Norwegian School of Economics

Bergen, Fall 2020

Cracking the hype of land-based salmon farming stocks

Investments in land-based compared to conventional salmon farming stocks

Tuva Einang Prestegard & Irem Havva Tekinöz

Supervisor: Aksel Mjøs

Master thesis, Economics and Business Administration

Major: Financial Economics

NORWEGIAN SCHOOL OF ECONOMICS

Abstract

The purpose of this thesis is to explore the differences in how investors value land-based compared to conventional salmon farming stocks, and how investors' sensitivities vary between the two industries. This study conducts three statistical analyses and a relative valuation, where each of them are supported by a qualitative analysis based on interviews with 28 market participants. Supplementary views are included to further explore how investors value the land-based salmon farming industry.

First, we examine whether there exists significant differences in how fluctuations in salmon price impacts land-based and conventional stocks. Our findings suggest that the salmon price impacts the valuation of conventional stocks significantly more than that of land-based stocks. These findings are supported by market participants, who argues that land-based stock valuations are mostly dependent on the binary outcome of success or no success rather than fundamental factors of profitability, such as the salmon price. Second, we conduct an event study to examine whether there exist a significant difference in the stock price reaction as a result of acute mass mortality events in the two industries. Our findings suggest that investors are significantly more sensitive to events occurring in land-based facilities. Market participants experience this to hold true, as such negative events represents a threat to the overall probability of success for land-based companies, while similar events in conventional salmon farming are seen as "occupational hazard". Thus, investors seem eager to sell its land-based shares quickly when these events occur. Third, we examine whether the price development of land-based salmon farming stocks are better explained by ESG, sustainability or technology indices compared to the seafood or the broader OBX index. Our results indicate that the OBX index best explains the price development for land-based stocks. However, the Seafood index performs poorly when reviewing its explanatory power to land-based stocks. This implies that the valuation of land-based and conventional salmon farming stocks differ substantially. Lastly, we conduct a relative valuation to examine how investors value stocks in both industries. This valuation show that most of the guided volumes from management of land-based companies have already been incorporated in stock valuations, and that, with the current pricing, investors believe in a high probability of success, thus incorporating little risk.

Our findings are however limited by the amount of available data, as well a limited number of listed land-based companies. Hence, we cannot conclude the persistence of our results in the future.

Preface

This thesis was written in the fall of 2020 at Norwegian School of Economics, as a part of our master's degree in Economics and Business Administration, where we both are majoring in Financial Economics. Therefore, it was in our interest to study the subject of investments in land-based salmon farming and contribute to an increased understanding of an emerging industry with limited economic research.

First, we would like to thank our supervisor, Aksel Mjøs, for valuable insight and guidance into econometric methods and feedback throughout the process of writing this thesis. We would also like to thank the Oslo Stock Exchange for their assistance in the data gathering process. Furthermore, we would like to thank our interviewees for taking the time to provide us knowledge about the industry. Without their insights, we would have had a substantially harder time connecting our quantitative analyses with real life and actual implications for the land-based salmon farming industry.

This last semester in Bergen have been different than what we expected due to the ongoing pandemic. However, we would like to thank our friends for priceless memories during our years here at NHH. In addition, we would like to thank our families for the love and support they have provided us throughout these years. We are left with enhanced insight into the entire salmon farming industry, and knowledge about how investors value disruptive technologies.

Bergen, December 2020

Contents

List of figures

List of tables

1. Introduction

Land-based farming of Atlantic salmon offers a unique value proposition, as it avoids the majority of biological and environmental issues related to conventional salmon farming. In addition, a combination of high salmon prices, higher costs to mitigate biological issues, lack of growth opportunities in conventional open-net pens, and a favourable license scheme for land-based initiatives has increased the interest in land-based salmon farming rapidly.

Expected increased market penetration drives investments in technological innovations in land-based production methods (Hardman, Steinberger-Wilckens, & van der Horst, 2013). As such, the volume of investments in land-based stock listed companies in Norways has increased substantially. This is illustrated in figure 1.1 showing the sum of trading volume for the land-based companies in the dark blue columns relative to sum of trading volume in percent of summed market capitalisation in light blue lines.

Atlantic Sapphire acted as a pioneer, being listed at Merkur Market 15th May 2018, and the trading volume for the company has since then increased by 888 percent. Moreover, short and long-term interest rates have, and the financial markets have experienced substantial multiple expansion the past years, forcing investors to take on more risk to achieve the same return. As such, investing in land-based salmon farming companies have proved to be very attractive.

Activity within the land-based industry have also increased substantially, and announced projects have ambitions to produce twice as large volumes as what was reported only one and a half years ago, within 2030 (Laks på Land, 2020b). Our motivation to study the subject of land-based salmon farming stocks is strengthened by the increased interest for land-based salmon farming among investors and the surge in land-based initiatives.

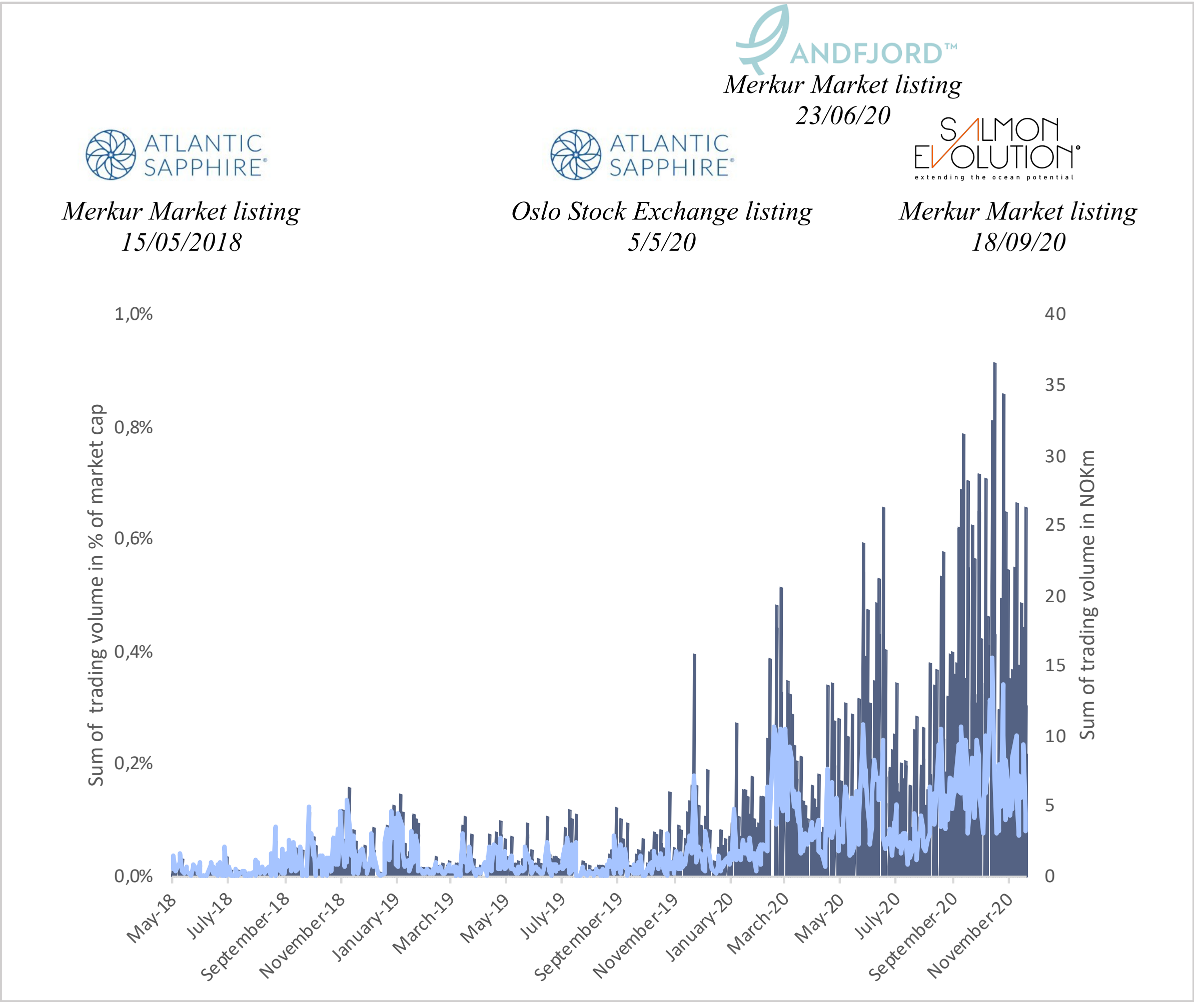


***Figure 1.1**: Sum of trading volume development for land-based companies relative to sum of trading volume in percent of total market capitalisation. Source. DN Investor and Bloomberg (2020)*

However, the majority of land-based companies are in an early phase, with no, or relatively low harvest volumes. The risk of investing in these companies is therefore seen as higher. Unexpected mass mortality events, which e.g. happened at Atlantic Sapphires' facilities in March and July 2020, have shown investors that land-based companies are more vulnerable to technological errors relative to conventional farmers. This is a direct cause of the technological complexity of land-based facilities which will further increase the risk of their biomass assets. To briefly introduce the acute mass mortality events, the event which occurred in March was caused by elevated nitrogen levels in the tanks which instantly culled the fish, while the mortality event in July was triggered by increased stress levels to the fish caused by construction work close to the tanks.

To briefly elaborate, we will provide a short description of the differences in land-based and conventional salmon farming. Production in land-based facilities is done in close containments on land. Land-based producers can choose between recirculating aquaculture (RAS), flow-through or hybrid-flow through systems, as we will elaborate in section 2.6. Conventional salmon farming is conducted in open-net pens where they rear fish in cages in open water. The RAS technology has already been used for production of post-smolt in closed containments in the last 40 years by traditional salmon farmers (Heinsbroek & Kamstra, 1990). The motivation for doing so is to grow smolt big on land before releasing it in sea, hence reducing the time in sea and, similarly, the risk for biological issues. As such, although this technology is not entirely new, the application of the technology on large scale fully out-grown salmon production represents a paradigm in the farming of salmon. Previous experience with the technology can thus provide investors who seek to invest in the land-based industry with a sense of security that the technology works. With this in mind, this thesis will only focus on large scale fully out-grown salmon farming production.

As the land-based companies are still at an early stage, and the industry could be argued to disrupt the traditional way of farming salmon, it is likely that different factors will influence the valuation of the two groups. Studying investors' sensitivities, and how they value land-based compared to conventional salmon farming companies are therefore of great interest in order to understand how investors value a potential disruptive innovation.

In this chapter, we present the motivation and objective of our study, and further our research question and hypotheses. Thereafter, we present previous research on the impact of salmon prices on stock returns, methodology on event study and draw an analogy of land-based salmon farming to Tesla as a disruptive innovation. Finally, we present the outline for this thesis.

1.1 Motivation, objective of the study and research question

This study examines the differences in how investors value land-based compared to conventional salmon farming companies, and how investors' sensitivities vary between the two salmon farming industries. The subject of investments in land-based salmon farming is a relevant topic that many market participants are highly interested in exploring more. We therefore believe this thesis will provide financial participants with reliable and up-to date analyses on land-based salmon farming. Our motivation to study land-based salmon farming is further strengthened by the anaology to the successful development in Tesla, which emphasises the potential value proposition other disruptive innovations, such as land-based salmon farming, holds.

First, our ambition is to explore whether fundamental factors affect the stock price of land-based relative to conventional salmon farming stocks differently. Discounted cash flow (DCF) theory can contribute to explore this at it is method to value companies. A fundamental factor of interest in the salmon farming industry is the underlying salmon price, which determines the profitability of the companies. However, as the land-based companies are still in a build-out phase, with relatively low sales, there may be other factors that determines the value of such stocks.

Second, we want to examine investors sensitivty to investments in land-based salmon farming. According to the efficient market hypothesis proposed by Fama (1970), new information released to the market will be the only driver of changes in stock prices. The occurrence of unexpected mass mortality events at salmon farming facilities will therefore drive the stock prices of these companies down. Observing the differences in investors' sensitivity towards these events in land-based relative to conventional open-net pen facilities, is therefore in our interest.

Thirs, our motivation for writing this thesis is strongly related to the development of Atlantic Sapphire, which is the largest an most progressed salmon farming company listed on the Oslo Stock Exchange. Many investors have noticed the similar trend this stock has had to other ESG, sustainability or technology stocks. One reason for the increased interest for land-based salmon farming is the technology's ability to reduce the biological issues in sea. Land-based players therefore argue that their business model will have a better environmental profile. These aspects acts as our motivation to analyse whether ESG, sustainability or technology indices can explain a large fraction of the variation in land-based stocks.

Throughout the whole thesis, when referring to land-based stocks, we refer to the tradable stocks of Andfjord Salmon, Atlantic Sapphire and Salmon Evolution, being the land-based salmon farming companies listed at the Oslo Stock Exchange at the time of writing. However, since Andfjord Salmon and Salmon Evolution have limited price history, we choose to conduct our statistical analyses on Atlantic Sapphire's stock returns, for which we also elaborate in the data chapter. It is also worth mentioning that among the stock listed players in Norway, only Atlantic Sapphire has harvested salmon, in both its Denmark and US facilities.

The findings in this thesis are limited by the amount of available data; our statistical analyses use eight stocks, of which the only land-based stock has been publicly listed for less than three years. Two more land-based companies have been listed during the process of writing this thesis, Andfjord Salmon and Salmon Evolution, but the restricted track record makes them only eligible for inclusion in our relative analysis. We therefore support our quantitative analyses with semi-structured interviews conducted with investors, financial analysts and industry players. The qualitative insight will act as a supplement for each quantitative analysis and therefore substantiate and guide our conclusions. In addition, a section regarding key topics for the land-based salmon farming industry is provided to express how investors value a disrupting technology within the salmon farming industry, and their willingness to pay.

In this thesis, we aim to provide valuable insight to the following research question:

What are the differences in how investors value land-based relative to conventional salmon farming stocks, and how does investors' sensitivities vary between the two salmon farming industries?

Fundamental factors do not determine the valuation of land-based stocks in the same way as for conventional salmon farming stocks. In addition, investors are more sensitive to investments in an immature industry, such as land-based salmon farming.

We also outline individual hypothesis for each of the three analyses conducted in this thesis:

Hypothesis for the impact of salmon price on stock returns: *The salmon price has a significantly lower impact on land-based relative to conventional salmon farming stock returns.*

Hypothesis for the event study: *Investors react significantly more to acute mass mortality events at land-based facilities relative to conventional open-net pen facilities.*

Hypothesis for the explanatory power of sustainability, ESG and technology indices on land-based stock returns: *ESG, sustainability and/or technology indices have the highest explanatory power on land-based stocks.*

1.2 Literature review

Previous research on the economic attractiveness of land-based salmon farming in Norway has been conducted by Ola Trovatn and Magnus Solheim (2019). However, they were more focused on the valuation of land-based salmon farming companies. Our thesis will differ from theirs by focusing on the differences in valuation and sensitivity between land-based and conventional salmon farming companies. However, to gain a complete picture of land-based salmon farming dynamics, we will recommend reading their thesis prior to reading ours, as we have limited our dynamics chapter in order to focus on the analyses which answer our research question.

Our research question has not been studied before as the interest for land-based salmon farming has increased just in the recent years, which means that there are limited historic data on land-based salmon farming stocks. However, much literature exists on the methodology event studies. Earlier research on the former analysis has, however, not included land-based stocks as the listings in Norway happened after 2018. Finally, we draw an analogy between land-based salmon farming and Tesla as potential disruptive innovations. There are limited examples of disruptive innovations operating side by side with the incumbent industry, but our interviewees highlight that Tesla is often referenced as a comparable disruption to land-based salmon farming. We discuss this further with investment perspectives (section 6.5.4) regarding the future of salmon farming.

1.2.1 The impact of salmon prices on stock returns

Kleven and Løken (2012) examine how changes in the salmon price affects the stock prices of salmon farming companies listed on the Oslo Stock Exchange. Since the study was conducted in 2012, no land-based salmon farming companies are included in their thesis. Kleven and Løken’s findings suggest that there was a positive relationship between changes in the two-month forward prices and the salmon farming stock prices. Furthermore, their findings show that the salmon price, represented by the Fish Pool Index (FPI), had no significant impact on the stocks, except for Lerøy and Marine Harvest. Kleven and Løken use dummy variables to check for shocks in the two-month forward prices and the salmon price (FPI). Their findings suggest that stock prices were relatively less sensitive to price changes when shocks occurred. Although finding significance in the relationship between two-month forward prices and the stock prices, they conclude that the direction of the salmon price do not seem to affect the direction of stock prices.

Our analysis on the impact of salmon prices on salmon farming stocks is inspired by the work of Kleven and Løken (2012), where we test for different forward prices and include dummies for price shocks in order to examine whether there is a significant difference in how the salmon price affects land-based stocks relative to conventional salmon farming stocks. We are aware of being inspired by an earlier master's thesis, which in contrast to research articles has not been through peer review and quality controls. However, as there are limited research articles on this topic we choose to take inspiration from their master's thesis for the methodology.

There have also been done similar studies carried out with other raw materials, such as oil, which will be indicative for a simple salmon price analysis. A widely cited paper by Bjørnland (2009) examines the effects of oil price shocks on stock returns in Norway by highlighting the transmission channels of oil prices for macroeconomic behaviour in the time period ranging from 1986 to 2010. Her findings suggest that a 10 percent increase in oil prices leads to an immediate increase of 2.5 percent of stock returns, after which the effect gradually dies out. Bjørndal's findings show that commodity prices will have a significant influence on stock returns, which motivates us to examine if the same dynamics exist for salmon prices on salmon farming stock returns. In addition, it will be interesting to examine whether the impact is different for land-based stocks. Several of our interviewees emphasised the oil price dynamics analogy to the salmon price analysis, which we discuss in investment perspectives (section 6.1.1).

1.2.2 Event study

Event studies are widely used by finance researchers when they are asked to measure the effect of an event on the value of a security. The key assumption for event studies is that the efficient market hypothesis holds, which states that the stock price reflects all available information, and only new information will cause a change in the price (Bodie, Kane, & Marcus, 2018). There are two approaches to event studies; the traditional residual approach and the event parameter approach. First, the traditional residual approach, as proposed by Fama, Fisher, Jensen, and Roll (1969) when studying the announcement of stock splits, estimates the market model on pre-event data and then use predictions from the event window (Kalchev, 2009). Therefore, this model is run in a two-step approach. The market model is used to estimate the slope and intercepts by using the estimation period. Next, the residuals are calculated as the actual minus the predicted value for each observation in the event window. The residuals represents abnormal returns, where the latter is defined as "return on a stock beyond what would be predicted by market movements alone" (Bodie et al., 2018). However, Karafiath (1988) shows that the event parameter approach will provide identical results by appending a binary variable with the value of zero or one to the right-hand side of the market model regression, as illustrated in equation 1 below with the dummy variable (D_t). This variable thus represents the abnormal returns for the given event. This enables the event study to run with only a single regression for each event compared to the two-step approach. As the event date is different for the companies we include in our event study, the estimation equation is proposed to be estimated separately for each company. The same approach is suggested by Binder (1998), and previously Thompson (1985), whom models abnormal returns for each event separately.

$$R_{it} = a_i + \beta_1 * R_{mt} + \beta_2 D_t + u_{it} \tag{1}$$

We find the event parameter approach to be more suitable and intuitive for our research, and thus make the work from a widely cited paper by Binder (1998), Karafiath (1988), as well as methodology proposed by Wooldridge (2012), as our primary sources when analysing investors' sensitivities to unexpected mass mortality events in land-based facilities compared to conventional open-net pens.

Deciding on an appropriate length for the event window is not easy, as the time for when the market fully incorporates news into the stock price is unknown (Krivin, Patton, Rose, & Tabak, 2003). Hillmer and Yu (1979) assume that some variables have constant distribution in the event window, which differs from the distribution outside the window. Their findings suggest that there is no difference in average price changes within the event window. However, increased variance is found. Hillmer and Yu (1979) also suggest that when the market is still absorbing new information, the variance within the event window should be higher than outside the window for non-news periods.

On the other hand, when departing from the assumption of Hillmer and Yu (1979), Krivin et al. (2003) examine various rules for determining the length of an event window, when analysing data with a limited number of observations. Among others, they argue that it is feasible to measure event windows individually for each event by deciding on an *ad hoc* rule when the sample of companies is relatively small. Unusual low returns or high volatility would be good indicators as to how long the market takes to react. However, a shortcoming of this *ad hoc* methodology is that the two individuals may conclude differently regarding the event window length. When determining an appropriate event window in our event study, we find that the approach of Krivin et al. regarding an *ad hoc* rule makes most sense, and thus, choose this work as our primary source.

1.2.3 Land-based salmon farming as a disruptive innovation

Theory on disruptive innovation was originally published by Christensen (1995). Hardman, Steinberger-Wickens and van der Horst (2013) define disruptive innovation as "innovations that are so different that their establishment in the market causes a disruption to the pre-existing system". Furthermore, they state that innovations are disruptive if they: 1) are produced by different manufactures in the supply chain, 2) require new infrastructure and 3) change the way in which users interact with the technology (Hardman et al., 2013).

The story of Tesla shows that markets with deeply entrenched incumbent technologies can be disrupted by high-end value disruptive innovations (Hardman et al., 2013). Well-known automotive brands sat on the fence prior to Tesla's successful market entry, and did not produce electric vehicles. After Tesla's victorious market entry, those well-known brands turned quickly and began the production of more climate-friendly vehicles. Today, almost every automotive brand produces its own electric vehicles.

Hardman, Steinberger-Wilckens and van der Horst (2015) argue that electric vehicles are shown in the literature to be disruptive, based on the three disruptive technology criteria mentioned. The majority of conventional salmon farming companies do not enter the land-based fully-out grown salmon production industry because production costs are not yet economicaly viable, and the technology is not proven on a large scale. Furthermore, the land-based industry can be considered as an analogy to Tesla's electric vehicles due to their similarities: both can be seen as disruptive innovations, both have high capital expenditures, both reduce environmental issues originally raised in their conventional technology and both seems to be priced higher by investors. In addition, land-based salmon farming is favoured by the Norwegian government by being allocated licences free of charge (Norwegian Ministry of Trade, Industry and Fisheries, 2015), the same for electric vehicle users who do not have to pay taxes. In addition, Tesla operates side by side with other automotive brands, which makes our analogy to the land-based salmon farming industry clearer as this industry may also operate side by side with the conventional salmon farming industry. Therefore, time will show if land-based salmon farming really can be classified as a disruptive innovation, which we discuss in section 6.5.4.

In contrast, Christensen, Raynor and McDonald (2015) state that the term *disruptive innovation* has, over the last 20 years, been abused to describe any situation where an industry experiencea a disruption and previously successful incumbents stumble. Therefore, Downes and Nunes (2017) argue that Tesla cannot qualify under Christensen's (1995) definition of a disruptive innovation yet. In his model, Christensen describes a disruptive innovation as a new entrant that offers substitute products using cheaper technology which are similar to products offered by mature incumbents. Furthermore, Downes and Nunes (2017) state that the technology Tesla offers is neither better or cheaper than internal combustion. However, Tesla's technology reduces the cost incurred on the society, which may make the product they provide both better and cheaper compared to internal combustions, as there is a substantial external cost associated with combustion vehicles. The same argument also holds for the land-based salmon farming industry.

Time will show if land-based salmon farming really can be classified as a disruptive innovation, which we discuss in section 6.5.4. Another classification of land-based stocks may therefore potentially be concept stocks. Hsieh and Walking (2006) defines concept stocks as "stocks with extremely low sales-to-price ratio", thus investors overprice such stocks because they extrapolate high growth rates inappropriately or underestimate the riskiness of the stock. In this thesis, we will focus on both of them, but mainly draw the analogy to disruptive innovations.

1.3 Outline

This thesis will start by providing an introduction to land-based salmon farming dynamics in order to offer the reader with industry-specific knowledge that is necessary for the comprehension of our findings. Within this, we will elaborate on the background for the development of land-based salmon farming. Furthermore, we will provide a sustainability assessment of salmon farming, and thereafter present supply-and-demand trends for Atlantic salmon. In the last section of the dynamics chapter, we will elaborate on the different technologies used in land-based salmon farming. Next, we present the theoretical concepts which forms the basis for the empirical findings. We continue by presenting the data we use in the analyses. This is followed by a presentation of our empirical findings. Within this, we first present findings on whether land-based salmon farming stocks are differently affected by the salmon price compared to conventional salmon farming stocks. Second, we present the event study to examine the differences in investors' sensitivities to unexpected mass mortality events which have happened at land and in sea. Third, we examine whether different ESG, sustainability and technology indices can explain the development of land-based stocks in the recent years. Finally, we present a relative valuation of salmon farming stocks to examine how investors value land-based and conventional salmon farming stocks. All of these analyses is supported with market participants' views, and further their point of view regarding premium pricing of land-raised salmon, production costs, technology and the future of the salmon farming industry. Furthermore, we will discuss limitations affecting our results as well as the robustness of our analyses. Finally, we present suggestions for further research on the topic of investments in land-based salmon farming and provide a comprehensive conclusion.

2. Land-based salmon farming dynamics

Increased demand and limited growth opportunities of Atlantic salmon have resulted in demand growth outpacing supply, which in turn has led to a substantial increase in salmon prices. However, biological and environmental issues has increased the cost base substantially for conventional salmon farming companies, therefore enabling land-based salmon farming to become economically competitive. The profitability of the seafood sector has further become high in the past decade, which indicates a market in need for a higher salmon supply (Holm et al., 2015). Thus, land-based salmon farming offers a unique value proposition to solve the supply-demand challenge in the industry. Figure 2.1 shows the average ratio of EBIT to kg and EBIT margins for a chosen group of conventional Norwegian salmon farmers listed at the Oslo Stock Exchange. Year-on-year growth rate in EBIT to kg from 2015 to 2016 was approximately 135 percent, and in the same time period, the average EBIT margin increased by 10 percentage points. The strong profitability of the stock-listed players is mainly caused by the strong salmon price development (Kontali, 2020a).

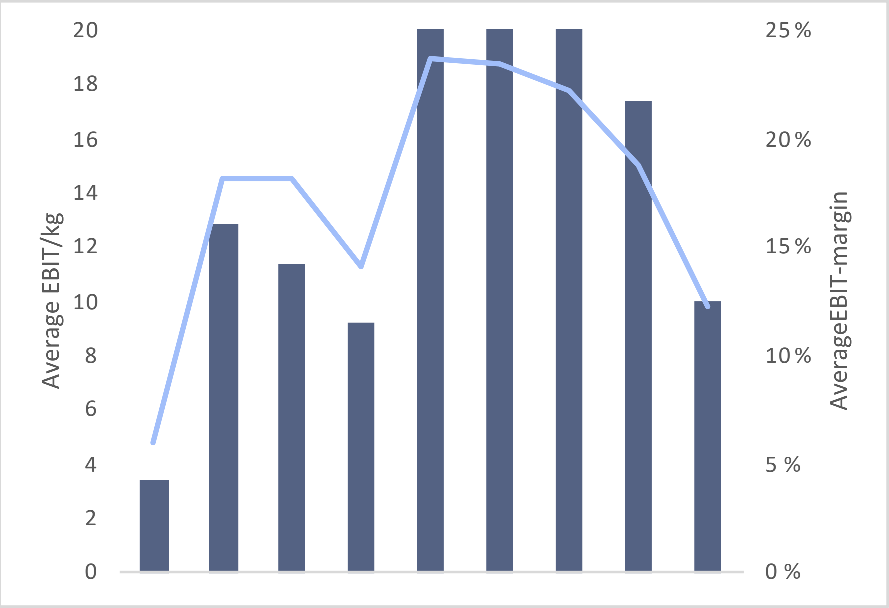


Figure 2.1: *Average EBIT to kg and EBIT margins for Bakkafrost, Mowi, Grieg Seafood, Lerøy Seafood Group, Norway Royal Salmon and SalMar. Source: Company annual reports*

While closed containment systems have been used for production of a limited number of species since the 1980, including post-smolt (Heinsbroek & Kamstra, 1990), developments in technology have led the ability to farm a wider variety of fish, including Atlantic salmon (Liu et al., 2016). However, farming harvestable sizes of Atlantic salmon has not yet been proven in large scale. To briefly illustrate the pros and cons of this emerging industry relative to the conventional one, figure 2.2 illustrates key advantages and disadvantages of land-based and conventional salmon farming.

Advantages

Land-based salmon farming

- Proximity to end-markets*
- Eliminates risk of lice
- Eliminates risk of escape
- Eliminates impact on wildlife
- More control over the production cycle

Conventional salmon farming

- Lower cost levels
- Necessary infrastructure available
- Short lead time

Disadvantages

Land-based salmon farming

- Energy usage
- Density in tanks reducing fish welfare
- Complexity of the technology
- Higher current production costs

Conventional salmon farming

- Biological issues
  - Rising production costs
  - Growth regulations
- Carbon emissions related to freight

Figure 2.2: *Key advantages and disadvantages of land-based compared to conventional salmon farming. *Applies to land-based salmon farming employing the recirculating aquaculture system (RAS).*

2.1 Sustainability assesment of farmed salmon

The Sustainable Development Goals (SDGs) are 17 integrated goals adopted by all United Nations (UN) member states in 2015, as illustrated in figure 2.3. The aim is to send a universal call to action against poverty, protecting the earth and ensure that all people live in peace and prosperity by 2030 (United Nations Development Programme, 2020). Fulfilling these ambitions requires effort by all sectors in society – where businesses play an important role. Responsible aquaculture can directly affect and impact seven of the SDGs: SDG 2 – Zero hunger, SDG 8 – Decent work and economic growth, SDG 9 – Industry, innovation and infrastructure, SDG 12 – Responsible consumption and production, SDG 13 – Climate action, SDG 14 – Life below water and SDG 17 – Partnerships to achieve the goal (Global Salmon

Initative, 2020a). These goals therefore set the basis for a sustainability comparison between land-based and conventional salmon farming, as well as comparison of the entire salmon farming sector to other protein sources.

Figure 2.3: *Sustainable Development Goals (SDGs) by the United Nations. Source: United Nations, 2020*

Farmed salmon is being promoted as a healthy source of protein, with high resource efficiency compared to alternative animal protein sources. For instance, farmed Atlantic salmon yields 28 percent protein retention, compared to 21 percent for pork and 14 percent for beef (Global Salmon Initative, 2020a). Protein retention is defined as gain in edible protein as a percent of the protein intake from food. Moreover, farmed salmon has a favourable feed conversion ratio (FCR), which is the amount of kg feed needed to grow the body weight of the animal by one kg. For instance, a feed conversion ratio of five would mean that for every five kg feed, the fish gains one kg of weight (Global Salmon Initiative, 2020b). The feed conversion ratio is estimated to be 1.25 for Atlantic salmon, compared to 3.85 for pork and 8 for beef (Global Salmon Initative, 2020a). Salmon farming also offers a lower carbon footprint (0.6 CO_2/40g serving) compared to other protein sources such as pork (1.3g CO_2/40g serving) and beef (5.9 CO_2/40g serving), and the water consumption is also less than in chicken, pork and beef production. Thus, salmon farming is seen as having a low environmental impact and greenhouse gas profile, therefore offering a more climate-friendly protein source compared to other animal protein sources.

Turning to the sustainability differences between land-based and conventional salmon farming, one major concern in open-net pens has been the challenge of increasing biological issues. This has led to an increasing interest in land-based salmon farming, as this way of producing salmon eliminates biological issues challenging the conventional industry, where treatment costs have increased substantially in the past years. Among these, sea lice and fish escapes are major issues, as well as the utilisation of sludge in sea. Land-based salmon farming offers increased control of the production environment in terms of temperature, light, predators, waterborne disease transmission (Holm et al., 2015). However, the benefit of these advantages must be measured against higher capital expenditures required to build a land-based facility, as well as costs associated with controlling the fish's environment. In terms of risk to the environment, it is reasonable to assume that land-based salmon farming will be able to contribute to reducing the impact on the aquaculture, for instance the negative impact on wild salmon and shrimp fields (Bjørndal et al., 2018). This is partly due to stricter purification requirements of land-based facilities relative to conventional open-net pen facilities. Risk of escape is also eliminated compared to traditional salmon farming in open-net pens as the salmon stays in closed containments. Lastly, the RAS technology has an advantage as it can be located closer to end-markets, and thus eliminate the freight cost and reduce the carbon footprint of transportation between production areas and consumers. Therefore, land-based salmon may appeal to consumers and investors who value the elimination of antibiotics and escapes, as well as the reduced impact on wildlife and reduced carbon footprint when facilities are located close to end-markets. Section 6.5.1 will discuss market participants' views on these benefits and challenges for land-based salmon farming, and further investigate whether land-raised salmon can justify a premium pricing due to the environmental factors mentioned above, as well as quality factors.

Conversely, in relation to the carbon footprint, a report conducted by NTNU in cooperation with Sintef Ocean and SNF conclude that land-based salmon farming production will have a carbon footprint that is 28 percent higher than what generated by salmon farming production in open-net pens (Bjørndal, Holte, Hilmarsen, & Tusvik, 2018). Their findings are dependent on several assumptions, particularly the economic feed conversion ratio, which is favourably assumed to be 1.15 for salmon farmed on land compared to 1.25 in open-net pens. Yet it is important to note that there are large variations in the economic feed conversion ratio in the Norwegian aquaculture industry and that these estimates are based on an average for all conventional and land-based companies. Other assumptions relate to the energy grid mix between renewable and non-renewable energy, and the fact that land-based salmon farming is still in an early phase.

However, as previously emphasised, a key advantage of land-based salmon production is the ability to locate farming facilities close to end-markets, therefore reducing transportation costs and potentially the carbon footprint as well. Liu et al. (2016) study the difference in carbon footprint between land-based RAS production in the US with open-net pen production in Norway. The carbon footprint findings illustrated in table 1 calculate the carbon footprint using the life cycle assessment methodology in four different scenarios. The air-freight advantage becomes apparent as the carbon footprint for the RAS technology located in the US is lower (7.40 CO_2 eq. per kg) compared to salmon farming in open-net pens in Norway (15.22 CO_2 eq. per kg). This is evident even when the electricity grid mix is from fossil fuels. On the flip side, if the RAS technology is located in Norway, the calculations imply a higher carbon footprint (7 CO_2 eq. per kg) compared to farming in open-net pens (3.39 CO_2 eq. per kg). Thus, a favourable carbon footprint is highly dependent on the location of the land-based facilities and the transmissions connected to transportation. We will see later in this thesis that the flexibility differences of land-based facilities also differs between the land-based technologies, which in turn will make the carbon footprint differ between the technologies.

Table 1: *Estimated carbon footprint of RAS- and open-net pen facilities at producer gate and retailer gate. Source: Liu et al. 2016*

CO_2 eq. per kg	**1a)**	**1b)**	**2a)**	**2b)**
Feed production	2.69	2.69	3.21	3.21
Construction of facility and equipment	0.39	0.39	0.02	0.02
Grow out and smolt (fuel and electricity)	3.48	0.21	0.16	0.16
Oxygen and lime	0.44	0.44	0.00	0.00
At producer gate (live weight)	**7.00**	**3.73**	**3.39**	**3.39**
Transport, road	0.03	0.03	0.06	0.06
Transport, air or water	0.00	0.00	11.40	0.09
Packaging and ice	0.37	0.37	0.37	0.11
Refrigeration during transport	0.00	0.00	0.00	0.10
At retailer gate (HOG)	**7.40**	**4.13**	**15.22**	**3.75**

1a) Salmon from a RAS system in the US running on a typical electricity mix of coal, gas, nuclear, wind and hydropower
1b) Salmon from a RAS system in the US running on electricity generated predominantly from hydropower
2a) Salmon from a Norwegian open-net pen system transported by airfreight to Seattle in the US
2b) Salmon from Norwegian open-net pen. system transported frozen by ship to Seattle in the US

2.2 Salmon supply

One important driver that has enabled operations on land has been the biological issues in sea that has limited the growth potential for conventional salmon farmers (Kontali, 2020b). Supply of Atlantic salmon, measured in whole fish equivalent (WFE) tonnes, has increased by 77 percent in the time period between 2010 and 2019, with a compounded annual growth rate (CAGR) of seven percent in the same time period (Kontali referred to in Mowi ASA, 2019). However, due to biological boundaries such as sea lice, diseases and escapes, annual growth rate fell to six percent in the time period from 2010 to 2020 (Kontali, 2020b). Moreover, Kontali's (2020b) expectations for further growth until 2030 is tightened to an annual growth rate of three percent, excluding the consideration of supplementary supply from land-based initiatives. The background for the decreasing trend in salmon supply is the increasing regulations which attempt to mitigate the environmental concerns and biological challenges by restricting capacity utilization of conventional salmon farmers maximum allowed biomass (MAB) licenses. Figure 2.4 illustrates historical and expected salmon supply for conventional salmon farming.

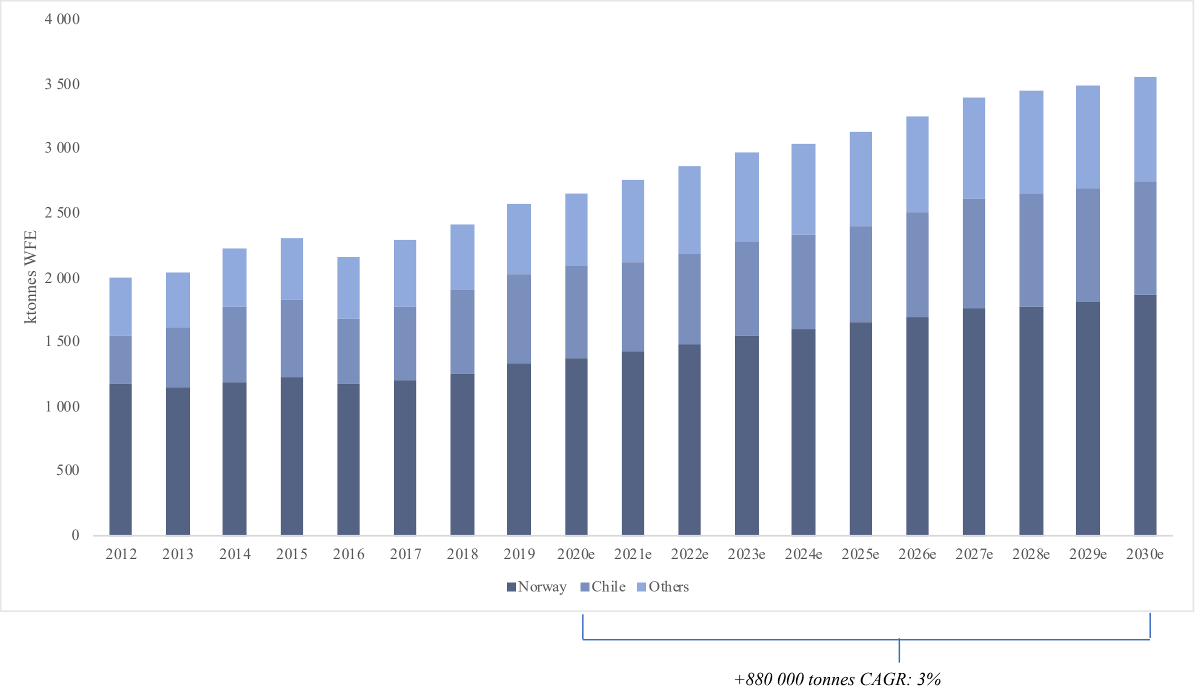


Figure 2.4: *Historical and estimated supply of Atlantic Salmon excluded supply from land-based initiatives. Source: Kontali (2020b)*

2.3 Salmon demand

The global population is growing, and is expected to grow to almost 10 billion by 2050 (Mowi ASA, 2019). This means that a profound change in the global food system is needed to nourish this growing population. According to Global Salmon Initiative (2020a), demand for food is expected to increase by 50 percent, and demand for animal-based foods by nearly 70 percent.

Furthermore, there has been a major increase in consumption of farmed salmon in the past decade, and a key driver to this increase is the changing consumer behaviours. Among these, increased health focus, a growing middle class, an aging population, as well as increased focus on climate change and resource efficiency have driven demand (Mowi ASA, 2019). As Atlantic salmon is a healthy, resource-efficient and climate-friendly protein source, compared to other animal protein sources, salmon seems to be a good fit for these global macro trends.

As people has become more health conscious, this has shifted behaviour towards consumption of nutritious protein sources, such as farmed salmon (Mowi ASA, 2019). In addition, the increase in number of obesity and lifestyle diseases could also contribute to this increased consumption. Lastly, the increasing aging population also drives this demand shift.

Consumption of premium food products, such as farmed salmon, is strongly linked to the wealth of consumers. Indexed GDP per capita in emerging markets has increased by 205 percent from 2004 to 2019, which shows that financial wealth has increased in emerging markets (Atlantic Sapphire, 2020). Thus, a growing middle class in large emerging markets is likely to be more attracted by premium nutritious protein rich foods, for instance fish, meat and eggs (Mowi ASA, 2019). Therefore, consumption of high-quality proteins is expected to increase going forward. In addition, emerging markets such as China, have been a very small market for the salmon industry. As this market becomes increasingly interested in salmon consumption, the potential for penetration is viewed as high. This is reflected in The Norwegian Seafood Council's expectations that Chinese salmon consumption will increase from 90,000 tonnes in 2017, to 240,000 tonnes in 2025 (E24, 2019).

Lastly, climate change is also a driver for the positive shift in salmon demand. Today, the world is faced with its greatest environmental challenge, and food production is in danger due to the risk of soil erosion (Mowi ASA, 2019). These concerns, regarding climate change, are influencing peoples dietary choices and as Atlantic salmon is seen as a resource efficient source to animal protein, people shift their consumption towards salmon.

2.4 Norwegian salmon farming regulatory framework

This section will briefly explain the regulatory regime for salmon farming in Norway, focusing on the traffic light system and licenses. A thesis written by Ola Trovatn and Magnus Solheim (2019) describes this section very well, including the historical development in regulations. In our thesis, we will only focus on the regulations that exist today in order to understand the reason why there are limited growth opportunities in sea. We also attempt to present the government's intention behind these strict regulations, as this is a major factor for the increase in land-based initiatives.

Production capacity stands for the upper limit for the amount of biomass a farmer can have in its cages in sea at a given point in time (Norwegian Ministry of Trade, Industry and Fisheries, 2020). The capacity is determined by the number of licenses and the limitation of these, measured in MAB.

2.4.1 The traffic light system

The traffic light system was implemented in 2017 and divides Norway into 13 production areas. The intention behind the new system is to implement growth regulations to provide a more sustainable aquaculture. An estimate of salmon lice impact on wild salmon, acts as the sole indicator for the green, yellow or red light that each production site receives for maximal allowed biomass (MAB) (Osmundsen, Olsen, & Thorvaldsen, 2020). Green, yellow and red light stands for acceptable, moderately and negative environmental impact respectively. Dependent on the light a production zone receives, farmers within that zone can be offered up to six percent increase, or told to reduce the biomass by six percent, in MAB, every second year. Yellow light indicates unchanged capacity (Norwegian Ministry of Trade, Industry and Fisheries, 2018).

2.4.2 Licences in land-based salmon farming industry

While the conventional salmon farming companies has to buy licenses through government auctions, land-based salmon farming companies receives allocated licenses continuously and free of charge (Norwegian Ministry of Trade, Industry and Fisheries, 2015). The government require conventional actors to pay for licences as the payment provides compensation for allowing a conventional farmer to displace the right of public access for a given aquaculture area. Thus, there is no reason to claim a fee from land-based players, as the areas the industry exploit are private properties, and usually disused industrial areas. In addition, land-based salmon farming is offered poorer framework conditions compared to traditional aquaculture, because the latter pay for the property where they operate, and pay the government a fee for a permission to farm salmon and trout.

Furthermore, the Norwegian industry relies heavily on the seafood industry, because fish export stands for the third largest export industry in Norway as of 2019 (Statistics Norway, 2019). Innovation will therefore be very important in order to maintain the competitive advantage. The Norwegian Ministry of Trade, Industry and Fisheries (2015) believe that land-based salmon farming will be able to provide the Norwegian supplier industry a competitive advantage if the Norwegian government facilitates for innovation in Norway. Thus, a fee for licenses in the land-based industry is seen as a barrier for profitability and competitiveness. Moreover, lack of facilitation for land-based salmon farming will mean a lost opportunity for Norwegian businesses. However, the Minister of Fisheries, Odd Emil Ingebrigtsen, does not exclude that land-based salmon farmers has to pay a fee for licenses in the future (Laks på Land, 2020a).

2.5 Planned production capacity of land-based projects

Today, there are more than 85 land-based salmon farming projects, whereas 30 of the facilities are going to be located in Norway (Laks på Land, 2020b). In sum, these projects have ambitions to produce 1.7 million WFE tonnes of salmon annually within 2030, which represents 66 percent of global salmon supply in 2019. This is twice as large volumes as what ras reported only one and a half years ago, which shows the big increase in land-based initiatives. However, development of projects is time consuming, and Kontali (2020b) expects that only 29 percent of the planned capacity will be realised by 2030. They also state that with establishment of land-based facilities, a significant phase concerns production planning, engineering and approval, which is the phase in which more than 80-95 percent of the current projects are in, as seen from figure 2.5. Kontali further expects that it will take 3-4 years for the salmon to find its customers after the first release of salmon. To put this in perspective, only 3-4 percent of the announced projects have done their first release, which shows that it may be unrealistic for the companies to achieve their planned capacity by 2030. Thus, it will take time before the market incorporate this increase in volumes. The map, in figure 2.6, illustrates a selection of the planned capacity globally. A comprehensive list of the 85 projects announced as of September 2020 is to be found in appendix.

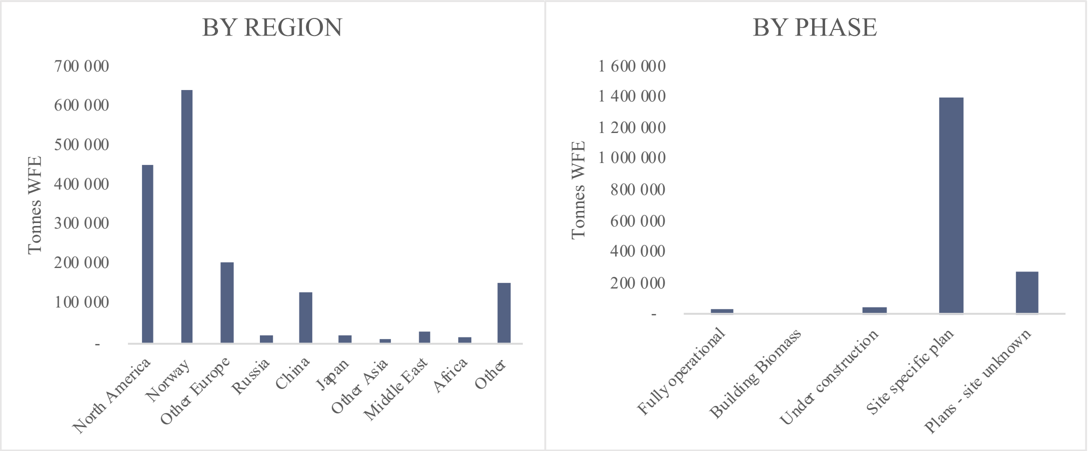


Figure 2.5: *Planned production capacity by region and phase. Source: Left – Laks på Land (2020) Right – Kontali (2020b).*

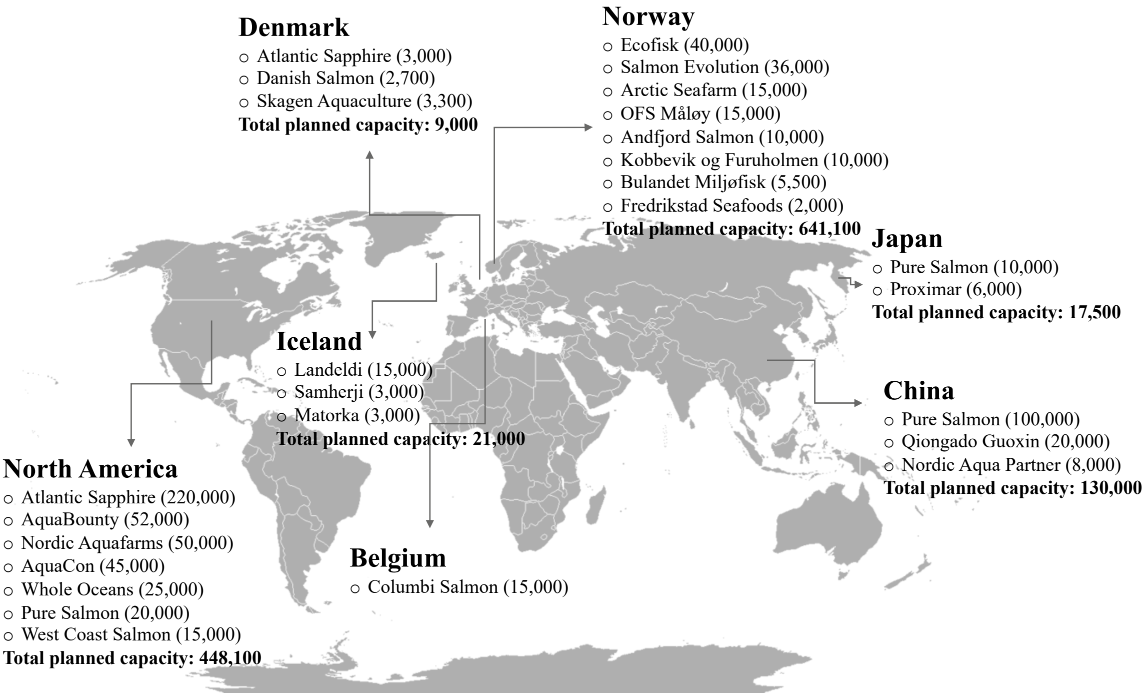


Figure 2.6: *Planned production capacity for selected land-based salmon farming players globally. Source: Laks på Land (2020b)*

If assuming that all planned land-based capacity will be realised within 10 years, land-based produced salmon would amount to one-third of all Atlantic salmon production in 2030 (Kontali, 2020a). This equals an annual growth rate of 7 percent for the whole sector, and an additional 2.6 million WFE tonnes supply. Although Kontali (2020b) believes the contribution from land-based projects will be significant for the supply side, it still expects a more moderate supply growth of 3 percent annually.

2.6 Land-based salmon farming technologies

In this section, we will present the three different technologies used in the land-based salmon farming industry. To briefly introduce, the RAS technology recirculate most of the water in the closed containment tanks by carrying out several cleaning treatments on the water with biological filters. The degree of water reuse depends on the scope of water treatment, but a recirculation rate of 95-99 percent is common (Aarhus referred to in Holm et al., 2015). Second, the flow-through technology pumps out water from a fresh water intake and circulate it through the fish tanks, where it is only used once before it is disposed, which reduces the recirculation rate to zero and eliminates the need for biological filters (Bjørndal et al., 2018). Lastly, the hybrid flow-through system has a recirculation rate of 30-70 percent, and this technology has enough fresh water intake to avoid the need of biofilter.

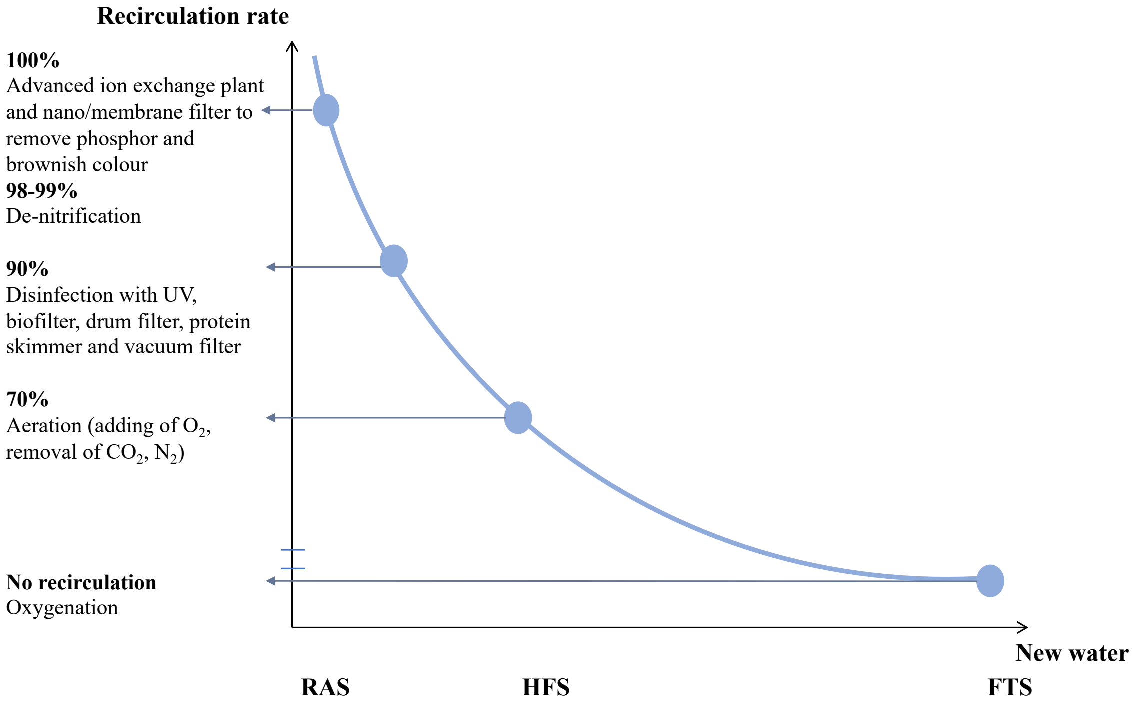


Figure 2.7: *Complexity as a function of recirculation rate. Source: Billund Aquaculture Services A/S (2010) and Salmon Evolution, (2020)*

Figure 2.7 show the complexity of the three mentioned land-based technologies as a function of the recirculation rate. RAS technology is here seen as the most complex technology, as it has a higher recirculation rate and makes use of biological filters. On the other hand, the complexity is substantially reduced for flow-through and hybrid flow-through systems as these technologies does not use biological filters. Still, as the hybrid flow-through technology recirculates more of the water compared to the flow-through technology, it is viewed as more complex.

2.6.1 Recirculating aquaculture systems (RAS)

Recirculating aquaculture systems (RAS) technology has experienced considerable development in the past 20 years. The water treatment process use mechanical particle removers and biological filters containing bacteria to eliminate, transform and defuse the water before removing carbon dioxide, provide the fish with oxygen, and remove waste and pathogens by disinfecting the water (Holm et al., 2015). Thus, the water is being filtrated and oxygenated before reuse. In the RAS-technology, the need for water is calculated as a function of feed consumption, which depends on the fish's metabolism and the size and type of biological treatment the facility is designed for. In line with this calculation, a report led by NTNU in cooperation with Sintef Ocean and SNF finds that RAS facilities requires between 300-500 litres of water per kg of feed per day, in order to filtrate the water properly (Bjørndal et al., 2018). The water is also added salinity and the pH-level is adjusted. The majority of the RAS facilities use a salinity degree of 12-14 percent, while selected producers use freshwater where they add 2-3 percent seawater.

One important argument which favours the RAS technology, is the opportunity to locate facilities close to end-markets, which eliminates the transportation cost and reduces the carbon footprint (Bjørndal et al., 2018). In addition, RAS-facilities with 99 percent recirculation rates also has the ability to be located inland, because the need for new water intake is limited.

As mentioned, high recirculation rate compared to flow-through systems makes RAS more complex and increases operational risk. Yet, compared to flow-through technology, RAS facilities reduce the need for external water significantly, and offer increased control over different production parameters, thus increasing the bio-security. On the other hand, RAS facilities require more space for the water treatment part compared to a flow-through facilities, especially due to the need for a biofilter. The fish thrive best and grow faster in stable temperatures around 12-13 degrees Celsius, and the low water intake makes it economically viable to hold temperatures stable at these levels. Lastly, high recirculation rates increase the energy consumption; The report led by NTNU in cooperation with Sintef Ocean and SNF calculate this to amount to between 6-9kWh/kg fish produced, where conventional salmon farming industry is expected to have substantially lower energy consumption, closer to zero (Bjørndal et al., 2018).

2.6.2 Flow-through systems (FTS)

Flow-through systems is based on pumping water from a fresh water intake and circulating it through the fish tanks, where it is only used once before it is disposed (Bjørndal et al., 2018). This technology does not recirculate any of the water, and the technology does therefore not use biofilters. Consequently, the complexity and operational risk of flow-through systems compared to RAS-technology is reduced, as illustrated in figure 2.7 above. However, reduced grade of recirculation and no biofilters may increase the risk of inconvenient biological particles coming into the closed containments through the water, as we elaborate later in the risk section 2.7. For instance, flow-through is the preferred technology for Andfjord Salmon. They are pumping up water under the lice belt from a depth of 30 and 160 metres, depending on the season, to eliminate the risk of sea lice and other biological particles (Andfjord Salmon, 2020). Even though this will reduce the risk of biological issues substantially, there is no guarantee that lice and algae’s will not find its way into the tanks.

As flow-through systems treat the water minimally, by only adding oxygen, their energy consumption is marginally reduced compared to the RAS technology with approximately 22 percent. On the other hand, as the flow-through solution requires continuous new water intake, these facilities need substantially more energy for temperature control. Thus, it is not economically viable for the flow-through facilities to control temperatures for optimal growth. The high water amounts water used in flow-through facilities also limits the flexibility in terms of location (Bjørndal et al., 2018). Flow-through facilities must therefore be located close to the shore with good access to fresh seawater.

Lastly, the complexity of the hybrid flow-through technology lies somewhere in between RAS and flow-through systems, depending on the recirculation rate. In the water treatment process for this hybrid flow-through system, the water is added oxygen and CO_2 is removed. Furthermore, this technology requires less pumping of water, which reduces the energy consumption (Salmon Evolution, 2020a). Lastly, as the recirculation rate is higher than for flow-through technologies, hybrid flow-through-facilities are more flexible in terms of location, and it also makes it economically viable to regulate the water temperature.

2.6.3 Comparison of production costs

In this section, we will briefly compare land-based and conventional salmon farming production costs. This is used as the basis for the discussion with views from investors, financial analysts and industrial players in section 6.5.2. Production costs at conventional salmon farming companies have trended upwards in the recent years. This is due to factors such as feed costs, biological costs and increased regulatory regime (Mowi ASA, 2019). Figure 2.8 illustrates the development of production costs, measured in WFE, from 2010 to 2019.

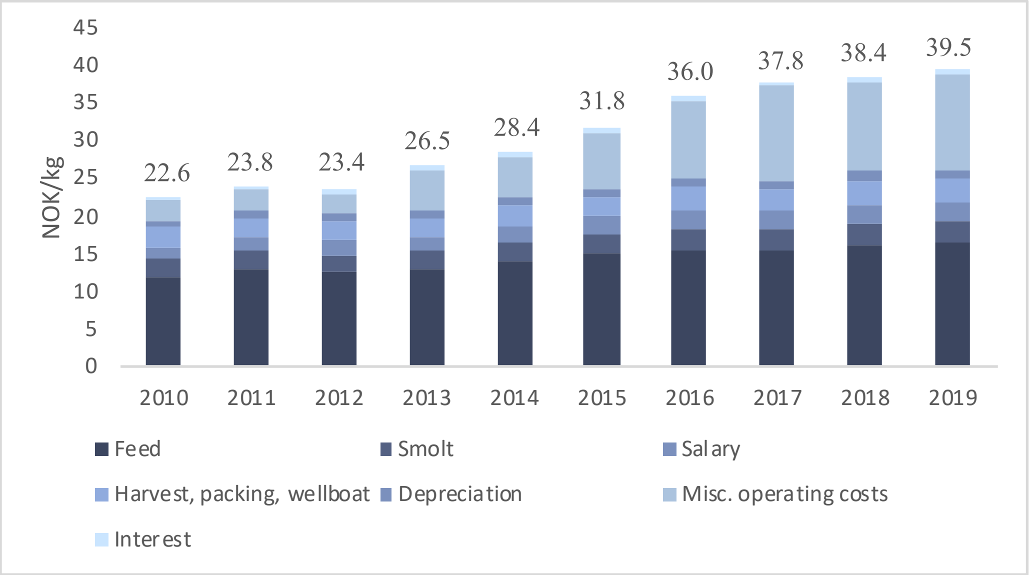


Figure 2.8: *Conventional salmon farming cost breakdown in NOK/kg (WFE) from 2010 to 2019. Source: Kontali and Nofima. referred to in Mowi ASA, 2019*

Furthermore, table 2 below illustrates cost estimates for conventional open-net pens, as well as RAS, flow-through and hybrid flow-through technologies. Production costs for conventional open-net pens are estimated by Kontali and Nofima, presented by Mowi (2019). Estimates for the RAS technology are gathered by Nordea Markets (2020), and supported by a report led by NTNU in cooperation with research institutes Sintef Ocean and SNF. which estimates a production cost of 43.60 NOK/kg, measured in WFE, for fully out-grown production at RAS facilities (Bjørndal et al., 2018). In comparison, Atlantic Sapphire guided with a production cost of 32.4 NOK/kg, measured in WFE, in 2023 for US landed production, in its company presentation in April 2018 (Atlantic Sapphire, 2018). This is substantially lower than Nordea Markets and the report conducted by NTNU with Sintef Ocean and SNF's estimates. However, it seems as if the energy cost is not included in Atlantic Sapphire's guiding. Furthermore, estimates for flow-through and hybrid flow-through technologies are based on company estimates from Andfjord Salmon and Salmon Evolution, for their assumed full capacity production. Thus, these company estimates are subject to a lot of doubt and could be highly optimistic due to subjectivity and uncertainty. As the example with Atlantic Sapphire, that guides with costs far below research estimates, indicates that one should view these estimates as purely indicative. We can now move on to compare costs between the technologies and with conventional salmon farming because assuming full capacity provides us with a correct basis for comparison.

Table 2: *Comparison of production costs. Source: Nofima, Nordea Markets, Atlantic Sapphire, Andfjord Salmon and Salmon Evolution (2020)*

NOK/kg	**Conventional open net-pen**	**RAS**	**Flow-through**	**Hybrid flow-through**
Smolt	2.9	4.3	5.5	-
Feed	16.4	15.8	15.7	-
Lice treatment	3.62*	0.0	0.0	-
Salaries	2.5	2.0	1.3	-
Electricity	0.0	5.6	1.0	-
Other costs	9.1	4.9	2.4	-
Depreciation	1.1	8.4	2.2	-
Financial costs	0.9	2.0	-	-
Slaughter incl. freight and packing	3.0	1.0	6.1	-
Production cost/kg (WFE)	**39.5**	**43.9**	**34.2**	**32.5**
Production cost/kg (HOG)	**43.9**	**48.8**	**38**	**36.1**
Transportation from facility to New York**	**15.0**	**3***	**15**	**15**
Cost per kg (HOG) delivered in New York	**58.9**	**51.8**	**53**	**51.1**
****Nofima estimates***				
*****If located in Florida***				

Focusing on production cost/kg, measured in WFE, we see that the RAS technology, due to its complexity, comes out as the most expensive technology for farming salmon (43.9 NOK/kg). Conventional salmon farming is therefore, measured in WFE, more attractive compared to RAS. However, if the RAS facility is located close to end-markets, and we assume a transportation cost of 15 NOK/kg to the US, this will reduce the production cost/kg substantially after delivery, compared to the other technologies. As 75 percent of the salmon produced in Norway are exported to the EU (Steinset, 2020), the reduction of transportation cost may be seen as minimal. On the other hand, we see that the flow-through technology estimates a lower production cost/kg measured in WFE compared to the RAS and the hybrid solution. This is mainly due to lower energy consumption and lower capex, which reduces the amount of depreciation. To sum up, based on companies' own estimates, we see that the flow-through system is expected to provide the lowest production costs/kg. However, as mentioned earlier, it is important to be critical of these estimates as they are made for commercial purposes and are consequently not entirely objective. In addition, it must be noted that the cost estimate for conventional open-net pens is an average estimate for all operating sites, meaning that the most efficient producers can operate with a substantially lower cost.

Comparing breakdowns illustrated in table 2 shows that land-based technologies benefit from having zero expected lice treatment costs. On the other hand, energy costs are significantly higher for all land-based technologies, especially for the RAS technology, as substantial amounts of energy is used for temperature control, pumping of water, filtering etc. Thus, the variation in the energy costs will be a considerable driver for the production cost. Finally, the technological risks, which we address in section 2.7, may have an impact on the mortality rate for salmon raised in land-based facilities. Although the mortality from lice, algal bloom and other diseases are diminished on land, the technological risks may still have material impact on the mortality rate for salmon raised on land. If so, production costs will be substantially affected by this.

Furthermore, as observed in table 2, feed is a substantial part of the production cost for all production technologies; however, it seems to be less for the land-based technologies. This is due to a lower feed conversion ratio expected for land-based technologies, as the technology offers increased control of the closed production environment. Moreover, the feed conversion ratio can be calculated both as a biologic and economic feed conversion ratio (Misund, 2019). Biologic feed conversion ratio relates to the amount of feed used per kg fish, while the economic feed conversion ratio relates to the amount of feed used per kg slaughtered fish. As the biomass is reduced after slaughtering, the economic feed conversion ratio will be higher than the biologic one. In addition, if mortality or escape incidents occur, this will also negatively affect the economic feed conversion rate.

To sum up, electricity, treatment, feed and freight costs are the main costs that determines the difference in production efficiency, of EBIT/kg, between the production technologies. Among these, the freight cost is the most substantial contributor to the differences between the production methods. This cost will be determined by the localisation of the facility relative to the end-markets.

2.7 Risks in land-based salmon farming

As the majority of the land-based initiatives are in an early-phase, with expected harvest coming in the next couple of years, the industry faces several risk factors. The majority of the companies today have no revenues, but high capital expenditures. Therefore, securing funding for future capital expenditures and growth, is crucial (Salmon Evolution, 2020a). The risk is related to whether the companies can get enough funding from investors as well as the cost of funding, which depends on the attractiveness of land-based projects. Events with negative outcome, for example acute mass mortality of salmon or technological errors, can affect the attractiveness and reputation of those companies and further narrow the capital markets' willingness to invest. Moreover, such events may also affect the perceived risk of land-based companies, and further increase cost of funding as investors require higher return on more risky investments.

Furthermore, the technological risk is seen as higher in the land-based compared to the conventional industry, which reasonably relates to the immaturity of the technology and the fact that it is not yet proven successful on large scale salmon production. Therefore, companies operating within the land-based industry are more vulnerable to technological errors relative to the conventional salmon farming industry and, further, how these errors affects the operations (Salmon Evolution, 2020a). In addition, significant errors in the technology could damage the production and biomass, which is seen as the most valuable asset. This would have a negative impact on future profitability and cash flows. Thus, technological risk relates to keeping the fish healthy and alive until they have grown to an economically attractive size in order to farm consistent and tasty salmon for the consumers (Nordea Markets, 2020). However, the technological risk will arguably be reduced gradually, as the companies increase their knowledge for the technology and more research is conducted on how to prevent technological errors.

Another risk relates to the water quality as it represents a crucial factor to ensure welfare and quality of the fish, as well as the economic result (Bjørndal et al., 2018). Water quality can be measured by factors such as water source, facility design, water treatment system and operating strategy. Water ensures necessary supply of oxygen and transports the fish's metabolic waste products, such as faeces, CO_2 and ammonia away. The need for new water into the tank systems is dependent on the fish's metabolism, size and type of biological treatment the facility is designed for. The risk is related to that when biofilters are not able to filter waste good enough, which in turn could lead to accumulation of nitrogen and bacteria that poisons the water. In addition, steady filtration of the water and adjusting the pH-level by adding minerals, are essential for good water quality and a stable production. Flow-through systems have several water quality parameters that easily can be measured relative to the RAS technology, which is more complex. Consequently, flow-through facilities can be viewed as having less water quality risk.

As land-based salmon production is carried out in closed containment, the risk for disease, sea lice and algae bloom is clearly reduced compared to conventional salmon farming (Bjørndal et al., 2018). However, once disease occurs, it is more difficult to get rid of it in RAS facilities. The infection arises in the biofilter or in the organic material, which is difficult to rinse. The tanks needs to be emptied out for up to six months to be disinfected, which represents lost production and lost revenues. Therefore, designing the RAS facility with respect to biosecurity is essential to enable successful operation and prevent empty tanks (Norwegian Veterinary Institute, 2019). A risk-reducing measure may be to increase biofilter capacity or incorporate in a share of reduced capacity of the biofilter (Bjørndal et al., 2018). In addition, establishing separate water treatment systems will be effective to reduce the risk of disease spreading.

The presence of the toxic gas, hydrogen sulphide (H_2S), is considered as an important technological risk factor in RAS facilities. Presence of H_2S in freshwater tanks will affect the pH-level, and can lead to acute mortality if measures are not taken quickly (Norwegian Veterinary Institute, 2019). H_2S occurs in the decomposition of biological material when bacteria without oxygen is present. The toxic gas can also occur when there is a lack of nitrate in the water during the denitrification process (Bjørndal et al., 2018). In 2018, approximately ten companies reported five events or fewer, and approximately nine companies reported more than five events with the presence of H_2S in their RAS facilities (Norwegian Veterinary Institute, 2019). At the same time, it was reported that approximately two companies observed five events or fewer with the presence of H_2S in their flow-through facilities, and it may therefore seem that RAS facilities have a higher risk of H_2S-poisoning relative to flow-through facilities. Thus, the presence of H_2S poses a sizeable risk. Monitoring the redox-potential, ensuring good water flow, measuring H_2S and having nitrate available if needed are vital measures to prevent the presence of H_2S (Buran Holan referred to in Bjørndal et al., 2018).

For instance, Atlantic Sapphire's facilities in Denmark experienced the death of 90 percent of the biomass in the fish tank, due to H_2S-poisoning in 2017 (Olsen, 2017). Such events affect the cash flows, and consequently the profitability, negatively as the majority of the biomass dies quickly. This means that harvest opportunities are pushed into the future, which further means that revenues must be discounted by a longer period of time. The time value of money consequently states that the value of the company decreases.

Furthermore, both RAS and flow-through facilities have experienced problems with elevated CO_2-levels in the water because of too little water replacement (Norwegian Veterinary Institute, 2019). Fifteen companies with a RAS facility reported in 2018 that they had experienced high CO_2-levels in five or fewer occasions, and six companies reported five or more events with this problem. On the other hand, around six companies with a flow-through facility reported five events or fewer, and around five companies reported five or more events with high CO_2-levels. Preventing high CO_2-levels is possible by designing pipe systems, pumping and water treatment facilities, and enabling continuous flow of water (Bjørndal et al., 2018).

As the flow-through technology does not conduct water treatment processes, the risk of biologic materials entering the tank is not fully eliminated. For instance, with the occurrence of a storm, the surface water, which contains biological materials, may be pushed down to greater ocean depths. Thus, these bacteria's may become present at the depths where flow-through facilities pump up water from.

Off-flavour of the fish due to the presence of geosmin-compounds is a technological risk affecting the quality of the fish. Geosmin is a bacteria observed in RAS facilities with biofilter, which gives the fish an earthy and muddy taste (Tekfisk, 2020). Presence of geosmin can affect the profitability of the companies if consumers perceive the fish as unattractive, as this will lead to a lower achieved sales price. Using cleaning tanks with flow-through of water before harvesting the fish is a measure to reduce the risk of an deterioration in the flavour (Bjørndal et al., 2018). In this process, the fish is moved, for the last 2-4 weeks before harvest, to purging tanks with increased degree of water change. The purpose of purging the fish is to ensure quality, by removing geosmin compounds, as well as any other contaminating bacteria accumulated in the flesh. In addition, the fish is starved for approximately one week to eliminate the effect on the flavour. This process is necessary to obtain a good quality taste of the fish, but it incurs costs as well as reducing the biomass.

Another sizeable risk is one of not being able to achieve estimated volume and size of the fish. The RAS technology is especially struggling with early sexual maturation. This is an issue in salmon farming, as matured salmon often exhibits reduced product quality and are more susceptible to microorganisms (Good & Davidson, 2016). Furthermore, the efficiency in terms of growth and feed conversion decreases. Sexual maturation is a function of several biological parameters, but a closed containment environment with higher temperatures, which increases the speed of growth, is one important reason for this issue. Atlantic salmon grow-out trials find male maturation in 4-5 kg salmon, by harvest time, as high as 80 percent, in RAS facilities. Thus, it poses a big concern for RAS facilities as the companies using this technology either need to slaughter their fish at a lower average weight or incur issues with male maturation. Both representing a source of major economic loss. Preventive measures may include proper lighting, temperature and salinity control (Bjørndal et al., 2018).

Finally, since land-based facilities are able to control the environment in their tanks, they are allowed to operate with a substantially higher density compared to open-net pens (Bjørndal et al., 2018). The usual maximum density for open-net pens are in the interval of 15-25 kg/m^2, while Salmon Evolution and Atlantic Sapphire estimates a maximum density of 80 and 85 kg/m^2, respectively, in its facilities. It is possible to operate with a density of 75 kg/m^2 for post-smolt of 115g in land-based facilities, but the risk of issues increases substantially for densities of 100-115 kg/m^2. In addition, these issues will arise earlier for larger-sized salmon. The risks relate to reduced growth, tear of fins and skin, reduced proportion of “optimal” fish and formation of wounds, and the only mitigating measure for this risk is to reduce the density. Although there is need for more research on this subject, the discussion above highlights the risk that the estimated density in land-based facilities could be too high, which in turn can pose a challenge for land-based salmon farming companies to obtain their estimated volumes.

To sum up, the risk of not reaching sizeable volumes and operating with high density in the tanks, seem to be the most prominent operational concerns. Specifically, in terms of the respective technologies, the complexity of the RAS technology increases the risk of, among others, H_2S-poisoning and off-flavour, while the flow-through technology face the risk of having an insufficient degree of filtration before the water is transported to the tanks.

3. Theory

In this chapter, we present the theoretical framework for this thesis. First, we present microeconomic theory on supply-demand dynamics, which determines salmon prices. We then present theory on negative externalities. This is used as the theoretical fundament when discussing environmental factors and its impact on a potential premium pricing of salmon farmed on land. Finally, we present the efficient market hypothesis in order to understand how unexpected events in companies affect stock prices.

3.1 Supply, demand and market equilibrium price

In a perfectly competitive market, the supply (S) and demand (D) model explains the interaction between suppliers and consumers of a good (Goolsbee, Levitt, & Syverson, 2013). Firms operating in this market is a price taker, and have to sell their products at the market equilibrium price (P). The price is determined by supply and demand forces in the market, which maximise the firms profit. The demand curve is perfectly elastic at the market equilibrium price, which means that the quantity demanded changes infinitely in response to a price change.

Shifts in the supply and/or demand curve affects both the price and the quantity of a good. When the demand curve shifts, price and quantity move in the same direction, as the supply curve is upward sloping. Figure 3.1 illustrates how demand and supply curve shifts affect the price and quantity of a good. An upward shift in the demand curve could for instance result from changing consumer behaviours, as increased knowledge about environmental factors arguably should lead to boosted consumption of salmon. Turning to the supply side, higher demand due to increased consume of a good tend to drive prices up, which in turn induces suppliers to produce more of the good, observed as a move along the supply curve. On the contradiction, when the supply curve shifts, price and quantity move in the opposite direction, as the demand curve is downward sloping. When the supply curve shifts in, suppliers produce less of a good and the market equilibrium price rise to reduce the quantity demanded. The price of Atlantic salmon is explained by this theorem. The supply side will be negatively affected if a massive volume of salmon dies at the same time, which in turn will increase the salmon price. Complementary to this, the pandemic created a substantial market imbalance for the salmon sector all along the supply chain (FAO, 2020). Producers in the first half of 2020 had to delay harvesting as long as possible due to the reduced demand. This led to a tighter than expected supply in the spring, a higher proportion of large fish in the pens and more harvesting in the second half year of 2020 (FAO, 2020), which reduced the salmon price.

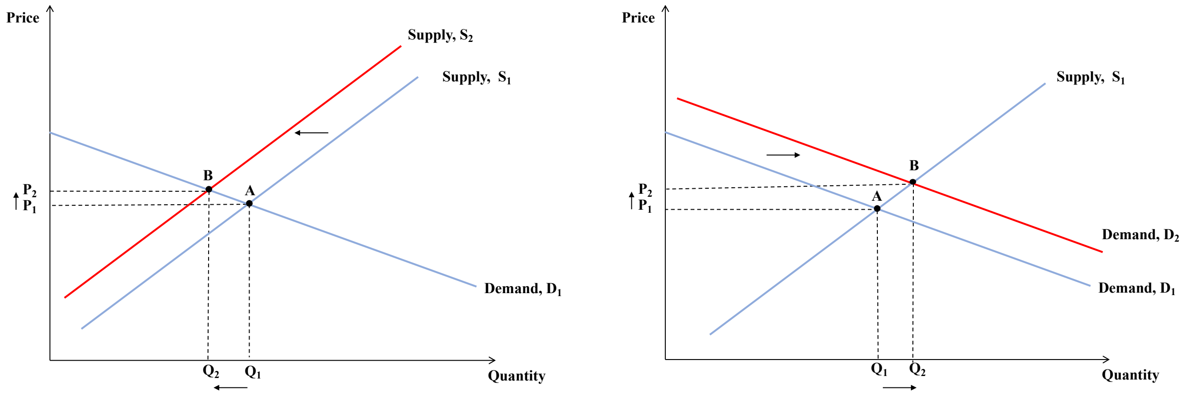


Figure 3.1: *Effect of leftward shift in the supply curve (left) and effect of rightward shift in the demand curve (right). Source: Goolsbee et al. (2013)*

3.2 Negative externalities

A negative externality is "a cost imposed on a third party not directly involved in an economic transaction" (Goolsbee et al., 2013). Negative externalities create inefficient outcomes because the social cost is greater than the private cost, as the former includes the external cost. A perfectly competitive market will fail to produce the optimal quantity of goods when negative externalities exists. Hence, the market will produce too much goods as the production is perceived as more profitable than what is actually true if incorporating the social cost.

External marginal cost (EMC) is the additional cost to the society when producing or consuming an additional unit of a good. When negative externalities are present, the social marginal cost (SMC) is obtained by adding together marginal cost (MC) and EMC. Social optimal production occurs at point A in figure 3.2, where P=MC. In this equilibrium, the socially optimal price is higher and the quantity produced lower than in point B. However, when the social marginal cost is ignored, the market output is greater than the socially optimal output. The production occurs at point B, and represents what happens in a perfect competitive market when negative externalities is ignored. At point A, consumers value the good as much as it costs society to produce it. However, production occurs at point B, and the area between points A and B represents consumers who value the good less than it costs society to produce. They buy the good only because the market price is low, and would not have bought if the true price was reflected. As a result, the negative externality and the market inefficiency creates a dead-weight loss equal to the shaded triangle in figure 3.2

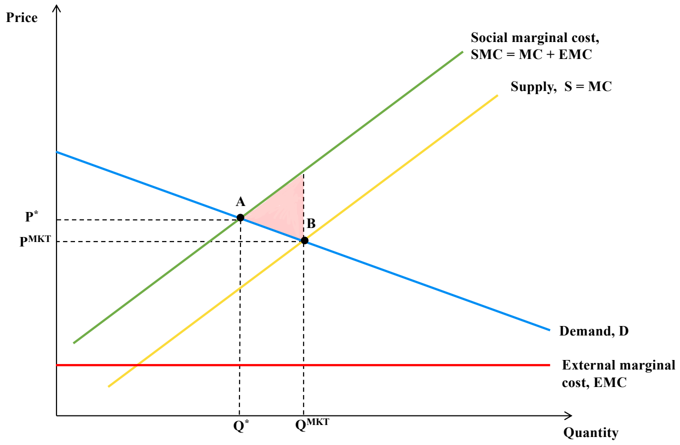


Figure 3.2: *Negative externalities. Source: Goolsbee et al. 2013*

3.3 Efficient Market Hypothesis (EMH)

The efficient market hypothesis (EMH) states that prices of securities fully reflect available information, thus the market is said to be efficient (Bodie et al., 2018). Investors' buying securities in an efficient market should thus expect to obtain an equilibrium rate of return. When the assumption of EMH holds, it will not be possible to "outperform the market" because the market price only changes when new information arrives. For instance, a takeover acquisition is likely to cause the market price of the target company to jump dramatically at the day of announcement, as the acquiring firm usually pays a substantial premium price over current market price. There will be no further shifts in the prices, as the price again reflects all available information.

Fama (1970) and Robert (1967) considered market efficiency in three different forms: *weak*, *semi-strong*, and *strong*. Weak-form of EMH asserts that stock prices reflect all past information from historical prices. The semistrong-form hypothesis claims that security prices reflect all publicly available information, and that changes in the price are reflections of that information. Finally, the strong-form hypothesis state that both public and insider information is reflected in the stock prices, which is seen as an extreme form of EMH. Information is seen as the most precious commodity, and if security prices reflect all available information, then price changes must reflect new information. In this thesis, we assume that the markets comply with the *semi-strong form* of EMH.

4. Empirical methodology

This chapter presents the econometric methodology and assumptions used to investigate how investors value land-based vs conventional salmon farming stocks and determine investors' sensitivity. The salmon price analysis exploits the benefit of panel data by using a pooled OLS approach. Furthermore, the event study employs a research design that models abnormal returns for each event individually, by following Karafiath (1988), Binder (1998) and Wooldridge (2012) methodology for the event parameter approach. Lastly, we employ simple OLS estimations for the explanatory power of indices analysis. We will further provide our model specification for each analysis in this chapter.

4.1 Panel data study

The salmon price correlation study examines land-based along with conventional salmon farming companies over the period from the 15th of May 2018 to 4th December 2020. Since our data consists of both cross-sectional and time series data with several companies observed in every period, it is a balanced panel study (Wooldridge, 2012). Equation 2 below represents a generalised panel data model:

$$y_{it} = \alpha_i + \beta_1 * x_{it} + \varepsilon_{it} \tag{2}$$

$i = 1, \dots, N$

$t = 1, \dots, T$

In equation 1, y_{it} denotes the dependent variable while x_{it} denotes the independent variable, which varies over time *t* and for each cross-sectional unit *i*. β explains the change in y_{it} when x_{it} changes with one-unit. The error term (ε_{it}) covers all unobserved factors expected to impact y_{it}. Due to the two-dimensional structure of panel data, the error term consists of both an unobserved time-invariant heterogeneity (α_i) and a time-variant idiosyncratic error term (u_{it}). Since *I* denotes firms in our analysis, α_i represents firm specific effects. Hence, the error term can further be broken down into:

$$\varepsilon_{\text{it}} = \alpha_i + u_{it} \tag{3}$$

Panel data offers several advantages over pooled cross-section analysis, such as increased number of observation and greater precision which can facilitate causal inference

(Wooldridge, 2016). Moreover, a useful advantage of panel data is to control for the potential presence of unobserved time-invariant fixed factors, as well as the unobserved time-variant idiosyncratic factors, which could be correlated with the independent variables in the model. Fixed time-invariant factors are constant over time but vary between different companies, such as geographic presence. On the other hand, unobserved time-variant factors vary over time but are constant between companies. A financial crisis may be an example of such a factor. If unobserved factors correlate with the independent variables, the model will suffer from heterogeneity bias (e.g. omitted variable bias), and the results will not be efficient. To control for this, one solution is to add control variables. However, determining which control variables to select may be difficult.

When conducting an econometric analysis of panel data, we cannot assume that the observations are independently distributed across time (Wooldridge, 2012). Therefore, a panel data requires special methods to analyse these type of data, where pooled OLS is the one we choose for our study.

4.1.1 Pooled OLS

The pooled OLS (POLS) model ignores the panel structure of the data, thus ignoring the time-invariant and individual-specific effects as well as the time-specific and individual-invariant effects (Wooldridge, 2016). Observations are pooled across time or group as well as across the cross-sectional units (Wooldridge, 2012). Hence, the observations are collected in a "pool" as a big cross-section, which makes it possible to run an OLS model. However, for the pooled OLS to be consistent, one must assume that x_{it} is uncorrelated with both the time-invariant term and the time-variant idiosyncratic term. When the first of this is violated, the pooled OLS suffers from heterogeneity bias (e.g. omitted variable bias) (Wooldridge, 2016). If the error terms are homoscedastic and autocorrelation doesn't exists, the pooled OLS will be efficient.

4.2 The event study methodology

When conducting an event study, we must first identify a pre-event, event and a post-event window. As illustrated in figure 4.1, the pre-event and post-event window is the time period where we assume normal returns of the stocks. Next, the event window is the short period of time where the variance of returns is expected to be higher, due to the announcement of the event occurring. This is consequently the window where the abnormal returns are tested for significance.

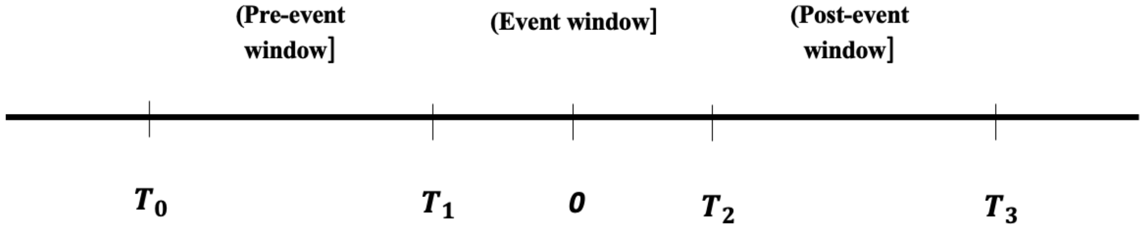


Figure 4.1: *Identification of the pre-event, event, and post-event window*

The event study methodology quantifies the relationship between the given event and stock returns by estimating the abnormal return when information about the event becomes public. Our event study will make use of the event parameter approach, which is an extension of the market model, where the entire model is run with one regression (Binder, 1998). This approach makes use of binary variables for the estimation of abnormal returns, which takes a value of one over the event window. Prior to finding abnormal returns from this regression, one needs to find an estimation of the normal stock returns in the absence of the event. An industry index will be used as a proxy for these normal returns, which we will elaborate on in the data chapter.

In event studies, binary independent variables (D_t) are the key components (Wooldridge, 2012). The goal of an event study is to examine whether a particular event influences stock returns (R_{it}), which is what the coefficient and statistical significane of the dummy variable provides us with an answer to. Equation 4 below represents a generalised equation used for event studies:

$$R_{it} = a + \beta_1 * R_{mt} + \beta_2 D_t + u_t \tag{4}$$

In equation 4, R_{it} represents the stock returns for firm I during time period t, while R_{mt} represents the market return, in our case, the industry index. Including the latter, controls for the possibility that broad industry movements might coincide with mortality events. Furthermore, D_t represents the event dummy variable.

4.3 Model specification

In this section, we will define the model specification for our three analyses. For the salmon price analysis, we will specify the main model as well as a supplementary model for increased insight purposes. Further, we will focus on the general form of each regression in the other two analyses.

4.3.1 The impact of salmon prices on stock development

In this analysis we make use of panel data as we have one cross-sectional dimension for companies and one time dimension. We exploit the benefits of pooled cross sections as this will increase our sample size, provide us with more precise estimators and give increased power to our test statistics (Wooldridge, 2012). Log transformed returns on salmon farming stocks are used as the dependent variable.

An interaction term between the salmon price and the category land-based is used to quantify the difference in salmon price impact on land-based compared to conventional stock returns. The category groups are non-equivalent, meaning that the companies are assigned into each group based on important differences between the two group of industries. For future research purposes, we have defined land-based companies as companies that deploy RAS or flow-through technology in full cycle production of salmon on land. Equation 5 below represents our main model.

$$log\ (R_{it}) = \alpha_i + \beta_1 log\ (X_{it}) + \beta_2 log\ (FPI_t) + \beta_3 LB_i + \beta_4 (LB_i * log\ (FPI_t)) + u_{it} \quad (5)$$

In equation 5, β_4 is the coefficient of interest measuring the effect of salmon price on land-based salmon farming stocks, beyond the impact on conventional salmon farming stocks. The stock returns of the included salmon farming companies are regressed on this interaction term as well as several control variables (X_{it}), the salmon price (FPI_t) and the land-based company category (LB_i). We will further elaborate the selection of variables in section 5.2.

To increase our understanding on how the salmon price impacts salmon farming stock returns, we define an additional model (equation 6). In this model, we replace the interaction term from equation 5 with an interaction term between the forward price for salmon and the land-based company category. This term will provide us with an understanding of whether land-based and conventional salmon farming stocks are affected differently by changes in forward salmon prices. Since forward prices represent expectations for future profitability, while salmon spot prices represent current profitability, we believe this second model will offer increased insight into differences in drivers for the valuation of land-based relative to conventional salmon farming stocks. The purpose of this second model specification is therefore to compare the magnitude and statistical significance of β_4 between equation 5 and 6.

$$log\ (R_{it}) = \alpha_i + \beta_1 log\ (X_{it}) + \beta_2 log\ (FPI_t) + \beta_3 LB_i + \beta_4 (LB_i * \log (M2_t)) + u_{it} \quad (6)$$

4.3.2 Event study

In our event study, we run nine individual OLS regressions with the same functional form. Equation 7 represents the general model specification. As we have identified only nine appropriate events for this event study, it will be feasible to run each event regression individually. In addition, the events occur on different points in time which means that the event dummy variable will be one for different dates. Furthermore, we use different indices for each event which therefore makes it more appropriate to run individual regressions.

$$log\ (R_t) = a + \beta_1 * \log (R_{m_t}) + \beta_2 D_t + u_t \quad (7)$$

$$log\ (R_t) = a_i + \beta_1 * \log (R_{m_t}) + u_t \quad (8)$$

In the event parameter approach, equation 8 is used to identify the index with the highest explanatory power before applying it as the market index in our main model, equation 7. Next, the model specified in equation 7 is estimated over the entire period. The event dummy coefficient is 1 for the event window and acts as an estimation of abnormal returns when an event occur. By looking at the magnitude and statistical significance on the dummy variable, in equation 7, we will observe whether investors have reacted significantly to the defined acute mass mortality event. Comparing β_2 between the nine regressions will provide us with insight into differences in investors' sensitivities for events occurring at land-based compared to conventional salmon farming facilities.

4.3.3 The explanatory power of ESG and technology indices on land-based stocks

In this final regression analysis, we run six individual OLS regressions with the same functional form. Equation 9 represents the general model specification.

$$log\,(R_{it}) = \alpha + \beta_1 log\,(X_{it}) + u_{it} \tag{9}$$

In equation 9, R_{it} represent Atlantic Sapphire's stock returns. The returns are regressed on different indices (X_{it}) and the corresponding r-squared from each regression will be compared. The explanatory power of each regression will give an indication as to how much the stock returns and the index correlate, and how much of the variance a stock index is able to explain of the stock returns. Thus, a regression with high explanatory power exhibits an index with similar development in returns as Atlantic Sapphire, which implies that the two are affected by similar factors. This analysis will therefore provide an intuition into how investors value Atlantic Sapphire. The different indices (X_{it}) we incorporate will be explained in detail in the data chapter.

5. Data

This chapter details how we select and gather data used in the three statistical analyses of this study: 1) the impact of salmon prices on stock returns 2) event study, 3) the explanatory power of ESG and technology indices on land-based stocks. We will also present the qualitative research methodology used to collect data from our interviews. A full list of our interviewees (n=28) is to be found in the appendix. As the majority of our data sample and descriptive statistics is the same for all three analyses, we will present sample selection, data source and requirements and descriptive statistics in common. For the selection of variables, we will present each analysis separately in order to thoroughly describe the variables we include in each analysis and the justification for the inclusion.

5.1 Sample selection

5.1.1 Identifying companies

In order to get valuable results from examination of the hypothesis in this study, we need to determine which salmon farming companies to include in the analyses. An important exclusion factor, when identifying companies to analyse, will be the availability of publicly listed companies. This is essential as we are dependent on historic share price information to conduct our analyses

Moreover, we also base this selection process on the length of share price history. Therefore, we do not include Salmon Evolution and Andfjord Salmon in our regression analyses, as these stocks only have a few months of price history. Several of our interviewees also emphasise that the development of Atlantic Sapphire will significantly influence the expectations for the land-based industry as a whole, as it is the largest and most progressed publicly listed land-based salmon producer. We will therefore assume that the availability of capital is largely dependent on Atlantic Sapphire’s success. Thus we argue that conducting these analyses with only Atlantic Sapphire as the land-based company will be representative for the land-based salmon farming sector. Therefore, when referring to “land-based stocks” in our three statistical analyses, this will only include Atlantic Sapphire’s stock returns. Andfjord Salmon and Salmon Evolution are, on the other hand, considered in the relative analysis (section 6.4) and the investment perspectives discussions as they are essential for the understanding of pricing dynamics in this industry. The stocks we choose to include in our regression analyses must therefore have been listed prior to Atlantic Sapphire's listing on 15th May 2018.

We further choose to limit this study to stocks listed on the Oslo Stock Exchange. The rationale is that we consider the stocks listed on the Oslo Stock Exchange to be representative of the total salmon farming market. This is because Norway's share of global production of farmed Atlantic salmon is more than half the total global production, with approximately 52 percent in 2019 (Kontali, 2020a), and the competences and service clusters in Norway dominate the industry. Further, salmon farming stocks listed on the Oslo Stock Exchange have operations in several locations across the world, thus this delimitation does not limit our study to geographical presence in Norway. The main reason for this exclusion is the availability of reliable and good information. In Norway, we are familiar with the requirements of the reporting for companies and we have better access to influential people working within the business. In addition, all pure land-based salmon farming stocks are listed on the Oslo Stock Exchange, thus this delimitation makes sense. To note, one land-based salmon farming stock is listed on Nasdaq, AquaBounty, but this company operates with genetically modified salmon (GMO). Based on our interviewees' assessments, we choose to exclude AquaBounty as the valuation of the company will arguably be dominated by the GMO part of the production. This makes it challenging to isolate the value of the land-based salmon farming technology, which is the part of the business we wish to examine.

In addition, we need to determine the right comparable conventional salmon farming companies, as our main goal of this study is to examine differences between land-based and conventional salmon farming stocks. We choose to include all conventional salmon farming stocks on the Oslo Stock Exchange, except for Austevoll Seafood. The reason for this exclusion is mainly because Austevoll does not act as a salmon farming company in line with other included salmon farming companies. The company rather operates as an investment company with majority ownership in different seafood companies, for instance Lerøy Seafood Group. Moreover, we are aware of the substantial differences in size of the companies included, as well as the different stage of the life cycle they operate in. Thus, we will discuss the challenges this poses to our analyses in the limitation chapter of this study.

Based on the discussion above, we identify eight salmon farming companies to include in the regression analyses of this thesis. These companies are listed in table 3 below.

***Table 3:** Overview of companies included for regression analyses*

Companies	Type	Market Cap (NOKbn)	Annual harvest 2020e (ktonnes)	Share Atlantic Salmon	Geographical presence (farming)	Post-smolt facilities
Atlantic Sapphire *	Land-based (RAS)	8	2	100 %	Denmark, Miami	-
Bakkafrost	Conventional	33	89	100 %	Scotland, Faroe Islands	Yes
Grieg Seafood	Conventional	9	90	100 %	Norway, British Colombia, Shetland	Yes
Lerøy Seafood Group	Conventional	34	183	38 %	Norway, Shetland	Yes
Mowi	Conventional	92	442	100 %	Norway, Faroe Islands, Ireland, Scotland, Canada, Chile	Yes
Norway Royal Salmon	Conventional	9	35	100 %	Norway, Island	Yes
SalMar	Conventional	55	164	100 %	Norway, Faroe Islands, Scotland	Yes
Salmones Camanchaca	Conventional	3	55	80 %	Chile	No

* 220 ktonnes full capacity

5.1.2 Identifying salmon mortality events

Turning to our event study, this analysis will be highly dependent on an accurate definition of events. As our event study will examine investors' sensitivity to the two acute mass mortality events that Atlantic Sapphire has experienced in 2020, we need to identify similar type of events for the conventional salmon farming companies. Our definition of acute mass mortality events includes technological errors, weather and water conditions, algae bloom and unexpected accidents such as fires. Furthermore, these events must have caused immediate death of a substantial volume of salmon and must have been reported as a one-off incident. These events happen without notice and become widely known in the market quickly.

Events with the occurrence of pancreas disease (PD), infectious salmon anaemia (ISA) and sea lice in conventional salmon farming are excluded from our analysis because such events do not happen in one day, but rather over a longer period of time. Therefore, the occurrence of such diseases does not lead to acute mortality in the same way as in the Atlantic Sapphire incidents. The events that have occurred at Atlantic Sapphire's facilities are seen as one-time occurrences among our interviewees, and as having minimal impact on the long-term outlook for the company. On the other hand, occurrence of PD, ISA and sea lice may have a more long-term effect on the companies effectivity on the areas they operate in, rather than a short-term fall. Thus, comparing Atlantic Sapphire's acute mortality events with occurrence of PD, ISA and lice in conventional salmon farming companies gives a distorted impression of investors’ sensitivity.

In addition to the events we choose to include, Atlantic Sapphire experienced a mass mortality event in 2017 due to H_2S poisoning at its facilities in Denmark, where 250 tonnes of fish were found dead due to anoxic conditions (Olsen, 2017). This was one of the first events displaying how vulnerable the industry is to technological errors which arguably opened investors’ eyes to the risk present in the RAS technology. However, this event is not included in our event study as it happened just prior to the NOTC listing, thus we have no data on how the event affected stock prices.

Table 4 below lists the events included in our event study with the following event windows. As several of the companies have insurance, the total cost of incident from the table represents the amount the company itself must account for.

Table 4: *Overview of unexpected mass mortality events and the chosen event windows*

Company	Event	Date of incident	Date of announcement	Total biomass lost (tonnes)	Total cost of incident (MNOK)	Cause of incident	Location	Event window
Atlantic Sapphire	1	28/07/2020	29/07/2020	250	5.0	Stress to fish because of construction nearby, caused by delays due to COVID-19	USA	29/07/2020
Salmones Camanchaca	2	18/05/2020	18/05/2020	1,008	2.9	Weather conditions affecting structures consisting of two modules	Chile	18/05/2020
Mowi	3	15/04/2020	17/04/2020	20	-	Drop in oxygen levels	Chile	17/04/2020
Bakkafrost	4	28/02/2020	08/03/2020	2,100	23.4	Storm	Faroe Islands	09/03/2020
Atlantic Sapphire	5	29/02/2020	02/03/2020	-	3.0	Design of facility and high nitrogen levels	Denmark	02/03/2020
Salmones Camanchaca	6	14/03/2019	15/03/2019	123	-	Algal bloom	Chile	15/03/2019
Lerøy Seafood	7	27/01/2019	28/01/2019	1,430	-	Fire in smolt facility	Norway	28/01/2019
Bakkafrost	8	20/09/2018	23/09/2018	375	7.2	Algal bloom	Faroe Islands	24/09/2018
Grieg Seafood Group	9	06/06/2018	06/06/2018	1,000	19.0	Algal bloom	Canada	06/06/2018

5.1.3 Defining event windows

The choice of event windows is determined based on Krivin et al. (2003) methodology regarding an *ad hoc* rule, as we elaborate in the literature review. Although conclusions on event windows may differ between studies using this method, we choose to define our event windows based on the observed price movements and changes in trading volumes of the stocks.

The advantage of choosing event windows in this way is that we are able to use information about the movements of the securities when determining the lengths (Krivin et al., 2003). Thus, we are able to isolate the event in question and exclude other news affecting the securities, which happen in the days surrounding the acute mortality event. In addition, as we only have nine events, the law of large numbers will not hold. Hence, we are more dependent on a rightful definition of the length of the event window to uncover the true effect of the event. A drawback of this approach is on the other hand that the determination of the event day could be inconsistent, as another researcher might come to a different conclusion for the length of the event days based on the same data.

We define date of announcement as day zero and assume that the markets are informed about the event this day. If the event was announced on a Sunday, day zero will be the following Monday. According to the semi-strong efficient market hypothesis, the stock price will then experience a jump when new information about acute mortality incidents are launched to the market.

For instance, when analysing the returns for event 5 we find that the period of low returns begins 24th February. Still, the event did not occur until 29th February, which was a Saturday. Therefore, the low returns prior to the event cannot have been a result of inside information. Further, the stock returns and volatility becomes highly influenced by the pandemic in the days after the announcement. We therefore choose to exclude these days from our event window, and choose to set only the date of announcement as our event window. However, we note that it looks like Atlantic Sapphire's investor's overreacted to the event on 2nd March as almost the entire share price decrease was retrieved the next day.

In our data material, we observe that event 7 stands out by having a period of low returns from two trading days prior to the event, which bottoms out at the day of announcement. From the first look, this could indicate that inside information entered the market prior to the announcement. Still, this is not the case as the event happened the day before, on a Sunday. These low returns must therefore be a result of other factors known to the market. There is no evident low returns in the days prior to the event either. Thus, we choose to an event window length equal to the day of announcement.

It is important that the event day is defined for movements caused by the event we are examining. For instance, Mowi's event 3 occurs only three days prior to its Q3 report announcement. Thus, we must not base the event window on the reaction to the Q3 report, but to the actual event we are interested in. For events where there are no visible reactions to the news, we choose to set the event window to the day of the announcement. We study each of the events with the same approach as above and actually conclude with an event window length equal to the day of announcement for all events. The robustness of this determination of event window length will be further discussed in the robustness chapter.

5.1.4 Data source and requirements

As the fully out-grown production of salmon at land-based facilities is yet in its early stage, and there are few listed companies available, our data material is limited. Thus, this work adopts a mixed methods research approach, with a concurrent design. Mixed method research is a design where the researchers combine quantitative and qualitative research approaches to develop a broader understanding of the question at hand, to strengthen a study's conclusions and to be able to crosscheck findings (Schoonenboom & Johnson, 2017). Concurrent design means that both quantitative and qualitative data are executed almost simultaneously. Our research components are independent as the implementation of one does not depend upon the results from the other. This is because our hypothesis is stated from the beginning, and both of the components are designated based on this. In our study, we primarily conduct quantitative analyses and supplement these finding with interviews from relevant market participants. We do this with a complementary purpose to strengthen the study's conclusions. In this section, we will elaborate on how we collect data and the requirements we focus on. A total list of our interviewees (n=28) is to be found in the appendix.

5.1.5 Quantitative research – data collection

We obtain daily financial data by Bloomberg in the period ranging from 15th May 2018 until 4th December 2020. The retrieved stock data from Bloomberg is adjusted for capital changes such as spin-offs, stock splits/consolidations, stock dividends/bonuses and rights offerings/entitlements. Furthermore, we gather historic and future salmon prices, for the same time period, from Fish Pool ASA, which include data from Nasdaq and Statistics Norway. Next, we construct a value weighted Nordic ESG index with data from Bloomberg, and include companies defined by DNB Markets. We explain the construction of this index in the appendix. Lastly, for the relative valuation analysis, we gather financial data for each company from the latest quarterly reports available, and adjust this for substantial changes in capitalisation post quarterly report release.

In the event study, the financial data is based on daily adjusted closing prices. Financial data in the salmon price correlation analysis is, on the other hand, on a weekly basis as the Fish Pool Index (FPI) data is only available as average weekly prices. Lastly, we use daily adjusted closing prices to analyse the explanatory power of different indices on land-based stocks. We process and gather data mainly in Excel, except for the construction of returns and panel data, which we conduct in RStudio. For our study, we require the selected companies to be publicly listed as of 2018 and during the entire time period. All items are quoted in NOK, and the study period extends from 15th May 2018 to 4th December 2020.

5.1.6 Qualitative research – Interview data collection

Our qualitative data collection is inspired by the work on the grounded theory presented by Glaser and Strauss (1967), and conduction of semi-structured interviews. The grounded theory aims to construct new theories that are grounded in data, by analysing research participants' behaviour, words and actions. The purpose is to develop new theories that can be tested empirically in the next phase (Svartdal, 2018). The grounded theory method promotes viewing data in new ways and explores researchers' idea about the data, by researching participants thoughts in depth (Charmaz, 2006).

The grounded theory aims to enable the interviewee to lead the conversation (Glaser & Strauss, 1967). Thus, it is recommended that the interview guideline is designed with open-ended, broad and non-judgmental questions. The semi-structured interview approach also makes use of a combination of closed and open-ended questions, followed by 'why' or 'how' questions (Adams W. , 2015). It is therefore important that the researchers are more objective towards the designed questions in the first interviews. As more interviews are conducted, and one gains more insight into the industry, the guideline can be adjusted in accordance to the perspectives and concepts emerging from previously conducted interviews. Hence, questions can gradually evolve to lead the discussion with greater clarity and to get a deeper insight into thoughts and statements from our interviewees.

As we conduct interviews with investors, financial analysts and both land-based and conventional salmon farming actors, we design three different interview guidelines based on each stakeholder's background. As the market participants have different expertise, this creates diversified perspectives regarding the industry and each of our hypotheses, thus supplementing findings from the quantitative analyses. We conduct our first interviews by following the interview guideline closely. As we gain more knowledge about the industry, we deviate from the guideline in order to lead the discussion further and gain a deeper insight into our key topics. Our approach is therefore in line with Glaser and Strauss's work on the grounded theory (1967).

5.2 Selection of variables

In this section, we will explain our variable selection for our three different analyses. Throughout the analyses we convert our stock prices into stock returns, as this gives the data advantageous statistical properties in terms of normalisation (Wooldridge, 2012). For the salmon price analysis, where we use weekly data, the returns are calculated between the same dates as the salmon price is announced. In addition, we log transform all returns, as illustrated in equation 10, in order to narrow the range of the variables as a mean to make the OLS estimation less sensitive to seasonal fluctuations and extreme values. In turn, this will make the model fit the data more accurately. This is especially important when analysing the salmon farming sector as this is an industry with high seasonal fluctuations. For the same reason as above, and in order to simplify the interpretation of regression results, we also log transform our control variables.

$$Log - transformed\ returns\colon\ ln\,(r_t) = ln\left(\frac{p_t}{p_{t-1}}\right) = ln(p_t) - ln\,(p_{t-1}) \qquad (10)$$

5.2.1 The impact of salmon prices on stock returns

Dependent variable

To analyse the relationship between salmon farming stocks and the salmon price, weekly log transformed returns of the nine salmon farming stocks are used as the dependent variable. As the salmon price is reported on a weekly basis, weekly returns must be used to obtain a unique corresponding salmon price for each observed stock return.

Independent variable

The independent variable of this analysis determines the explicit difference in impact the salmon price has on land-based relative to conventional salmon farming stock returns. This is expressed as an interaction term between a dummy variable and the salmon price, where the dummy variable takes a value of one for land-based companies. The dummy variable is thus multiplied with the salmon price variable (FPI : Land-based). As seen from the illustration in figure 5.1(b), this interaction term enables the two categories, land-based and conventional, to have different slope coefficients, which is how we are able to isolate the salmon price effect on land-based stock returns (Kleven & Løken, 2012).

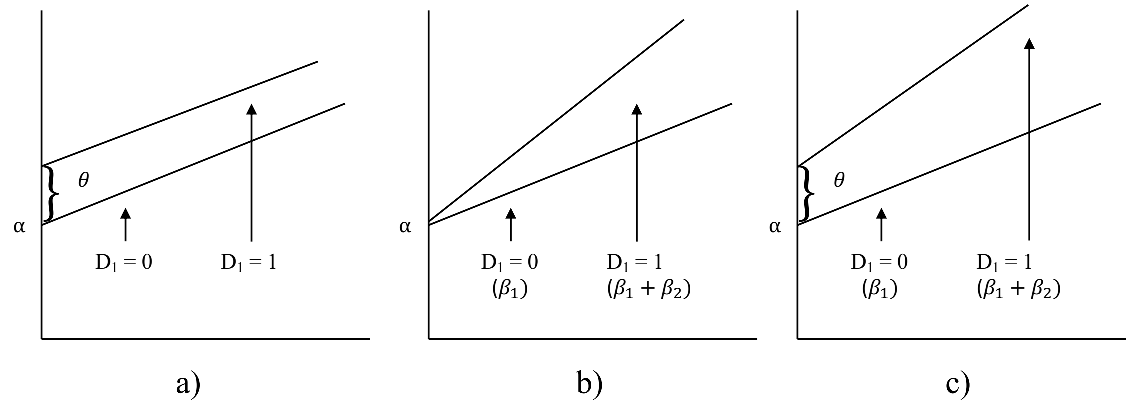


Figure 5.1: *Regression models for dummy variables. Source: Wooldridge, 2012*

Control variables

We choose to include control variables such as the OBX index, price shocks, and forward prices, which are all thought to affect the company's stock return. This is done to isolate the effect of the variable of interest. Each control variable and the justification for inclusion is described below.

We choose the OBX index as the market index in this analysis. The justification for using the broader market index instead of the industry-specific Seafood index is to avoid perfect collinearity issues between the index we choose and the salmon price. Perfect collinearity inflates the variance of at least one of our regression coefficients, which may introduce biases into our estimations (Wooldridge, 2012). Figure 5.2 below illustrates the development of the two indices and the salmon price over the time period we analyse. Here, we see that the salmon price and the Seafood index fluctuate more compared to the OBX index. Further, it looks as if the Seafood index also correlates more with the salmon price. To figure out whether this intuition is true, we run a correlation test for the two indices and the salmon price. As seen from table 5, we cannot reject the null hypothesis that the true correlation is equal to zero between the OBX index and the salmon price. Conversely, we can reject the same null hypothesis for the Seafood index and the salmon price. Thus, the OBX index is a better choice for this analysis.

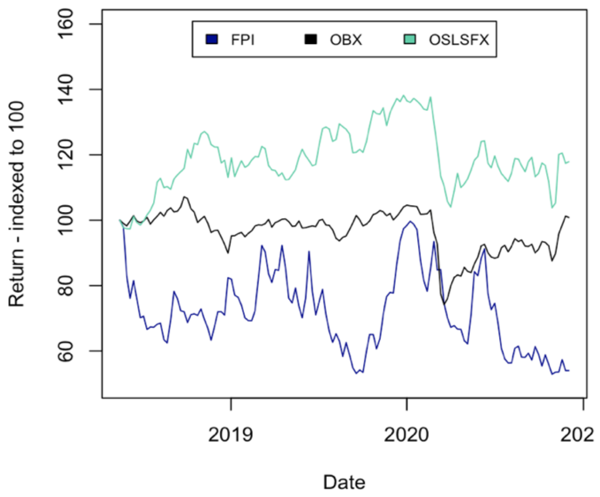


***Figure 5.2:** FPI development compared to OBX and OSLSFX*

Pearson correlation coefficients

	Fish pool index (FPI)
OBX	0.06532
OSLSFX	0.26201***

Alternative hypothesis: true correlation is not equal to 0
Significance levels: *p<0.1; **p<0.05; ***p<0.01

***Table 5:** Correlation of log transformed returns between FPI and OSE indices*

The OBX index normally consists of the 25 most traded shares at the Oslo Stock Exchange (Oslo Stock Exchange, 2020). It aims to reflect the Oslo Stock Exchange investment universe by incorporating a highly liquid composition of shares. The index is further value weighted based on a free float adjusted market capitalisation which is rebalanced semi-annually. Only automatic trades are included in the index and the six days with the highest turnover for each security are excluded. We expect the OBX index to correlate positively with the stock returns of the companies as dynamics affecting the broader market likely affect salmon farming stocks as well.

Salmon price (FPI)

We include the salmon price as a control variable to isolate the different effect the salmon price has on land-based relative to conventional salmon farming stock. The salmon price is represented by the Fish Pool Index (FPI). The index is calculated with a 95 percent share from the Nasdaq salmon price index and a 5 percent share from SSB prices. The fixed size distribution is 30 percent 3-4kg, 40 percent 4-5kg and 30 percent 5-6kg salmon. Prices are reported on a weekly basis and we expect the salmon price to correlate positively with the stock returns as higher achieved prices imply higher earnings and profitability for the companies.

As the salmon price that is reported represents the prevailing prices in the market from the week before, it is reasonable to argue that the lagged salmon price should be included in the analysis as well. We perform separate regressions with different lags of the salmon price to test for inclusion of lagged salmon prices. However, they turn out to be insignificant and do not improve the explanatory power of the model substantially. In addition, inclusion of lagged variables consumes degrees of freedom and introduces multicollinearity issues (Wooldridge, 2012). Thus, we choose to not include a lagged salmon price variable in this analysis.

Forward price (M2)

Salmon farming stock returns are also likely to be correlated with expectations of forward salmon prices. Thus, we choose to include the forward price as a control variable in our analysis. The forward prices obtained represent the expectations of Fish Pool Index members towards salmon prices for the coming months (Fish Pool, 2020). These expectations are validated by existing contracts as well as the demand for buying or selling at Fish Pool.

In order to determine which forward price corrects for the most variation in our data, we choose to run separate regressions and include different forward prices, ranging from one to six months. Here, we find that the forward prices of two months fit our data best. We therefore choose to include the two-month forward price as a control variable, and expect it to have a positive correlation with the stock returns.

Land-based dummy

It will also be interesting for this study to examine whether land-based salmon farming stocks have experienced an excess return over conventional salmon farming stocks. We therefore include the dummy variable, which takes the value of one for land-based companies, as a control variable. As seen from the illustration in figure 5.1 (a) above, the dummy for land-based companies enables the two categories to have different intersections with the y-axis (Wooldridge, 2012), which in this analysis enables land-based salmon farming stocks to have different returns compared to conventional salmon farming stocks. Our expectation is that this dummy will correlate positively with the stock returns, meaning that land-based stocks have experienced an excess return the past years.

Price shocks

Lastly, Kleven and Løken (2012) find that the stock returns are less sensitive to price changes when shock occurs. Therefore, we control for price shocks in the salmon price and two-month forward prices by including dummies for extreme changes in these variables. These shocks can occur due to general market turmoil that affects the supply and/or demand for salmon. Intuitively, a positive shock is expected to correlate positively with the stock returns, while a negative shock should have the opposite effect. This will obviously depend on the timing.

As we see from equations 11 and 12 below, we need to define one dummy for positive price shocks, and one for negative price shocks. As we need to do this for both the salmon price and the two-month forward price, we end up with four dummy variables representing these shocks. A shock in forward prices is defined as changes above 1 percent and below -1 percent, while shocks to the salmon spot price are defined as changes above 7 percent and below -7 percent. These thresholds are based on the standard deviation of the forward and salmon spot price data we have obtained. We find the standard deviation to be 0.9 percent for two-month forward prices and 6.9 percent for salmon spot prices. The thresholds are therefore set to be just above one standard deviation.

$$M2D1 = \begin{cases} 1, & M2_t \geq 1\% \\ 0, & M2_t < 1\% \end{cases}, \quad M2D2 = \begin{cases} 1, & M2_t \leq -1\% \\ 0, & M2_t > -1\% \end{cases} \tag{11}$$

$$FPID1 = \begin{cases} 1, & FPI_t \geq 7\% \\ 0, & FPI_t < 7\% \end{cases}, \quad FPID2 = \begin{cases} 1, & FPI_t \leq -7\% \\ 0, & FPI_t > -7\% \end{cases} \tag{12}$$

5.2.2 Event study

Dependent variable

Daily stock returns for the six companies with identified acute mass mortality events represent the dependent variable of this analysis. We define our time frame as 90 days prior to and 90 days past the day of the event. Thus the estimation is done on a total time frame of 181 days, including the event window. This will be equal for all events and each of the nine events will be run as individual regressions.

Independent variable

The independent variable of the event study is represented by a dummy variable, which takes the value of one for days defined within the event window, as explained in section 5.1.3. This is the variable of interest as it measures the abnormal returns and determines whether the stock market reacts significantly to news of unexpected mass mortality events. The dummy variable therefore enables the regression equation to have a different intercept if there has occurred an acute mass mortality event has occured. The statistical significance and magnitude of the event dummy coefficient will be compared between each individual regression, to explore differences in investors' sensitivity between land-based and conventional salmon farming stocks.

Control variable

Lastly, the control variable of this analysis will be represented by a broad stock market index. As the market index is used to measure the theoretical normal returns, the index with the highest explanatory power over the pre-event and post-event window, for each event, will be the best one to use in the event study regression (Krivin et al., 2003). The two broad market indices employed in this analysis are therefore the OBX index (OBX) and the Oslo Stock Exchange Seafood Index (OSLSFX), which are further described below. The efficient market hypothesis states that all information known to the market should be represented in the respective index. Therefore, unexpected company specific shocks, such as unexpected mass mortality events, should be the only cause of abnormal deviations from this index. Thus, we do not control for additional variables in this analysis.

Oslo Seafood Index

The Oslo Stock Exchange Seafood Index comprises nine seafood-related securities. Calculations of the index are based on a free float of outstanding shares and is rebalanced semi-annually (Oslo Stock Exchange, 2020). Shares from the same body with a weight above 30 percent of the total market value of the index are capped. This applies to Mowi, with a market capitalisation corresponding to approximately 33 percent of the index. This weight is therefore capped at 30 percent. Finally, securities registered in countries outside the European Economic Area, such as Salmones Camanchaca which is located in Chile, are only allowed a maximum weight of 10 percent in the index.

5.2.3 The explanatory power of ESG and technology indices on land-based stocks

Dependent variable

In this analysis we aim to figure out which index is best at capturing the return development of Atlantic Sapphire since its initial public offering (IPO). Hence, log transformed returns of Atlantic Sapphire is used as the dependent variable in six individual regressions.

Independent variable

We identify six indices with different characteristics to use as independent variables in each regression, and base our choice on their classification and geographic presence. Therefore, we choose ESG, technology and general market indices for the world and the Nordics for this analysis. We will use the OBX index and the Oslo Stock Exchange Seafood Index as two of these indices. A description of the other indices follows below.

Oslo Information Technology Index (OSE45GI)
The information technology index on the Oslo Stock Exchange is an industry index under the global industry classification standard (GICS) (Oslo Stock Exchange, 2020). The information technology sector includes all companies involved in internet software and services, as well as areas within communication equipment and technology hardware, among others. The companies are listed on either the Oslo Stock Exchange or Oslo Axess, and there are 21 companies operating within this sector today. The index is calculated with a free float number of shares and is reweighted semi-annually. We choose to include this index as we are interested in exploring whether a technology index in Norway is better suited to explain the development of Atlantic Sapphire compared to its own sector index, the Oslo Seafood Index.

MSCI Sustainability Index
The MSCI Sustainability Index is one of many ESG related indices MSCI construct (MSCI, 2020a). MSCI is one of the biggest providers of constructed indices with more than 1,500 ESG related indices. The difference between an ESG index and a sustainability index is that ESG indices are usually comprised of companies that exhibit favourable ESG profiles compared to industry peers, while the sustainability indices are comprised of companies where the core business addresses at least one of the worlds social and environmental challenges. Thus, we choose to include a sustainability index in this analysis as the salmon farming sector addresses some of these challenges.

The index is constructed with a minimum of 30 securities at all times and companies included must generate at least 50 percent in cumulative sales from one or more of the 11 sustainable impact categories (MSCI, 2019). Securities included must also meet the minimum ESG standards. The index is weighted based on sustainable impact dollar sales for each security and adjusted for the security free float market capitalisation times the security index inclusion factor. Lastly, the sector weights are capped at 20 percent, and the index is reviewed on a quarterly basis and rebalanced on a semi-annual basis.

Nordic ESG Index
DNB Markets has defined a set of companies to include in a Nordic ESG Index. We have therefore constructed a value-weighted index based on these ten companies with a maximum

weight of 30 percent for each security. The companies are defined as pure ESG leaders in their respective countries which include Norway, Sweden and Denmark. We examine this index as we attempt to determine whether land-based salmon farming stocks are priced similarly to ESG stocks. We will explain the construction of this index in the appendix.

MSCI World Information Technology Index (MSCIWIT)
All securities included in this index are classified as part of the information technology sector by the Global Industry Classification Standards (GICS) (MSCI, 2020b). It is designed to capture the large- and mid-cap segment across 23 developed markets in the world, including Norway. The index is based on MSCI global investable market index methodology which uses free float adjusted market capitalisation weights. For a security to be included it must have a free float market capitalisation of at least 50 percent of the Equity Universe Minimum Size Requirements. Thus, the securities included are of a certain size. We include this index as we are interested in exploring whether Atlantic Sapphire has had a similar stock development to the world's technology sector, as both have experienced an upward trend in the past years, and the stocks included can be seen as disruptive in the same way as the land-based salmon farming stocks.

5.3 Descriptive statistics

5.3.1 Market capitalisation of selected companies

Market capitalisation refers to the total market value of a company's outstanding shares of stocks (Berk & DeMarzo, 2014) and corresponds to the company's stage in its business development (Merrill, 2020). Small-cap and mid-cap businesses offer more growth potential, but are however more risky compared to mature large-cap companies. This is due to the relative limited sources to which smaller companies have access, which makes them more exposed to market turbulence. In addition, large-cap companies often have bigger and more solid financial investors compared to small-cap or mid-cap companies, with smaller investors of industry backgrounds. Moreover, large-cap companies further have more liquidity in their stocks compared to small-cap or mid-cap companies. Therefore, investments in large-cap stocks are considered as more conservative as these favour less risk above growth potential.

Figure 5.3 illustrates market capitalisation of the included companies, where Mowi, SalMar and Bakkafrost have relatively higher market capitalisation than, for instance, Salmones

Camanchaca, Grieg Seafood and Atlantic Sapphire. Our limitation chapter will further elaborate on how the differences in market capitalisation for companies we analyse affect our results.

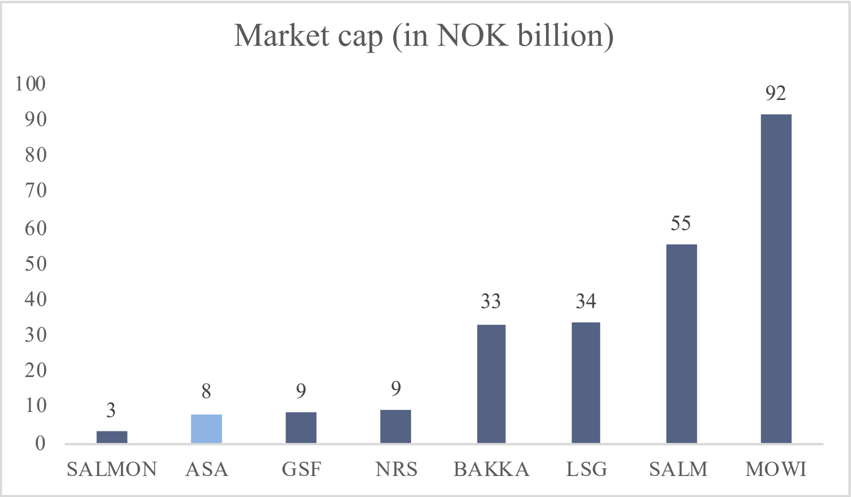


Figure 5.3: *Market capitalisation of selected salmon farming companies as of 4th December 2020*

5.3.2 Summary statistics

Table 6: *Descriptive statistics of companies included in this thesis. Returns are illustrated as simple returns.*

		Atlantic Sapphire	Bakkafrost	Grieg Seafood	Lerøy Seafood Group	Mowi	Norwegian Royal Salmon	SalMar	Salmones Camonchacas	Andfjord Salmon	Salmon Evolution
		ASA	**BAKKA**	**GSF**	**LSG**	**MOWI**	**NRS**	**SALM**	**SALMON**	**ANDF-ME**	**SALME-ME**
Returns	**Min**	-16.22 %	-13.97 %	-17.89 %	-14.76 %	-10.16 %	-14.12 %	-10.95 %	-25.40 %	-8.83 %	-6.51 %
	Median	0.00 %	0.18 %	-0.06 %	-0.04 %	0.03 %	0.17 %	0.04 %	0.00 %	-0.19 %	-1.33 %
	Mean	0.13 %	0.07 %	-0.02 %	-0.01 %	0.00 %	0.04 %	0.06 %	0.02 %	-0.31 %	-1.25 %
	Max	18.28 %	7.33 %	10.77 %	7.88 %	7.41 %	8.68 %	10.89 %	17.02 %	8.00 %	8.07 %
Standard deviation	**Min**	2.61 %	2.12 %	2.62 %	2.11 %	1.86 %	2.32 %	2.21 %	2.65 %	NA	NA
Volume	**Min (NOKm)**	0.0	13.5	9.4	16.3	101.8	0.5	26.2	0.0	0.1	1.1
	Median (NOKm)	2.8	55.2	30.6	55.1	256.6	11.7	88.7	0.1	1.0	4.0
	Mean (NOKm)	12.0	76.5	37.9	63.5	290.3	15.8	105.9	1.0	1.9	8.8
	Max (NOKm)	973.9	3,861.0	219.4	457.6	1,015.0	248.1	703.1	70.7	31.2	101.0
Number of observations		615	615	615	615	615	615	615	615	91	28

Table 6 presents descriptive statistics for the financial data of the salmon farming companies included in this thesis. Although Salmon Evolution and Andfjord Salmon are excluded from our regression analyses, they are included in the relative analysis. Thus, we choose to include them in the descriptive statistics as well.

As seen from table 6, we observe that Atlantic Sapphire has experienced the highest average return of 0.13 percent, in the time period ranging from 15th May 2018 to 4th December 2020.

We also observe that Bakkafrost, Norway Royal Salmon, SalMar and Salmones Camanchaca have also had a positive average return, while the remaining companies have had a negative or zero return since 2018. We also observe a discrepancy between the mean and the median returns for the companies. This could indicate that the simple return distributions are skewed, which is one of the reasons we use log transformed returns in our regression analyses. This will further be discussed in the appendix.

Furthermore, it is evident that Atlantic Sapphire and Salmones Camanchaca have the highest spread of returns in the data which could indicate a higher volatility for these companies. We see from the standard deviation, which is a measure of risk, that this is true. In addition to Grieg Seafood, these two companies have the highest standard deviation of around 2.6 percent. The high standard deviation could be a result of two factors, one of them being operation-specific conditions and the other one being low liquidity. Low liquidity relates to the traded volume in the stock. If this is low on average, each trade will have a bigger impact on the stock price, which could imply a higher volatility in the returns.

To elaborate, table 6 above also presents the metrics for volume traded for each company. Here, we observe that both Atlantic Sapphire and Salmones Camanchaca have days with no trade. In addition, when looking at the average traded volume in percent of the company's market capitalisation, we observe that Salmones Camanchaca has five times less volume traded compared to Atlantic Sapphire. They respectively have 0.03 percent and 0.15 percent traded volume in percent of its market capitalisation. Hence, the traded volume may correlate with the market capitalisation of the companies, as small-cap companies have lower volumes traded. Still, Grieg Seafood, which is of a similar size to Atlantic Sapphire, has a much higher volume traded. Thus, when viewing the substantial difference in the liquidity together with the similar standard deviation of the stock returns, this may imply that Grieg Seafood's volatility relates more to operation-specific conditions, while Atlantic Sapphire's volatility relates more to the low liquidity of the stock.

Lastly, Andfjord Salmon and Salmon Evolution also seem to suffer from low liquidity in their stocks. This is reasonable as the stocks are traded on Merkur Market, which is an unregulated and less liquid market place. It is also worth mentioning that Atlantic Sapphire just recently transferred to the Oslo Stock Exchange from Merkur Market (5th May 2020), which could be a reason for the company's lower average volume traded relative to conventional stocks over the time period in which we conduct our analyses.

5.3.3 Salmon price (FPI) and forward prices

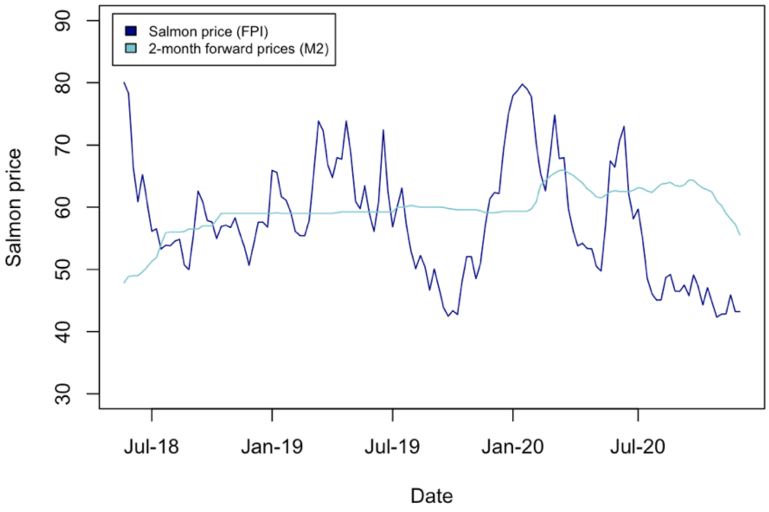


Figure 5.4: *Price development of trailing and forward salmon prices*

As we observe from figure 5.4, the average salmon price over the past two years has averaged around 60 NOK/kg. This is substantially higher compared to the average salmon price from year 2000, which was approximately 38 NOK/kg (Statistics Norway, 2020).

Furthermore, the salmon price seems to vary substantially, as observed in figure 5.4. Asche, Msiund, and Oglend (2016) suggest that the spot price displays deterministic seasonal patterns which is most likely due to periodic harvesting patterns. To reduce mortality rates when smolts are released into seawaters, the release is usually in the spring and autumn when water temperatures are optimal. This results in significant seasonal patterns for harvesting volumes which in turn affects the spot price according to the supply-demand theorem.

Lastly, we observe that the two-month forward prices are more stable at approximately 60 NOK/kg, which coincides with the average of the salmon price. This makes sense as it reflects the expectations of forward prices that has prevailed in the market over the past years. In addition, forward prices can deviate substantially from spot prices due to short-term volatility. For instance, the pandemic will affect the spot prices significantly, but should not change the expected supply and demand dynamics for the future substantially (Emmons & Timothy, 2002). On the other hand, the Fish Pool Index forward prices are constructed based on members expectations, and are thus highly dependent on the number of members using Fish Pool. Therefore, these prices could be subject to low liquidity which is also a viable reason for the low volatility.

6. Empirical findings

In this chapter, we present our findings of how investors value land-based compared to conventional salmon farming companies, and further investigate investors' sensitivity to investments in land-based salmon farming. Findings from our interviews are presented for each analysis. In addition, we include a separate section regarding premium pricing of land-raised salmon, production costs, technology and the future of the salmon farming industry. First, we show how the salmon price impacts stock returns of land-based and conventional salmon farming stocks. Second, we present the event study to observe investors' sensitivity to unexpected mortality events for land-based compared to conventional salmon farming stocks. Next, we present the explanatory power of multiple ESG and technology indices on land-based stocks to examine which of these indices have the highest significant explanatory power on land-based stocks. Thereafter, we present a relative valuation to examine how investors value salmon farming companies. Finally, we summarise insights from our market participants'.

6.1 The impact of salmon prices on stock returns

Hypothesis: *The salmon price has a significantly lower impact on land-based relative to conventional salmon farming stock returns.*

At first glance at figure 6.1 below, it seems that Atlantic Sapphire is less correlated with the rest of the salmon farming stocks and the salmon price (FPI). This observation is supported by the correlation coefficients from table 7, where we can conclude that Atlantic Sapphire's stock price does not correlate with the salmon price. On the other hand, we observe that SalMar and Salmones Camanchaca do not correlate with the salmon price either and therefore we cannot draw a conclusion based on these figures alone. Furthermore, it looks as if Atlantic Sapphire has experienced an excess return over the past two years compared to the general seafood sector. Lastly, we observe an upward trend in Atlantic Sapphire's stock price. However, the stock experienced a more substantial drop due to the pandemic, compared to the other seafood stocks and the salmon spot price.

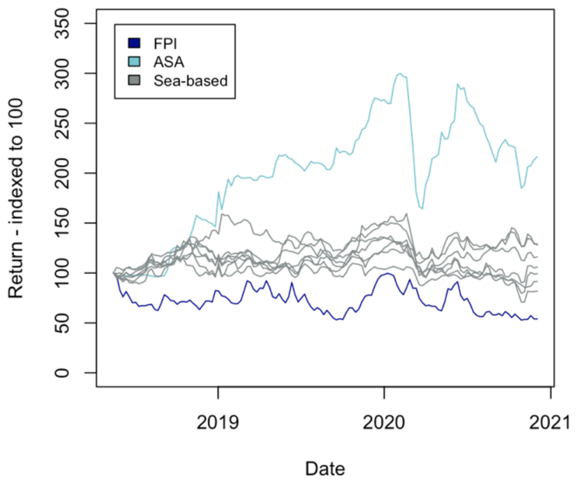


Figure 6.1: *FPI and stock price development*

Pearson correlation coefficients	FPI
ASA	0.0072
BAKKA	0.2353***
GSF	0.2860***
LSG	0.2209**
MOWI	0.2425***
NRS	0.3061***
SALM	0.1587*
SALMON	0.0897

Alternative hypothesis: true correlation is not equal to 0
Significance levels: *p<0.1; **p<0.05; ***p<0.01

Table 7: *Log transformed correlation coefficients*

Conducting a pooled OLS, on the specified models in section 4.3.1, provides us with the results from table 8. We employ panel data in the regressions and our dependent variable is thus log transformed returns of both land-based and conventional salmon farming stocks. Each regression is run with a new set of independent variables in order to capture as much variation in the data as possible. The pooled OLS method is used in all regressions with group clustered standard errors employed for robust estimation (Wooldridge, 2016). As we have a small dataset and therefore a small number of clusters, we make use of small sample bias adjustment to the clustered standard errors as well. This gives less weight to influential observations (RStudio, n.d.).

The variable of interest in our main model (regression 3) is the interaction term between the salmon price and the dummy for land-based companies (FPI: Land-based). This term explains whether the salmon spot price (FPI) has a different effect on the returns of land-based compared to conventional salmon farming companies. It will also be interesting to look at the interaction term between two-month forward prices and the land-based dummy (M2: Land-based) in regression 4 to see whether there exist differences in the relationship here as well. In addition, the land-based dummy in isolation is of interest as it will explain a potential excess return for land-based salmon farming stocks.

All models include the broad OBX index, the salmon price (FPI) and two-month forward prices (M2) as control variables. Comparing regression 1 and regression 2, which respectively include salmon price shocks (FPI shock) and two-month forward price shocks (M2 shock), we see that regression 1 is able to explain more of the variation in the data relative to regression

2. In addition, we observe that the forward price shocks are not statistically significant. We therefore choose to build on to model 1 for further analysis.

The difference between regression 3 and 4 is the interaction term. In model 3, we use salmon spot prices in the interaction term, while in model 4 we use the two-month forward prices. Regression 3 is able to explain slightly more of the variation in the data, and the interaction term between the salmon price and the land-based dummy (FPI : Land-based) is statistically significant. Hence, regression 3 acts as our main model specification of this analysis.

Table 8: *Summary of regression results of the salmon price analysis*

	Dependent variable: Log transformed returns on salmon farming stocks			
	1	2	3	4
OBX index	0.641***	0.658***	0.641***	0.641***
	(0.067)	(0.078)	(0.067)	(0.068)
Fish pool index (FPI)	0.156***	0.094***	0.171***	0.156***
	(0.048)	(0.026)	(0.049)	(0.048)
Two month forward prices (M2)	0.373***	0.314	0.373*	0.431**
	(0.192)	(0.285)	(0.192)	(0.196)
FPI shock (more than 7% change = 1)	-0.022***		-0.022***	-0.022***
	(0.006)		(0.006)	(0.006)
FPI shock (less than -7% change = 1)	-0.006		-0.006	-0.006
	(0.007)		(0.007)	(0.007)
Land-based dummy			0.005	0.006
			(0.004)	(0.004)
FPI : Land-based			-0.116**	
			(0.045)	
M2 : Land-based				-0.460
				(0.286)
M2 shock (more than 1% change = 1)		0.003		
		(0.007)		
M2 shock (less than -1% change = 1)		0.004		
		(0.011)		
Constant	0.006***	0.001	0.005**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	1,064	1,064	1,064	1,064
R^2	0.243	0.217	0.250	0.247
Adjusted R^2	0.240	0.213	0.245	0.242
F Statistic	67.993*** (df = 5;1058)	58.627*** (df = 5;1058)	50.215*** (df = 7;1056)	49.374*** (df = 7;1056)

Significance levels: *p<0.1; **p<0.05; ***p<0.01

Looking at our main model (regression 3), we observe that the coefficient for the positive salmon price shock variable is negative, which is surprising. We expected that a positive price shock would increase the stock returns, but here we observe that a positive price shock leads to an exp(-0.22) - 1 = 1.98 percent decrease in the stock returns. The reason for this likely relates to the timing of the price shocks. As we see from the regression coefficients, the stock returns of salmon farming stocks are more dependent on changes in the OBX index relative to the salmon spot price. A negative return of the OBX index could therefore outweigh the impact of a positive price shock. This is apparent from our data as the times where a positive price shock corresponds to substantial negative returns in the salmon farming stocks, the OBX index has also exhibited a substantial negative return.

Regression 3 further includes the interaction term between the salmon price and the land-based dummy (FPI: Land-based). This interaction term is statistically significant on the five percent level with a negative sign on the coefficient. Hence, this supports our hypothesis that land-based stocks are less affected by changes in the salmon price, and that the two categories have different slope coefficients. The coefficient of this interaction term indicates that a one percent change in the salmon price will affect the return on land-based salmon farming stocks by approximately 0.12 percent less than for conventional salmon farming stocks. Thus, a one percent increase in the salmon price would lead to a 0.171 – 0.116 = 0.055 percent increase in the returns for land-based stocks. This is arguably a negligible impact but it makes sense as Atlantic Sapphire's stock returns will be affected by the development of the salmon price times the probability of success, while conventional salmon farming stocks are only affected by the salmon price.

Furthermore, regression 3 indicates that a one percent increase in the salmon price will increase the stock return for conventional salmon farming stocks by 0.171 percent, while a one percent increase in the two-month forward prices increases the stock returns by 0.373 percent. A positive coefficient on both variables makes sense in an economic framework, as the salmon price determines the profitability of salmon farming companies. However, this also implies that salmon farming stock returns are more affected by expectations of future compared to salmon spot prices.

Another interesting observation is that the land-based dummy has a positive sign on the coefficient. Still, it is not statistically significant and we cannot therefore conclude that Atlantic Sapphire has experienced an excess return over the conventional salmon farming stocks in the past two years.

Turning to regression 4, we observe that the interaction term between two-month forward prices and the land-based dummy is not statistically significant. Hence, we cannot conclude that land-based stock returns are affected differently by changes in the two-month forward prices relative to conventional salmon farming stock returns. Forward salmon prices are arguably a more important factor for the present value of growth opportunities. As it can be argued that the value of land-based stocks only consists of the present value of growth opportunities, it makes sense that forward salmon prices will affect land-based stocks more than salmon spot prices, thus making the impact of forward salmon prices on land-based stocks more equal to the impact on conventional stocks.

In conclusion, our findings indicate that salmon spot prices affect land-based salmon farming stocks less in comparison to conventional salmon farming stocks, which confirms our hypothesis. However, we cannot conclude in any significant excess return for land-based stocks or any different influence from forward prices. Our findings may therefore indicate that there may be different factors influencing land-based compared to conventional salmon farming stock returns, but that there also exist factors that impact the two groups in similar ways. We will discuss this further in the section below, with market participant's views.

6.1.1 Investment perspectives

The majority of our interviewees supports our hypothesis and believe that the salmon price affects land-based significantly less compared to conventional salmon farming stock returns.

For traditional salmon farming companies, 70-80 percent of future earnings are dependent on the salmon price, given that the volume and cost picture is seen as stable. Our interviewees further emphasise that conventional salmon farming stocks are priced at a 2-3 year market balance. Therefore, the salmon spot price is an important determiner for conventional salmon farming profits, and therefore also the stock returns.

Turning to the valuation of land-based companies, these stocks are argued to be more dependent on future expectations of success compared to conventional salmon farming stocks. An analogy with concepts stocks can therefore be drawn, in line with Hsieh and Walking (2006). Thus, investors believe that land-based stocks mainly react to news related to the development of the company, such as, progress in the build-out phase, technological errors and cost overruns. In addition, our interviewees emphasise that there is little clarity on production and investment costs, as well as the time-perspective regarding achievement of targeted volumes. Thus, factors determining future earnings, and therefore the stock price development for land-based companies, will be proof of concept, time perspective, costs and future salmon prices. Hence, salmon spot prices appear to be a minor part of what determines future earnings for land-based stocks compared to conventional salmon farming stocks.

However, the salmon price is still a determinant factor of profitability in land-based projects because it acts as a cornerstone for determining the sales price of salmon. Furthermore, as expectations for future salmon prices rely on current prices, these prices will inevitably affect future profitability for all salmon farming companies. Changes in salmon spot prices may therefore affect land-based stock returns to some extent, but changes in forward salmon prices will probably affect the stock returns significantly more. Hence, this argument correspond with our findings in section 6.1.

On the other hand, interviewees who disagree with our hypothesis emphasise that land-based companies have higher production costs as they are ramping up their operations. This could therefore justify a higher sensitivity to the salmon price as land-based salmon farming companies are more dependent on a high salmon price to become profitable. Such an argument therefore indicates that land-based stocks should correlate more with the salmon price compared to conventional salmon farming stocks. However, this argument seems less convincing compared to the discussion above.

Still, one major reason for the surge in land-based salmon farming projects is the increased profitability the seafood sector has experienced in the past years, which is mainly a result of high salmon prices. We can compare this situation to the time when the oil sector experienced a boom of extraordinary oil prices. At that time, drilling activities increased and it became more attractive to establish operations in the sector as it was profitable to enter even though the company could not compete on cost efficiency. Similarly, high salmon prices enable the same dynamics with increased market entry. Land-based salmon farming can be viewed as such a competitor, which is not necessarily competitive on cost, but profitable when salmon prices are high. Several interviewees therefore believe high salmon prices will be important for the future development of the land-based industry.

In conclusion, both our qualitative analysis supports our quantitative analysis that the salmon spot prices affects land-based stocks significantly less compared to conventional salmon farming stocks. Furthermore, our interviewees argue that, while conventional salmon farming stocks correlate nicely with the salmon spot price, land-based stock will probably correlate more with the de-risking of the stocks. Hence, fundamental elements such as temporary fluctuations in the salmon price will be of less importance for the land-based stocks.

6.2 Event study

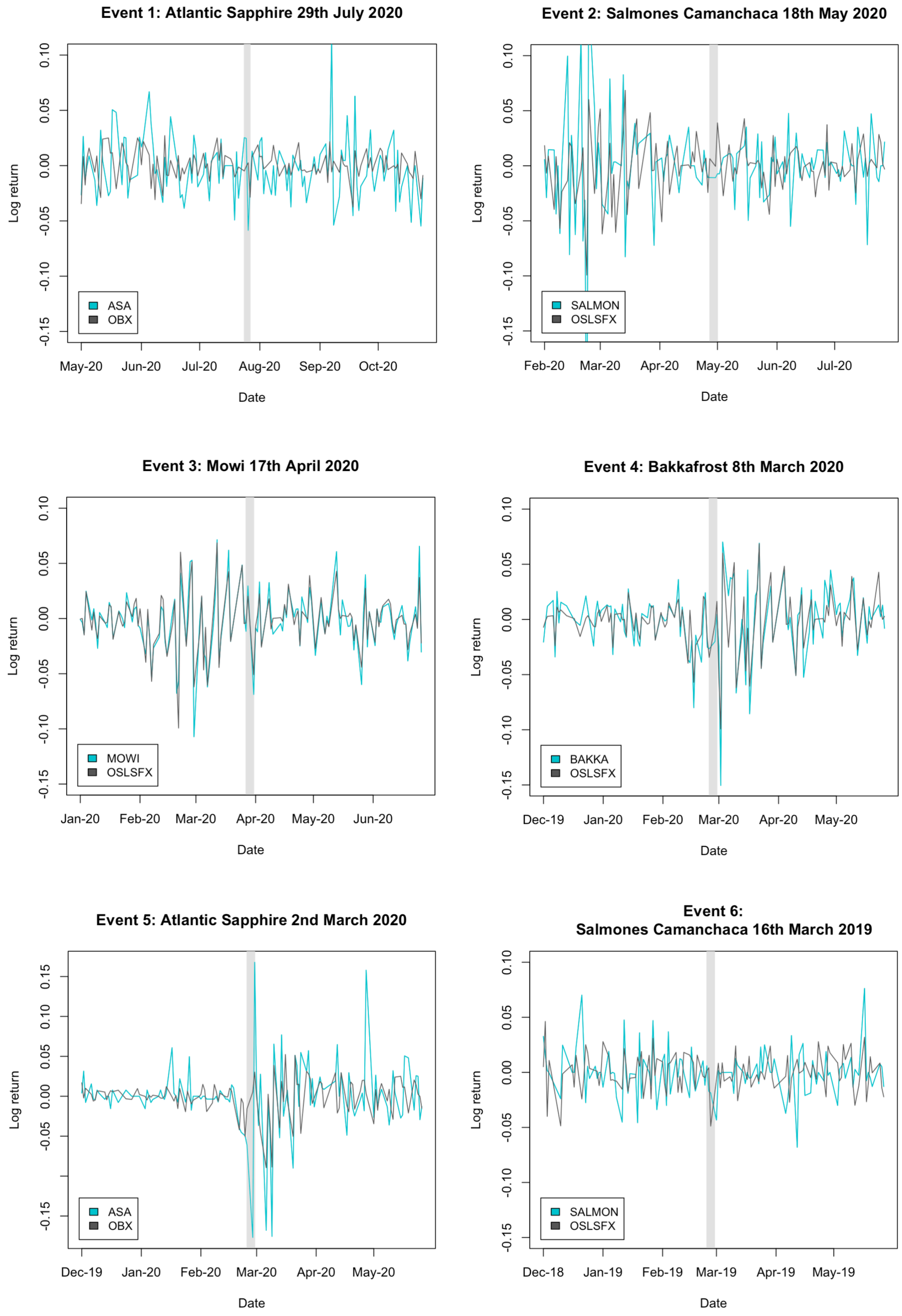
Hypothesis: *Investors react significantly more to acute mass mortality events at land-based facilities relative to conventional open-net pen facilities*

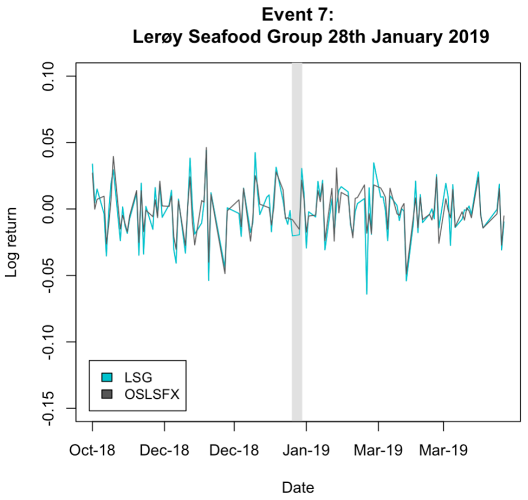
To develop insight into investors' sensitivity towards acute mass mortality events, in salmon farming companies of different sizes, we start by looking at figure 6.2 below. Here, the stock price development for each event is plotted for a total of 181 days, spread symmetrically around the event window, as we elaborate in the data chapter. The respective index we use as the market model for each event is plotted alongside the stock returns, and the event window, with two trading days surrounding it, is shaded in grey.

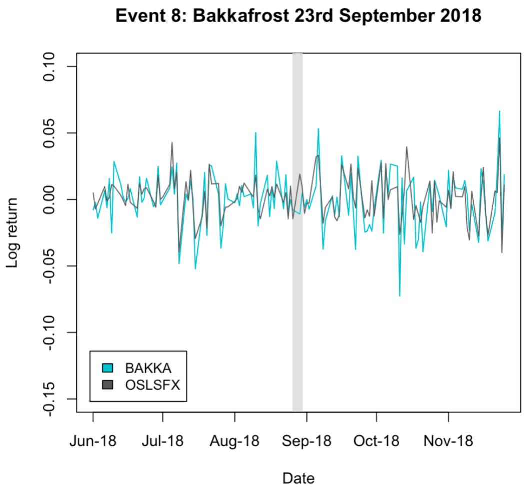
First, we observe that most of the acute mass mortality events appear to have had no impact on the stock returns. However, it seems as if investors react substantially more to event 1 and event 5, which both happened at Atlantic Sapphire's facilities. These observations suggests that investors are more sensitive to events occurring for land-based compared to conventional salmon farming stocks, in line with our hypothesis.

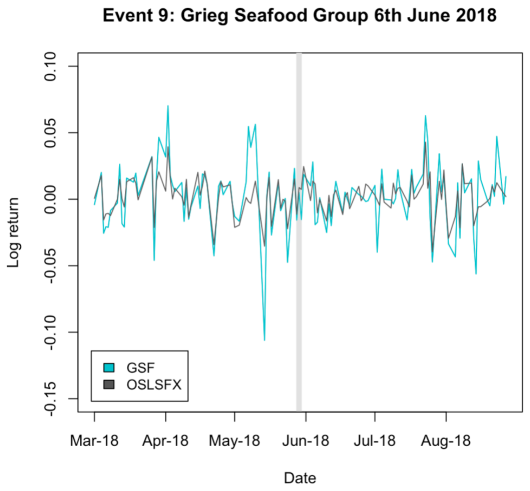
In addition, we observe that the pandemic affects the stock price reactions substantially. Looking at events 2-5, which occurred in March, April and May, we observe a substantially higher volatility compared to January and February, as well as to the other events. Thus, investors may have reacted more to news in these months due to the general market uncertainty. In contrast, the market calmed down over the summer, which arguably makes it easier to isolate the reactions to event 1.

Figure 6.2: *Stock price development of companies included in the event study*




Event 7:
Lerøy Seafood Group 28th January 2019


Event 8: Bakkafrost 23rd September 2018


Event 9: Grieg Seafood Group 6th June 2018

Turning to the analysis, we run nine individual OLS regressions and obtain the results presented in table 9. Each regression is run with a stock index as the market model, where the indices included are the OBX and the Oslo Stock Exchange Seafood index. The index we choose for each regression depends on which index has the highest explanatory power for the stock returns over the entire period we analyse. We compare the magnitude and statistical significance of all event-dummies to obtain an understanding of the difference in investors' sensitivity to acute mass mortality events. Robust standard errors are employed in event 3 to adjust for heteroscedasticity and serial correlation issues, while a lagged dependent variable is included in Bakkafrost's event 8 and Salmones Camanchaca's event 2 to adjust for serial correlation issues.

From table 9, we observe that four out of our nine defined events result in a significant reaction in the stock returns. We exclude Bakkafrost's event 8 in this definition, as we require a significance level of five percent to conclude with rejection of our null hypothesis.

Furthermore, most of the estimated event dummy coefficients have a negative sign, indicating that the stocks experience negative returns when announcing an acute mass mortality event. Still, when the coefficient is not statistically significant, we cannot conclude that the negative return is greater than general stock volatility.

Both of Atlantic Sapphire's events result in a statistically significant reaction to the stock returns. For the event occurring on 27th July, our model indicates that this event led to an exp(-0.058)-1= 5.6 percent drop in the stock returns. The stock reaction to the event occurring on 2nd March was of a greater magnitude, with the event leading to an exp(-0.184) - 1 = 16.8 percent drop in the stock returns. Furthermore, Salmones Camnchaca's event 2 becomes significant with an exp(-0.009) – 1 = 0.9 percent drop in the returns. Still, this is a much lesser reaction compared to the two in Atlantic Sapphire. Lastly, the event occurring at Mowi's facilities, in May, also led to a significant reaction in the stock returns. However, this event actually led to an increase in the stock returns which indicates that other news in the market may have offset the impact of the negative acute mass mortality announcement. These results support our hypothesis that investors are more sensitive to acute mass mortality events that occur in land-based compared to conventional salmon farming facilities.

Table 9: *Summary of regression results event study*

Dependent variable: Log transfromed returns of salmon farming stocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ASA 29/07/2020	SALMON 18/05/2020	MOWI 17/04/2020	BAKKA 08/03/2020	ASA 02/03/2020	SALMON 15/03/2019	LSG 28/01/2019	BAKKA 23/09/2018	GSF 06/06/2018
Market model	0.565***	0.623*	1.023***	1.058***	1.016***	0.163	1.081***	0.959***	1.373***
	(0.174)	(0.343)	(0.078)	(0.060)	(0.147)	(0.122)	(0.050)	(0.001)	(0.103)
Event dummy	-0.058**	-0.009**	0.009***	-0.017	-0.184***	-0.011	-0.002	-0.029*	-0.006
	(0.025)	(0.003)	(0.002)	(0.016)	(0.035)	(0.022)	(0.009)	(0.015)	(0.016)
Constant	-0.002	-0.001	-0.001	0.001	0.002	-0.00002	-0.001	-0.001	-0.001
	(0.002)	(0.004)	(0.001)	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)
Observations	125	122	122	117	118	116	120	128	121
R^2	0.113	0.130	0.857	0.736	0.391	0.022	0.799	0.532	0.602
Adjusted R^2	0.098	0.116	0.854	0.731	0.380	0.005	0.795	0.520	0.595
F Statistic	7.747*** (df =2;122)	8.836*** (df = 2;118)	355.7*** (df = 2;119)	158.9*** (df = 2;114)	36.887*** (df = 2;115)	1.288 (df = 2;113)	232.1*** (df = 2;117)	46.52*** (df = 3;123)	89.31*** (df = 2;118)

Significance levels: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Moreover, we observe a substantial difference in the reaction of the two events occurring for Atlantic Sapphire. An explanation for this difference cannot be related to the total cost of incident, as the event occurring in July amounted to a NOK 5 million cost for Atlantic Sapphire compared to the event in May, which incurred a total cost of NOK 3 million for the company.

However, the event in May was caused by high nitrogen levels in the tanks, which has been a well-known issue in land-based facilities. Such an event may therefore be seen as a greater threat to the probability of success, compared to the incident in July, caused by construction delays which stressed the fish and resulted in an acute mass mortality event. The latter event will arguably be easier to mitigate in the future.

To sum up, the results from our event study supports our hypothesis that investors are more sensitive to acute mass mortality events happening at land-based compared to conventional salmon farming facilities. Furthermore, it seems as though the total cost of incident is not the determinant factor of the magnitude in the stock reaction to incidents in land-based stocks. It could therefore be argued that investors' perception of the threat to the probability of success, caused by the event, is a more likely explanation for the difference in magnitude of these stock reactions. Still, it must be noted that the pandemic is a dominant factor here, which we will elaborate on in the limitation chapter.

6.2.1 Investment perspectives

Most of our interviewees agree with the hypothesis that investors are more sensitive to acute mass mortality events occurring for land-based compared to conventional salmon farming companies. Several investors highlight the fact that these mass mortality events raise questions and uncertainty around the viability of this immature technology on fully out-grown salmon production. This may lead to investors losing faith in the concept overall, which supports a sharp reaction in the share price when acute mass mortality events occur. Yet our interviewees highlight that the event occurring in July was of less concern compared to the event in May, which was caused by elevated nitrogen levels. Conventional salmon farming companies have, on the other hand, a proven technology which is why investors are much less concerned with acute mass mortality events occurring in open-net pens.

Furthermore, our interviewees highlight the possible implication of low liquidity in Atlantic Sapphire's stock. They emphasise that the low liquidity may result in greater reactions in Atlantic Sapphire's stock price, when new information enters the market, compared to the conventional stocks.

Another argument, which advocates for a lesser reaction of conventional salmon farming stocks to unexpected mass mortality events, is the fact that many of the listed conventional companies are big, with a diverse portfolio of sites in different locations and countries. This means that an event occurring in one of the company’s locations will affect only a fraction of the company’s total production. On the other hand, Atlantic Sapphire’s incidents wipe out almost the entire production at the respective site, which in turn represents the majority of its total production.

An argument which, on the other hand, contradicts our hypothesis is that many investors are aware of the risks associated with investing in a young company without a proven concept. Thus, investors should expect such events to occur for land-based companies while they grow and improve their technology. They also argue that such events, in time, will lead to increased knowledge and better design of their facilities. Still, they highlight the fact that rational and professional investors usually expect such events, but “other” investors might not and therefore react sharply as these events occur.

Moreover, the sharp counter reaction of the stock returns in the days following the event at Atlantic Sapphire’s facilities in March, is probably a result of management’s ability to reassure their investors about the viability of the technology. Several investors highlight that they had close contact with the management right after the announcement of the event. From these conversations, investors highlight that the management provided good explanation to the incidents, which reassured them and convinced them of not to withdraw their investment. Furthermore, they emphasise the importance of having faith in the management in such early phase companies. Investors were also quickly contacted by the management right after the event in July.

To sum up, the majority of the market participants believe that investors are more sensitive to investments in land-based compared to conventional salmon farming stocks. Size of the company plays a major role, as the traditional salmon farming companies have diverse portfolios and will be less affected by mortality events compared to Atlantic Sapphire with a relatively low production volume. Yet, investors who invests in Atlantic Sapphire argue that they are aware of the risks associated with investing in an early phase company, which should have favoured a lesser reaction to such events. Moreover, the management’s ability to reassure investors, after such incidents occur, demonstrates the considerable confidence investors place in the management. However, it seems as though investors still reacts substantially more strongly to such events at land-based facilities. We can therefore conclude that market participants also support our findings in section 6.2, in line with our hypothesis.

6.3 The explanatory power of ESG, sustainability and technology indices on land-based stocks

Hypothesis: *ESG, sustainability and/or technology indices have the highest explanatory power on land-based stocks.*

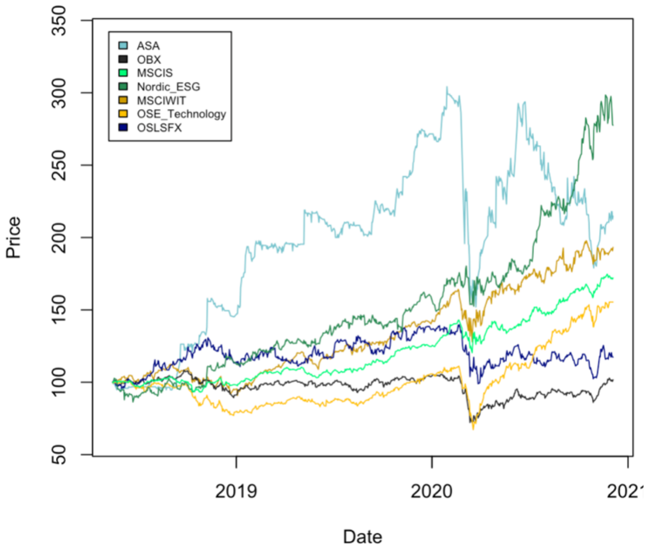


***Figure 6.3**: Stock indices development since Atlantic Sapphire IPO*

	Pearson correlation coefficients
	ASA
OBX	-0.1818***
MSCISI	0.6120***
OSE_Technology	0.3157***
OSLSFX	0.6328***
MSCIWIT	0.6515***
Nordic_ESG	0.5795***

Alternative hypothesis: true correlation is not equal to 0
Significance levels: *p<0.1; **p<0.05; ***p<0.01

***Table 10**: Simple returns correlation coefficients between Atlantic Sapphire and stock indices*

To begin with, in figure 6.3 we observe the stock development of Atlantic Sapphire compared to the chosen group of stock indices. At first glance, it seems that Atlantic Sapphire's stock considerably outperformed all included stock indices up until March of 2020, when the pandemic hit. After this point, only the Nordic ESG Index outperforms Atlantic Sapphire's stock returns. In addition, it seems that similar to the ESG, sustainability and technology indices, Atlantic Sapphire also has experienced an upward trend in the past two years. However, Atlantic Sapphire's positive trend was halted sharply by the pandemic, in contrast to the ESG, sustainability and technology indices. Turning to the Seafood index and the broad OBX index, it looks as if they have had no evident positive trend.

Furthermore, it is hard to determine which index explains most of the stock development in Atlantic Sapphire from figure 6.3. The similar trend in Atlantic Sapphire and the ESG, sustainability and technology indices may indicate that one of these indices will be able to explain most of the development. Still, none of them seems to correlate much with Atlantic Sapphire in 2020.

From the correlation coefficients in table 10 above, it looks as if there is a high correlation between Atlantic Sapphire's stock returns and the MSCI technology index, the MSCI sustainability index and the Nordic ESG index, which could imply a similar pricing of Atlantic Sapphire to these types of stocks. This is also true for the Seafood index. The OBX index, on the other hand, correlates negatively with Atlantic Sapphire's stock prices. Still, it must be noted that these correlation coefficients are based on stock price development and not log transformed returns.

Table 11: *Summary of regression results for the index explanation analysis*

Dependent variable: Log transformed returns of Atlantic Sapphire (ASA)						
	1	2	3	4	5	6
OBX index	0.737*** (0.158)					
OSE technology index		0.475*** (0.134)				
Oslo Seafood Index			0.373*** (0.096)			
MSCI sustainability index				0.607*** (0.191)		
Nordic ESG index					0.211*** (0.079)	
MSCI world information technology index						0.195* (0.114)
Constant	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Observations	643	643	643	643	643	643
R^2	0.142	0.073	0.064	0.049	0.020	0.015
Adjusted R^2	0.141	0.072	0.063	0.047	0.018	0.014
F Statistic (df = 1; 641)	106.294***	69.546***	44.012***	32.912***	12.899***	9.860***

Significance levels: *p<0.1; **p<0.05; ***p<0.01

Table 11 provides us with results from the specified models from section 4.3.3. We run six individual OLS regressions with log transformed returns for Atlantic Sapphire as the dependent variable. Each regression is run with a new stock index as the explanatory variable in order to examine which index is best at explaining the variation in Atlantic Sapphire's stock returns, and thus improve our understanding of how investors price land-based stocks. As our data contain heteroscedasticity and serial correlation issues, we employ robust standard errors, which also adjust for small sample bias, in all regressions (Wooldridge, 2012).

The adjusted r-squared is the most interesting element in these regressions as it indicates each index' ability to explain variation in land-based salmon farming stock returns. We see that all indices, except the MSCI information technology index, are statistically significant at the one percent level, meaning they are all able to explain some of the development in land-based salmon farming stocks. On the other hand, there are substantial differences in how much the indices are able to explain. Our findings surprisingly suggest that the broad OBX index has the highest adjusted r-squared, of 14.1 percent, and therefore acts as the most appropriate index to use as reference for land-based stocks. These findings are surprising as our hypothesis suggests that the ESG, sustainability, and/or technology indices are better at explaining the development in land-based stocks. Hence, we see that our findings do not support our hypothesis for this analysis. One potential reason for this result might be that the uncertainty regarding Atlantic Sapphire's probability of success prohibits sector specific and fundamental factors to affect the stock returns. Therefore, fluctuations in the broader market sentiment may be the only factor, in addition to company specific news, which will affect the stock returns. Hence, fluctuations in the OBX index may prompt investors also owning Atlantic Sapphire to rebalance their portfolios and holdings in this stock at the same time.

Moreover, our results in table 11 suggest that the Seafood index has a low explanatory power of 6.3 percent. This further emphasises that the stock development of land-based salmon farming stocks deviates substantially from the stock development of conventional salmon farming stocks. We can especially see this if we compare the correlation between land-based stocks and the Seafood index with the correlation between conventional salmon farming stocks, of similar size, and the Seafood index. E.g. the Seafood index has an explanatory power of 40-50 percent for both Grieg Seafood Group and Norway Royal Salmon. This result also support our findings from the salmon price analysis in section 6.1.

We additionally observe that the OSE technology index is the second best index to explain land-based salmon farming stock's performance, with 7.2 percent explanatory power. Compared to the MSCI information technology index, with only 1.4 percent explanatory power, it looks as if land-based stocks exhibit characteristics that are more compatible with companies in the technology index at the Oslo Stock Exchange. One possible reason for this, which is in line with our hypothesis, may be that both the land-based salmon farming industry and companies included in the OSE technology index disrupt the traditional way of operating. This argument may also hold true for the MSCI information technology index, which emphasises that land-based salmon farming stocks may in general be more affected by local conditions compared to global. The ESG and sustainability indices, on the other hand, performs poorly which contradicts our hypothesis.

Although the OBX index yield the highest r-squared of all our regressions, it is still only able to explain 14 percent. This low explanatory power can probably be explained by the fact that stock prices of land-based companies are driven by a binary outcome of success or no success. Therefore, day-to-day news and company specific events, which impacts their probability of success, will create big fluctuations in land-based salmon farming stock prices, while it will not be of importance to the investors of conventional salmon farming stocks or other stocks listed at the Oslo Stock Exchange. On the other hand, more fundamental drivers of stock prices, such as interest rates, will probably not affect land-based salmon farming stocks to the same extent as for conventional salmon farming stocks.

In short, our findings from this analysis convey that the OBX index explains the most of the variation in land-based stock returns, compared to other included ESG, sustainability and technology indices. It can also be noted that land-based stocks have experienced a similar trend to ESG, sustainability and technology stocks, but that these indices are still not able to explain a lot of the fluctuations in land-based stock returns. Additionally, it looks as if land-based salmon farming stocks are better explained by local stock indices, which is probably because a majority of its shareholders are Norwegian. Based on these results, we cannot conclude that our hypothesis is correct. However, these findings support our findings from the salmon price analysis in section 6.1, as it indicates that land-based stocks are not driven by fundamental factors to the same extent that conventional salmon farming stocks are.

6.3.1 Investment perspectives

Market participants' views, with regard to whether ESG indices can have a significant explanatory power on land-based stocks, seem to be unclear. Our interviewees emphasise that it is hard to determine if these companies can fully be categorised as an ESG stock, in line with stocks included in ESG indices.

On the one hand, as the technology for farming salmon on land is believed to reduce the majority of biological issues raised in sea, several of our interviewees state that salmon farmed on land improves fish welfare compared to salmon farmed in traditional open-net pens. With this in mind, they argue in favour of a higher ESG score for land-based compared to conventional salmon farming stocks, and in turn believe that ESG indices could have an explanatory power on land-based stock returns. They also believe Atlantic Sapphire stock returns have had an excess return over conventional salmon farming stocks. However, our findings in section 6.1 imply that we cannot conclude with an excess return.

Conversely, several of our interviewees argue that there should not exist a causal relationship between ESG indices and land-based salmon farming stocks. Still, some investors may favour the sustainability profile land-based salmon farming companies brand, as this is argued to reduce negative externalities upon third parties. Furthermore, as the mortality rate for fully out-grown production in land-based facilities is not yet fully known, and the technological risk is very high, they emphasise that it is difficult to categorise land-based salmon farming stocks as ESG stocks today. The fact that Atlantic Sapphire has experienced unexpected mortality events makes it even more difficult for investors to address their concerns regarding fish welfare, and thus the environmental assessment. They consequently emphasise that it will be interesting to analyse whether an ESG-premium may be visible in the future, when the production volumes achieve a steady state.

Although this group may not believe in a premium pricing due to environmental factors, some interviewees point out that Atlantic Sapphire's stock returns may have had a significant excess return over conventional salmon farming stocks. Yet, they emphasise momentum as an explanation behind this, instead of ESG factors.

When discussing whether technology indices can explain the variation of land-based salmon farming stocks, several interviewees emphasise the successful development the technology stocks experienced, as an implication of COVID-19 restrictions in 2020. However, this is not true for Atlantic Sapphire, as it experienced a substantial drop in stock returns.

In sum, our quantitative findings suggest that sustainability, ESG and technology indices does not explain the development of Atlantic Sapphire's stock returns well. However, several interviewees emphasise that ESG indices should have an explanatory power on land-based stock returns as this industry should improve fish welfare, as well as offering a more sustainable value proposition compared to the conventional salmon farming industry. Nevertheless, as the fully out-grown salmon production on land is not yet developed fully, the majority of our interviewees point out that it is difficult to manifest land-based salmon farming stocks as ESG stocks. Hence, the qualitative analysis imply that our hypothesis is not correct, which supports our findings in section 6.3.

6.4 Relative valuation

In this section, we present our findings from the relative valuation by using multiples to examine the different valuation among salmon farming peers. With this analysis, we will also provide a discussion regarding the pricing of land-based stocks compared to conventional stocks. We choose to focus on the enterprise value to kilogram (EV/kg) multiple due to three main factors. First, land-based salmon farming companies have negative profits, which makes earnings multiples meaningless to interpret. Second, the EV/kg multiple is the most commonly used valuation metric in the salmon farming industry, as it indicates how much investors pay for each kilogram of production per year (SEB Enskilda, 2014). Lastly, the EV/kg multiple is more relevant to use when comparing land-based and conventional salmon farming stocks, as the enterprise value also incorporates the capitalisation of the companies, which differ substantially between land-based and conventional players.

It is important to note that any comparison using multiples does not necessarily provide the most accurate valuation of land-based salmon farming companies, given that other metrics that one would usually include in a similar valuation discussion e.g. EBIT/kg, ROA etc. would be meaningless at this stage. However, we still argue that the relative valuation ratios we provide below could give a reasonable indication of the pricing of the land-based salmon farming stocks. This also limits the inference we can make regarding the relative valuation of conventional stocks.

Table 12 below illustrates our findings from the multiple valuation, where share prices have been retrieved as of 4th December, and land-based stocks are highlighted. Current volumes for land-based salmon farming companies are very low or zero, as the companies are still in an early phase. Thus, using multiple valuation with current volumes will not be representative for the valuation of land-based stocks, as much of their value lies in the expectations for future volumes. In order to compare land-based with conventional salmon farming stocks, we therefore use planned long-term capacity volumes, as stated from the companies' last available financial reports, when calculating EV/kg. In addition, we estimate the EV/kg multiples for the 2024 harvest, which we see as a near-term milestone for the land-based companies. Lastly, when capital expenditures occur, cash is converted to assets on the balance sheet which affects the enterprise value of the company. In order to compare the multiples for land-based and conventional salmon farming stocks, we therefore need to include all capital expenditures that the land-based companies are expected to incur before reaching 2024 volume estimates, and full capacity volumes. This inclusion is necessary because land-based salmon farming companies invest heavily as they build out their facilities, compared to conventional salmon farming companies which are assumed to have fully operational facilities.

As conventional salmon farming stocks have matured in their operations, and the supply growth of open-net pens is limited, we assume that investors do not price in substantial growth in volumes for these stocks. Therefore, we use guided volumes for 2020 in the EV/kg ratio of conventional stocks. This will not be fully representative for the volumes of conventional farmers in the future, as they probably will experience some growth, but gives, however, an indication of the differences in valuation between the two industries.

Furthermore, we estimate a probability of success for the land-based stocks based on the EV/kg multiples from table 12. The probability of success is estimated by assuming that land-based stocks would be priced at the median EV/kg ratio of conventional stocks if investors fully believed in the volume targets that land-based companies presents. The probability of success is therefore calculated by dividing the EV/kg multiple for each land-based stock by the median EV/kg multiple for conventional stocks.

Lastly, we observe large variations in the EV/kg multiples between the salmon farming players, where for instance, Bakkafrost has a substantially higher EV/kg multiple compared to Grieg Seafood. One reason for these variations is the operational efficiency of the companies, as Bakkafrost has operated with a significantly better EBIT margin over the years compared to Grieg Seafood. It is actually possible to show a linear trend between EV/kg multiples and the EBIT margin, where higher EBIT margins correlate with higher EV/kg multiples (ABG Sundal Collier, 2020). Thus, as an investor would be willing to pay more for volumes that create higher margins, we adjust for the EBIT margin potential in the probability of success estimates. This is done by dividing the probability of success for land-based companies by the relative cost efficiency between the production methods. The production cost, including transportation cost, from section 2.6.3 is used for this adjustment.

Table 12: *Multiple valuation of the seafood sector at the Oslo Stock Exchange*

Ticker	Market data (NOKm)			Additional capex needed (NOKm)		Volume (ktonnes)		Multiples			Prob of success adj.	
	Price NOK/share	Mcap	EV	2024e	Full capacity	2020e / 2024e	Full capacity	EV/kg 2020e / 2024e	EV/kg Full capacity	Avg. EBIT NOK/kg 2012-2019 *	2024e	Full capacity
ANDFJ-ME******	43	1,550	1,315	750	5,280	13	88	165x	75x	-	75 %	34 %
ASA**	102	8,177	8,068	6,750	31,500	55	220	269x	180x	-	125 %	83 %
BAKKA***	561	33,179	34,981	-	-	89	-	393x		23x		
GSF******	77	8,648	12,689	-	-	90	-	141x		8x		
LSG	56	33,602	37,078	-	-	183	-	203x		11x		
MOWI****	177	91,555	107,121	-	-	442	-	242x		12x		
NRS	208	9,072	9,776	-	-	35	-	279x		14x		
SALM	487	55,177	59,488	-	-	164	-	363x		16x		
SALME-ME******	6	1,233	505	2,307	10,430	16	70	178x	156x	-	77 %	67 %
SALMON*****	51	3,379	4,342	-	-	55	-	79x		2x		
Mean (conventional)								243x		13x		
Median (conventional)								242x		13x		

** Retreived from companies annual reports*
*** Average exchange rate USD/NOK Q2'20 = 10.02, Calculations done post share capital increase*
**** Average exchange rate DKK/NOK Q3'20 = 1.43*
***** Average exchange rate EUR/NOK Q3'20 = 10.67*
****** Average exchange rate USD/NOK Q3'20 = 9.13*
******* Calculations done post share capital increase*

As production volumes in land-based companies are essentially zero, the current valuation, in terms of EV/kg, is way above that of conventional peers. Since none of the land-based companies will obtain positive profits in 2020, their enterprise value is exclusively related to the present value of growth opportunities (PVGO).

When looking at EV/kg multiples, which incorporates future growth, we see that investors value land-based stocks below conventional salmon farming stocks. Therefore, this may indicate that investors incorporate several risk factors for the future value of land-based stocks. For the 2024 volume estimates, Atlantic Sapphire is trading just above the median for conventional stocks. Thus, investors seem to be fairly confident that Atlantic Sapphire will achieve its first 55,000 tonnes of production, as seen from table 12. When looking at the probability of success, where the EBIT margin potential is accounted for, this indicates that investors believe there is a 100 percent probability that Atlantic Sapphire will achieve higher volumes than the 55,000 tonnes expected for the 2024 harvest. However, we cannot say anything about when investors expect these volumes to be achieved. Furthermore, we see that investors are more uncertain when it comes to Atlantic Sapphire's full capacity goal. Here, the probability of success is approximately 80 percent, which indicates that some uncertainty is incorporated with regard to full capacity volume estimates. Still, this probability can be seen as fairly high, given the complexity of the technology and the high volume targets, which are actually above most analyst estimates.

We also see that there exist differences in investors' valuation of the three land-based companies as well. When looking at the EV/kg estimates, from table 12, we observe that

Atlantic Sapphire is priced at a higher multiple than both Salmon Evolution and Andfjord Salmon. One explanation could be the favourable EBIT/kg potential of Atlantic Sapphire due to the freight cost advantage. Still, we see from the probability of success, where this EBIT/kg potential is accounted for, that there also must be other explanations for the higher multiple. Another reason may therefore be investors' belief in the different technologies. When looking at the probability of success for full capacity, it seems as if investors are more confident that the RAS and hybrid flow-through technology will succeed compared to Andfjord Salmon's special case of flow-through technology. Section 6.5.3 will present a discussion regarding investors' perspectives on the different technologies, and examine several reasons for the difference in valuation. It must also be noted that confidence in management, and other related factors, are extremely important for emerging companies. Thus, differences in valuation could also originate from company-specific factors instead of the technology choice.

To sum up, it is obvious that considering today's production levels, the land-based stocks are priced at elevated levels compared to those of conventional players. However, land-based stocks are in a start-up phase which means that most of their value lies in the expectations of future growth. Therefore, when estimating multiples based on future volumes, we see that the valuation of land-based stocks is closer to what we currently observe for conventional stocks, while still pricing in some risk of the concepts not succeeding. It is also evident that there are substantial differences in the valuation of the three land-based stocks. This could be due to several factors, with important ones being technology differences and freight cost advantages. Lastly, this multiple valuation indicates that investors have the most faith in Atlantic Sapphire among the listed land-based stocks.

6.4.1 Investment perspectives

Investors focus on numerous factors when considering investments in the land-based industry. First, investors express the importance of management skills and industry experience. This is essential to manage an immature technology effectively, as well as being able to guide with a realistic timeline for the build-out phase. Otherwise, the biomass assets will stand upon an immense risk. Although bull investors arguably believe in the management of land-based salmon farming companies, several bear investors argue that the most experienced people are still to be found in conventional salmon farming companies. In addition, financial backing from large reliable investors that have faith in the company may further create credibility for those who have not yet invested.

Second, it is argued that a reason for the increased interest for land-based salmon farming companies in the past years is the lack of valuable alternative investments and low interest rates. With a great deal of uncertainty with regards to several industries, such as the oil sector, due to the environmental shift, some investors admits that they are changing their behaviour. Therefore, they have started to place capital in industries with core businesses that addresses sustainable development goals, in line with the UN's definition (2020), such as the land-based salmon farming industry attempts to do. In addition, as the salmon farming sector in the past years has experienced high profitability, the land-based industry is seen as an attractive industry to invest in.

Overall, we observe that investors who already have entered the land-based industry may not seem to have a perception that the risk of investing in an emerging industry is high, and that they seem to rely heavily on the managements statements. With this discussion in mind, it may be argued that the probability of success found in section 6.4 should have been lower if investors had incorporated risk factors properly.

6.5 Supplementary views from market participants

In this section, we present supplementary views from market participants in order to examine whether land-raised salmon can justify a premium pricing, and investors' points of view on costs and technology, as well as discussing the future of the salmon farming industry. Market participants' views are gathered by semi-structured interviews, conducted with 28 interviewees, which we also list in the appendix. We believe this section will act as a supplementary view on how investors value a disrupting technology within the salmon farming sector, and their willingness to pay.

On the one hand, investors that believe in the land-based salmon farming production method sees this as a 2.0 solution compared to the conventional one. Proximity to end-markets, increased control of the production environment, a likely better environmental profile and improved fish quality are seen as key advantages by our interviewees. On the other hand, investors who are more sceptical towards fully out-grown salmon production on land are focusing on several concerns they believe will halt the development. Complexity of the technology, high energy consumption, challenges of attracting talent abroad, biological difficulties and elevated capital expenditures are key disadvantages that industry players elaborate on.

6.5.1 Premium pricing of land-raised salmon

In this section, we provide a summary of our discussion with investors, financial analysts and industry players regarding a potential premium pricing of land-raised salmon as a result of environmental and quality factors. What both most bull and bear interviewees have in common is their belief in achieving a short-run premium pricing when land-based production volumes are low, in line with the standard supply-demand theorem. Furthermore, as the exposure to sea lice and diseases is reduced, our interviewees believe that this will increase consumers' willingness to pay. Therefore, a premium pricing seem to be justified in the short-term. However, asking whether a premium can be achieved in the long-term spurs a more intense discussion and several contrasting views.

On the one hand, several investors believe that producing salmon on land fulfils necessary criteria to be classified as climate-friendly. Ticking the sustainability box is argued to be ever more important to attract consumers for protein sources and food in general, thus justifying a premium pricing. Several investors argue that moving salmon production onto land removes the negative externalities forced upon third parties i.e. the negative impact on wild-salmon and shrimp fields. Sludge management is further mentioned as an externality for society, which, the management of land-based companies claim to deal with properly. For instance, Atlantic Sapphire's facilities in Denmark commit to filtering off the sludge and use it for biogas production, while in Miami it commits to dewatering the sludge to 30 percent dry matter, which is accepted as a solid waste for offsite compositing or disposal (Atlantic Sapphire, 2019). The management of Andfjord Salmon further state that they will use the sludge in energy production, while the management of Columbi Salmon mention that they plan to use the sludge as biological material to cultivate useful crops.

The environmental benefits are also dependent on the technology used in the respective land-based facilities. Investors believing in the flow-through technology argue that pumping water under the sea lice belt is a major advantage. Geographic location along coasts will however be important for such facilities, as they are not as flexible as RAS and hybrid flow-through technologies. When RAS facilities are located close to end-markets, several of our interviewees argue this may defend a premium pricing of land-raised salmon as customers may favour the reduction in carbon footprint as well as the salmon being branded as "local food".

In particular, Atlantic Sapphire is shown as an outstanding example in terms of the premium pricing it achieved for its first harvested volumes, in the US on 28th September. Figure 6.4 illustrates Atlantic Sapphire's salmon retail price, in 2020, against an average of sea-raised salmon alternatives. Here, we see that Atlantic Sapphire's salmon is priced at a 50 percent premium, 60 NOK/kg, against the average of sea-raised salmon alternatives, 41 NOK/kg. Atlantic Sapphire does not reveal exact harvest volumes or the average weight of the salmon distributed. However, the management of the company announced their plan to harvest approximately 1,000 tonnes in the US before the end of 2020. A consensus of equity analysts assumes Atlantic Sapphire's salmon in the US will achieve a 17 NOK/kg premium compared with Norwegian salmon in the early phase, given a long-term salmon price of 58 NOK/kg. This seems in line with what Atlantic Sapphire actually has been able to achieve. However, we also observe that some analysts point to a diminishing price premium as the volumes increase. For instance, Nordea Markets expects the premium to narrow down to 5 NOK/kg when volumes exceed 15,000 tonnes (Nordea Markets, 2020). Most investors and financial analysts agree that Atlantic Sapphires' local branding is a driver of premium pricing; however, some investors argue that this factor alone is not enough to sustain a premium pricing.

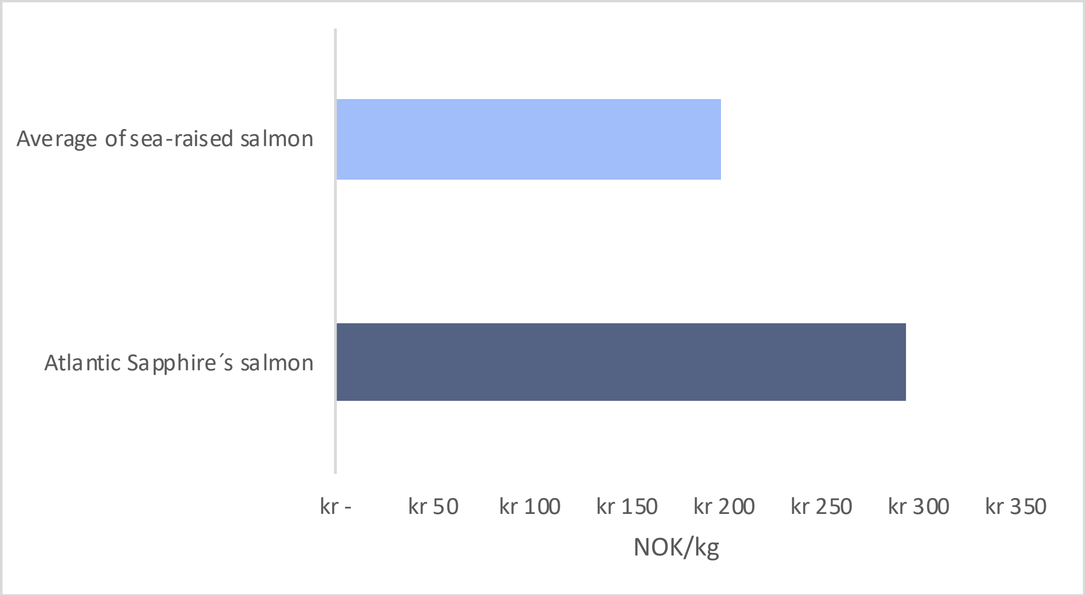


Figure 6.4: *Atlantic Sapphire's salmon retail price in NOK/kg compared to an average[1] of sea-raised salmon retail prices in 2020, Source: Korban, 2020*

---

[1] Average group of sea-raised salmon consists of that supplied to Walmart, Kroger, Albertsons, Whole Foods, as well as Trader Joe's BBW-cut" fillet salmon and H-E-B, Giant Eagle in Norway and Faroese salmon. Source: Korban, 2020

Despite the strong arguments made for considering land-based salmon farming a greener alternative compared to its sea-based peers, several interviewees also raises their concerns regarding the actual environmental profile of land-based salmon production. This group of interviewees emphasise that land-based salmon farming companies may seem to greenwash their salmon by claiming it to be more climate-friendly than it actually is. Technological risks need to be weighted up against the sustainability gain, and as the land-based technology is not yet proven on fully out-grown salmon production, fish welfare of land-raised salmon poses a substantial risk. If land-based companies are unable to eliminate crucial technological errors, negatively affecting the biomass, the consequences may be a weakened reputation for salmon farmed on land. In turn, a weaker reputation will impact consumer perception of land-raised salmon and increase the difficulty of branding the salmon as climate-friendly.

As 75 percent of the salmon produced in Norway is exported to the EU (Steinset, 2020), the freight-advantage of flexible location is not seen as a valid argument to favour a substantial reduction in carbon footprint, as EU is argued to be a close end-market to Norway. Thus, several investors argue that the air freight-advantage is only valid to discuss when assuming both conventional and land-based companies deliver salmon to the US or Asia. Thus, as Norway export limited amounts of salmon to the US today, the reduction of carbon footprint could actually be viewed as minimal. This argument can be supported by the findings of Liu et al. (2016), which show that the RAS technology has a higher carbon footprint (7 CO_2 eq. per kg) when eliminating the air-freight advantage compared to traditional open-net pens (3.39 CO_2 eq. per kg). In sum, several investors thus argue that they do not think land-based salmon farming will achieve a better ESG score compared to the conventional salmon farming, and will therefore not justify a premium pricing of land-raised salmon due to environmental factors.

Sources and uses of energy are also an important factor for the sustainability assessment for our interviewees. Land-based salmon farming requires significantly more energy than the traditional way of farming, mainly due the dependency of pumping up and recirculating water. As we see see in the calculations of Liu et al. (2016) (table 1, section 2.2), higher energy need is a major factor increasing land-based production methods' carbon footprint, as the majority of energy today stems from coal and gas sources. Certain investors believe some players will install renewable energy sources in close proximity to their facilities. In fact, selected companies have already revealed such plans. However, this ambition may seem unrealistic in the short-term for two reasons. First, building renewable energy sources is capital intensive.

Second, land-based companies will likely focus on building out their facilities, and prove their technology for fully out-grown salmon production, before making investments that do not directly contribute to securing the biomass and achieving steady production volumes. Thus, giving an impression to investors that some land-based facilities will run on energy sourced from wind or solar power is argued by bear investors to be "greenwashing".

Quality is another aspect our interviewees take into consideration when discussing premium pricing potential. Salmon raised on land are continuously run on counterflow causing the fish to swim against strong currents, which leads to a more marbled fish, similar to the wild salmon. As marbled fish is perceived as more premium, this also supports a premium pricing. On the other hand, several interviewees mention the earthy and muddy taste, due to geosmin compounds, of salmon raised on land as a negative consequence of RAS facilities. It may therefore seem as if the previous occurrence of geosmin, which we elaborate upon in section 2.7, has left its mark and still influences experts' perception of land-raised salmon. Although the problem with geosmin is likely to have been solved, the current solution increases capex needs as it requires the fish to be placed in another tank prior to harvesting.

To sum up, the land-based salmon farming industry has yet to reach a consensus view as to whether the environmental and quality factors regarding land-raised salmon can justify a long-term premium pricing. The sustainability assessment that land-raised salmon provides, and the superior branding, might justify a premium pricing, but there are wide discrepancies among experts and their views on how sustainable land-based salmon farming *actually* is. In the short-term, however, both bull and bear interviewees agree in their belief in a premium pricing while production volumes are still low.

6.5.2 Costs

An important factor making land-based salmon farming an attractive market to enter is the rise in costs related to biological issues in conventional salmon farming. The cost of producing salmon in open-net pens has almost doubled from 2008 to 2019 (Norwegian Directorate of Fisheries, 2020), thereby significantly improving land-based competitiveness. Many land-based salmon farming companies are projecting that costs will come down to approximately 44 NOK/kg at full capacity, as we see for the RAS technology in table 2 (section 2.6.3), which is above the average cost of conventional salmon farming companies. In addition, facilities located close to end-markets will reduce the transportation costs significantly compared to those of conventional salmon farmers in Norway. Although these cost levels sound promising for land-based salmon farming, investors are divided in their opinion regarding the underlying estimates.

Several stakeholders in the salmon farming industry believe these cost estimates are overly optimistic, and that many market participants underestimate the risks embedded in this newly developed industry. The scepticism is in particular related to capital expenditures, e.g. Atlantic Sapphire and DNB Markets (2018) which in 2018 guided with a range of approximately 90-110 NOK/kg in investment costs for its first US phase of 1,000 tonnes for Atlantic Sapphire's production. However, Liu et al. (2016) finds this cost to be 139 NOK/kg for a 3,300 tonnes RAS facility. This is substantially higher than what Atlantic Sapphire and DNB Markets estimate, and suggests extreme uncertainty regarding cost estimates as well as a likely optimistic view from land-based players. On the other hand, underestimating capital expenditure needs in developing industries is not an uncommon practise. Also, estimates provided by corporate management are likely to be influenced by commercial interests, i.e. they will seldom reflect a completely objective assessment of the project in question. It can therefore be argued that many investors already incorporate this risk in their valuation of the businesses.

Furthermore, feed is the largest cost component in salmon production. Our interviewees are divided in their opinions on whether the feed cost will be lower or higher for land-based compared to conventional salmon farming, but they do agree it will depend on the feed conversion ratio. Some argue that within a controlled environment, land-based players are able to reduce the feed conversion ratio, and thus reduce the cost of feed. On the other hand, there is a difference between economic conversion ratio and biological conversion ratio. Most interviewees believes the biological conversion ratio will come down, but some are more sceptical about the economic conversion ratio as they believe land-based facilities are liable to experience several mortality issues in the future. Lastly, the different requirements of the feed in land-based and conventional facilities are not believed to affect the cost of feed per kg for the two production methods. Thus, difference in cost of feed is exclusively dependent on the feed conversion ratio.

In addition, many of our interviewees believe that cost estimates for land-based players are highly dependent on whether the companies manage to obtain the volume of production they guide for. As mentioned in section 2.7 about risks within the land-based industry, land-based facilities operate with a much higher density of fish in their tanks. This is essential to secure economic viability of land-based operations, but this also increases the risk of issues such as reduced fish welfare, as it can stress the fish and hamper their appetite. Thus, some interviewees emphasise that the density estimates could be too optimistic, which in turn will make it challenging for companies to actually achieve their estimated volumes. On the other hand, investors in land-based companies believe most issues will be dealt with and overcome in time as knowledge and experience build. Thus, it seem as if investors holding this point of view have faith in managements' estimations of full capacity cost levels, although they emphasise that the companies will likely not be able to reach these cost levels in the near-term future.

Although all our interviewees emphasise the uncertainty regarding cost estimates, most agree that reduced cost levels are essential for the success of land-based salmon farming. With today's cost estimates, land-based players are dependent on continued biological issues in open-net pens to be competitive. The high salmon prices in the past years have enabled less cost competitive alternatives to enter the market, e.g. land-based players. Consequently, a downward pressure on prices going forward could squeeze out land-based players if they are unable to produce salmon at sustainable cost levels. On the flip side, the unique cost advantage of land-based players, i.e. locating RAS and hybrid flow-through facilities close to end-markets to reduce freight cost, is frequently mentioned by our interviewees as something that in the long-run can become a sustained competitive advantage for land-based players.

6.5.3 Technology

Investors express widely differing views with regards to which technologies hold the greatest growth potential. Flexibility in terms of location, production costs and the biological closeness to open-net pen production and the difference in complexity are viewed as the most important factors to consider.

On the one hand, as we discuss above in section 6.5.1, proximity to end-markets is seen as a key advantage of the land-based salmon farming industry by many investors. Thus, these investors prefer RAS and hybrid flow-through over flow-through technology solutions. On the other hand, complexity of RAS is by many seen as a draw-back of the technology, which potentially pulls investors towards the flow-through technology. These investors favour the significantly lower complexity of the flow-through technology, and that the operations are more close to that of open-net pens.

Furthermore, there are several examples to show that the biological challenges related to the traditional salmon farming industry are not absent in land-based facilities. Several of our interviewees state that the issue with algal bloom will still be present in the flow-through technology, despite sourcing water from a depth of 80 metres. If this statement is true, such incidents may contradict a common argument by land-based farming promoters believing in the flow-through technology; pumping water from great depths omits many of the biological challenges in the traditional salmon farming industry as bacteria do not thrive at these temperatures. In addition, several RAS facilities have experienced issues concerning the accumulation of bacteria in the tanks resulting in hydrogen sulphide, among other problems, and thus mass mortality of the salmon. However, many investors believe that these challenges related to algal bloom outbreaks and bacteria accumulation can be dealt with as the producers continuously improve their understanding of the technology in land-based facilities. But the current issues nevertheless underscore the importance of not taking the eventual success of such technologies as given.

Another aspect to consider when operating within highly complex technology and biology is attracting the right talent. Many investors are focusing on the great advantages of being located close to end-markets, but there are also disadvantages tied to this relocation. Norway has access to a world-leading cluster of RAS technology experts; however, this cluster is not of great size. If new production facilities where to be located in, for example, the US or Asia, it might prove difficult to attract the brightest minds to a completely new location. On the other hand, if these projects prove to be successful, our interviewees argue that the talent will follow. Still, this could come at a greater cost.

In short, the choice of technology is an important factor for investors seeking to invest in the land-based industry, as the technologies offer different advantages and disadvantages. Investors that favour proximity to end-markets are more optimistic about the RAS technology, while investors who value a less complex production technology seem to be more optimistic about the flow-through technology.

6.5.4 The future of the salmon farming industry

As a concluding question, we ask our interviewees whether the two forms of salmon farming are supplementary to each other and can co-exist, or if there is only room for one form of farming. As with our other questions, the interviewees hold different views. Several of them argue that a high salmon price is a key enabler for successful market entry for the land-based industry. Furthermore, if the land-based technology becomes proven on fully out-grown salmon production, our interviewees argue that land-based salmon farming could take market shares in the future. However, the conventional way of farming salmon is expected to grow further, but at a somewhat slower pace than previously, at an annual growth rate of 3 percent (Kontali, 2020b). It will take time for the land-based players to supply the same volumes as the conventional players. Moreover, our interviewees argue that it is too early to state whether land-based salmon farming will dominate the market, as the technology is yet to be proven. It also seems as if the development of Atlantic Sapphire has a significant influence on the expectations for the land-based industry as a whole, as it is one of the largest and has made the most progress among land-based producers. The majority of our interviewees thus expect these two ways of farming salmon to operate side by side in the foreseeable future.

Conventional salmon farming players, however, are still sitting on the fence, awaiting clear signs as to how the land-based industry will evolve. Meanwhile, the majority of those players have improved their knowledge of the RAS technology as it has been used for production of post-smolt for the last 40 years (Heinsbroek & Kamstra, 1990). Producing post-smolt allows the smolt to grow big on land before releasing it in sea. Reducing the time spent in the sea from approximately 16-18 months down to approximately 10 months also means that conventional salmon farmers may avoid biological issues and costs. A list of conventional salmon farming companies who have invested in post-smolt facilities can be found in table 3 (section 5.1.1). Still, they are yet to accept land-based salmon farming as a credible threat.

Several market participants also emphasise that M&A activity may be expected. If the fully out-grown salmon production at land-based facilities becomes proven, and the costs come down, this industry will arguably be a threat to the conventional salmon farming industry. Therefore, conventional salmon farming companies may acquire land-based salmon farming companies to stay competitive. On the other hand, it may be that the conventional industry prevails over the biological issues in sea with their post-smolt facilities or other initiatives, thus posing a threat to the future of land-based salmon farming. Another rational for acquisition may therefore be to purchase already built land-based facilities to grow smolt and reduce costs implied by biological issues.

To sum up, we can draw an analogy to Tesla's successful history, as we elaborate in the literature review. The future of land-based salmon farming may follow the same trends as for the electric vehicle market if the fully out-grown salmon production technology works, costs come down and the industry can be documented as more climate-friendly. Consequently, the conventional salmon farming industry should continue to follow the development of land-based salmon production closely, and in time, consider to pursue fully-out grown land-based salmon operations as a supplement to their current production, either by building its own land-based facilities or by acquring existing land-based players.

7. Limitations

In this chapter, we elaborate on the limitations of our analyses and the potential implications that could bias the inference of our findings. We also evaluate the robustness of our results, and provide suggestions for further research on the topic of land-based salmon farming.

7.1.1 Limited track record and number of companies

Our findings are limited by the number of observations we have for land-based salmon farming stocks; our statistical analyses use eight stocks, of which the only land-based stock has been publicly listed for less than three years. This naturally limits our ability to estimate fundamental dynamics and future expectations of this industry. Hence, the quantitative insights we provide on the development of the land-based salmon farming industry can be highly influenced by temporary fluctuations.

Moreover, as a result of having limited number of companies to choose from, we only conduct our analyses on Atlantic Sapphire's historical data. A probable implication of this restriction could be that our findings may not be representative for the entire land-based salmon farming industry. For instance, there may be company specific factors, such as being the first-mover in the industry or the managements reliability, that drives the valuation compared to land-based specific factors.

In addition, each of the listed land-based salmon farming companies uses different technologies, which makes them not entirely comparable to each other. As such, it is hard to isolate how investors value each of the technologies employed in land-based salmon farming production, as company specific factors disturb this assessment.

In sum, our results could be negatively impacted due to these limitations, and we cannot conclude the persistence of our results in the future. To mitigate these limitations, we support our quantitative findings by conducting interviews with investors, financial analysts and industrial players. We believe our findings are strengthened by our interviewees' experiences and views. As such, our findings could be seen as more reliable.

7.1.2 Size and phase of companies included

Comparing companies with substantially different market capitalisation act as a limitation in our thesis as market capitalisation can be viewed as a proxy for risk. This is because large-cap companies can be argued to be more diversified as they usually have production sites at several geographic areas and a higher production capacity, compared to small-cap companies, e.g. Atlantic Sapphire, with relatively low and concentrated production capacity. Thus, a larger market capitalisation of the company will usually induce a smaller stock price reaction to e.g. an unexpected mass mortality event, in line with Merrill's (2020) arguments regarding small-cap and large-cap companies.

In addition, the differences in which phase the companies are in will also impact the stock's liquidity and the fundamental drivers of the stock price. For instance, this is evident in our findings as land-based salmon farming stocks are less affected by fluctuations in the salmon price relative to the conventional stocks, and that land-based salmon farming stock prices are mainly derived from their implied probability of success. Therefore, our study is affected by our comparison of Atlantic Sapphire, which is still pioneer in the salmon farming industry, with conventional companies, that have achieved a steady state production. Hence, our findings on Atlantic Sapphire's stock return may not persist in the long-run when the company reaches a steady state production. As we are aware of this limitation, we try to mitigate its impact by highlighting comparisons between Atlantic Sapphire and conventional players of similar size.

7.1.3 The pandemic creating volatile markets

The global pandemic severely impacted the financial markets in 2020. As such, our findings are also affected substantially. Rising concerns about the consequences of the COVID-19 virus for the economy, at the same time as strict measures where imposed to prevent spread of the virus, sent the global stock market down significantly in March 2020. Due to great uncertainty worldwide, the pandemic created high volatility in the market, causing investors to react considerably to news regarding for instance infection rates, new measures, and the work with a vaccine. As the market capitalisation of land-based stocks are substantially smaller, such a recession will likely affect land-based stocks more than conventional salmon farming stocks.

Thus, the pandemic may have affected the relationships we examine in this study. For instance, in the index explanatory power analysis, the impact of COVID-19 may have led to all indices experiencing similar developments, causing higher explanatory power of indices on land-based stocks compared to 2018 and 2019. This implication is elaborated further in the robustness analysis and illustrated in table 16.

In addition, it must be noted that the pandemic causes extreme volatility in March and April, which highly affects our event study. This increased volatility may distort the true reaction of investors to such events as general uncertainty increases investors perception of risk. In addition, the sudden increase in volatility creates severe heteroscedasticity issues in our analysis, which further limits our inference.

Similarly, the salmon price analysis will arguably be affected by the pandemic. Here, we attempt to mitigate the increased volatility by adjusting for price shocks. We include dummies for shocks in the salmon spot price and believe it will capture some of the volatility caused by the pandemic, as the general downturn also affects the supply-demand dynamics for the salmon price. However, this adjustment may not be enough to alleviate the full effect of COVID-19, as other factors, which we cannot adjust for, may also cause shocks in the stock prices.

7.1.4 Limitations of the event study

As the event study methodology has some major draw-backs, and we are examining very few events, it is reasonable to dedicate a section in the limitation chapter to discuss the limitation of this analysis in detail.

First of all, the event study methodology rely on the assumption of an efficient market (Woon, 2004). This assumption may not be valid in some circumstances. Stock prices may not fully and immediately reflect all available information as individual investors might respond randomly to a specific event. Investors normally respond to events in waves, thus abnormal returns might be spread out over a longer period of time. Therefore, a significant “spike” in the abnormal returns graph will not be visible.

Second, precision regarding the length of the event window is not easy to determine. When selecting long event windows, it will be difficult to control for other confounding factors. Therefore, length of the event window is subject to a trade-off between improved estimation accuracy and potential parameter shifts (Sitthipongpanich, 2011). In the robustness analysis we will test for how sensitive our event study is to this limitation.

Additionally, the results in terms of magnitude and the significance of abnormal returns will rely on the research design (Woon, 2004). We base our methodology on the literature of Karafiath (1988), Binder (1998) and Woolridge (2012) regarding the event parameter approach, yet there exists other event study methods in the literature, which could induce different results.

Furthermore, a different choice of the market (R_{mt}) can change the results of the abnormal returns (Woon, 2004). For instance, as Salmones Camanchaca has its entire operations in Chile, neither the OBX nor the Seafood index is able to capture the variance in the stock returns. As such, the explanatory power of the chosen market model, OSLSFX, only has an explanatory power of 5.6 percent compared to 57.8 percent for Grieg Seafood over the entire period we examine. As the index is used to measure the theoretical normal returns, which in turn will affect our estimations for abnormal returns, the use of an inadequate index could distort our findings. False significance can occur as an implication of this, if the market index and the stock return moves in different directions, or we could fail to detect significant reactions in the stock returns.

7.1.5 Primary insider trading

Following the unexpected mass mortality events in March and July 2020 at Atlantic Sapphire's facilities, board members and primary insiders bought shares in Atlantic Sapphire several days after the events occurred. Table 13 illustrates amount of shares bought at given prices for the days following the events at Atlantic Sapphire's facilities in March and July 2020. Buying shares in their own company after such acute mass mortality events may seem like a measure done to prevent the stock price from falling sharply. Alternatively, it may be that insiders persist their faith in the company, and thus saw the fall in stock price as an opportunity to purchase stocks at an attractive discount to what they as insiders deem to be a fair price. Either way, these insider acquisitions will dampen the stock reactions. This is especially true for a company with low liquidity, such as Atlantic Sapphire.

Table 13: *Insider acquisition of shares in Atlantic Sapphire following the mass mortality events in March and July 2020. Source NewsWeb Oslo Stock Exhcange (2020)*

Date	# of shares bought	Average price	Name	Position in ASA
02/03/2020	15,000	91.88	Johan E Andreassen	CEO and Chairman
02/03/2020	100,000	91.03	Alexander Reus	Board Member
02/03/2020	3,200	90.73	Karl Øysein Øyehaug	CFO
04/03/2020	4,500	109.50	Svein Taklo	CDIO
10/03/2020	350,000	92.00	Runar Vatne	Board Member and Primary Insider
10/03/2020	21,000	95.49	Andre Skarbø	Board Member and Primary Insider
29/07/2020	1,500	113.00	Johan E Andreassen	CEO and Chairman

Looking at the event occurring 2nd March, the liquidity at the day of the event amounted to NOK 74 million. In comparison, the average liquidity of Atlantic Sapphire's stock returns since listing is NOK 12 million, which show the substantial increase of activity the day of the event. This further means that insider acquisition accounted for approximately 15 percent of the traded volume at the event day. Hence, insider trading may have affected the stock price substantially for such an illiquid stock, and this may also affect findings from the event study. We are aware of this limitation, however eliminating specific trades from our data material is not possible as we use daily stock price data.

7.2 Robustness analysis

In this section, we will first discuss our model choice for the salmon price analysis. We also evaluate the robustness of results obtained in the event study and the analysis regarding explanatory power of different indices. Additional robustness issues and tests are presented in the appendix.

7.2.1 The impact of salmon prices on stock returns

For panel data analysis, four different models can be employed. Models include pooled OLS (POLS), Fixed Effects (FE), Random Effects (RE), and First Difference (FD). We perform an F-test for fixed effects and a Breusch Pagan LM test for random effects, which both rejects H_0 of no effect (Park, 2010). Therefore, we perform a Hausman test which will give a good idea of which model to choose. We fail to reject the null hypothesis from the Hausman test, which means that the RE model is not suffering from violation of the Gauss-Markov theorem. As the

RE model is more efficient than FE, this indicates that we should choose a RE model in our salmon price analysis.

As one of our key explanatory variables in the salmon price analysis is a dummy variable, which is constant over time, we cannot use the FE or the FD model to estimate its effect on y (Wooldridge, 2012). We therefore need to choose between RE and POLS. Although the Hausman test indicate that RE is the most efficient, this model is less common to apply in research articles. We therefore choose to use POLS in our panel data model.

From table 14 below, we observe that the estimated coefficients from our main model in the salmon price analysis are consistent independent of which model is employed. Hence, this may imply that our results in the salmon price analysis is robust.

Table 14: *Comparison of panel data models*

	Dependent variable: Log returns on salmon stocks		
	POLS	FE	RE
OBX index	0.641***		0.641***
	(0.067)		(0.067)
Fish pool index (FPI)	0.171***		0.171***
	(0.049)		(0.049)
Two month forward prices (M2)	0.373*		0.373*
	(0.192)		(0.192)
FPI shock (more than 7% change = 1)	-0.022***		-0.022***
	(0.006)		(0.006)
FPI shock (less than -7% change = 1)	-0.006		-0.006
	(0.007)		(0.007)
Land-based dummy	0.005	0.005	0.005
	(0.004)	(0.004)	(0.004)
FPI : Land-based	-0.116**	-0.116**	-0.116**
	(0.045)	(0.045)	(0.045)
Constant	0.005**		0.005**
	(0.002)		(0.002)
Observations	1,064	1,064	1,064
R^2	0.250	0.013	0.112
Adjusted R^2	0.245	-0.129	0.106
F Statistic	50.215***(df = 7;1056)	6.164***(df = 2;929)	132.643***

Significance levels: *p<0.1; **p<0.05; ***p<0.01

7.2.2 Event study

The length of the pre-event and post-event window will not have a substantial impact on our result, given that we choose a long enough window to obtain a good estimation of normal returns. However, the length of the event window will influence our results substantially. To test for how sensitive our results are to this parameter, we run our event parameter approach regression on different lengths of the event-window, where we incorporate 1, 2 and 3 days past the day of announcement into the event-window. As most of our defined events are announced almost immediately after they occur, we choose to not include days prior to the announcement into the event window. Table 15 show the results we obtain on the dummy coefficients.

We observe that the statistical significance of the abnormal returns quickly disappears when increasing the length of the event-window. This indicate that the abnormal returns, occurring from the events we examine, are not persistent in the market over a longer period of time. This implies that the efficient market hypothesis holds, as the impact of the event is fully incorporated in the company's share value the same day as the event is announced. It must be noted that the regression results leads to a persistence of significant negative abnormal return for Salmones Camanchaca. Still, we emphasise the poor fitting of Salmones Camanchaca's stock returns to the Seafood index, elaborated in the limitations chapter, which could pose as an explanation for this.

Furthermore, we observe that the coefficients remain negative for most regressions, when the event-window length increases. The persistence of negative coefficients could indicate that the market does not bounce back to stock prices observed prior to the event immediately. Thus, it can be argued that the effect of the acute mass mortality event actually results in a persistent lower value of the security. Still, we see that the market corrects its stock reaction somewhat in the days following the event, as the magnitude of the abnormal negative returns dampen.

The results from this robustness evaluation show the great importance of choosing the correct length of the event-window. We are confident that an event window of one day, which we define as the day of announcement, is the right length for this analysis, as we perceive the financial market to be efficient and assume that the semi-strong efficient market hypothesis holds. In addition, as the events represent acute incidents where all information is distributed to the market at once, we do not believe that market participants incorporate this information over more than one day.

***Table 15**: Estimations on event dummy coefficients for different event-window lengths*

Dependent variable: Log transfromed returns of salmon farming stocks

Event window	(1) ASA 29/07/2020	(2) SALMON 18/05/2020	(3) MOWI 17/04/2020	(4) BAKKA 08/03/2020	(5) ASA 02/03/2020	(6) SALMON 15/03/2019	(7) LSG 28/01/2019	(8) BAKKA 23/09/2018	(9) GSF 06/06/2018
1 day	-0.058**	-0.009**	0.009***	-0.017	-0.184***	-0.011	-0.002	-0.029*	-0.006
	(0.025)	(0.003)	(0.002)	(0.016)	(0.035)	(0.022)	(0.009)	(0.015)	(0.016)
2 days	-0.029	-0.021**	-0.003	-0.015	-0.023	-0.032**	0.003	-0.016	-0.016
	(0.018)	(0.010)	(0.009)	(0.011)	(0.113)	(0.015)	(0.007)	(0.012)	(0.011)
3 days	-0.016	-0.020**	-0.003	0.0003	-0.012	-0.024**	0.004	-0.009	-0.016*
	(0.015)	(0.009)	(0.006)	(0.009)	(0.076)	(0.012)	(0.005)	(0.009)	(0.009)
4 days	-0.017	-0.009	-0.006	-0.012	-0.013	-0.018*	0.0002	-0.006	-0.009
	(0.013)	(0.01)	(0.005)	(0.018)	(0.057)	(0.093)	(0.005)	(0.008)	(0.008)

Alternative hypothesis: true mean is not equal to 0
Significance levels: *p<0.1; **p<0.05; ***p<0.01

7.2.3 The explanatory power of different indices on land-based stocks

As the explanatory power of all indices included in this analysis is fairly small, it is of great interest to examine whether the OBX index has persistently been the best index at explaining the development in Atlantic Sapphire. Table 16 show the regression results when regressing Atlantic Sapphire’s stock returns on different indices in respectively 2018, 2019 and 2020. This will further show us how the pandemic affected the relationships between indices and Atlantic Sapphire’s stock returns, as highlighted in the limitations.

We test for this by changing the time frame of the regressions and observe how this changes our results. Table 16 shows that the OBX index is the only index that is statistically significant in all years. In contrast, ESG, sustainability and technology indices are only statistically significant in 2020. Furthermore, the explanatory power of the OBX index is better than for the other indices in all years. Thus, we can argue that our analysis is robust, as changing the time span does not change our results. Still, there are substantial differences between the years, with 2020 standing out. Here, all indices are statistically significant and the explanatory power increases substantially, where a one percent increase in the OBX index indicates a 0.927 percent increase in Atlantic Sapphires stock return in 2020. Thus, Atlantic Sapphire’s stock returns seem to have followed the OBX index closely in 2020, and the pandemic is probably a good reason for this dynamic. This is probably because news related to COVID-19 has dominated the development of global financial markets this year, which has made stocks from different sectors behave more similar to each other than usual.

Table 16: *Robustness analysis of explanatory power of different indices*

Dependent variable: Log return of Atlantic Sapphire (ASA)			
Explanatory variable:	2018	2019	2020
OBX total return index	0.306***	0.319***	0.927***
Adjusted R^2	0.021	0.029	0.208
OSE technology index	0.055	0.095	0.686***
Adjusted R^2	-0.005	-0.0004	0.135
Oslo Seafood Index	0.112	0.242***	0.527***
Adjusted R^2	0.003	0.049	0.090
MSCI sustainability index	0.210	0.253	0.763***
Adjusted R^2	-0.001	0.015	0.072
Nordic ESG index	0.177	0.105	0.268*
Adjusted R^2	0.018	0.015	0.021
MSCI world information technology index	-0.094	0.164	0.274***
Adjusted R^2	-0.002	0.008	0.024
Constant	0.002	0.002	-0.001
	(0.001)	(0.001)	(0.001)

Significance levels: *p<0.1; **p<0.05; ***p<0.01

7.3 Suggestions for further research

As our data availability is limited, it would be interesting and beneficial for researchers to build on our literature when the land-based industry is more developed and has reached a steady state of production. As such, researchers would have access to an increased number of observations. As we find in our study, land-based companies are today more driven by the probability of success, rather than fundamental factors. When a steady state of production is obtained, fundamental factors will prevail for the valuation of these companies. Thus, the overall pricing differences in the salmon farming sector may become clearer as the sector will be priced on the same premises. Furthermore, when number of companies operating within the different technologies increase, it may be easier to quantify the difference in valuation between the technologies as well as a potential ESG premium. Hence, a further extension of our study when the land-based sector gets more established could be to examine differences in pricing among companies with different technologies, and focusing on the ESG premium those technologies may justify.

8. Conclusion

An accelerated interest in the land-based salmon farming industry has evolved over the recent years. Our contribution to the empirical literature of this emerging industry has focused on studying the differences in how investors value land-based compared to conventional salmon farming stocks, and how investors' sensitivities vary between these two industries. We also provide a comprehensive discussion from market participants regarding their views on our key topics for this thesis. This study investigate this by testing our main hypothesis: *Fundamental factors do not determine the valuation of land-based stocks in the same way as for conventional salmon farming stocks. In addition, investors are more sensitive to investments in an immature industry, such as land-based salmon farming.*

We test this hypothesis by employing different empirical methods in three statistical analyses, in addition to conducting a relative valuation. These findings are supported with semi-structured interviews conducted on 28 market participants. Each of the three statistical analyses aim to investigate independently defined hypotheses, which all contribute to answering our research question.

The objective of the first analysis is to investigate whether the salmon price affects the valuation of land-based stocks, and whether this differ for conventional stocks. Pooled OLS regressions are employed to test the following hypothesis: *The salmon price has a significantly lower impact on land-based relative to conventional salmon farming stock returns.*

Our findings in this first analysis provide evidence supporting our hypothesis. The main model infer that the effect of changes in salmon prices are negligible for land-based stock returns, i.e. that other factors will play a larger role in explaining the stock development. Market participants argue this is because the valuation of land-based stocks are mainly driven by the de-risking of the stock, i.e. increased probability of success. The model is tested for different panel data methods, but yield similar results. Hence, we can conclude that land-based salmon farming stocks are affected less by salmon spot prices compared to conventional salmon farming stocks. The findings from our supplementary model further indicate that changes in expectations of future salmon prices affects the stock returns more compared to salmon spot prices. However, we cannot conclude that forward salmon prices impact the stock returns of our two categories differently.

The second analysis addresses differences in investor's sensitivity towards investments in land-based compared to conventional salmon farming stocks by conducting an event study. The event parameter approach are used to test the following hypothesis: *Investors react significantly more to acute mass mortality events at land-based facilities relative to conventional open-net pen facilities.*

Our findings support our hypothesis and suggest that investors are significantly more sensitive to acute mass mortality events occurring in land-based facilities compared to open-net pen facilities. The event study further show that, between incidents occurring in land-based facilities, investors perceived threat to the probability of success determine the magnitude of the stock reaction. Additionally, the stock returns quickly bounce back in the days following the events for Atlantic Sapphire. This is likely because the management is quick to reach out and provide reliable explanations to its investors following the announcements. We can therefore conclude that investors have reacted significantly to incidents occurring in land-based facilities, and that investors place a considerable confidence in the management of these companies, which makes the reactions short-lived.

The objective of the last quantitative analysis is to examine which index will provide the highest explanatory power on land-based stocks. This will provide insight into how land-based stocks are priced. We run simple OLS regressions to test the following hypothesis: *ESG, sustainability and/or technology indices have the highest explanatory power on land-based stocks.*

The results from this analysis contradicts the above mentioned hypothesis. This show that the even though Atlantic Sapphire have experienced a similar trend to sustainability, ESG and technology indices, these indices are not able to explain day-to-day fluctuations in land-based stocks returns. Our findings rather show that the broad OBX index is the index that explains most of the previous variation of land-based stock returns. However, the Seafood index performs poorly, which support our main hypothesis that land-based stocks are not affected by the same fundamental factors as their conventional salmon farming peers. This is in line with the first analysis, that other factors, such as the binary outcome of success or no success, drives the valuation of land-based stocks.

Supplementary, we present a relative valuation to examine how land-based stocks are valued relative to their salmon farming peers. We can conclude from the relative valuation that land-based stocks are valued solely on the present value of growth opportunities. Investors incorporate a high probability of success for these growth opportunities, as most of the targeted volumes the management presents have already been incorporated in the stock price. This is especially true for Atlantic Sapphire, whose valuation implies the highest probability of success among all land-based companies. Hence, land-based companies access to funding in capital markets seem to depend on the development of Atlantic Sapphire.

The discussion provided by investors, financial analysts and industrial players concludes that it is difficult to assess a premium pricing of land-raised salmon in the long-run, as there is a discrepancy in investor perceptions regarding the sustainability profile of land-based salmon farming. Regarding cost, they emphasise that current estimates are subject to high uncertainty, but that reduced cost levels are essential to ensure competitiveness. Therefore, the freight cost advantage is stressed as a sustained competitive advantage for land-based players in the long-run. The technology choice is further important, but investors disagree on which technology they believe provide the best value proposition, although several of the presented arguments suggest it is the RAS technology. Lastly, most market participants' conclude that both land-based and conventional salmon farming companies could operate side-by-side in the future. It is unclear whether and when the conventional players will pursue land-based operations as a supplement to its current production, but for now, they continue to pay close attention to the development of the land-based industry.

It must be noted that the available time horizon, as well as the limited number of stock listed land-based players constitute the two major limitations to this study. Our work therefore represents a snapshot of how investors currently value land-based compared to conventional salmon farming stocks. Hence, we cannot conclude the persistence of our results in the future.

Finally, our principal result implies that land-based stocks are not determined by fundamental factors in the same way as for conventional stocks. Land-based stock prices are determined by the de-risking of the stock, while conventional stock prices are determined by fundamental factors, such as the salmon price. In addition, investors are more sensitive to acute mass mortality events at land-based facilities compared to conventional open-net pens. Hence, we can conclude that investors are more sensitive to other factors influencing the stocks, e.g. acute mass mortality events, in this immature industry.

9. References

ABG Sundal Collier. (2020). *Andfjord Salmon: Ready for a big backyard pool party.* Oslo: ABG Sundal Collier.

Adams, J., Hayunga, D., Mansi, S., Reeb, D., & Verardi, V. (2018). Identifying Outliers in Finance. *Financial Management, 48*(12), 345-384.

Adams, W. (2015). Conducting semi-structured interviews. In K. E. Newcomer, H. P. Hatry, & J. S. Wholey, *Handbook of Practical Program Evaluation* (pp. 492-505). New Jersey: Jossey-Bass, 4th ed.

Andfjord Salmon. (2020). *Investor Presentation.* Retrieved September 2020, from https://www.dropbox.com/s/zvsy87xypyxk93c/Andfjord%20Salmon%20AS%20-%20Company%20presentation.pdf?dl=0

Asche, F., Msiund, B., & Oglend, A. (2016). The Spot-Forward Relationship in the Atlantic Salmon Market. *Aquaculture Economic Management, 20*(1), 24-53.

Atlantic Sapphire. (2018). *Company Presentation.* Retrieved December 2020, from https://atlanticsapphire.com//assets/images/ATLAS-Investor-presentation-April-24th-2018.pdf

Atlantic Sapphire. (2019). *Atlantic Sapphire.* Atlantic Sapphire. Retrieved December 2020, from ESG Report 2019: https://atlanticsapphire.com//assets/images/Atlantic-Sapphire-ESG-Report-2019.pdf

Atlantic Sapphire. (2020, April 30). *Atlantic Sapphire.* Retrieved December 2020, from Atlantic Sapphire AS - Prospectus: https://atlanticsapphire.com//assets/images/Atlantic-Sapphire-AS-Prospectus-dated-30-April-2020.pdf

Berk, J., & DeMarzo, P. (2014). *Corporate Finance.* Essex, England: Pearson.

Billund Aquaculture Services A/S. (2010). *Food and Agriculture Organization of the United Nations.* Retrieved November 2020, from Introduction to Recirculation Aquaculture: http://www.fao.org/fileadmin/templates/SEC/docs/Fishery/Fisheries_Events_2012/Recirculation/RAS_3_of_5_Billund_Aquaculture_-_Izmir_2010.pdf

Binder, J. J. (1998, February). The Event Study Methodology Since 1969. *11*(2), 111-137.

Bjørndal, H. C. (2009, May). Oil Price Shocks and Stock Market Booms in an Oil Exporting Company. *Scottish Journal of Political Economy, 56*(2), 232-254.

Bjørndal, T., Holte, E. A., Hilmarsen, Ø., & Tusvik, A. (2018). *Analyse av lukka oppdrett av laks - landbasert og i sjø: produksjon, økonomi og risiko.* Ålesund & Trondheim: NTNU, Sintef Ocean and SNF. Retrieved September 2020, from http://fisk.no/attachments/article/6572/landbasert-lakseoppdrett-analyse.pdf

Bodie, Z., Kane, A., & Marcus, A. J. (2018). *Investments.* New York: McGraw-Hill Education.

Charmaz, K. (2006). *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis.* SAGE Publications.

Christensen, C. M., Raynor, M. E., & McDonald, R. (2015, December). *Harward Business Review.* Retrieved November 2020, from What Is Disruptive Innovation?: https://hbr.org/2015/12/what-is-disruptive-innovation?registration=success

Christensen, C., & Bower, J. L. (1995, January-February). *Harward Business Review.* Retrieved November 2020, from Disruptive Technologies: Catching the Wave: https://hbr.org/1995/01/disruptive-technologies-catching-the-wave

DNB Markets. (2018). *Merging the biologically possible with the economically viable.* Oslo: DNB Markets.

Downes, L., & Nunes, P. (2017). *Disruptive Innovation: Is Tesla Really a Disruptor? (And Why The Answer Matters).* Retrieved December 2020, from Harward Business Review: https://hbr.org/2017/08/is-tesla-really-a-disruptor-and-why-the-answer-matters

Emmons, W. R., & Timothy, Y. J. (2002, January). *The Futures Market as Forecasting Tool: An Imperfect Crystal Ball*. Retrieved November 2020, from Federal Reserve Bank of Saint Louis: Regional Economist: https://www.stlouisfed.org/publications/regional-economist/january-2002/the-futures-market-as-forecasting-tool-an-imperfect-crystal-ball

Fama, E. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance, 25*(2), 383-417.

Fama, E., Fisher, L., Jensen, M., & Roll, R. (1969). The Adjustment of Stock Prices to New Information. *International Economic Review, 10*(1), 1-21.

FAO. (2020). GLOBEFISH Highlihts July 2020. *A quarterly update on world seafood markets*(3).

Fish Pool. (2020). *Forward Prices*. Retrieved September 2020, from Fish Pool - Part of Oslo Børs ASA: https://fishpool.eu/price-information/forward-prices-3/

Glaser, B., & Strauss, A. L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research.

Global Salmon Initative. (2020a). *Sustainable Salmon Farming: The Future of Food.* Retrieved October 2020, from Global Salmon Initiative: https://globalsalmoninitiative.org/files/documents/GSI_Handbook_2020.pdf

Global Salmon Initiative. (2020b). *Sustainability Report: Feed Conversion Ratio*. Retrieved November 2020, from Global Salmon Initiative: https://globalsalmoninitiative.org/en/sustainability-report/protein-production-facts/#feed-conversion-ratio

Good, C., & Davidson, J. (2016). A Review of Factors Influencing Maturation of Atlantic Salmon, Salmo salar, with Focus on Water Recirculation Aquaculture System Environments. *Journal of the World Aquaculture Society, 47*(5), 605-632.

Goolsbee, A., Levitt, S., & Syverson, C. (2013). *Microeconomics.* New York: Worth Publishers.

Hardman, S., Shiu, E., & Steinberger-Wilckens, R. (2015). Changing the fate of Fuel Cell Vehicles: Can lessons be learnt from Tesla Motors? *International Journal of Hydrogen Energy, 40*(4), 1625-1638.

Hardman, S., Steinberger-Wilckens, R., & van der Horst, D. (2013). Disruptive innovations: The case for hydrogen fuel cells and battery electric vehicles. *International Journal of Hydrogen Energy, 38*(15), 15438-15451.

Heinsbroek, L., & Kamstra, A. (1990). Design and Performance of Water Recirculation Systems for eel Culture. *Aquacultural Engineering, 9*(3), pp. 187-207.

Hillmer, S., & Yu, P. (1979). The Market Speed of Adjustment to New Information. *Journal of Financial Economics*.

Holm, J. C., Vassbotn, K., Hansen, H., Eithun, I., Andreassen, O., Asche, F., & Reppe, F. (2015). *Laks på land - en utredning om egne tillatelser til landbasert matfisk oppdrett av laks, ørret og regnbueørret med bruk av sjøvann.* Technical report, Oslo.

Hsieh, J., & Walking, R. A. (2006). The history and performance of concept stocks. *Journal of Banking & Finance, 30*(9), 2433-2469.

Kalchev, G. (2009). Securities Litigation and Stock Returns: an Event Study,. *International Conference Managerial Solution for global & local markets during the crisis* (pp. 1-20). Kiel, Hamburg: ZBW - Leibniz Information Centre for Economics. Retrieved December 2020, from http://hdl.handle.net/10419/148358

Kampevoll, F. (2019, June 16). *E24*. Retrieved November 2020, from Spår trettendobling innen 2025: Tror på norsk lakse-boom i Kina: https://e24.no/naeringsliv/i/K3bEre/spaar-trettendobling-innen-2025-tror-paa-norsk-lakse-boom-i-kina

Karafiath, I. (1988). Using dummy variables in the event methodology. *The Financial Review, 23*(3), 351-357.

Kleven, H., & Løken, A. K. (2012, May 15). *Sammenhengen mellom laksepris og aksjekursen til lakseselskaper på Oslo Børs.* Oslo: NMBU. Retrieved October 2020, from Sammenhengen mellom laksepris og aksjekursen til lakseselskaper på Oslo Børs.

Kontali. (2020a). *Salmon World 2020.* Technical report.

Kontali. (2020b). Utsikter for landbasert matfiskoppdrett. *Seafood Talks: Laks på Land 2020.*

Korban, D. (2020, September 29). *Intrafish*. Retrieved September 2020, from Here's the retail price for Atlantic Sapphire's first US land-based farmed salmon: https://www.intrafish.com/prices/heres-the-retail-price-for-atlantic-sapphires-first-us-land-based-farmed-salmon/2-1-884052

Krivin, D., Patton, R., Rose, E., & Tabak, D. (2003). *Determination of the Appropriate Event Window Length in Individual Stock Event Studies.* SSRN Electronic Journal.

Laks på Land. (2020a). Politisk hjørne: Rammevilkår og tilrettelegging. Hva kan vi vente oss det neste tiåret? Redaktør Thorvald Tande i samtale med fiskeri- og sjømatminister Odd Emil Ingebrigtsen. *Laks på Land.*

Laks på Land. (2020b). *Laksplosjonen.* Technical report.

Liu, Y., Rosten, T., Henriksen, K., Hognes, E. S., Summerfelt, S., & Vinci, B. (2016, March). Comparative economic performance and carbon footprint of two farming models for producing Atlantic salmon (Salmo salar): Land-based closed containment system in freshwater and open net pen in seawater. *Aquacultural Engineering, 71*, 1-12.

Merrill. (2020). *Company size: Why market capitalization matters*. Retrieved November 2020, from Merrill - A Bank of America Company: https://www.merrilledge.com/article/company-size-why-market-capitalization-matters-ose

Misund, B. (2019, June 21). *Fôrfaktor*. Retrieved November 2020, from Store Norske Leksikon: https://snl.no/f%C3%B4rfaktor

Mowi ASA. (2019). *Salmon farming industry handbook.* Technical report. Retrieved from Salmon farming industry handbook.

MSCI. (2019, May). *MSCI ACWI Sustainable Impact Index Methodology.* Retrieved November 2020, from MSCI: https://www.msci.com/eqb/methodology/meth_docs/MSCI_ACWI_Sustainable_Impact_Index_May2019.pdf

MSCI. (2020a). *MSCI ESG Indexes.* Retrieved November 2020, from MSCI: https://www.msci.com/documents/1296102/17835852/MSCI-ESG-Indexes-Factsheet.pdf/3b449b87-d470-977a-3b56-77095b8d8fc7

MSCI. (2020b). *MSCI World Information Technology Index (USD)*. Retrieved November 2020, from MSCI: https://www.msci.com/documents/10199/69aaf9fd-d91d-4505-a877-4b1ad70ee855

Nordea Markets. (2020). *Jackpot on ESG, growth and valuation.* Oslo: Nordea Markets.

Norwegian Directorate of Fisheries. (2020, November 26). Retrieved December 2020, from Lønnsomhetsundersøkelse for laks og regnbueørret: Matfiskproduksjon: https://www.fiskeridir.no/Akvakultur/Tall-og-analyse/Statistiske-publikasjoner/Loennsomhetsundersoekelser-for-laks-og-regnbueoerret

Norwegian Ministry of Trade, Industry and Fisheries. (2015). *Forutsigbar og miljømessig bærekraftig vekst i norsk lakse- og ørretoppdrett.* Retrieved September 2020, from https://www.regjeringen.no/contentassets/6d27616f18af458aa930f4db9492fbe5/no/pdfs/stm201420150016000dddpdfs.pdf

Norwegian Ministry of Trade, Industry and Fisheries. (2018). *Havbruk til havs - Ny teknologi, nye områder.* Retrieved September 2020, from https://www.regjeringen.no/contentassets/e29cc668cbf54448a599c6da58cb1b9f/rapport-havbruk-til-havs.pdf

Norwegian Veterinary Institute. (2019). Retrieved October 2020, from Fiskehelserapporten 2018: https: //www.vetinst.no/rapporter-og-publikasjoner/rapporter/2019/fiskehelserapporten-2018.

Olsen, S. (2017, July 11). *iLaks*. Retrieved October 2020, from Atlantic Sapphire har funnet årsaken til massedød: https://ilaks.no/atlantic-sapphire-har-funnet-arsaken-til-massedod/

Oslo Stock Exchange. (2020, January). *Index Methodology - Oslo Børs Equity Indices.* Retrieved Nov 2020, from Oslo Børs : https://www.oslobors.no/Oslo-Boers/Produkter-og-tjenester/Markedsdata/Aksjeindekser

Osmundsen, T. C., Olsen, M. S., & Thorvaldsen, T. (2020). The making of a louse - Constructing governmental technology for sustainable aquaculture. *Environmental Science and Policy*(104), 121-128.

Park, H. M. (2010). *Practical Guides To Panel Data Analysis.* Retrieved December 2020, from International University of Japan: https://www.iuj.ac.jp/faculty/kucc625/writing/panel_guidelines.pdf

Roberts, H. (1967). *Statistical versus clinical prediction of the stock market.* Center of Research in Security Prices: University of Chicago.

RStudio. (n.d.). *Getting Started in Fixed/Random Effects Models using R*. Retrieved November 2020, from RStudio: https://rstudio-pubs-static.s3.amazonaws.com/372492_3e05f38dd3f248e89cdedd317d603b9a.html

Salmon Evolution. (2020a). *Investor Presentation.* Retrieved November 2020, from https://salmonevolution.no/wp-content/uploads/2020/11/Company-presentation-June-2020-Salmon-Evolution-web.pdf

Schoonenboom, J., & Johnson, R. (2017). How to Construct a Mixed Methods Research Design. *Kolner Zeitschrift fur Soziologie und Sozialpsychologie, 69*(2), 107-137.

SEB Enskilda. (2014). *Structural shift to demand-driven market.* Oslo: SEB Enskilda.

Sitthipongpanich, T. (2011). Understanding the event study. *34*(130), 59-68.

Statistics Norway. (2019). *Fakta om Norsk næringsliv: De største næringene*. Retrieved December 2020, from Statistics Norway: https://www.ssb.no/nasjonalregnskap-og-konjunkturer/faktaside/norsk-naeringsliv#blokk-1

Statistics Norway. (2020, October). *Exports of Salmon*. Retrieved October 2020, from Statistics Norway: https://www.ssb.no/en/laks

Steinset, T. A. (2020, May 18). *Statistisk Sentralbyrå*. Retrieved November 2020, from Oppdrettslaks til heile verda: https://www.ssb.no/jord-skog-jakt-og-fiskeri/artikler-og-publikasjoner/oppdrettslaks-til-heile-verda

Svartdal, F. (2018, September 20). *Grounded Theory*. Retrieved November 2020, from Store norske leksikon: https://snl.no/grounded_theory

Tekfisk. (2020, February 11). Retrieved October 2020, from Emmen smak på landbasert laks er en utfordring: https://www.tekfisk.no/havbruk/emmen-smak-pa-landbasert-laks-er-en-utfordring/2-1-753704

Thompson, R. (1985). Conditioning the return generating process on firm specific events: a discussion of event study methods. *Journal of Financial and Quantitative Analysis, 20*(2), 151-186.

Trovatn, O., & Solheim, M. (2019). *The Economic Attractiveness of Land-based Salmon Farming in Norway.* Bergen: NHH.

United Nations. (2020). *Communications materials*. Retrieved November 2020, from United Nations: https://www.un.org/sustainabledevelopment/news/communications-material/

United Nations Development Programme. (2020). *Sustainable Development Goals*. Retrieved November 2020, from United Nations Development Programme: https://www.undp.org/content/undp/en/home/sustainable-development-goals.html

Wooldridge, J. M. (2012). *Introductory Econometrics: A Modern Approach.* Mason, Ohio: South-Western Cengage Learning.

Wooldridge, J. M. (2016). *Introductory Econometrics: A Modern Approach.* Nelson Education.

Woon, W. S. (2004). *Introduction to the event study methodology.* Retrieved October 2020, from Singapore Management University: http://users.telenet.be/webdesignsite/Bachelorproeven/Bronnen/analyst%20recommendations/Introduction_to_the_Event_Study_Methodology%5B1%5D.pdf

10. Appendix

The appendices offer complements to the results presented in the thesis. First, we present a comprehensive list of the 85 land-based salmon farming projects worldwide, before presenting our list of interviewees (n=28). Finally, we present our findings from testing our data for the OLS assumptions and how we treat outliers.

10.1 Planned land-based salmon farming projects

Companies	Country	Harvesting	Planned capacity (tonnes)
Andfjord Salmon AS	Norway	No	65,000
Aqua Group	Russia	No	2,500
Aquabang	USA	No	10,000
AquaBounty	USA	Yes	52,000
AquaCon USA	USA	No	45,000
Aquaproduct	Russia	No	7,500
Arctic Seafarm AS	Norway	No	15,000
Asset Buyout Partners	Norway	No	35,000
Atlantic Sapphire	USA	Yes	220,000
Atlantic Sapphire Denmark	Denmark	Yes	3,000
BDV/SAS	France	Yes	100
Berliner Land Lachs	Germany	No	2,000
Blue Horizon Coho	China	Yes	500
Bordemar	Chile	No	24,000
Brumer Development	South-Africa	No	2,000
Bulandet Miljøfisk AS	Norway	No	5,500
Cape D”or Salmon	Canada	Yes	7,000
Cape Nordic	South-Africa	No	1,800

Columbi Salmon	Belgium	No	15,000
Danish Salmon AS	Denmark	Yes	2,700
Dongwon Industries	South-Korea	No	20,000
Driva Aquaculture AS	Norway	No	25,000
Ecofisk AS	Norway	No	40,000
EFC Invest AS	Norway	No	6,000
Erko Seafood AS	Norway	No	15,000
Fifax	Finland	No	3,200
Finger Lakes Fish	USA	Yes	400
Fredrikstad Seafoods AS	Norway	Yes	2,000
Gaia Salmon AS	Norway	No	7,500
Gigante Salmon AS	Norway	No	10,000
Global Fish	Poland	Yes	450
Havlandet RAS	Norway	No	10,000
Helgeland Miljøfisk AS	Norway	No	50,000
Hjelvik Matfisk AS	Norway	No	2,500
Hudson Valley Fish	USA	Yes	1,200
Jurassic Salmon	Poland	Yes	1,000
Kazan-anlegg	Russia	No	10,000
Kobbevik og Furuholmen	Norway	No	10,000
Landeldi	Iceland	No	15,000
Local Ocean	France	No	15,000
Lofoten Salmon AS	Norway	No	7,500
Losna Seafood AS	Norway	No	28,600
Matorka	Iceland	Yes	3,000

Namgis Kuterra	Canada	Yes	250
Norcantabric	Spain	No	3,000
Nordic Aqua Partner	China	No	8,000
Nordic Aquafarm	USA	No	50,000
Nordic Salmon AB	Sweden	No	10,000
OFS Andenes AS	Norway	No	15,000
OFS Måløy AS	Norway	No	15,000
OFS Nordkapp AS	Norway	No	20,000
Proximar	Japan	No	6,000
Pure Salmon	Japan	Yes	1,500
Pure Salmon	Worldwide	No	110,000
Pure Salmon China	China	No	100,000
Pure Salmon France	France	No	10,000
Pure Salmon Japan	Japan	No	10,000
Pure Salmon Lesotho	Lesotho	No	10,000
Pure Salmon Middle East	Middle East	No	10,000
Pure Salmon South-East Asia	Asia	No	10,000
Pure Salmon USA	USA	No	20,000
Qiongdao Guoxin	China	Yes	20,000
Quality Salmon AB	Sweden	No	100,000
RH Invest AS	Norway	No	100,000
Salfjord AS	Norway	No	36,500
Salmofarms AS	Norway	No	10,000
Salmon Evolution AS	Norway	No	36,000
Salmon Terra AS	Norway	No	8,000

Samherji	Iceland	Yes	3,000
Sande Aqua AS	Norway	No	33,000
SeafoodGroup AS	Norway	No	12,000
Skagen Aquaculture	Denmark	No	3,300
Smart Salmon AS	Norway	No	5,000
Smart Salmon France	France	No	10,000
Sustainable Blue	Canada	Yes	1,000
Swiss Lachs	Switzerland	Yes	2,300
Taste Of BC	Canada	Yes	1,250
Tianjin Changjiufada	China	Yes	500
Tomren Fish AS	Norway	No	10,000
Upstream Salmon	South-Africa	No	2,000
Vadheim Akvapark AS	Norway	No	6,000
Viking Labels	Dubai	No	20,000
West Coast Salmon	USA	No	15,000
Whole Oceans	USA	No	25,000
Xinjiang E”he Construction	China	Yes	1,000
Sum			**1,668,550**

Source: (Laks på Land, 2020b)

10.2 Interviewees

Financial advisors

Name: Alexander Aukner
Title: Equity Research Analyst
Coverage: Seafood
Firm: DNB Markets
Date: 16/09/2020

Name: Anders Aune Berntsen
Title: Investment Banking Associate Director
Coverage: Seafood and foods
Firm: DNB Markets
Date: 28/09/2020

Name: Heidi Stenmark
Title: Equity Research Analyst
Coverage: Seafood
Firm: Pareto Securities
Date: 20/10/2020

Name: Daniel Loe Laberg and Lars Christian Øverland
Title: Manager and Senior Manager
Firm: EY Transaction Advisory Services
Date: 01/10/2020

Name: Herman Dahl
Title: Equity Research Analyst
Coverage: Seafood
Firm: Nordea Markets
Date: 22/09/2020

Name: Martin Kaland
Title: Equity Research Analyst
Coverage: Seafood
Firm: ABG Sundal Collier
Date: 20/10/2020

Name: Ola Trovatn
Title: Equity Research Analyst
Coverage: Seafood
Firm: Carnegie
Date: 13/10/2020

Name: Dag Sletmo
Title: Senior Vice President
Firm: DNB Ocean
Date: 12/10/2020

Investors

Name: Dag Hammer
Title: Portfolio Manager
Firm: DNB Asset Management
Date: 25/09/2020

Name: Lars Ørving Eriksen
Title: Investment Manager
Firm: Middelborg
Date: 07/10/2020

Name: Bjørnar Misund
Title: Investment Manager
Firm: Farvatn
Date: 08/10/2020

Name: Espen Furnes
Title: Senior Portfolio Manager
Firm: Delphi Fondene
Date: 23/10/2020

Name: Bjørn Hallvard Knappskog
Title: BDO
Firm: Pemco
Date: 22/10/2020

Name: Ann Kristin Brautaset
Title: Deputy Director Equities
Firm: Folketrygdfondet
Date: 30/10/2020

Name: Jann Molnes
Title: Portfolio Manager
Firm: Holberg Fondene
Date: 06/10/2020

Name: Tore Tønseth
Title: Investment Director & Chairman at Salmon Evolution
Firm: Ronja Capital & Salmon Evolution
Date: 03/11/2020

Name: Audhild Aabø
Title: Portfolio Manager
Firm: Nordea Asset Management
Date: 29/10/2020

Name: Joakim Sundby Johansen
Title: Investment Director
Firm: Summa Equity
Date: 05/11/2020

Name: Leif Eriksrød
Title: Senior Portfolio Manager/ Head of Equity Team
Firm: Alfred Berg Fondene
Date: 23/10/2020

Industrial players

Name: Per Grieg jr.
Title: Chairman
Firm: Grieg Group
Date: 04/11/2020

Name: Ragnar Joensen
Title: Board Member
Firm: Tytlandsvik Aqua
Earlier experience: Marine Harvest
Date: 28/10/2020

Name: Even Søfteland
Title: CEO
Firm: Capmare
Date: 23/10/2020

Name: Helge Krøgenes
Title: Director of Finance/Business Development
Firm: Andfjord Salmon
Date: 13/11/2020

Name: Kolbjørn Giskeødegård
Title: CFO
Firm: Columbi Salmon
Earlier experience: Equity Analyst at Nordea Markets
Date: 21/09/2020

Name: Regin Jacobsen
Title: CEO
Firm: Bakkafrost
Date: 23/11/2020

Name: Nils Viga
Title: CEO
Firm: Tytlandsvik Aqua
Earlier experience: Marine Harvest
Date: 29/10/2020

Name: Jørgen Borthen
Title: R&D Director
Firm: Norsk Sjømatsenter
Date: 29/09/2020

Navn: Lars Henrik Haaland
Title: CFO
Firm: Nordic Aquafarms
Date: 13/11/2020

10.3 OLS Assumptions

In this thesis, we employ ordinary leased squares regression estimation in our analyses. Therefore, we need to make sure the OLS assumptions are met to assure that we have unbiased and reliable results from our estimations in this study. In the following sections, we will consider the five classical assumptions under OLS estimation. If these are met, we can say that OLS will be the best linear unbiased estimator, and will satisfy the Gauss-Markov theorem (Wooldridge, 2012). As we use time series data in our analyses, we also need to consider a sixth assumption; stationarity of time series.

10.3.1 Stationarity

A stationary time series process is one where the statistical properties do not change with time. Thus, the time series has a constant mean, variance and covariance over time (Wooldridge, 2012). This is necessary in order to model relationships with regressions because non-stationary behaviours, such as trends and cycles may reveal relationships in the data that does not exist. In finance, this is usually dealt with by using returns instead of closing prices for stocks, as several issues such as trend is evident for the latter. In addition, log transformed returns are often assumed to be independent and identically distributed normal. From the figure 10.1 below, we see that log transformed returns displays a constant mean, variance and covariance over time. We therefore choose to use log transformed stock returns in our regressions to fulfil the stationarity criteria.

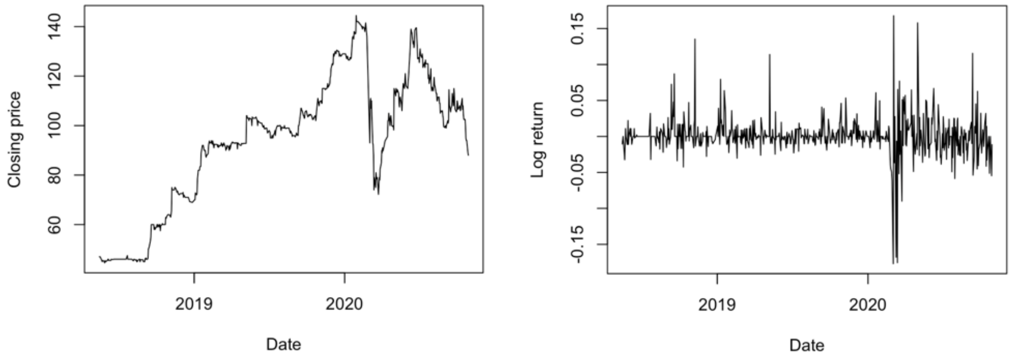


Figure 10.1: Atlantic Sapphire closing prices and log transformed returns

By running an augmented Dickey-Fuller test for stationarity on our return data, we obtain statistical significant test-statistics, which mean that we can reject the null hypothesis stating that the log transformed returns are non-stationary. Using log transformed returns therefore fulfils our stationarity assumption.

Table 17: *Agumented Dickey-Fuller test for a selection of variables*

Agumented Dickey-Fuller test for stationarity	
	Dickey-Fuller
Returns in salmon price analysis	-19.526***
Returns on Atlantic Sapphire	-12.521***
Returns on OBX index	-13.886***

Alternative hypothesis: stationary
Significance levels: *p<0.1; **p<0.05; ***p<0.01

10.3.2 No perfect collinearity

The "no perfect collinearity" assumption refers to the collinearity between our independent variables (Wooldridge, 2012). If an independent variable is a perfect linear combination of the other included independent variables, this assumption will be violated. As such, our model will suffer from perfect collinearity, and the OLS estimators cannot be interpreted. We will test for this assumption for our salmon price analysis (section 6.1), as the model in this analysis consists of several independent variables that could potentially form a linear relationship.

Table 18: *Pearson correlation coefficient for the salmon price analysis*

Pearson correlation coefficients			
	OBX	FPI	M2
OBX	1	0.07	-0.14
Fish pool index (FPI)	0.07	1	-0.01
Two month forward prices (M2)	-0.14	-0.01	1

Table 18 shows the Pearson correlation coefficient between the independent variables, which will determine whether our model suffers from perfect collinearity. We see that there exist some correlation between the independent variables, which is allowed, but not to the extent that multicollinearity is a concern. The correlation between the two-month forward prices and the OBX index has the highest negative correlation of 14 percent. Still, this is far from becoming a multicollinearity issue. Hence, our model does not suffer from perfect collinearity issues.

In addition, multicollinearity issues can arise in the presence of dummy variables in the regression equation (Wooldridge, 2012). If a dummy variable is specified for each category, we get perfect multicollinearity between the two dummies as they can be written as a linear relationship between one another ($Category_{1} = 1 - Category_2$). We avoid this problem by creating one less dummy variable than we have categories.

10.3.3 Zero conditional mean

The zero conditional mean assumption states that the unobservable error term (u_{it}) must have an expected value of zero and be uncorrelated with all of the independent variables (Wooldridge, 2012). At first glance at the histograms below, in figure 10.2 to 10.4, we see that our regression residuals are normally distributed around zero. Second, if the error terms are correlated with any of our explanatory variables this might result in biased estimations. This can occur if we have omitted any variables, which affects our dependent variable and correlates with our explanatory variables. Thus, a violation of the zero conditional mean assumption would lead to endogeneity issues. There is no formal test for this assumption, but we have addressed the endogeneity issue throughout our analysis by including different variables we believe will have an impact on stock returns, and at the same time are correlated with our explanatory variables, e.g. we include two-month forward prices in our salmon price analysis.

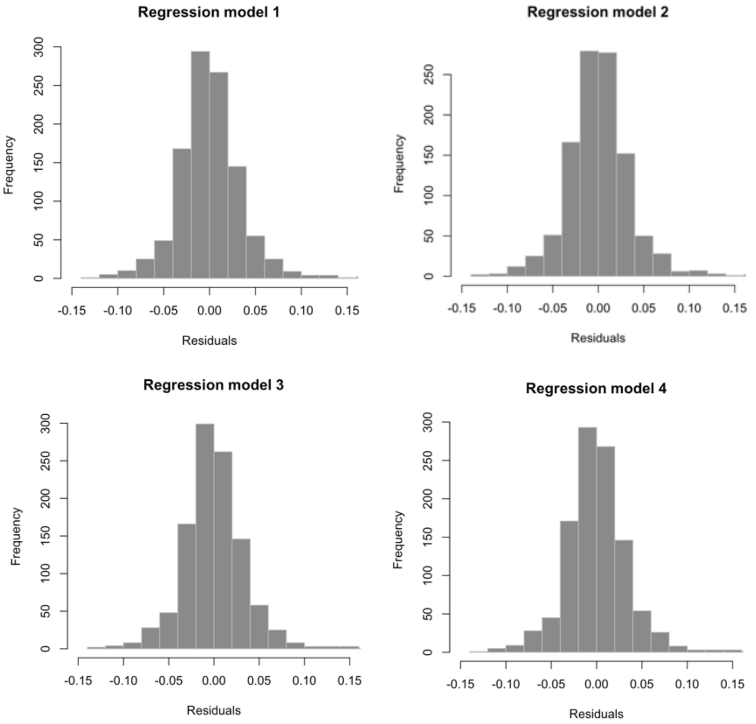


***Figure 10.2**: Histogram of residuals from the impact of salmon prices on stock development analysis*

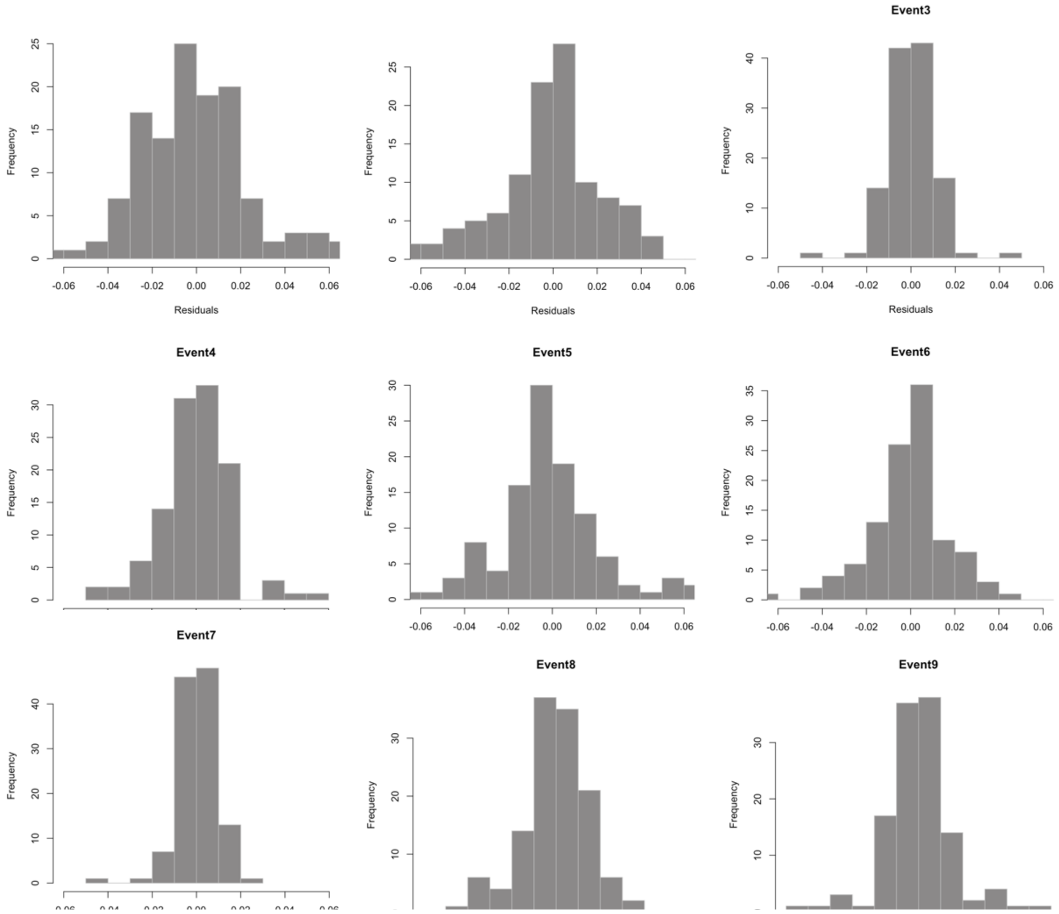


***Figure 10.3:** Histogram of residuals from event study*

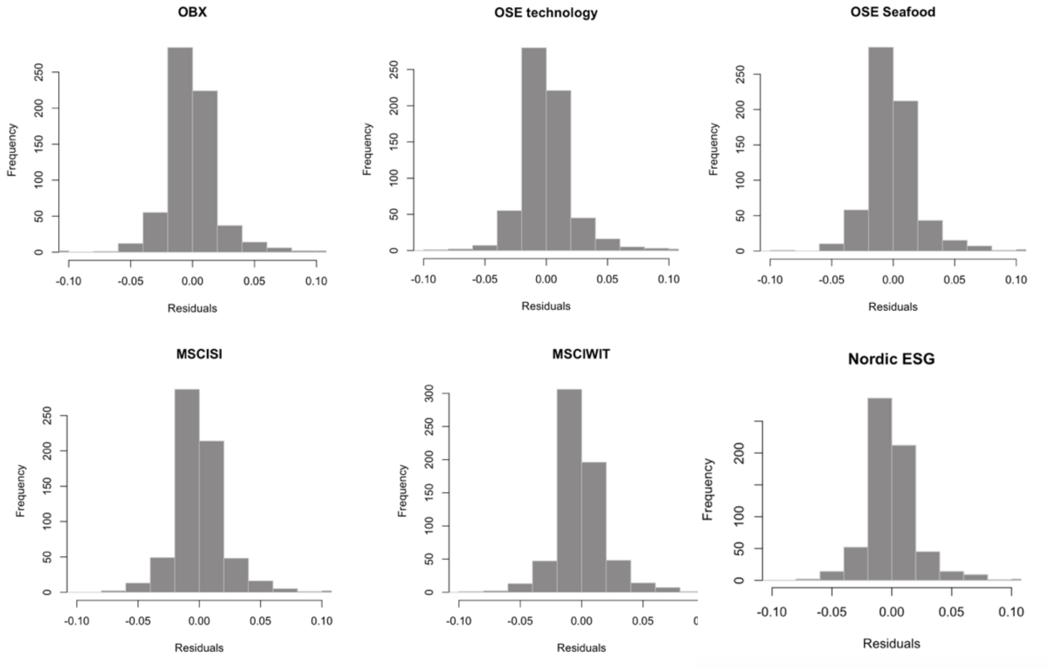


Figure 10.4: *Histogram of residuals from the explanatory power of indices on land-based stock analysis*

10.3.4 Homoscedasticity

The homoscedasticity assumption assumes that the error term (u_{it}) has the same variance across all values of independent variables (Wooldridge, 2012). The assumption ensures reliable results and accurate confidence intervals and p-values from our regressions. This homoscedasticity issue is likely to occur in stock price data, as such data are often cyclical in nature. We therefore run the Breusch Pagan test to test for homoscedasticity, which assumes normality of the error terms which we see from the figures, 10.2 to 10.4, above is maintained.

The null hypothesis is that we have homoscedasticity in the error terms, thus a p-value below five percent implies heteroscedasticity in the error terms. Table 19 below shows that we have heteroscedasticity issues in several of our regression models within the three analyses.

Table 19: *Breusch Pagan test statistics*

Salmon price analysis		
Model	**BP**	**P-value**
1	22.646***	0.00039
2	13.496**	0.01915
3	41.211***	7.376e -07
4	38.830***	2.106e -06

Event study		
Model	**BP**	**P-value**
Event1	0.9422	0.624
Event2	5.0196*	0.081
Event3	11.249***	0.004
Event4	4.1837	0.182
Event5	2.5833	0.275
Event6	2.0843	0.353
Event7	0.1698	0.919
Event8	0.4203	0.811
Event9	1.9332	0.736

Index explanation analysis		
Model	**BP**	**P-value**
OBX	5.1354**	0.02344
OSE_IT	12.028***	0.00052
OSLSFX	4.5786**	0.03237
MSCISI	6.4331**	0.01120
Nordic ESG	0.89455	0.34420
MSCIWIT	9.93200***	0.00162

Heteroscedasticity has no impact on the unbiasedness and consistency of our estimates, but it can impact the reliability of our p-value and t-statistics (Wooldridge, 2012). We therefore need to adjust for this by using robust standard errors in regressions where the Breusch Pagan statistic is significant. In our panel data regression, this is done by clustering the error terms, where we allow for changing variances across groups within each cluster. We also employ robust standard errors in a similar way for our linear regressions, but these are not clustered. As we have a small dataset with only nine time series in our panel data model, we still might have problems with unreliable error terms despite clustering. Still, we employ a small sample bias adjustment, which gives less weight to influential observations. This should help the reliability of the error terms.

10.3.5 Durbin-Watson test for autocorrelation

Since our regressions are based on time series data, we need to run a Durbin-Watson (DW) test to check for autocorrelation in the residuals. The problem of autocorrelation can occur when analysing historic data, as stock prices tend to change minimally from the day before (Wooldridge, 2012). If the residuals suffer from autocorrelation, the t, F and chi squared distributions are invalid. A solution to this problem is to use returns instead of price changes in the regression analysis. Thus, by using log transformed returns to moderate the problem of autocorrelation.

The Durbin-Watson statistic will have a value between 0 and 4, where a value between 1.5 and 2.5 is considered to be normal. A value below 2 means that there exist a positive autocorrelation in the residuals, indicating that the returns from yesterday are positively correlated with the returns of today. A value above 2 means, on the other hand, that we have negative autocorrelation.

Table 20: *Durbin-Watson test statistics*

Salmon price analysis		
Model	**DW**	**P-value**
1	1.4344***	2.2e -16
2	1.3872***	2.2e -16
3	1.4302***	2.2e -16
4	1.4292***	2.2e -16

Event study		
Model	**DW**	**P-value**
Event1	2.0139	0.970
Event2	2.7055***	0.000
Event3	2.3638**	0.050
Event4	2.2656	0.182
Event5	2.2835	0.118
Event6	2.3784*	0.056
Event7	2.2923*	0.090
Event8	2.4740***	0.010
Event9	1.3552	0.508

Index explanation analysis		
Model	**DW**	**P-value**
OBX	2.1941**	0.018
OSE_IT	2.1599**	0.050
OSLSFX	2.2353***	0.002
MSCISI	2.2208***	0.002
Nordic ESG	2.2066***	0.004
MSCIWIT	2.1881**	0.022

Table 20 above shows the Durbin-Watson statistics for the different regression models and analyses, alongside the corresponding p-value. Almost all models in both the salmon price and the index explanation analysis have a significant DW statistic, which means that we have a problem with autocorrelation in our data. This is not surprising as time series and panel data observe the same object over time, thus todays observation will likely correlate with the observation from yesterday. We account for this by clustering the error terms across groups and employ similar robust standard errors for our linear regressions, as explained for our solution to heteroscedasticity issues. The "arellano" covariance estimator is used when we have an issue with both heteroscedasticity and serial correlation, "White1" is used when we only account for heteroscedasticity issues, while we include lags of the dependent variable if we only have issues with serial correlation, as for event 8 in the event study. Furthermore, we note that regression 6 and 7 in the event study is significant on the ten percent level. Still, we choose to not make any adjustments for tests that has a p-value above five percent.

10.4 Outlier detection and treatment of missing values

A usual problem in finance regression analyses is how to treat outliers, and if they should be treated at all. The most common way to adjust for outliers is called winsorising. Adams, Hayunga, Mansi, Reeb, and Verardi (2018) argues that this approach replaces the most extreme values in the dataset with the next smallest or largest values in order to get more efficient and robust estimates. Even though this is a common approach in finance, it has its draw backs. Most importantly, by replacing a value of an observation with a value of another observation, this changes the information contained in that observation, which in turn could introduce biases to our estimations. Moreover, in our event study, these extreme values are actually the most important values, and removing them could therefore lead to incorrect inference. For the two other regressions, the outliers are a part of the natural variation in the data, thus removing them might prevent us from detecting relationships that actually are present in the data. Therefore, we choose to not winsorise our data, as we believe this actually introduces new biases in our estimations instead of making them more robust.

Still, outliers in our data, which occur due to for instance missing values should be adjusted for. First, we have some missing variables in our dataset. There are two reasons to why these errors have occurred. First, some of the stocks we analyse are less liquid than others, thus there might be days where these stocks have no trades and the cells would therefore be empty. Since our dataset is relatively small, we correct for this by replacing the empty cell with the closing price of the day before. This is representative as it indicates a zero return on that specific day. Second, when calculating the Nordic ESG index, we use stocks from Sweden and Denmark as well. These countries have different holidays, compared to Norway, and as we use dates corresponding to Norwegian trading days, these indices will have some missing values as the stock exchange is closed. We adjust for this in the same way as for the less liquid stocks.

10.5 Construction of Nordic ESG index

The Nordic ESG index is constructed as a free float value weighted index. Included stocks are defined by DNB Markets, as listed in table 21 below, and are all characterised as pure ESG stocks in the Nordic region. Historic daily market cap and closing prices is retrieved for each included stock, in NOK from Bloomberg. Each stock weight in the index is therefore continuously changing based on the market capitalisation development of the security. The maximum weight of each stock in the index is set to 30 percent, where Ørsted A/S and Vestas Wind Systems are capped at this level the entire period.

***Table 21:** Stocks included in the Nordic ESG index*

Companies	Average Mcap (NOKm)	Average share of index
Ørsted A/S	333,264	29 %
Vestas Wind Systems	160,032	29 %
NIBE Industries AS	66,603	20 %
Tomra	37,296	12 %
Scatec Solar	12,878	3.6%
NEL	10,610	2.8%
Bonheur	6,552	2.0%
Powercell	6,020	1.5%
ClimeOn	2,821	0.9%
Vow	1,488	0.4%