Universitetet
i Stavanger

UIS BUSINESS SCHOOL

MASTER'S THESIS

STUDY PROGRAM: Master of Science – Business Administration	THESIS IS WRITTEN IN THE FOLLOWING SPECIALIZATION/SUBJECT: Economics of Innovation IS THE ASSIGNMENT CONFIDENTIAL? (**NB**! Use the red form for confidential theses)

TITLE: Dependence of Profitability on Time, Sector & Region across Aquaculture Value Chains in Norway

AUTHOR(S)		SUPERVISOR:
Candidate number: 4015 ………………… …………………	Name: Bakhtawar Khan …………………………………… ……………………………………	Ragnar Tveterås

Table of Contents

Acknowledgements

I would like to take a moment to thank Prof. Ragnar Tveterås for his immense contribution, help and guidance throughout the course of this project.

I have had the privilege to learn a lot from him and have received help and support whenever I requested for his time. I just want to thank him for all his contribution on this research project.

Studying at the UiS Business School has been a great learning experience and every member of the faculty has imparted their valuable knowledge and instruction over the course of the master's program.

I am grateful to the administration and the faculty for all the guidance, instruction, and support throughout the years.

1.0 Introduction

About 71% of earth is covered in water and 96.5% of this water is held by the oceans. (USGS, 2019). However, according to the United Nations Food and Agriculture Organization (FAO) estimates that only about 2% of this production comes from the oceans. (OECD, 2016)

As the global population grows food security is becoming an increasing challenge. The world population is expected to rise from 7.4 billion in 2016 to 8.1 billion in 2025 (OECD, 2016). This means that global food security will present challenges to satiate world population demand for protein.

Marine Harvest states that salmon is the most protein resource efficient biological produce. (Harvest, 2018). Protein resource efficient means how much animal food protein is produced from every unit feed protein fed to the animal. Salmon has a protein retention of 31% which makes it the most sustainable and efficient when compared to other food produce such as pork (18%), poultry (21%) and beef/cattle (15%) (Harvest, 2018). It also has the carbon footprint comparable to chicken. For every 2.9Kg of edible product per Kg CO2, making it far more efficient than pork and beef (Cermaq, 2012).This brings us to the importance of studying aquaculture.

Aquaculture is an important sector in Norway. Norway being the worlds largest producer of farmed salmon with a harvest size of 1.25 million tonnes in 2015 (Tridge, 2019) makes salmon farming not only an attractive investment sector for the government, policy makers and investors but also within and beyond in family owned farms and public corporations that operate in the aquaculture industry in Norway.

While there has been significant amount of research on aquaculture production and the development (Asche, et al., 2013), (Asche, Tveterås, & Roll, Future Trends in Aquaculture: Productivity Growth and Increased Production Chapter 9, 2008) of this industry over time there is little attention paid to studying the impact of the aquaculture value chains in Norway. The aim of this study is to conduct an aquaculture profitability analysis of the Norwegian Aquaculture companies and to understand how profitability depends upon time, sector, and economic regions within Norway.

We believe this type of analysis of determinants of profitability on time, sector and region through econometric testing will allow us to understand which sectors are most profitable as well as which counties in Norway provided the highest returns over the period analyzed. In addition to the above our analysis will present how profitability fluctuates over time. Through this analysis we hope that the reader will get a better understanding of how profitability depended on these three dimensions for the Norwegian aquaculture industry.

This thesis is divided into eight sections. An introduction that defines the problem statement and the main research question we have attempted to investigate followed by a description of the salmon production value chain. To understand how the research question is dependent on time, sector, and region it is important to first understand the salmon industry and the production value chain. Next in section 3 we share the economic measures we used to test against our hypotheses. Part 4 of the report will shed light on the economic models constructed to test the validity against our research question. Followed by section 5 which sheds light on the descriptive analysis of the data set we used, and the methods used to conduct our statistical analysis of firm return on assets and operating margins. In this section we also share analysis regarding the breakup of sectors and answers such as count of firms by county and sector are addressed.

Section 6 presents the results of our regressions and section 7 will deal with an investigation into the within and between variability of firm's economic returns. Within and between variability analysis of firms provides further insights into how profitability is affected across the different aquaculture sectors that make up marine and freshwater aquaculture value chains. Furthermore, section 8 provides conclusions of our analysis and further areas of research to as an extension to this endeavor.

List of Abbreviations

The following table provides the list of abbreviations used throughout the report to denote aquaculture sectors and economic measures used.

Abbreviation	**Full Form**
03.211	Production of fish and shellfish in sea and coastal fish farming in marine and coastal aquaculture
03.212	Production of fry and fry in sea and coastal fish farming
03.213	Services related to sea and coastal fish farming
03.221	Production of fish and shellfish in freshwater fish farming
03.222	Production of fry and fry in freshwater fish farming

03.223	Services related to freshwater fish farming
ROT	Return on Total Assets
OpsMargin	Operating Margin

2.0 The Aquaculture Value Chain

Aquaculture industry is divided into six sectors that represent the value chain of aquaculture from the start to the end product. The end product in aquaculture is the finished product, which is primarily salmon, however, this end product comes through a series of stages of the production cycle. The various stages of the value chain include broodstock (spawn and eggs), smoltification, edible fish, fish processing, trade, export and suppliers of technical services.

When we talk about aquaculture it is also important to distinguish between freshwater aquaculture and seawater or marine aquaculture. Although they belong to the same industry, they our often different in the very nature and the biological environment that affects each of them. The aquaculture value chain in Norway as per by the Directorate of Fisheries has created three sectors that indicate firms operating in marine aquaculture, while the remainder of the three are for freshwater aquaculture producers in Norway. The different sectors within the Norwegian aquaculture industry are described below. For the purposes of our study our econometric analysis of profitability will cover all the following sectors. The descriptions of the Nace Sector Codes taken as per Statistics Norway are below.

03.211 Production of fish and shellfish in sea and coastal fish farming in marine and coastal aquaculture.

Includes commercial production of aquatic organisms in sea or coast, with a view to slaughter for human consumption Includes sea cattle: farming of crustaceans, molluscs and echinoderms in the form of bottom culture without that the animals are held in captivity

03.212 Production of fry and fry in sea and coastal fish farming

Includes production of roe, fry or smolt in sea or coast produced with a view to transfer to other locations and services related to marine and coastal aquaculture

03.213 Services related to sea and coastal fish farming

Processing and preservation of fish, shellfish and molluscs Production of ready-to-feed feed for domestic animals including concentrated feed and feed supplements and unmixed feed for domestic animals. Production of feed materials for livestock. livestock fine-tuning yarns and nets operated as independent activities are grouped under 33.19. Repair of other equipment

03.221 Production of fish and shellfish in freshwater fish farming

Includes freshwater-based fish farming inclusive of freshwater fish farming, freshwater crustaceans, bivalve freshwater molluscs and other freshwater molluscs and freshwater animals

03.222 Production of fry and fry in freshwater fish farming

Includes production of roe, fry or smolt in sea or coastal aquaculture produced with a view to transfer to other locations and services in freshwater aquaculture

03.223 Services affiliated freshwater fish farming

Fish processing of crustaceans, crustaceans and molluscs. Production of ready-to-feed feed for domestic animals including concentrated feed and feed supplements and unmixed feed for domestic animals. Production of feed materials for livestock.

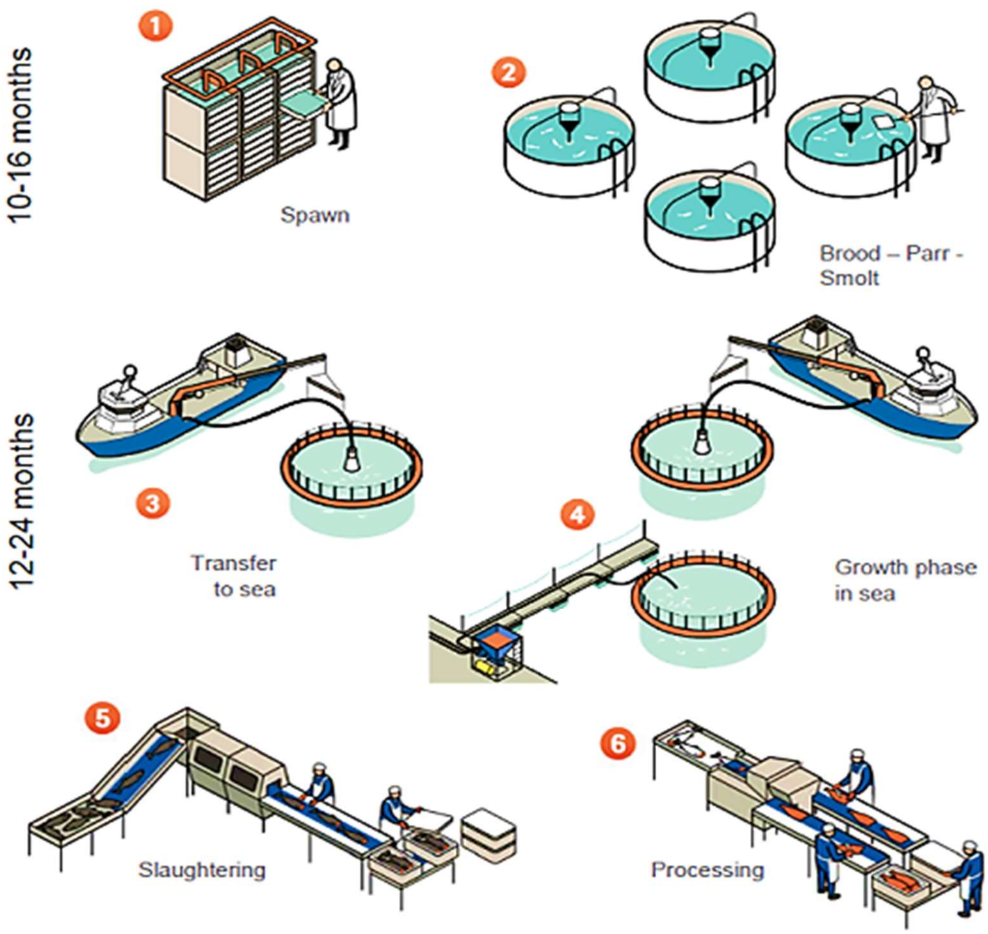
The following table presents the short names that we have used in this report to denote the different sectors:

NACE Code	Long Name	Short Name
03.211	Production of fish and shellfish in sea and coastal fish farming in marine and coastal aquaculture	ProdMarineAkvaKultur
03.212	Production of fry and fry in sea and coastal fish farming	ProdFryHatchryMarineAkvaKultur
03.213	Services related to sea and coastal fish farming	SrvcsMarineAkvaKultur
03.221	Production of fish and shellfish in freshwater fish farming	FreshWaterAkvaKultur
03.222	Production of fry and fry in freshwater fish farming	ProdFryHatchFrshWtrAkvaKultur
03.223	Services affiliated freshwater fish farming	SrvcFreshWaterAkvaKultur

2.1 Farmed Atlantic Salmon Production Value Chain

The aquaculture value chain has several stages. To understand the reason for our econometric analysis it will be beneficial for the reader to get an overview of the various stages of the aquaculture business cycle. The following diagram depicts the aquaculture value chains for Atlantic salmon production cycle. The NACE sector codes explained above related directly form stages of the production cycle.

Figure 1: Atlantic Salmon Production Value Chain



Source: The Atlantic Salmon Life/Production cycle. "Salmon Farming Industry Handbook 2016, Marine Harvest

As depicted above in the diagram, the initial phase is that of the broodstock where the eggs are stripped from the female species fertilized and then transported to a hatchery. This hatchery is stage 1 of the process in the diagram above. This is the most delicate part of the value chain. This stage can be related to the likes of an incubation phase. It takes approx. a period between one to two months in which the larvae are hatched from the eggs. This yolk sack larvae are called fry. Fry feed on the yolk for the first few weeks after which they are put on a starter diet when they are about a month old. This is the most delicate stage of the entire life cycle process. In Norway, significant technological improvements have created a very successful survival rate of more than 70%, whereas the rest of the world averages with a survival rate of less than 0.5% (Bjørndal, 2011).

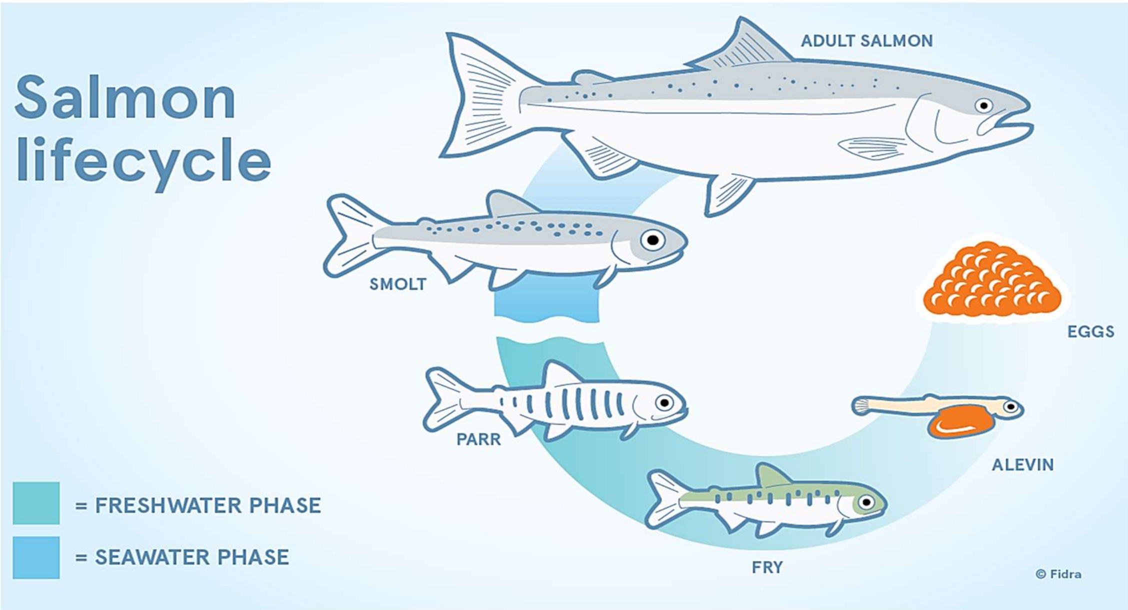
At stage 2 the fingerlings are transferred to freshwater ponds that are created at salmon farms for the smoltification process to take place. Smoltification process is the stage of the production cycle where fish is grown in freshwater tanks where it slowly matures to adapt to saltwater conditions. The smoltification process in Atlantic salmon takes around 16 months from the time they are hatched. At the end of the smoltification period the Atlantic salmon weights about 70-140g. At this stage, the smolt are ready to be transported to saltwater grow out ponds along the Norwegian coastline in designated licensed areas provided to fish farmers by the Norwegian Fisheries Directorate. These first two stages of the production process correspond to NACE code 03.212 and 03.222, the production of fry in sea water and fresh water.

The grow out phase or stage 3 takes a period of 12 to 18 months after which the salmon weigh anywhere between 2 to 8kg (Bjørndal, 2011). The reported variation in weight varies from one source to other. Other sources such as (Young, 2017) report that this weight can be anywhere between 4 to 5 kilos. Stage 3&4 in Figure:1 correspond to 03.211 and 03.221 known as the production of fish and shellfish in sea and fresh water aquaculture.

After the grow out phase the Salmon are transported to processing center's where they are cleaned and slaughtered and finally packaged and distributed to food retailers. These last two stages of the production cycle pertain to the services sectors within aquaculture. Services sectors in both fresh and sea water fish species pertain to NACE codes 03.213 and 03.223 and named as Services related to coastal or marine, and/or freshwater aquaculture sectors.

Furthermore, the following Fig1.1 is a visual depiction of the Salmon life cycle and its physical attributes at the stages described in Fig1.

Figure 1.1

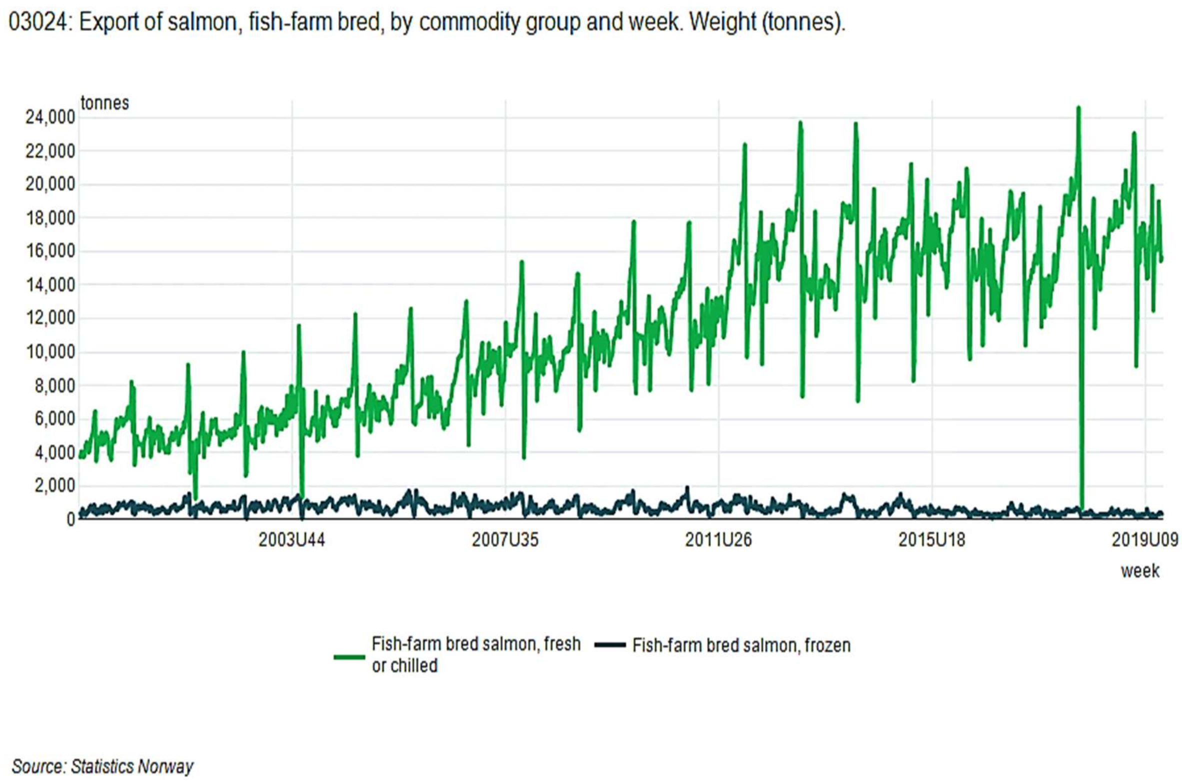


Source: www.bestfishes.org.uk

Salmon Farming has been a fast and steady growing industry in Norway. What makes this such a fast-growing industry is dependent on its profitability. Profitability is one of the most important factors that drives capital and investments into the industry. Investor confidence increases when the companies they invest in give healthy Returns on Investment (ROI). Therefore, in the primary focus of our research has been to investigate the profitability across the Aquaculture value chain. As explained above based on the NACE sector definitions extracted from the Fisheries Directorate, we further investigate how the profitability of each firm is affected based on panel data regression of financial data collected over a period from FY2007 till FY2017.

2.2 Salmon Price Development and Production Growth in Norway

Figure 2.1



The graph above is a consolidated picture of the growth in the exports of Salmon over time in Norway. The period captured covers weekly export sales data by weightage (tonnes) from FY00 until week 24 in FY19. Therefore, this is the most current and updated data available to substantiate the evidence that salmon exports and production has seen an upward trend.

The data shows week 1, FY00, total export amount by commodity. There are two commodities in the exports of salmon, fresh or chilled and frozen categories are available. The demand and production of fresh or chilled category however far outweighs the demand and therefore the corresponding supply of the other. Combining both commodities, the total exports in week 1 of FY00 amounted to 4111 tons whereas at the close of week 24, FY19 the total export stands at 15962 tons. The production peaked in week 50, FY17 and reached 25167 tons.

Figure 2.2

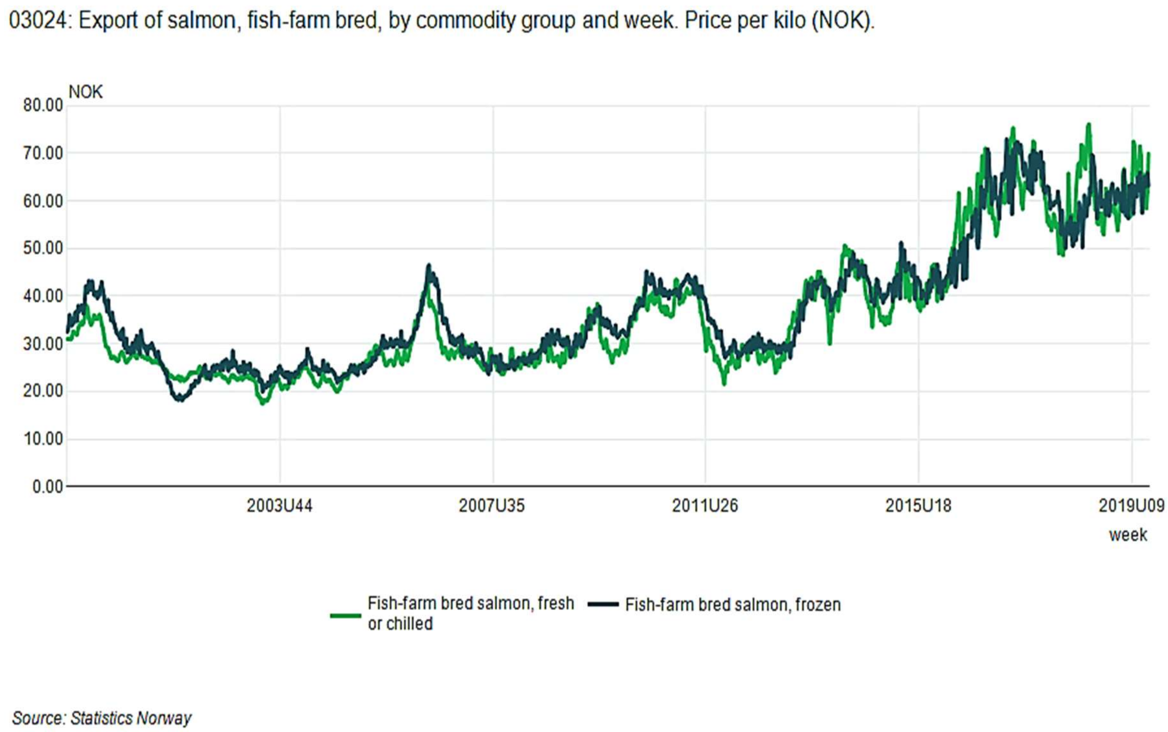


Fig 2.2 above shows the corresponding price movements of both fresh or chilled and frozen salmon products over the same period shown in Figure 2.1. Figure 2.2 shows a general upward trend of the price of salmon in NOK per kilo. Fresh or frozen commodity peaked in FY17 week 03 when it reached NOK76.09 per Kg and the frozen category peaked in FY16 week 47 when it reached NOK72.91 per Kg. At T=0 which is week 1, FY00 the price for fresh and frozen salmon export was NOK30.98 and NOK 32.54 respectively, however at the close of week 24, FY19 the price has reached NOK69.90 and NOK63.21 per kilo for fresh and frozen categories.

Another interesting fact we find from the production and price development graphs is a measure of the increase in production versus the increase in price. From the starting point in FY00 until week 24 in FY19 we noticed that the price of Salmon had increased by 125% in nominal terms for fresh salmon category while the production had increased by 288.2%. This indicates a reduction in the costs of production. The decrease in the cost of production can be attributed to the productivity growth in this industry over time as the salmon industry has witnessed a high degree of technological innovation since the 1980's (Andersen, 2008).

Figure 2.3

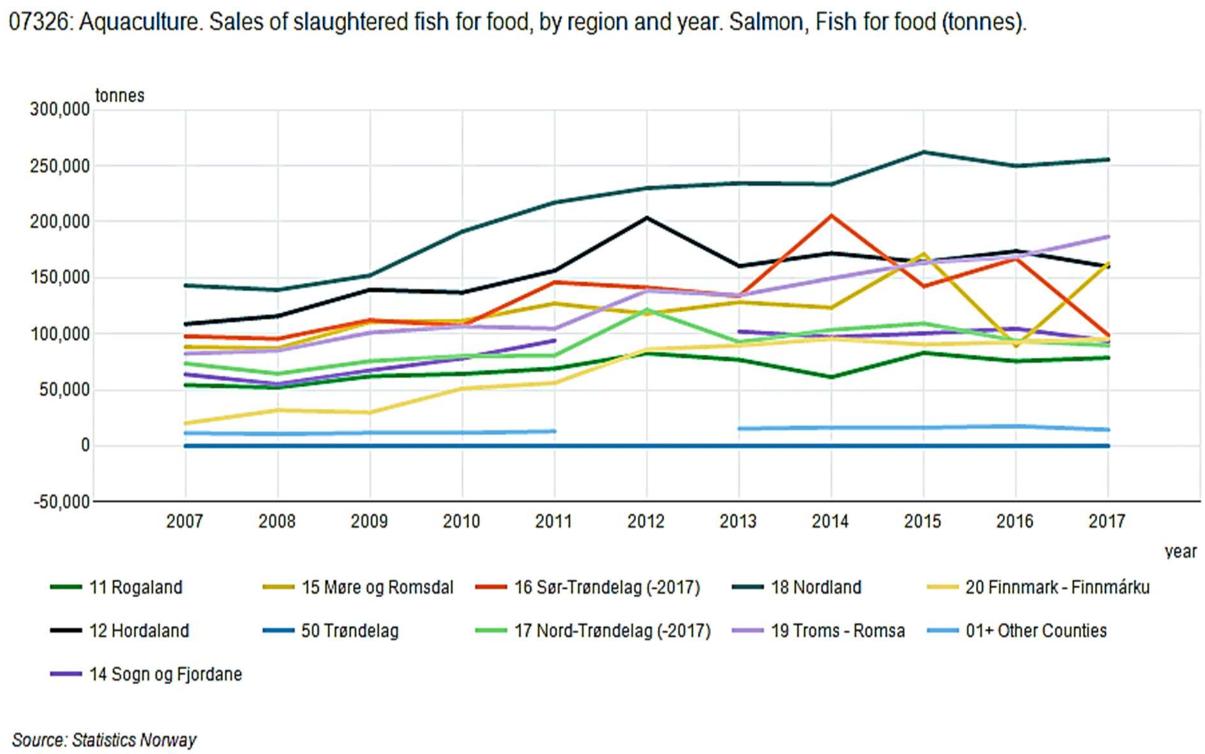


Figure 2.3 is graph of the production amounts in tonnes for the counties. Except for Trøndelag and 01+ Other Counties[1] all other counties show an upward trend in the production numbers over the ten-year period of our econometric panel data set. The leader in salmon production was Nordland with 250,000 tonnes in sales of slaughtered salmon for food followed by Troms – Roms and Hordaland.

Earlier literature indicates marked upsurge in productivity growth (Andersen, 2008) and downstream innovations such as improvement in logistics and transportation networks. We note from (Roll, Tveterås, & Asche, 2007) that improvements in the supply chain is equally important as productivity growth for the increased competitiveness aquaculture has experienced in Norway.

[1] As per Statistics Norway counties with low aggregate numbers were clubbed together prior to 2018

Figure 2.4

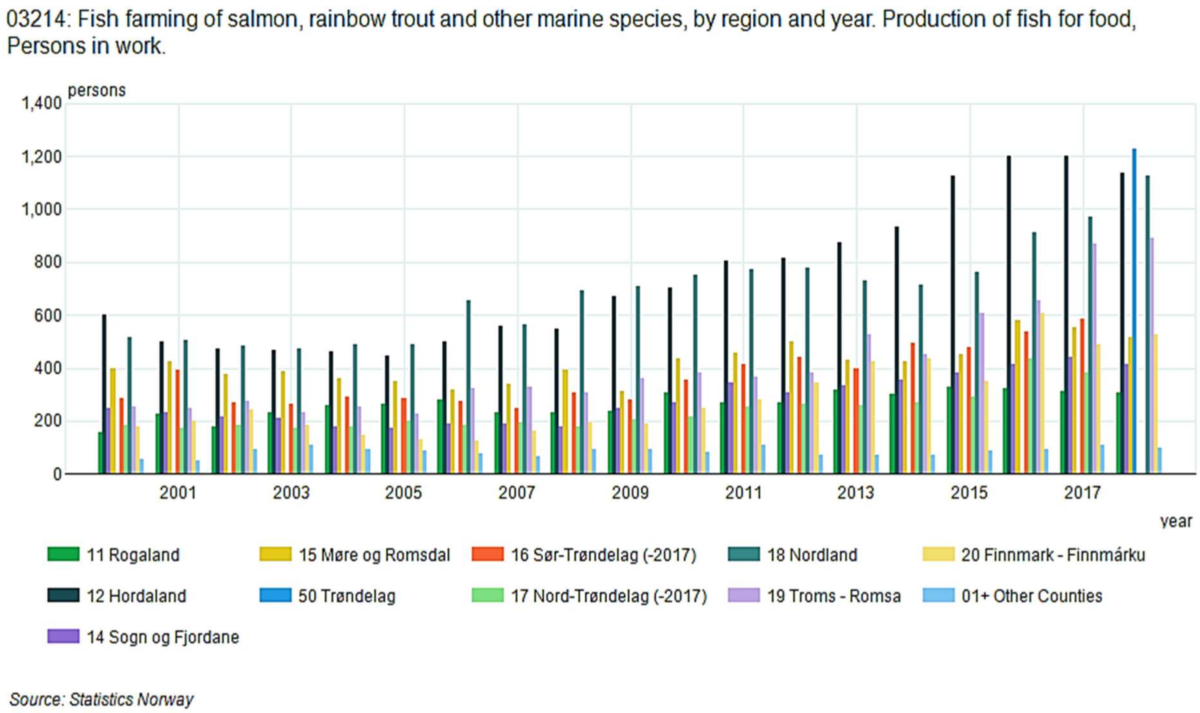
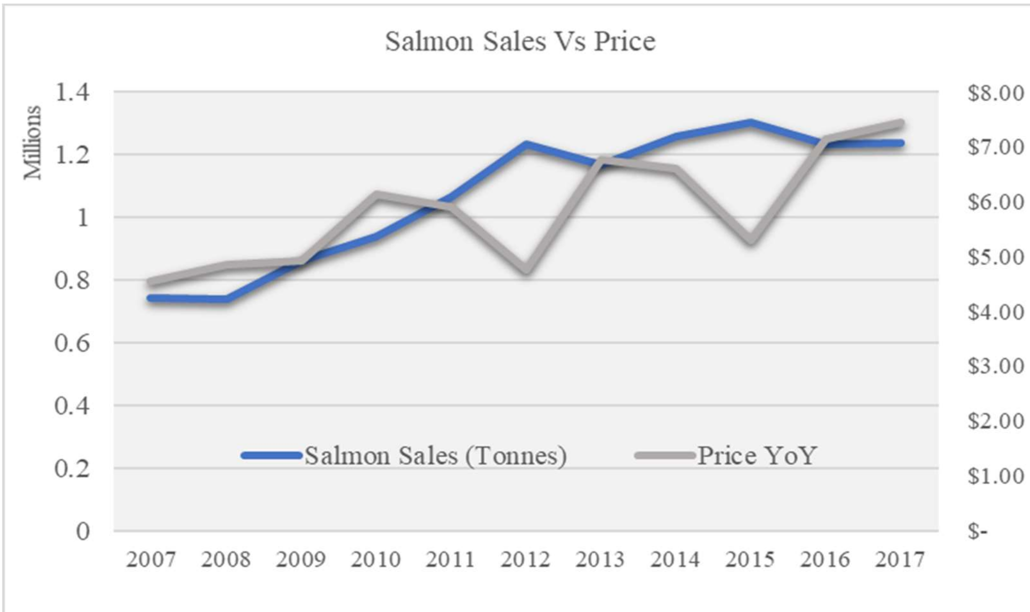


Figure 2.4 shows the number of people employed through aquaculture by county from FY00 till FY18. Although we do see an upward trend in the number of persons employed the upward trend is not as high as we find in production rates which indicates to productivity increases (Asche, et al., 2013)

2.3 Production and Price movements between FY07 to FY17

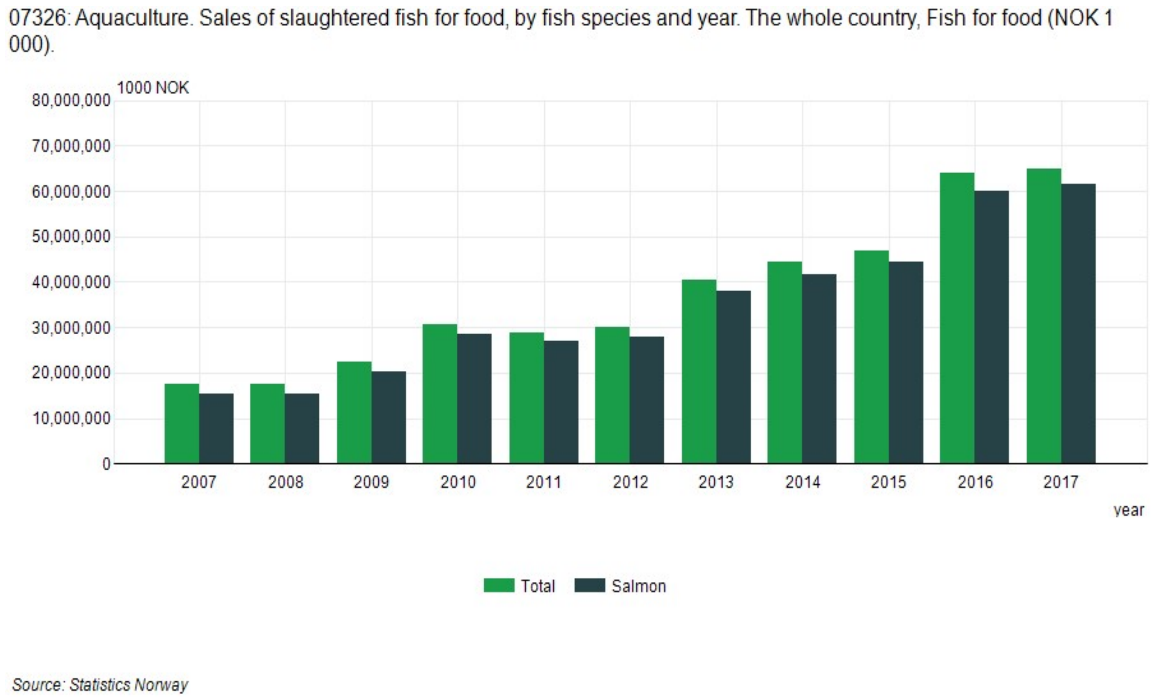
Figure 2.5



Source: Statistics Norway & YCharts.com

When we analyze the period that coincides with our panel data set, we find continued growth patterns in the industry indicating that there is still room for growth. The figure above shows salmon production in millions of tonnes in Norway from FY07 till FY17 plotted on the primary axis versus the average yearly price of Norwegian salmon in world markets given in US$/Kg. The graph indicates that although production has consistently increased over the ten-year period there have been significant fluctuations in the price of Norwegian salmon. This indicates higher within variability in profitability in aquaculture firms as a higher within variability is directly affected by the price of salmon which fluctuates based on demand and supply dynamics. In turn, the supply is affected due to biological hazards that affects this industry such as salmon lice that can damage the harvest. A most recent example is loss of approx. 11,600 tonnes of farmed salmon that died because of the algae bloom north of Nordland and in the south Tromsø. As per the Fiskedirektoratet it is estimated that approximately 720 Million NOK in forgone sales of produced salmon has been lost ((Aase, 2019).

Figure 2.6



Source: Statistics Norway

While other species are also farmed, salmon remains the top product. Figure 2.5 above indicates total sales of salmon versus the total sales of all species of fish in aquaculture produced in Norway between FY07-FY17. This figure represents the heavy weightage of salmon sales out of all other species farmed in aquaculture for food production. Over the ten-year period salmon sales have heavily dominated the aquaculture sector forming on average 92% of total aquaculture sales between FY07 to FY17. This brings us back to the important discussion of salmon farming for food security as we earlier quoted the FAO report on food security.

3.0 Measures of Economic Returns

We use two financial ratios to measure farm economic returns (Schechter, 2017). These financial ratios are both important indicators of management efficiency, business risk and profitability. The following two formulas used to calculate the dependent variables are as follows:

1. $Return\ on\ Total\ Assets\ (\%) = \frac{Net\ Income}{Total\ Assets} X\ 100$
2. $Operating\ Margin\ (\%) = \frac{Operating\ Income}{Sales\ Revenue}\ X\ 100$

ROT (Return on Total Assets) is a good measure of firm profitability relative to its assets. We chose to use return on total assets instead of farm net income or return on equity because return on equity ratios do not consider the farm's debt capital. We note in (Flaten, Tveterås, & Gudbrand, 2011) that financial investments in fish farms our noted in total assets. Therefore, return on total assets poses to be a good measure to determine business risk and management of the farm and total return on investment.

Operating Margin on the other hand is an effective measure of business risk. Operating margin indicates the return on sales and is widely used in financial analysis of companies to determine management effectiveness and business risks. Operating margin is often denoted as EBIT (earnings before interest and taxes). The reason why this is a good choice for measuring firm profitability is because it takes into account farm's COGS (Cost of Goods Sold), which is the direct cost of the entire production value chain beginning from hatchery, smoltification to grow out phase and production of farmed Salmon. Furthermore, it also accounts for the firm sales revenue as well as the production capacity of a farm. Let us take a closer look as to how this is the case.

The formula for Sales Revenue is as follows:

$$Sales\ Revenue = Price\ of\ Farmed\ Atlantic\ Salmon\ X\ Quantity\ of\ Farmed\ Atlantic\ Salmon\ sold$$

It is clear from the equation that price fluctuations will affect farm sales revenue due to changes to the price of Atlantic Salmon in the world markets. Quantity on the other hand is related to farm size.

For the purposes of this paper we will not delve into the determinants of farm size on profitability since that requires an entirely distinct set of variables and analysis. However, for the purpose of using our economic measures it is useful to understand how sales revenue is an important part of the Operating Margin ratio that we have used in our analysis.

In short, our two economic measures account for Total Assets, Total Debt, Sales Revenue, Price of Atlantic Farmed Salmon, Cost of Goods Sold, Labor Salaries, Ordinary Depreciation, Changes in Inventories, and other operating expenses. Furthermore, to support our analysis we find evidence in (Engle, 2012) that pertaining to the nature of aquaculture business return on assets and operating margin are effective measures of profitability that take into account expenses related to farm expenses incurred through fish feed, labor both full time and part time, fuel, gas, oil and electricity charges, repairs, maintenance and depreciation.

Lastly, there are also limitations to using Operating Margin and Return on Total Assets. These limitations, however, pertain to the use of these ratios for comparisons in companies across the same industry. If we were to compare these ratios with another industry, then these measures would not be effective. The reason for that is every business/industry is different in nature. Every industry has a distinct set of expenses that affect it. These measures specially Operating Margin considers business related expenses as well as COGS, thus it would not be appropriate to compare expenses the same way in two different industries.

4.0 Econometric Model Specification

Our analysis determines the significance of Time, Sector and Regions on firm profitability in the aquaculture value chain in Norway. Therefore, to test our research question, we developed five economic models. We have chosen to disperse econometric testing for Time, Sector, and Region for the two economic measures mentioned above separately.

We conducted separate tests for several reasons. Firstly, testing Sector and Region in one model presented issues with perfect collinearity. (Kopalle & Mela, 2002) states that collinearity can reduce parameter variance estimates and creates asymmetric variable omission bias. This means that positive correlation can result in less precise estimates and can induce parameters to switch signs and impact the model R-squared value.

In addition to this, we also noticed that STATA automatically omits variables when they are in collinearity with another variable since it disturbs the robustness of the model. Since we expected Sector and Region dummies to have dependency, we regressed each set of dummy variables separately. We also added two further models where we interacted Time and Sector as well as Time and Region.

We used a noconstant model using analytic weights function in STATA. A noconstant model is used when possibilities of collinearity exist amongst independent variables (Schechter, 2017), a case that is similar to our research question. Furthermore, we also used Analytic Weights function denoted by *aweight* in our econometric models to allow greater accuracy to our data set (Dupraz, 2013).

Since our dataset has a large variation of firms both small and large from owner operator level to large corporations when analyzing statistical dependence, the analytic weights option takes each observation as a group mean. This gives us a more accurate picture because some smaller firms that have negative returns do not get a greater weightage in the computation of our regression analysis.

Altogether we ran ten regressions, five for each of our economic measures discussed earlier i.e. Return on Total Assets (ROT) and Operating Margin (OpsMargin) as follows:

1. Time

2. Sector
3. Region
4. Time & Region
5. Time & Sector

The following presents the two general models tested for Hypotheses:

1. $ROT = \beta 1d2007 + \beta 2d2008 + \beta 3d2009 + \beta 4d2010 + \beta 5d2011 + \beta 6d2012 + \beta 7d2013 + \beta 8d2014 + \beta 9d2015 + \beta 10d2016 + \beta 10d2017 + \gamma 1dProdMarineAkvaKultur + \gamma 2dProdFryHatchryMarineAkvaKultur + \gamma 3dSrvcsMarineAkvaKultur + \gamma 4dFreshWaterAkvaKultur + \gamma 5dProdFryHatchFrshWtrAkvaKultur + \gamma 6dSvcsFreshWaterAkvaKultur + \delta 1dRogaland + \delta 2dAkershus + \delta 3dHordaland + \delta 4dBuskerud + \delta 5dNordland + \delta 6dFinnmark + \delta 7dTrøndelag + \delta 8dHedmark + \delta 9dMøreRomsdal + \delta 10dOppland + \delta 11dOslo + \delta 12dØstfold + \delta 13dSognFjordane + \delta 14dTelemark + \delta 15dTroms + \delta 16dVestAgder + \delta 17dVestfold + \delta 18dAustAgder, [aweight = w\_TotalAssets], noconstant$
2. $Operating\ Margin = \beta 1d2007 + \beta 2d2008 + \beta 3d2009 + \beta 4d2010 + \beta 5d2011 + \beta 6d2012 + \beta 7d2013 + \beta 8d2014 + \beta 9d2015 + \beta 10d2016 + \beta 10d2017 + \gamma 1dProdMarineAkvaKultur + \gamma 2dProdFryHatchryMarineAkvaKultur + \gamma 3dSrvcsMarineAkvaKultur + \gamma 4dFreshWaterAkvaKultur + \gamma 5dProdFryHatchFrshWtrAkvaKultur + \gamma 6dSvcsFreshWaterAkvaKultur + \delta 1dRogaland + \delta 2dAkershus + \delta 3dHordaland + \delta 4dBuskerud + \delta 5dNordland + \delta 6dFinnmark + \delta 7dTrøndelag + \delta 8dHedmark + \delta 9dMøreRomsdal + \delta 10dOppland + \delta 11dOslo + \delta 12dØstfold + \delta 13dSognFjordane + \delta 14dTelemark + \delta 15dTroms + \delta 16dVestAgder + \delta 17dVestfold + \delta 18dAustAgder, [aweight = w\_TotalOperatingRevenue], noconstant$

The two models represent the entire hypothesis to be tested for the economic measures, however, for the purposes of robustness of results and perfect collinearity issues between independent variables we separately ran five different regressions for each economic measure. This means that our first model included only time dummy regressions for ROT and OpsMargin while we removed all other dummy variables from the regression.

Similarly, we conducted a test for sector dummies removing both time and region variables from the model and vice versa for the region dummies. In addition to this we also added two additional tests for each of the economic measures on Time & Sector and Time & Region dummies. The results of the regression are reported in Section 6. Regression results for the unweighted models are presented in the appendices as they are not part of our discussion.

5.0 Descriptive Analysis of Data Set and Firms

The dataset we used for our econometric testing is financial statement data for all firms operating within the Aquaculture under six specified NACE sector codes described earlier in this paper. These NACE sector code data for 03.211, 03.212, 03.213, 03.221, 03.222, 03.223. We converted this data into a panel data set to conduct quantitative testing. Our dataset covers financial statement data of a total of 1396 firms in Norway from 2007 till 2017, that are operating the six NACE sectors mentioned above. These sectors cover the Aquaculture value chain for both marine and freshwater aquaculture.

After the conversion of the panel data set, we had a total of 15356 observations. The financial data columns were converted to numeric variables since statistical testing otherwise would not be possible in STATA.

Our profitability analysis focuses on testing profitability coefficients across Norwegian aquaculture firms based on Time, Sector and Region. Aquaculture and agriculture are similar businesses in nature due since both are biological in nature and both are characterized by long production cycles (Flaten, Tveterås, & Gudbrand, 2011). Due to this proximity of the nature of these two industries the risks associated in the two industries are also related.

Risks related to natural calamities, production risks, pest attacks, crop/fish diseases are a common likelihood for both businesses. Furthermore, since these are both biological businesses in their essence, they both variate in yield affecting through geography in which they located. Climate plays a key role in both these industries as well as the price of end product. Aquaculture is affected directly due to the price of Atlantic Salmon in the markets. Price variability therefore affects profitability as it directly drives a firms Sales Revenue.

Hence, for our econometric analysis to have some meaning and sufficiency we must consider three factors when determining the profitability of Aquaculture in Norway. These three facets are profitability variability and dependence on 1) Time, 2) Sector 3) Geographic Location. Variation in profitability across sectors is important because the value drivers in each sector of Aquaculture are different and therefore different value drivers drive factors and stages of the production cycle. Spatial diversification is another important reason for having Regional or Geographic Location variable. Since fish farming like agriculture has an outdoor grow out phase component the growth of Salmon is affected by water temperature, oxygen scarcity in the water, Salmon lice susceptibility are all important factors that directly affect production cycle from region to region in Norway (Thyholdt, 2012). These differences make it important to study the effects of regional differences on firm profitability.

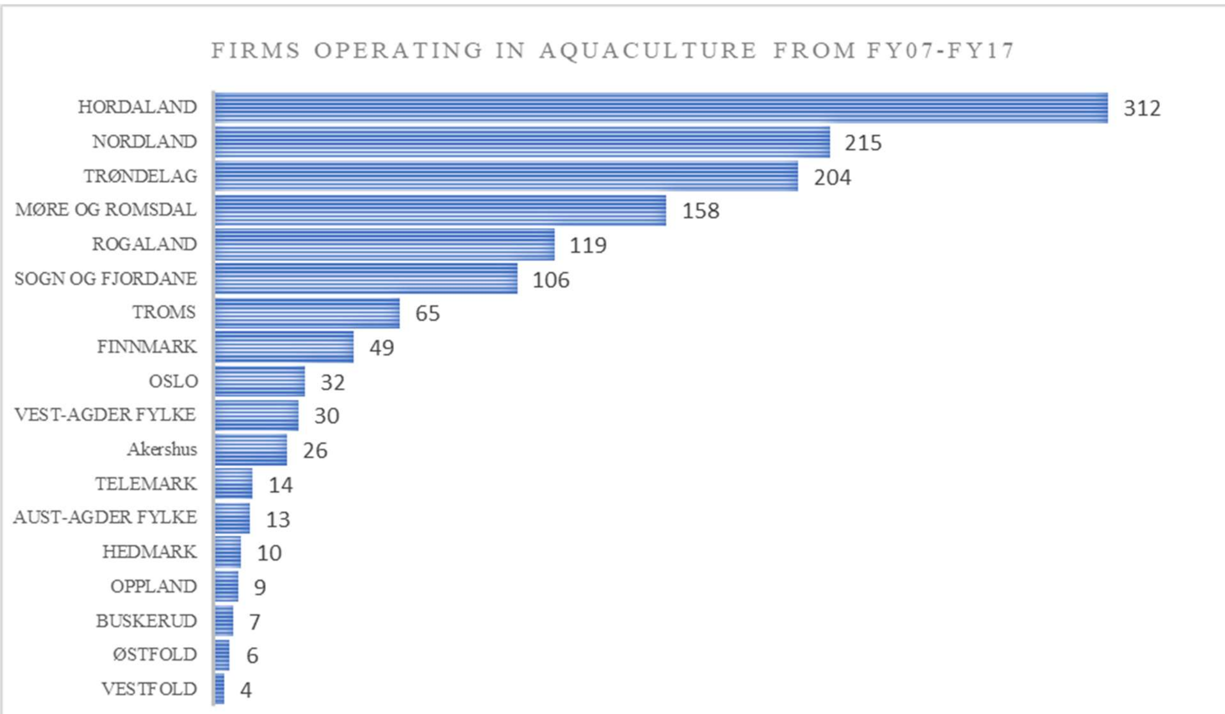
We use an ordinary least square regressions on farm level panel data from 2007 to 2017. We use a no constant coefficient model as follows to capture the three specific effects of time, sector, and region. Our analysis includes two sets of equations testing the dependence of 1) Return on Total Assets on Time, Sector and Region dummies and 2) Operating Margin on the Time, Sector and Region dummies. The model we used is a no constant regression model. No constant regression models are better suited when there is likelihood of collinearity between independent variables. Since the nature of our Time, Sector and Region dummies pose similarities in terms of the nature of each of the category dummies we were constantly getting results with perfect collinearity issues. Therefore, we have used a no constant regression model to conduct our Hypotheses because it yields higher T-statistics and significant p-values.

Altogether to conduct this analysis we created dummy variables from FY 2007 till 2017 and all six NACE sector dummies in addition to the 18 regional dummies. In total 34 dummy variables. The empirical results of our econometric tests our presented and discussed in section 6 of this report.

5.1 Distribution of firms across sectors and regions

We had a total of 1397 firms associated within the six NACE sectors. In this section we will present an analysis of the breakdown of the firms operating in various sectors and regions within Norway.

Figure 5.1



The breakdown from the table sheds light on how the Aquaculture industry is distributed across the six sectors in the aquaculture industry. As is evident the highest number of firms are in 03.211 (Production of fish and shellfish in sea and coastal fish farming in marine and coastal aquaculture) operated in Hordaland followed by Nordland and Trøndelag.

Figure 5.2

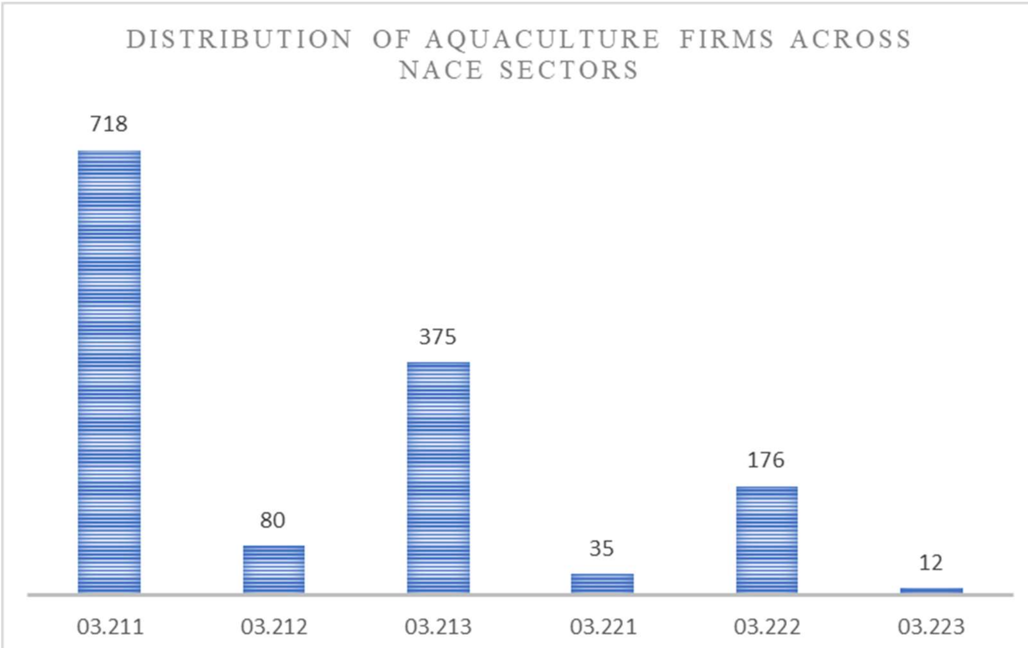


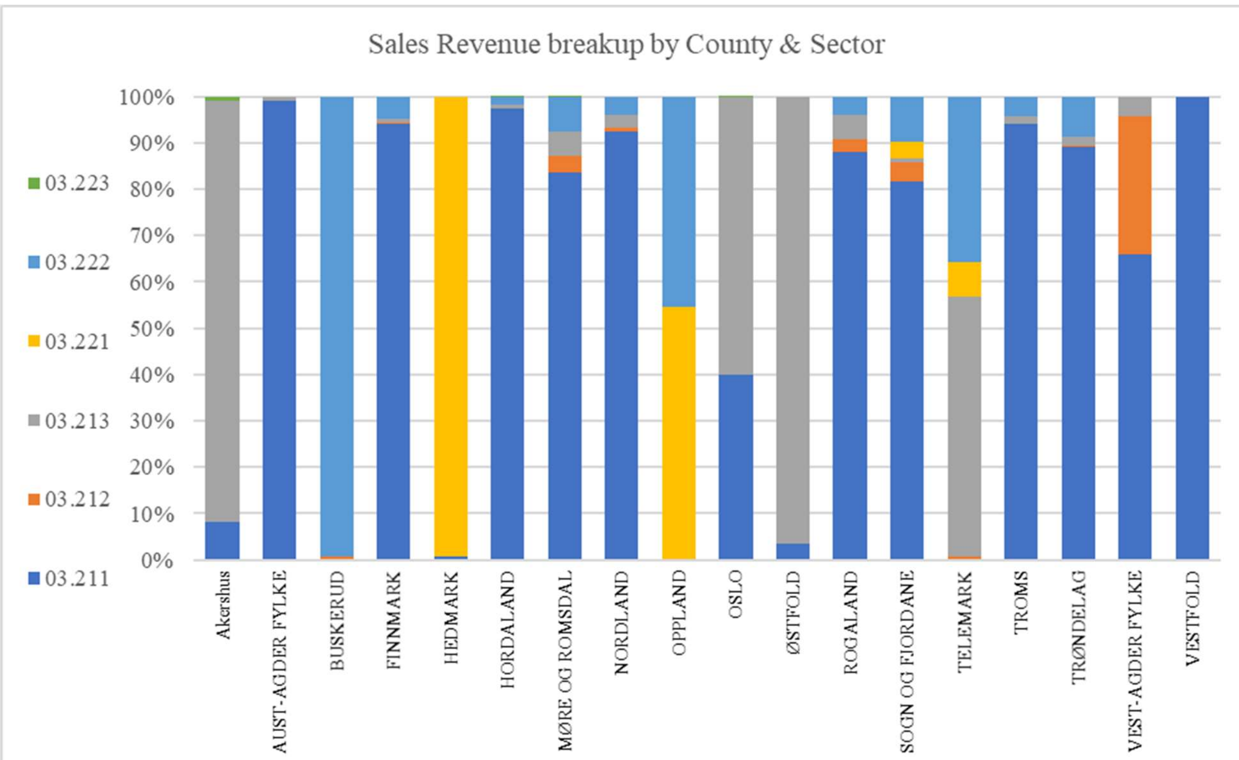
Fig 5.2 indicates that the aquaculture industry in Norway is skewed towards sector 03.211. This is the sector associated with the production of salmon in Norway and is associated with marine aquaculture. As it is evident this is the most populated sector in terms of firms located within this sector and the subsequent 03.213 (Services related to sea and coastal fish farming).

Fresh Water Aquaculture though a relatively new sector does hold some promise. However, the technology constraints for this sector requires further investment (E&Y Norway, 2018).

5.2 Sales Revenue by County by Sector

The graph below is breakdown in percentage of the proportion of Sales Revenue for each NACE sector across each of the economic regions in Norway. The graph below indicates the proportion of sales revenue that is generated in each region pertaining to a specific sector[2]. As is evident from this breakup we can see that Aust-Agder, Finnmark, Hordaland, Møre og Romsdal, Nordland, Rogaland, Sogn og Fjordane, Troms, Trøndelag and Vestfold have the highest in total of sales revenue that is generated from activities classified as 03.211, which corresponds to production of marine and coastal aquaculture.

Figure 5.3



Fresh Water aquaculture is another sector that has recently developed and has seen investment into the development of this sector. However, this sector still needs further development as indicated in Fig 5.2 that the number of firms operating in this sector are only 35 and located in

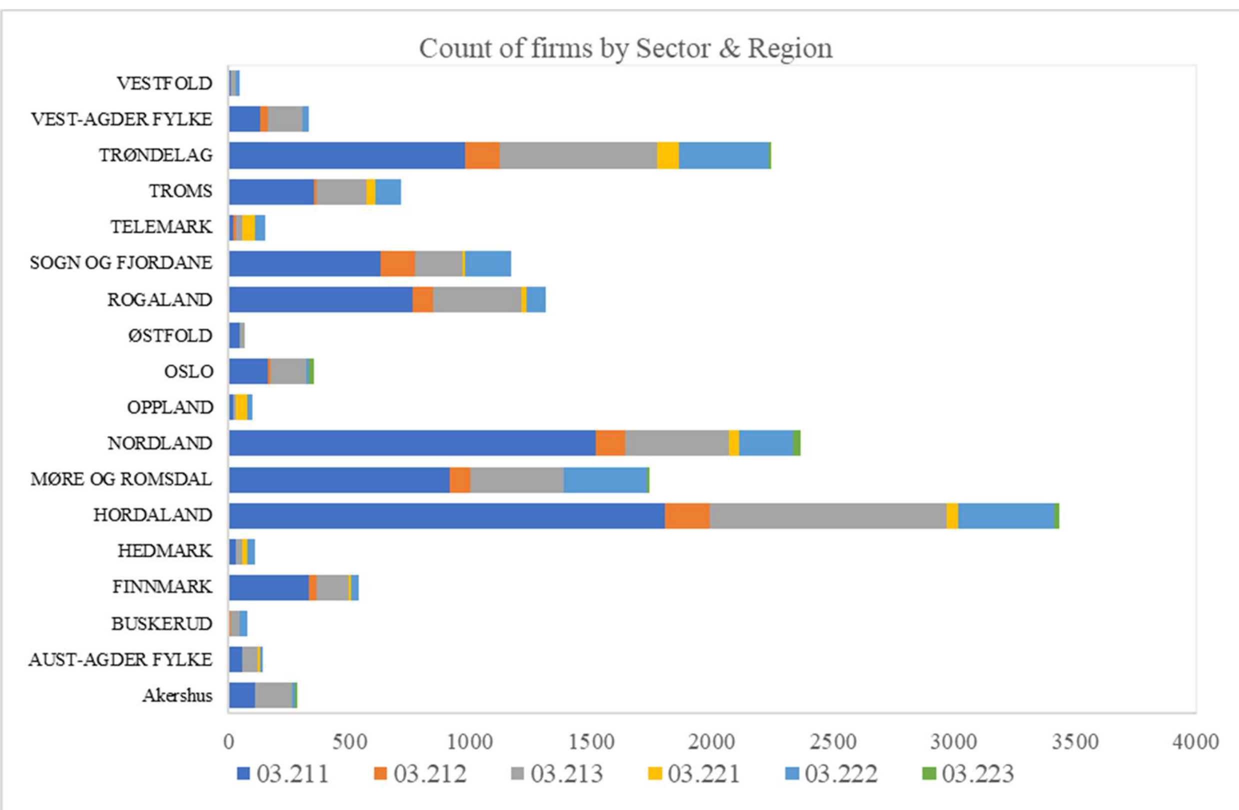
[2] The graph does not show revenue since it is meant to show the dispersion of activity by sector in each region

only two counties Hedmark and Oppland however, we note that industry analysts are looking to this sector as a future possibility for diversification.

Figure 5.4 shows the count of firms operating within each sector further segregated at the county level. Again, it is evident that Hordaland has the highest number of firms operating in 03.211 (Production of fish in sea water). It is also noticeable that proximity to grow out pens or open net fish farms for salmon production along the coast create growth in other sectors such as 03.212 (Production of Fry and Hatchery) which is related to the brood stock and smoltification stage in the salmon production life cycle.

A concentration of 03.213 services related to stage 5 & 6 in *Fig 1. Atlantic Salmon Production Value Chain* can also be found when looking at the figure below. This makes logical sense as proximity to grow out net-pen fish farms require slaughtering and processing services which includes salmon lice treatments which makes up the supply side of the industry.

Figure 5.4



5.3 Distribution of Economic Returns Across Regions

Analysis of our panel data set indicates FY16 to be the best year over the ten-year period. The mean ROT and Ops Margin observed for a firm operating within 03.211, the production of salmon and other saltwater fish species experienced a growth of 27.3% followed by FY17 with growth rate of 23.8%. The results also indicate all positive mean values indicating positive growth rates in this sector. In freshwater aquaculture (03.221) we can also observe positive returns with FY13,14 and 16 being the best years over the period. The results indicate a minimum of 5.6% and 6.1% in returns in seawater and freshwater production sectors, respectively.

Similarly, our data shows positive growth in operating margins with margins as high as 33.6% and 30.8% in FY16 and 17 for seawater species. Positive margins were also observed in freshwater species with as high as 29.2% and 29.4% in FY13 and 14, respectively. We again notice that services sectors associated with sea and freshwater species indicate some years with negative growth. However, there are more occurrences of negative growth in services related to freshwater versus seawater production. We can attribute lower returns in freshwater services to the small number of firms operating in this sector and the high costs associated with a less developed supply chain. (Andersen, 2008).

Freshwater aquaculture is an upcoming industry and it is at its beginning stages. Substantial technological innovation and development of supply networks would be required before these positive growth rates can be observed in this area. From Fig 5.2 we find that there are only 12 firms operating within this sector and altogether only 35 firms operating in freshwater production sectors (03.221). In (Tveterås & Bettese, 2006) we learn that agglomeration externalities positively effect on the production possibility frontier and the technical inefficiency of firms. The study further finds that localized knowledge spillovers and substitution of internal inputs and the execution of production tasks causes fewer errors in the decision-making process thereby making firms more technically efficient in terms of production. We believe that the small number of firms operating within freshwater aquaculture is the cause of negative returns.

Furthermore, we discover congruence with our analysis of small number of firms correlates to a greater likelihood of generating lower or negative growth rates. We find yet another similarity by looking at the mean ROT and OpsMargin by sector and county.

Firstly, we noticed that Akershus, Oslo and Østfold show negative mean returns. This points us to the same argument above i.e. related to agglomeration externalities and knowledge spillovers. This is also substantiated by revisiting Fig 5.4 which shows the number of firms located by sector in each county. These three counties all have small number of firms operating within the area. It is also evident from Fig 5.3 that they have reliance on the services industry for seawater aquaculture.

Lastly, although it seems from Fig5.7 and 5.8 that Vestfold has the highest return on capital but it is important to view these results in their entirety otherwise the interpretations can be misleading because if one looks at the mean returns by county for seawater aquaculture one would think that Vestfold has the highest return on assets. However, this number is misleading if analyzed by its own because this mean return is generated from a few firms. For a macro level study such as this endeavor, we must also look at the number of firms operating within the county and sector and then assess the mean returns. If a larger set of firms generate a healthier mean return, then that would be a more conclusive evidence for profitability for the region.

The next section of this report will shed light on the results of our econometric regressions.

Figure 5.5 Mean ROT by Year and Sector (Weighted)

	NACE-bransjekode					
Year	3.211	3.212	3.213	3.221	3.222	3.223
2007	.0871781	-.0023658	.0765797	.1093817	.1441962	-.1666667
2008	.0564222	-.1025387	-.0028644	.1701673	.086742	-.0903029
2009	.1409886	-.1085973	-.0073923	.0615747	.0529806	-.0383655
2010	.2248982	.0371996	.0198249	.1284252	.0850184	-.0164703
2011	.1183849	-.0218897	.010982	.0687718	.1001686	-.0440419
2012	.0398439	-.0219406	-.0165173	.0690242	.0792243	-.0353541
2013	.1832709	.0088829	.028114	.2912033	.0600089	-.0006796
2014	.1727363	.1151747	.0902084	.2666087	.0780301	.0019164
2015	.1557156	.0841855	.1013828	.1009667	.0482554	-.0056567
2016	.2738704	.0512014	.1230963	.2513774	.0719962	.02175
2017	.2388735	.0470769	.1086594	.1010821	.053917	-.1153736

Figure 5.6 Mean OpsMargin by Year and Sector (Weighted)

	NACE-bransjekode					
Year	3.211	3.212	3.213	3.221	3.222	3.223
2007	.1303383	-.0072666	.093754	.0905006	.2353066	-.0493827
2008	.0891149	-1.324134	.0020943	.1587842	.1396149	-1.287905
2009	.1870985	-.3786418	-.0062632	.0595087	.1059818	-2.211699
2010	.2889973	.1195736	.0253012	.1063326	.1523777	
2011	.1718217	-.049896	.0175628	.05624	.1829958	-4.201745
2012	.0619878	-.0663497	-.0216657	.0593556	.1534417	-.2260324
2013	.2512558	.0303032	.0368865	.2923382	.1173575	-.0562802
2014	.2374207	.2184722	.1084213	.2940226	.1539022	.1149425
2015	.195584	.1692685	.1443141	.1000555	.1021497	-22
2016	.3363184	.1722186	.1784345	.2412173	.1587167	.3369684
2017	.3088183	.1728933	.1694019	.0950386	.1258299	.0106762

Figure 5.7 Mean ROT by Region and Sector (Weighted)

	NACE-bransjekode					
Fylke	3.211	3.212	3.213	3.221	3.222	3.223
AUST-AGDER FYLKE	.0790862		.3146402			
Akershus	-.0421478		-.0199966			-.5413156
BUSKERUD		.0799568			.047008	
FINNMARK	.1483263	-.0868693	.1780142		.0089912	
HEDMARK	-.0887859			.0383941		
HORDALAND	.1688547	.0027009	.074834	.0529715	.0532168	.0450113
MØRE OG ROMSDAL	.02426	.0415123	.1074194		.0430813	-.4603374
NORDLAND	.1592454	.019804	.1594475	.0887668	.0512191	-.1113006
OPPLAND				.199179	.1013273	
OSLO	-.0097201		-.1913915			-.0152831
ROGALAND	.1360839	.0630247	.1603321		.1561036	
SOGN OG FJORDANE	.2206137	.1132321	.0635623	.2475189	.1438047	
TELEMARK		-.0076618	-.0011232	-.2093818	.1481887	
TROMS	.2611051	-.00932	.0868938		.0634871	
TRØNDELAG	.2051804	.0697326	.1057483	-.0455287	.0939696	
VEST-AGDER FYLKE	.1627108	.3203553	-.0690001			
VESTFOLD	.2666756					
ØSTFOLD	-.0321206		.0518519			

Figure 5.8 Mean OpsMargin by Region and Sector (Weighted)

	NACE-bransjekode					
Fylke	3.211	3.212	3.213	3.221	3.222	3.223
AUST-AGDER FYLKE	.1610787		.3088729			
Akershus	-.7820935		-.1774791			-2.567827
BUSKERUD		.6700125			.0812813	
FINNMARK	.2065144	-.6785369	.1334044		.025833	
HEDMARK	-.4463795			.03338		
HORDALAND	.2183941	.0441662	.114287	.0436874	.1343677	.0368777
MØRE OG ROMSDAL	.0310743	.2237965	.0952889		.0644086	-.4488117
NORDLAND	.2613356	.070452	.2291946	.0800451	.1454341	
OPPLAND				.2913635	.1425132	
OSLO	-.0262337		-.7464134			.2711864
ROGALAND	.2271168	.1143346	.2257266		.2068024	
SOGN OG FJORDANE	.2502202	.1597416	.2077794	.2222147	.1727284	
TELEMARK		-4.246836	.000469	-2.717635	.1236501	
TROMS	.3171898	-.3134845	.1968696		.160536	
TRØNDELAG	.2467636	.1717898	.0945812	-.0209611	.1559534	
VEST-AGDER FYLKE	.2827415	.2289944	.0368191			
VESTFOLD	.1471476					
ØSTFOLD	-2.722838		.0423946			

6.0 Empirical Results

This section of our research effort will share evidence of dependence or determinants of the two economic measures to gauge the dependency of the firm on Time, Sector and Region. Our regression analysis tests both weighted and unweighted models to check the validity of our argument against what we have presented in this paper. These results are shared below in the subsequent sections.

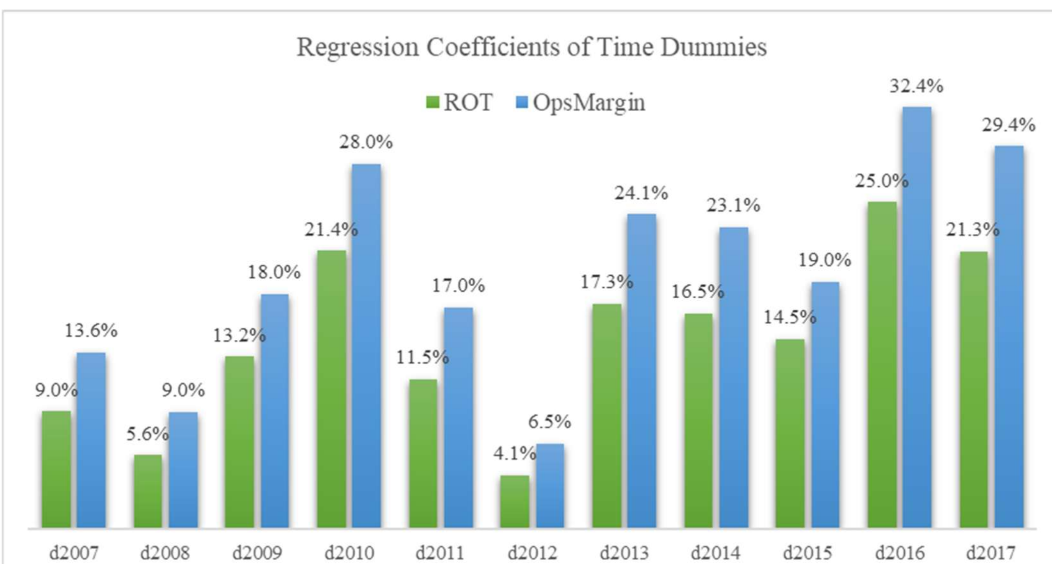
We use both weighted and unweighted models to test the significance of Time, Sector and Region on economic profitability measures namely Return on Total Assets and Operating Margin. The weighted model however provides a more accurate picture (Dupraz, 2013). And our results indicate less unexplained variation in the form of a higher R-squared and Adjusted R-squared value hence, for the discussion and interpretation of results we will keep our discussion limited to the weighted regression models. The unweighted models are presented in the appendices to this report.

6.1 Time

From our weighted model in Appendix 1a we find Time to have a significant impact on profitability measured through firms return on total assets. We find that all time dummy variables have a p-value of 0.00 with positive co-efficient values for all the years. The highest coefficient was noted to be for FY16 with coefficient of 0.2504. Denoting that on average the return on total assets was positively affected by 25.04% in FY16 and 0.0564 or 5.64% in FY08 being the lowest. OpsMargin coefficient values show an even greater magnitude than ROT. All time dummies indicate significance at the 1% level and fall in congruence with ROT for the years. FY16 and FY17 were the highest indicating that on average a firm's OpsMargin was positively affected by 32.4% and 29.4% respectively holding everything else constant.

The difference in co-efficient magnitudes is due to the price variation of Atlantic Salmon. The high variability in the price of Salmon is the cause for such a wide range of difference between the highest and lowest time dummy coefficients. We further substantiate our claim through an analysis of the firm wise within and between variability analysis in section 7.0 of this report.

Figure 6.1



The above denotes an average upward trend in the coefficient values for time dummies. We believe this is because of strong productivity growth leading to decreased production costs and improved competitiveness (Asche F. , Farming the Sea, 2008). Furthermore, in (Asche, Tveterås, & Roll, Future Trends in Aquaculture: Productivity Growth and Increased Production Chapter 9, 2008) we find a higher degree of control over the production process allows technological innovation to a much larger extent causing the price of production to fall.

6.2 Sector

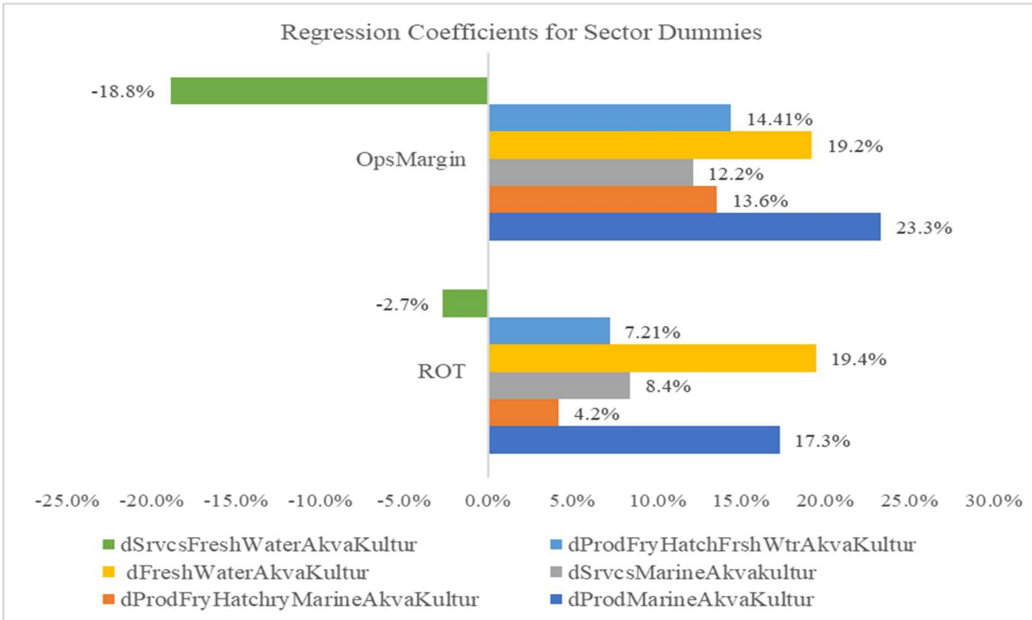
For ROT we find all sector dummies except for NACE sector 03.223, Services for freshwater aquaculture to have positive coefficients that are significant at the 1% level. Only 03.223 has a negative coefficient, however it is not significant. All other sector dummies show a zero p-value indicating highly significant dependence on the sector a firm belongs. We also find that only two of the sectors return significant values for OpsMargin which are 03.211 and 03.222. The coefficient for production of marine aquaculture which is comprised of salmon production indicates healthy margins (23.3%) and is highly significant with a p-value of zero. Fig 6.2 below shows a plotted graph of the coefficients for the two economic measures.

We also find 03.211, production of marine aquaculture has the second highest magnitude indicating that on average a firm operating in production of salmon will generate an ROT of 17.2%, and OpsMargin of 23.3%, holding everything else constant. This high value was expected as it aligns with our analysis and the rapid growth in the production of salmon in Norway.

03.221, production of freshwater aquaculture stands as the highest in magnitude. The coefficient is 19.4% and the result is significant at the 1% level. Both the two production sectors pertaining to stage 3 & 4 which is carried out either in grow out ponds in seawater or land based fresh aquaculture systems indicate strong positive correlation.

The lowest coefficient was of 03.212 was the lowest followed by 03.222 with values of 4.2% and 7.2% respectively. Both are sectors pertaining to hatchery, and production of fry pertaining to stage 1 & 2 in Fig1.

Figure 6.2



6.3 Region

11 regional dummies indicate a positive correlation with firm ROT and 7 for OpsMargin and are highly significant. For ROT, the strongest correlation was for Vestføld at 26.6%, followed by Troms at 23.1% and Sognafjord at 20.4%. Oslo at -7.3% shows a negative correlation to firm ROT and the results were significant at the 1% level. The regression results for the model are available in Table 6.3.

Nordland had the largest coefficient value, followed by Hordaland, SognFjordane and Trøndelag. The results were as per our expectations and nothing out of the ordinary was observed. We expected counties with a high count of firms operating in salmon production associated with sector 03.211, see Fig 5.4, to have positive coefficient values and high significance indicating congruence with prior literature review conducted for this paper. Regions exhibit positive correlation to firm ROT and the number of firms operating within the sector which points agglomeration effects and productivity growth and economies of scale obtained through more developed supply networks, availability of skilled labor and knowledge spillover effects.

Hordaland, Finnmark, Tromsø, Nordland, Trøndelag, Rogaland and SognFjordane all showed highly significant results with high OpsMargin. The following graph shows a plotted graph against the regression coefficients.

Furthermore, we note that those regions that are located on the western coastline of Norway from Rogaland all the way up north to Finnmark show positive coefficients that are highly significant while those counties that are either landlocked, or located to the southwest side of Norway except for Vest-Agder show negative coefficients for region dummies with weak significance. If we match our results to the map of the Norwegian counties, we can draw a general conclusion for profitable areas for salmon farming. This finding is also substantiated with Fig 5.4 which shows the number of firms operating in each sector by county. The counties with positive coefficients and highly significant p values show healthy economic returns and have a high number of marine aquaculture firms situated in the county. This in turn points us to the literature we shared regarding economies of scale and developed supply networks (Roll, Tveterås, & Asche, 2007). Our results indicate that location does form an important factor in salmon farming.

Figure 6.3

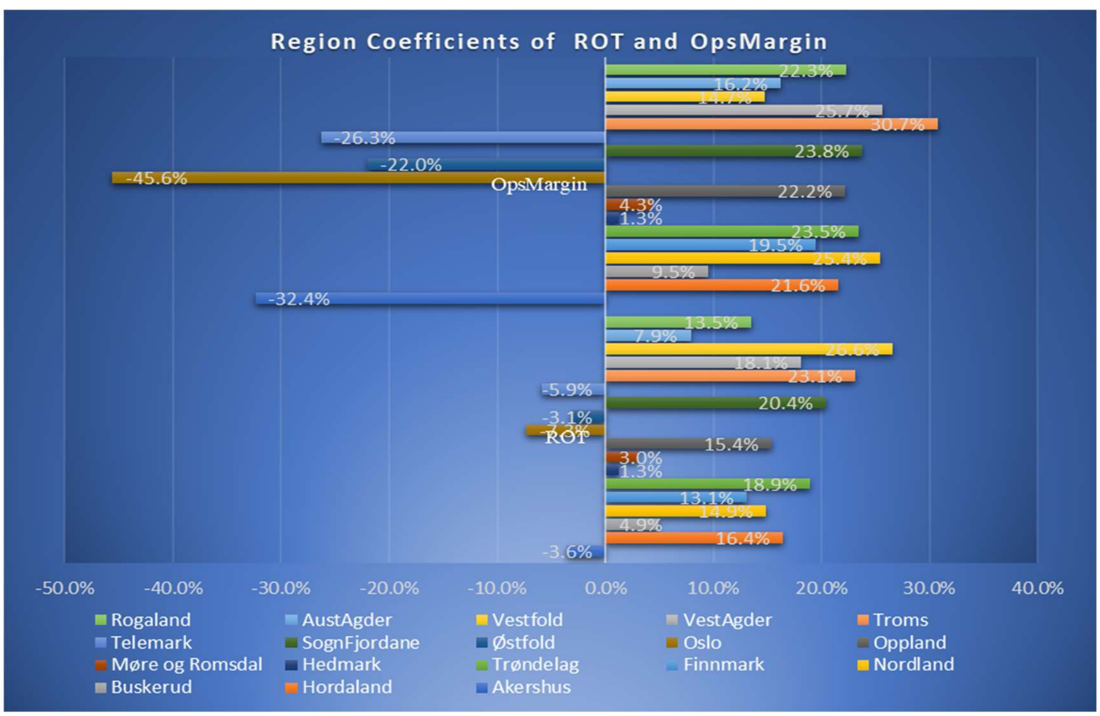
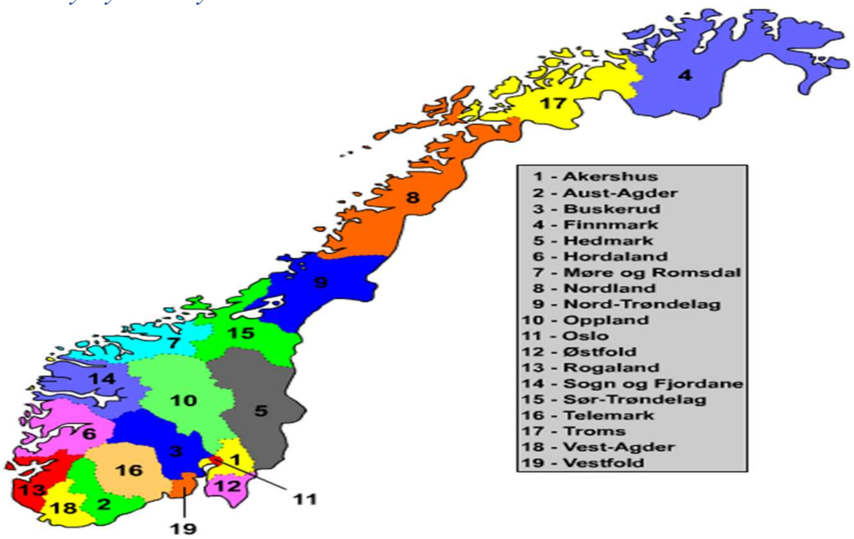


Fig 6.4 Map of Norway by County



Source: https://no.wikipedia.org/wiki/Regionreformen_i_Norge

Fig 6.4 is a map of Norway by counties[3]. When one analyzes the geography of the counties, a pattern starts to emerge. Firstly, our analysis of production rates, count of firms, persons employed by sector, indicates those counties that lie on the western side of Norwegian coastline have performed better in terms of profitability with highly significant results.

Secondly, the number of marine aquaculture production sector firms far outweighs any other sector indicating scale economies, developed supply chain and proximity of farms within the respective regions. Also, it seems from this map that water temperatures and the biological environment favourable to the production of salmon also lies to the west coast of Norway. On the other hand, all mainland regions have low to nonexistent presence in 03.211 and have diversified into hatchery and production of fry (03.212) or services sectors (03.212 & 03.223). This makes sense as proximity of open net pen farms to the command and control would make logistical sense since management decisions could be implemented at a faster pace and provide greater monitoring of activities on the farms. Regions denoted by # 13, 6, 14, 7, 15, 9, 8, 17 & 14 all denoted those counties that have healthy economic returns and highlight significant correlation to firm profitability. This also points to external economies of scale generated through clustering in economic regions of similar firms as highlighted in (Asche T. R., 2015). The results of the regressions are provided below.

---

[3] The map is prior to 2018. Nord-Trøndelag and Sør-Trøndelag were merged into one county.

Lastly, (Solheim & Tveterås, 2017) we find supporting evidence of benefits from co-location in the upstream oil and gas industry in Norway. The paper states that when firms operating within a sub sector in an industry cluster together they benefit from productivity and agglomeration. The value chains generated as a result creates synergies for firms within the sector that generates localized external economies. Our findings, specifically to the dependence of marine aquaculture (03.211) indicates that a similar mechanism may be present within aquaculture in Norway.

Table 6.1 Time dummy regression on ROT

Source	SS	df	MS			
Model	152.881824	11	13.8983476	Number of obs	=	5,033
Residual	85.9483039	5,022	.017114358	F(11, 5022)	=	812.09
Total	238.830128	5,033	.047452837	Prob > F	=	0.0000
				R-squared	=	0.6401
				Adj R-squared	=	0.6393
				Root MSE	=	.13082

ROT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	.0899816	.0085156	10.57	0.000	.0732873	.1066759
d2008	.056406	.0081961	6.88	0.000	.040338	.0724739
d2009	.1323726	.0077589	17.06	0.000	.1171618	.1475835
d2010	.2135323	.0070463	30.30	0.000	.1997185	.2273461
d2011	.1147819	.0066978	17.14	0.000	.1016513	.1279125
d2012	.0413215	.0064782	6.38	0.000	.0286213	.0540216
d2013	.1725151	.0059227	29.13	0.000	.160904	.1841263
d2014	.1650592	.0055737	29.61	0.000	.1541323	.175986
d2015	.1454951	.0056399	25.80	0.000	.1344384	.1565518
d2016	.2504949	.0048481	51.67	0.000	.2409906	.2599992
d2017	.2129297	.0045714	46.58	0.000	.2039677	.2218917

Table 6.2 Sector Dummy Regression on ROT

Source	SS	df	MS			
Model	137.926837	6	22.9878061	Number of obs	=	5,033
Residual	100.903291	5,027	.020072268	F(6, 5027)	=	1145.25
Total	238.830128	5,033	.047452837	Prob > F	=	0.0000
				R-squared	=	0.5775
				Adj R-squared	=	0.5770
				Root MSE	=	.14168

ROT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dProdMarineAkvaKultur	.1729332	.0021083	82.02	0.000	.1688	.1770664
dProdFryHatchryMarineAkvaKultur	.0421074	.0159096	2.65	0.008	.0109177	.0732972
dSrvcsMarineAkvakultur	.0844735	.0140894	6.00	0.000	.0568522	.1120948
dFreshWaterAkvaKultur	.1944936	.0472633	4.12	0.000	.101837	.2871503
dProdFryHatchFrshWtrAkvaKultur	.0720743	.0078886	9.14	0.000	.0566092	.0875395
dSrvcsFreshWaterAkvaKultur	-.0266953	.0611189	-0.44	0.662	-.146515	.0931243

Table 6.3 Regional dummy regression on ROT

Source	SS	df	MS			
Model	140.505561	18	7.80586449	Number of obs	=	5,033
Residual	98.324567	5,015	.019606095	F(18, 5015)	=	398.13
				Prob > F	=	0.0000
Total	238.830128	5,033	.047452837	R-squared	=	0.5883
				Adj R-squared	=	0.5868
				Root MSE	=	.14002

ROT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dAkershus	-.0361034	.0935938	-0.39	0.700	-.2195882	.1473813
dHordaland	.1641417	.0032073	51.18	0.000	.1578541	.1704293
dBuskerud	.0499789	.2041233	0.24	0.807	-.3501919	.4501497
dNordland	.1498466	.0039679	37.76	0.000	.1420677	.1576255
dFinnmark	.1319013	.0110651	11.92	0.000	.1102089	.1535936
dTrøndelag	.189605	.004696	40.38	0.000	.1803988	.1988112
dHedmark	.0133191	.3124909	0.04	0.966	-.5992996	.6259378
dMøreRomsdal	.0305639	.0104736	2.92	0.004	.0100312	.0510967
dOppland	.1543417	.1538881	1.00	0.316	-.1473463	.4560296
dOslo	-.073741	.0267536	-2.76	0.006	-.1261898	-.0212922
dØstfold	-.0312574	.0866896	-0.36	0.718	-.2012068	.138692
dSognFjordane	.2047909	.0090658	22.59	0.000	.1870179	.2225639
dTelemark	-.0592317	.0979688	-0.60	0.545	-.2512933	.13283
dTroms	.2311649	.0087101	26.54	0.000	.2140894	.2482405
dVestAgder	.1812555	.0509839	3.56	0.000	.0813049	.2812062
dVestfold	.2666756	.5850847	0.46	0.649	-.8803461	1.413697
dAustAgder	.0798896	.0659027	1.21	0.225	-.0493084	.2090876
dRogaland	.1357972	.0134493	10.10	0.000	.1094307	.1621636

Table 6.4 Time & Sector regression on ROT

Source	SS	df	MS			
Model	159.294208	16	9.95588802	Number of obs	=	5,033
Residual	79.5359195	5,017	.015853283	F(16, 5017)	=	628.00
				Prob > F	=	0.0000
Total	238.830128	5,033	.047452837	R-squared	=	0.6670
				Adj R-squared	=	0.6659
				Root MSE	=	.12591

ROT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	.0896964	.0428419	2.09	0.036	.0057076	.1736852
d2008	.0564563	.0427839	1.32	0.187	-.0274188	.1403314
d2009	.1332055	.0427096	3.12	0.002	.049476	.2169351
d2010	.2138306	.0425953	5.02	0.000	.1303251	.2973361
d2011	.1164775	.0425416	2.74	0.006	.0330774	.1998776
d2012	.0430608	.0425102	1.01	0.311	-.0402777	.1263994
d2013	.1738225	.0423319	4.11	0.000	.0908335	.2568116
d2014	.1670482	.0422749	3.95	0.000	.0841709	.2499255
d2015	.150076	.0422798	3.55	0.000	.0671892	.2329627
d2016	.2570992	.0421972	6.09	0.000	.1743743	.339824
d2017	.2236268	.0421978	5.30	0.000	.1409008	.3063529
dProdMarineAkvaKultur	.0078729	.0420646	0.19	0.852	-.074592	.0903378
dProdFryHatchryMarineAkvaKultur	-.1623509	.044345	-3.66	0.000	-.2492865	-.0754152
dSrvcsMarineAkvakultur	-.1055281	.0438435	-2.41	0.016	-.1914805	-.0195757
dFreshWaterAkvaKultur	0	(omitted)				
dProdFryHatchFrshWtrAkvaKultur	-.0942262	.0426018	-2.21	0.027	-.1777443	-.0107081
dSrvcsFreshWaterAkvaKultur	-.1904333	.0686773	-2.77	0.006	-.3250708	-.0557958

Table 6.5 Time & Region regression on ROT

Source	SS	df	MS		
				Number of obs	= 5,033
				F(29, 5004)	= 354.13
Model	160.58481	29	5.53740725	Prob > F	= 0.0000
Residual	78.2453175	5,004	.015636554	R-squared	= 0.6724
				Adj R-squared	= 0.6705
Total	238.830128	5,033	.047452837	Root MSE	= .12505

ROT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	.1620297	.1736281	0.93	0.351	-.1783575	.5024169
d2008	.1290688	.1736014	0.74	0.457	-.211266	.4694037
d2009	.2038657	.1735771	1.17	0.240	-.1364215	.5441529
d2010	.2834979	.1735434	1.63	0.102	-.0567232	.623719
d2011	.1856416	.173536	1.07	0.285	-.1545651	.5258483
d2012	.1122835	.1735278	0.65	0.518	-.2279071	.4524741
d2013	.2433758	.1735059	1.40	0.161	-.0967717	.5835234
d2014	.2354566	.173499	1.36	0.175	-.1046776	.5755907
d2015	.2130177	.1735079	1.23	0.220	-.1271338	.5531692
d2016	.3222997	.1734782	1.86	0.063	-.0177936	.662393
d2017	.2853489	.1734745	1.64	0.100	-.0547372	.625435
dAkershus	-.2971556	.1925247	-1.54	0.123	-.6745884	.0802772
dHordaland	-.0645162	.1734518	-0.37	0.710	-.4045577	.2755252
dBuskerud	-.1826791	.2516099	-0.73	0.468	-.6759448	.3105866
dNordland	-.0834922	.1734637	-0.48	0.630	-.4235572	.2565727
dFinnmark	-.1029692	.1737089	-0.59	0.553	-.4435148	.2375765
dTrøndelag	-.0473761	.1734784	-0.27	0.785	-.3874697	.2927175
dHedmark	-.2222647	.3285688	-0.68	0.499	-.8664035	.4218742
dMøreRomsdal	-.2097698	.1736808	-1.21	0.227	-.5502603	.1307207
dOppland	-.0807495	.2212795	-0.36	0.715	-.5145544	.3530553
dOslo	-.3193626	.1750664	-1.82	0.068	-.6625694	.0238442
dØstfold	-.3283416	.1899416	-1.73	0.084	-.7007104	.0440271
dSognFjordane	-.0325976	.1736167	-0.19	0.851	-.3729625	.3077673
dTelemark	-.2990421	.1942474	-1.54	0.124	-.6798521	.081768
dTroms	-.0154068	.1736029	-0.09	0.929	-.3557444	.3249309
dVestAgder	-.0623759	.1793065	-0.35	0.728	-.4138953	.2891435
dVestfold	.0351925	.5505395	0.06	0.949	-1.044106	1.114491
dAustAgder	-.1569908	.1831425	-0.86	0.391	-.5160303	.2020487
dRogaland	-.0936649	.1738437	-0.54	0.590	-.4344748	.247145

Table 6.6 Time dummy regression on OpsMargin

Source	SS	df	MS		
				Number of obs	= 3,989
				F(11, 3978)	= 111.51
Model	227.711613	11	20.7010557	Prob > F	= 0.0000
Residual	738.480099	3,978	.185641051	R-squared	= 0.2357
				Adj R-squared	= 0.2336
Total	966.191713	3,989	.242214017	Root MSE	= .43086

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	.1356152	.0327859	4.14	0.000	.0713364	.199894
d2008	.089684	.0322053	2.78	0.005	.0265436	.1528243
d2009	.1802387	.0283414	6.36	0.000	.1246737	.2358036
d2010	.2800542	.0253109	11.06	0.000	.2304306	.3296779
d2011	.1698848	.0255617	6.65	0.000	.1197696	.22
d2012	.0653342	.025518	2.56	0.010	.0153046	.1153638
d2013	.2414792	.0219891	10.98	0.000	.1983683	.2845902
d2014	.2314587	.0207147	11.17	0.000	.1908463	.2720711
d2015	.189691	.0202041	9.39	0.000	.1500798	.2293023
d2016	.3235394	.0172895	18.71	0.000	.2896423	.3574365
d2017	.2937513	.0168371	17.45	0.000	.2607412	.3267614

Table 6.7 Sector dummy regression on OpsMargin

Source	SS	df	MS			
				Number of obs	=	3,989
				F(6, 3983)	=	180.22
Model	206.29779	6	34.3829649	Prob > F	=	0.0000
Residual	759.893923	3,983	.190784314	R-squared	=	0.2135
				Adj R-squared	=	0.2123
Total	966.191713	3,989	.242214017	Root MSE	=	.43679

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dProdMarineAkvaKultur	.2330317	.0071885	32.42	0.000	.2189382	.2471252
dProdFryHatchryMarineAkvaKultur	.1358805	.0825643	1.65	0.100	-.0259917	.2977528
dSrvcsMarineAkvakultur	.1217506	.0492102	2.47	0.013	.0252712	.21823
dFreshWaterAkvaKultur	.1922326	.1370935	1.40	0.161	-.0765474	.4610126
dProdFryHatchFrshWtrAkvaKultur	.1441916	.0325747	4.43	0.000	.080327	.2080562
dSrvcsFreshWaterAkvaKultur	-.1884114	.8509813	-0.22	0.825	-1.856811	1.479988

Table 6.8 Region dummy regression on OpsMargin

Source	SS	df	MS			
				Number of obs	=	3,989
				F(18, 3971)	=	62.50
Model	213.286916	18	11.8492731	Prob > F	=	0.0000
Residual	752.904797	3,971	.189600805	R-squared	=	0.2208
				Adj R-squared	=	0.2172
Total	966.191713	3,989	.242214017	Root MSE	=	.43543

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dAkershus	-.3236225	1.064389	-0.30	0.761	-2.410423	1.763178
dHordaland	.215971	.0108979	19.82	0.000	.194605	.237337
dBuskerud	.0951915	.8177191	0.12	0.907	-1.507997	1.69838
dNordland	.2541972	.0153144	16.60	0.000	.2241724	.2842219
dFinnmark	.1947756	.0398248	4.89	0.000	.1166966	.2728546
dTrøndelag	.2349171	.0154939	15.16	0.000	.2045403	.2652938
dHedmark	.0127381	.9431402	0.01	0.989	-1.836346	1.861823
dMøreRomsdal	.0432419	.0363699	1.19	0.235	-.0280636	.1145474
dOppland	.2217037	.5468165	0.41	0.685	-.8503637	1.293771
dOslo	-.4561163	.2056339	-2.22	0.027	-.8592741	-.0529585
dØstfold	-.220489	2.180484	-0.10	0.919	-4.495462	4.054484
dSognFjordane	.2375831	.0288582	8.23	0.000	.1810049	.2941614
dTelemark	-.262998	.6827134	-0.39	0.700	-1.6015	1.075504
dTroms	.3073786	.0297722	10.32	0.000	.2490083	.3657488
dVestAgder	.2567829	.1759427	1.46	0.145	-.0881637	.6017295
dVestfold	.1471476	1.288532	0.11	0.909	-2.3791	2.673395
dAustAgder	.162124	.2766064	0.59	0.558	-.3801798	.7044278
dRogaland	.2232471	.0508839	4.39	0.000	.1234862	.323008

Table 6.9a Time & Sector regression on OpsMargin

Source	SS	df	MS			
				Number of obs	=	3,989
				F(16, 3973)	=	77.87
Model	230.650249	16	14.4156406	Prob > F	=	0.0000
Residual	735.541463	3,973	.185135027	R-squared	=	0.2387
				Adj R-squared	=	0.2357
Total	966.191713	3,989	.242214017	Root MSE	=	.43027

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	.0693846	.1391516	0.50	0.618	-.2034306	.3421997
d2008	.0236769	.1390144	0.17	0.865	-.2488694	.2962231
d2009	.1136253	.1381875	0.82	0.411	-.1572998	.3845504
d2010	.2132706	.1375949	1.55	0.121	-.0564926	.4830338
d2011	.1043228	.1376268	0.76	0.448	-.165503	.3741485
d2012	.0003032	.1376185	0.00	0.998	-.2695063	.2701126
d2013	.1759143	.1365504	1.29	0.198	-.0918012	.4436297
d2014	.166676	.1363389	1.22	0.222	-.1006247	.4339767
d2015	.1258604	.136241	0.92	0.356	-.1412484	.3929692
d2016	.2597754	.1358708	1.91	0.056	-.0066076	.5261585
d2017	.2323421	.1358952	1.71	0.087	-.0340887	.4987728
dProdMarineAkvaKultur	.071875	.1353081	0.53	0.595	-.1934049	.337155
dProdFryHatchryMarineAkvaKultur	-.0636507	.1576982	-0.40	0.687	-.3728276	.2455263
dSrvcsMarineAkvakultur	-.0626691	.1435268	-0.44	0.662	-.3440622	.218724
dFreshWaterAkvaKultur	0	(omitted)				
dProdFryHatchFrshWtrAkvaKultur	-.0075124	.1389043	-0.05	0.957	-.2798428	.264818
dSrvcsFreshWaterAkvaKultur	-.3282355	.8491552	-0.39	0.699	-1.993056	1.336585

Table 6.9b Time & Region regression on OpsMargin

Source	SS	df	MS			
				Number of obs	=	3,989
				F(29, 3960)	=	44.08
Model	235.791559	29	8.1307434	Prob > F	=	0.0000
Residual	730.400154	3,960	.184444483	R-squared	=	0.2440
				Adj R-squared	=	0.2385
Total	966.191713	3,989	.242214017	Root MSE	=	.42947

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	.0069078	.331552	0.02	0.983	-.6431208	.6569364
d2008	-.0380768	.3312233	-0.11	0.908	-.6874611	.6113075
d2009	.0500283	.3309469	0.15	0.880	-.5988141	.6988706
d2010	.1503376	.3307071	0.45	0.649	-.4980347	.7987098
d2011	.0416926	.3307529	0.13	0.900	-.6067694	.6901546
d2012	-.0635778	.3307138	-0.19	0.848	-.7119631	.5848074
d2013	.1091869	.3305063	0.33	0.741	-.5387917	.7571654
d2014	.0997712	.3304477	0.30	0.763	-.5480923	.7476348
d2015	.0564442	.3304377	0.17	0.864	-.5913999	.7042882
d2016	.1887658	.330285	0.57	0.568	-.4587788	.8363103
d2017	.1574434	.3302562	0.48	0.634	-.4900448	.8049315
dAkershus	-.4342508	1.100432	-0.39	0.693	-2.591716	1.723215
dHordaland	.1261228	.3300396	0.38	0.702	-.5209407	.7731863
dBuskerud	.007067	.8713744	0.01	0.994	-1.701318	1.715452
dNordland	.1567217	.330213	0.47	0.635	-.4906817	.8041251
dFinnmark	.0916233	.3321972	0.28	0.783	-.5596704	.742917
dTrøndelag	.1407592	.3302209	0.43	0.670	-.5066598	.7881782
dHedmark	-.0778787	.9869941	-0.08	0.937	-2.012943	1.857186
dMøreRomsdal	-.0393177	.3318077	-0.12	0.906	-.6898476	.6112123
dOppland	.1279705	.632215	0.20	0.840	-1.111527	1.367468
dOslo	-.5163415	.3872383	-1.33	0.182	-1.275547	.2428637
dØstfold	-.3545885	2.175796	-0.16	0.871	-4.620375	3.911198
dSognFjordane	.1401663	.3310932	0.42	0.672	-.5089629	.7892955
dTelemark	-.3598912	.7498264	-0.48	0.631	-1.829973	1.110191
dTroms	.1999007	.3311813	0.60	0.546	-.4494012	.8492025
dVestAgder	.1319472	.3727784	0.35	0.723	-.5989085	.8628029
dVestfold	.060623	1.313007	0.05	0.963	-2.513611	2.634857
dAustAgder	.0736701	.4280762	0.17	0.863	-.7656004	.9129406
dRogaland	.1303869	.3336627	0.39	0.696	-.5237799	.7845538

7.0 Within & Between Variability in Aquaculture Sectors

Variability is denoted as the divergence of data from the mean (Investopedia, 2016). In this section of our analysis of profitability of aquaculture value chains in Norway we will share findings of the within farm variability in each of the respective sectors of aquaculture value chain versus the between farm variability.

Within farm variability in profitability specifically Return on Total Assets and Operating Margins the two dependent variables analyzed in our statistical analysis refers to variability in profitability in a farm across time while Between farm variability refers to variability that results across different farms or in our case the different companies. Between farm variability is dependent on several factors that can influence profitability. These factors could be related to feed usage, the quality of feed, fertilizer use or extension services ((Kaliranjan & Flinn, 1983). The paper further states that between farm variability is affected through technical efficiency which is determinant on other factors such as education and farming experience. Between farm variability in profitability is also

(Flaten, Tveterås, & Gudbrand, 2011) states that within farm variability is highly dependent on exogenous shocks. While price is a principal factor in farm profitability between farm variability differs based on farmer's ability, soil and water properties, topographic position, and even personal characteristics.

Within farm variability could be caused by physical, financial, and labor constraints as well variable climatic conditions and annual management decisions year on year. From our computation we find that within farm variability is consistently higher for the marine/coastal aquaculture. A lower between farm variability indicates dispersion of knowledge throughout the industry which is a plus. It also denotes that a lower firm to firm variation indicates that differences in knowledge, technology and the diffusion of innovation, experience level and education are less variable in both marine and freshwater aquaculture industries.

The between variability which points to management effectiveness, experience, technological knowledge, and expertise is higher in Fresh-water aquaculture. Since our dataset contains both large, small, midsized and owner operator level family run fish farms we expected to have high between variability between these diverse groups. Large corporations for example such as Marine

Harvest have access to financial capital that provides them the ability to afford expensive machinery and state of the art fish farms. On the other hand, smaller fish farms that are not public corporations farm salmon based on knowledge passed on from generations and labor is provided by family members. This creates a less specialized form of farming when compared with large corporations. Economies of scale are indicated within larger firms in Norwegian aquaculture firms indicating larger companies have increased production (Asche, et al., 2013), which points to the reason for differences between groups of aquaculture firms.

The within farm variability for marine aquaculture for ROT is 5.09 versus 2.68 for freshwater. Similarly, 03.212 and 03.222 stand at 0.73 and 5.53 indicating a higher within group variation in freshwater hatchery sectors. Services sectors for both sea and freshwater had 5.53 and 9.17, respectively. The within farm variability for 03.211 marine aquaculture for OpsMargin was the highest at 147.02 followed by 03.212, hatchery and production of fry in marine aquaculture. We believe this variability is again due to small and large farms operating within these sectors as we previously mentioned that aquaculture is skewed towards marine farming and associated sectors therefore, the highest variability is also visible in these sectors due to the large number of players.

Table 7.1 Within and Between Variability in Marine Aquaculture (ROT)

. by NACEbransjekode: xtsum ROT

-> NACEbransjekode = 3.211

Variable		Mean	Std. Dev.	Min	Max	Observations
ROT	overall	-.2171587	5.104688	-207.3333	69	N = 2787
	between		.3023882	-.9026018	.1393038	n = 11
	within		5.09676	-206.6479	68.66234	T-bar = 253.364

-> NACEbransjekode = 3.212

Variable		Mean	Std. Dev.	Min	Max	Observations
ROT	overall	-.1478557	.7448569	-7.6	.8661461	N = 250
	between		.1210259	-.3690124	.015998	n = 11
	within		.7355439	-7.378843	.8175886	T = 22.7273

-> NACEbransjekode = 3.213

Variable		Mean	Std. Dev.	Min	Max	Observations
ROT	overall	-.3056313	5.552465	-124	56	N = 988
	between		.5163434	-1.70191	.1424619	n = 11
	within		5.531337	-122.6037	55.55191	T-bar = 89.8182

Table 7.2 Within and Between Variability in Fresh Water Aquaculture (ROT)

-> NACEbransjekode = 3.221

Variable		Mean	Std. Dev.	Min	Max	Observations
ROT	overall	-.288151	2.775781	-26.2	1.486631	N = 95
	between		.6286989	-1.972044	.3060856	n = 11
	within		2.686971	-24.51611	1.883948	T = 8.63636

-> NACEbransjekode = 3.222

Variable		Mean	Std. Dev.	Min	Max	Observations
ROT	overall	-.2258664	5.614933	-155.5	14.91667	N = 869
	between		.6156074	-1.918479	.2272147	n = 11
	within		5.58384	-153.8074	14.46359	T = 79

-> NACEbransjekode = 3.223

Variable		Mean	Std. Dev.	Min	Max	Observations
ROT	overall	-2.572943	10.61503	-58.25	10.42857	N = 44
	between		5.819247	-15.01012	3.425694	n = 11
	within		9.17425	-45.81283	12.44029	T = 4

Table 7.3 Within and Between Variability in Marine Aquaculture (OpsMargin)

```
. by NACEbransjekode: xtsum OpsMargin
```

-> NACEbransjekode = 3.211

Variable		Mean	Std. Dev.	Min	Max	Observations
OpsMar~n	overall	-5.812366	147.2864	-6700	84.07692	N = 2191
	between		8.862179	-31.43298	-.8079812	n = 11
	within		147.0212	-6674.379	83.03895	T = 199.182

-> NACEbransjekode = 3.212

Variable		Mean	Std. Dev.	Min	Max	Observations
OpsMar~n	overall	-8.3364	56.32493	-676.8571	4.555555	N = 160
	between		11.07251	-37.57077	-.4210226	n = 11
	within		55.18767	-647.6227	29.91174	T = 14.5455

-> NACEbransjekode = 3.213

Variable		Mean	Std. Dev.	Min	Max	Observations
OpsMar~n	overall	-.3003545	2.128466	-24.5	1.221059	N = 740
	between		.2991113	-1.179434	-.0616756	n = 11
	within		2.116396	-24.47557	1.493414	T = 67.2727

Table 7.4 Within and Between Variability in Fresh-water Aquaculture (OpsMargin)

-> NACEbransjekode = 3.221

Variable		Mean	Std. Dev.	Min	Max	Observations
OpsMar~n	overall	-.7495241	2.774941	-20	.5933333	N = 86
	between		.9458335	-3.34169	-.064537	n = 11
	within		2.592084	-17.40783	3.1855	T = 7.81818

-> NACEbransjekode = 3.222

Variable		Mean	Std. Dev.	Min	Max	Observations
OpsMar~n	overall	-.3293217	4.275981	-56.71875	41.35678	N = 796
	between		.3071924	-.7944098	.1463826	n = 11
	within		4.266001	-56.28801	41.06276	T = 72.3636

-> NACEbransjekode = 3.223

Variable		Mean	Std. Dev.	Min	Max	Observations
OpsMar~n	overall	-2.742038	6.417398	-22	.4222222	N = 16
	between		6.754466	-22	.2363584	n = 10
	within		3.406317	-14.16198	1.185935	T = 1.6

8.0 Summary & Conclusion

Aquaculture has grown over the years as a significant industry in Norway. Salmon exports increased by over 288% since FY00 until FY19 while the price increased by 125% indicating decreasing production costs. Salmon production grew between FY07 and FY17 starting at NOK 15.49Billion in FY07 to NOK 61.63Billion in FY17 in sales of slaughtered fish for food.

Our results indicate that 03.211 production of seawater aquaculture shows the most promising economic returns as measured by return on total assets and business risks measured through operating margins. FY16 and FY17 clearly stood out amongst the data set as the best years in terms of profitability for the salmon production firms. We find that time plays a critical role in profitability since external shocks in the form of price fluctuations and disease outbreaks directly affect firm profitability. A decrease in price that causes the reduction in margins thereby reducing overall profitability and operating margins while diseases outbreaks create losses through loss of sales revenue.

Sectors on the hand are closely related to cluster formation and technological development that the aquaculture industry has undergone over the years. The growth in the salmon production has caused 03.211 production of marine aquaculture to outrun all other sectors in Norway. The reasons are dependent on agglomeration externalities, production efficiencies, knowledge spillovers and external economies generated through cluster formation and developed supply networks due the sheer number of players operating within a sector. These factors play a vital role drive profitability growth over time.

Lastly, regions also play a highly significant role in firm profitability and geographic location plays an integral role in the performance of the company. This is evident through the regression results which indicate that firms located in counties that have access to the western coast of Norway that comprises of the North Sea, Norwegian Sea and the Barents Sea in the north comprise of a heavy presence of salmon production companies.

Those counties that do not have access to the western coastline tend to specialize in sectors that pertain to services related to the aquaculture industry. This makes logical sense since proximity of open net pen fish farms and the command and control offices presents fewer management challenges and makes for easier monitoring and control over the production operations. On the other hand, the clusters formed as a result of concentrated grow out salmon farms within counties has created external economies of scale for the firms in these regions. This finding is further supported by benefits of co-location and we find that within aquaculture in Norway a similar mechanism may be present.

In the end, there is further need to deep dive into how firm size affects profitability within aquaculture in Norway. Specifically, we think that studying the impact of firm size versus sales revenue and its relation to research and development should be particularly and interesting area to investigate with the aquaculture industry in Norway.

Bibliography

Aase, A. (2019). *Fiskedirektoratet*. Hentet 06 15, 2019 fra https://www.fiskeridir.no/Akvakultur/Nyheter/2019/0519/11-600-tonn-doed-laks-i-nord

Andersen, R. &. (2008). The Price Responsive of Salmon Supply in Short and Long Run. *Marine Resource Economics, 23*, 425-437.

Asche, F. (2008). Farming the Sea. *Marine Resource Economics, 23*, 527-547.

Asche, F., Tveterås, R., & Roll, K. H. (2008). Future Trends in Aquaculture: Productivity Growth and Increased Production Chapter 9. I *Aquaculture in the Ecosystem* (ss. 271-292). Springer.

Asche, S. Z., Asche , F., Sandvold, H. N., Roll, K. H., Zhang, D., & Sørvig, A. (2013). Salmon Aquaculture: Larger Companies and Increased Production. *Aquaculture Economics & Management, 17*, 322-339.

Asche, T. R. (2015). Profiting from Agglomeration? Evidence from the Salmon Aquaculture Industry. *Regional Studies Association*, 1-13.

Berge, A. (2017). *SalmonBusiness*. Hentet 06 20, 2019 fra https://salmonbusiness.com/these-are-the-worlds-20-largest-salmon-producers/

Bjørndal, F. A. (2011). *The Economics of Salmon Aquaculture.*

Cermaq. (2012). *Carbon Footprint.* Cermaq.

Dupraz, Y. (2013, September 18). Using Weights in Stata. *Paris School of Economics* , ss. 1-6.

E&Y Norway. (2018). *The Norwegian Aquaculture Analysis.* Oslo: Ernst & Young.

Engle, C. R. (2012). Determining the Profitability of Aquaculture Business: Using Income Statements and Enterprise Budgets. *Southern Regional Aquaculture Center*.

Fidra. (2019). Salmon Life Cycle . North Berwick : Fidra.

Flaten, O., Tveterås, R., & Gudbrand, L. (2011). A comparative study of risk exposure in agriculture and aquaculture. *Food Economics, Acta Agriculturae Scandinavica, Section C*(8:1), 20-34.

Harvest, M. (2018). *Salmon Farming Industry Handbook.* Oslo: Marine Harvest AS.

Investopedia. (2016). *www.investopedia.com*. Hentet 06 08, 2019 fra https://www.investopedia.com/terms/v/variability.asp

Kaliranjan, K., & Flinn, J. C. (1983). The Measurement of Farm Specifc Technical Efficiency. *Pakistan Journal of Applied Economics, 2*(2), 167-180.

Kopalle, P. K., & Mela, C. F. (2002). The impact of collinearity on regression: the asymmetric effect of negative and positive correlations. *Applied Economics*, 667-677.

Marine Harvest . (2017). *Marine Harvest Integrated Annual Report* .

OECD, F. (2016). *OECD-FAO Agricultural Outlook 2016-2025.* Paris: OECD Publishing. Hentet fra http://www.fao.org/3/a-i5778e.pdf

Proff Regnskap. (2019). Hentet 06 15, 2019 fra https://www.proff.no/regnskap/marine-harvest-norway-as/flekkefjord/produsenter/IFV69FB016D/

Roll, K. H., Tveterås, R., & Asche, F. (2007). Productivity Growth in the Supply Chain - Another source of competitiveness for Aquaculture. *Marine Resource Economics, 22*, 329-334.

Sanguinaire, M. (2018). *www.wikipedia.org*. Hentet 06 28, 2019 fra https://no.wikipedia.org/wiki/Regionreformen_i_Norge

Schechter, C. (2017). *Statalist The Stata Forum*. Hentet 06 22, 2019 fra https://www.statalist.org/forums/forum/general-stata-discussion/general/1421715-estimation-option-noconstant-why

Solheim, M. C., & Tveterås, R. (2017). Benefitting from co-location? Evidence from the. *The Extractive Industries & Society, 4*(4), 904-914.

Statistics Norway. (u.d.). Hentet 06 23, 2019 fra https://www.ssb.no/en/jord-skog-jakt-og-fiskeri/statistikker/fiskeoppdrett/aar

The Norwegian Fisheries Directorate. (u.d.). Hentet 06 17, 2019 fra www.fiskeridir.no

Thyholdt, S. B. (2012). The Importance of Temperature in Farmed Salmon Growth: Regional Growth. University of Tromsø.

Tridge. (2019). *Tridge Market Intelligence*. Hentet 06 27, 2019 fra https://www.tridge.com/hs-codes/030212/export

Tveterås, R., & Bettese, G. E. (2006). Agglomeration Externatilities, Productivity, and Technical Inefficiency. *Journal of Regional Science, 46*(4), 605-625.

USGS. (2019). *USGS Science for changing world*. Hentet 06 23, 2019 fra https://www.usgs.gov/special-topic/water-science-school/science/how-much-water-there-earth?qt-science_center_objects=0#qt-science_center_objects

Young, E. &. (2017). *The Norwegian Aquaculture Analysis.* Ernst & Young Norge.

Appendix 1:

Regression estimates of Time dummy variables on firm's Operating Margin – Using Analytic Weights (Weighted Model)

Source	SS	df	MS
Model	227.711613	11	20.7010557
Residual	738.480099	3,978	.185641051
Total	966.191713	3,989	.242214017

Number of obs	=	3,989
F(11, 3978)	=	111.51
Prob > F	=	0.0000
R-squared	=	0.2357
Adj R-squared	=	0.2336
Root MSE	=	.43086

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	.1356152	.0327859	4.14	0.000	.0713364	.199894
d2008	.089684	.0322053	2.78	0.005	.0265436	.1528243
d2009	.1802387	.0283414	6.36	0.000	.1246737	.2358036
d2010	.2800542	.0253109	11.06	0.000	.2304306	.3296779
d2011	.1698848	.0255617	6.65	0.000	.1197696	.22
d2012	.0653342	.025518	2.56	0.010	.0153046	.1153638
d2013	.2414792	.0219891	10.98	0.000	.1983683	.2845902
d2014	.2314587	.0207147	11.17	0.000	.1908463	.2720711
d2015	.189691	.0202041	9.39	0.000	.1500798	.2293023
d2016	.3235394	.0172895	18.71	0.000	.2896423	.3574365
d2017	.2937513	.0168371	17.45	0.000	.2607412	.3267614

Appendix 2:

Regression estimates of Sector dummy variables on firm's Operating Margin – Using Analytic Weights (Weighted Model)

Source	SS	df	MS
Model	206.29779	6	34.3829649
Residual	759.893923	3,983	.190784314
Total	966.191713	3,989	.242214017

Number of obs	=	3,989
F(6, 3983)	=	180.22
Prob > F	=	0.0000
R-squared	=	0.2135
Adj R-squared	=	0.2123
Root MSE	=	.43679

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dProdMarineAkvaKultur	.2330317	.0071885	32.42	0.000	.2189382	.2471252
dProdFryHatchryMarineAkvaKultur	.1358805	.0825643	1.65	0.100	-.0259917	.2977528
dSrvcsMarineAkvakultur	.1217506	.0492102	2.47	0.013	.0252712	.21823
dFreshWaterAkvaKultur	.1922326	.1370935	1.40	0.161	-.0765474	.4610126
dProdFryHatchFrshWtrAkvaKultur	.1441916	.0325747	4.43	0.000	.080327	.2080562
dSrvcsFreshWaterAkvaKultur	-.1884114	.8509813	-0.22	0.825	-1.856811	1.479988

Appendix 3:

Regression estimates of Time dummy variables on firm's return on total assets – Without Analytic Weights (Unweighted Model)

Source	SS	df	MS			
				Number of obs	=	5,033
				F(11, 5022)	=	2.48
Model	737.561196	11	67.0510178	Prob > F	=	0.0043
Residual	135934.789	5,022	27.0678592	R-squared	=	0.0054
				Adj R-squared	=	0.0032
Total	136672.35	5,033	27.1552454	Root MSE	=	5.2027

ROT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	-.0322362	.2881497	-0.11	0.911	-.5971354	.532663
d2008	-.1998501	.2801028	-0.71	0.476	-.7489738	.3492736
d2009	-.0486703	.2723206	-0.18	0.858	-.5825376	.4851969
d2010	.0225152	.265153	0.08	0.932	-.4973005	.5423309
d2011	-.2271905	.256942	-0.88	0.377	-.7309089	.2765279
d2012	-.2199334	.2508954	-0.88	0.381	-.711798	.2719311
d2013	-1.058079	.2439053	-4.34	0.000	-1.53624	-.5799185
d2014	-.43288	.2369755	-1.83	0.068	-.8974554	.0316954
d2015	-.1661185	.2249314	-0.74	0.460	-.6070822	.2748452
d2016	-.3245665	.2094519	-1.55	0.121	-.7351837	.0860507
d2017	-.0373826	.1990749	-0.19	0.851	-.4276564	.3528912

Appendix 4:

Regression estimates of Sector dummy variables on firm's return on total assets – Without Analytic Weights (Unweighted Model)

Source	SS	df	MS			
				Number of obs	=	5,033
				F(6, 5027)	=	3.53
Model	572.685954	6	95.447659	Prob > F	=	0.0017
Residual	136099.664	5,027	27.0737347	R-squared	=	0.0042
				Adj R-squared	=	0.0030
Total	136672.35	5,033	27.1552454	Root MSE	=	5.2032

ROT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dProdMarineAkvaKultur	-.2171587	.0985611	-2.20	0.028	-.4103814	-.0239359
dProdFryHatchryMarineAkvaKultur	-.1478557	.329082	-0.45	0.653	-.7929998	.4972885
dSrvcsMarineAkvakultur	-.3056313	.1655372	-1.85	0.065	-.6301564	.0188938
dFreshWaterAkvaKultur	-.288151	.5338414	-0.54	0.589	-1.334713	.7584109
dProdFryHatchFrshWtrAkvaKultur	-.2258664	.1765079	-1.28	0.201	-.5718989	.1201661
dSrvcsFreshWaterAkvaKultur	-2.572943	.7844184	-3.28	0.001	-4.110745	-1.035141

Appendix 5:

Regression estimates of Region dummy variables on firm's return on total assets – Without Analytic Weights (Unweighted Model)

Source	SS	df	MS			
				Number of obs	=	5,033
				F(18, 5015)	=	2.00
Model	976.219875	18	54.2344375	Prob > F	=	0.0070
Residual	135696.13	5,015	27.0580519	R-squared	=	0.0071
				Adj R-squared	=	0.0036
Total	136672.35	5,033	27.1552454	Root MSE	=	5.2017

ROT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dAkershus	-.7766984	.666014	-1.17	0.244	-2.082377	.5289801
dHordaland	-.7380789	.1506642	-4.90	0.000	-1.033447	-.4427112
dBuskerud	.0451511	1.261606	0.04	0.971	-2.428148	2.518451
dNordland	.0012174	.171403	0.01	0.994	-.3348074	.3372422
dFinnmark	-.3924924	.3943425	-1.00	0.320	-1.165576	.3805913
dTrøndelag	.0742101	.1900673	0.39	0.696	-.2984048	.4468251
dHedmark	-.5758163	1.226061	-0.47	0.639	-2.979431	1.827799
dMøreRomsdal	-.1776313	.2488328	-0.71	0.475	-.6654523	.3101897
dOppland	.1231964	.8669559	0.14	0.887	-1.576416	1.822809
dOslo	-.5368144	.5927928	-0.91	0.365	-1.698947	.6253186
dØstfold	-.5366132	1.644933	-0.33	0.744	-3.761401	2.688175
dSognFjordane	-.2412298	.2307897	-1.05	0.296	-.6936785	.2112189
dTelemark	-.5541664	.7213509	-0.77	0.442	-1.96833	.8599967
dTroms	.2455575	.3303105	0.74	0.457	-.4019955	.8931105
dVestAgder	-1.460106	.6173324	-2.37	0.018	-2.670348	-.249865
dVestfold	.2197096	1.839091	0.12	0.905	-3.385713	3.825132
dAustAgder	.0147805	.8920903	0.02	0.987	-1.734106	1.763667
dRogaland	-.0607071	.2591169	-0.23	0.815	-.5686895	.4472753

Appendix 6:

Regression estimates of Time dummy variables on firm's Operating Margin – Without Analytic Weights (Unweighted Model)

Source	SS	df	MS
Model	161434.973	11	14675.9066
Residual	47955906.7	3,978	12055.2807
Total	48117341.6	3,989	12062.5073

Number of obs	=	3,989
F(11, 3978)	=	1.22
Prob > F	=	0.2690
R-squared	=	0.0034
Adj R-squared	=	0.0006
Root MSE	=	109.8

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2007	-5.401812	6.645189	-0.81	0.416	-18.43011	7.626484
d2008	-1.423082	6.503786	-0.22	0.827	-14.17415	11.32798
d2009	-3.51226	6.425357	-0.55	0.585	-16.10956	9.08504
d2010	-3.027883	6.216005	-0.49	0.626	-15.21474	9.158972
d2011	-2.744978	6.034964	-0.45	0.649	-14.57689	9.086933
d2012	-1.211058	5.860506	-0.21	0.836	-12.70093	10.27882
d2013	-1.028844	5.731333	-0.18	0.858	-12.26547	10.20778
d2014	-1.1714	5.61768	-0.21	0.835	-12.1852	9.842401
d2015	-18.3253	5.351156	-3.42	0.001	-28.81656	-7.834034
d2016	-.4568395	5.080778	-0.09	0.928	-10.41801	9.504333
d2017	-1.42495	4.871434	-0.29	0.770	-10.97569	8.125791

Appendix 7:

Regression estimates of Sector dummy variables on firm's Operating Margin – Without Analytic Weights (Unweighted Model)

Source	SS	df	MS
Model	85460.8521	6	14243.4753
Residual	48031880.8	3,983	12059.2219
Total	48117341.6	3,989	12062.5073

Number of obs	=	3,989
F(6, 3983)	=	1.18
Prob > F	=	0.3131
R-squared	=	0.0018
Adj R-squared	=	0.0003
Root MSE	=	109.81

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dProdMarineAkvaKultur	-5.812366	2.346056	-2.48	0.013	-10.41195	-1.212782
dProdFryHatchryMarineAkvaKultur	-8.3364	8.681598	-0.96	0.337	-25.35719	8.684391
dSrvcsMarineAkvakultur	-.3003545	4.036861	-0.07	0.941	-8.214861	7.614153
dFreshWaterAkvaKultur	-.7495241	11.8416	-0.06	0.950	-23.96569	22.46664
dProdFryHatchFrshWtrAkvaKultur	-.3293217	3.892271	-0.08	0.933	-7.960352	7.301709
dSrvcsFreshWaterAkvaKultur	-2.742038	27.45362	-0.10	0.920	-56.5665	51.08243

Appendix 8:

Regression estimates of Region dummy variables on firm's Operating Margin – Without Analytic Weights (Unweighted Model)

Source	SS	df	MS
Model	247729.28	18	13762.7378
Residual	47869612.4	3,971	12054.8004
Total	48117341.6	3,989	12062.5073

Number of obs	=	3,989
F(18, 3971)	=	1.14
Prob > F	=	0.3033
R-squared	=	0.0051
Adj R-squared	=	0.0006
Root MSE	=	109.79

OpsMargin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dAkershus	-3.271084	22.41168	-0.15	0.884	-47.21056	40.66839
dHordaland	-.5715342	3.562199	-0.16	0.873	-7.555445	6.412377
dBuskerud	.2797786	28.34878	0.01	0.992	-55.29975	55.85931
dNordland	-1.868675	4.058116	-0.46	0.645	-9.824862	6.087511
dFinnmark	-.1311834	9.592777	-0.01	0.989	-18.93841	18.67605
dTrøndelag	-4.673691	4.28023	-1.09	0.275	-13.06534	3.717963
dHedmark	-.3095295	30.45148	-0.01	0.992	-60.01152	59.39246
dMøreRomsdal	-.8526692	6.109121	-0.14	0.889	-12.82998	11.12464
dOppland	.168505	18.29906	0.01	0.993	-35.70793	36.04494
dOslo	-2.62263	19.40908	-0.14	0.893	-40.67533	35.43007
dØstfold	-.8192274	44.82336	-0.02	0.985	-88.69818	87.05972
dSognFjordane	-1.108947	5.234241	-0.21	0.832	-11.371	9.153104
dTelemark	-1.624962	17.811	-0.09	0.927	-36.54452	33.29459
dTroms	-.2816171	7.540707	-0.04	0.970	-15.06564	14.5024
dVestAgder	-10.27081	16.94164	-0.61	0.544	-43.48593	22.94431
dVestfold	.125803	38.81817	0.00	0.997	-75.9796	76.23121
dAustAgder	-5.520311	20.74918	-0.27	0.790	-46.20036	35.15974
dRogaland	-27.87785	6.469694	-4.31	0.000	-40.56208	-15.19361