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Stock Price Development of Fish Farming Companies

Which variables have an impact on the stock price of companies listed on the Oslo Stock Exchange?

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NORWEGIAN SCHOOL OF ECONOMICS

Preface

This master’s thesis marks the final chapter of our education at the Norwegian School of Economics. The process has been incredibly demanding and has required a substantial amount of work and focus, but it has been an excellent opportunity to challenge both our knowledge and our analytical abilities. We decided to write about the fish farming industries due to several reasons.

Firstly, the fish farming industry has grown substantially ever since its inception during the 1970s, and the companies in this sector have faced substantial challenges ranging from financial crises to biological issues such as sea lice.

Secondly, the fish farming companies have presented innovative ideas to face both current and future challenges. This has become even more relevant recently following the substantial decline in the salmon prices due to the effect of COVID-19.

Lastly, we are both interested in a career within the fish farming industry and this has given us an excellent opportunity to learn more about the mechanisms and market dynamics of the industry.

Finally, we would like to thank our supervisor Yuanhao Li for helping us throughout the entire process with his advice and for sharing his useful insight into the fish farming industry. We would also like to thank Morten Sæthre for his useful guidance with econometrics in Stata. Furthermore, we would like to thank Kontali Analyse for providing us with the data we required to complete our analysis.

Bergen, March 4th, 2021.

Summary

The purpose of our paper is to identify how different variables have an impact on the share price of the fish farming companies listed on the Oslo Stock Exchange. In other words, we look at how changes in these variables are reflected in the individual share price of each company. In order to examine this relationship, we have decided to use a time series analysis where the dividend-adjusted share price of each respective fish farming company is the dependent variable. The independent variables are the global harvest volumes of salmon, the NASDAQ salmon price, the EUR/NOK and USD/NOK currency exchange rates and finally the Oslo Stock Exchange Benchmark Index, OSEBX.

Our analysis is based on monthly data for each of these variables from January 2009 to September 2020. We decided to include 2020 as we believe it would be interesting to examine the impact of COVID-19 on the variables and consequently the stock price of each fish farming company. Considering we only had monthly observations for all variables, we did not split our data into two time periods as we believe it would require substantially more observations to obtain an accurate analysis.

In our analysis we found that there was a positive statistically significant relationship between the salmon price and share prices of Mowi, Norway Royal Salmon and Bakkafrost. Our findings are likely of interest to investors seeking either a high or low exposure to the salmon price. The results also suggested that there was a negative statistically significant relationship between the global harvest volume and the share price of each company, except for Norway Royal Salmon. However, the results varied for some companies for different lags. Surprisingly, the results also suggested there were no statistical significance between the share price of the fish farming companies and the EUR/NOK and USD/NOK exchange rates, except for Salmar. This result was quite surprising considering an appreciation of the EUR against the NOK should, all else equal, lead to an increase in the salmon price due to an increase in foreign demand, and consequently an increase in the revenues of the fish farming companies. A reason for why there was no statistical significance could possibly be due to the fish farming companies utilizing currency hedging to avoid fluctuations in their revenues.

Table of contents

Overview of Tables & Figures

1. Introduction

1.1 Motivation and topic

The Norwegian fish farming industry has grown substantially the last couple of years which is reflected both in terms of the increase in total harvest volume and the export value of salmon. A significant reason for this growth is due to increasing demand for salmon in addition to a somewhat limited supply of salmon due to specific aquaculture requirements, license requirements and a set of other variables we will discuss in our paper.

A majority of the largest fish farming companies in Norway are listed on the Oslo Stock Exchange and the stock prices of these companies have increased substantially in recent years. The increase in the salmon price has mainly been driven by a limited supply of salmon and a weak NOK. The industry has also suffered from biological issues such as sea lice, which has taken a toll on the salmon health in the fish farms around the country. Following the world-wide lockdowns which started in March 2020, the HORECA-market (Hotels-, Restaurants- and Café-market) has suffered and consequently the demand for salmon decreased drastically.

We find these market mechanisms and variables to be very interesting and have decided to examine these subjects through time series analysis to answer our research topic:

> *How do changes in variables such as the global harvest volume, the salmon price, the EUR/NOK exchange rate and the USD/NOK exchange rate impact the stock prices of the fish farming companies listed on the Oslo Stock Exchange?*

1.2 Structure of the thesis

In chapter 2 we intend to discuss some of the related literature which has touched upon research questions and topics which are similar to our paper. There are some previous studies on the fish farming industry, and we will summarize their findings and how it relates to our paper. **In chapter 3** we introduce the fish farming industry, its industry structure and characteristics. We also present the production process, cost structure and the historical development of the industry. Furthermore, we also look at market dynamics in the industry such as supply, demand and pricing. Finally, we also comment on the impact of COVID-19 and the future outlook for the fish farming industry. This section is essential as it introduces the reader to the fish farming industry, in addition to building a foundation for understanding how the market dynamics work and how all these variables are related.

In chapter 4 we present the financial theory such as the Capital Asset Pricing Model, different types of market efficiency and currency theory. This section of our paper creates a theoretical framework for the rest of our analysis on the stock prices of the fish farming companies. **In chapter 5** we present our selection of variables we consider to be relevant for explaining changes in the stock price. We split this section into a part about our dependent variable which is the stock price of each respective fish farming company, and another part about our independent variables the global supply, the salmon price and exchange rates. We also comment on why we have selected these exact variables and why they are relevant to our analysis.

In chapter 6 we introduce the econometric methodology used in our analysis, such as the Ordinary Least Squares (OLS) method and its assumptions. In addition to this we touch upon stationarity. **In chapter 7** we discuss the data used in our analysis. More specifically, we explain where they have been retrieved from and how they have been utilized. We also examine some of our descriptive statistics, correlations, model specifications, trend, and dummy variables and finally our hypotheses for the analysis.

In chapter 8 we present our findings and discuss each individual variable in depth. Finally, **in chapter 9** we present a conclusion of our findings and weaknesses with our models and analysis. In addition to this we make suggestions for further research related to our topic.

2. Litterature review

A paper written by Røssland and Skudal (2017) examined the relationship between the future prices of salmon and the stock prices of fish farming companies on the Oslo Stock Exchange. Through an empirical analysis using time series data, they found that there is a significant relationship between the future prices of salmon and the stock price of fish farming companies. Their results indicated that when the future prices of salmon change, the stock prices move in the same direction. They further pointed out that the model had a relatively low explanatory power in terms of R^2 and speculated that it may have been due to an insufficient number of variables in their analysis.

Trodal and Risnes (2017) attempted to identify how exposed stock-listed fish farming companies are to the salmon price by OLS-regression for several independent variables such as the salmon price, the OSEBX, currencies and interests. Their analysis showed significant results which indicated that the fish farming companies listed on the Oslo Stock Exchange were exposed to the salmon price. The level of exposure differed from firm to firm. The paper also looked at Chilean fish farming companies, but they did not find any significant exposure to the salmon prices.

Hessvik and Bjørvik (2016) looked at variables that have an impact on the stock prices of Norwegian fish farming companies. In this paper, they used time series analysis to examine what sort of impact variables such as the salmon price, the supply of salmon, interest rates and currencies had on the Oslo Seafood Index (OSLSFX). They found that there was a positive significant relationship between the OSLSFX and the salmon price. However, they also stated that their analysis gave ambiguous answers on the relationship between the harvest volume and the OSLSFX, as their results showed significant relationships with both negative and positive coefficients when using different lags.

Kleven and Løken (2012) examined the relationship between the spot price of salmon with the share price of salmon companies. They utilized an OLS regression analysis where the results indicated that the Fish Pool Index (FPI) only had a significant impact on the share price of Lerøy Seafood Group and Mowi, formerly known as Marine Harvest.

A paper by Algbrigtsen (2007) examined how the salmon price impacts the stock price of the salmon companies on the Oslo Stock Exchange. Through the use of a time series analysis, she found that there was a strong relationship between the two variables. Similarly to this paper, Syltesæter and Utgård (2012) looked at how the salmon price is formed on the Fish Pool futures market and how the salmon price impacts the market value of Marine Harvest and Lerøy Seafood Group. Their findings, using OLS regression, suggested that both the futures price and the spot price of salmon have a significant impact on the share prices of the two companies.

Our contribution to this literature will be to look at each specific fish farming companies on the Oslo Stock Exchange rather than using an index consisting of these companies. We believe our findings will be useful as it will illustrate the differences between the fish farming companies in terms of measuring how exposed they are to fluctuations in variables such as the salmon price and the other variables presented in this thesis.

3. The fish farming industry

In this section we intend to introduce the fish farming industry and its characteristics. We will primarily focus on the Norwegian fish farming industry as it represents the majority of the world's harvest of Atlantic salmon. We start by looking more closely at the industry structure and its characteristics such as the production process, as it allows us to obtain an understanding of how the industry works and its mechanisms. Following this, we look at the historical development of the industry, the fish farming market and the largest fish farming companies in Norway. Finally, we will discuss the future outlook for the fish farming industry.

3.1 Industry structure and characteristics

3.1.1 The Norwegian fish farming industry

In Norway, the fish farming industry is very consolidated, and the largest players are responsible for a substantial amount of the total harvest volume. For example, the stock-listed fish farming companies represent about 51% of the total Norwegian harvest volume. Mowi is by far the largest company and accounts for 20% of the total harvest volume. The volume is given in tonnes head on gutted (HOG).[1]

Head on gutted (HOG)

Company	Harvest Volume 2019	Share %
Mowi	236 900	20%
Salmar	153 100	13%
Lerøy	128 700	11%
NRS	30 500	3%
Grieg Seafood	57 600	5%
Top 5 Harvest Volume	**606 800**	51%
Total Harvest Norway	**1 200 100**	100%

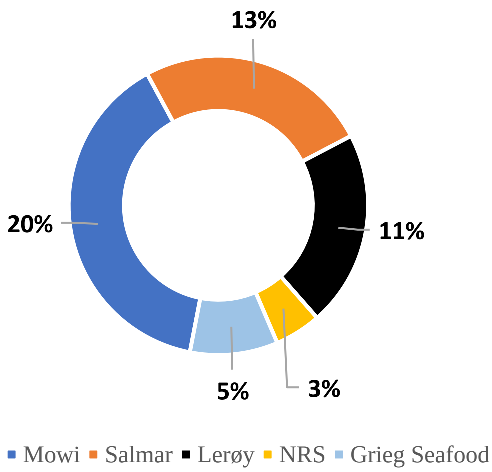

Table 1: Stock-listed companies and their share of the total harvest volume (HOG) in Norway. (Source: Salmon Farming Industry Handbook 2020, p. 48)

[1] Generally, about 13% of live weight is lost during the gutting process, so head on gutted (HOG) is about 87% of the original live weight.

3.1.2 Regulations in the Fish Farming Industry

Every fish farming company in Norway is required by law to hold a license to farm salmon. The number of licenses is limited and are allocated by the government in auctions. These licenses usually allow a fish farming company to hold a maximum allowed biomass (MAB) of 780 tonnes live weight (Mowi, 2020, p. 81). In other words, one license permits a MAB of 780 tonnes, except for Troms and Finnmark where they are allowed 945 tonnes per license. A company can have several sites and each of these sites may hold multiple licenses. However, each site has a total capacity limit. This has placed a limitation on the production capacity of farmed salmon and consequently contributed to a significant increase in the salmon prices. Historically these license allocations have happened in irregular periods of time while also being based on a wide variety of criteria (Norwegian Government, 2019, p. 44). In 2019, there were 1051 grow-out seawater licenses for salmon and trout in Norway (Directorate of Fisheries, 2019).

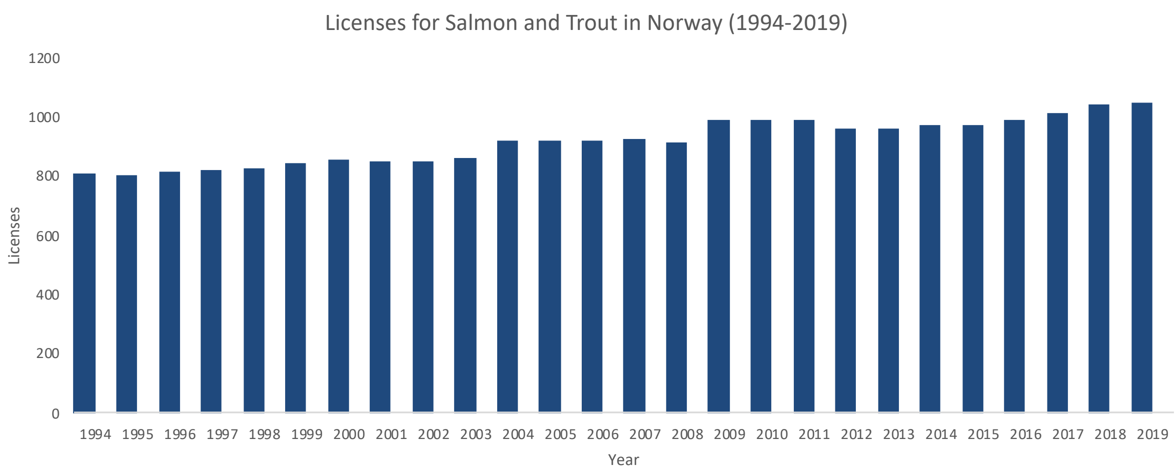

Figure 1: Licenses for Salmon and Trout in Norway (1994-2019). (Source: Directorate of Fisheries)

3.1.3 Companies

There are several stock-listed fish farming companies, but there are some significant differences between many of them. For example, some stocks are practically illiquid in terms of trading volume, such as Salmones Camanchaca. Furthermore, all of its production takes place in Chile and the salmon is primarily sold to non-EU markets. Consequently, we did not include this company in our analysis. There are also several land-based fish farming companies listed on the Oslo Stock Exchange and Euro Next Growth. We decided to exclude land-based fish farming companies such as Atlantic Sapphire, Salmon Evolution and Andfjord

Salmon, because they are yet to produce any substantial quantities of salmon.[2] We have also excluded both Ice Fish Farm and Icelandic Salmon as they have just recently become listed on the Euro Next Growth. We will primarily look at the fish farming companies represented in the Oslo Seafood Index as the majority of these have sufficient trading volumes and sell their salmon primarily to the same market.

Mowi ASA

Mowi ASA is the largest salmon farming company in the world, with a total production in 2019 of 435 904 tonnes HOG (Mowi, 2019). About 54% of the supply comes from Norway, followed by 15% from Chile, 15% from Scotland and 12,5% from Canada. The remaining harvest volume comes from Ireland and the Faroes.

Salmar ASA

Salmar ASA is the second largest stock-listed company in Norway after Mowi ASA, in terms of market capitalization. Their total harvest volume in 2019 was 166 200 tonnes HOG (Salmar, 2019). Approximately 92% of their total harvest volume comes from their Norwegian fish farms, while the remaining 8% is from Scotland and Iceland.

Grieg Seafood ASA

Grieg Seafood ASA is currently one of the smallest fish farming companies on the Oslo Stock Exchange. Grieg Seafood has operations in Norway, Shetland and Canada. In 2019, the company had a total harvest volume of 82 973 tonnes HOG (Grieg Seafood, 2019). About 70% of their harvest volume comes from their Norwegian fish farms, while the remaining 30% is split almost evenly between Canada and Shetland.

Lerøy Seafood Group ASA

Lerøy Seafood Group ASA had a total harvest volume of about 171 100 tonnes HOG in 2019 (Lerøy Seafood, 2019). Their main operations are located in Norway which represents more than 75% of their total harvest volume, with the remaining volume coming from their fish

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[2] Salmon Evolution and Andfjord Salmon are yet to produce any salmon as of January 2021. Atlantic Sapphire harvested its first salmon in Q4 2020. Combined with their harvest volume in Q1 2021, the company had a total harvest volume of 507 tonnes HOG (Furuset, 2021).

farms in Scotland. Lerøy Seafood Group is partially owned by another stock-listed company, Austevoll Seafood ASA.

Bakkafrost ASA

Bakkafrost ASA is the only fish farming company listed on the Oslo Stock Exchange with no fish farming operations in Norway. In total, the company produced 65 109 tonnes HOG, of which 68% of the volume came from the Faroe Islands. The remaining harvest volumes came from their fish farms in Scotland.

Norway Royal Salmon ASA

Norway Royal Salmon ASA is yet another fish farming company listed on the Oslo Stock Exchange and reported a total harvest volume of approximately 30 500 tonnes HOG. Nearly all of their production comes from their fish farms in Norway, but they also own 50% of a small fish farming company in Iceland, Arctic Fish, which harvested 3 321 tonnes HOG in 2019.

Austevoll Seafood ASA

Austevoll Seafood ASA stands out from the other fish farming companies for two reasons. Firstly, although Austevoll Seafood is considered a fish farming company due to its inclusion in the Oslo Seafood Index, it is in fact merely so because of its investment in Lerøy Seafood Group ASA, of which Austevoll owns 52,7%. Secondly, the remaining business consists of pelagic fishing, production of fish oil and fish meal, and consumer products.

3.2 Production process

The figure below illustrates a typical value chain in the salmon industry. However, the value chain differs from company to company. For example, Mowi and Bakkafrost have a significantly higher degree of vertical integration when compared to for example Norway Royal Salmon which is currently reliant on suppliers of smolt and fish feed.

Figure 2: Typical Value Chain in the Salmon Industry (Source: Modified from Salmar Annual Report 2019)

The process of fish farming begins with the hatching of eggs, whereby the smolt is kept in fresh water until it is transferred to seawater. This usually takes between 8 to 18 months depending on variables such as temperature. Following this, the process of smoltification begins, in which well boats transport the smolt from freshwater to net pens in the sea water. This part of the process normally takes 12 to 18 months at which point the salmon will grow to approximately three to six kilos, depending on operational conditions such as temperature, feeding, mortality and lice conditions. (Norwegian Government, 2019, p. 42). The final stage involves the harvesting of the salmon, followed by processing whereby it is transformed into a wide range of products before it is sold in the market.

3.3 Cost structure

Both revenue and production costs for the farming companies are exposed to currency effects. Most sales are in Euro and part of the production costs, mainly fish feed costs, are also in other currencies (Moe, 2019, p. 25). More specifically, approximately 56% is traded in Euros, 24% is traded in USD, 13% in NOK and the remaining 7% in other currencies. Raw materials, which make up 85% of the cost to produce fish feed, is usually quoted in US Dollars and Euro, with shares of 70% and 30%, respectively (Mowi, 2020, pp. 75-76). With fish feed representing 46% of the total production cost, this reveals the potential major effects that the different currencies can have. However, the cost of fish feed as a percentage of total costs has decreased from about approximately 53% in 2010 to around 40% in 2018 (Directorate of Fisheries, 2019). The overall costs have increased substantially since 2005, but the growth has slowed down since 2016, as illustrated in the figure below.

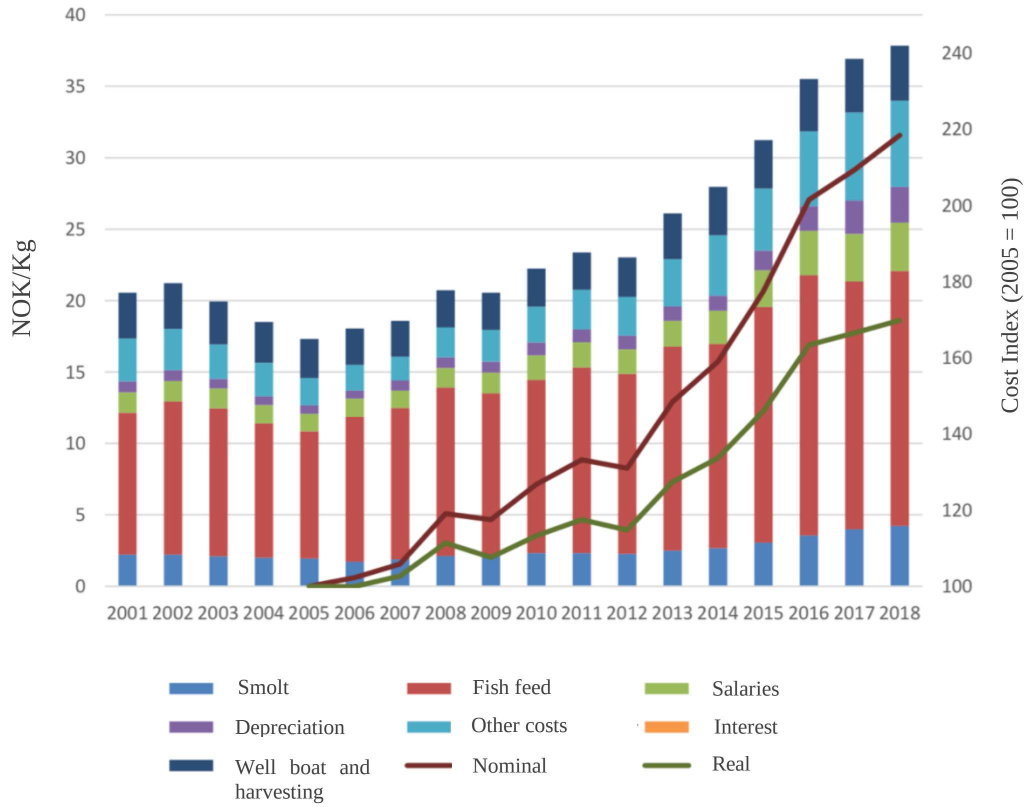

Figure 3: Cost Structure in the fish farming industry (2001-2018). (Source: Nofima & Kontali)

2018 (Iversen, et al., 2018, p. 1). When the total costs are adjusted for inflation, the production costs were estimated to have increased by 67% since 2005. The cost of fish feed has increased and is primarily driven by higher prices for inputs and raw materials, of which fish oil, fish meal, soymeal and rapeseed oil are the most important ones. The costs of smolt have increased by 78% from 2012 to 2017, mainly due to fish farming companies using larger smolt. There is a hypothesis among fish farming companies that by using larger smolt, the salmon has to spend less time in seawater, which consequently results in higher turnover and reduces the need for treating sea lice. Therefore, this requires investments in facilities and more fish feed.

The biological costs are reflected in “other costs” in the figure above and have increased substantially the last couple of years. More specifically, the biological costs consist mainly of sea lice treatment costs. The entire fish farming industry is struggling with sea lice and it has resulted in reduced harvest weights, increased mortality, and increased use of cleaner fish and sea lice treatment to combat sea lice. The fish farming industry has not been able to offset the increase in production costs partly due to limitations on the production growth of salmon caused by regulations, and also due to the fact that only a few locations around the world have suitable aquaculture conditions for fish farming. The primary reason for the increase in production costs is due to the increase in feed cost and sea lice treatment costs. The focus on automation and increased efficiency has only partly offset these cost increases (Iversen, et al., 2019, p. 9). The Norwegian government also has a “traffic-light” system whereby the potential increase in production volumes in a given region depends on the sea lice situation. A region with a green light is allowed to increase its production capacity by up to 6%, a yellow light region must maintain the current production capacity, while the red-light regions are required to reduce their production capacity by 6% (Norwegian Government, 2020).

3.4 Historical development - the Norwegian farming industry

The fish farming industry in Norway had its first breakthrough in the early 1970s when salmon was successfully raised in net pens and eventually harvested. In the following years, the Norwegian fish farming industry expanded substantially. This prompted the Norwegian government to establish a system whereby companies had to apply for licenses to operate fish farms (Norwegian Government, 2019, p. 11). This was implemented in 1973 and its intention was to regulate the growth in the industry, in terms of the size of the companies, the competition between them and local environmental issues. This has placed limitations on the production of farmed salmon. Conversely, the license system has also resulted in higher salmon prices and increased market power for the fish farm companies due to limited competition in the industry and a smaller supply side.

The industry continued to expand during the 1980s at which point the government decided to completely halt the allocation of licenses in different time periods. This allowed the government to decide which regions to prioritize. During the end of the 1980s, the production volumes had increased substantially to such an extent that the supply exceeded demand. Consequently, the salmon prices declined significantly. A combination of high debt levels and issues with sea lice and algae resulted in a wave of bankruptcies. From 1986 to 1994, 255 fish farming companies went bankrupt (Eikaas, 2011, p. 18).

In 1991, to alleviate the pressure on the fish farming industry, the law of 1973 was mitigated such that majority owners were no longer required to have a local affiliation. Thus, the industry began consolidating through mergers and acquisitions. During the early 2000s, the supply of salmon exceeded the demand, which caused the salmon price to fall yet again. This led to more fish farming companies going bankrupt and several companies were forced to restructure. This was also around the time several fish farming companies became stock-listed companies on the Oslo Stock Exchange. Throughout the first years there were a lot of mergers and restructurings before the market consolidated and stabilized. Today, the fish farming industry represents one of the largest industries in Norway and exported farmed salmon for NOK 72 billion in 2019 (SSB, 2020). However, the industry is currently facing several challenges such as sea lice, limitations on production capacity and the decline in demand due to COVID-19.

3.5 The fish farming market

3.5.1 Global production

The global salmon supply has increased by a compound annual growth rate (CAGR) of about 3,2% since 2012. The largest supply comes from Norway and Chile, which together represent more than 78% of the total worldwide harvest volume.

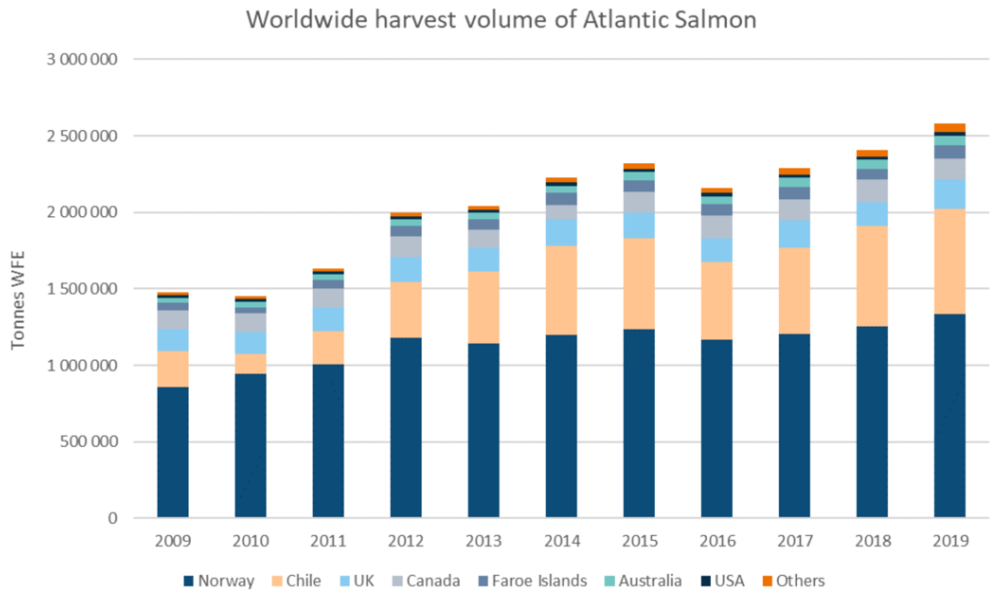

Figure 4: Global salmon production by country (2009-2019). (Source: Kontali).

Norway is by far the largest salmon producer in the world, with a total supply of approximately 1,33 million tonnes whole fish equivalent (WFE) in 2019, representing 51,6 % of the total volume. Chile, the second largest supplier, represents 26,7 % of the total volume and has increased by more than 188% from 2009 to 2019. The growth in the worldwide production has increased rapidly since 2010, but due to both aquaculture constraints and limitations on fish farming licenses, the growth rate is expected to stagnate the next couple of years.

However, progress has been made in land-based fish farming, which could potentially remove some of these constraints in the future.

3.5.2 The Salmon Production Market – Supply

The primary challenges for the fish farming industry are its issues with biological costs and limitations on production growth. In order to farm salmon successfully, there are several conditions which need to be met. For example, the temperature must range between zero and twenty degrees Celsius, and optimally between eight and fourteen degrees. Furthermore, there must also be a sufficient current to ensure a flow of water throughout the fish farm. As a result of this, the supply of salmon is somewhat limited.

In addition to this, practically all countries require companies to apply for salmon farming licenses due to regulations. As previously mentioned, these licenses place limitations on the maximum allowed biomass the owner of the license is permitted to hold. The Norwegian government has placed restrictions on license volume growth due to environmental concern and other concerns related to issues with biological issues such as sea lice. However, offshore farms and land-based salmon farming may allow for a substantially higher production of salmon in the future, given that the current technology is improved upon.

3.5.3 The Salmon Export Market

The vast majority of the global salmon production takes place in Norway, but nearly all of the salmon is exported abroad. Figure 5 below illustrates the substantial growth in the export value of Norwegian salmon. According to data from SSB, the export value from 2007 to 2019 has increased from NOK 17 billion to NOK 72 billion, representing an increase of more than 315%. In terms of CAGR, this amounts to approximately 12,6%.

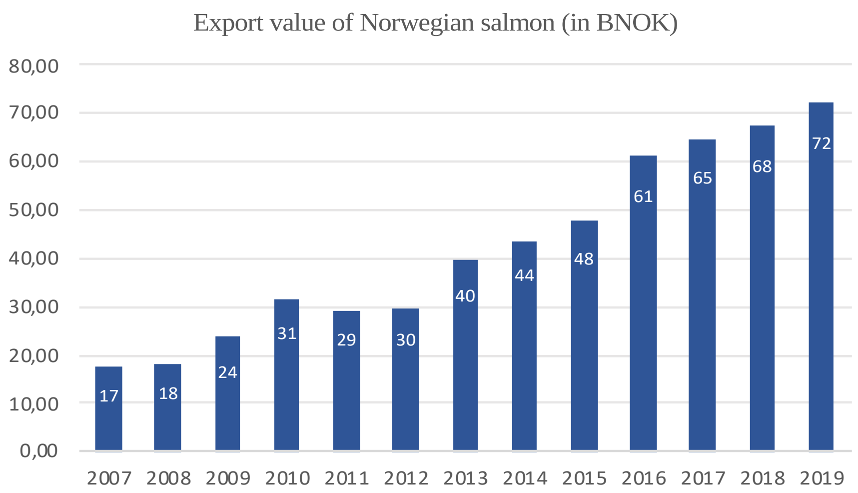

Figure 5: Export value of Norwegian Salmon (2007-2019). (Source: SSB)

An interesting observation is the fact that although the export value of Norwegian salmon has increased continuously since 2012, the export in terms of volume has only increased by a CAGR of 1,73%. The main reason for this is due to a weak NOK, which stimulates exports as a depreciation of NOK makes exported goods cheaper for other countries, leading to a higher demand for the Norwegian salmon (Nygård, 2020). The figure below illustrates the export volume of Norwegian salmon in the period 2009-2019.

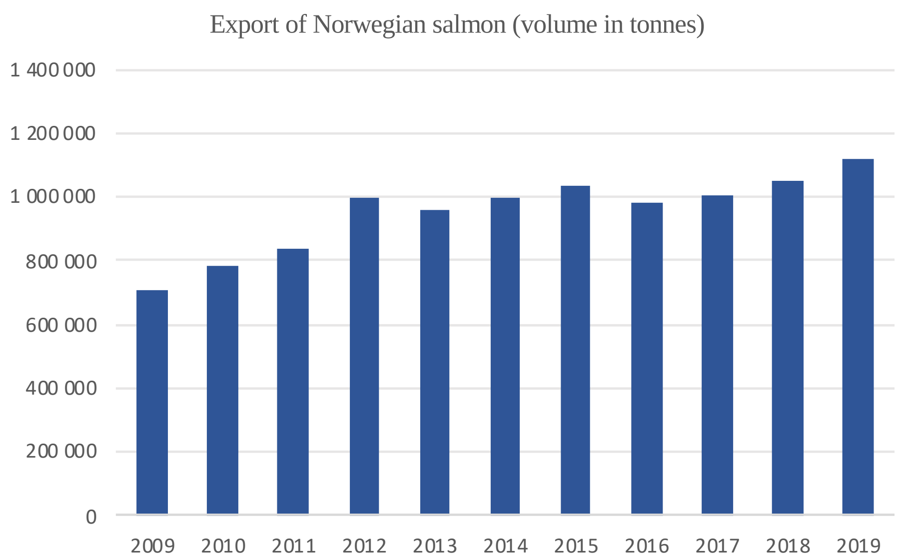

Figure 6: Export volume of Norwegian Salmon (2009-2019). (Source: SSB)

In order to obtain a better picture of how variables such as currency differences impact salmon price, one needs to examine how much is exported to each country. The figure below illustrates the export markets for Norwegian salmon.

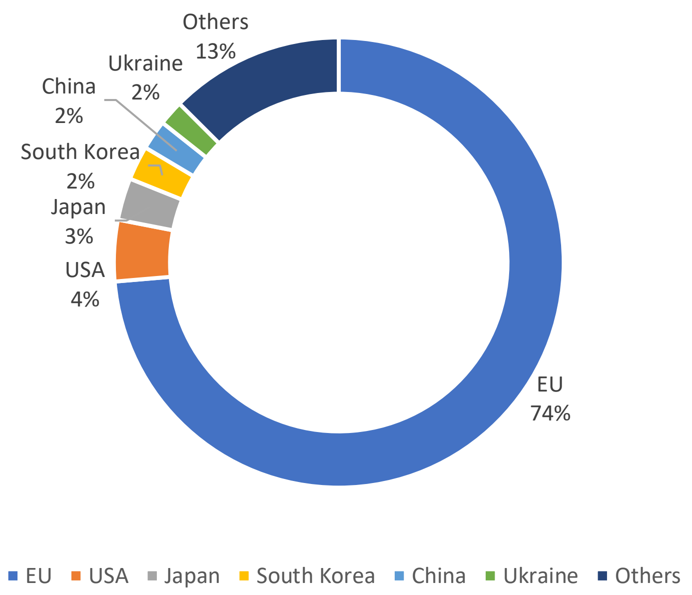

Figure 7: Export Markets for Norwegian Salmon (2019) (Source: SSB)

The primary market for the Norwegian salmon is the European Union (EU), with Poland, France and Denmark being the largest purchasers. Thus, as the EU is the main market for Norwegian salmon, the EUR/NOK currency exchange rate should in theory have a substantial impact on the salmon price. The most significant change in terms of export volumes can be observed when looking at the Russian market. In 2013, more than 11% of the total Norwegian export volumes of salmon went to the Russian market. This changed in August 2014 when Russia banned imports of Norwegian fish due to political reasons related to the sanctions following the Russian annexation of Crimea. The reason why countries such as Poland, the Netherlands and Denmark import such substantial amounts of Norwegian salmon is due to their processing industry whereby they process the salmon into a wide variety of products and then sell them on to other countries (Røssland & Skudal, 2017, p. 11).

3.5.4 Pricing

The salmon price (NQSalmon) is determined by demand and supply. An increase in demand, combined with supply restrictions, has led to an increase in the salmon price the last several years. Although the salmon price has been very volatile during the most recent years, it has reached a price of more than 80 NOK/kg a few times, in contrast to the steadier level of 30-50 NOK/kg in the years before 2015. The figure below illustrates the salmon price from 2009 - 2020 and the data is publicly available from Nasdaq (2020).

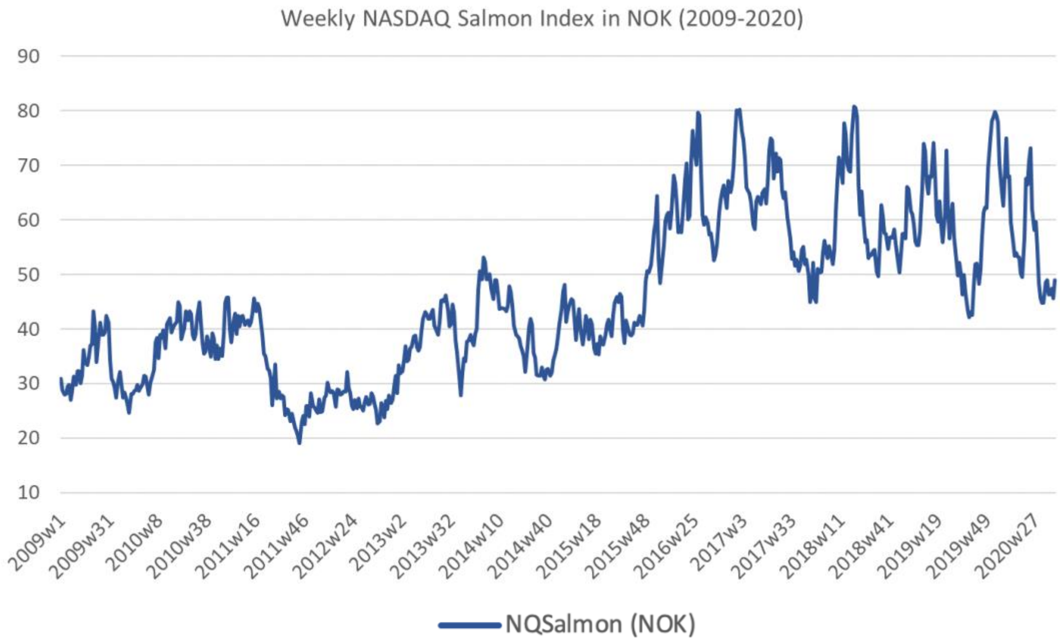

Figure 8: Salmon Price (NQSALMON) in the time period 2009 - 2020 (Source: Fish Pool).

The salmon price is somewhat cyclical, mainly due to differences in demand and growth conditions throughout the year. According to Mowi (2020), harvesting of salmon is spread relatively evenly across the year, although the better growth conditions in the second half of the year leads to increased harvest volumes during this period. As a result of lower harvest volumes during the summer, the salmon price is usually higher this time of the year. Furthermore, due to high harvest volumes from August to October, the salmon price tends to be lower in this period. Mowi (2020) further states that since the planning and production cycle spans over several years, it is difficult to adjust the production levels on a short-term basis. Therefore, with demand and harvest volumes changing according to season, this has been the main reason for the high volatility of the salmon price. The demand is typically highest in the holiday of December, and consequently the price is normally higher at the end of the year.

3.6 The Impact of COVID-19

The fish farming industry, like most of the industries worldwide, is highly dependent on international trade. Thus, once the coronavirus began to spread and was characterized as a pandemic, it rapidly had a substantial impact on the international trade. Countries all over the world implemented restrictions in terms of both travelling, transporting, and closing down large parts of the food service sectors such as the HORECA-market (hotels/restaurants/cafes). The HORECA-market represents a substantial share of the worldwide purchasers of farmed salmon. In the EU, about 70% of the Atlantic salmon was sold to retailers, while 30% was sold to the foodservice industry (Mowi, 2020, p. 103). Consequently, once these hotels, restaurants and cafes were shut down, the demand for salmon dropped significantly. For example, according to SSB (2020), the Norwegian export of salmon from March to August amounted to approximately 431 500 tonnes in 2020, while during the same period in 2019 the quantity was closer to 471 000 tonnes. Although the demand from the HORECA-market has been negatively affected by the restrictions, the demand for farmed salmon has been partly offset by increased demand from the retail-segment in several countries within the EU (Norwegian Seafood Council, 2020). Seafood analyst Paul Aandahl in Norwegian Seafood Council stated that as a result of this shift in demand from the HORECA-market to the retail market, a significant share of the exports has shifted towards countries such as Poland as it has the largest fish processing industry (Skalleberg, 2020).

The industry-wide lockdowns throughout the world also had a severe impact in terms of logistics. The fish farming industry in Norway transports nearly all of its harvested salmon abroad, primarily through air travel on passenger airplanes. Thus, once cross-border flights were banned or discouraged by several countries throughout the EU, the fish farming industry experienced several flight cancellations and suffered increased air freight costs (FAO, 2020). Furthermore, the fish farming industry is part of an extensive value chain which requires a lot of transportation. For example, fish farming companies rely on inputs from the fish feed sector which again relies on inputs of for example fish meal, fish oil and soy protein concentrate from other companies which produce these inputs all over the world. Therefore, the industry is still facing challenges in terms of logistics which has resulted in a supply chain disruption within the global fish food chain (FAO, 2020).

Figure 9: Extended Value Chain in the Salmon Industry (Source: Modified from Bakkafrost Annual Report 2019)

COVID-19 has also had an impact on currencies which the fish farming companies rely on, namely the EUR/NOK and the USD/NOK. As previously mentioned, most fish farming companies in Norway export their salmon abroad. Thus, if the EUR appreciates against the NOK, their revenues will increase due to the increase in the salmon prices. At the same time, an increase in the USD/NOK will result in higher costs as most of the fish feed is bought in USD. The figure below illustrates the daily development of the EUR/NOK and the USD/NOK from January 2020 up until November 2020.

Figure 10: Historical development of the EUR/NOK and USD/NOK (January 2020 – September 2020) (Source: Norges Bank)

It was around the beginning of March of 2020 that the coronavirus began to spread rapidly worldwide, which resulted in a nationwide lockdown in Norway and several other countries. Once lockdowns were implemented, investors feared that there would be a substantial decline in the global economic activity. As a result of this uncertainty, the oil price began to plummet. Thus, as the NOK is strongly correlated with the oil price, the NOK depreciated against both the EUR and the USD. In addition to this, during times of financial uncertainty, investors usually place their money in currencies that are considered to be safe. The EUR and the USD are examples of this due to their high liquidity. Consequently, according to Kolbjørn Giskeødegård in Nordea Markets, as the NOK depreciated against the EUR, the decline in salmon prices due to the decline in demand was partly offset by a weaker NOK (Knudsen, 2020).

In order to obtain a better understanding of how COVID-19 has impacted the salmon price, we decided to look at the difference in the salmon price in 2020 relative to 2019. The table below illustrates the significant drop in the salmon price once lockdowns were implemented during March 2020. The illustration seems to suggest that for 2020, the increase in the EUR against the NOK has offset the decline in demand and that Norwegian fish farming companies received a sizeable part of the foreign exchange gain compared to 2019.

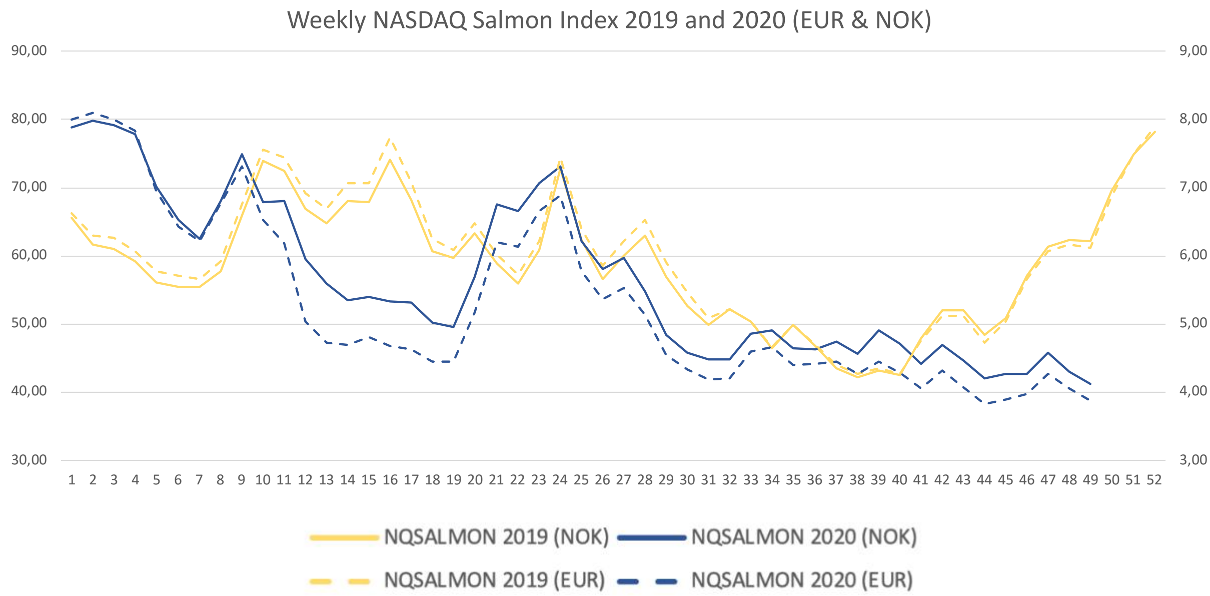

Figure 11: Weekly NQSALMON in NOK and EUR (2019-2020). (Source: Fish Pool 2020c)

In August 2020, the Norwegian Seafood Council released data that showed the export value of Norwegian salmon declined by 13% to NOK 5,3 billion. The volume of salmon exported also fell by 7% to 95 100 tonnes. According to Tom-Jørgen Gangsø in Norwegian Seafood Council, the difference between the percentage export value decline and volume decline was a result of lower salmon prices during the “Second Corona Wave” in August, in addition to an appreciation of the NOK which no longer sufficiently offset the loss of demand for salmon (Skalleberg, 2020).

3.7 Future Outlook for the Fish Farming Industry

According to Gibson (2020), Kontali estimates that the total worldwide supply in 2020 will increase by 3,6% from 2019. However, the growth may differ depending on several variables such as the effect of sea lice, temperature and contributions from both offshore and land-based farming.

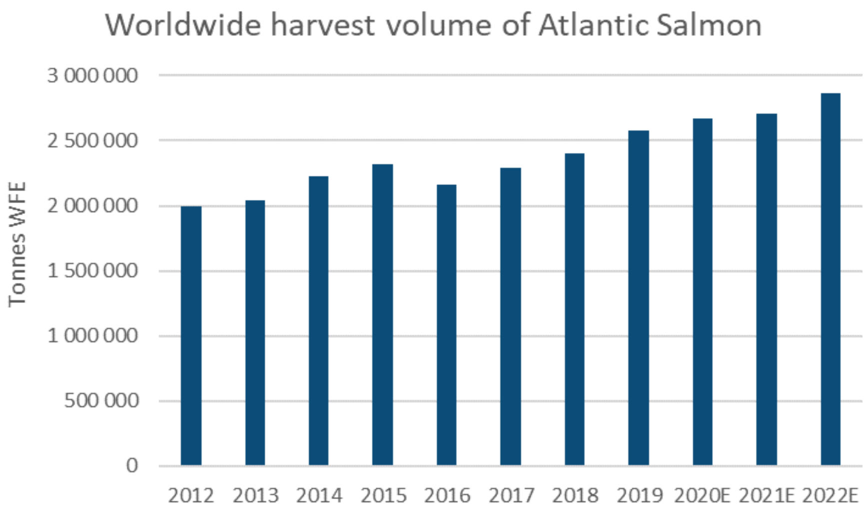

Figure 42: Worldwide harvest volume of Atlantic Salmon (2012-2022E) (Source: Gibson (2020) & Kontali).

Global trends such as population growth, aging populations, limitations on the supply of wild fish and focus on healthy high-quality protein food will likely contribute to increase the future demand of salmon and consequently the production volumes.

Due to the increase in the global salmon production, the industry has faced shortage issues in terms of marine fish feed such as fish oil and fish meal. Marine material makes up about 25-30% of the Norwegian fish feed (Moe, 2019, p. 16). As a result of this, the use of vegetable materials such as wheat and soy have become more prevalent in the industry. In addition to this, fish farming companies are developing and researching alternative fish feed sources such as protein rich krill, algae and insects in an effort to become more sustainable in terms of their carbon footprint. Soy protein concentrate (SPC) is one of the main ingredients utilized in fish feed production in Norway, but the deforestation in the Amazon which has taken place as a result of the demand for SPC, has caused large companies such as Mowi to reconsider their purchase of Brazilian soy. In the coming years it is therefore likely that the industry will look for more sustainable protein sources to reduce its carbon footprint.

One of the largest problems facing the fish farming industry is the costs related to salmon lice, a parasite that feeds on the skin and blood of the salmon. The prevalence of lice has increased in line with the growth of the fish farming industry and represents a threat to wild salmon and marine life. As a result of this, the costs of treating the lice have increased and the frequent treatment of lice has caused the parasite to become resistant to traditional de-licing methods. Recent studies estimated that the cost of the salmon lice amounted to approximately NOK 5.2 billion in 2018 (Berglihn & Iversen, 2019). In order to combat the salmon lice, the largest industry players have significantly increased their R&D expenditure (Moe, 2019, p 45). For example, Salmar has received development licenses for offshore farming facilities in the open ocean. Due to the ability to submerse these offshore farming facilities even further below the sea level, strong currents remove both fish feed leftovers and excrements. This contributes to a significantly lower risk of sea lice and consequently lowers the costs related to lice treatment.

Yet another trend is land-based fish farming as it allows for a substantially higher production volume due to the facility not being as reliant on favorable aquaculture conditions. Furthermore, by using technology such as recirculating aquaculture systems, the company can mitigate problems with both sea lice and escapes. Land-based facilities allows for more control in terms of water quality, recirculation of water, temperature and fish feeding. However, the technology is still in its infancy and the costs are currently higher than the traditional fish farm facilities. Another downside with land-based farming is that the majority of these facilities in Norway currently have a carbon footprint which is about 28% higher than the normal net pen production (Moe, 2019, p.12). However, if the technology utilized in land-based farming is improved and is successfully able to reduce both costs and carbon footprint, we will likely see substantially more land-based farms all over the world.

The industry has also experimented with producing larger post-smolt due to the smaller smolt being significantly more vulnerable once transferred to net-pens. When the smolt is kept in post-smolt facilities for a longer amount of time, the fish will be able to grow to a larger size and subsequently be required to spend less time in net-pens until it is harvested. As a result of this, the salmon will be less exposed to sea lice. In addition to this, as the salmon spends less time in open net-pens, the carbon footprint is also reduced. Yet another reason why the industry has taken great interest in this is because it enables a reduction in the production period due to higher flexibility. By utilizing larger post-smolt, the production capacity could increase by 50% as the amount of production cycles is increased from four to six within a seven-year timeline (Moe, 2009, p.18).

The future of the fish farming industry will very likely be shaped by variables such as sustainability and development in terms of technology improvements. The industry is currently facing challenges with sea lice, sustainable fish feed, shortage of fish feed, and sea lice as well as production capacity limitations due to a lack of favorable aquaculture locations. However, through experimental technology and innovative concepts such as offshore farming and land-based farming, the fish farming industry could solve these problems and ensure continued growth in the coming years.

4. Theory

In this section we intend to discuss the theoretical foundation for our analysis, such as the pricing of stocks using the capital asset pricing model, different types of market efficiency and the implication they have with regards to how much information is reflected in a stock price, and finally currency exchange rates. Although we do not determine a valuation of the different fish farming companies in our paper, we believe it is useful to present different factors which may impact the pricing of these companies.

4.1 Valuation of Stocks

In this section we will discuss a theoretical model which determines the pricing of stocks. There are several theoretical models which take different approaches to value a company. Consequently, the same company may very well have a completely different valuation depending on which method is used. However, due to its simplicity, the capital asset pricing model (CAPM) is commonly used as a tool in the valuation of stock prices. Furthermore, the level of market efficiency may have an impact on the pricing of a stock. Consequently, we find it useful to briefly present the different market efficiency theories. In our paper, we do not make any assumptions about which market efficiency is the correct one, we merely emphasize that valuations of stocks may differ due to different levels of market efficiency.

4.1.1 The Capital Asset Pricing Model

According to Fama & French (2004), asset pricing theory was initiated by the Capital Asset Pricing Model (CAPM) of William Sharpe (1964) and John Lintner (1965). In essence, the CAPM illustrates the relationship between systematic risk and expected return, whereby systematic risk represents the inherent risk to the market as a whole. The model is commonly used in the financial world to compute an appropriate expected return for a given stock. The formula for the CAPM, as presented by Kenton (2020), is given by:

$$E(r_i) = r_f + \beta_i(E(r_m) - r_f) \tag{4.1}$$

where:

$E(r_i)$ = Expected return.

r_f = Risk-free rate.

β_i = The beta, which represents the systematic risk. More specifically, the asset's sensitivity relative to the market portfolio.

$E(r_m)$ = The expected return of the market.

$(E(r_m) - r_f)$ = The market risk premium.

When an investor intends to purchase an asset or a stock, he/she expects to be compensated for the risk they are taking. In addition to this, investors also require a compensation for the time value of money, which is represented by the risk-free rate in the CAPM-formula. The beta, β_i, measures how sensitive the stock is relative to the market. If a given stock has a beta which exceeds 1, it will be more volatile than the market. Conversely, a beta lower than 1 indicates that the stock price is less volatile than the market. Once the beta is multiplied with the market risk premium, while also taking into account the time value of money through the risk-free rate, we obtain a discount rate which is used to find an appropriate value of a stock. The way in which the CAPM is constructed shows us that the investors should be compensated for systematic risk they are exposed to through a higher expected return. However, the investor is not compensated for idiosyncratic risk which is specific to each company. This is due to the fact that an investor is able to eliminate this risk by holding a diversified portfolio.

The CAPM relies on a set of assumptions which do not hold up in the real world. There are several economists who argue that empirical tests prove that the CAPM is not applicable (Fama & French, 2004). For example, the model relies heavily on historical data to compute a future return of a stock. It is assumed that the beta remains constant while in real life the beta may vary significantly over time. Furthermore, the model also assumes that all investors share a consensus with regards to both risk and expected returns, while also having access to the same information. Regardless, the CAPM is a widely used financial model due to its simplicity, in addition to offering an intuitive measurement of risk.

4.1.2 Market Efficiency

In an ideal market, all information is already fully reflected in stock prices which means there are no stocks that are overvalued or undervalued (Fama, 1970). Consequently, there would be no way for an investor to outperform the market. The more efficient a market is, the less arbitrage is available for investors to take advantage of. However, the idea that all information is reflected in stock prices is widely considered to be unrealistic. Thus, we distinguish between three forms of market efficiency, namely weak-form, semi-strong form and strong-form (Bodie et al., 2014, p. 353).

Weak-Form Efficiency

The weak-form hypothesis states that all information which is available through examining market data, such as historical prices and trading volume, is already reflected in stock prices. Essentially, this would mean that trend analysis is ineffective as an investor will not be able to use historical performance to predict future performance. The random walk theory states that changes in stock prices do not follow any patterns and that they are not dependent on past performance. Proponents of this theory, such as Fama (1965, pp. 5-6), argue that it is not possible to use historical prices to predict the future prices.

Semi-Strong Efficiency

If the market has semi-strong-form efficiency, stock prices reflect all information about historical stock prices, publicly available information such as fundamental data and management quality, and lastly all future expectations (Maverick, 2020). In this case, the only way to outperform the market would be if an investor had access to information which was not publicly available.

Strong-Form Efficiency

The most extreme efficient market hypothesis is the strong-form hypothesis. In this case, all available information to the firm such as historical prices, fundamental data and insider information is already reflected in the stock prices. In other words, there is no way for the investor to outperform the market.

4.2 Currency Market Theory (Currency Exchange Rates)

Given that export is a substantial part of the fish farming industry, we would like to study the effect of currency exchange rates. Furthermore, much of the production cost is exposed to currency effects as fish feed is purchased in foreign currencies. The effect of exchange rates is therefore an interesting factor to examine as it effects many aspects of the production and sales of farmed salmon. Thus, we will present some theory on exchange rates to obtain a better understanding of the influence and effects of it.

The nominal exchange rate shows the price of one currency compared to another and can be denoted as:

$$E = \frac{C^F}{C^D} \quad (4.2)$$

Here E represents the amount of foreign currency (C^F) for one unit of domestic currency (C^D). Appreciation of the domestic currency NOK is an increase in the value of NOK in relation to other currencies. Hence, less NOK is required to purchase one unit of the foreign currency. If NOK depreciates, the value of NOK decreases, resulting in more NOK required to purchase one unit of the foreign currency (Williamson, 2014, p. 568). Considering that a substantial portion of the production costs for Norwegian fish farming companies are in foreign currencies, it is evident that a change currency exchange rates will have an effect on the fish farming companies' expenses.

When considering export in general, a depreciation of NOK would as an isolated effect stimulate export. This is due to a decreased value of NOK making exported goods cheaper for foreign countries, leading to a higher demand of the goods exported. By utilizing the equation presented above, we can see that a depreciation of NOK would result in foreign countries receiving more value in NOK for one unit of their currency. Contrastingly, appreciation of NOK implies that foreign countries must pay more for the same exported goods, leading to reduced export (Williamson, 2014, p. 569).

5. Methodology

5.1 Ordinary Least Squares method

In this section we will present the model used in our analysis. With the purpose of displaying any significant correlations between the independent variables and our dependent variable, we decided to use time series analysis. The ordinary least squares (OLS) model is a commonly used model for this. We will first give a short introduction of the model, followed by a description of the assumptions for this type of regression.

OLS is a type of linear least squares method used to estimate the parameters in a regression model by minimizing the distance between the values of the dependent variable and the regression line. This is done by minimizing the sum of the squared residuals. Hence, the regression coefficients are chosen by the OLS estimator such that the estimated regression line is as close to the actual observed data as possible (Stock & Watson, 2015, p. 118). Since our model will include several independent variables, we will use a multiple regression model. Generally, according to Wooldridge (2016, p. 348), we can write a model with multiple independent variables with time series data as:

$$y_t = \beta_0 + \beta_1 x_{t1} + \beta_2 x_{t2} + \ldots + \beta_k x_{tk} + u_t \qquad (5.1)$$

for i = {1,2, …, k), where k is the number of variables and t = {1, 2, …, n), where n is the number of observations (time periods). The dependent variable is denoted by y_t, and the independent variables by x_{tk}. β_0 is the intercept, while β_i measures the change in y with respect to x_i, holding all other factors fixed. u_t is the error term quantifying how much of y_t is not explained by our independent variables.

The model estimated by OLS can be written in a general form as:

$$\hat{y}_t = \hat{\beta}_0 + \hat{\beta}_1 x_{t1} + \hat{\beta}_2 x_{t2} + \ldots + \hat{\beta}_k x_{tk} \qquad (5.2)$$

The hatted values are estimates of the corresponding betas and are obtained by the method of OLS choosing the estimates that minimizes the squared residuals. This is the linear regression that is most similar to the actual observed values of both the dependent and independent variables (Trodal & Risnes, 2017, p. 42).

5.2 OLS assumptions

According to Wooldridge (2016), there are six assumptions for time series regressions. We have tested our variables to determine if these assumptions hold. In the following we will briefly present the assumptions, in addition to the results from our tests.

Assumption 1 - Linear in parameters

This assumption states that the time series process follows the linear model where a one unit increase in one of the independent variables prompts a one unit increase in the dependent variable. The general model presented in (5.2) shows linearity in the parameters.

Assumption 2 - No perfect collinearity

This assumption states that no independent variable can be constant nor a perfect linear combination of the other independent variables. This would mean that OLS is unable to generate estimates of regression coefficients because of perfect collinearity. Although the independent variables can be correlated, it eliminates perfect correlation.

If there is an exact linear relationship between two or more independent variables, we have perfect multicollinearity. One rule of thumb to detect if multicollinearity is present is if the correlation between two independent variables is higher than 0.8-0.9 (Franke, 2010). Our correlations presented in 7.2 indicate that there are no critical levels of multicollinearity present amongst the independent variables.

Assumption 3 - Zero conditional mean

The next assumption that needs to be fulfilled is that for each time period, *t*, the expected value of the error term, u_t, given the independent variables, X, for all periods, must equal zero (Wooldridge, 2016, p. 318).

$$E(u_t|X) = 0, \quad t = 1, 2, \ldots, n \tag{5.3}$$

This implies that the error term must be uncorrelated with the independent variables
in each time period and that the independent variables are strictly exogenous. However, in practice the necessary assumption is:

$$E(u_t|x_{t1}, x_{t2}, \ldots, x_{tk}) = 0 \tag{5.4}$$

This assumption is sufficient for proving the consistency of the OLS estimator. When it holds, the independent variables, x_{ij}, are said to be contemporaneously exogenous. The expected value of the error term will equal zero if a constant is present in the regression model.

Assumption 4 - Homoscedasticity

This assumption means that the variance of the error term u_t, given the independent variables x_{ij}, cannot depend on x_{ij}. The assumption holds if u_t and x_{ij} are independent and the variance of u_t is constant over time. When this assumption does not hold, the errors are said to be heteroskedastic. In this case OLS does not provide the estimate with the smallest variance.

In order to test if this assumption holds, we have conducted a White's test. This statistical test determines if the variance of the errors in the regression models are homoscedastic, i.e. have a constant variance. The results from these tests are presented under each model in appendix 1-7 and show that heteroscedasticity is not an issue for any of the regression models, except for Grieg Seafood Group (model 3).

Assumption 5 - No serial correlation

According to this assumption the errors in two different time periods must be uncorrelated. This can be expressed as

$$Corr\ (u_t, u_s|X) = 0 \qquad (5.5)$$

for all time periods where t ≠ s. If this assumption does not hold, we say that the errors are serial correlated or autocorrelated. This would result in one variable affecting the value of the variable in the next time period. Autocorrelation is a potential problem when dealing with time series data, as the data is not randomly sampled.

For detecting autocorrelation, the Durbin-Watson test is the most frequently used. The test detects autocorrelation of first order in the residuals from the regression models. We have also used the Ljung-Box test to test for autocorrelation of more lags than one, as in the Durbin-Watson test. The results from these tests are presented in appendix 1-7. The results from the Durbin-Watson tests conclude that there is no autocorrelation in any of the models. The same is found with the Ljung-Box test for all models except for model 2 (Salmar).

Because of indications of heteroskedasticity in model 3 and autocorrelation in model 2, we adjusted for this by applying the method Newey-West. This method uses Newey-West standard errors that are robust to heteroskedasticity and autocorrelation. When using the method in Stata, it does not output R^2 nor adjusted R^2. Due to Newey-West reporting the same regression coefficients, we can, according to Musau (2018), pick these statistics from the equivalent OLS regressions to obtain a goodness of fit of the models.

Assumption 6 - Normality

The last assumption states that the errors u_t, are independent of the explanatory variables X and are independently and identically distributed (i.i.d.) with a mean of zero and a variance of σ^2, i.e., Normal (0, σ^2). This implies homoskedasticity, exogeneity and no autocorrelation. To test if this assumption holds, we used the Jarque-Bera test. The test compares the skewness and kurtosis of the data to check if it matches with normally distributed errors. The results from these tests, shown in appendix 1-7, show that some of the models violate this assumption. However, there are few consequences associated with violating the normality assumption. When the sample size is sufficiently large (>10 observations per variable), a violation will not impact the results in a noticeable way (Schmidt & Finan, 2018). With large sample sizes, the normality assumption is not needed as the Central Limit Theorem ensures an approximate normality distribution.

5.3 Stationarity

Stationarity in the data is an important assumption when utilizing the OLS method. In essence, stationarity means that the statistical properties of a process which generates a time series do not change over time. More specifically, a time series process is stationary when the probability distributions are stable over time. We have two types of stationarity, strong stationarity and weak stationarity. Strong stationarity requires shift-invariance in time whereby the distribution of a finite sub-sequence of random variables of the stochastic process remains the same as we shift it along the time index axis (Palachy, 2019). In other words, the distribution is the same throughout the entire time period in our data set in the sense that the probability of *y* falling within an interval is the same regardless of which time period is observed. Weak stationarity requires that the mean remains unchanged throughout all the time points, and that the covariance between the two time points depend only on the difference between the two time points. In order for a time series to have weak stationarity, the following conditions must be satisfied:

$E(y_t) = \mu$, i.e. the mean is constant (5.6)

$Var(y_t) = \sigma^2 < \infty$, i.e. the variance is constant (5.7)

$E(y_{t1} - \mu)(y_{t2} - \mu) = y_{t2-t1}$, i.e. the covariance is constant (5.8)

A time series which needs to be differentiated once in order to become stationary is defined as a I(1) series, i.e. that it is integrated of order 1. If the time series is I(0), integrated of order 0, it has weak stationarity (Woolridge, 2016, p. 358). There are several types of non-stationary processes according to Iordanova (2020), such as the following:

- **Random Walk** ($Y_t = Y_{t-1} + \varepsilon_t$), i.e. the current value is a result of the previous period value plus a white noise. In a random walk, the variance becomes infinite over time and a random walk is consequently unpredictable.
- **Random Walk with Drift** ($Y_t = \alpha + Y_{t-1} + \varepsilon_t$), i.e. the value at time *t* is a result of the previous value, plus a drift-term α and the stochastic component ε_t. A characteristic of this non-stationary process is that there is no long-run mean reversion and that its variance is dependent on time.
- **Deterministic Trend** ($Y_t = \alpha + \beta_t + \varepsilon_t$), i.e. the value at time *t* is regressed on the time trend β_t. In this case, the mean will grow around a trend which is fixed, constant and independent of time.
- **Random Walk with Drift and Deterministic Trend** ($Y_t = \alpha + Y_{t-1} + \beta_t + \varepsilon_t$), i.e. a combination of the two non-stationary processes.

If a time series is mean reverting, i.e., that it returns to a certain mean over time, it is stationary. If a time series is non-stationary, it will not be possible to apply the results to all the time periods we are looking at. Furthermore, it may lead to *spurious regressions*, whereby the regression will indicate that there is a relationship between the variables even though that is not the case. In this scenario, the regression will often compute a high R^2 in addition to significant coefficients. Consequently, F-tests and t-tests will become invalid due to these tests being built on assumptions that the time series is stationary.

If our time series has a unit root, then it is not stationary. Therefore, in order to test for stationarity, it is common to use a *unit root test* such as the Augmented Dickey-Fuller test. There are four different ways in which the test can be used, but the null hypothesis (H_0) which says that the variable has a unit root is the same for all the cases. The different cases are presented below.

Case	Process under H0	Regression Restrictions
1	Random walk without drift	$\alpha = 0, \delta = 0$
2	Random walk without drift	$\delta = 0$
3	Random walk with drift	$\delta = 0$
4	Random walk with drift or without drift	(none)

Table 2: Augment Dickey Fuller Test Cases. (Source: Stata, 2020a).

The Dickey-Fuller test works as follows: We have a model which we assume is equal to $(y_t = \alpha + y_{t-1} + u_t)$ in which u_t is an i.i.d. error term with a mean of zero. A Dickey-Fuller test means that the model, $(y_t = \alpha + \rho y_{t-1} + \delta t + u_t)$ is fitted by OLS where either α or δ is set equal to 0. To control for serial correlation in the regression, we use the augmented Dickey-Fuller test whereby the model is fitted to the form:

$$(\Delta y_t = \alpha + \beta y_{t-1} + \delta t + \zeta_1 \Delta y_{t-1} + \zeta_2 \Delta y_{t-2} + \cdots + \zeta_k \Delta y_{t-k} + \epsilon_t) \qquad (5.9)$$

where the number of lags is specified by the term *k*. The table below shows the results from our stationarity tests. Before the tests were conducted, our variables were adjusted for trends and potential outliers.

We have used the Schwarz Bayesian Information Criterion (SBIC) to select the optimal number of lags. The SBIC attempts to resolve the issue of overfitting a model, which happens by adding too many parameters, through the inclusion of a penalty term for the number of parameters (Schwarz, 1978, p. 462). The table below illustrates the results from our ADF-test.

Augmented Dickey Fuller		
Variable	Lag (SBIC)	t-value*
Mowi	0	-9.812
Salmar	0	-11.359
Grieg	0	-8.213
Lerøy	0	-11.281
Norway Royal Salmon	0	-9.021
Bakkafrost	0	-12.190
Austevoll	0	-10.652
NQSalmon	0	-12.255
Volume	4	-7.279
EUR	0	-12.865
USD	0	-12.877

* Critical value: -3,51 at 1% significance level and -2.89 at 5% significance level

Table 3: Results from Augmented Dickey-Fuller test. (Source: Own table).

The table shows that for all variables we reject the null hypothesis of a unit root present and conclude that all variables are stationary. The number of lags used for each variable, is based on the SBIC criterion and is explained in section 6.1.

6. Econometric Model

In this section of the paper, we present the model we have used to analyze our data and clarify our decision to include lags and dummy variables.

6.1 Amount of Lags

Research within the field of economics shows that the dependent variable often reacts to the explanatory variable with a lapse of time. In other words, the effect of a change in the explanatory variable does not necessarily impact the dependent variable instantaneously (Wooldridge, 2016, p. 314).

This type of delay is commonly referred to as a *lag*. For example, a change in the supply of salmon will have an impact on salmon prices, which subsequently may impact the share prices of fish farming companies. Thus, it might take some time until investors have taken this new information into account such that it is fully reflected in the stock prices. Consequently, we decided to use lags of our explanatory variables to account for these lapses of time.

When deciding how many lags to include, there are several caveats one needs to consider. If you include too many lags in your model, it may result in an inflation of the standard errors of the coefficient estimates. Conversely, including too few lags may cause an estimation bias (Hanck et al., 2020, p. 411). When determining how many lags to include in a model, it is common to use an information criterion to choose the optimal number of lags. These criterion models introduce a penalty term, whereby the more parameters are included in the model, the higher the penalty will be. We used the SBIC which uses the following test to decide the number of lags which minimizes the value of SBIC:

$$SBIC = -2\left(\frac{LL}{T}\right) + \frac{\ln{(T)}}{T} t_p \tag{6.1}$$

Where LL is the log likelihood, T is the number of observations and t_p is the number of parameters in the model (Stata, 2010b).

Based on our information criteria model, we found that the optimal number of lags to use was 0 for the NQSALMON, EUR and USD, while for harvest volume it was 4. The harvest volume clearly stands out with a lag of four, representing significant results only after a 4-month time delay. We speculate that since a change in the stock prices of fish farming companies is in part a result of changing salmon prices, which again changes depending on the supply of salmon, there will naturally be some time delay until one can observe the impact of these changes.

Variable	Lag (SBIC)
NQSalmon	0
Volume	4
EUR	0
USD	0

Table 4: Number of significant lags based on SBIC. (Source: Own table).

6.2 Trend and Dummy Variables

In order to obtain a valid regression model, the variables must often be adjusted for potential trends and seasonal variations. By eliminating trends from a time series, we can more accurately analyze the volatility. Without adjusting for time trends, the R-squared of the regression model will be inflated. However, the fish farming industry is cyclical in nature, whereby salmon prices usually increase at the end of the year due to the holiday demand. Because this is a recurring trend each year, the change in the salmon price during this period is not new information nor a shock. Consequently, we would expect that these systematic price patterns around the holidays are already priced in and should not have a major impact on the companies' stock prices. As a result of this, we believe that there is no need to account for these trends in our regression.

According to Wooldridge (2016, p. 296) the OLS regression is highly sensitive to outliers and influential observations. An influential observation is an observation that has a greater impact on the values estimated in the regression model than other observations. Detection of these outlying observations is therefore an essential part of a good regression model.

To adjust for non-recurring shocks such as COVID-19, we have implemented a dummy variable in our models. We added a dummy variable for the period February to April in 2020 to handle the abnormally high volatility during the Covid-19 pandemic.

6.3 Selection of Variables

In this section of our paper, we intend to present the selected variables which will be utilized in our model. The variables we deem to be of interest are the companies' respective stock prices, the salmon price, global harvest volume, and the EUR/NOK and USD/NOK exchange rates.

6.3.1 Dependent Variables

In our model, we will look at the dividend-adjusted stock prices of each fish farming company listed on the Oslo Stock Exchange. Consequently, this includes Mowi ASA, Salmar ASA, Grieg Seafood ASA, Lerøy Seafood Group, Norway Royal Salmon ASA, Bakkafrost P/F and Austevoll Seafood ASA. We decided to look at each fish farming company separately rather than using the Oslo Seafood Index as the companies within this index are different in terms of size. Furthermore, for some of the companies, such as Mowi, the operations in Norway represent about 54% of their total harvest volume. Meanwhile, other companies such as Salmar, Lerøy and Norway Royal Salmon harvest more than 90% of their salmon in Norway. Therefore, we believe it would be interesting to look at these companies independently in our analysis. In addition to this, the companies also have different leverage ratios and other company-specific differences. For example, Lerøy Seafood Group also sells white fish and Austevoll Seafood Group produces fish meal and fish oil in addition to its salmon production through its investment in Lerøy Seafood Group.

6.3.2 Independent Variables

The independent variables we have selected are the variables which we believe will have a significant impact on our dependent variable. These are the variables to be used when building our model and are presented in this section.

Global Supply

According to economic theory regarding demand and supply, there is a clear relationship between supply and the price of a good. It is therefore sensible to include supply as an independent variable in our model. Since the Norwegian export prices are affected by the total supply in the global market, we have chosen this as a measure for the salmon supply. The figure below shows the development of the monthly harvest volume of Atlantic salmon and the monthly salmon price.

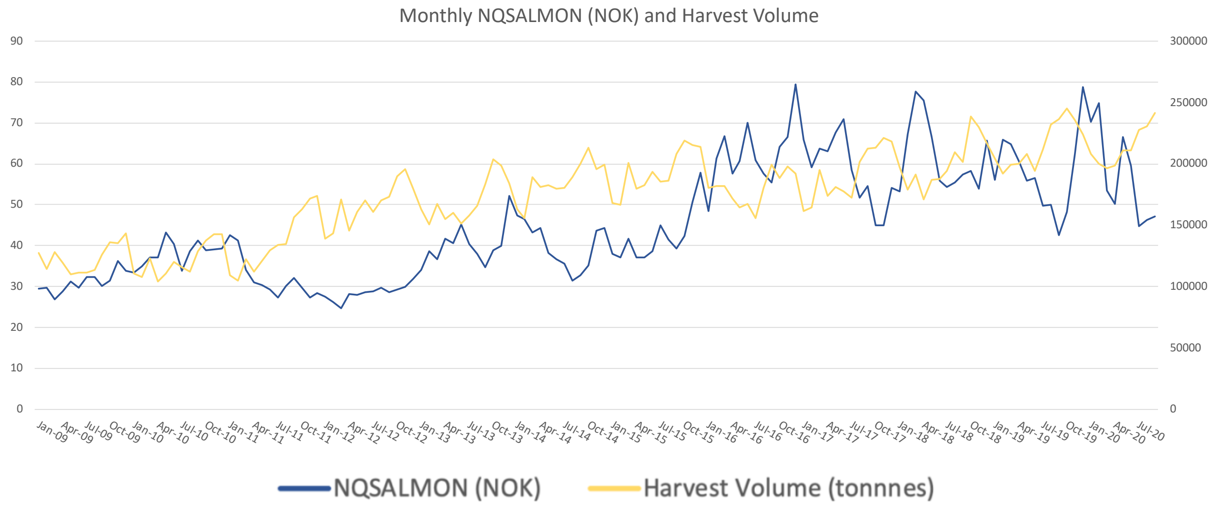

Figure 13: Monthly NQSALMON (NOK) and Harvest Volume (2009-2020). (Source: Kontali & FishPool).

A quick glance at the figure seems to suggest that there is a negative relationship between the harvest volume and the salmon price. In other words, it seems as if an increase in the harvest volume leads to a decrease in the salmon price (FPI). The salmon price fell substantially during 2011 due to several reasons. Firstly, there was a significant increase in supply of salmon from both Norway and other salmon producing countries, according to Paul Aandahl, market analyst at the Norwegian Seafood Council (Hvamstad, 2011). Secondly, Kolbjørn Giskeødegård in Nordea Markets stated that the salmon prices had stayed at a fairly high level prior to 2011 and several customers refused to purchase salmon at these prices and instead bought substitutes such as white fish or shrimps (Bjørnstad, 2011). Thirdly, following a long period of issues with infectious salmon anemia (ISA) from 2007 until 2009, Chile began to increase its production during 2011 (Mathiassen, 2011).

In 2014, following the Russian import ban of Norwegian salmon, the salmon price dropped temporarily but it was offset by demand from other markets such as the EU (Holland, 2015). In 2016, biological issues in both Norway and Chile resulted in a lower supply from fish farming companies which made it difficult to meet the growing demand, according to Giskeødegård (Hvamstad, 2016).

Salmon price

For fish farming companies, most of the revenues originate from production and sales of salmon. Hence, the price of salmon is of great significance to their earnings and is therefore included in our model for the analysis of the companies' stock prices.

Fish Pool ASA offers an international marketplace for buying and selling of financial salmon contracts (Fish Pool, 2020b). Their aim is to create predictability in fish and seafood markets exposed to risk by providing a correct reflection of the market price. Fish Pool ASA provides customers with a synthetic market price of salmon through its Fish Pool Index (FPI). The Index represents the monthly settlement price used in financial settlements of all the contracts at Fish Pool. The FPI is calculated weekly using elements based on the average weekly spot price of buying and selling Atlantic Salmon (Fish Pool, 2020c). The two elements are presented in table 5 below.

Index	Description	Weight
NASDAQ Salmon Index	Exporters' selling prices (superior quality, 3-6 kg, HOG)	95 %
Statistics Norway (SSB)	Norway's export statistics for fresh, gutted salmon	5 %

Table 5: Weighted indices used in calculation of FPI. (Source: Fish Pool Index).

The Nasdaq Salmon Index makes up nearly all of the FPI and reflects the weekly spot price of fresh Atlantic superior salmon, head-on gutted, to the European market (Nasdaq, 2017). Furthermore, it also reflects the actual physical transactions of salmon and is widely used by analysts, journalists and academia. Consequently, we have used the Nasdaq Salmon Index instead of the FPI as we believe it will give a more accurate picture of the spot price of salmon.

The overall trend the last couple of years is characterized by an upward movement in the salmon prices. This is likely due to limitations on fish farming licenses in addition to an increasing demand for salmon and supply issues due to biological issues such as sea lice and other diseases. Another essential reason for the increase in the salmon price is due to the weakening of the NOK against other currencies such as the Euro. From 2012 to 2018, 70% of the price increase was due to the growth in demand, 28% of the price increase was a result of a weak NOK, while production growth contributed negatively by 7% (Capia, 2019).

Currency

Volatile currencies may have a substantial impact on fish farming companies since nearly all of the supply in Norway is exported abroad. In 2019, Norwegian fish farms harvested about 1.33 million tonnes of salmon**,** of which most of it was exported (Kontali, 2020). According to the seafood analyst Giskeødegård, an appreciation of the EUR against the NOK will result in a higher salmon price (Knudsen, 2020). Consequently, due to that fact that 71% of the farmed salmon in Norway is exported to the EU, the EUR/NOK currency will likely be one of the primary drivers of the salmon price. The Norwegian Seafood council, in collaboration with the data analytics company Capia, found that a 10% weakening of the NOK results in a 3,5% increase in the salmon prices (Jensen, 2019).

Furthermore, most fish feed costs are in USD and a weakening of the NOK will therefore likely lead to higher costs due to more expensive raw materials, which again may partly offset the gain from an appreciation of the EUR/NOK exchange rate. For example, a report by Nofima in collaboration with Kontali, stated that some of the most important raw materials for fish feed are fishmeal, soya meal, fish oil and rapeseed oil. In their report, they found that due to a depreciation of the NOK, the cost of the raw materials and consequently the fish feed has increased. The figures below illustrate how despite the cost of some of the raw material has decreased in term of USD, the currency effect due to a weakening of the NOK has resulted in higher prices. Therefore, we believe it is essential to include currency exchange rates such as the EUR/NOK and the USD/NOK in our analysis.

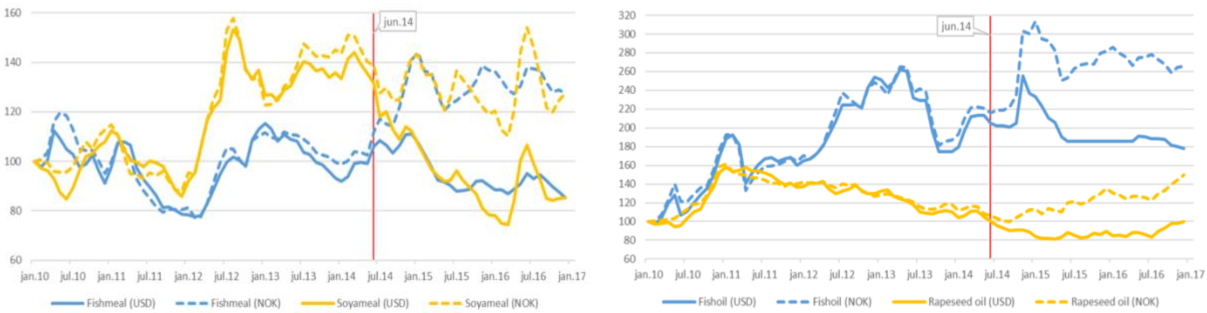

Figure 14: Currency effects on the price of raw materials used in fish feed (2010-2017) (Source:Nofima).

The Benchmark Index (OSEBX)

The fish farming stock prices are very likely to move with the overall stock exchange market. Thus, we believe it is important to adjust for this overall market impact. Empirically, it is common to use stock exchange indexes to reflect the overall market returns. Considering all of our stocks are listed on the Oslo Stock Exchange, we believe it makes sense to use an index which accurately reflects the overall returns of the Norwegian stock market. Oslo Stock Exchange stated that the Oslo Børs Benchmark Index (OSEBX) sufficiently reflects the overall returns of the stocks listed on the stock exchange. If the fish farming companies made up the majority of the OSEBX market value, including the index as a regressor would make the regression invalid. However, the table below shows that the companies only represent about 10,32% of the overall OSEBX market cap (Oslo Stock Exchange, 2020).

Company	Mowi	Bakkafrost	Salmar	Lerøy Seafood	Grieg Seafood
Share of OSEBX	4,2 %	1,6 %	2,4 %	1,6 %	0,5 %
Total Share	**10,32 %**				

Table 6: Fish farming companies' share of total OSEBX market value. Source: (Oslo Stock Exchange, 2020)

Consequently, we believe including the OSEBX as an independent variable makes sense. This share of total market value has remained almost the same the last years, fluctuating between approximately 10-12%.

6.4 Model Specification

In order to examine how the fish farming companies' stock prices are affected by the selected variables, we formulated an overall model which is as follows:

$$\Delta Ticker_t = \beta_0 + \beta_1 \Delta OSEBX_t + \beta_2 \Delta NQSalmon_t + \beta_3 \Delta Volume_t + \beta_4 \Delta Volume_{t-1} + \cdots + \beta_7 \Delta Volume_{t-4} + \beta_8 \Delta EUR_t + \beta_9 \Delta USD_t + \beta_{10} D_{COVID} + \varepsilon_t$$

where ticker is each company's stock ticker on the Oslo Stock Exchange.

All variables in the model are logarithmic returns. In section 7 we elaborate on how the variables were defined. Furthermore, the stock price of each company has been adjusted for dividends. Each company's specific model was modified to obtain the highest adjusted R^2 and the specific models can be found in chapter 8 and appendix 1-7.

6.5 Historical Data & Coefficient Hypotheses

Harvest Volume and Salmon Price (NQSALMON)

The change in the global harvest volume will very likely have a substantial impact on the salmon prices as it will impact the supply of salmon on markets worldwide. Figure 13 illustrates a relationship in which an increase in the supply of global harvest volumes results in a lower salmon price.

However, the magnitude of this relationship is different throughout the data period due to it being offset by other variables such as changes in the EUR/NOK exchange rate and the demand/supply curve. Thus, we expect that:

An increase in harvest volumes will lead to a lower salmon price

The EUR/NOK and the Salmon Price

The Norwegian fish farming companies primarily export their salmon to the EU and as the transactions take place in Euros, the relationship between the salmon price and the EUR/NOK exchange rate should in theory move somewhat in the same general direction. Figure 15 below shows that they do indeed move in the same direction.

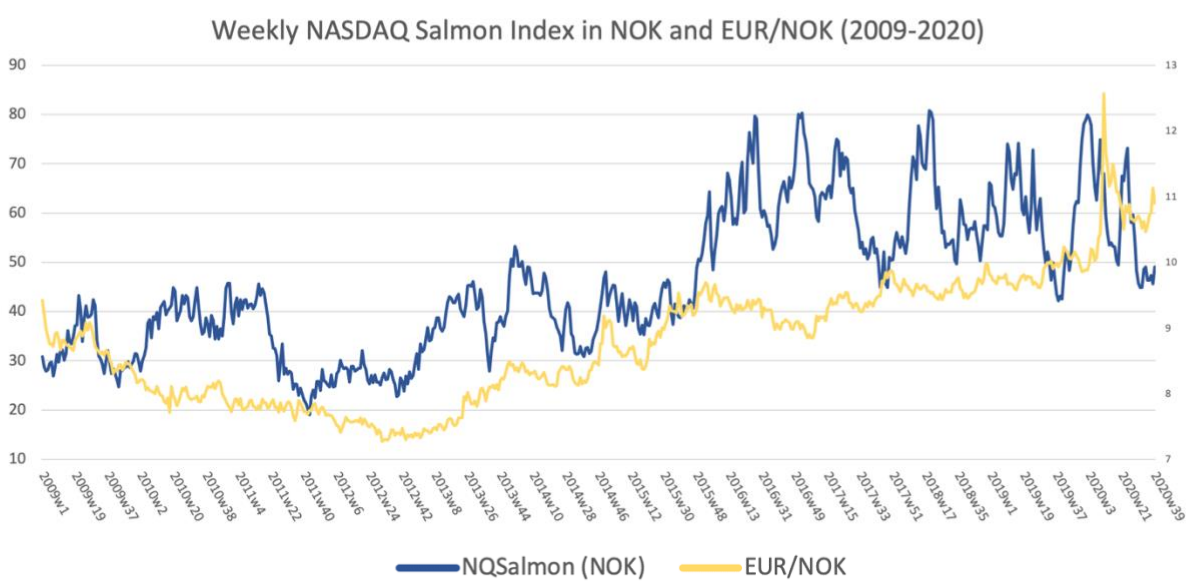

Figure 15: EUR/NOK and NQSALMON in NOK (2009-2020). (Source: Norges Bank & Nasdaq).

The relationship between the two variables became even more visible once COVID-19 became a pandemic and drastically reduced the demand for salmon. In March 2020, the EUR appreciated substantially against the NOK. Thus, although the demand for salmon dropped sharply, and with it the salmon prices, the appreciation of the EUR against the NOK partly offset the decline in the salmon prices. Therefore, we expect that:

An increase in the EUR/NOK exchange rate will increase the salmon price and consequently the share prices of the companies in our analysis

Historical development of the salmon price and fish farming stocks

The Norwegian fish farming companies are very dependent on the salmon price. This means that an increase in the salmon prices will usually be reflected in increased revenues and profits, given that the increase in the salmon price is not driven by lower supply as a result of biological issues. We also acknowledge that variables such as biological costs have a substantial impact on profits, but it is difficult to obtain an accurate estimate/driver of these costs. Consequently, we will focus on the salmon price and believe it is reasonable to assume that the stock prices of the fish farming companies will increase along with an increase in the salmon prices. Figure 16 below illustrates that they seem to move in the same direction.

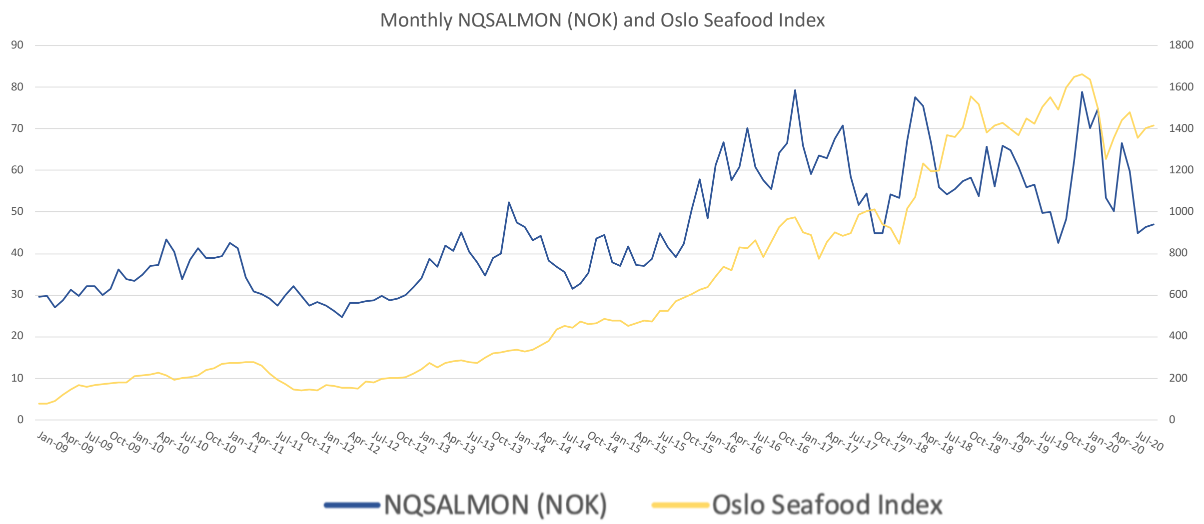

Figure 16: Monthly NQSALMON (NOK) and the Oslo Seafood Index (2009-2020). (Source: Oslo Stock Exchange & Nasdaq).

Therefore, we expect that:

An increase in the salmon price will result in an increase in the stock prices of the companies in our analysis

7. Data

In this section of our paper, we present the source of our data, and how it has been adjusted prior to our analysis. We also comment on challenges with our data, descriptive statistics, correlations, our model specification and finally our coefficient hypotheses.

For financial time series, logarithmic first differences, or log returns, are often applied. This enables us to interpret the results as relative changes in the variables and lets us compare variables with very different base values. Additionally, the logarithmic differencing can help stabilize and detrend the data, making the time series stationary, as indicated by our stationarity tests in 5.3.

We have calculated logarithmic first differences for the dependent and independent variables for our analysis. This was done by the following equation for each variable:

$$\Delta V_t = \ln\left(\frac{V_t}{V_{t-1}}\right) \tag{7.1}$$

where V_t is the observation at time t, and V_{t-1} is the value of the same variable the previous period (month).

Salmon Price

The data for the salmon price was retrieved from Nasdaq. The Nasdaq Salmon Index is computed based on a different set of size categories, namely 3-4kg, 4-5kg and 5-6kg which had weightings of 30%, 40% and 30%, respectively. Prior to 2013, it was common to use the salmon price provided by NOS Clearing ASA until it was replaced with the Nasdaq Salmon Index. Due to the difference in how these indexes were computed, Kontali Analyse researched the data and found that the historical difference had been about 0,75 NOK/kg (Nasdaq, 2014, p. 4). After conversations with Simen Thorbeck, Head of trading at Fish Pool ASA, we were instructed to add 0,75 NOK/kg to the old NOS price to obtain an accurate representation of the salmon price throughout the period 2009-2020. The data is computed weekly, but as we have used monthly data for all our variables, we took the last value of each month to create a data set based on monthly values. We used the Nasdaq Salmon Index as it reflects actual physical transactions of salmon and is commonly used by analysts, academia and journalists (Nasdaq, 2017).

Harvest Volume

We obtained our harvest volume data from Kontali Analyse, a company with expertise within the seafood sector. Kontali has an extensive database which covers both the aquaculture and fisheries industry. The data we have used is based on the reported harvest volumes from all major salmon producing countries. The data set is based on the global monthly reported harvest volumes in the period January 2009 to September 2020.

Currencies

The currencies such as the EUR/NOK and the USD/NOK were retrieved from the Bloomberg Terminal and were downloaded in both daily, weekly and monthly values. However, in our model, we only used the monthly values. The data set is from the period January 2009 to September 2020.

Oslo Stock Exchange and Stock Prices

We used the historical data of the main index, OSEBX, from 2009-2020, which is available at the Oslo Stock Exchange website. The index consists of a representative set of companies which are considered to sufficiently reflect the development of all the stocks on the Oslo Stock Exchange and is adjusted for dividends. The stock prices of our selection of fish farming companies were retrieved from the CapitalIQ terminal. All stock prices were also adjusted for dividends and used as monthly values from January 2009 to September 2020.

Potential challenges with our data

There are some potential challenges with our data which may have had an impact on the significance and/or the goodness of fit. For example, a substantial part of the companies listed on the Oslo Stock Exchange consists of companies within the oil industry. Consequently, in times where the oil price has declined substantially, we exthe OSEBX may have pulled the stock prices of the fish farming companies down with it, even if the salmon price did not decline during these time periods.

Furthermore, another challenge with our data is its limitations in terms of observations. The harvest volumes were only available on a monthly basis and consequently all our other variables were compiled monthly as well. Thus, the amount of data may be somewhat limited. As a result of this issue, we believe that splitting the data set into two or more periods in our analysis will not add any useful information due to the significant lack of observations. If all our variables were available in a weekly format, the results would likely be substantially more accurate and possibly show a more significant relationship between the variables.

7.1 Descriptive Statistics

Table 7 illustrates the descriptive statistics of the fish farming share prices in our data set. On average, all the share prices have increased in the period we have examined. The table shows that Salmar, Grieg Seafood and Bakkafrost have had the biggest increase in stock prices in the period we examined. From one month to the next, Grieg has had the highest increase, in addition to having the highest volatility based on the standard deviation. Conversely, the stock price of Austevoll had the lowest increase in the period examined, while the Bakkafrost stock price had the lowest volatility out of all the companies we looked at.

Variable	Mean	Std. Dev.	Min	Max
Mowi	0,0219	0,0905	-0,32	0,35
Salmar	0,0254	0,0878	-0,24	0,30
Grieg Seafood	0,0254	0,1330	-0,45	0,64
Lerøy Seafood	0,0214	0,0877	-0,23	0,26
Norway Royal Salmon	0,0219	0,1130	-0,39	0,29
Bakkafrost	0,0252	0,0843	-0,18	0,24
Austevoll	0,0164	0,0957	-0,26	0,41

Table 7: Descriptive statistics of dependent variables based on logarithmic first difference (Source: Own table).

The table below shows the descriptive statistics of our independent variables. We can see that the salmon price has had a significantly higher standard deviation compared to the other variables. This reflects the high volatility of the salmon price. The harvest volume has on average increased by the most in our data set, which reflects the steady growth by which the global harvest volume has increased over the years.

Variable	Mean	Std. Dev.	Min	Max
Salmon Price (NQSALMON)	0,0033	0,1137	-0,34	0,28
Volume	0,0046	0,0872	-0,27	0,20
EUR	0,0015	0,0211	-0,04	0,10
USD	0,0021	0,0337	-0,07	0,10

Table 8: Descriptive statistics of independent variables based on logarithmic first difference (Source: Own table).

7.2 Correlation

In the table below we have computed a correlation matrix which illustrates how the OSEBX, the fish farming stock prices, the salmon price (NQSalmon), volume, EUR and USD correlate with each other.

Variable	OSEBX	Mowi	Salmar	Grieg Seafood	Lerøy Seafood	Norway Royal Salmon	Bakkafrost	Austevoll	FPI	Volume	EUR	USD
OSEBX	1,0000											
Mowi	0,3621	1,0000										
Salmar	0,3362	0,6682	1,0000									
Grieg Seafood	0,3376	0,6687	0,5132	1,0000								
Lerøy Seafood	0,3461	0,7936	0,7349	0,5829	1,0000							
Norway Royal Salmon	0,2347	0,4371	0,4615	0,6538	0,5186	1,0000						
Bakkafrost	0,1571	0,6185	0,6503	0,4634	0,5618	0,4235	1,0000					
Austevoll	0,3284	0,6601	0,6980	0,5720	0,8153	0,5072	0,5078	1,0000				
Salmon Price (NQSALMON)	0,0179	0,2567	0,1705	0,1196	0,1418	0,1992	0,2272	0,1140	1,0000			
Volume	-0,0798	-0,1379	-0,1563	-0,0916	-0,1705	-0,0390	-0,1362	-0,1692	-0,0477	1,0000		
EUR	-0,4927	-0,0571	-0,0094	-0,1208	-0,0233	0,0019	-0,0195	-0,0744	0,0703	0,1259	1,0000	
USD	-0,4889	-0,0903	-0,1007	-0,1127	-0,0951	0,0400	-0,0384	-0,0628	0,0795	0,1834	0,6924	1,0000

Table 9: Correlation matrix. (Source: Own table).

The table shows that all the companies have positive coefficients, which makes sense considering the companies are exposed to the same variables. The two companies with the highest correlation are Lerøy Seafood Group and Austevoll Seafood. This is due to the fact that Austevoll owns 52,69% of Lerøy Seafood Group. Consequently, it is natural that if Lerøy's stock price increases or decreases, Austevoll's stock will move in the same direction. The companies with the lowest correlation are Bakkafrost and Norway Royal Salmon, with a reported correlation of 0,4235.

When we look at the correlation between the companies and the salmon price (NQSALMON) we see that there is a positive coefficient, which is just as we expected considering an increase in the salmon price will increase the revenues of all the fish farming companies. Furthermore, we also see that all the companies have a negative correlation with the harvest volume. This makes sense as an increase in the harvest volume will result in increased supply of salmon and consequently a lower salmon price. Both the Euro and the US dollar have a negative coefficient for all companies except for Norway Royal Salmon. This is quite surprising considering that we expect an increase in the Euro should, all else equal, result in a higher salmon price. The OSEBX has a substantially more negative correlation with both the Euro and the US Dollar compared to the fish farming companies. This is natural due to the fact that oil and gas companies represent about 20% of the OSEBX, and the share price of these companies are commonly known to increase when the oil price increases, which often leads to an appreciation of the NOK against foreign currencies (Johansen, 2020).

8. Analysis

In this section, we intend to examine how different variables such as the salmon price (FPI), global harvest volume, the EUR/NOK exchange rate and the USD/NOK exchange rate impact the stock prices of the fish farming companies on the Oslo Stock Exchange. The last couple of years, the stock prices of these companies have increased substantially, as reflected by the growth in the Oslo Børs Seafood Index (OBSFX) which has increased by approximately 200% since January 2015 (Oslo Stock Exchange, 2020). The previously mentioned variables all have some sort of impact on the profits of fish farming companies and through our time series analysis we intend to examine these relationships to check if they are in fact significant.

8.1 Results

In this section we present the results of our analysis. Each company with its respective model and our discussion of the findings, is presented individually.

As mentioned in section 6.4, our analysis is based on the overall model:

$$\Delta Ticker_t = \beta_0 + \beta_1 \Delta OSEBX_t + \beta_2 \Delta NQSalmon_t + \beta_3 \Delta Volume_t + \beta_4 \Delta Volume_{t-1} + \cdots + \beta_7 \Delta Volume_{t-4} + \beta_8 \Delta EUR_t + \beta_9 \Delta USD_t + \beta_{10} D_{COVID} + \varepsilon_t$$

For each company the model is modified to obtain the preferred model with the highest adjusted R^2.

8.1.1 Mowi

The table below illustrates the regression results for Mowi.

Source	Obs.	Prob > F	R-squared	Adj. R-squared
Model	138	0,0000	0,2556	0,2094

Mowi Share Price	Coeff.	Std. Err.	t	P > |t|
OSEBX	0,9052	0,1906	4,75	0,000
Spot	0,1376	0,0610	2,26	0,026
Volume	-0,2265	0,0817	-2,77	0,006
Volume - L1	0,0466	0,0810	0,58	0,566
Volume - L2	-0,0907	0,0808	-1,12	0,263

EUR	0,3191	0,4202	0,76	0,449
USD	0,3501	0,2886	1,21	0,227
COVID-dummy	-0,0453	0,0492	-0,92	0,358
Cons	0,0113	0,0072	1,56	0,121

Table 10: Results from time series analysis of Mowi, monthly data 2009-2020 (Source: Own table).

The F-test tests the overall significance of our model, where the null hypothesis is that the coefficients in our regression model are all zero. In our case, the F-test with its p-value of 0,000 suggests that we reject the null-hypothesis, indicating that the independent variables in fact can reliably predict the dependent variable. In other words, the overall model fit seems good. The model shows that the OSEBX-variable has a coefficient of about 0,905 which is statistically significant at the 1%-level. Since our variables are logarithmic first differentiated, the coefficients are interpreted as percentage changes. In other words, if the OSEBX increases by 1%, the stock price of Mowi increases by 0,905%. We also observe that the salmon price (NQSALMON) is statistically significant at the 5%-level and has a positive coefficient of about 0,138. All else equal, this means that a 1% increase in the salmon price results in a 0,138% increase in the Mowi stock price.

The harvest volume with 0 lags (--.) is statistically significant at the 1%-level, while the other monthly lagged coefficients (L1-L4) are statistically insignificant. The harvest volume has a negative coefficient of about -0,2265. In other words, if the harvest volume increases by 1%, the zero-lags variable suggests that the Mowi stock price will decrease by 0,2265%. As we expected, an increase in harvest volume seems to result in a decrease in the share price of Mowi. We will discuss these findings in section 8.2. Surprisingly, neither the Euro nor the US Dollar had statistically significant coefficients despite the fact that the fish farming industry is very exposed to fluctuations in both currencies, even though the EU is the main export market for these companies. We also included a dummy to account for the effects of Covid-19 during February, March and April in 2020. In our model for Mowi, it seems as if it had no significant impact as the coefficient is not statistically significant. The R-squared is about 0,256 which means the model can explain 25,6% of the variance in the stock price of Mowi.

8.1.2 Salmar

The table below illustrates the regression results for Salmar.

Source	Obs.	Prob > F	R-squared	Adj. R-squared
Model	139	0,0000	0,2303	0,1891

Salmar Share Price	Coeff.	Std. Err.	t	P > |t|
OSEBX	0,8964	0,2099	4,27	0,000
Spot	0,0790	0,0658	1,20	0,232
Volume	-0,1673	0,0658	-1,92	0,057
Volume - L1	-0,0740	0,0723	-1,02	0,307
EUR	1,0123	0,3501	2,89	0,004
USD	-0,1744	0,2656	-0,66	0,512
COVID-dummy	-0,0296	0,0386	-0,77	0,444
Cons	0,0159	0,0076	2,09	0,039

Table 11: Results from time series analysis of Salmar, monthly data 2009-2020 (Source: Own table).

The STATA output shows that the F-test with its p-value of 0,000, indicates that there is an overall good model fit. According to the results, a 1% increase in the OSEBX results in a 0,896% increase in the Salmar stock price. The salmon price is not statistically significant. The harvest volume with 0 lags (--.) is statistically significant at the 10%-level and has a negative coefficient of -0,1673. Thus, for the zero-lag variable, a 1% increase in the harvest volume leads to a 0,1673% decrease in the Salmar stock price. Interestingly, with a p-value of 0,004, the Euro is statistically significant at the 1% level for Salmar. This indicates that there is indeed a relationship between the Salmar stock price and the Euro. The coefficients show that if the Euro appreciates by 1% against the NOK, the Salmar stock price increases by about 1,01%. The COVID-dummy is not statistically significant. The R-squared is 0,23 which means the model can explain 23% of the variance in the Salmar stock price.

8.1.3 Grieg Seafood Group

The table below illustrates the regression results for Grieg Seafood Group.

Source	Obs.	Prob > F	R-squared	Adj. R-squared
Model	139	0,0000	0,2014	0,1587

Grieg Seafood Share Price	Coeff.	Std. Err.	t	P > |t|
OSEBX	1,3055	0,4619	2,83	0,005
Spot	0,0777	0,0732	1,06	0,291
Volume	-0,2993	0,1545	-1,94	0,039
Volume - L1	-0,1820	0,1407	-1,29	0,198
EUR	0,5730	0,7076	0,81	0,420
USD	0,2422	0,4042	0,60	0,550
COVID-dummy	-0,0873	0,0227	-3,85	0,000
Cons	0,0147	0,0112	1,31	0,192

Table 12: Results from time series analysis of Grieg Seafood, monthly data 2009-2020 (Source: Own table).

The F-test, with its p-value of 0,000 shows that the model for Grieg Seafood has an overall good fit. The OSEBX is statistically significant at the 1% level, reflecting that a 1% increase in the OSEBX results in a 1,305% increase in the stock price. The salmon price is not statistically significant, but the harvest volume with zero lags is significant at the 5%-level and has a negative coefficient of -0,299. In other words, an increase of 1% in the harvest volume leads to a -0,299% decrease in the stock price. Interestingly, the COVID-dummy is indeed very significant for Grieg Seafood Group, reflected in its statistical significance at the 1%-level. This suggests that COVID-19 had an adverse effect on the stock price of Grieg Seafood. The R-squared is about 0,201, meaning that the model can explain 20,1% of the variance in the Grieg stock price.

8.1.4 Lerøy Seafood Group

The table below illustrates the regression results for Lerøy Seafood Group.

Source	Obs.	Prob > F	R-squared	Adj. R-squared
Model	136	0,0003	0,2268	0,1650

Lerøy Seafood Share Price	Coeff.	Std. Err.	t	P > |t|
OSEBX	0,9178	0,1979	4,64	0,000
Spot	0,0920	0,0594	1,55	0,124
Volume	-0,2644	0,0844	-3,13	0,002
Volume - L1	0,0049	0,0806	0,06	0,951
Volume - L2	-0,0781	0,0816	-0,96	0,340
Volume - L3	0,0620	0,0803	0,77	0,441
Volume - L4	-0,2620	0,0836	-3,13	0,002

EUR	0,4951	0,4288	1,15	0,250
USD	0,2236	0,2822	0,79	0,43
COVID-dummy	-0,0170	0,0479	-0,36	0,723
Cons	0,0111	0,0070	1,59	0,114

Table 13: Results from time series analysis of Lerøy Seafood Group, monthly data 2009-2020 (Source: Own table).

We observe that the F-test for Lerøy Seafood Group has a p-value of 0,000, which indicates that the independent variables can reliably predict the dependent variable. The OSEBX is statistically significant at the 1% level and shows that a 1% increase in the OSEBX leads to a 0,9178% increase in the Lerøy Seafood Group stock price. Both the harvest volume with 0 lags and with 4 lags are statistically significant at the 1% level. The results suggest that for the zero-lags volume, a 1% increase in the harvest volume will result in a -0,26% decrease in the Lerøy stock price. The coefficient of the four-month lagged variable indicates that a 1% increase in the harvest volume today will lead to a 0,26% decrease in the Lerøy stock price by in four months. Furthermore, the regression shows there was no statistical significance for the US Dollar, the Euro or the COVID-dummy. The R-squared of the model was approximately 0,23, suggesting that the model can explain about 23% of the variance in the Lerøy stock price.

8.1.5 Norway Royal Salmon

The table below illustrates the regression results for Norway Royal Salmon.

Source	Obs.	Prob > F	R-squared	Adj. R-squared
Model	114	0,0116	0,1537	0,0978

Norway Royal Seafood Share Price	Coeff.	Std. Err.	t	P > |t|
OSEBX	0,9385	0,3092	3,04	0,003
Spot	0,1851	0,0872	2,12	0,036
Volume - L1	-0,2033	0,1277	-1,59	0,114
Volume - L3	-0,1935	0,1232	-1,57	0,119
EUR	0,5325	0,6797	0,78	0,435
USD	0,4336	0,4507	0,96	0,338
COVID-dummy	-0,0354	0,0674	-0,53	0,600
Cons	0,0155	0,0107	1,44	0,152

Table 14: Results from time series analysis of Norway Royal Salmon, monthly data 2009-2020 (Source: Own table).

The F-test with its p-value of 0,011 shows that the independent variables reliably predict the dependent variable. The OSEBX is statistically significant at the 1% level and illustrates that a 1% increase in the OSEBX results in a 0,939% increase in the stock price. The salmon price is statistically significant at the 5% level and suggests that a 1% increase in the salmon price results in a 0,185% increase in the stock price. The harvest volume is not statistically significant, with or without any lags. The Euro, US Dollar and the COVID-dummy are not statistically significant. The R-squared is about 0,154, which suggests that the model can explain 15,4% of the variance in the Norway Royal Salmon stock price.

8.1.6 Bakkafrost

The table below illustrates the regression results for Bakkafrost.

Source	Obs.	Prob > F	R-squared	Adj. R-squared
Model	126	0,0020	0,1711	0,1219

Bakkafrost Share Price	Coeff.	Std. Err.	t	P > |t|
OSEBX	0,4804	0,2128	2,26	0,026
Spot	0,1360	0,0618	2,20	0,030
Volume	-0,2247	0,0885	-2,54	0,012
Volume - L4	-0,1590	0,0865	-1,84	0,068
EUR	0,6388	0,4460	1,43	0,155
USD	-0,1103	0,2974	-0,37	0,711
COVID-dummy	-0,0924	0,0487	-1,90	0,060
Cons	0,0247	0,0075	3,30	0,001

Table 15: Results from time series analysis of Bakkafrost, monthly data 2009-2020 (Source: Own table).

The F-test with its p-value of 0,002 suggest that the overall model fit is good. The OSEBX is statistically significant at the 5% level and shows that a 1% increase in the OSEBX results in a 0,48% increase in the Bakkafrost stock price. With a p-value of 0,03 for the salmon price, the variable is statistically significant at the 5% level, suggesting that a 1% increase in the salmon price results in a 0,136% increase in the Bakkafrost stock price. The harvest volume with zero lags is statistically significant at the 5%-level. The coefficient shows that a 1% increase in the harvest volume results in a 0,22% decrease in the stock price. The Euro and US dollar are not statistically significant. The COVID-dummy is statistically significant at the 10%-level.

8.1.7 Austevoll Seafood

The table below illustrates the regression results for Austevoll.

Source	Obs.	Prob > F	R-squared	Adj. R-squared
Model	136	0,0070	0,1713	0,1050

Austevoll Seafood Share Price	Coeff.	Std. Err.	t	P > |t|
OSEBX	0,9372	0,2168	4,32	0,000
Spot	0,0099	0,0651	0,15	0,879
Volume	-0,2427	0,0925	-2,62	0,010
Volume - L1	-0,0590	0,0883	-0,67	0,505
Volume - L2	-0,0214	0,0894	-0,24	0,811
Volume - L3	-0,0021	0,0880	-0,02	0,981
Volume - L4	-0,1243	0,0916	-1,36	0,178
EUR	0,2552	0,4699	0,54	0,588
USD	0,2591	0,3092	0,84	0,404
COVID-dummy	-0,0181	0,0525	-0,34	0,731
Cons	0,0066	0,0077	0,86	0,390

Table 16: Results from time series analysis of Austevoll Seafood, monthly data 2009-2020 (Source: Own table).

The F-test shows that we have a small p-value of 0,007, indicating that the independent variables can reliably predict the dependent variable. The OSEBX is statistically significant at the 1% level and suggests that a 1% increase in the OSEBX will increase the stock price of Austevoll Seafood by 0,9372%. The spot price of Austevoll is not statistically significant at all. However, the harvest volume with zero lags is statistically significant at the 1% level and indicates that if the volume increases by 1%, the share price decreases by -0,24%. The Euro, US Dollar and COVID-dummy are all statistically insignificant. The R-squared of 0,17 suggests that the model can explain 17% of the variance in the Austevoll stock price.

8.2 Discussion of our findings

In this section we will summarize and discuss our findings. Overall, the model with the highest R-squared was Mowi, suggesting that the model could explain 25,6% of the variance in the stock price. The R-squared in our models are fairly similar to previous studies on the salmon price. For example, Trodal and Risnes (2017) reported that their regressions on the fish farming companies on the Oslo Stock Exchange had an R-squared which ranged between 0,09 and 0,244, where Mowi contributed with the highest R-squared. In our regressions, the company with the lowest R-squared was Norway Royal Salmon. The US Dollar was statistically insignificant for all the companies. The COVID-dummy was statistically significant for both Bakkafrost and Grieg Seafood, with statistical significance at the 10%- and 1%-level, respectively. The Euro was only statistically significant for Salmar with significance at the 1%-level. In terms of the OSEBX, all companies reported statistical significance with positive coefficients, as expected.

The Salmon Price (NQSALMON)

The salmon price is statistically significant for Mowi, Bakkafrost and Norway Royal Salmon. Mowi had the most statistically significant coefficient with a p-value of 0,026. There are several potential reasons as to why neither Austevoll Seafood nor Grieg Seafood have statistically significant coefficients for the salmon price. For example, Austevoll Seafood is primarily exposed to the salmon price and its independent variables through its 52,7% ownership in Lerøy Seafood Group. Furthermore, the remaining business of Austevoll Seafood consists of pelagic fishing, production of fish oil and fish meal, and consumer products. Thus, we expected that the share price would be less dependent on the salmon price.

However, we did expect the spot price to have a substantially higher significance than what the regression output suggests. We expected that the salmon price would be statistically significant for Grieg Seafood, but the stock price has historically been quite volatile due to company-specific reasons. The stock price has experienced sharp declines due to negative one-off events in their operations in Canada and adverse biological developments in their Shetland operations (Six News, 2011). Furthermore, the company has also suffered substantially due to poor results from its investments in fish farming facilities on the Isle of Skye. In September 2020, the operations on the Isle of Skye were discontinued (The Fish Site, 2020).

For Lerøy Seafood Group and Salmar, the salmon price was not statistically significant. It seems as if the changes in their respective share prices are captured by the harvest volume rather than the salmon price itself. The figure below illustrates the exposure that the fish farming companies have against the salmon price. The companies which did not have a statistically significant coefficient for the salmon price are excluded from the model.

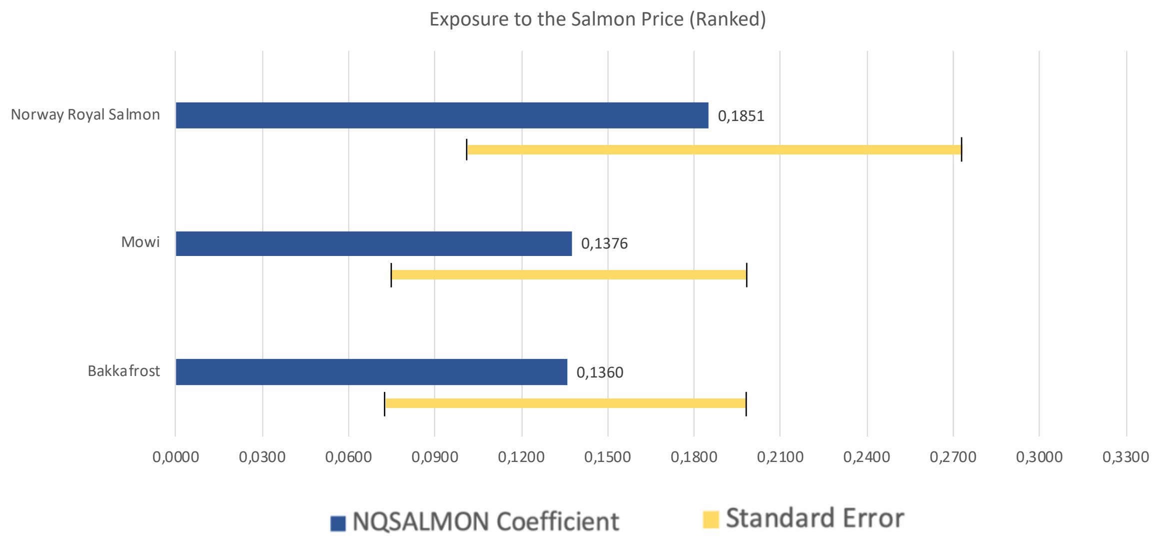

Figure 17: Exposure to the salmon price (NQSALMON). (Source: Own figure).

When we ranked the exposure to the salmon price for each of the companies which reported statistically significant results, the coefficients ranged from 0,136 to 0,185. Furthermore, we also found that Norway Royal Salmon had the highest exposure to changes in the salmon price. Thus, if an investor believes the salmon price will increase and wants to profit on his theory, then an investment in Norway Royal Salmon will be of particular interest. The other fish farming companies had lower coefficients which may be in part due to either their substantially higher market capitalization and/or a higher degree of price hedging when compared to Norway Royal Salmon. Overall, our results suggest that the salmon price only has a significant impact on the share price for some of the fish farming companies on the Oslo Stock Exchange. We did expect that the salmon price would be statistically significant for all the companies due to the fact that the revenue which fish farming companies is able to obtain is directly dependent on the salmon price.

The Harvest Volume

The coefficient for the harvest volume was statistically significant for all the companies, except for Norway Roya Salmon, and with various amounts of lagged variables. All the companies, except for Norway Royal Salmon, had statistically significant coefficients for the zero-lagged volume variables. Mowi, Lerøy Seafood and Austevoll were the only companies with a zero-lagged volume variable which was statistically significant at the 1% level. For the same zero-lagged variable, Bakkafrost and Grieg Seafood reported statistical significance at the 5%-level, while Salmar reported statistical significance at the 10%-level. The results also show that both Lerøy and Bakkafrost have a statistically significant 4-month lagged variable with significance levels of 1% and 10%, respectively.

Based on our findings it seems that there is some conflicting evidence for whether or not the effect of changes in harvest volume on the respective share prices occurs instantaneously or lagged, due to the fact that nearly all of the coefficients were statistically significant for the zero-lagged variables and for some companies even the 4-month lagged variables. A potential reason for this could be due to more widely available information regarding harvest volumes, allowing investors to price in these changes in harvest volumes more rapidly.

Currency

The fish farming companies in Norway export most of their salmon abroad, mainly to the EU. However, a substantial amount of the total traded currency which Norwegian exporters are exposed to, consists of US Dollars. As previously mentioned, the raw materials used in fish feed production is primarily US Dollars and should consequently have an impact on the cost side for fish farming companies.

The results from our analysis show that the Euro was the only currency which had statistical significance. The Euro was statistically significant for Salmar at the 1%-level with a positive coefficient of 1,01, reflecting that a 1% appreciation in the Euro against the NOK results in an approximate 1,01% increase in the Salmar stock price. The fact that the coefficient is positive is in line with our expectations, as an increase in the Euro should result in higher salmon prices and consequently favorable returns for fish farming companies which primarily receive income in Euro. When the Euro appreciates against the NOK, the demand for Norwegian salmon increases and the fish farming companies are able to obtain a higher salmon price in NOK.

According to economic theory of supply and demand, once a country experiences increased demand for its goods due to a weakening of its currency, the export of the goods will increase, which should result in increased supply. This increase in supply should in turn result in lower prices for the goods over time until a new equilibrium has been reached. Consequently, if the Euro appreciates against the NOK and the fish farming companies receive higher prices in NOK, they will naturally want to increase the supply. However, due to regulations such as license requirements and a limited number of locations suitable for fish farming due to the need for specific aquaculture conditions, it seems as if the supply side has not been able to keep up with demand. Therefore, this may be the reason for why the salmon price has trended upwards the last couple of years and consequently pulled both the revenues and stock prices of the fish farming companies up with it. This is in line with previous findings by Hessvik and Bjørvik (2016) which suggested that the fish farming industry in Norway has not been able to increase its supply sufficiently to meet the demand for salmon.

The figure below suggests that in the last couple of years, the Norwegian fish farming companies have received a large share of the foreign exchange gain. This seemingly became even more clear during 2020 when the Euro appreciated substantially against the NOK, which depreciated once the oil price began to fall and investors placed their money in safer currencies such as the Euro and US Dollar.

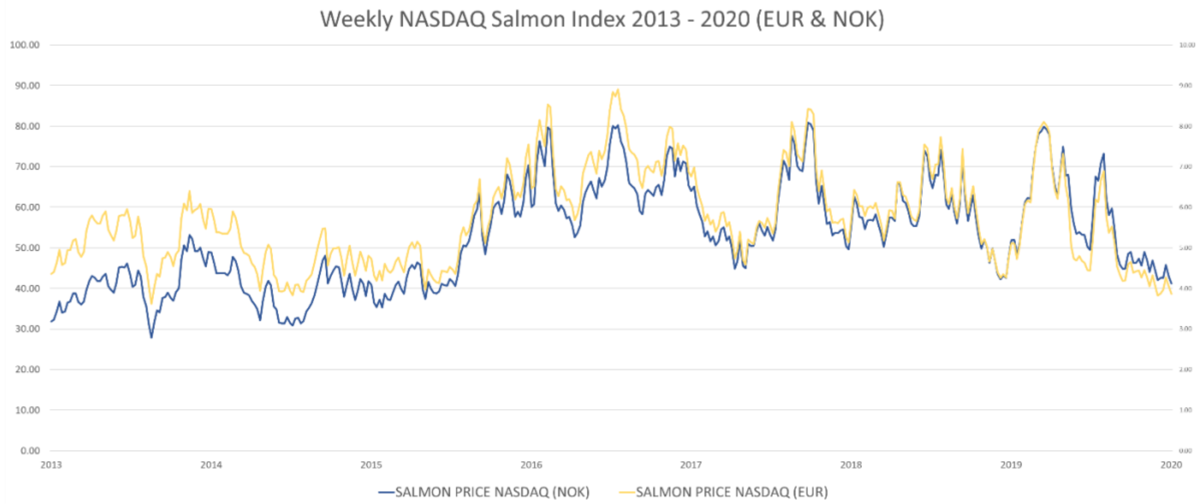

Figure 18: Weekly Nasdaq Salmon Index in EUR & NOK (2013-2020), (Source: Nasdaq).

Contrary to our expectations, the US Dollar was not statistically significant for any of the companies we analyzed. Furthermore, we also expected that the Euro would be statistically significant for most of the fish farming companies, and not just Salmar and Bakkafrost. One reason for why this is the case may be due to the fact that the use of currency hedging contracts has become more prevalent. Several of the major fish farming companies often hedge currency risk using back-to-back contracts (Mowi, 2020, p. 75).

The OSEBX

The OSEBX was significant for all of the companies in our analysis, of which all had statistical significance at the 1%-level, except for Bakkafrost. Furthermore, Bakkafrost also had a substantially lower coefficient compared to the other companies. We believe this is likely due to Bakkafrost being a Faroese-based company. They have no fish farming operations in Norway and their exposure to currency risks is primarily the exchange rate between the EUR/DKK, the GBP/DKK and the USD/DKK. Consequently, it makes sense that a company which has no presence in Norway has a lower coefficient for the OSEBX than the other fish farming companies in our analysis.

9. Conclusion

In this paper we have attempted to quantify how changes in variables such as the global harvest volume of salmon, the Nasdaq salmon price, currency exchange rates like the EUR/NOK and USD/NOK, and the OSEBX impact the share prices of our selected fish farming companies. Prior to our analysis we presented several different hypotheses. With regards to the salmon price, we expected the following:

An increase in the salmon price will result in an increase in the share prices of the companies in our analysis

However, although all companies had positive coefficients for the salmon spot price, the results showed that only Mowi, Bakkafrost and Norway Royal Salmon had statistical significance. A reason for why only some companies reported statistically significant spot prices may be due to a lack of observations as we had to use monthly observations rather than weekly. We also ranked the exposure to the salmon price for each fish farming company and found that Norway Royal Salmon had the highest one. Thus, an investor looking for exposure to the salmon price will likely find our results interesting. The coefficient of the salmon price differed significantly for several of the companies, which may be due to differences in contract hedging. Companies which are substantially larger, such as Mowi, might utilize price hedging to a larger degree as their harvest volumes are substantially larger compared to for example Norway Royal Salmon.

We also examined another variable which is essential to the fish farming industry, namely the global harvest volume. Based on the theory of supply and demand we made the following hypothesis:

An increase in harvest volumes will lead to a lower salmon price

The harvest volume was statistically significant at various lags for all the companies, except for Norway Royal Salmon. Mowi, Bakkafrost, Salmar, Lerøy Seafood Group, Grieg Seafood and Austevoll had statistically significant harvest volumes for the zero-lagged variable and with negative coefficients. Lerøy Seafood Group and Bakkafrost also reported statistical significance for the 4-month lagged variable. The results show a somewhat conflicting evidence as it is unclear if the impact of changes in harvest volumes happens immediately or with a lagged effect. However, it seems as if the effect for the most part occurs almost immediately. This may be due to investors having access to information about changes in harvest volumes, consequently resulting in these changes to be instantly priced into the stock prices of the fish farming companies. Overall, our findings suggest that an increase in the global harvest volume results in a reduction in the stock prices for the fish farming companies, which makes sense considering an increase in the supply of the good will lead to increased competition among the companies in the industry.

Finally, we also had a hypothesis that there was a relationship between the EUR/NOK exchange rate and the salmon price, due to most of the harvest volume being exported to the EU market. Consequently, we made the following hypothesis:

An increase in the EUR/NOK exchange rate will increase the salmon price and consequently the share prices of the companies in our analysis

Our findings suggested that for Salmar, an appreciation of the EUR against the NOK resulted in an increase in their share price. However, for all other companies, neither the EUR/NOK nor USD/NOK were statistically significant. This was surprising considering an appreciation of the EUR against the NOK should result in an increased salmon price and subsequently increase the revenues of fish farming companies. A possible reason for why our results suggest otherwise may be explained by the use of currency hedging contracts, a tool that is commonly used by large companies such as Mowi.

9.1 Weaknesses of our analysis and suggestion for further research

One of the most significant weaknesses of our analysis is the availability of data. Although we have daily prices for all the stock prices, the OSEBX and currencies, the salmon price was only available in a weekly format while the global harvest volume was only available in monthly values. Consequently, as we used monthly values for all our variables in our model, there are some missing values which could potentially increase the significance of our variables if they were included. This issue would become even more clear if we were to split our analysis into two periods, resulting in even fewer number of observations in the two models. An insufficient number of observations could potentially give somewhat misleading results.

Another important point is the fact that several of the fish farming companies suffered company-specific events such as salmon lice issues during different time periods throughout 2009-2020 and consequently saw their stock prices decline even though the salmon price did not decline. Some of the companies have also had other company-specific issues which other fish farming companies did not experience. For example, Grieg Seafood has struggled with both high amounts of sea lice and poor investments in both Canada and the Isle of Skye. The operations in the Isle of Skye were so poor that Grieg Seafood initiated a liquidation process after deciding to shut down its operations. These company-specific issues have been reflected throughout the last couple of years with sharp changes in the stock price, and since their market capitalization has historically been substantially lower compared to competitors such as Mowi, Lerøy and Bakkafrost, the stock price was likely much more volatile when responding to these events. In other words, it could be interesting to carry out an in-depth research paper where they took account of these one-time events for each fish farming company, given that the issues in question were not industry-wide occurrences which took place at the same time.

We also believe it would be interesting to look more at the hedge-ratio of each respective fish farming company, both in terms of how much of their salmon harvest is sold at pre-determined prices and their respective currency hedges. The use of currency hedges may partly explain why currencies such as the Euro was only significant for some of the companies in our analysis. Lastly, it would also be interesting to look at the share of harvest volume which is sold to the EU market for each respective fish farming company, as a company such as Mowi has significant harvest volumes in Chile. Consequently, their share price may be sensitive to changes in the demand for salmon from other markets, in addition to being exposed to other currency exchange rates than the EUR/NOK and USD/NOK.

Lastly, we could have added another variable such as the three-month Norwegian Interbank Offered Rate (NIBOR) to capture the effect that lower interest rates stimulate investments. In other words, with lower interest rates, it becomes less expensive for companies to finance their investments.

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Appendix

Appendix 1: Model 1 – Mowi ASA

reg MOWI osebx spot volume l1.volume l2.volume eur usd dm_covid

```
      Source |       SS           df       MS      Number of obs   =       138
-------------+----------------------------------   F(8, 129)       =      5.54
       Model |  .278088861         8  .034761108   Prob > F        =    0.0000
    Residual |  .809899524       129  .006278291   R-squared       =    0.2556
-------------+----------------------------------   Adj R-squared   =    0.2094
       Total |  1.08798838       137  .007941521   Root MSE        =    .07924

------------------------------------------------------------------------------
        MOWI |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       osebx |   .9052047    .190553     4.75   0.000      .528191    1.282218
        spot |   .1376336   .0609734     2.26   0.026     .0169962     .258271
             |
      volume |
         --. |   -.226537   .0817475    -2.77   0.006    -.3882765   -.0647975
         L1. |   .0466296    .081041     0.58   0.566    -.1137119    .2069711
         L2. |  -.0907009   .0807582    -1.12   0.263     -.250483    .0690811
             |
         eur |   .3191429   .4202282     0.76   0.449    -.5122888    1.150575
         usd |   .3500618   .2885836     1.21   0.227    -.2209079    .9210314
    dm_covid |  -.0453329   .0491589    -0.92   0.358     -.142595    .0519293
       _cons |   .0113108   .0072378     1.56   0.121    -.0030095     .025631
```

Heteroskedasticity

```
estat imtest, white

White's test for Ho: homoskedasticity

         against Ha: unrestricted heteroskedasticity

         chi2(38)     =     37.63

         Prob > chi2  =    0.4865

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      37.63     38    0.4865
            Skewness |       8.27      8    0.4075
            Kurtosis |       3.07      1    0.0795
---------------------+-----------------------------
               Total |      48.97     47    0.3938
```

Autocorrelation

Durbin Watson

```
estat dwatson

Durbin-Watson d-statistic(  9,   138) =  1.970671
```

Ljung-Box

```
wntestq res_MOWI

Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    35.8159
 Prob > chi2(40)           =     0.6591
```

Normality

```
jb res_MOWI

Jarque-Bera normality test:  35.57 Chi(2)  1.9e-08

Jarque-Bera test for Ho: normality:
```

Appendix 2: Model 2 – Salmar ASA

```
newey SALM osebx spot volume l1.volume eur usd dm_covid, lag(1)


Regression with Newey-West standard errors      Number of obs     =        139
maximum lag: 1                                  F(  7,       131) =       5.59
                                                Prob > F          =     0.0000

------------------------------------------------------------------------------
             |             Newey-West
        SALM |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       osebx |   .8964428   .2098717     4.27   0.000     .4812666    1.311619
        spot |   .0789611   .0658162     1.20   0.232     -.051239    .2091612
             |
      volume |
         --. |  -.1672759   .0870776    -1.92   0.057    -.3395361    .0049843
         L1. |  -.0740297   .0722576    -1.02   0.307    -.2169724    .0689131
             |
         eur |   1.012296   .3500577     2.89   0.004     .3197987    1.704794
         usd |  -.1744379   .2655811    -0.66   0.512    -.6998206    .3509448
    dm_covid |  -.0296183   .0385594    -0.77   0.444     -.105898    .0466614
       _cons |   .0159444   .0076452     2.09   0.039     .0008203    .0310685
```

Heteroskedasticity

```
estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(30)     =     32.88
         Prob > chi2  =    0.3276

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      32.88     30    0.3276
            Skewness |       5.98      7    0.5426
            Kurtosis |       0.00      1    0.9566
---------------------+-----------------------------
               Total |      38.86     38    0.4307
---------------------------------------------------
```

Autocorrelation

Durbin Watson

```
estat dwatson

Durbin-Watson d-statistic(  8,   139) =  2.009338
```

Ljung-Box

```
wntestq res_SALM

Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    66.4399
 Prob > chi2(40)           =     0.0054
```

Normality

```
jb res_SALM
Jarque-Bera normality test:  1.264 Chi(2)  .5314
Jarque-Bera test for Ho: normality:
```

Appendix 3: Model 3 – Grieg Seafood ASA

newey GSF osebx spot volume l1.volume eur usd dm_covid, lag(1)

```
Regression with Newey-West standard errors      Number of obs     =        139
maximum lag: 1                                  F(  7,       131) =      18.84
                                                Prob > F          =     0.0000

------------------------------------------------------------------------------
             |             Newey-West
         GSF |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       osebx |   1.305525   .4618835     2.83   0.005     .3918089     2.21924
        spot |   .0776926    .073219     1.06   0.291    -.0671521    .2225373
             |
      volume |
         --. |  -.2993292   .1544905    -1.94   0.055    -.6049483    .0062899
         L1. |  -.1819596   .1406779    -1.29   0.198    -.4602541    .0963348
             |
         eur |   .5729877     .70775     0.81   0.420    -.8271106    1.973086
         usd |   .2422046   .4042248     0.60   0.550    -.5574485    1.041858
    dm_covid |  -.0873225   .0226828    -3.85   0.000    -.1321945   -.0424505
       _cons |   .0146796   .0112044     1.31   0.192    -.0074855    .0368446
```

Heteroskedasticity

```
estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(30)     =     72.74
         Prob > chi2  =    0.0000

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      72.74     30    0.0000
            Skewness |      14.06      7    0.0502
            Kurtosis |       3.71      1    0.0542
---------------------+-----------------------------
               Total |      90.50     38    0.0000
---------------------------------------------------
```

Autocorrelation

Durbin Watson

```
estat dwatson

Durbin-Watson d-statistic(  8,   139) =  1.819236
```

Ljung-Box

```
wntestq res_GSF

Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    47.9230
 Prob > chi2(40)           =     0.1823
```

Normality

```
jb res_GSF
Jarque-Bera normality test:  9.937 Chi(2)   .007
Jarque-Bera test for Ho: normality:
```

Appendix 4: Model 4 – Lerøy Seafood Group

reg LSG osebx spot volume l1.volume l2.volume l3.volume l4.volume eur usd dm_covid

```
      Source |       SS           df       MS      Number of obs   =       136
-------------+----------------------------------   F(10, 125)      =      3.67
       Model |   .21276671        10  .021276671   Prob > F        =    0.0003
    Residual |  .725214893       125  .005801719   R-squared       =    0.2268
-------------+----------------------------------   Adj R-squared   =    0.1650
       Total |  .937981604       135  .006948012   Root MSE        =    .07617

------------------------------------------------------------------------------
         LSG |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       osebx |   .9178289   .1978951     4.64   0.000     .5261699    1.309488
        spot |   .0919738   .0594329     1.55   0.124    -.0256513    .2095988
             |
      volume |
         --. |  -.2643997   .0844296    -3.13   0.002    -.4314964   -.0973031
         L1. |   .0049374   .0805535     0.06   0.951     -.154488    .1643629
         L2. |  -.0781136   .0815576    -0.96   0.340    -.2395262     .083299
         L3. |   .0620423   .0803326     0.77   0.441    -.0969459    .2210305
         L4. |  -.2620265   .0836264    -3.13   0.002    -.4275335   -.0965194
             |
         eur |   .4951079   .4288043     1.15   0.250     -.353549    1.343765
         usd |   .2235574   .2821642     0.79   0.430    -.3348805    .7819953
    dm_covid |  -.0170096   .0478777    -0.36   0.723    -.1117656    .0777463
       _cons |   .0111407   .0069953     1.59   0.114    -.0027039    .0249853
```

Heteroskedasticity

```
estat imtest, white

White's test for Ho: homoskedasticity

         against Ha: unrestricted heteroskedasticity

         chi2(57)     =     57.63

         Prob > chi2  =    0.4517

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      57.63     57    0.4517
            Skewness |       6.56     10    0.7659
            Kurtosis |       0.65      1    0.4184
---------------------+-----------------------------
               Total |      64.85     68    0.5859
---------------------------------------------------
```

Autocorrelation

Durbin Watson

```
estat dwatson

Durbin-Watson d-statistic( 11,   136) =  2.024688
```

Ljung-Box

```
wntestq res_LSG

Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    31.2945
 Prob > chi2(40)           =     0.8361
```

Normality

```
jb res_LSG
Jarque-Bera normality test:  2.813 Chi(2)   .245
Jarque-Bera test for Ho: normality:
```

Appendix 5: Model 5 – Norway Royal Salmon ASA

reg NRS osebx spot l1.volume l3.volume eur usd dm_covid

```
      Source |       SS           df       MS      Number of obs   =       114
-------------+----------------------------------   F(7, 106)       =      2.75
       Model |  .221561302         7  .031651615   Prob > F        =    0.0116
    Residual |  1.22041412       106  .011513341   R-squared       =    0.1537
-------------+----------------------------------   Adj R-squared   =    0.0978
       Total |  1.44197542       113  .012760844   Root MSE        =     .1073

------------------------------------------------------------------------------
         NRS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       osebx |   .9385464   .3092403     3.04   0.003     .3254474    1.551645
        spot |   .1850951   .0872407     2.12   0.036     .0121319    .3580583
             |
      volume |
         L1. |  -.2033304   .1277404    -1.59   0.114    -.4565883    .0499274
         L3. |  -.1935346   .1232341    -1.57   0.119    -.4378583    .0507891
             |
         eur |   .5325395   .6796595     0.78   0.435    -.8149516    1.880031
         usd |   .4336377   .4506693     0.96   0.338     -.459858    1.327133
    dm_covid |  -.0354117     .06741    -0.53   0.600    -.1690585    .0982351
       _cons |   .0155065   .0107393     1.44   0.152    -.0057852    .0367982
```

Heteroskedasticity

```
estat imtest, white

White's test for Ho: homoskedasticity

         against Ha: unrestricted heteroskedasticity

         chi2(30)     =     41.25

         Prob > chi2  =    0.0829

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      41.25     30    0.0829
            Skewness |      10.20      7    0.1776
            Kurtosis |       1.51      1    0.2192
---------------------+-----------------------------
               Total |      52.96     38    0.0542
---------------------------------------------------
```

Autocorrelation

Durbin Watson

```
estat dwatson

Durbin-Watson d-statistic(  8,   114) =   1.92492
```

Ljung-Box

```
wntestq res_NRS

Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    25.6274
 Prob > chi2(40)           =     0.9622
```

Normality

```
jb res_NRS

Jarque-Bera normality test:  16.88 Chi(2)  2.2e-04

Jarque-Bera test for Ho: normality:
```

Appendix 6: Model 6 – Bakkafrost P/F

reg BAKKA osebx spot volume l4.volume eur usd dm_covid

```
      Source |       SS           df       MS      Number of obs   =       126
-------------+----------------------------------   F(7, 118)       =      3.48
       Model |  .152137418         7  .021733917   Prob > F        =    0.0020
    Residual |  .737005443       118  .006245809   R-squared       =    0.1711
-------------+----------------------------------   Adj R-squared   =    0.1219
       Total |  .889142861       125  .007113143   Root MSE        =    .07903

------------------------------------------------------------------------------
       BAKKA |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       osebx |   .4804353   .2127709     2.26   0.026      .059091    .9017797
        spot |    .136023   .0618089     2.20   0.030     .0136246    .2584214
             |
      volume |
         --. |  -.2247256   .0885035    -2.54   0.012    -.3999866   -.0494645
         L4. |  -.1589883   .0864696    -1.84   0.068    -.3302217    .0122451
             |
         eur |   .6388459   .4459781     1.43   0.155    -.2443122    1.522004
         usd |  -.1102896   .2974482    -0.37   0.711    -.6993181    .4787388
    dm_covid |  -.0924196   .0487276    -1.90   0.060    -.1889134    .0040743
       _cons |   .0246585   .0074719     3.30   0.001      .009862    .0394549
```

Autocorrelation

```
estat imtest, white

White's test for Ho: homoskedasticity

         against Ha: unrestricted heteroskedasticity

         chi2(30)     =     17.46

         Prob > chi2  =    0.9666

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      17.46     30    0.9666
            Skewness |       4.26      7    0.7490
            Kurtosis |       0.07      1    0.7864
---------------------+-----------------------------
               Total |      21.80     38    0.9837
---------------------------------------------------
```

Autocorrelation

Durbin Watson

```
estat dwatson

Durbin-Watson d-statistic(  8,   126) =  2.150932
```

Ljung-Box

```
wntestq res_BAKKA

Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    38.2537
 Prob > chi2(40)           =     0.5490
```

Normality

```
jb res_BAKKA
Jarque-Bera normality test:  .0594 Chi(2)  .9708
Jarque-Bera test for Ho: normality:
```

Appendix 7: Model 7 – Austevoll Seafood ASA

reg AUSS osebx spot volume l1.volume l2.volume l3.volume l4.volume eur usd dm_covid

```
      Source |       SS           df       MS      Number of obs   =       136
-------------+----------------------------------   F(10, 125)      =      2.58
       Model |  .180018292        10  .018001829   Prob > F        =    0.0070
    Residual |  .870731694       125  .006965854   R-squared       =    0.1713
-------------+----------------------------------   Adj R-squared   =    0.1050
       Total |  1.05074999       135  .007783333   Root MSE        =    .08346


------------------------------------------------------------------------------
        AUSS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       osebx |   .9371705   .2168423     4.32   0.000     .5080127    1.366328
        spot |   .0098982   .0651232     0.15   0.879    -.1189887    .1387851
             |
      volume |
         --. |  -.2426994   .0925132    -2.62   0.010    -.4257944   -.0596043
         L1. |   -.059036    .088266    -0.67   0.505    -.2337253    .1156533
         L2. |  -.0214127   .0893662    -0.24   0.811    -.1982795    .1554541
         L3. |   -.002118   .0880239    -0.02   0.981    -.1763283    .1720923
         L4. |  -.1242662   .0916331    -1.36   0.178    -.3056195     .057087
             |
         eur |   .2552151   .4698594     0.54   0.588    -.6746949    1.185125
         usd |   .2590785   .3091795     0.84   0.404     -.352826    .8709831
    dm_covid |  -.0180728   .0524617    -0.34   0.731     -.121901    .0857554
       _cons |   .0066062   .0076651     0.86   0.390    -.0085639    .0217762
```

Heteroskedasticity

```
estat imtest, white

White's test for Ho: homoskedasticity

         against Ha: unrestricted heteroskedasticity

         chi2(57)     =     65.96

         Prob > chi2  =    0.1947

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      65.96     57    0.1947
            Skewness |      12.53     10    0.2512
            Kurtosis |       1.45      1    0.2280
---------------------+-----------------------------
               Total |      79.94     68    0.1524
---------------------------------------------------
```

Autocorrelation

Durbin Watson

```
estat dwatson

Durbin-Watson d-statistic( 11,   136) =  1.984018
```

Ljung-Box

```
wntestq res_AUSS

Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    29.4058
 Prob > chi2(40)           =     0.8911
```

Normality

```
jb res_AUSS
Jarque-Bera normality test:  14.08 Chi(2)  8.8e-04
Jarque-Bera test for Ho: normality:
```