusted investment costs, the depreciation expense will vary during the project lifetime. Investment costs for “Brilliant™” are stated and discussed under section 5.2.2.3. Table 26 presents the depreciation expenses on the different asset components of “Brilliant™” related to the initial investment costs in the beginning of the development phase of the project.

Component	Initial investment cost	Asset lifetime	Annual depreciation expense
Fish pen	4,250	15	283
Net	1,500	5	300
Sensor unit	1,200	8	150
Dead fish collector	350	5	70
Total	**7,300**		**803**

Table 26: Annual depreciation expenses related to initial investments for "Brilliant™", in 1000 NOK

Inflation adjusted investment costs will increase the annual depreciation expenses for "Brilliant™" after replacement of components in year 5 and 8.

The estimated asset lifetimes and investment costs for a conventional open pen are retrieved from the SNF-report nr. 07/18 (Bjørndal, T. & Tusvik, A., 2018). The investment costs for open, conventional pens are stated and discussed under section 5.2.2.3 below. Table 27 presents the annual depreciation expenses for the initial investment costs of a conventional pen during the development phase in year 0 to 8. Note that for the conventional pen, the replacement of the net and sensory unit in year 3 and 6, and the replacement of the fish pen in year 8 will affect the depreciation expenses due to inflation adjusted investment costs.

Component	Initial investment cost	Asset lifetime	Annual depreciation expense
Fish pen	1,678	8	210
Net	366	3	122
Sensory unit	161	3	54
Total	**2,204**		**385**

Table 27: Annual depreciation expenses related to initial investments for conventional pen, in 1000 NOK

The total forecasted depreciation expenses during the development phase for "Brilliant™" and the conventional pen is summed in table 28. The depreciation expenses of inflation adjusted replacement investments are included.

Year	0	1	2	3	4	5	6	7	8
"Briljant"	803	803	803	803	803	842	842	842	868
Conventional pen	385	385	385	396	396	396	407	407	443

Table 28: Total depreciation expenses over the development phase for "Brilliant™" and conventional pen, in 1000 NOK

5.2.2.2 Corporate tax rate

The corporate tax rate in Norway, where Roxel Aqua is based and operates, in 2019 is 22 % (The Norwegian Government, 2019). Referring to the strategic analysis, we assume that the present tax rate of 22 % will be stable over the years of the project. The assumption is based on the agreement on the Tax Settlement and a prerequisite that a possible change of government will not raise corporate taxes in the future.

5.2.2.3 CAPEX

Initial investment costs

The initial investment costs are expected to be the most deviant variables between the two fish pens. For "Brilliant™", the investment costs are estimated to be significantly higher than for a conventional pen. This is due to uncertainty because of new technology and higher production costs of the pen due to the robustness and durability of the components. The latter are thus strengths of the innovative pen, as it does not require as much maintenance and frequent replacement during its useful years. Further, the "Brilliant™" pen is expected to have a much higher useful lifetime than a conventional pen.

It is assumed that both pens are manufactured and ready for operation in year 0, and that total investments costs in the same year includes costs related to installation and preparation of the fish pen in the sea, ready for operation.

For "Brilliant™", the investment expenditures are based on estimates from Akva Group ASA, whom has budgeted production costs for each component of the pen based on information from Roxel Aqua. The pen and net are very robust and are constructed to tolerate waves up to 5 m/H_s, which explains the high investment costs related to a conventional pen. However, the robustness of these components increases the estimated lifetime and thus reduces the need and costs for replacements. The estimated initial investment costs for “Brilliant™” are listed in table 29.

Initial investment costs, “Brilliant™”		
Component	**Asset lifetime**	**Investment cost**
Fish pen	15	4,250.00
Net	5	1,500.00
Sensor unit	8	1,200.00
Dead fish collector	5	350.00
Total		**7,300.00**

Table 29: Initial investment costs for “Brilliant™”, in 1000 NOK

The estimated investment costs for a conventional open pen are retrieved from the SNF-report nr. 07/18 (Bjørndal, T. & Tusvik, A., 2018). The investment costs reported for open, sea-based salmon farming facilities are based on information from Akva Group and a number of salmon farming companies. As the numbers are retrieved from a reliable source and based on an industry average as well as a leading manufacturer of fish farming pens, and the values are new, the estimated costs are considered relevant and reliable for the use of this thesis. However, the investment costs for the pen and the net are revised upwards with 20 %. The argument for this is that these components need to be more robust to endure the more challenging conditions in terms of waves and currents at an exposed facility and must thus be moderated and upgraded. The open, conventional pens in use today are located closer to the coastal areas and manufactured for the specific environment. For a conventional pen to be considered an alternative in offshore farming, the pen needs to be made robust and the net denser. The estimated lifetime of the components will, however, not be adjusted. The inflation adjusted and upsized estimated investment costs for the conventional pen is presented in table 30.

Initial investment costs, conventional pen		
Component	**Asset lifetime**	**Investment cost**
Fish pen	8	1,677.50
Net	3	366.00
Sensor unit	3	160.65
Total		**2,204.15**

Table 30: Initial investment costs for the conventional pen, in 1000 NOK

PP&E costs

PP&E is short for property, plant and equipment and includes the investment costs for replacement of components after the estimated usage lifetime has expired. The expense item includes the cost for new components such as net, sensor unit and dead fish collector. The investment replacements are adjusted by inflation annually.

The years of component replacements for "Brilliant™" and the conventional pen was illustrated in figure 21 and 22. The figures present investment replacement costs for "Brilliant™" in year 5 and 8, and in year 3, 6 and 8 for the conventional pen. Investment replacement expenses will further be based on the initial investment costs in year 0, referring to table 29 and 30 above.

Table 31 presents the PP&E costs for "Brilliant™" and the conventional pen in the years of component replacements during the development phase, in 1000 NOK.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
"Brilliant™"	-	-	-	-	-	2,043	-	-	1,406
Conventional pen	-	-	-	559	-	-	593	-	1,965

Table 31: Estimated PPE costs, in 1000 NOK

Summary of CAPEX

Capital expenditures are estimated to be significantly higher for "Brilliant™" than the conventional pen. Initial investment costs, including the costs of all components making up the pens, installment and preparations, are estimated to be over 3 times higher for "Brilliant™" than a conventional pen. Investment costs for "Brilliant™" are considered highly uncertain, as the pen is of new technology and has not yet been manufactured. The significant difference in manufacturing costs are explained by more durable materials increasing the estimated lifetime of "Brilliant™". Consequently, the pen requires less frequently replacements of expired components than a conventional pen.

5.2.3 Terminal value

5.2.3.1 Terminal value

Perpetual growth rate

The perpetual growth rate is the stable growth rate of the future project cash flows calculated in the terminal value when the project reaches its steady state. As the steady state is based on a stable production and investments in equilibrium, no production growth is assumed in the project. This is also based on the MAB of the pens and the licensing system, which limits the production volume. Consequently, the only way for the project to experience growth is based on estimated increasing salmon prices or decreasing production and/or operating costs. However, these variations may equalize each other, and a stable cash flow is again predicted. Further, a company can never grow at a rate higher than the growth rate of the economy. Based on these arguments, the perpetual growth rate of the project's FCFF's in the calculated terminal value is assumed to equal the estimated inflation rate of 2 %.

Terminal value

The free cash flows to firm in the terminal year, calculated after the final year of the development phase in year 8, includes the expected stable inflows and outflows of cash estimated until perpetuity. The operating revenue and (most of) the operating expenditures in the terminal value represents the values in the cash flows from year 8, adjusted by the perpetual growth rate. Capital expenditures and depreciations, as well as replacement costs for components, are however not representative for the perpetual future in year 8. In year 8, replacements are commenced, and the CAPEX does not represent the annual expenditures for the years to come. Instead, the average CAPEX on the investments based on real values in year 9 will be used as the basis in the terminal value. The depreciation expenses will follow the same method. For the replacement costs, average historical values from the 8-year development phase is applied. The calculations of the cash flows in year 9 are presented in the appendix.

"Brilliant's™" free cash flows in year 9 is forecasted to 6,644 NOK, in 1000 NOK. The terminal value is further calculated as

$$TV_{Brilliant} = \frac{7{,}555}{(0.11 - 0.02)} = 83{,}946 \text{ NOK}$$

The free cash flow of the conventional pen in year is estimated to 3,122 NOK, in 1000 NOK, and the terminal value is

$$TV_{Conventional} = \frac{3{,}969}{(0.11 - 0.02)} = 44{,}098 \text{ NOK}$$

5.2.3.2 Residual value

For "Brilliant™", the residual value is calculated as a sum of the BV of all components in the end of year 8. The main asset, the fish pen, have an estimated lifetime of 15 years, which means it is estimated to operate fully for another 7 years after the terminal year. The net and the dead fish collector were replaced in year 5, and with useful lifetimes of 5 years, they still have one more year of useful lives. The sensor unit was impaired in year 7 and replaced in year 8 and have thus only been depreciated for one year. Table 32 presents the residual value of components of "Brilliant™" in the end of year 8. The calculated total residual value is 3,339 NOK, stated in 1000 NOK.

Component	**BV of investment, applied years**	**Depreciation years in terminal year**	**∑D**	**RV, terminal year**
Fish pen	4,250	9	2,550	1,700
Net	1,656	4	1,325	331
Sensor unit	1,406	1	176	1,230
Dead fish collector	386	4	309	77
Total				**3,339**

Table 32: Estimated residual value of "Brilliant™" in terminal year, in 1000 NOK

The components of the conventional open pen, the net and the sensor unit, are impaired in the end of year 8 and does not hold any residual value. The fish pen itself is expected to be replaced in the terminal year and has only been depreciated over one year. The residual value of the conventional pen is thus equal to the book value of the fish pen investment, minus one year of the estimated annual depreciation. A total residual value of 1,720 NOK, in 1000 NOK, is calculated for the conventional pen and presented in table 33.

Component	BV of investment, applied year	Depreciation years in terminal year	∑D	RV, terminal year
Fish pen	1,965	1	246	1,720
Net	412	3	412	-
Sensor unit	181	3	181	-
Total				**1,720**

Table 33: Estimated residual value of the conventional pen in terminal year, in 1000 NOK

Summary of terminal value

The total of the terminal value and residual value for both pens in the end of year 8 follows in table 34. These values will be discounted over the WACC and included in the NPV calculations.

	TV_T	RV_T	Sum TV_T
"Brilliant™"	73,817	3,339	77,156
Conventional pen	34,694	1,720	36,414

Table 34: Estimated total TV for "Brilliant™" and conventional pen, in 1000 NOK

5.2.4 WACC

Estimating an appropriate WACC to be applied the project valuation can be complex and difficult. This is partly due to the financing plan and owner structure of the whole "Octopus" investment project that the fish pen is a part of. The financing plan and calculated WACC for the "Octopus" project will be used as a basis when estimating the WACC for the fish pen, as will industry averages and discussion.

5.2.3.1 Financing plan

After discussions with the project management of Roxel Aqua, the preliminary financing plan for the "Octopus" project is approved and could be included when calculating the discount rate used to value the different fish pens, as the pen of choice will be encompassed in the same project. However, the single fish pen, "Brilliant™" or conventional pen, is in this thesis treated as an individual project. The WACC estimated for the whole "Octopus" project may thus be considered overstated, as the total project is far more capital intensive and riskier than the investment in the fish pen itself. Thus, the WACC for "Octopus" may understate the value of the fish pens and will therefore not be used directly.

According to the financing plan, the "Octopus" project will be financed with equity, loan from parent company, convertible bond loan, loan from credit institutions and revolving credit facility. A credit facility is a loan facility that can be used after the borrower's needs. It is a flexible loan where the borrower only pays interests for the amount deducted on the loan and pays a commitment fee on the part of the facility that is not used. The facility is priced with the NIBOR rent plus a margin, and the term is normally 3-5 years. Looking at "Brilliant™", however, the initial investment costs for the fish pen only make up about 30 % of the total investment costs for the "Octopus" project, or 25 % of the investment costs if investing in a conventional pen. The investment costs for the "Brilliant™" project are thus remarkably lower than for the whole "Octopus" project, and may possibly be financed through equity and a single credit institution loan alone.

5.2.3.2 Cost of equity

To calculate the cost of equity, the capital asset pricing model would be used. The 10-year annual average of the government bonds issued by the Bank of Norway would be used as the risk-free rate, as this is argued as the most used risk-free rate in valuations. In accordance with the studies performed by EY (2014), an average of the government yield will lead to a more stable valuation result, especially if the yield presents with high volatility. However, calculating the beta for this project is considered problematic, as there are few or no similar projects in the industry to base the equity beta value on. Furthermore, the company betas of the industry are highly variable, and using an industry average would therefore assume to yield an unreliable project risk. According to the owners of Roxel AS, the cost of equity for Roxel Aqua is expected to be 10 % and is the rate that should be assumed when calculating the WACC, or discount rate, to value the “Octopus” project. The same cost of equity rate of 10 % is considered appropriate for the valuation of “Brilliant™”.

5.2.3.3 Cost of debt

The total cost of debt depends on the financing structure and plan for the asset or project to be valued. For the “Octopus” project, the debt share of the project is assessed to be financed through four different positions; loan from the parent company Roxel AS, convertible bond loan, loan from credit institutions and revolving credit facility. As argued, “Brilliant™” is less capital intensive than the total “Octopus” project and can thus be financed through fewer debt positions. If the project were to be financed merely through a credit institution loan, the lending rate would depend on the credit rate of the investor, which is unmanageable for a new company. Therefore, the total cost of debt estimated for “Octopus” will be applied as the appropriate rate, as Roxel Aqua already have made detailed calculations on this. Roxel Aqua’s own estimations yield a cost of debt of 4.8 %. The rate will be adjusted to 5.0 % and represent the cost of debt assumed in the calculation of the WACC used for the “Brilliant™” project.

5.2.3.4 WACC

According to the “Octopus” project financing plan, the total project is assumed to be financed with 40 % equity and 60 % debt. As discussed, the total project is far more capital intensive than the project involving the single fish pen component. Also, Folkvord, B., et al. (2019) assumes an equity ratio of 60 % on an investment analysis calculated on a conventional open pen and a new technological offshore facility (2019). Based on this, and the fact that the “Brilliant™” or conventional pen is less capital intensive than the total project, the equity ratio will be assumed to 60 % and the debt ratio to 40 %.
A summary of the WACC inputs follows in table 35.

Input	Value
Cost of equity,	10 %
Equity ratio,	60 %
Cost of debt,	5 %
Corporate tax rate, T	22 %
Debt ratio,	40 %

Table 35: WACC inputs

The WACC can then be calculated for the "Brilliant™" project as:

$$WACC = (0{,}10 \times 0{,}60) + (0{,}05 \times (1 - 0{,}22) \times 0{,}40) = 0{,}0756 \approx 7{,}60\ \%$$

The calculated WACC for the "Brilliant™" project is estimated to 7.60 %. However, as discussed in section 3.1.1.1.1, Damodaran (2012) argues that the cost of equity should be higher for riskier investments. This project is considered a risky investment, as it involves new technology, uncertainty in cash flow generations and investment costs, and it can thus be argued if the calculated WACC, or discount rate, should be raised. The argument for raising the discount rate in risky investments is to adjust for uncertainty and decrease the calculated NPV to avoid accepting overstated outcomes that can be the result if one does not take risk into account. Raising the discount rate and consequently lowering the NPV outcome, may prevent taking on unacceptable risks and increases the criteria for accepting the investment. According to Jacobs and Shivdasami (2012), nearly 70 % of corporate executives in U.S. companies adjust the calculated WACC to account for the specific risk profile of an investment. Further, the similar investment analysis of a conventional open pen and offshore farming facility performed by Folkvord, B., et al. (2019) applies a WACC of 10 %. This discount rate was estimated on the basis of conversations with financial analytics, salmon farming companies, corporate finance advisors of investment banks and empirical studies. In other words, the assumed 10 % WACC is well argued for. To estimate a project specific WACC, one has to know the systematic risk in the project's cash flow and adjust the discount rate for the risk contributions for the specific project. However, this procedure may be very difficult and the adjustment almost impossible to calculate. Hence, the risk adjustment must be based on pure assumptions alone. Folkvord, B., et al. (2019) argues that their estimated 10 % WACC apply to investments in existing farming technology, and that a higher discount rate should be used for investments in new technology. The reason for this is due to the uncertainty that the technology will function in practice, and that the use of a rate of 10 % will overstate the NPV of the project. Folkvord, B., et al. further implies that investments in new farming technologies should be considered as “frontier development” projects. Such projects can mostly be found in the oil and gas industry, where many comparable projects regarding new technology, sustainable growth and high risk can be found. The hurdle rates used in new projects in the oil industry are usually between 12 to 16 % (Wood MacKenzie, 2018). However, one can also argue if these discount rates can be considered applicable, as projects in the oil sector are usually exceedingly more capital intensive than of a fish farming pen. Based on these arguments and the discussion, the calculated WACC for the “Brilliant™” project of 7.6 % will be raised to adjust for uncertainty and risk. However, the discount rate will not be assumed to be as high as for projects in the oil industry. The estimated WACC for the “Brilliant™” project is assumed to be 11.0 %, which is between the WACC estimated by Folkvord, B., et al. and the lowest rate used in new technology projects in the oil sector.

Summary of WACC

The estimated WACC is set to 11.0 % and will be the rate used in the discounting of the FCFF for both pens. The discount rate is based on calculations and industry averages, with an upward adjustment for risk and uncertainty.

5.3 Monte Carlo Simulation

In this section, the different steps in a Monte Carlo simulation explained under 3.3.1 will be projected to assess a simulation of selected variables. Step 1 in modelling the project has already been described under section 5.1.1, and the two latter steps of selecting the parameters to be simulated and estimating the forecasting errors will follow.

5.3.1 Parameters to be simulated

The parameters selected to be simulated in a Monte Carlo simulation is based on the assessment of uncertainty from section 4.2, from the modelling of the project equations in section 5.2.1 and on own assessment. The variables will be presented under each equation variable and summed up to conclude. Note that a Monte Carlo simulation is time-consuming, and it may be difficult to estimate forecasting errors. Accordingly, only a few selected variables will be simulated.

5.3.1.1 Project lifetime

The project lifetime is discussed in section 5.1.1. Although there is indeed uncertainty with the lifetime of the project and usage life of the "Brilliant™" pen, this factor is not considered a variable to be included in a simulation. The lifetime is not a parameter that is estimated to change over time, as the factor will have to be set in advance before initiating the project in order to plan the project and estimate the correct depreciation rate. Although changes in estimated lifetime can happen during a project, this is not something that will be taken into account in this NPV valuation. Conclusively, the project lifetime is not prone to forecasting errors and the lifetime discussed in section 5.1.1 will be considered rational.

5.3.1.2 Operating revenue

From a revenue stand, the interesting variables from an uncertainty point of view is the two factors making up the sales revenue; the price of salmon and the harvested volume of salmon. The price of salmon is considered highly uncertain in regard to the historical price fluctuations and volatility, and uncertainty in the future production of salmon that determine the supply and demand. Fish Pool is considered a reliable source when it comes to forecasting salmon prices but estimating flat prices for the future is assumed to be an uncertain approximation. Further, the price of salmon has a great impact on the calculated revenue and the net FCFF's. Therefore, the salmon prices will be simulated in a Monte Carlo simulation.

The harvested volume is dependent on several underlying factors. Whilst parameters like the survival rate of salmon, wastage and average weight of the harvested salmon are considered uncertain, these parameters accumulate the uncertainty related to the harvested volume. However, the harvested volume is assumed to be stable over the project years, and the underlying factors making up the harvested volume, will not be selected for a simulation.

Expenditures classified as cost of goods sold will not be simulated. Although all these expense items may be considered uncertain and have a high impact on the operating revenue and contribution on the total costs, including all these expenditures will be time-consuming and the outcomes may be less efficient than assessing the variables related to the sales revenue. The cost of feed is assumed to be higher for a conventional pen than for "Brilliant™". Furthermore, it is estimated to be the greatest expenditure in the NPV calculations. Because the feed costs are also influenced by many underlying factors, the expense item is considered applicable for simulation.

5.3.1.3 OPEX

All operating expenditure variables can be considered uncertain. However, the cost of insurance, labor and other operating costs are considered relatively constant as fixed costs across the project lifetime and will not be included in a simulation. Further, license costs are fixed, one-time costs that are not assumed to be prone to estimating errors.

Costs related to fish health could be a variable of relevance. The expense item is estimated to be slightly higher for "Brilliant™" than the conventional pen, it is influenced by several other variables and because of the assumed environmental effects of "Brilliant™", the variable is of great interest. However, it contributes minimally to the total costs, and thus the final NPV calculation. It is therefore not selected for simulation, as small changes are not assumed to have a significant impact on the result.

5.3.1.4 CAPEX

Capital expenditures includes initial investment costs, PP&E costs and the cost of licenses. As discussed, all investment assets will be purchased from retailers and are not considered prone to big variations, although prices for "Brilliant™" are considered uncertain. Cost estimates for "Brilliant™" are retrieved from the manufacturer, or supplier, and it will be difficult to estimate a probability for the price differing from the suggested. For the conventional pen, the investment costs are retrieved from industry averages and are therefore not considered considerably uncertain. Nevertheless, investment costs were revised upwards to reflect a more robust construction, which increases the risk of forecasting errors. The initial investment costs are considered one-time costs in year 0 and are not dependent on forecasting. However, investment costs are an exceptionally significant part of the CAPEX and NPV outcome and have a great impact on the result and the investment decision. Still, as the capital expenditures are not considered changing variables throughout the project lifetime, but fixed costs, they will not be selected for a Monte Carlo simulation.

5.3.1.5 Discount rate

The discount rate, or WACC, may be considered the most critical and uncertain variable in a valuation, as discussed in previous sections. However, the discount rate will not be included in the Monte Carlo simulation, as it is not considered a variable, but a constant rate. Instead, uncertainty related to the WACC will be assessed under a sensitivity analysis to follow in section 6.

5.3.1.6 Summary

Table 36 summarize the variables selected for further estimation and simulation and relates to both pens. Selected variables include the price of salmon and the cost of feed. By simulating these two factors, uncertainty is somewhat accounted for on both aspects of the EBIT calculations; the revenue side and the cost side. The selected variables are considered the items with highest uncertainty for each aspect, and which have the greatest impact on the net cash flows. Variables that are not selected in a Monte Carlo simulation may still be assessed under a sensitivity analysis in section 6.

Equation aspect	Variable	Definition
Sales revenue	p^{salmon}	Price of salmon
COGS	c^{feed}	Cost of feed

Table 36: Parameters selected for a Monte Carlo simulation

5.3.2 Estimated forecasting errors

The estimated forecasting errors for the selected variables to be simulated is to follow, in order to set the basis for uncertainty.

5.3.2.1 Price of salmon

Historically, the price of salmon has had a great increase in growth during the last decade. However, the history presents with high volatility and fluctuations, in addition to cyclical changes throughout a year. Assuming flat prices for the future may be somewhat biased, at least if uncertainty is not taken into account. As clarified in the strategic analysis, the standard deviations from the last two years was 13 % and 15 %, whereas the past 5-year average presents a 13 % standard deviation. Forecasting errors of plus 15 % and minus 10 % are assumed for the simulation. This is based on the historical price variance, future expectations and with regards to analytical forecasts of assumed stable prices.

5.3.2.2 Cost of feed

Prices of feed have been fairly stable during the last 10 year, with an almost constant growth rate of about 4 %. However, as most raw materials in the feed production are imported, the prices are highly affected by the Norwegian exchange rate. In this thesis, a weak NOK and high feed prices are assumed in the future. Yet, a decrease in the exchange rate may reduce the feed prices and thus cost of feed greatly. Furthermore, a sudden increase in the production of salmon is likely to increase the demand for fish feed, which may raise the feed prices. In other words, the cost of feed is an uncertain variable. For “Brilliant™”, it is further assumed a higher feed conversion rate, which is estimated to decrease the feed costs relative to a conventional pen. This assumption increases the uncertainty of the expenditure further, and thus make the cost of feed prone to estimation errors. Forecasting errors of plus/minus 10 % are assumed for the cost of feed and relates to both fish pens.

6. Results

The results from the investment analysis and the Monte Carlo simulation are calculated and collected in the following chapter.

The estimations and forecasts of the FCFF's are based on numbers generated from the investment and production from one single fish pen. To make the results comparable, as the "Brilliant™" pen is estimated to produce a higher volume of harvested salmon than a conventional pen, the results from the NPV model are converted to NOK/kg. That is, the value output in 1000 NOK from each pen is divided by the corresponding estimated total harvested volume. In addition, the internal rate of return, IRR, and the pay-back period for each investment are calculated.

The Monte Carlo simulations will give a stance on how estimated standard deviations on the price of salmon and cost of feed can affect the NPV results.

A sensitivity analysis is also included to assess how sensitive the NPV output is to deviations in selected variables. The tested variables include factors that are expected to have a great impact on the discounted cash flows and the final outcomes and includes scenarios for future estimates.

Finally, an alternative approach for calculating and comparing the NPV of "Brilliant™" relative to a conventional pen is presented. The alternative calculation ignores the cost of a farming license, as it is based on the use of "Brilliant™" in today's farming facilities compared to a conventional pen. The approach thus looks at "Brilliant™" from a steady state, where investment can be undertaken by other salmon farming companies in the future.

6.1. NPV results

6.1.1 “Brilliant™”

“Brilliant’s™” forecasted free cash flows to firm, from the development phase from year 0 through year 8, are discounted over a WACC of 11.0 %. The net present value in year 0 is calculated by the sum of the discounted cash flows and the discounted terminal value, together with the present value of the residual value at the end of year 8. The forecasted cash flows, based on the values estimated in section 5.2, and calculated NPV of “Brilliant™” are presented in table 37.

Year	0	1	2	3	4	5	6	7	8
Sales revenue	-	45,365	43,546	44,421	45,305	46,215	47,141	48,076	49,045
- COGS	15,661	19,343	20,082	20,859	21,677	22,539	23,446	24,401	25,409
Operating revenue	- 15,661	26,022	23,463	23,562	23,628	23,676	23,695	23,675	23,636
- OPEX	9,969	10,361	10,778	11,223	11,697	13,926	12,746	13,327	27,728
- depreciation	803	803	803	803	803	842	842	842	868
EBIT	- 26,434	14,857	11,882	11,536	11,127	8,908	10,108	9,506	- 4,960
- 22 % tax	- 5,815	3,269	2,614	2,538	2,448	1,960	2,224	2,091	- 1,091
- CAPEX	7,300	-	-	-	-	2,043	-	-	1,406
+ depreciation	803	803	803	803	803	842	842	842	868
FCFF	- 27,115	12,392	10,071	9,801	9,483	5,747	8,726	8,256	- 4,407
Discounted FCFF	- 27,115	11,164	8,174	7,166	6,246	3,411	4,665	3,977	- 1,912
TV									73,817
RV									3,339
Discounted TV+RV									33,480
NPV	49,256								

Table 37: Calculated NPV of “Brilliant™”, in 1000 NOK

The estimated FCFF’s presents a high negative value in year 0. This is caused by the high investment costs related to the initial investment of the fish pen in year 0 and no generation of income the same year. The first population of salmon is harvested in year 1, which then presents with the first revenue from sales and positive cash flows in the following years. “Brilliant’s™” operating revenue is relatively stable throughout the development phase, generating a constant profit of about 23,600 NOK, in 1000s, from year 2. Operating expenditures are, however, increasing, resulting in a decreasing annual EBIT during the development phase. Increasing costs related to fish health and varying other operating costs are the cause of this decrease, together with estimated flat salmon prices and a relatively constant operating revenue. The negative forecasted EBIT in the terminal year is due to costs of converting the development permit to a farming license. Capital expenditures related to replacement investment in a new sensor unit is also responsible for a further decrease in the FCFF. However, the residual value of the fish pen and its components after year 8 somewhat makes up for this negative final cash flow.

The fundamental valuation of "Brilliant™" results in a net present value of 49,256 NOK, stated in 1000 NOK. Divided by the estimated harvested volume of salmon of 850,000, this yields an NPV in NOK/kg of 57.95. The results present a positive present value, which indicates that the investment in "Brilliant™" is profitable and should be undertaken.

The calculated internal rate of return, IRR, for "Brilliant™" is 27.3 %. This means that any discount rate below 27.3 % will yield a positive net present value for the investment in this alternative. The estimated IRR is considerably high, meaning that the investment will be assumed to be profitable even when discounted over a very high WACC.

Table 38 further presents the cumulative cash flows for "Brilliant™" during the development phase. Note that the terminal value is included in year 8. With year 0 representing the year of initial investments and no operating revenue, the accumulated generated cash flows indicate that "Brilliant™" will have a pay-back period of about 4.2 years. This means that this investment alternative will have earned back the initial investment and costs in the beginning of year 4, and that the cumulative cash flow's will be positive, assuming positive net FCFF's, from this year on.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cumulative FCFF	- 27,115	- 15,951	- 7,777	- 611	5,635	9,046	13,711	17,688	49,256

Table 38: Cumulative FCFF's for "Brilliant™", in 1000 NOK

6.1.2 Conventional pen

The forecasted cash flows generated by the conventional pen are also discounted over a WACC of 11.0 %. The sum of the discounted FCFF's, terminal value and residual value makes up the resulted net present value. The NPV of the conventional pen is presented in table 39.

Year	0	1	2	3	4	5	6	7	8
Sales revenue	-	41,138	39,488	40,282	41,084	41,908	42,749	43,596	44,475
- COGS	16,590	19,990	20,725	21,495	22,305	23,156	24,051	24,993	25,984
Operating revenue	- 16,590	21,147	18,763	18,787	18,779	18,752	18,698	18,604	18,491
- OPEX	9,490	9,873	10,282	12,219	11,184	11,682	13,809	12,789	28,669
- depreciation	385	385	385	396	396	396	407	407	443
EBIT	- 26,465	10,888	8,096	6,171	7,199	6,674	4,481	5,408	- 10,621
- 22 % tax	- 5,822	2,395	1,781	1,358	1,584	1,468	986	1,190	- 2,337
- CAPEX	2,204	-	-	559	-	-	593	-	1,965
+ depreciation	385	385	385	396	396	396	407	407	443
FCFF	- 22,462	8,878	6,700	4,651	6,011	5,602	3,309	4,625	- 9,806
Discounted FCFF	- 22,462	7,998	5,438	3,401	3,960	3,324	1,769	2,228	- 4,255
TV									34,694
RV									1,720
Discounted TV+RV									15,801
NPV	17,202								

Table 39: Calculated NPV of conventional pen, in 1000 NOK

As for "Brilliant™", the conventional pen presents a negative net cash flow in year 0, due to initial investments in the fish pen asset and zero revenue from sales. The conventional pen also generates moderately constant operating revenue from year 2 through 8, averaging around 18,700 NOK. Operating expenses are increasing throughout the development period, again caused by increasing health costs and fluctuating other operating costs. With estimated higher costs related to fish health and more frequent replacement costs, the operating expenditures for the conventional pen are increasing at a higher rate than for "Brilliant™". The cost of license results in a negative FCFF in the terminal year, which is thus neglected in the calculation of the terminal value.

The final outcome of the fundamental valuation of the conventional pen is a calculated net present value of 17,202 NOK, in 1000 NOK. With an estimated harvested volume of salmon of 770,800, the NPV results in 22.32 NOK/kg. The NPV is a positive number and thus suggests that the investment in a conventional pen will be profitable for project.

The conventional pen has a calculated internal rate of return of 15.2 %. The IRR is exceptionally lower than the calculated internal rate of "Brilliant™", but it is still fairly higher than the estimated WACC of 11.0 % and the investment is therefore assumed to be profitable even when applying a higher discount rate.

Year	0	1	2	3	4	5	6	7	8
Cumulative FCFF	-22,462	-14,463	-9,025	-5,625	-1,665	1,659	3,428	5,656	17,202

Table 40: Cumulative FCFF's for conventional pen, in 1000 NOK

As table 40 presents, the conventional pen has negative cumulated cash flows during the first 5 years. The pay-back period is calculated to 5.9 years, which means that it will take almost 6 years for the conventional pen to pay back the initial investment undertaken in year 0. The first positive accumulated FCFF will take place in the end of year 5.

6.1.3 Summary of NPV results

The NPV calculations resulted in positive NPV values for both fish pens. "Brilliant™" presented with an NPV in NOK/kg over 2 times higher than the conventional pen. Furthermore, the internal rate of return was over 10 % higher for "Brilliant™" and the pay-back period of the initial investment costs was almost 2.6 years less than for the conventional pen. These findings imply that based on the fundamental valuation, "Brilliant™" would be a more profitable investment alternative than the conventional open pen.

6.2 Monte Carlo simulation results

The Monte Carlo simulation was performed with the use of a software from Palisade, a provider of risk and decision analysis software. The simulation tool used, called @risk, is an add-in software to MS Excel.

The total FCFF forecasts and NPV calculations were modelled in Excel. The variables chosen for simulations were selected as the inputs, and the calculated NPV equation was selected as the output to be defined from the @risk simulation. A PERT distribution was chosen to model the data. This distribution assumes that the selected variables are normally distributed and generates a distribution with a realistic probability (RiskAMP, 2019). The variables to be simulated were modelled with estimated maximum, minimum and mean values, where the PERT distribution emphasizes the value that is "most likely" to occur.

All simulations were performed with 10,000 iterations.

6.2.1 Simulation of salmon prices

Simulated salmon prices were based on the forward prices obtained from Fish Pool, defined in section 5.2. The salmon price outputs were modelled to interrelate with the simulated price from the previous year, starting with the Fish Pool forward price in year 0. This means that the salmon price for each year were simulated based on the inflation-adjusted simulation outcome from the previous year, and that uncertainties accumulate for each year.

The mean value in the PERT distribution in year 0 was set as the estimated salmon price for that same year. The mean for the following years was thus modelled to equal the simulated output from the previous year, plus a 2 % increase due to inflation. The minimum value was estimated as a 10 % decrease of the mean price, whereas the maximum value was set as an increase from the mean by 15 %.

6.2.1.1 “Brilliant™”

Figure 26 illustrates the NPV results of simulated salmon prices for “Brilliant™”.

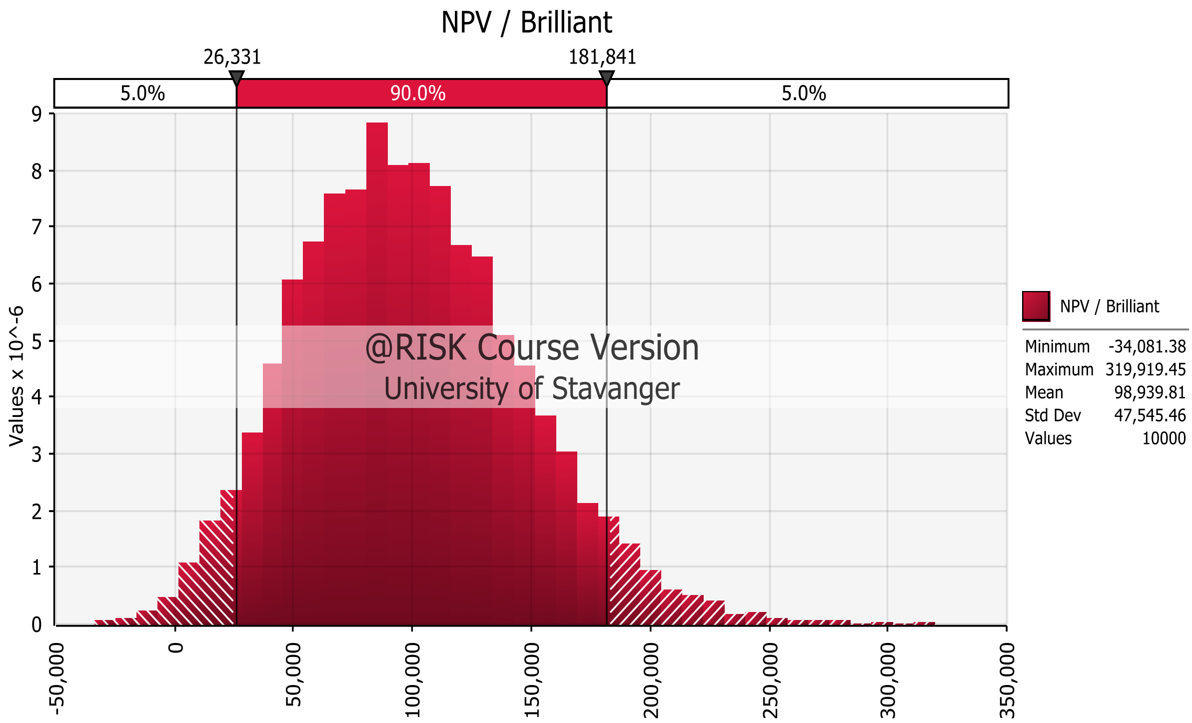

Figure 26: Simulated salmon prices, NPV outcomes for “Brilliant™”, in 1000 NOK

The mean NPV of “Brilliant™” with simulated salmon prices presents a mean of 98,940 NOK (in 1000 NOK), or 116.4 NOK/kg. The yielded result is exceptionally higher than the calculated static NPV of 57.95 NOK/kg. It is assumed that the net present value estimated under this Monte Carlo simulation can provide a more accurate result, as volatility in the salmon prices are taken into account. Damodaran (2012) argues that the mean NPV can be seen as the expected outcome. Figure 26 illustrates further that the NPV with 90 % certainty will be located within an interval between approximately 26,300 and 181,800 NOK. This means that the static estimated NPV from section 6.1.1 is located in the lowest range of the 90 % confidence interval, assuming a possible annual price decrease of 10 % and increase of 15 %. Because the uncertainty in the salmon prices accumulate over the time, the simulation result in a high range of possible outcomes, were even negative present values are possible.

6.2.1.2 Conventional pen

The static NPV for the conventional pen, calculated in section 6.1.2, was 17,202 in 1000 NOK, or 22.32 NOK/kg. Figure 27 presents the NPV outcomes after simulating salmon prices, with a reported mean of 62,184 NOK. Divided by the estimated harvested volume of salmon for the conventional pen, this yields an NPV of 80.67 NOK/kg.

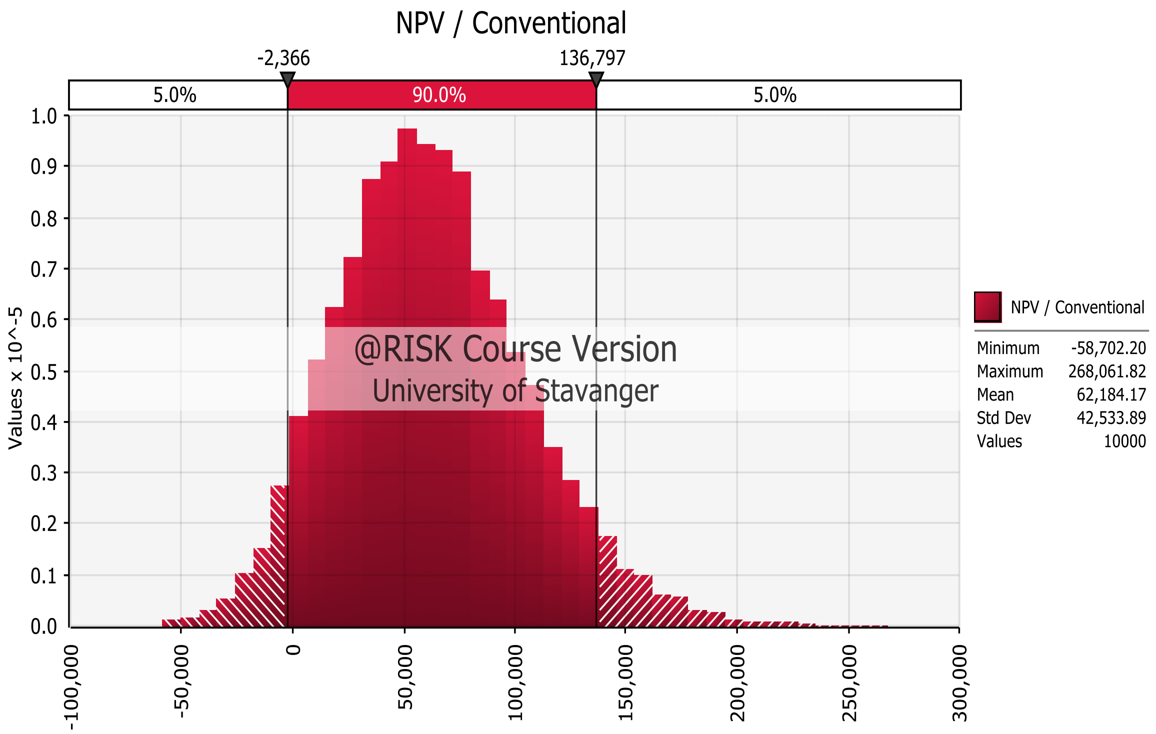

Figure 27: Simulated salmon prices, NPV outcomes for conventional pen, in 1000 NOK

The conventional pen also presents a higher expected value after simulating the salmon prices. The static NPV for the conventional pen is located in the bottom range of the 90 % confidence interval. This may imply that by accounting for uncertain salmon prices, with a projected higher upward than downward standard deviation, it is more likely that the two fish pens can achieve higher net present values than from a static model. The conventional pen may also yield negative NPV results if decreasing salmon prices accumulate over time. In fact, a negative value of -2,366 is possible in a 90 % confidence interval.

6.2.2 Simulation of feed costs

The cost of feed for both pens were simulated on the same basis as for the salmon prices, where the cost values in one year were interrelated with the simulated cost of feed from the previous year. This means that the simulation of the cost variable in year 0 affected the estimated mean, and thus simulation basis, for year 1, and so on. By interrelating the variables, the annual standard deviations accumulate over time.

The standard deviation for the cost of feed was specified to 10 %, which means that the minimum values were set as 10 % less than the mean, and maximum values were a 10 % increase from the mean. The mean in year 0 was defined as the estimated cost of feed for the particular fish pen from section 5.2. For the following years from 1 through 8, the mean was set as the inflation-adjusted simulated value from the previous year.

6.2.2.1 “Brilliant™”

Figure 28 presents the NPVs of “Brilliant™” after simulating the cost of feed with interrelated variables. The mean NPV of 49,253 NOK, in 1000 NOK, is practically equal to the estimated static value for fish pen. With an equally upward and downward biased projected annual mean value, the outcome is as expected. The range shows, however, that possible NPVs of 34,227 NOK and 62,833 NOK are possible within a 90 % confidence interval. The PERT distribution illustrates a smaller range of possible NPV outcomes than the distribution of the salmon price simulation. This indicates that the NPV outcomes are less fluctuating when simulating the cost of feed, and/or that the NPV outcome is less affected by this expenditure than the salmon price.

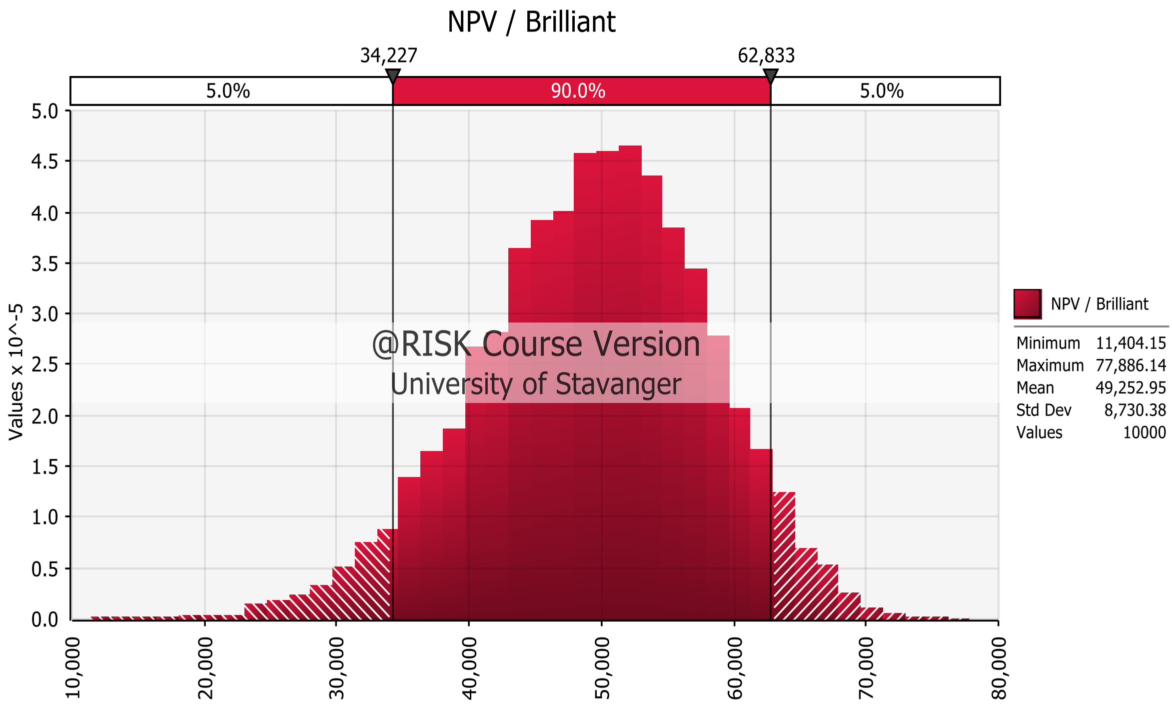

Figure 28: Simulated cost of feed, NPV outcomes for "Brilliant™", in 1000 NOK

6.2.2.2 Conventional pen

The same results from the cost of feed simulation of "Brilliant™" is observed for the conventional pen. Figure 29 illustrates a mean NPV of 17,194 NOK after simulation, which is about equal to the static NPV for the conventional pen. Further, the distribution presents a smaller range of possible NPV outcomes than from the simulation of salmon prices. However, the possible minimum value for the conventional pen is negative, which indicates that the accumulating standard deviations of the cost of feed may result in high expenditures yielding a negative operating revenue and thus net present value of the conventional pen.

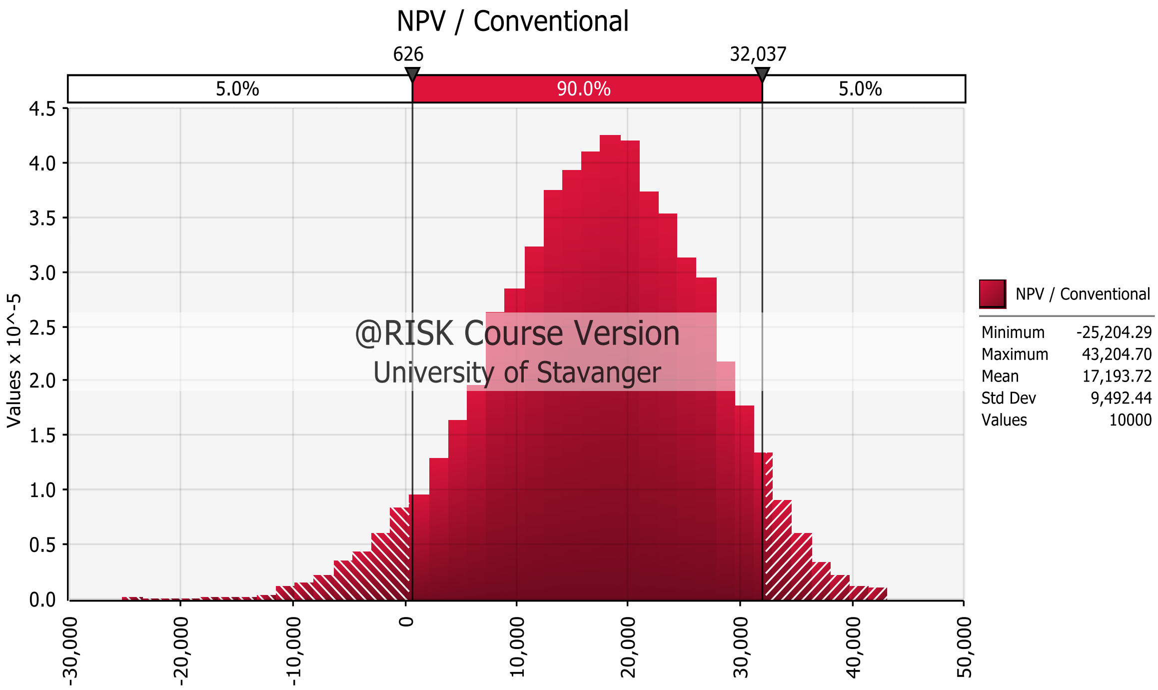

Figure 29: Simulated cost of feed, NPV outcomes for conventional pen, in 1000 NOK

6.2.3 Summary of Monte Carlo simulation

The results of the Monte Carlo simulations may yield better predicted NPVs, as uncertainty has been taken into account. Simulations performed on the salmon prices indicates that, for a projected higher upwards bias than downward on the prices, the NPV of "Brilliant™" and the conventional pen are elevated compared to the NPVs resulting from the static model. The Monte Carlo simulations are therefore thought to be in favor of the valuation of the two fish pens.

Results from simulations of the cost of feed illustrated possible outcomes of NPVs if the costs were projected with equal upward and downward standard deviations. The mean NPVs were equal to the static calculated values for both fish pens, but for the conventional pen, negative values were possible.

All simulation results present a higher expected mean NPV in NOK/kg for "Brilliant™" than the conventional pen.

6.3 Sensitivity analysis

A sensitivity analysis is included in order to look at different scenarios of some uncertain variables and how they may affect the NPV results. For both pens, the price of salmon and the discount rate, or WACC, are considered the most uncertain factors in the calculations, in which also are assumed to have the biggest effect on the valuation outcome. The sales revenue is merely based on the selling price of salmon, at least in the short run. Small changes in the salmon price will therefore have a great impact on the operating revenue, and consequently the NPV. Further can small changes in the discount rate also affect the valuation result, and the difficulty of estimating a correct rate may yield a biased NPV if uncertainty is not taken into account.

"Best case" and "worst case" scenarios on forecasted salmon prices and the estimated WACC are to be analyzed for "Brilliant™" and the conventional pen.

6.3.1 Salmon price scenarios

In the static NPV model, the estimated salmon prices were based on Fish Pool forward prices with assumed flat prices from year 2 and onwards. The flat prices are only adjusted by inflation annually, but the assumption may be very unrealistic. In 2017 and 2018, the historic salmon prices presented annual standard deviations of 15.0 and 13.0 %, respectively. This means that, if following the historic trends, the future salmon prices may be about 14.0 % lower or higher than estimated flat prices. Taking this into account, "best" and "worst" scenarios of the future salmon price and how they impact the NPV are analyzed. A "best case" scenario implies an annual increase of assumed 10.0 % in the salmon prices. A "worst case" scenario, however, will suggest an annual price decrease of 10.0 %. Although an annual price increase of 10 % may seem unlikely, it is not impossible. If the demand for salmon increases considerably and the environmental problems of the aquaculture industry are not solved in the near future, the salmon price may expect high annual growths. On the other side, if the industry were to find solutions to the environmental problems, the future production level of salmon and the supply may increase greatly. If there additionally is a decrease in demand, the price of salmon may decrease annually. Consequently, it is possible that the industry can face different scenarios related to the price of salmon, which will affect the profitability of the suppliers.

The salmon price in year 0 is based on the estimated forward price of 52.90 NOK/kg. We will further analyze how the "best" and "worst" scenarios will impact the NPV output of the two fish pens.

6.3.1.1 "Brilliant™"

The results of the "best" and "worst" case scenarios of the future salmon prices for "Brilliant™" are defined in table 41.

	NPV in 1000 NOK	NPV in NOK/kg
"Best case"	316,526	372.38
"Worst case"	- 126,164	- 148.43

Table 41: NPV outcomes of sensitivity analysis of salmon prices, "Brilliant™"

The best-case scenario presents an NPV of 316,526 thousand NOK, or 372.38 NOK/kg. This value is significantly higher than the outcome of the static model with estimated flat prices. Assuming an annual increase in the price of salmon of 10.0 % will therefore yield an exceptionally high NPV for "Brilliant™", in fact over 6 times higher than the calculated NPV in NOK/kg with flat prices. Oppositely will the worst-case scenario of annually decreasing prices present with a negative calculated NPV. This scenario implies that "Brilliant™" will not be profitable and investment should not be undertaken.

6.3.1.2 Conventional pen

The "best" and "worst" case scenarios for the conventional pen, presented in table 42, also show a highly increased NPV value in the best case, and a negative NPV in the worst case compared to the static model. The "best-case" scenario has an increase of over 12 times the NPV in NOK/kg compared to the static NPV outcome. With assumed decreasing annual salmon prices, the NPV results in a negative value, which is beyond negative than the worst-case NPV for "Brilliant™". This indicates that the conventional pen may be more vulnerable and affected by fluctuating salmon prices.

	NPV in 1000 NOK	NPV in NOK/kg
"Best case"	261,300	339.00
"Worst case"	- 140,142	-181.81

Table 42: NPV outcomes of sensitivity analysis of salmon prices, conventional pen

The “best-case” scenario indicates that for assumed increasing salmon prices, the high difference in NPV of “Brilliant™” and the conventional pen from the static model is evened out. In the static NPV model, “Brilliant™” yielded an NPV in NOK/kg of 2.6 times higher than the conventional pen, or 160 % higher in value. In the “best-case” salmon price scenario, however, the difference was only 9.8 % in favor of “Brilliant™”. This suggests that with assumed increasing salmon prices of 10.0 %, the investment in both pens will be profitable and that there will only be a difference of about 10.0 % in the net present values.

6.3.2 Discount rate scenarios

The WACC used to discount the cash flows and terminal value to present values have a big impact on the NPV result. In this section we will examine how a change in the discount rate may affect the present value of the investment decision and investigate how sensitive the output is to changes. In the static model, a WACC of 11.0 % was estimated as the appropriate discount rate. As discussed in section 5.2.3.4, a discount rate of 10.0 % is argued for when valuing salmon farming companies with existing technology, whereas a rate of over 12.0 % is used for new technology projects within the oil sector. Based on this, we will examine how a one-percent change in the WACC impacts the NPV results for both pens. The “best case” scenario thus implies a discount rate of 10.0 % and the “worst case” scenario will be discounted over a rate of 12.0 %.

6.3.2.1 “Brilliant™”

The result of the net present value calculations under the two scenarios are listed in table 43. The results show that a WACC of 10.0 %, as in the “best case”, increase the NPV in NOK/kg from 57.95 to 67.40. This is a value increase of 16.3 % only caused by a one-percentage point increase in the discount rate. Oppositely, a WACC of 12.0 % will decrease the NPV in

NOK/kg to 50.35. This is a decrease of 13.1 % compared to the outcome of an applied 11.0 % discount rate.

	NPV in 1000 NOK	NPV in NOK/kg
"Best case"	57,287	67.40
"Worst case"	42,798	50.35

Table 43: NPV outcomes of sensitivity analysis of WACC, "Brilliant™"

The sensitivity analysis results suggest that "Brilliant™" is sensitive and affected by a changing discount rate, where only a 1.0 % change in the rate may increase or decrease the present value outcome by over 16.0 % and 13.0 %, respectively. However, both scenario outcomes result in a positive NPV.

6.3.1.2 Conventional pen

Table 44 presents the WACC sensitivity analysis scenarios for the conventional pen.

	NPV in 1000 NOK	NPV in NOK/kg
"Best case"	20,902	27.12
"Worst case"	14,230	18.46

Table 44: NPV outcomes of sensitivity analysis of WACC, conventional pen

The conventional pen is also sensitive to changes in the discount rate. Here, a 1.0 % decrease in the rate results in a 21.5 % increase in the NPV stated in NOK/kg compared to the static outcome. A WACC of 12.0 %, however, changes the NPV in NOK/kg from 22.32 to 18.46. This is a 20.9 % decrease in the NPV. In other words, the conventional pen seems to be more sensitive to changes in the WACC compared to "Brilliant™", where a 1.0 % change in the WACC resulted in an upward or downward change in the NOK/kg value of about 21.0 % from the static model.

6.3.3 Summary of sensitivity analysis

The performed sensitivity analyzes indicates that outcomes and predictions of the future salmon prices are crucial for the investment decisions. In a “worst-case” scenario of annual 10.0 % declining salmon prices, the NPV of the two fish pens is negative, indicating that investments should not be undertaken. In other words, if one assumes that the demand in the salmon farming industry is to decrease significantly, or we will have a great increase in supply, this may impact the salmon price and result in annually declination in the price. Consequently, investments in the industry may not be profitable. However, assuming annual price growths are associated with high NPVs and investment profits. With an estimated annual price increase of 10.0 %, the difference in NPV of the two pens is evened out compared to the static models and both pens will generate high NPVs.

Scenarios with a one-percentage change in the discount rate had the same effect on the two pens. A decrease from the applied static WACC from 11.0 % to 10.0 % increased the value in NOK/kg for both “Brilliant™” and the conventional pen, whereas a WACC of 12.0 % decreased the NPVs compared to the static model.

Conclusively, both sensitivity analyzes proved the conventional pen to be more sensitive to changing salmon prices and a change in the discount rate than “Brilliant™”. This may be positive in “best case” scenarios, where the conventional pen is expected to experience higher growths in NPV than “Brilliant™”. However, “Brilliant™” is to prefer in “worst case” scenarios, where the NPV of this investment alternative will decrease by a less amount than a conventional pen. Nevertheless, “Brilliant™” resulted in higher net present values in all scenarios compared to the conventional pen.

6.4 Alternative NPV assessment

"Brilliant™" is constructed for, but not limited to, salmon farming in exposed sea. It is highly possible and assumed that the innovation and features of the fish pen will benefit the salmon farming facilities in use today, located at the coastal areas of Norway. This means further that "Brilliant™" is not limited to the "Octopus" project, Roxel Aqua and offshore farming. As the NPV calculation results proved that "Brilliant™" has a higher present value and can be considered more profitable than a conventional pen in offshore farming at a new facility, it may also be profitable for competitors to invest in the innovative pen in the future. This alternative NPV assessment is included because it may be interesting to look at the other possibilities of "Brilliant™" and whether or not it can be assessed as a more profitable investment in today's facilities. The following valuation assumes that "Brilliant™" is an existing alternative fish pen on the market, and that cash flows related to the pen can be viewed as in a steady state phase. The alternative approach will then look at the NPV of "Brilliant™" and a conventional pen based on an existing facility in use today. This means that license costs are neglected from this approach, because it is assumed that the investor is an established market supplier of salmon.

The cash flows will be calculated for a total of 8 years, that is from year 0 to year 7. This equals the expected usable lifetime of a conventional pen, which will be set as the investment period. After year 7, the conventional pen is considered useless and the investment is over. Only the residual value of the two pens will consequently represent the terminal value in the calculations.

The submersible pen is assumed to generate the same environmental quantifications and advantages related to this when used in other environments. The advantages result in a higher production level and lower production and operation costs compared to a conventional pen. It is therefore assumed that "Brilliant™" can generate the same cash flows in coastal locations as in exposed sea, and the cash flows for "Brilliant™" in year 0 to 7 in this alternative approach will thus be the same as for the static investment project.

A conventional open pen in use today is constructed for salmon farming at coastal areas. The estimated investment costs for the conventional pen was, for the "Brilliant™" investment project, revised upwards by 20 %. In this alternative approach, the conventional pen will be based on the industry average investment costs based on salmon farming facilities on today's locations, hence not inflated by 20 % as in the original model. The estimated production volume and all costs are, however, expected to be the same.

Because this alternative approach assumes that both "Brilliant™" and the conventional pen are now existing fish pen alternatives to be valued in an established salmon farming facility, a WACC of 10.0 % is applied. This is lower than the originally applied 11.0 % WACC argued for when the technology is new and untried and presents the industry average WACC as reported by Folkvord, B. et al. (2019).

To summarize; the alternative approach looks at the investment in "Brilliant™" versus the conventional pen based on a period equal to the estimated lifetime of the conventional pen of 8 years. Any residual values from investments are considered the terminal value, and the investment costs of the conventional pen are not imposed a 20 % increase. License costs are neglected from the forecasts, and cash flows and residual values are discounted over a WACC of 10.0 %. All other variables are held equal the estimated values of the original NPV model in section 6.1.

6.4.1 "Brilliant™"

The forecasted cash flows and calculated NPV of "Brilliant™" based on the alternative approach are listed in table 45, where all values are stated in 1000 NOK.

Year	0	1	2	3	4	5	6	7
Sales revenue	-	45,365	43,546	44,421	45,305	46,215	47,141	48,076
- COGS	15,661	19,343	20,082	20,859	21,677	22,539	23,446	24,401
Operating revenue	- 15,661	26,022	23,463	23,562	23,628	23,676	23,695	23,675
- OPEX	9,969	10,361	10,778	11,223	11,697	13,926	12,746	13,327
- depreciation	803	803	803	803	803	842	842	842
EBIT	- 26,434	14,857	11,882	11,536	11,127	8,908	10,108	9,506
- 22 % tax	- 5,815	3,269	2,614	2,538	2,448	1,960	2,224	2,091
- CAPEX	7,300	-	-	-	-	2,043	-	-
+ depreciation	803	803	803	803	803	842	842	842
FCFF	- 27,115	12,392	10,071	9,801	9,483	5,747	8,726	8,256
Discounted FCFF	- 27,115	11,265	8,323	7,364	6,477	3,569	4,925	4,237
Discounted RV								1,306
NPV	20,351							

Table 45: Calculated NPV of "Brilliant™" based on alternative approach, in 1000 NOK

The calculated NPV of 20,351 results in an NPV in NOK/kg of 23.94. As the value is positive, assumptions imply that the investment will be profitable and should be accepted.

6.4.2 Conventional pen

Table 46 lists the forecasted cash flows and NPV outcome of the alternative approach for the conventional pen.

Year	0	1	2	3	4	5	6	7
Sales revenue	-	41,138	39,488	40,282	41,084	41,908	42,749	43,596
- COGS	16,590	19,990	20,725	21,495	22,305	23,156	24,051	24,993
Operating revenue	- 16,590	21,147	18,763	18,787	18,779	18,752	18,698	18,604
- OPEX	9,490	9,873	10,282	12,219	11,184	11,682	13,809	12,789
- depreciation	385	385	385	396	396	396	407	407
EBIT	- 26,465	10,888	8,096	6,171	7,199	6,674	4,481	5,408
- 22 % tax	- 5,822	2,395	1,781	1,358	1,584	1,468	986	1,190
- CAPEX	1,869	-	-	467	-	-	467	-
+ depreciation	385	385	385	396	396	396	407	407
FCFF	- 22,127	8,878	6,700	4,743	6,011	5,602	3,436	4,625
Discounted FCFF	- 22,127	8,071	5,537	3,563	4,105	3,478	1,939	2,374
Discounted RV								92
NPV	7,034							

Table 46: Calculated NPV of conventional based on alternative approach, in 1000 NOK

The NPV of the conventional pen is also positive, with a value of 7,034 NOK or 9.13 NOK/kg. This further implies that investing in a conventional pen will yield profit for an investor and that the investment should be undertaken.

6.4.2 Summary of alternative approach

The alternative NPV approach neglected the cost of license and forecasted cash flows over a period of 8 years, instead of assuming that the cash flows would continue until perpetuity. The results exhibited positive net present values for both fish pens, implying that “Brilliant™” and a conventional pen are considered profitable alternatives for farming companies today. However, “Brilliant™” presented a much higher NPV in NOK/kg than the conventional pen and will thus be a better investment.

7. Conclusion

This final section includes a conclusion on the results of the fundamental valuation and analyzes, and on the research question. A discussion of the arguments, methods and conclusion will finalize the thesis.

7.1 Conclusion

The main focus of this thesis was to assess the new technology and innovation of "Brilliant™", and to examine if investing in this alternative fish pen would be profitable and the optimal choice for Roxel Aqua. The research question specified in the introduction was "*Will the investment in new technology of a submersible fish pen be profitable and should the investment be undertaken?".* To find an answer to the question, a fundamental analysis of "Brilliant™" was performed, in addition to a conventional open pen. By assessing "Brilliant™" and comparing the result to the alternative fish pen in use in the industry today, the investment decision can be made on a better basis.

The result of the fundamental valuation proved that "Brilliant™" in fact generated a positive net present value, which indicates that the investment will be profitable. Estimating the variables and forecasting the cash flows used in the calculation was based on a comprehensive strategic analysis of the Norwegian aquaculture industry. However, some estimated variables were considered highly uncertain and assessed in an own section. Selected uncertain variables were simulated under a Monte Carlo simulation, and a sensitivity analysis was included to examine how changes in certain factors influenced the valuation output. In all cases, "Brilliant™" resulted with a higher NPV in NOK/kg than a conventional pen. For expected declining salmon prices of 10.0 %, however, none of the fish pens' net present values were positive and investing in a fish pen would thus not be considered profitable. Furthermore, the submersible, innovative pen proved to be less sensitive to changes in the salmon price or discount rate.

To conclude, the investment in new technology of "Brilliant™" will be profitable for Roxel Aqua, and a better investment alternative than the conventional pen operating in the aquaculture industry today. Hence, the investment in "Brilliant™" should be undertaken. The alternative NPV assessment further suggests that “Brilliant™” may be a profitable investment also for other salmon farming companies that are not operating in exposed sea. The new technology of the submersible fish pen is not only profitable, but the expected benefits of “Brilliant™” may be a solution for the environmental problems of the aquaculture industry. By reducing the incidences of sea lice and infection of diseases and improving the living conditions for the farmed salmon, “Brilliant™” might have what it takes to turn the industry around.

7.2 Discussion

As with most valuation approaches, the net present value model may yield uncertain results. The model is based on numerous assumptions, based on historical trends, analyst predictions and own estimates, and is thus prone to high forecasting errors. Historical trends may say something about future scenarios but cannot be explained as representative for the future. Further will analyst and own assumptions be disposed to deviations, as it is impossible to predict the future. By applying a different valuation model than the net present value model of fundamental valuation, the result could have been different. However, a fundamental valuation based on a comprehensive strategic analysis is still considered the most appropriate model for this thesis, especially when simulations and sensitivity analysis have been included. A discussion of other factors that could yield a different result and conclusion on the valuation is to follow.

First of all, all historical values and production costs extracted from the Directorate of Fisheries are based on the average production of Atlantic salmon and rainbow trout. This may yield biased estimated costs values in relation to the expected, as it is not possible to extract the numbers of rainbow trout from the estimations. Furthermore, the extracted costs are based on today's farming facilities at coastal areas. Salmon farming in exposed sea may therefore yield different values than what is predicted and estimated for the two fish pens in this thesis.

Further, the production costs retrieved from the Directorate of Fisheries' profitability survey, in which most of the estimations in this thesis are based on, are average results presented from companies of the Norwegian aquaculture industry. The Directorate pinpoints that there is a significant spread of reported costs between the companies, fluctuating between – 50.0 % and 30.0 % from the average. Production costs depend mostly on the size and location of the facility. The result of this thesis is thus only based on values from the industry average, where the application of different values could result in a completely different outcome from the valuations.

Macroeconomic factors will always be uncertain. No one knows what will happen in the future, and how future scenarios may impact and interrelate with other factors affecting the industry, a specific company or future investment decisions. A PESTEL is therefore a useful tool applied in the fundamental analysis and valuation, as some uncertain factors can be predicted on a better basis. This can lead to a positive practicality on the investment decision. However, some uncertainty related to factors in a specific industry, here the Norwegian aquaculture industry, may only be reduced in terms of experience and knowledge. For the predicted high uncertainty of the investment costs and component lifetimes of "Brilliant™", other manufacturers in the industry could be inquired with price estimations for the production of the fish pen. This could help reduce the uncertainty linked to the high investment costs of the fish pen.

The cost of equity and debt is based on Roxel Aqua's own estimations, whereas the debt and equity ratios over total capital are simply based on own assumptions. How much of the project or investment is financed by debt may have an impact on the calculated WACC. Furthermore, if the financing plan for the project in relation to debt is differentiating from what is predicted by Roxel, the estimated WACC could be higher or lower. The sensitivity analyzes illustrated how sensitive the NPV results of the two pens were to a 1.0 % change in the WACC.

Another variable that have a great impact on the terminal value, and conclusively the NPV result, is the perpetual growth rate. The perpetual growth rate could have been included in a sensitivity analysis to demonstrate how sensitive the valuation results were to changes in this variable. It is assumed that only a small change in the growth rate can change the NPV by some amount, and that this rate thus is of great importance.

Finally, the estimated project lifetime may yield a different result if the lifetime was not set as perpetual and with a projected terminal value. Another option would be to set the project lifetime equal to the asset lifetime of "Brilliant™" of 15 years. This could be done for the original model and/or the alternative model. The conventional pen would thus have to be reinvested during the 15-year period, in order to make the results comparable in time. The terminal value would then equal the residual value of remaining components. This method could generate a different outcome of the NPV model, although looking at the alternative approach, it is not very likely.

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Appendix

Figure 30 and 31 presents the share of operating costs to total OPEX for “Brilliant™” and the conventional pen, respectively. The shares are based on average costs throughout the development phase from year 0 through 8.

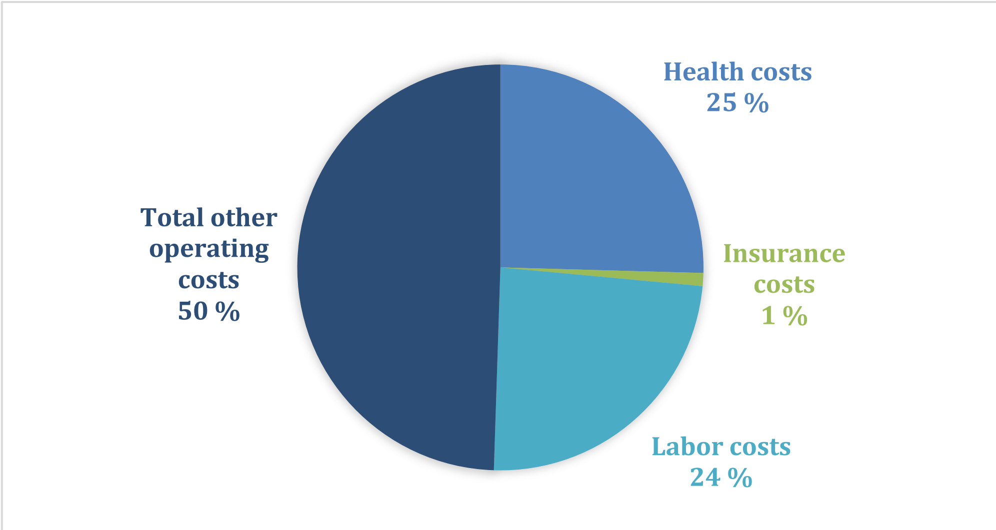

Figure 30: Average OPEX shares of total OPEX for “Brilliant™”

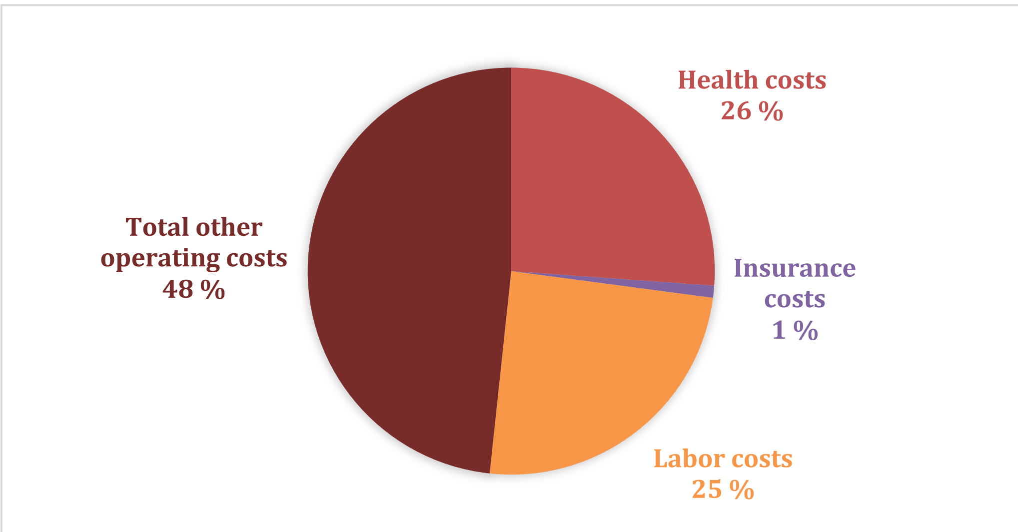

Figure 31: Average OPEX shares of total OPEX for conventional pen

Table 47 and 48 presents the calculation of the cash flows in year 9 and the terminal value in the end of year 8 for “Brilliant™” and the conventional pen, respectively.

Year	8	9
Sales revenue	49,045	
- COGS	25,409	
Operating revenue	23,636	24,108
- OPEX	27,728	14,631
- depreciation	868	960
EBIT	- 4,960	8,517
- 22 % tax	- 1,091	1,874
- CAPEX	1,406	960
+ depreciation	868	960
FCFF	- 4,407	6,644
Discounted FCFF	- 1,912	
TV	73,817	
RV	3,339	
Discounted TV+RV	33,480	

Table 47: Estimated cash flows in year 9 and terminal value for "Brilliant™", in 1000 NOK

Year	8	9
Sales revenue	44,475	
- COGS	25,984	
Operating revenue	18,491	18,861
- OPEX	28,669	14,398
- depreciation	443	460
EBIT	- 10,621	4,003
- 22 % tax	- 2,337	881
- CAPEX	1,965	460
+ depreciation	443	460
FCFF	- 9,806	3,122
Discounted FCFF	- 4,255	
TV	34,694	
RV	1,720	
Discounted TV+RV	15,801	

Table 48: Estimated cash flows in year 9 and terminal value for conventional pen, in 1000 NOK