MASTER'S THESIS

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What factors affect the share price of salmon farming companies listed on the Oslo Stock Exchange?

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Abstract

The purpose of the study is to examine which factors affect the share price of salmon farming companies in the period April 2007 to November 2020. Based on previous research, we have included seven explanatory variables, which consist of three industry-specific factors and four macroeconomic factors. As the dependent variable, we have created an equally weighted portfolio as a representative of the salmon farming companies. The portfolio comprises salmon farming companies listed on the Oslo Stock Exchange.

To answer the problem statement, we have used a regular regression model, and one extended model with seasonally adjusted variables for global production volume and biomass. We also include an ARIMA model with external regressors to substantiate the results of the adjusted model. Our results find a significant relationship for all the models between the portfolio and the variables OSEBX and the spot price. For the seasonally adjusted model as well for the ARIMA, global production volume is significant. Biomass is only significant for the seasonally adjusted model.

Furthermore, our study examines how the variables affect the portfolio through the time period. The significance of several variables does change, this is also the case whether it has a positive or negative affection on the portfolio returns. Thus, the study emphasizes the importance of studying how different factors affect salmon farming companies and could yield a deeper understanding of how these have changed over the recent years.

Acknowledgements

This thesis is written as a final part of our Master of Science in Business at Nord University in Bodø, with a major in Finance. The motivation for this study is based on our personal interests within the Norwegian salmon farming industry. It has been an interesting and educational process, which at times has also been challenging. The work has increased our knowledge of the Norwegian salmon farming industry and our analyzing skills. We have used the software R to carry out the analyses.

We would like to thank our supervisor Oleg Nenadić for good and constructive input throughout the process. We would also like to thank Kontali Analyse for their contribution with data.

Bodø, 25.05.2021

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Sammendrag

Hensikten med studiet er å undersøke hvilke faktorer som påvirker aksjekursen på oppdrettsselskaper som er notert på Oslo Børs i perioden april 2007 til november 2020. På bakgrunn av tidligere forskning har vi valgt å inkludere syv ulike forklaringsvariabler. Vi har inkludert bransjespesifikke faktorer som endringer i laksepris, globalt produksjonsvolum og biomasse, samt makroøkonomiske faktorer som endringer i valutakurser for euro og amerikanske dollar, OSEBX og langsiktig rente. Vår avhengige variabel er en likevektet portefølje som består av syv oppdrettsselskaper som var notert på Oslo Børs ved utgangen av 2020.

For å besvare problemstillingen har vi benyttet en regresjonsmodell uten sesongjustert data, samt en regresjonsmodell der variablene globalt produksjonsvolum og biomasse er sesongjustert. For å underbygge resultatene for den sesongjusterte modellen har vi også benyttet en ARIMA modell med eksterne regressorer. For alle de tre modellene viser resultatene en signifikant sammenheng mellom porteføljen og variablene OSEBX og laksepris. For regresjonsmodellen med sesongjustert data er globalt produksjonsvolum og biomasse signifikant. Globalt produksjonsvolum er også signifikant i ARIMA modellen vi benytter.

Videre undersøker studien hvordan de ulike variablene påvirker porteføljen gjennom perioden. Resultatene viser endringer i hvilke variabler som er signifikante, samt om variablene har en positiv eller negativ innflytelse på avkastningen til porteføljen. Dermed understreker studien viktigheten av å studere hvordan ulike faktorer påvirker oppdrettsselskaper, og kan gi en dypere forståelse i hvordan faktorene har endret seg de siste årene.

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1 Introduction

Since the 1970s the salmon farming industry in Norway has increased dramatically. The export and production of salmon have multiplied, and the industry has constantly surpassed itself (EY, 2018). In recent years the industry has experienced a favorable price development as a result of increasing demand and a limited supply. A reason for the limited supply is due to an increased focus on environmental causes, regulations, and other restrictions. Hence, the industry has a limited possibility to increase the production capacity. Another cause is due to the biological aspect of the industry, where the production time is long and several risks like diseases, salmon louse, and other factors could occur.

The Norwegian salmon farming industry is one of the most important distributors of salmon. This is due to the Norwegian coast providing good production conditions, and the long traditions have made Norwegian salmon recognized worldwide. Today you could experience Norwegian salmon in various cities around the world. One reason for the increased worldwide demand is due to the versatility of salmon, where you could experience it in several different dishes. The importance of Norwegian salmon farming has also made the Oslo Stock Exchange become the most important marketplace for the aquaculture sector (Oslo Børs, 2012). Based on these factors, we want to examine the relationships and impact factors that affect the behavior of salmon farming companies listed on the Oslo Stock Exchange. Therefore, we have the following problem statement:

What factors affect the share price of salmon farming companies listed on the Oslo Stock Exchange?

To answer the problem statement, we will use regression analysis with an equally weighted portfolio as the dependent variable. The portfolio will consist of various salmon farming companies listed on the Oslo Stock Exchange. As independent variables, we will include three industry-specific factors which are changes in salmon prices, global production volume, and biomass, as well as four macroeconomic variables consisting of the changes in exchange rates for Euro and US Dollar, OSEBX and long-term interest rates.

We also want to see if the variables have a change in the impact on the portfolio through the time period of the data. By doing so, we hope to be able to contribute with a new useful insight into the industry. Therefore, we have created the following sub-problem:

How stable are the influencing factors for salmon farming companies listed on the Oslo Stock Exchange over time?

We have chosen to divide the study into seven main chapters with different subchapters. The salmon farming industry will be presented in Chapter 2. We will in Chapter 3 and 4 present previous research within the topic and theoretical frameworks. Furthermore, Chapter 5 presents the methodology and description of the data. Analyses and results from the study will be presented in Chapter 6. Finally, we will in chapter 7 present the conclusion where the problem statement will be answered.

2 Presentation of the salmon farming industry

In this chapter, we introduce the salmon farming industry by looking at the history and characteristics. Afterwards, we will present the fish farming companies that will be included in the analysis, before we finally look at future prospects. We will mainly focus on the Norwegian fish farming industry through the chapter. The chapter will provide a better understanding of the industry before the later analyses.

2.1 History and development

The beginning of salmon farming in Norway can be traced all the way back to the 1850s when attempts were made to hatch salmon roe, this had been tried elsewhere in Europe previously. The breakthrough in Norwegian salmon farming is considered to be over a hundred years later. It came after a lot of trial and error where they attempted to use ponds for farming, this was because other countries had success with it. The focus was instead shifted to salt water, which helped to form the basis for the breakthrough. In 1970, the brothers Sivert and Ove Grøntvedt started using new technology, an octagonal floating cage, at Ansnes on Hitra. The new cage technology achieved impressive results and attracted attention from the entire Norwegian coast. The brothers did not want to keep the knowledge to themselves and welcomed everyone who wanted to study their technology to Ansnes (Hovland et al., 2014).

The development in the aquaculture industry was rapid, which created a need for public regulation of the industry. Public sector wanted to be able to adapt the production conditions, which was the reason why "konsesjonsloven" was introduced in 1973. Through the law, the public sector could regulate developments in the industry. A high growth continued beyond the 1980s, and harvested volume increased from about 8,000 tons in 1990 to about 150,000 tons in 1990. The high growth should prove to be the start of what is described as the biggest crisis in Norwegian aquaculture. Although the industry was regulated by the public sector, the rapid growth had led to overproduction and decreasing prices, in addition to diseases becoming a problem. Many companies struggled financially, which led to as many as 181 facilities going bankrupt between 1988 and 1991. To reverse the negative trend, changes were made in "oppdrettsloven" (Hovland et al., 2014). Previously, there had been strict requirements that the majority interests must have a local affiliation, but this requirement was now abolished. It contributed to a consolidation in the industry with acquisitions and mergers, and changed the industry to consist of fewer and larger companies (NOU 2019: 18). Over the 1990s, the growth in the aquaculture industry increased again and the industry entered an industrial phase (Hovland et al., 2014).

The beginning of the 2000s marks the start of a new crisis. Again, production had increased faster than market demand, and many companies had financial problems. In the same period, several of the largest companies were also listed on the stock exchange. These companies had large fluctuations in share prices due to the uncertainty in the industry. New changes had to be made to get out of the crisis. The solution was a more sustainable development, which meant more regulations from the public sector based on how much the politicians thought the environment could withstand (Hovland et al., 2014). The industry is still today strongly regulated by the public sector, something we will return to in subchapter 2.3 about regulations.

Today

The industry has developed to be one of Norway's most important export industries (NOU 2019:18). In 2019, Norway exported salmon worth 72.5 billion Norwegian kroner (NOK), at an average spot price of NOK 59.15 per kilo (Fish Pool, 2019). Norway is the country in the world that produces the most salmon, and stands for over 50% of the market worldwide, and over 95% of the salmon produced in Norway is exported (NOU 2019:18).

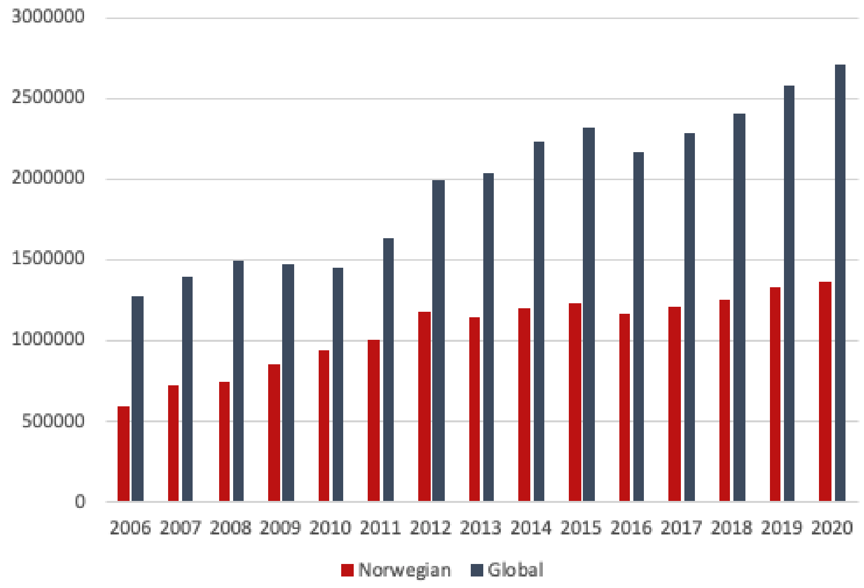


Figure 1: Production volume for Norway and globally in tons whole fish equivalent (WFE)

(Source: Kontali Analyse)

The figure shows that production volume has doubled during the period. The growth in the industry is due to an increase in both the supply and the demand. Much of the change in the supply can be explained by systematic breeding. In the 1980s, it took about three years before the smolt that was released was ready to be harvested, but due to systematic breeding, the time is now reduced. This is despite the fact that the slaughter weight has increased (Asche & Roll, 2014). Systematic breeding as well as better technology and increased competence are key factors when it comes to the increase in the supply side. The increased demand for salmon is largely due to increased marketing, increased supply, and better logistics (Asche, Roll & Tveteras, 2007).

Marketing has been necessary to increase the popularity of the product worldwide and has created a snowball effect for further development. Among other things, it has made logistics a crucial part of the industry (Asche et al., 2007). Today trucks and planes are widely used in the transport of salmon and makes it possible to get fresh Norwegian farmed salmon in large parts of the world. The largest export markets today mainly consist of the EU, Asia, and North America, as shown in Figure 2. Europe is the biggest export market, which received 71% of the salmon produced in Norway in 2018 (NOU 2019:18). The similarity in these markets is that they consist of countries with mainly good willingness to pay where supermarkets dominate the retail trade. Supermarkets account for over 80% of retail sales of seafood in several of these countries and have an important role in market growth in the aquaculture industry (Asche et al., 2007).

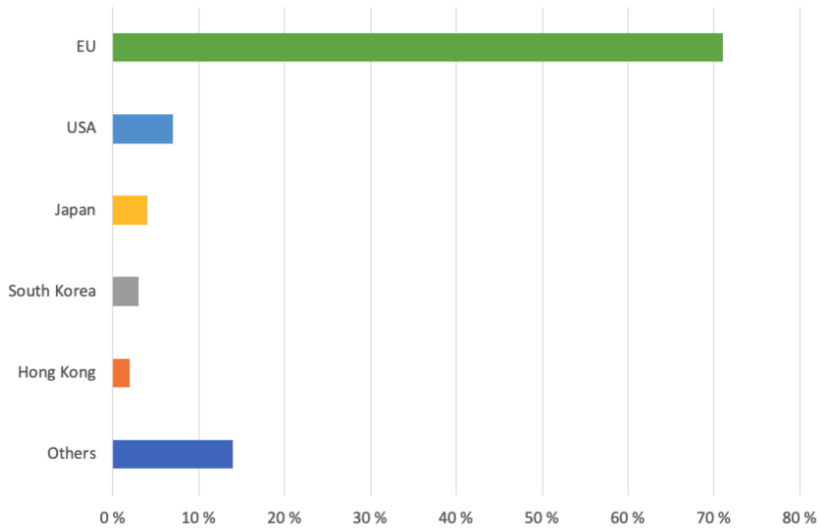


Figure 2: Export of Norwegian salmonids in 2018 by country

(Source: NOU 2019: 18)

Due to the high demand and high prices the salmon farmers have increased their revenues by 300% in the last ten years (EY, 2018). Today the biggest salmon farming companies are included in the Oslo Stock Exchange. The value of the seafood companies on the Oslo Stock Exchange Seafood Index (OSLSFX) is close to NOK 270 billion as of October 2019. The share prices for the companies listed on OSLSFX have more than tripled in the recent five years. OSLSFX mainly consist of companies with ownership interests in Norwegian aquaculture and make up to about 90% of the market value of the index. The rest of the companies included in the index are companies in the seafood industry with aquaculture activities in other countries than Norway (NOU 2019:18). The salmon farming companies are the biggest contributors to the OSLSFX and had over 70% of the market capitalization in 2012 (Oslo Børs, 2012). As seen from Figure 3, it appears that the last decade has been characterized by a positive trend in the share price development for fish farming companies listed on Oslo Stock Exchange.

Figure 3: Share price development for selected indices on the Oslo Stock Exchange
(Source: Oslo Børs)

2.2 Industry structure

Due to seawater temperature requirements, biological constraints, and other natural constraints, farmed salmon are only produced in a few countries. These are Norway, Chile, Scotland, Canada, the Faroe Islands, Iceland, Ireland, USA, New Zealand, and Tasmania. Figure 4 illustrates how much the biggest production countries account for in total production. The figure shows that Norway and Chile are by far the largest producers. Historically, the main markets for Norway have been the EU, Asia, and Russia, until Russia introduced import bans in 2014. For Chile, it has been the USA, Asia, and South America (Mowi, 2020a).

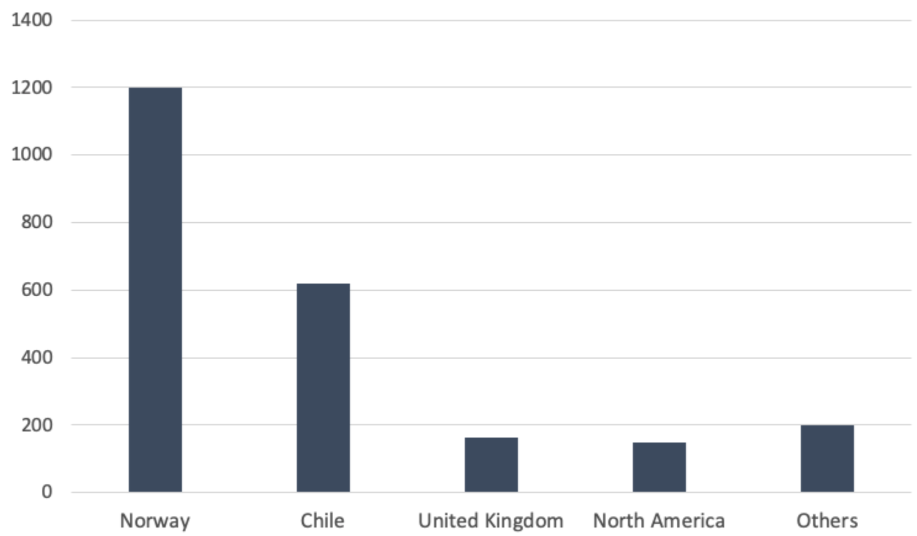


Figure 4: Harvested Atlantic Salmon in thousand tons gutted weight equivalent (GWT) from 2019 (Source: Mowi, 2020a)

In Norway, Chile and Scotland, the aquaculture industry previously consisted of several, but smaller companies. The industry has been through a period of consolidation that forms the basis of what it looks like today. Consolidation is expected to continue in the future, even though there has been a lesser degree of it in recent years. Table 1 shows the proportion of the production volume of the ten largest companies in Norway in 2019. It emerges that the companies together produced close to 70% of the market volume, while Mowi was the largest company with almost 20% of Norwegian production (Mowi, 2020a).

Company	Share of volume
Mowi	19.74%
SalMar	12.76%
Lerøy Seafood	10.72%
Mitsubishi / Cermaq	6.08%
Grieg Seafood	4.80%
Nova Sea	3.83%
Nordlaks	2.92%
Sinkaberg-Hansen	2.54%
Alsaker Fjordbruk	2.54%
Norway Royal Salmon	2.54%
Top 10	68.48%
Total volume in the market	100.00%

Table 1: Proportion of produced volume for top 10 salmon farming companies in Norway in 2019 (Source: Mowi, 2020a)

2.3 Regulations

The regulation related to the maximum permitted biomass (MTB) was introduced in 2005. MTB means that fish farmers cannot surpass the permitted biomass in the cages for each license. Most permits contain 780 tons of MTB, while in Troms and Finnmark the permits have been 945 tons (NOU 2019: 18). There is a great demand for permits to farm fish. Permits are normally granted on an ongoing basis upon application, but commercial fish permits for salmon, trout and rainbow trout in seawater are limited in number. This means that permits are granted when the ministry decides. MTB has been introduced to control the growth with regard to disease, salmon louse and local pollution (Fiskeridirektoratet, 2017).

In 2017, the traffic light system was officially introduced along the coast of Norway. This means that an assessment of the environmental situation in the various production areas will be carried out (Hosteland, 2017). It was introduced to continue to achieve growth in the industry, at the same time as the wild salmon is taken into consideration. In the assessment of the production areas in 2020, nine areas received green light. This means that they will have the opportunity to increase production by up to 6%. Two areas received yellow light, which does not involve any change. The last two production areas received a red light because the impact of salmon louse on wild salmon was too big, thus they had to reduce the production by 6% (Regjeringen, 2020).

2.4 Production process

The process of producing salmon begins in freshwater in three different phases, as roe, fry and smoltification. First, roes are fertilized in a vessel with fresh water at eight degrees Celsius. It takes around two months before the roe hatches and goes into the fry phase. When the fry begins to absorb feed, the fry is moved to a larger tank and goes through the smoltification process. After living a total of 10 to 16 months in freshwater, the salmon is ready to be released into cages in the sea. At this point, the salmon is between 60 and 100 grams. After 14 to 22 months the salmon reaches the slaughter weight, which is between four and six kilos. When optimal weight has been achieved, the salmon is transported to the slaughterhouse before being gutted, washed and sorted according to quality and size. To maintain the good quality, the salmon is packed on ice in closed boxes before it is sold in the market (laks.no, n.d.).

The sea temperature is an important factor in the production process and affects how long it takes for the salmon to reach ready-to-slaughter weight. An important condition is that the sea temperature is between 0 and 20 degrees Celsius, but the optimal is between 8 and 14 degrees Celsius. If the temperature is below 0 degrees Celsius, the risk of death among the salmon will increase. At too high temperatures, the risk of diseases will be too big, thus the growth rate will decrease. Since salmon grow faster in the summer than the winter in Norway, more salmon must be harvested in the summer and into the autumn in order not to exceed MTB. Chile has a competitive advantage, since they have more stable and optimal sea temperatures, hence the salmon need less time to achieve ready-to-slaughter weight (Mowi, 2020a).

Production costs

Through the production process from roe to ready-to-sell salmon, a number of costs arise. Figure 5 shows that costs have increased steadily since 2008. Average production costs per kilo increased by 85.6% from 2008-2019. Feed costs are the largest, followed by other operating costs. Other operating costs include costs related to the treatment of salmon louse and diseases. This has increased considerably in recent years and contributes to an increase in total production costs.

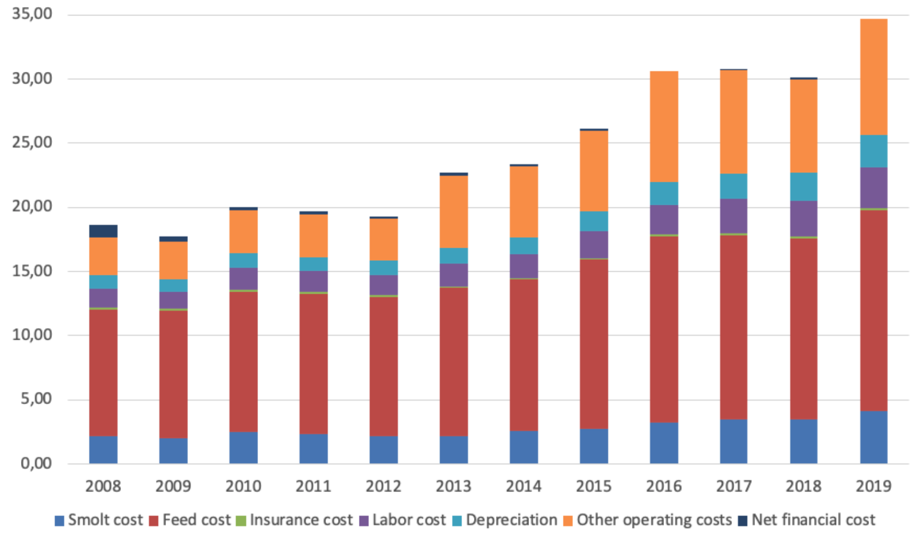


Figure 5: Development of production costs in Norwegian kroner per kilogram

Average figures per company for the whole of Norway

(Source: Fiskeridirektoratet, 2020)

Table 2 shows the various costs in relation to the total costs in 2008 and in 2019. In addition to production costs from Figure 5, slaughter costs are also included. Feed accounts for 40-50% of the total, while smolt, other operating costs and slaughter costs are also significant. The largest percentage increase is related to other operating costs, which illustrate the growing problems in the industry related to lice and diseases. There has also been a percentage increase in costs related to smolts, salaries and depreciation.

	2008	2019
Smolt	10.14%	10.73%
Feed	47.31%	40.86%
Insurance	0.72%	0.40%
Labor	6.92%	8.33%
Depreciation	5.14%	6.74%
Other operating costs	13.96%	23.48%
Net financial costs	4.52%	-0.25%
Slaughter costs including shipping cost	11.30%	9.71%

Table 2: Cost items for 2008 and 2019, including harvesting costs

Average figures per company for the whole of Norway

(Source: Fiskeridirektoratet, 2020)

2.5 Companies

We will in more detail present the salmon farming companies that are listed on the Oslo Stock Exchange. These companies are Mowi, Lerøy Seafood, SalMar, Grieg Seafood, Bakkafrost, Norway Royal Salmon and Austevoll Seafood. In 2019, these companies harvested a total of 925.8 thousand tons of salmon. The largest company, Mowi, harvested around 47% of the total, while the smallest company, Norway Royal Salmon, harvested only 3%.

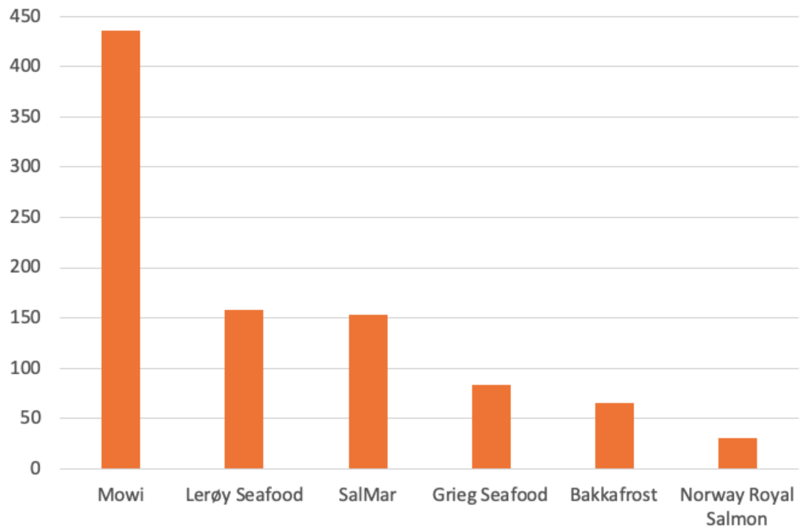


Figure 6: Harvested volume per thousand tons of salmon for companies listed on the Oslo Stock Exchange (Source: Annual reports for the different companies)

Mowi

Mowi has since their start-up in 1964 been through several mergers and different names but went back to the name Mowi in 2018 after being under the name Marine Harvest since 2006. Marine Harvest was created after mergers and acquisitions, with known brand names like Pan Fish and Fjord Seafood. Mowi is today one of the largest seafood companies in the world, and currently operates in 25 countries, and has 12,200 employees. They have control of the entire value chain internally, everything from feed to sale and marketing (Mowi, 2021). In addition to Norway, the company does farming in Chile, Canada, Scotland, Ireland, and the Faroe Islands. Harvested volume in Norway accounts for more than half of the total harvested volume, followed by Chile, Canada, and Scotland, while Ireland and the Faroe Islands harvest the least (Mowi, 2020b).

Lerøy Seafood

One of the largest companies in the seafood industry is Lerøy Seafood, which has roots dating back to 1899. In addition to salmon farming, they also do farming of trout and catching of whitefish. In 1999, the company had its first investment in salmon production, and was in 2002 listed on the Oslo Stock Exchange. In addition to aquaculture and wild fishing, the company engages in product development, processing, marketing, sales, and distribution, which means that they themselves have control of large parts of the value chain (Lerøy Seafood, 2021). Lerøy Seafood has 4,700 employees and engages in fishing and aquaculture along the entire coast of Norway, at the same time as they also have production and distribution in Sweden, Denmark, Finland, the Netherlands, France, Spain, Portugal, and Turkey (Lerøy Seafood, 2020).

SalMar

SalMar was established in 1991 after an acquisition that contained a license for production of salmon farming and a whitefish harvesting/processing plant from a company that had gone into liquidation. The company was listed on the Oslo Stock Exchange in May 2007. Today, the company has developed into one of the world's largest and most efficient producers of salmon. SalMar runs most of the value chain itself as they have their own production from roe/broodstock to the sale of finished goods. The company conducts farming activities along the coast of Norway from Møre and Romsdal in the south to Troms and Finnmark in the north. They also have farming activities in Iceland and Scotland, and have sales offices in Asia, something that makes SalMar the world's second largest salmon farming company. Today, the company has approximately 1,700 employees (SalMar, 2021).

Grieg Seafood

Grieg Seafood was created in the early 1990s by entrepreneur Per Grieg Jr. and the shipping-based Grieg family, and was listed on the Oslo Stock Exchange in 2007. Although the company has grown a lot since the start-up, the Grieg family is still the largest owner. The company operates in Norway, Canada, and the UK, and has its headquarters in Bergen. They have around 900 employees spread across the locations (Grieg Seafood, 2021).

Bakkafrost

Bakkafrost is a company from the Faroe Islands that deals with salmon farming. On their website, they write that the cold and stable sea temperature in the Faroe Islands is perfect conditions for salmon farming. The company was established in 1969 by the brothers Hans and

Róland Jacobsen, before the third brother also joined the company three years later. They started with salmon farming in 1986. In 2008, the shareholders in Bakkafrost and Vestlax agreed to merge the companies. The two companies were merged in January 2010 and were listed on the Oslo Stock Exchange in March 2010.

Bakkafrost describes themselves as one of the most vertically integrated companies in the industry. They have a fully integrated value chain, where they control everything from feed to a finished product (Bakkafrost, 2021). According to the annual report from 2019, the company harvests in the Faroe Islands and in Scotland. Nearly 90% of harvested volume was harvested in the Faroe Islands, and the rest in Scotland. In 2020, Bakkafrost bought 100% of The Scottish Salmon Company (Bakkafrost, 2021).

Norway Royal Salmon

In 1992, 34 salmon farmers joined forces to engage in sales and marketing of farmed salmon and founded Norway Royal Salmon. Since then, the company has expanded through buying ownership interests in smaller fish farming companies. The company's head office is located in Trondheim, while they have a sales office in Kristiansand. In March 2011, Norway Royal Salmon was listed on the Oslo Stock Exchange. Over the next five years, the company wants to develop from being a medium-sized company to being a large one (Norway Royal Salmon, 2021). Among other things, they aim to grow by taking greater control of the value chain. In 2019, salmon from the company was sold to 55 different countries. 84% of the volume sold was exported, most of it to countries in Europe and the rest to Asia (Norway Royal Salmon, 2020).

Austevoll Seafood

Austevoll Seafood is different from the other salmon farming companies we have presented. It is a holding company exercising active ownership in its operational subsidiaries. The start of the company dates back to 1981 when Helge and Ole Rasmus Møgster established Austevoll Havfiske AS together with their father. Austevoll Seafood includes the ownership and operation of fishing vessels, both pelagic and white fish, fishmeal plants, canning plants, freezing plants, salmon farming, and sales and marketing. The main locations for the Austevoll Group are in Norway, Chile, UK, and Peru. In 2006, the company was listed on the Oslo Stock Exchange. Figure 7 present Austevoll Seafood's company overview. The grey squares illustrate Salmon/Whitefish, and the white ones illustrate Pelagic. As shown in the figure, the company owns 52.69% of Lerøy Seafood, which is also included in our portfolio (Austevoll Seafood, 2021).

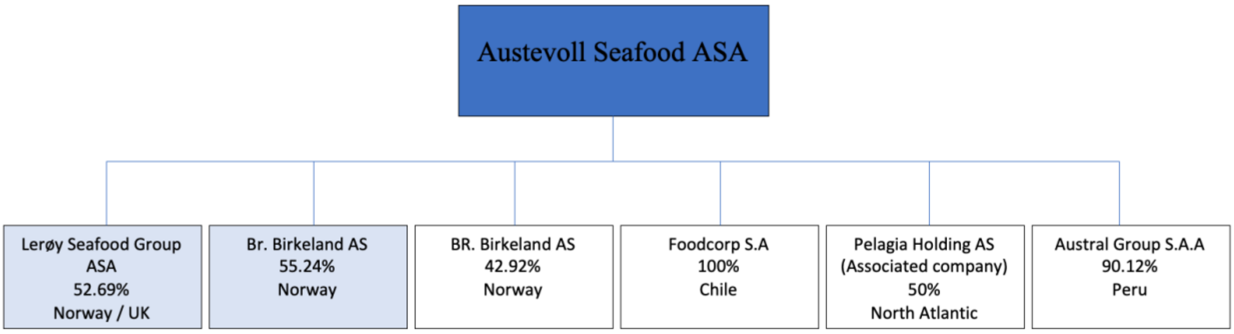


Figure 7: Company overview Austevoll Seafood ASA

(Source: Austevoll Seafood ASA, 2021).

2.6 Future prospects

The salmon farming industry has grown a lot in the recent years. The Norwegian government has stated that it wants significant growth in aquaculture in the coming years as well. Existing companies in the industry want to be bigger than they already are, and they will grow by taking part in several steps of the value chain and operating more sustainably. Something that has been discussed within the industry as a part of operating more sustainably is land-based farming. In recent years, planned land-based farming has accelerated.

There are various reports and analyses on land-based farming, with different results. How land-based farming will affect environmental emissions is uncertain. Some believe that it has more emissions, while others believe that emissions are reduced. With land-based farming, the emissions associated with transport will be less. This is because the production can be placed close to the end market. The location of production close to the end market is one of the reasons why many are skeptical about running land-based farming in Norway. This is because large parts of the production in Norway are exported.

An advantage of land-based farming is a reduced risk of diseases, lice, and escapes. The aquaculture industry is vulnerable to external environmental factors. From 2013 to 2018, the average salmon price of farmed salmon increased by more than 50%. This is because producers have not been able to produce enough in relation to demand. Part of the reason for this is lice, diseases, and escapes (EY, 2020). In addition to solving problems with escapes, salmon louse and discharges, up to 95% of the water in the facilities is recycled. The water can be carefully controlled, and the process requires less water, which means that the facilities can be located almost anywhere (Havforskningsinstituttet, 2021). Although there are several benefits to land-based farming, they are struggling with funding. Many lenders are sceptical and require a large amount of equity (EY, 2020). Only a fraction of the planned facilities is financed, and few are fully financed. This means that the farmers have to build in several steps and show that they are able to produce quality salmon at the right cost (Berge, 2020). In May 2019, Fredrikstad Seafood started production as the first facility in Norway. The facility has a production capacity of 1,500 tons of salmon but has a projected size of 6,000 tons. The company is awaiting the expansion of the facility (Riise, 2019).

To reduce the problems with lice and diseases in the industry, the use of larger smolts has also been discussed. This will reduce the time of the salmon being in sea water, and thus the risk of salmon louse will be reduced. In addition, larger smolts will be more robust against diseases than small ones. In the closed facilities where the smolt is produced, it will be easier to prevent disease. Although there are several advantages to larger smolts, it will also bring disadvantages. Larger smolts will need more time to grow before they can be moved into the sea, which will increase costs for producers (EY, 2020).

The salmon farming industry is facing an exciting time. If they gain control of the challenges in the industry, especially related to lice and diseases, the conditions will be conducive to further growth.

3 Literature review

The salmon farming industry has become a popular topic to research in Norway, due to this there has been a lot of studies in the sector. The broader focus that we have witnessed is focusing on the volatility, biological factors, relation between the spot price and related companies traded on the Oslo Stock Exchange, the Fish Pool Index (FPI), and also there are quite a few forecasts done for the spot price. In our literature review we found a lot of interesting research that could be important variables to use to explain the impact factors that affect the salmon-related companies traded on the Oslo Stock Exchange. Therefore, our problem statement is based on findings from several different studies. We have chosen to divide the literature review into different categories, where we first will present some studies within the raw material market. There is a growing literature addressing how industry-specific factors may also play a role in explaining stock returns. Afterward, we will present a study of exchange rates within the industry, before we look at studies that describe demand and supply effects. Further, we will show some studies within the forward market, volatility, and price prediction. Finally, we will include a compilation of the articles we have presented.

3.1 Raw materials

Tjaaland, Westgaard, Osmundsen & Frydenberg (2015) address the risk factors that drive U.S. oil and gas companies' share returns in the period 2000 to 2015. They divide the companies into four sub-sectors and the period into three sub-periods. The model builds on a one-factor market model and consists of monthly data that is transformed using the logarithmic function. The results show that industry-specific factors increase the stock returns of the companies, and the different sub-periods showed different results.

Misund (2018) tries to highlight the importance of including fundamental factors when examining the drivers of returns of companies in a specific industry. He examines the determinants of ten salmon companies in the period 2006 to 2016. A multifactor model with monthly data is used to study how stock returns for the companies are affected by common market-wide risks and industry-specific risk factors. The market-wide macro factors include the market excess returns, the Fama-French-Carhart risk factors, exchange rates, and oil price. As industry-specific risks Misund includes the salmon price, and shocks in biomass, harvest, and seawater temperature. The results in the study demonstrate that the most important determinants of salmon firm total stocks returns are the market-wide macro factors, but that returns also are sensitive to changes in industry-specific risk factors.

Steen & Jacobsen (2020) apply quantile regression to investigate the relationship between risk factors and monthly stock price returns at both industry- and firm level for the salmon farming industry. They include eight salmon farming companies listed on the Oslo Stock Exchange from 2007 to 2016. As an indication of which common market-wide risk factors that serve as determinants for salmon farming stock returns, they refer to Misund (2018) and his findings. To adjust for the general market risk, they use OSEBX. Further they include the lagged stock return of the industry leader, in addition to changes in exchange rates, changes in the long-term interest rate, and changes in the salmon price. Steen & Jacobsen find that changes in the salmon price and the lagged returns for the major company in the industry have a positive impact on company stock price returns. In addition, they find that the overall market returns have a positive impact.

3.2 Exchange rate

In the article "The Effects of Exchange Rates on Export Prices of Farmed Salmon" by Xie, Kinnucan & Myrland (2008), they study the changes in exchange rates with respect to the export price of salmon. Given the international market for salmon, currency is a factor that can affect prices in the market. They included exchange rates in the inverse CBS demand system to investigate if the export prices in local currency are sensitive to exchange rates fluctuations. This study included the major countries who produce salmon. They found that the exchange rate pass-through in the export price was complete for Chilean pesos and British pounds, but that it was not complete for NOK and US Dollars. Hence, the producers in Chile and the UK are to a larger extent affected by short-term fluctuations in the exchange rates against the countries which they export to, rather than for the rest of the producing countries. As a result, they found that an isolated 1% appreciation of the trade- weighted peso reduces the Chilean export price by 0.96% and increases export prices in Norway by 0.13% and the UK by 0.59%. Appreciation of the Norwegian trade-weighted currency leads to a reduction of 0.39% for the Norwegian export price, an increase of 0.23% for the Chilean export price and no effect on the UK and the rest of the world's prices. Thus, they conclude that the exchange rates are an important factor to the export prices of farmed salmon. They conclude that the exchange rates are statistically significant and empirically important and monetary phenomena should not be overlooked when explaining salmon prices.

3.3 Demand and supply

In “Are Prices or Biology Driving the Short-Term Supply of Farmed Salmon?” Asheim, Dahl, Kumbhakar, Oglend & Tveteras (2011) are looking at a dataset from 1995 to 2007. The dataset consists of 135 monthly observations of price, biomass, and water temperature. They conclude that the price of salmon has a limited influence on the supply of salmon in the short-term. The supply is largely determined by biomass at present, and other exogenous factors in the market. Expanding the horizon from months to years reduces the importance of biological and other factors, and the price will have a greater influence for the supply of salmon (Asheim et al., 2011). To understand the role of price in the supply for farmed salmon in short and longer terms, the authors suggest combining their research with the findings from Andersen, Roll & Tveteras (2008).

Andersen et al. (2008) estimates a profit function for Norwegian salmon farmers to look at the industry's short- and long-term supply response separately. They use a dataset that ranges from 1985-2004 and consists of 3580 observations on an annual basis with roughly 80 variables reported. On average the farming companies were observed for 6.1 years. The result indicated, as their beliefs, that the salmon producers have limited opportunities to respond to short-term changes in price, hence the supply elasticity is close to zero. They found that their own price elasticity of feed and work is inelastic in the short-term. The price response increases relative to the prices of input factors, especially for the price of feed. Supply elasticity increases in the long term and is therefore more flexible. But since they have limited short-run responsiveness, given exogenous prices, there will be a lag in the optimum level. They argue that delayed response can lead to long-term production that is overestimating the demand and leads to falling prices and reduced profits. A repetitive pattern can explain the cyclical variations around the trend of profit, and the observed volatility could be explained by a combination of high response in the long-term and limited response in the short-term. The authors assume that profits will remain volatile if the industry is competitive with many producers. The reason is that individual producers have fewer incentives to limit the offer when prices are high.

3.4 Forward market, volatility, and prediction of price

Asche, Misund & Oglend (2016) examine whether the future contracts traded on the FPI could be an unbiased estimator for spot prices. To examine the research topic, they use monthly spot prices and future contracts with length between one and six months in the period 2006 to 2014. They use weekly data from FPI for the spot price and convert it to monthly price using the average of the sum. By examining the lead lag relation in the salmon market, they find that future prices are cointegrated up to maturities of six months. Their findings contradict a lot of earlier empirical studies. They suggest this could be due to the salmon market is yet immature and has not reached the stage where forward prices are able to predict future spot prices.

Volatility in the salmon market was investigated by Oglend (2013), who uses weekly NOS prices in NOK from 1995 to week 37 in 2012. The factors that are examined are the introduction of maximum permitted biomass in Norway, the establishment of Fish Pool, price trends on input factors, changes in demand for seafood and other foods, the Chilean ISA crisis in 2009 and increased use of bilateral trade contracts. Using GARCH modeling, Oglend finds that increased prices for presumed substitutes such as meat and other fish species, as well as feed prices, have an impact on the volatility of salmon prices. The continuous volatility is confirmed by Asche, Misund and Oglend (2019) in "The Case and Cause of Salmon Price Volatility". They observe that the volatility has more than doubled, with an increase in the annualized volatility from 15 to 35% in the past 10 years. In the research they point out that salmon has gone from below-average, to being one of the most volatile commodities compared to other similar commodities. This is observed by comparing it with the Goldman Sachs Commodity Spot Index (GSCI), which has a decrease from 23 to 19% in the same period. They focus on the Norwegian salmon industry, since Norway stands for over 50% of the worldwide production. To see the trends in the volatility they use an ARCH-test from 1 to 30-week lags for $h_t = 1$. This gives an estimate of the price volatility trend, which has increased by 0.13% per week on average. The empirical findings support their hypothesis that the cause of increased salmon price volatility is due to a reduction in the elasticity of the supply. To try to explain the reduced supply response, they discuss three different factors that have occurred in the market over the sample period. First the salmon industry has matured and consolidated into fewer and larger production units. Second, an increasingly sophisticated and complex downstream supply chain has emerged that demands a stable supply of fresh salmon. At last, concerns over the environmental sustainability of growth in Norwegian, and other countries, production have resulted in restrictions on new production licenses. Due to these factors, Asche et al. (2019) conclude that there has been a stagnation in the production growth, and an increase in the demand.

Bloznelis (2018) forecasts the price with respect to a short-term period**.** He predicted the short-term spot price of salmon using 16 models. The models vary from different time series models, like ARIMA and ARFIMA models to neural network and K- nearest neighbors, using weekly data from 2007-2014. Five different explanatory variables were used in the prediction. These were the spot price, export volume from Norway, the price of futures contracts, an equally weighted index for the share price of four out of the five largest fish farming companies in Norway and the exchange rate between the EURO and NOK. As a result, all the forecasting models predicted the direction of the price with more than 50% accuracy, and three methods above 60% for the nearby two weeks. The K-nearest neighbors was the best method for one week ahead, vector error correction model for two and three weeks ahead, while the futures prices did best for four and five weeks. He concluded that the nominal gains in forecast accuracy over a naïve benchmark is small, but the economic value is considerable. By using a simple trading strategy for timing with respect to the prices forecasted, the profit for a salmon farmer could increase by around 7% (Bloznelis, 2018).

3.5 Compilation

Table 3 presents a summary of the literature we have included. The first column shows the author and year of the article, while the second column is what the article examines. The last column summarizes how factors affect what the article examines. For example, for the article written by Asheim, Dahl, Kumbhakar, Oglend & Tveteras (2011), biomass and seasonal factors affect short-term supply, but the price does not.

Author(s)	What	Conclusion(s)
Tjaaland, Westgaard, Osmundsen & Frydenberg, 2015	Stock returns (Oil and gas)	Oil price (+) Market (+) Gas price (+)
Misund, 2018	Stock returns	Market-wide macro factors (+) Salmon price (+)
Steen & Jacobsen, 2020	Stock returns	Salmon price (+) Lagged returns of the industry leader (+) Overall market returns (+)
Xie, Kinnucan & Myrland, 2008	Export price of salmon	Exchange rate (+)
Asheim, Dahl, Kumbhakar, Oglend & Tveteras, 2011	Short-term supply	Price (-) Biomass (+) Seasonal factors (+)

Andersen, Roll & Tveteras, 2008	Short- and long-term supply	Short-term: price (-) Long-term: price (+) and biological factors (-)
Asche, Misund & Oglend, 2016	Forward market	Futures lead spot price (-)
Oglend, 2013	Volatility	Increased prices for substitutes (+)
Asche, Misund & Oglend, 2019	Volatility	Reduction in the elasticity of the supply (+) Increase in demand (+)
Bloznelis, 2018	Prediction short-term spot price	Can increase the profit by using simple trading strategy (+)

Table 3: Compilation literature review

4 Theory

Theories that could be relevant before the analysis will be presented in this chapter. We will briefly describe market efficiency and portfolio theory, before we move on to valuation models for pricing of stocks. Then we will briefly look at theory of spot and forward rates, before we finally describe theory related to exchange rates.

4.1 Efficient market hypothesis

Kendall & Hill (1953) conducted an analysis to find a systematic connection in the movements of securities. Their findings suggest that securities prices are randomly evolving. This study helped to form the basis of the theory of efficient markets. Fama (1970) introduced the efficient market hypothesis. The hypothesis reflects the notion that stocks already reflect all available information. A change in the stock price would only take place as a response to new information. The stock market would not have been efficient if it were possible to predict the movements in the stock prices perfectly. This means that the ability to predict prices would indicate that all available information is not reflected in the stock price. New information, which also means changes in the stock price, must be unpredictable. The stock prices should follow a random walk. A random walk means that changes in the price should be random and not predictable (Bodie, Kane & Marcus, 2018).

There are three versions of the efficient market hypothesis, where the difference is the meaning of “all available information”. The three versions are the weak-form, the semistrong- form and the strong-form. With the weak-form hypothesis the stock prices contain all historical information, which means that the information will lose the value. The reason is that all will have the same information at the same time, thus a buy signal will result in an immediate price increase. Semistrong-form includes the weak-form in addition to all publicly available information regarding the prospects of a firm. Examples of publicly available information could be accounting reports. Such information is available for the rest of the market, and it will therefore not be possible to achieve excess returns from this information. The last one, the strong-form, includes the semi-strong form and all other information, both public and private information. It also includes information that is only available to company insiders. It is an extreme version of market efficiency. Although it includes inside information, few people believe that corporate officers have access to relevant information long enough before the public release to enable them to use the information to trade profit. There are many measures to avoid insider trading, and to trade on the basis of information provided by insiders is considered to be in violation of the law (Bodie et al., 2018).

4.2 Portfolio theory

Asset allocation accounts for a large part of the variability in risk and returns for a typical investor's portfolio. Optimal capital distribution is therefore one of the most important decisions within portfolio construction and asset management, and involves adjusting the share of the portfolio's underlying assets to minimize volatility and maximize returns (Sharpe, 1992). In asset management, diversification is used to reduce the risk associated with an investment, without giving up a corresponding share of the return.

The total risk of a portfolio will depend on the systematic and unsystematic risk. Systematic risk represents the market specific risk, which is the risk of potential factors that can affect the overall performance of the financial markets that the investor is exposed to. Examples of these factors could be recession, change in interest rate, inflation, and other macroeconomic influences. These tend to affect the entire market simultaneously, and because of this they are difficult to hedge and not diversifiable. Therefore, you want compensation for investing in the market. In contrast to the systematic risk, the unsystematic is the risk regarding security, company, or industry specific risk. The unsystematic risk can be reduced by diversification by asset allocation. Since the unsystematic risk can be diversified away, the exposure does not increase the expected return (Bodie et al., 2018).

4.2.1 Modern portfolio theory

Markowitz (1952) established a mathematical framework that showed that it is possible to reduce unsystematic risk considerably through diversification of assets with low correlation. This theory is today known as modern portfolio theory (MPT). MPT argues that the characteristics of an investment's risk and return should not be viewed individually, but rather as how the investment affects the overall portfolio's risk and return.

The expected return on a portfolio is the weighted sum of the individual securities expected return. Thus, Markowitz's theory of expected risk and return could be illustrated through a portfolio consisting of two assets, for example stocks and bonds. Expected return for the portfolio:

$$E(r_p) = \sum_{i=1}^{n} w_i E(r_i) \quad (1)$$

Where $E(r_p)$ is the expected return on the portfolio, w_i is the share of assets in the portfolio, and $E(r_i)$ is the expected return on assets. Variance of the portfolio:

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i \sigma_i \cdot w_j \sigma_j \cdot \rho_{r_i r_j} \quad (2)$$

Where σ_p^2 is the variance of the portfolio's expected return in the period, w_i and w_j are weightings in respectively assets i and j, σ_i and σ_j are the standard deviation of assets i and j, respectively, and $\rho_{r_i r_j}$ is the correlation between assets. The portfolio's risk is determined by the variance and is affected by the correlation between the assets in the portfolio. The correlation coefficients vary between -1 and 1. A correlation coefficient of 1 indicates that the assets are perfectly correlated so that the assets move equally in the same direction. A coefficient of -1 indicates that the assets are perfectly negatively correlated and moves equally in the opposite direction. Assets with a high correlation will thus increase the risk in the portfolio, while assets with a low correlation could potentially reduce the total risk of the portfolio.

4.3 Pricing of stocks

There are several different methods you can use to value stocks. Which method you choose will depend on the purpose of the valuation since the different methods could give different results. Two widely used methods are the dividend discount model and the cash flow model.

Dividend discount models are present value models based on dividends. Dividends is a payment to shareholders authorized by a corporation's board of directors. One must make assumptions related to expected future growth in earnings and distribution ratios to estimate the expected dividend. The growth rate of the dividend payments will often change over time, thus it could be difficult to estimate future dividend payments. A simplified model for calculating the value of a stock is the Gordon growth model. It was developed by Gordon & Shapiro (1956) and Gordon (1962) and is based on the assumption that dividends grow with a constant growth (Pinto, Henry, Robinson, Stowe & Wilcox, 2015). The model can be expressed as follows:

$$Stock\ value = \frac{DPS_1}{k_e - g} \tag{3}$$

Where:

DPS_1 is expected dividends at time 1

k_e is required return on equity

g is the constant growth rate in dividends

The required rate of return needs to be higher than the growth. If the growth is higher than the required rate of return it will be a negative value.

The purpose for the cash flow model is to estimate the expected cash flows. There are two important elements of discounted cash flow valuation. First, we estimate the cash flows and then discount the cash flows to account for the time value of money. A cash flow can both be risk-free and risky. The risk-free is not as challenging as the risky, because the risky cash flows need to be discounted with a rate that reflects the risk (Pinto et al., 2015). The present value of its expected future cash flows can be expressed as follows:

$$Value\ = \sum_{t=1}^{t=n} \frac{CF_t}{(1+r)^t} \tag{4}$$

Where:

n is the number of periods

CF_t is the cash flow at time t

r is the discount rate of required rate of return

The Capital Asset Pricing Model, CAPM, is an equation for the required rate of return that gives us insight into what kind of risk is related to return. Modern portfolio management by Harry Markowitz was the foundation for CAPM in 1952, but the model was later published by Sharpe (1964), Lintner (1965) and Mossin (1966) (Bodie et al., 2018). The equation assumes a risk averse investor that takes investment decisions based on the average return and variance of the return of the total portfolio (Pinto et al., 2015). The equation for the model is:

$$E(r_i) = r_f + \beta_i \left[E(r_M) - r_f\right] \tag{5}$$

Where:

$E(r_i)$ is expected return on individual asset

r_f is risk-free rate

β_i is the risk factor of the asset

$E(r_M)$ is expected return on market portfolio

Expected return is the risk-free interest rate plus a market premium. In order to achieve a higher return, one must take a higher risk. Risk-free interest rate is the interest rate you can achieve without taking risk (Bredersen, 2015). Examples of a risk-free investment could be a bank deposit, or the interest rate on short-term or long-term bonds issued by the state or municipality. Risk-free investments always generate a positive and stable return over time, but the return will be low. In order for an investor to consider another investment alternative, the return must be higher as it will be a more uncertain alternative (Damodaran, 2012).

4.4 Theory of spot and forward rates

Fish Pool ASA was established in 2005 and is located in Bergen in Norway. It is an international marketplace for buying and selling salmon contracts. Fish Pool ASA does not offer physical trading in fish, but offers future financial contracts (Fish Pool, n.d.a). Trading of these contracts is done anonymously. NASDAQ OMX is a counterparty in the contracts and assures that everyone holding contracts can pay on maturity. Prices are quoted on purchases and sales two years ahead. The forward prices are a result of traders' expectations of salmon prices. Prices and conditions cannot be renegotiated, but the contracts can be resold at Fish Pool (Jordal, 2014).

A forward contract means that the buyer and seller make an agreement to carry out a transaction in the future, and the terms of the transaction are agreed today. The risk of changes in the exchange rate is removed for both buyer and seller (Bredersen, 2015). Spot trading is an agreement to buy or sell today. A forward contract should be priced equal to future spot price at time T, provided that there are no arbitrage opportunities. A formula for this can be as follows, where r is the current interest rate at time t with maturity T:

$$f^t(t) = S(t)e^{r(T-t)} \tag{6}$$

4.5 Exchange rate theory

Changes in exchange rates can affect both the revenues and costs of export and import companies, and could potentially reduce profit to a great extent. Thus, it is an important factor to take into consideration for the salmon farming industry. The exchange rate can be written as:

$$E = \frac{Number\ of\ units\ of\ domestic\ currency}{1\ unit\ foreign\ currency} \tag{7}$$

When NOK increases in value, it appreciates. An appreciation in NOK will weaken Norwegian competitiveness and make Norwegian goods relatively more expensive. The Norwegian export will weaken. The opposite will happen if NOK decreases in value, then it depreciates. A depreciation of NOK will give Norwegian producers a price advantage, and export will be strengthened.

Whether an investor wants to invest capital in the home country or abroad will depend on interest rates. If the investor invests in the home country it will achieve an interest rate equivalent to i, and if the investor invests abroad, the exchange rate will affect the return in addition to the foreign interest rate. This can be showed in the equation:

$$i = i^W + \frac{E^e_{+1} - E}{E} \tag{8}$$

Where:

i is the domestic interest rate

i^W is foreign interest rate

E^e_{+1} is expected exchange rate

E is today's exchange rate

This equation is known as the interest parity condition and indicates the equilibrium of the currency market. The domestic interest rate equals the foreign interest rate plus the expected appreciation of the foreign currency. If i or i^W changes, a change in currency is also necessary to maintain the equilibrium in the market. A decline in domestic interest rates will increase the return on deposits abroad, hence the investors will move their deposits. Investors will offer domestic currency and demand foreign currency. Domestic currency will depreciate. In order to regain equilibrium, the domestic currency must appreciate. As the domestic currency appreciates, we will again achieve equilibrium, even if the foreign interest rate is higher than the domestic interest rate. Changes in exchange rates will, as previously mentioned, also affect the competitive environment in relation to exports and imports. A depreciation of the domestic currency will increase exports, which will increase the level of income. The interest rate will increase, and the exchange rate will decrease, and this will also affect the equilibrium. The process will continue until you again reach $i = i^W$ (Mishkin, 2019).

5 Method and data description

In this chapter, we will present methodological frameworks and the data used in this study. To answer the problem statement, a quantitative approach is used. We will start by briefly presenting Ordinary Least Squares, and further look at stationarity, autocorrelation, and ARIMA. In the end, we will in detail present the data that we use to carry out this study.

5.1 Ordinary Least Squares

Ordinary Least Squares (OLS) is one of the most common methods in regression analysis. OLS is used to find a theoretical connection between observed values. It constructs the best linear relationship between the dependent variable, y_t, and the independent variables, x_t. This is done by minimizing the sum of the squared residuals. In general form OLS can be presented as:

$$y_t = \alpha + \beta_1 x_{1t} + \beta_2 x_{2t} + \cdots + \beta_k x_{kt} + u_t \tag{9}$$

Where k is the number of variables and t is time periods. The parameters are as follows:

y_t = Dependent variable at time t

x_t = Independent variables

α = Intercept

β_i = Coefficients

u_t= Error term that quantifies how much is not explained in the explanatory variables included in the model

OLS is based on five underlaying assumptions. These are:

(1) $E(u_t) = 0$	Expected value of the errors is zero
(2) $var(u_t) = \sigma^2 < \infty$	The variance of the errors is constant and finite over all values of x_t
(3) $cov(u_i, u_j) = 0$	The errors are uncorrelated to each other
(4) $cov(u_t, x_t) = 0$	Between the error and corresponding x variate there is no relationship
(5) $u_t \sim N(0, \sigma^2)$	The error terms, u_t, are normally distributed

If assumptions 1-4 holds, then OLS are known as best linear unbiased estimators (BLUE) (Brooks, 2019; Wooldridge, 2013):

Best - Use the estimator with the smallest variance.

Linear - $\hat{\alpha}$ and $\hat{\beta}$ are linear estimators.

Unbiased - The actual values of $\hat{\alpha}$ and $\hat{\beta}$ will on average be equal to their true values.

Estimator - For the true value of α and β, $\hat{\alpha}$ and $\hat{\beta}$ are estimators.

5.2 Stationarity

An important concept in time series analysis is to examine if the series is stationary or not. This is important since it can affect its behavior and properties. We can distinguish between a strictly- and a weakly stationary process. A time series is strictly stationary if the distribution is constant over time. A series is said to be weakly or covariance stationary if it satisfies these three equations for $t = 1, 2, \ldots, \infty$:

$$E(y_t) = \mu \tag{10}$$

$$E(y_t - \mu)(y_t - \mu) = \sigma^2 < \infty \tag{11}$$

$$E\left(y_{t_1} - \mu\right)\left(y_{t_2} - \mu\right) = \gamma_{t_2 - t_1} \forall_{t_1, t_2} \tag{12}$$

A stationary process should have a constant mean, a constant variance and a constant autocovariance structure. The autocovariance determines how y is related to its previous values. For a stationary series it depends on the difference between t_1 and t_2 (Brooks, 2019).

If one of the three conditions for stationarity is violated, the process is described as nonstationary. We distinguish between two forms of nonstationary, stochastic (random walk with drift), and deterministic (trend stationary process). To make the variables stationary, you could in the first case use differencing. Then it is said to be difference-stationary. In a trend-stationary process, the time series can be made stationary by extracting a time trend (Dougherty, 2016).

To find out if a time series is stationary, you can use a unit root test. An example of such a type of test could be an Augmented Dickey-Fuller test (ADF), which is one of the most widely used unit roots tests. The null hypothesis, H_0, tests whether one or more unit roots exist in the time series. It uses a certain number of lags for the dependent variable to ensure that the error term is not autocorrelated. It is important to use the correct number of lags in the test (Brooks, 2019).

5.3 Autocorrelation

When the value in a time series correlates with its previous lags, we have autocorrelation. It can potentially be a problem within time series data, since one does not use a random sample. If there is autocorrelation, it can lead to errors in the estimation of standard errors, which could lead to wrong conclusions. Autocorrelation can be illustrated through a plot, but could be difficult to interpret correctly, therefore a statistical test should also be carried out. There are several types of autocorrelation tests, but Durbin-Watson (DW) is known as one of the simplest. DW is a test for first order autocorrelation, it means that it only tests for a relationship between an error and its immediately previous value. The test can be written as:

$$u_t = \rho u_{t-1} + v_t \tag{13}$$

where $v_t \sim N(0, \sigma_v^2)$. A null hypothesis, H_0, and an alternative hypothesis, H_1, are used in the test: H_0: $\rho = 0$ and H_1: $\rho \neq 0$. If H_0 is retained the errors are independent of one another. DW can be statistically expressed as:

$$DW = \frac{\sum_{t=2}^{T}(\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{t=2}^{T}\hat{u}_t^2} \tag{14}$$

The test has two critical values: an upper critical value, d_U, and a lower critical value, d_L, in addition to a value where the null hypothesis can neither be retained nor rejected. Figure 8 provides an overview of possible outcomes in DW.

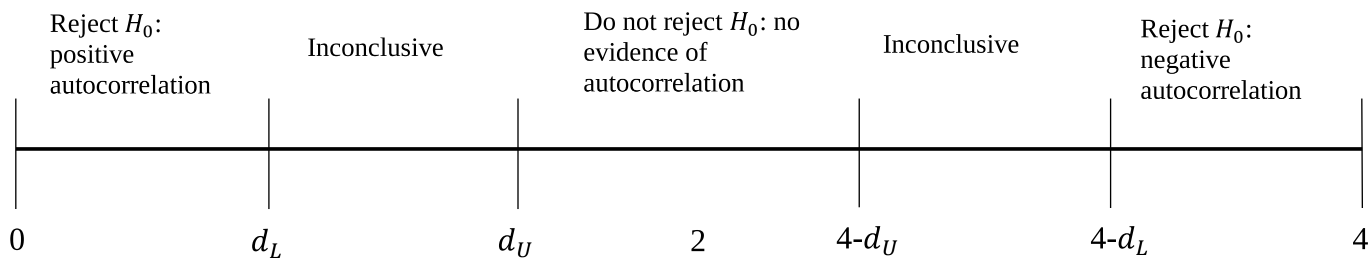


Figure 8: Rejection and non-rejection regions for Durbin-Watson test

(Source: Brooks, 2019).

DW has some weaknesses. To obtain valid test results, several assumptions must be taken into account, in addition to the fact that it only tests for first order autocorrelation. Breusch-Godfrey (BG) can be a good alternative to DW, as it is a more general test. With BG one can avoid fulfilling the conditions in DW, and it allows multiple lags. If one rejects H_0 with BG it will be concluded that the dataset contains autocorrelation. If only a part of H_0 must be rejected, H_0 must be rejected as whole. It can be challenging to find the right number of lags, and there is no clear answer to this. It is common to experiment with a range of values or look at the frequency of the data one uses. In any case, there should be a statistical model without evidence of autocorrelation in the residuals (Brooks, 2019).

If autocorrelation is detected, the assumptions for OLS are not met. To deal with the problem with autocorrelation it is possible to use a Generalised Least Squares (GLS) procedure. The Cochrane-Orcutt procedure is a popular approach. It works by assuming a specific form of autocorrelation. One can divide the procedure into two four steps, based on the following equation:

$$\begin{gathered} y_t = \beta_1 + \beta_2 x_{2t} + \beta_3 x_{3t} + u_t \\ u_t = \rho u_{t-1} + v_t \end{gathered} \tag{15}$$

The first step is to estimate the equation using OLS, and ignore the residual autocorrelation. The next step is to obtain the residuals, and run the regression.

$$\hat{u}_t = \rho \hat{u}_{t-1} + v_t \tag{16}$$

Then, one obtain $\hat{\rho}$ and construct y_t^* by using the estimate of $\hat{\rho}$. Finally, one runs the GLS regression. The regression can be written as:

$$y_t^* = \beta_1^* + \beta_2 x_{2t}^* + \beta_3 x_{3t}^* + v_t \tag{17}$$

This equation has an error term that does not contain autocorrelation. It is possible to achieve better results by reviewing steps 2-4 of the procedure several times (Brooks, 2019).

5.4 ARIMA

An autoregression model (AR) is a model where the current-period value of a variable is based on its previous-period values plus an error term. We can do an autoregression of p orders, AR(p), where p is the number of past values of x_t to predict the current value of x_t (Brooks, 2019). AR(p) can be expressed as:

$$x_t = b_0 + b_1 x_{t-1} + b_2 x_{t-2} + \cdots + b_p x_{t-p} + \varepsilon_t \tag{18}$$

One of the simplest time-series models is the moving average model (MA) (Brooks, 2019). It looks at the autocorrelations to determine whether x_t is correlated only with its preceding and following values, and can in this way see if a time series fits an MA(1) model (DeFusco, McLeavey, Pinto & Runkle, 2015).

$$\begin{gathered} x_t = \varepsilon_t + \theta\varepsilon_{t-1}, E(\varepsilon_t) = 0, E(\varepsilon_t^2) = \sigma^2 \\ Cov(\varepsilon_t, \varepsilon_s) = E(\varepsilon_t, \varepsilon_s) = 0 \text{ for } t \neq s \end{gathered} \tag{19}$$

There are also more complicated moving-average models. We can have a model with q periods. MA(q) can be written as:

$$\begin{gathered} x_t = \varepsilon_t + \theta\varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}, E(\varepsilon_t) = 0, E(\varepsilon_t^2) = \sigma^2 \\ Cov(\varepsilon_t, \varepsilon_s) = E(\varepsilon_t, \varepsilon_s) = 0 \text{ for } t \neq s \end{gathered} \tag{20}$$

Also, for a MA(q) model we examine the autocorrelations to tell whether it fits a time series. The first q autocorrelations will be significantly different from 0, and all autocorrelations beyond that will be equal to 0. It is difficult to say in advance whether a time series is autoregressive or moving average, but an autoregressive model is in most cases the best one (DeFusco et al., 2015).

It is possible to combine the autoregressive model and the moving average model. Then you have an autoregressive moving-average model (ARMA) (Brooks, 2019). The ARMA model can be presented as:

$$x_t = b_0 + b_1 x_{t-1} + \cdots + b_p x_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}$$
$$E(\varepsilon_t) = 0, E(\varepsilon_t^2) = \sigma^2, Cov(\varepsilon_t, \varepsilon_s) = E(\varepsilon_t \varepsilon_s) = 0 \text{ for } t \neq s \tag{21}$$

Where $b_1, b_2, \dots, b_p$ are autoregressive parameters, and $\theta_1, \theta_2, \dots, \theta_q$ are the moving-average parameters. Negative with the ARMA model is that it can be very unstable. The model also depends on the data sample that is used and the particular ARMA model estimated. This should be taken into consideration when analyzing the results from ARMA models (DeFusco et al., 2015).

Another approach is ARIMA, which stands for autoregressive integrated moving average model (Brooks, 2019). In the article written by Box and Pierce (1970) they refer to Box and Jenkins which based on previous research presented a common way of estimating an ARIMA model. They include three steps that are identification, estimation, and diagnostic checking. The steps involve determining the order of the model, estimating the parameters, and deciding whether the model is appropriate (Box and Pierce, 1970).

One can distinguish between two types of ARIMA models, non-seasonal and seasonal. This means that ARIMA models are capable of modeling seasonal data. A seasonal ARIMA model includes additional seasonal terms in the model. For non-seasonal, we use the terms (p, d, q), while for seasonal (P, D, Q) are used. Thus, the complete model can be called an ARIMA (p, d, q) x (P, D, Q) model, where p is the order of the autoregressive part, d is the degree of first differentiation involved, and q is the order of the moving average part (Hyndman & Athanasopoulos, 2018). The seasonal part can be explained by the fact that P is the number of seasonal autoregressive (SAR) terms, D is the number of seasonal differences, and Q is the number of seasonal moving average (SMA) terms.

If autocorrelation is found in a multiple regression model, an ARIMA model can be a good alternative. The ARIMA model can add more lags to eliminate the autocorrelation. By doing so, one can adapt the regression model as an ARIMA model with regressors. One will specify the correct AR and MA terms to fit the pattern that was observed in the original multiple regression model. To identify the numbers of AR and MA terms that are needed, one can look at the ACF and PACF plots (Nau, n.d.).

5.5 Data

To carry out the analysis, we have used R and applied data on a monthly frequency in the period April 2007 to November 2020. Since several of the companies were listed on the Oslo Stock Exchange in 2007, we think this is a natural starting point. Based on previous studies, we have chosen several variables that we want to analyze in more detail. As a dependent variable, we have created an equally weighted portfolio, while as independent variables we have included three industry-specific variables and four macroeconomic variables. Table 4 shows all the variables used in the study, their form and which databases that have been used.

Variable	**Measure**	**Source**
Portfolio	$\Delta Port_t = ln\left(\frac{Port_t}{Port_{t-1}}\right)$	Yahoo Finance
Spot price	$\Delta SP_t = ln\left(\frac{SP_t}{SP_{t-1}}\right)$	Fish Pool
Exchange rate USD/NOK	$\Delta USD_t = ln\left(\frac{USD_t}{USD_{t-1}}\right)$	Norges Bank
Exchange rate EUR/NOK	$\Delta EUR_t = ln\left(\frac{EUR_t}{EUR_{t-1}}\right)$	Norges Bank
OSEBX	$\Delta OSEBX_t = ln\left(\frac{OSEBX_t}{OSEBX_{t-1}}\right)$	Titlon
Long term interest rate	$\Delta Int_t = ln\left(\frac{Int_t}{Int_{t-1}}\right)$	Norges Bank
Global production volume	$\Delta Prod_t = ln\left(\frac{Prod_t}{Prod_{t-1}}\right)$	Kontali Analyse
Biomass	$\Delta Bio_t = ln\left(\frac{Bio_t}{Bio_{t-1}}\right)$	Fiskeridirektoratet

Table 4: Definition of the variables

5.5.1 Dependent variable

The dependent variable is an equally weighted portfolio measuring the log returns of the seven companies presented in Chapter 2. These companies are Mowi, Lerøy Seafood, SalMar, Grieg Seafood, Bakkafrost, Norway Royal Salmon and Austevoll Seafood. This is a small selection, but these companies represent a large proportion of the Norwegian salmon farming industry. Therefore, we have chosen to create an equally weighted portfolio with these companies to represent the salmon farming industry.

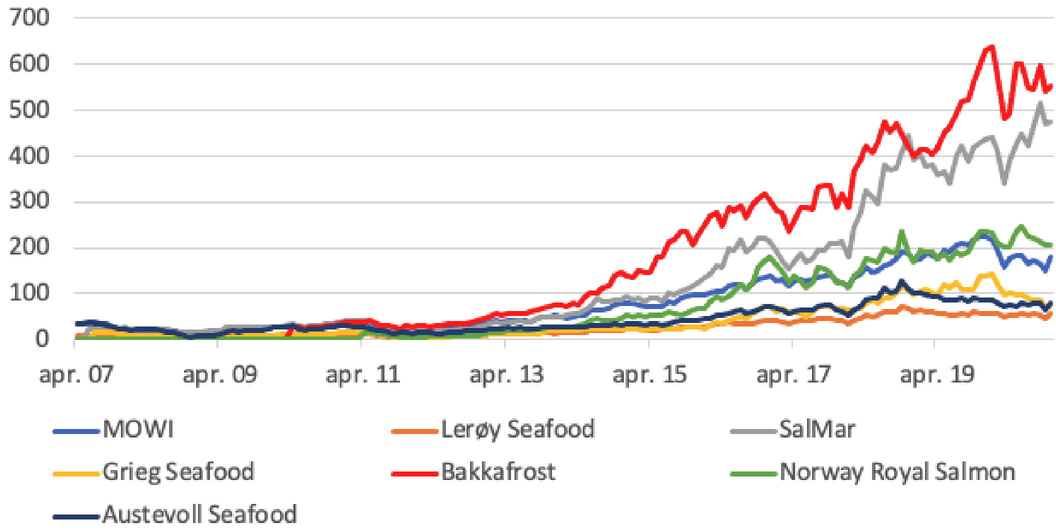


Figure 9: Development in share prices for the seven companies in the portfolio

(Source: Yahoo Finance)

5.5.2 Independent variables

Spot price

The salmon farming companies mainly produce and sell salmon, thus the price of salmon will have an impact on earnings. The price can be represented through spot or futures prices. Based on the findings of Asche et al. (2016) we have chosen to use the spot price. The spot price is downloaded from the FPI™. FPI™ is the basis for settlement of all financial contracts in Fish Pool. It consists of the two indexes which are Nasdaq Salmon Index and Statistic Norway (SSB), where Nasdaq represent the exporters selling prices and SSB the Norwegian export statistics. The Nasdaq Salmon Index is weighted at 95%, and SSB is weighted at 5%. In addition, the FPI™ bases the price on size, where 3-4 kilos and 5-6 kilos are weighted 30% each, while 4-5 kilos are weighted 40% (Fish Pool, n.d.b). The spot price downloaded from FPI™ is on a weekly frequency. We convert the weekly price into monthly by taking the mean of the sum, the same way as Asche et al. (2016).

Figure 10 shows the development in spot price in NOK per kilo from January 2006 to January 2020. The price was at its lowest in the autumn of 2011 when it was less than NOK 20 per kilo, while the highest price for the period is from the spring of 2018 at over NOK 80 per kilo. Before the salmon price reached its lowest value in 2011, there was a significant decrease in prices. This decrease may be due to expectations of increased supply in 2012 when a lot of smolts were released, especially in Chile, in 2010 and in 2011 (Lier, 2011). After the big decrease in 2011, the price of salmon rose again in value. In 2014, there was a new, slightly larger decrease in the price. This may be due to the aforementioned Russian import ban on Norwegian salmon. The figure shows that there have been large fluctuations in the price during the period, especially in the last five years. Low flexibility in production due to the strict regulations is pointed out as one of the reasons for the high volatility in the market (Asche, Misund & Oglend, 2018). Misund believes that people must prepare for the fact that such fluctuations in the industry are becoming more common than before, and that they have come to stay (Ytreberg, 2018).

Figure 10: Development in spot price in Nowegian kroner per kilogram

(Source: Fish Pool)

Exchange rates

As written in Chapter 2, 71% of the salmon produced in Norway in 2018 were exported to countries in Europe (NOU 2019: 18). This means that many buyers pay in EUR, and the exchange rate will affect the companies' earnings in NOK. The USA is also a fairly large export market for Norway, in addition to some raw materials related to production being imported in USD. Therefore, we have chosen to include exchange rates for both EUR and USD in relation to NOK.

Figure 11: Development in exchange rates for EUR/NOK and USD/NOK

(Source: Norges Bank)

In Figure 11, we can see that NOK has weakened in the last 6-7 years before a small strengthening in the last year. As described in the theory section, a weakening of NOK will strengthen Norwegian exports. Figure 12 below shows the change in exports per ton and the Euro exchange rate from 2007 to 2020. The figure highlights a relationship we think is important for the Norwegian salmon farmers, due to the great extent of salmon that are exported to the EU. One can see that changes in exchange rates and exports seem to have the same pattern over recent years, but it is difficult to see a connection in the first years that is included in the figure.

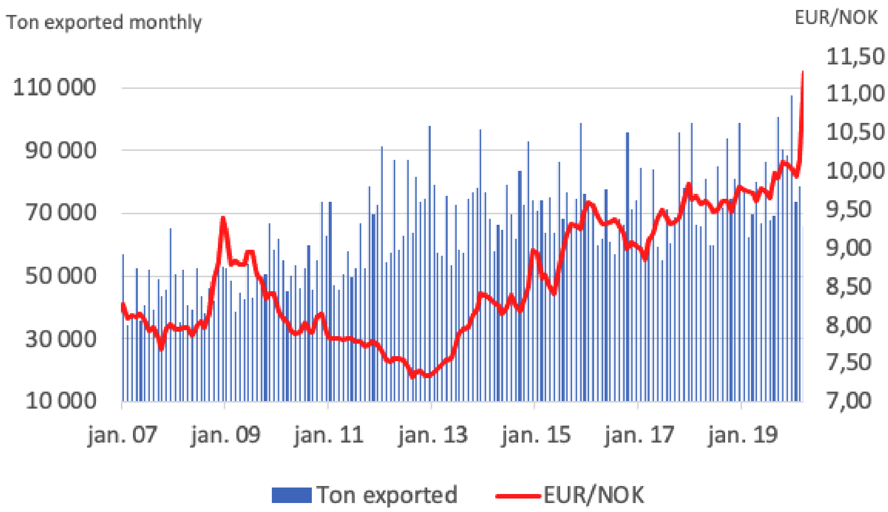


Figure 12: Tons of salmon exported monthly and exchange rate for EUR/NOK

(Source: SSB; Norges Bank)

OSEBX

The returns of the companies we have included in the portfolio will probably be affected by the general development in the market. Stock exchange indices are often used as a representative of market returns, and are usually obtained from the stock exchange where the companies examined are listed. Since the companies included in the portfolio are listed on the Oslo Stock Exchange, we use the main index, known as OSEBX. There are several different indices, also indices that may consist of companies in specific sectors, such as OSLSFX which is a separate index for seafood. The reason why we have chosen to use OSEBX is that it represents the overall development in the whole market. The development is illustrated in the figure below.

Figure 13: Development of OSEBX

(Source: Titlon)

Interest rate

The interest rate level in a country will affect the activity level. Tjaaland et al. (2015) point out that interest rates will affect investments and are a risk factor for companies. A higher interest rate will lead to fewer investments as it will be more expensive to finance investments. Within the fish farming industry, there will be several investments related to the entire production process, such as rafts, smolt facilities and slaughterhouses. The interest rate will also affect which financial assets investors want to invest in. As written in the theory, when interest rates are high, a higher return on risk-free investments will be achieved than at a low interest rate level, and investors may invest in risk-free assets.

Tjaaland et al. (2015) and Steen & Jacobsen (2020) have in their studies chosen to use the long-term interest rate. As described in the literature review, these are studies within the market of raw materials. Therefore, we have also included the long-term interest rate. As a proxy for the long-term interest rate, we have used the Norwegian ten-year bond yield. Figure 14 shows the development in recent years. As can be seen from the figure, it has decreased during the period.

Figure 14: Development in the Norwegian ten-year bond yield

(Source: Norges Bank)

Global production volume

In addition to the salmon price, the sales volume will be of great importance for the companies' turnover, and the sales volume will be affected by the offered volume, i.e., the production volume. There is a relationship between development in price and offered volume. If the offered volume is higher than the demand, the price of the item will have a negative shift, and vice versa if the offered volume is lower than the demand. How much the companies' earnings change due to volume changes will depend on how the salmon price changes in relation to volume. We want to see if global production volume affects the returns of the companies and are therefore included as one of our variables. Figure 15 indicates that there is a negative relationship between the global production volume and the salmon price. With an increase in the production volume, the salmon price is reduced, and a reduction in the production volume leads to an increase in the salmon price.

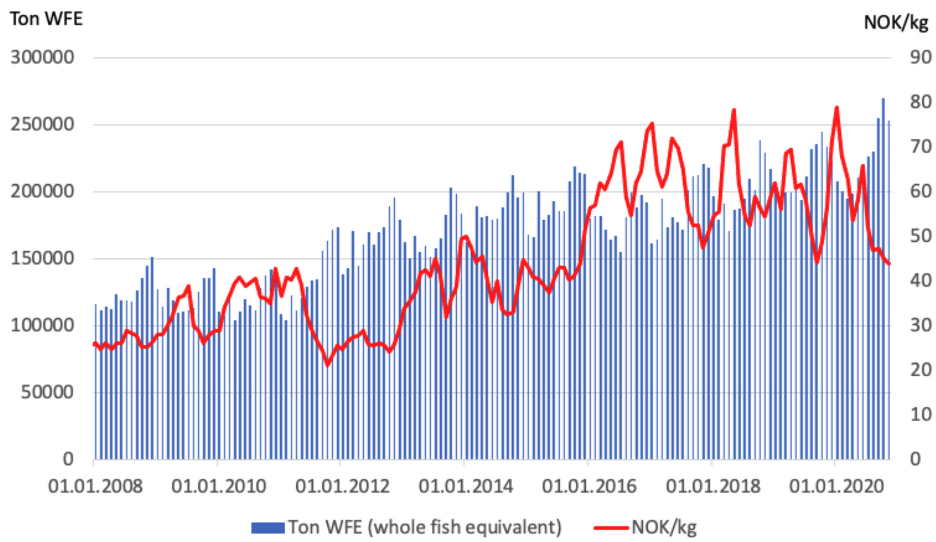


Figure 15: Development in total global production volume and the spot price

(Source: Kontali Analyse; Fish Pool)

Biomass

Biomass measures the amount of salmon there is in the floating cages. Using the numbers for biomass, one can look at seasonal variations, as well as estimate future offers of volume. One must consider escape, illness, and death in the estimation of future offered volume. The estimated numbers for future offered volume may be an indicator of the earnings the companies can expect. The figure shows the development in biomass and the spot price for the last 12 years.

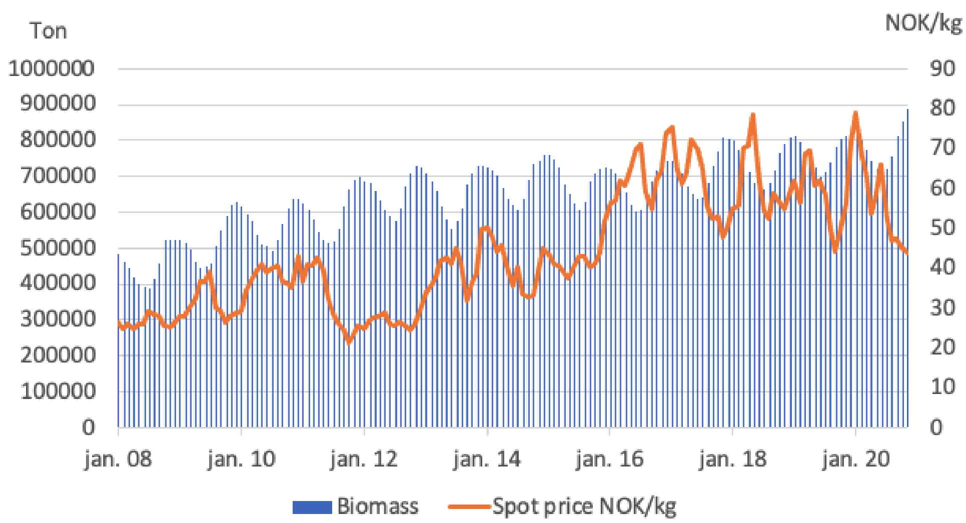


Figure 16: Development in biomass in tons and the spot price

(Source: Fiskeridirektoratet; Fish Pool)

The salmon farming industry is an industry with biological restrictions. Thus, it is not unreasonable whether the variables global harvest volume and biomass contain seasonal variations. As mentioned in the chapter about production, more salmon is harvested in Norway during the summer due to better growth conditions. Therefore, we will also include a model where these two variables are seasonally adjusted. This procedure will be explained in more details in Chapter 6 where the models are presented.

5.5.3 Descriptive statistic of the variables

Table 5 summarizes the descriptive statistic of the data. The dataset used for this study consists of 163 monthly observations, N, and all variables are log transformed. Due to increased share prices in the salmon farming industry, it is not surprising that the mean for the portfolio is higher than the mean for OSEBX. All variables, except interest rates, have had a positive average development during the period. The interest rate is the most volatile variable, with a minimum of -0.3983 and a maximum of 0.3242, followed by the spot price with a minimum of -0.2599 and a maximum of 0.2524. These two variables also have higher standard deviations than other variables, which can make them riskier. The most stable variable is the adjusted volume with a minimum of -0.0425 and a maximum of 0.0727. It is closely followed by the two exchange rates. These variables also have the lowest standard deviation. Furthermore, we can see that variables with higher standard deviations generally have higher quantiles. Although some of the variables have quite similar upper and lower quantiles. The portfolio, OSEBX, and global production volume are the ones with the highest tail trends.

Descriptive Statistic

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Port	163	0.0122	0.0734	-0.1843	-0.0268	0.0571	0.2297
SP	163	0.0026	0.0996	-0.2599	-0.0617	0.0689	0.2524
USD	163	0.0025	0.0273	-0.0573	-0.0125	0.0180	0.1295
EUR	163	0.0017	0.0183	-0.0481	-0.0090	0.0092	0.1085
OSEBX	163	0.0041	0.0595	-0.2906	-0.0164	0.0347	0.1469
Int	163	-0.0110	0.0904	-0.3983	-0.0447	0.0348	0.3242
Prod	163	0.0055	0.0859	-0.2697	-0.0457	0.0581	0.1965
Bio	163	0.0049	0.0453	-0.0752	-0.0322	0.0407	0.1403
$Prod_{adj}$	163	0.0037	0.0145	-0.0425	-0.0072	0.0122	0.0727
Bio_{adj}	163	0.0042	0.0532	-0.1230	-0.0334	0.0424	0.1344

Table 5: Descriptive statistics for the data sample

6 Analysis and results

This chapter examines the robustness of our three models, and their properties against the assumptions of OLS. Our first model, model 1, is a regular regression model. Model 2 and ARIMA contain the same data as model 1, but the biomass and global production volume is seasonally adjusted. The models will be further explained when the assumption of OLS has been met. Further, we will discuss the variables in more detail, and how they affect the portfolio, with respect to theory and previous research. At the end we will look at the stability of the variables, and how they affect the portfolio over time, using a rolling window.

6.1 Robustness of the models

Stationarity

To check if the time series are stationary, we use an ADF test. Table 6 shows in the first column p-values before differencing, while the values in the second column are p-values after differencing in first order. In the first column, the ADF test has a high p-value for most of the variables, which indicates non-stationarity, while after differentiating in the first order we get a P-value of 1% and no unit roots. This means that the data is now stationary and the H_0, which is that the data contain unit roots, can be rejected. In the further analyses, the variables will be used after differencing and log transformation.

	Levels	First difference
	P-values	P-values
Port		0.01
SP	0.323	0.01
USD	0.360	0.01
EUR	0.820	0.01
OSEBX	0.046	0.01
Int	0.372	0.01
Prod	0.01	0.01
Bio	0.046	0.01
$Prod_{adj}$	0.482	0.01
Bio_{adj}	0.427	0.01

Table 6: Augmented Dickey-fuller test

Multicollinearity

Correlation

	Port	SP	USD	EUR	OSEBX	Int	Prod	Bio
Port	1							
SP	0.207	1						
USD	-0.268	0.046	1					
EUR	-0.205	0.075	0.598	1				
OSEBX	0.418	0.069	-0.463	-0.331	1			
Int	0.161	0.068	-0.362	-0.291	0.220	1		
Vol	-0.171	-0.247	0.086	0.120	-0.026	0.046	1	
Bio	-0.117	-0.230	-0.028	0.019	-0.096	0.005	0.202	1

Table 7: Correlation matrix for the data

Table 7 presents the correlation matrix of the data over the sample period. As expected, the portfolio has the highest correlation with OSEBX, with a positive correlation of 0.418. In addition to OSEBX, spot price, and interest rate have a positive correlation to the portfolio. The correlation between all the variables is below 0.5, except for the two exchange rates with each other, which have a correlation of 0.598. Steen & Jacobsen (2020) also find a high correlation between the exchange rates in their study. It is according to theory that there is a connection between these, since exchange rates should reflect the economic situation in a country and NOK is included in both quotations.

The correlation coefficients between most variables indicate that we should not have any problems with multicollinearity. Nevertheless, we want to check the variables for multicollinearity, especially the exchange rates. We test the variables through the Variance Inflation Factor (VIF) test. Table 8 shows that all values are below the level that is considered problematic, therefore we do not expect multicollinearity to be a problem for our models. Thus, we use all the included variables in the further analyses.

	Model 1		Model 2	
Variable	VIF	1/VIF	VIF	1/VIF
SP	1.14	0.87	1.09	0.92
USD	1.88	0.53	1.93	0.52
EUR	1.61	0.62	1.60	0.63
OSEBX	1.32	0.76	1.31	0.77
Int	1.19	0.84	1.20	0.84
Prod	1.13	0.88	1.09	0.92
Bio	1.10	0.91	1.09	0.91

Table 8: VIF test

Autocorrelation

To test for autocorrelation in model 1 and model 2, we use Durbin-Watson (DW) test and Breusch-Godfrey (BG) test. To find critical values for the DW test, we use the DW significance table. We find that the lower critical value, d_L, is 1.5446, and the upper critical value, d_U, is 1.7268. Thus, $4 - d_U$ and $4 - d_L$ become 2.2732 and 2.4554, respectively.

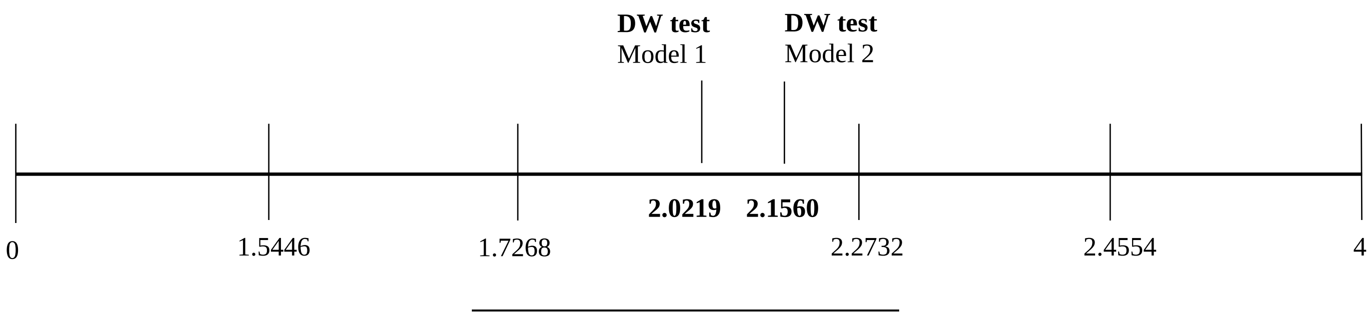


Figure 17: Durbin-Watson test

For model 1 we find a DW value of 2.0219, and for model 2 the value is 2.1560. Thus, the models are within the critical values. This suggests that we do not have any problems with first order autocorrelation.

As mentioned in chapter 5, DW has some weaknesses. Thus, we also use the BG test. When carrying out the BG test we have tested for several lags but have chosen to include four lags in the table. Table 9 shows that there should not be a problem with autocorrelation in model 1, and we retain H_0. However, for model 2 there is a problem with autocorrelation with two lags, and H_0 must be rejected.

Breusch-Godfrey	Lags	Kji2	Prob > Kji2
Model 1	1	0.028	0.866
	2	5.727	0.057
	3	5.830	0.120
	4	7.066	0.132
Model 2	1	1.128	0.288
	2	7.302	0.026
	3	7.361	0.061
	4	8.246	0.083
H_0: No autocorrelation in the residuals			
H_1: Autocorrelation in the residuals			

Table 9: Breusch-Godfrey test

To deal with the problems of autocorrelation in model 2 we use the Cochrane-Orcutt procedure. Table 10 shows the BG test for model 2 after we have conducted the procedure. As can be seen from the table, we can now retain H_0 for this model as well. Thus, for further analyses we will use model 2 after the Cochrane-Orcutt procedure. As described in subchapter 5.4, an ARIMA model is a good alternative to use during autocorrelation. Since we first had problems with autocorrelation in model 2, we want to include ARIMA with external regressors to substantiate the results of model 2.

Breusch-Godfrey	Lags	Kji2	Prob > Kji2
Model 2	1	0.057	0.811
	2	5.872	0.053
	3	5.886	0.117
	4	6.760	0.149
H_0: No autocorrelation in the residuals			
H_1: Autocorrelation in the residuals			

Table 10: Breusch-Godfrey test after Cochrane-Orcutt procedure

For ARIMA, we have used the Ljung-Box test to test for autocorrelation. We can see that the p-value is 0.4862, thus we can retain H_0.

Ljung-Box	P-value
ARIMA	0.486
H_0: No autocorrelation in the residuals	
H_1: Autocorrelation in the residuals	

Table 11: Ljung-Box test for ARIMA

Homoscedasticity

To see whether the data is homoscedastic, one can visualize the errors in a plot. A plot will be able to give an overall picture, but one should also use formal statistical tests. We have chosen to use the Breusch-Pagan test that is widely used to test for heteroscedasticity.

Breusch-Pagan test	Kji2	Prob > Kji2	Conclusion
Model 1	8.733	0.272	Retain H_0
Model 2	14.582	0.042	Reject H_0
ARIMA	1.024	0.985	Retain H_0
H_0: Homoscedasticity			
H_1: Heteroscedasticity			

Table 12: Breusch-Pagan test

From the table it can be seen that we can retain H_0 and state homoscedasticity for model 1 and ARIMA. This means that the models' variance of the error terms is constant, and the assumption for OLS is met. For model 2, H_0 must be rejected, which indicates heteroscedasticity. Heteroscedasticity means that the error variance does change over time, which can lead to misleading conclusions. To deal with this we use robust standard errors. The idea of robust standard errors is to allow non-constant variance. In the rest of the thesis, model 2 will be used after it has been adjusted with robust standard errors and the Cochrane-Orcutt procedure has been conducted.

Normal distribution

To test whether the residuals are normally distributed we have used a Bera-Jarque (BJ) test. We have also looked at the different plots of the residuals. Using a histogram or a Q-Q plot, one can look for the normally distributed shape of the data. In a BJ test, the null hypothesis, H_0, is that the residuals are normally distributed around zero, it is examined against the alternative hypothesis, H_1, which states that the residuals are not normally distributed. H_0 is rejected if the test is significant (Brooks, 2019). From the test results we see that we can retain H_0, thus we can say that the residuals are normally distributed at a 0.05 p-value.

Bera-Jarque	Kji2	Prob > Kji2
Model 1	3.266	0.195
Model 2	2.715	0.257
ARIMA	0.919	0.632
H_0: Residuals are normally distributed		
H_1*:* Residuals are not normally distributed		

Table 13: Bera-Jarque test

6.2 Models

Model 1 can be described as a regular regression model, while model 2 being an extended model with seasonally adjusted variables for global production volume and biomass. The ARIMA model with external regressors are as described used to substantiate the results of model 2. The adjustment made for biomass and global production volume is an STL decomposition, which stands for seasonal and trend decomposition using loess (Cleveland, Cleveland & Terpenning, 1990). This is done due to the cyclical pattern in the salmon farming industry. An advantage of this is it could give a more meaningful explanation since the seasonal pattern can obscure important features in data and make it hard to research period-to-period movements. The models are derived as follows:

$$\Delta lnPort = \beta_1 + \beta_2 ln\Delta SP_t + \beta_3 ln\Delta USD_t + \beta_4 ln\Delta EUR_t + \beta_5 ln\Delta OSEBX_t + \beta_6 ln\Delta Int_t + \beta_7 ln\Delta Prod_t + \beta_8 ln\Delta Bio_t + u_t$$

$$\Delta lnPort = \beta_1 + \beta_2 ln\Delta SP_t + \beta_3 ln\Delta USD_t + \beta_4 ln\Delta EUR_t + \beta_5 ln\Delta OSEBX_t + \beta_6 ln\Delta Int_t + \beta_7 ln\Delta Prod_{adj_t} + \beta_8 ln\Delta Bio_{adj_t} + u_t$$

The ARIMA model has been selected using a four-step approach, where some details of the final model can be seen in Appendix A. First, we evaluated the need for variance-stabilizing transformations. Then we look at the need for order of non-seasonal (p, d, q) and seasonal

(P, D, Q). We used the ACF and PACF, and the AIC criterion for measurement. We also conducted the Ljung-Box test for autocorrelation, and at last we evaluated the significance of the coefficients.

6.3 Regression results

Regression results

	Dependent variable:	
	Portfolio	
	Model 1	Model 2
	(1)	(2)
SP	0.1121**	0.1520***
EUR	-0.1304	-0.1264
USD	-0.1847	-0.2360
Int	0.0361	0.0079
$Prod_{adj}$		-0.9306**
Bio_{adj}		-0.1740*
OSEBX	0.4316***	0.4564***
Prod	-0.0945	
Bio	-0.0439	
Constant	0.0120**	0.0150***
Observations	163	163
R^2	0.2318	0.2829
Adjusted R^2	0.1971	0.2503
Residual Std. Error	0.0658 (df = 155)	0.0649 (df = 155)
F Statistic	*** (df = 7; 155)	*** (df = 7;155)
Note:		*p<0.1; **p<0.05; ***p<0.01*

Table 14: Regression results model 1 and model 2

ARIMA

	Dependent variable:
	Portfolio
ar1	-0.1769**
ma1	-0.9106***
sma1	-0.1403*
SP	0.1299***
EUR	-0.1837
USD	-0.3151
OSEBX	0.4406***
Int	0.0081
$Prod_{adj}$	-0.9047***
Bio_{adj}	-0.1547
Note:	*p<0.1; **p<0.05; ***p<0.01*

Table 15: Results ARIMA

As seen from the results all of the coefficients from the variables share the same signs in the three models, and are also quite similar in the estimates. However, we do see that the estimate for change in the global production volume differs the most when comparing model 1 to model 2 and ARIMA, which are quite similar. This is also the case for the estimate for the change in biomass, but this spread is not that big. Since we are looking at the variables in the model on a logarithmic form the estimates of the coefficients are elasticities. This means that coefficients are the estimated percent change in our portfolio, for 1% change in the independent variables.

Looking at the adjusted R^2 we see that model 1 has an adjusted R^2 of 0.1971 which indicates 19.71% of the variation in the returns of the portfolio can be explained by the variables. For model 2 we have an adjusted R^2 of 0.2503. With respect to adjusted R^2, model 2 has the best explanation of the portfolio returns for the salmon farming companies listed on the Oslo Stock Exchange. However, both of these results are a bit low compared to the results from Misund (2018) and Steen & Jacobsen (2020), where they have roughly 0.47 and 0.43. Even though we use some different variables than these studies, we will try to get a deeper understanding of why our results differ in the rolling window part.

6.4 Discussion

Spot Price

The results show a significant spot price for all the models, indicating that the spot price is a determinant of the portfolio's returns. The estimate is quite similar for all of the three models, and indicates that a 1% change in the spot price would affect the portfolio returns by roughly 0.11 to 0.15% according to our models. This is something we expected as several studies have pointed out a connection between spot price and returns in the salmon farming industry (Bloznelis, 2018; Misund, 2018; Steen & Jacobsen, 2020). The salmon farming companies are mainly engaged in the production and sale of salmon, and earnings will therefore to a large extent be directly affected by the spot price. Therefore, it is not unreasonable to believe that the spot price can be an indicator when evaluating their shares.

Exchange rates

From subchapter 4.5 in the theory part, the experience is that a weak NOK will be an advantage for Norwegian companies in the export market as this increase's competitiveness. Xie et al. (2008) conclude that the exchange rates are an important factor to the export prices of farmed salmon. Since over 95% of Norwegian salmon production is exported, export prices may have an impact on the companies' earnings. In addition, income in foreign currency and a weak krone will lead to higher cash flows. According to the cash flow model described in subchapter 4.3, higher cash flows will lead to higher share value. For these reasons, we had expectations that changes in the exchange rates of both the Euro and the US Dollar would affect the share price of the salmon farming companies.

Somewhat surprisingly, none of the models shows a significant relationship with exchange rates, which indicates that exchange rates do not have an impact on the portfolio. There may be several reasons why this factor is not a determinant of the portfolio returns. One reason may be that the salmon companies use hedging against exchange rates.

OSEBX

Since all the companies included in the portfolio are listed on the Oslo Stock Exchange, we did not believe it was unlikely with a positive connection between the portfolio and OSEBX. The coefficient for OSEBX ranges from 0.43 to 0.46 and is significant at a 1% level for all of our three models. An increase in OSEBX by 1% will increase the portfolio returns by 0.43 to 0.46% depending on which model is used. The results indicate that salmon farming company stocks are less risky than OSEBX, and that the development in the share price of the companies shown in Figure 9 is not due to high systematic risk. Our results are also consistent with previous literature.

Long-term interest rate

The long-term interest rate is not statistically significant in any of our models. This means that changes in the long-term interest rate do not seem to explain changes in the returns of our portfolio. Since the interest rate level in a country will affect the country's activity level and the investment choices of investors, it is somewhat surprising that the interest rate does not affect the share price. Nevertheless, our results correspond with the results of Steen & Jacobsen (2020). As Steen & Jacobsen (2020) points out, a possible explanation may be that the long-term interest rate serves as a proxy for the state of the economy, the borrowing cost, and the required rate of return for investors. The borrowing cost and the required rate of return for investors implies a negative relationship, and the state of the economy implies a positive relationship.

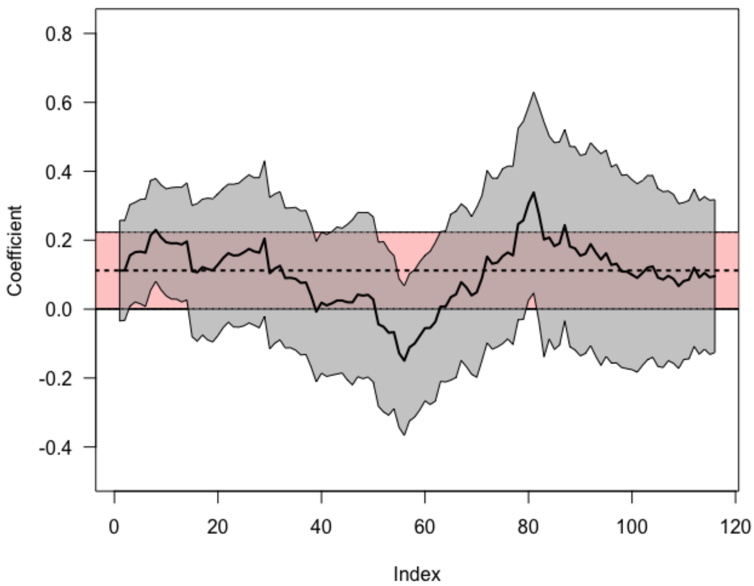
Global production volume and biomass

Changes in global production volume are significant for both model 2 and ARIMA, but not for model 1. Changes in biomass are significant for model 2 with a p-value of 10%, and almost at 10% level for the ARIMA. Model 1 also stands out with a lower estimate of how much the changes in global production volume and biomass affect the portfolio, and the largest difference in the models is seen in global production volume. One reason for this is that model 1 does not adjust for the seasonal variations in the salmon farming industry, where the seasonality can be seen in the pattern of Figures 15 & 16. Apart from this, we see that an increase in global production volume and biomass will have a negative effect on the portfolio, where global production volume has the biggest impact on all of the models. One explanation for this may be that changes in biomass will not have an immediate effect due to the production time that affects all the companies in the industry. On the other hand, a positive change in the global production volume will have a direct effect on the market through a higher supply of salmon. And as seen from Figure 15, an increase in the global production volume yields a lower spot price and could thus reduce profits and consequently affect the returns of the portfolio. The value of biomass could be a good indicator of future global production volume, but in the long-term it could be affected by disease, salmon louse and other factors that can weaken the explanatory power.

The result from the regression seems to be in line with what Andersen et al. (2008) conclude. They find that the structure of the industry gives a short-term opportunity to respond to prices and can give a delayed response, which could overestimate the demand over time and create falling prices and earnings. This is due to the salmon farming companies having less incentives to reduce the supply when prices are high. This could explain the negative effect of changes in biomass and global production as we see from the regression results.

6.5 Rolling window

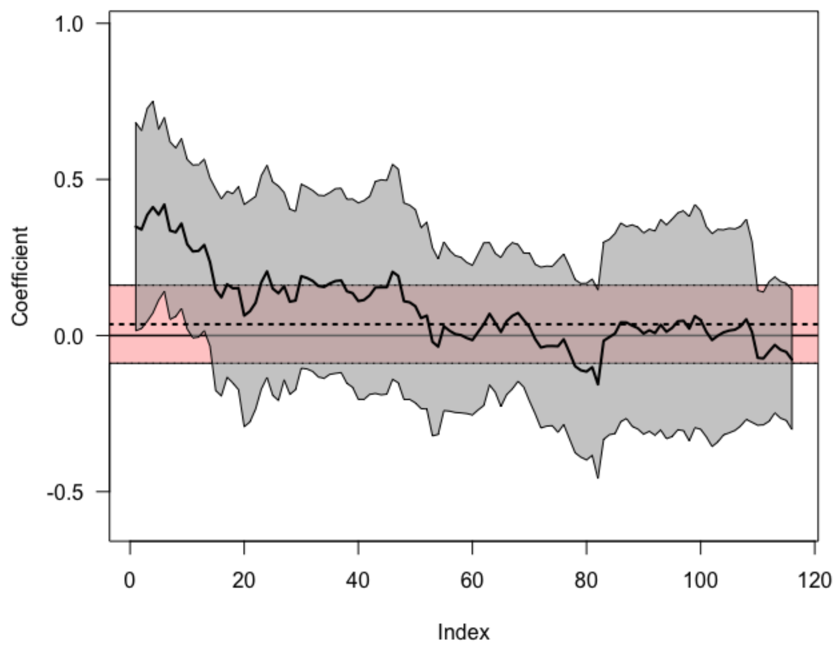
Misund (2018) emphasizes the importance of examining risk factors and the relationship to share price returns, and how they change over time. Working with the data in the early phase of this study we found that recent data gave a poor degree of explanation and no significant variables. We have therefore examined the variables in model 1 with respect to their coefficients, and how these change and affect the portfolio in different time periods through a rolling window.



Note: The estimate of the given coefficient in the different time periods is the whole black line, while the estimate of the coefficient from model 1 is illustrated as the black dashed line. The confidence interval for the given coefficient is illustrated in the red area, and a significant coefficient in the model is reflected when the red area is excluded from the zero. This is easier illustrated from the OSEBX coefficient, which is included in Appendix B panel c. Also, if the grey area moves above the zero line, the coefficient is significant for that exact time period. The rolling regression is illustrated through the grey area and runs for a period of 48 months. Index 1 will therefore be given at month 1 to 48, index 2 from 2 to 49, etc, and represent the data period 2007: 4 to 2020: 11.

Figure 18: Rolling window spot price

In Figure 18 we see that the estimate of the coefficient of the spot price is relatively volatile throughout the period. Even though the spot price is significant in the model, it is only significant for two short periods, which are relatively small compared to when it is insignificant. When the spot price becomes significant in the model is illustrated through the grey area moving above the zero line, shown in indexes 5-18 and 77-79. The significance is shorter at the end of the period, and from Figure 10 we see that this applies to the time where the salmon price had a rapid increase at the end of 2015. In later periods we see that the spot price reaches all-time high several times in the period between 2016-2020. However, the spot price is not significant in explaining the returns of the portfolio in this period. A possible explanation of why the significance has decreased when the spot price is at its highest, may be due to the increased volatility. The increased volatility for this period is also observed in Figure 10. This has been documented by Asche et al. (2019), which points out that salmon has gone from being below average volatile commodity to one of the most volatile with an increase from 15 to 35% in the last ten years. Thus, the increased volatility in the spot price could make it a poor determinant of earnings and future earnings, due to the rapid change, and thus reduce the significance of the spot price explaining the returns in recent times. Another possibility of the spot price has become less significant in explaining the portfolio returns, could be to a greater amount of the salmon is sold through contracts at Fish Pool. Hence, the salmon farming companies could become less exposed to the volatile spot price, and the significance of the spot price would in that case be less important in explaining portfolio returns. This could be an interesting topic to research further, due to the findings from Asche et al. (2016), where they find that the salmon market is yet immature and has not reached the stage where forward prices are able to predict future spot prices.



Note: The estimate of the given coefficient in the different time periods is the whole black line, while the estimate of the coefficient from model 1 is illustrated as the black dashed line. The confidence interval for the given coefficient is illustrated in the red area, and a significant coefficient in the model is reflected when the red area is excluded from the zero. This is easier illustrated from the OSEBX coefficient, which is included in Appendix B panel c. Also, if the grey area moves above the zero line, the coefficient is significant for that exact time period. The rolling regression is illustrated through the grey area and runs for a period of 48 months. Index 1 will therefore be given at month 1 to 48, index 2 from 2 to 49, etc, and represent the data period 2007: 4 to 2020: 11.

Figure 19: Rolling window interest rate

The interest rate is not a significant variable and therefore it does not explain the returns of the portfolio in the model. However, illustrated in the figure above it turns out to be significant at the beginning of the period. Comparing Figure 14 and Figure 19, it seems that a rising interest rate has a positive and significant effect on the returns of the portfolio. In later periods we see that a decreasing interest rate has an estimate that affects the portfolio in a negative way, but is insignificant. It can be argued that a lower discount rate, as a consequence of a decreasing long-term interest rate, will increase the present value of future cash flows for the companies, which could positively affect the share price due to assumptions of higher future earnings. Nevertheless, a decrease in the interest rate could also reflect a slowdown in the market due to the financial crisis and other factors, and could be interpreted as low expected earnings and growth in the market. This was the case in 2008 with the financial crisis, just a year after the start of our dataset. This might be an important factor in explaining why it turned out insignificant in the model, and could also be the reason why the estimate changes towards zero and has a negative effect on the portfolio. However, the connection between stocks and interest rates is a subtle relationship, which is influenced by various factors and perceptions in the market.

We have included the figures for the rest of the variables in the appendix. For the exchange rate variables, we believed that there would be significant periods. However, we just see a small negative significant impact of the USD in the middle of 2013. When comparing Figure 12 and Appendix B panel a and b it is difficult to draw any conclusions of the relationship between export of salmon and exchange rates. However, due to the structure of the industry it is hard to believe that the salmon farming companies are able to increase their export volume to a great extent when the exchange rates are advantageous and vice versa. Another explanation of exchange rates being insignificant in the model is as mentioned that the salmon farming companies could handle the exchange risk themselves through hedging. This is natural to believe, due to around 95% of the Norwegian production volume being exported. This could suggest that the exchange rate is foremost a risk exposure within the industry that can be dealt with.

OSEBX is the most significant variable in the model but is only significant in different intervals between 2007-2012. Despite a positive impact on the portfolio in the model, it also has a negative insignificant impact at times. This could be explained by the importance of the oil price for the OSEBX, where Misund (2018) found no significant relationship between salmon farming companies listed at OSEBX and the oil price. Thus, we do not expect the salmon farming companies to be directly affected by a decrease in the oil price. Hence, the negative insignificant effect on the portfolio by OSEBX could be explained by the drop in the oil price between 2014-2016. This might be the reason why OSEBX turns out insignificant for the portfolio returns for the rest of the period. This can be shown in Appendix B panel c.

In the beginning of the period, we see that the global production volume has a negative significant impact on the portfolio. This might be an effect of what Andersen et al. (2008) conclude, that the salmon farmers can overestimate the demand and over time create falling prices and earnings. In more recent times we see a positive shift in the estimates, but it is insignificant. However, one reason for this shift could be explained by the findings of Asche et al. (2019). They find that there has been a stagnation in production growth, and an increase in demand. This is due to a more consolidated industry, as well as restrictions and regulations in production. Nevertheless, since the estimate in recent times is not significant for both the global production volume and the biomass it is difficult to draw any conclusions.

As seen, most of the variables are significant only in the beginning, and none of the variables seems to be stable over time. This could explain why we have a less degree of explanation in our models compared to what we have seen from other research articles. This is also observed from our dataset in early phases of the study, where recent data gave a poor degree of explanation. The results indicate that there are other variables that have been or are important in explaining returns for the salmon farming companies listed on the Oslo Stock Exchange than what we have included.

7 Conclusion

The purpose of the study was to examine which factors that affect the returns of the salmon farming companies listed on the Oslo Stock Exchange. Three industry-specific factors and four macroeconomic factors were selected based on our literature review. These variables were used in one regular regression model and one extended seasonally adjusted model. We also used an ARIMA with external regressors to substantiate the latter model.

Our results show that the spot price and OSEBX have a positive significant relationship in all the models used. This is consistent with the study by Steen & Jacobsen (2020) who also found these variables significant. We did not find the long-term interest rate and the exchange rates between EUR/NOK and USD/NOK significant, which is the results of Misund (2018) and Steen & Jacobsen (2020) as well. The estimate of the coefficients for these variables was quite similar in our three models, which means that the change in the portfolio would be almost identical. However, the global production volume is significant for the seasonally adjusted model as well for the ARIMA. Biomass is only significant for the seasonally adjusted model.

In addition to the regression analysis, we also use a rolling window to examine how stable the results are over time. Findings from the rolling window indicate that the variables used are not stable over time, and seem to become a less important factor of explaining the returns for the portfolio throughout the time period. This could explain why we have a somewhat lower degree of explanation of the models than previous studies. For OSEBX, we only see a significant relationship in early periods of the dataset. The spot price is significant in the beginning, and for a small period in the late 2015. Our results suggest that this could be due to the increased volatility in the spot price of salmon in recent years. The exchange rates do not seem to be a determinant of the portfolio returns, but could potentially be viewed as a risk factor that can be hedged. As for the global production, we see a negative significant effect on the portfolio in the early period. This might be explained by Andersen et al. (2008), where they find that salmon farmers can overestimate the demand and over time create falling prices and earnings. From what we have seen in this study, the salmon industry seems to be changing rapidly. Our study emphasizes the importance of studying factors that affect the industry, and could yield a new insight into how factors affect the returns of salmon farming companies listed on the Oslo Stock Exchange over the recent years.

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Appendix

Appendix A: Plot of residuals for ARIMA

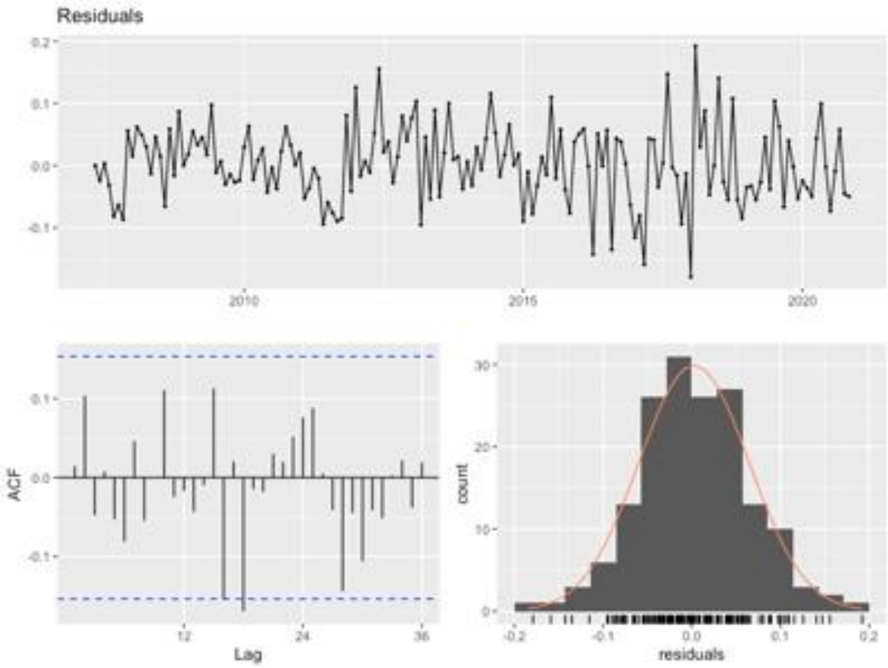
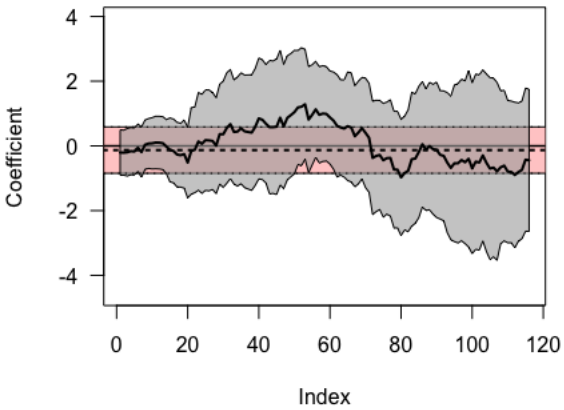
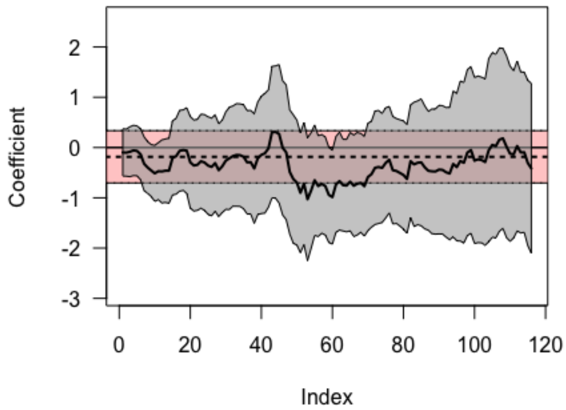


Figure 20: Plot of residuals for ARIMA

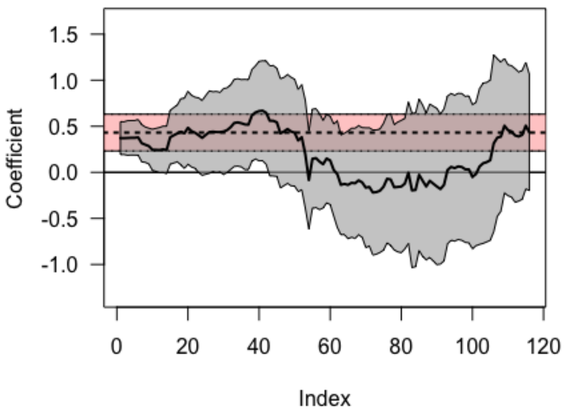
Appendix B: Rolling window



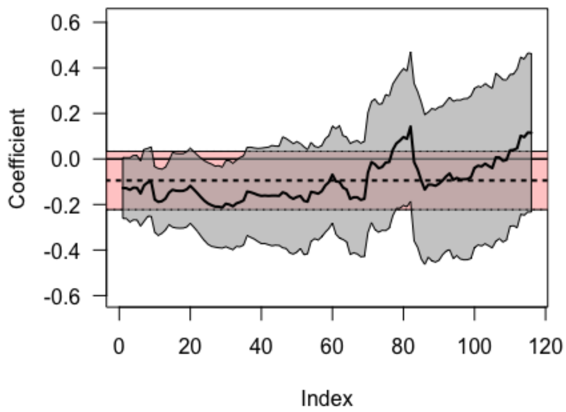
(a) Euro



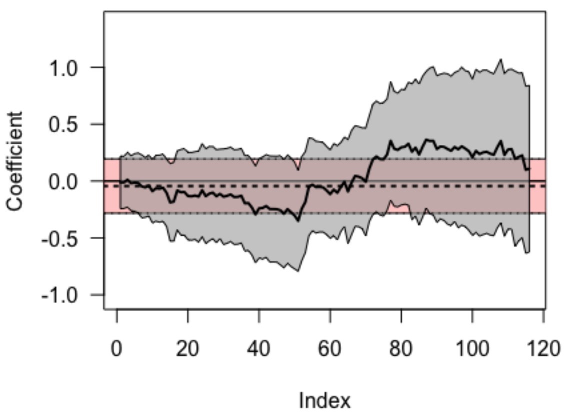
(b) USD



(c) OSEBX



(d) Production volume



(e) Biomass

Figure 21: Rolling window

Appendix C: Critical values for DW

n\k	1		2		3		4		5		6		7		8		9		10	
31	1.147	1.274	1.085	1.345	1.022	1.425	0.960	1.509	0.897	1.601	0.834	1.698	0.772	1.800	0.710	1.906	0.649	2.017	0.589	2.131
32	1.160	1.283	1.100	1.351	1.039	1.428	0.978	1.509	0.917	1.597	0.856	1.690	0.794	1.788	0.734	1.889	0.674	1.995	0.615	2.104
33	1.171	1.291	1.114	1.358	1.055	1.432	0.995	1.510	0.935	1.594	0.876	1.683	0.816	1.776	0.757	1.874	0.698	1.975	0.641	2.080
34	1.184	1.298	1.128	1.364	1.070	1.436	1.012	1.511	0.954	1.591	0.896	1.677	0.837	1.766	0.779	1.860	0.722	1.957	0.665	2.057
35	1.195	1.307	1.141	1.370	1.085	1.439	1.028	1.512	0.971	1.589	0.914	1.671	0.857	1.757	0.800	1.847	0.744	1.940	0.689	2.037
36	1.205	1.315	1.153	1.376	1.098	1.442	1.043	1.513	0.987	1.587	0.932	1.666	0.877	1.749	0.821	1.836	0.766	1.925	0.711	2.018
37	1.217	1.322	1.164	1.383	1.112	1.446	1.058	1.514	1.004	1.585	0.950	1.662	0.895	1.742	0.841	1.825	0.787	1.911	0.733	2.001
38	1.227	1.330	1.176	1.388	1.124	1.449	1.072	1.515	1.019	1.584	0.966	1.658	0.913	1.735	0.860	1.816	0.807	1.899	0.754	1.985
39	1.237	1.337	1.187	1.392	1.137	1.452	1.085	1.517	1.033	1.583	0.982	1.655	0.930	1.729	0.878	1.807	0.826	1.887	0.774	1.970
40	1.246	1.344	1.197	1.398	1.149	1.456	1.098	1.518	1.047	1.583	0.997	1.652	0.946	1.724	0.895	1.799	0.844	1.876	0.749	1.956
45	1.288	1.376	1.245	1.424	1.201	1.474	1.156	1.528	1.111	1.583	1.065	1.643	1.019	1.704	0.974	1.768	0.927	1.834	0.881	1.902
50	1.324	1.403	1.285	1.445	1.245	1.491	1.206	1.537	1.164	1.587	1.123	1.639	1.081	1.692	1.039	1.748	0.997	1.805	0.955	1.864
55	1.356	1.428	1.320	1.466	1.284	1.505	1.246	1.548	1.209	1.592	1.172	1.638	1.134	1.685	1.095	1.734	1.057	1.785	1.018	1.837
60	1.382	1.449	1.351	1.484	1.317	1.520	1.283	1.559	1.248	1.598	1.214	1.639	1.179	1.682	1.144	1.726	1.108	1.771	1.072	1.817
65	1.407	1.467	1.377	1.500	1.346	1.534	1.314	1.568	1.283	1.604	1.251	1.642	1.218	1.680	1.186	1.720	1.153	1.761	1.120	1.802
70	1.429	1.485	1.400	1.514	1.372	1.546	1.343	1.577	1.313	1.611	1.283	1.645	1.253	1.680	1.223	1.716	1.192	1.754	1.162	1.792
75	1.448	1.501	1.422	1.529	1.395	1.557	1.368	1.586	1.340	1.617	1.313	1.649	1.284	1.682	1.256	1.714	1.227	1.748	1.199	1.783
80	1.465	1.514	1.440	1.541	1.416	1.568	1.390	1.595	1.364	1.624	1.338	1.653	1.312	1.683	1.285	1.714	1.259	1.745	1.232	1.777
85	1.481	1.529	1.458	1.553	1.434	1.577	1.411	1.603	1.386	1.630	1.362	1.657	1.337	1.685	1.312	1.714	1.287	1.743	1.262	1.773
90	1.496	1.541	1.474	1.563	1.452	1.587	1.429	1.611	1.406	1.636	1.383	1.661	1.360	1.687	1.336	1.714	1.312	1.741	1.288	1.769
95	1.510	1.552	1.489	1.573	1.468	1.596	1.446	1.618	1.425	1.641	1.403	1.666	1.381	1.690	1.358	1.715	1.336	1.741	1.313	1.767
100	1.522	1.562	1.502	1.582	1.482	1.604	1.461	1.625	1.441	1.647	1.421	1.670	1.400	1.693	1.378	1.717	1.357	1.741	1.335	1.765
150	1.611	1.637	1.598	1.651	1.584	1.665	1.571	1.679	1.557	1.693	1.543	1.708	1.530	1.722	1.515	1.737	1.501	1.752	1.486	1.767
200	1.664	1.684	1.653	1.693	1.643	1.704	1.633	1.715	1.623	1.725	1.613	1.735	1.603	1.746	1.592	1.757	1.582	1.768	1.571	1.779

Table 16: Critical values DW