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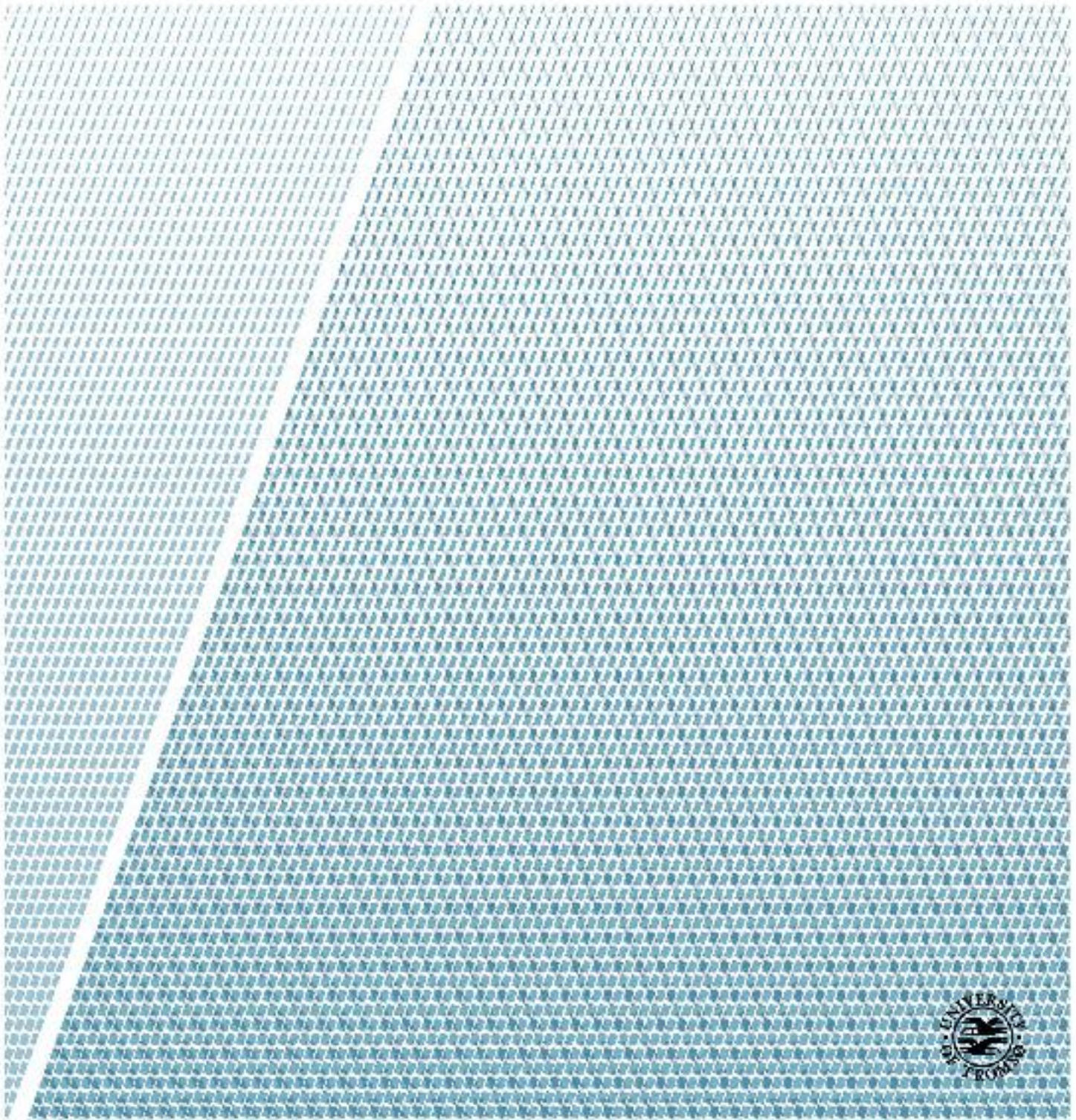THE ARCTIC
UNIVERSITY
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NORWEGIAN COLLEGE OF FISHERIES SCIENCE

The causal relationship between salmon prices and share prices.

Price analysis on the Oslo Stock Exchange.

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ACKNOWLEDGMENTS

ABSTRACT

Atlantic salmon ((*Salmo salar, Linneaus,1758*)) is a commodity traded globally and salmon exports are one of the main sources of income for Norway. Despite the great growth both in supply and the demand in the last decades, there is still a substantial variability in industry profits level and an important part of such variability is due to fluctuation in salmon prices. This Master Thesis analyse whether this fluctuation is cause of the variability in share prices, for salmon producer companies listed on the Oslo Stock Exchange (OSE) ,or by the contrary, if the fluctuation in share prices influences the salmon price oscillations. The companies analyzed were Marine harvest, Lerøy, Salmar and Cermaq, and the causal direction were tested using the Granger causality test. Overall, test results indicate that share prices have influence on salmon prices for Salmar, Marine Harvest and Lerøy. However, there is no a clear influence in the case of Cermaq. Analysing the other direction of causality, the salmon prices only influence the share prices for Salmar and Lerøy, but Marine Harvest and Cermaq are not affected by the salmon prices.

Key words: Salmon prices, share prices, causality, volatility, efficient market hypothesis.

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1. INTRODUCTION

The salmon farming industry in Norway has evolved during the last decades from a local small scale to a global industry (Forsberg and Guttormsen 2006). Commercial aquaculture started in the 1970's, since then it has become into a major industry in coastal areas. The geographic position of Norway and its natural attributes provide the ideal circumstances for fishery and aquaculture. This aspect enabled Norway to become the world's second largest exporter of fish and seafood products (FAO 2010). Intensive farming of Atlantic salmon *(Salmo salar, (Linnaeus, 1758))* is, by far, the most important activity, representing more than 80% of the total Norwegian aquaculture production (FAO 2013).

Atlantic salmon is a commodity traded globally, and it has experienced a substantial growth rate both in supply and demand during the last 30 years (FishPool 2013) The use of marine cages in farming industry enhanced to grow from 151 000 tonnes in 1990 to 1.3 million tonnes in 2012 (FAO 2013). Despite a minor downfall of the salmon market prices in 2012, the total first hand value reached NOK 31 billion in aquaculture industry. A total of 1.2 million tonnes, worth NOK 29 billion, were sold in 2012 (SSB 2013) . This makes salmon exports one of the major sources of incomes for Norway, excluding oil, gas and metals; and it is believed that there is still considerable potential for future growth (FAO 2013). However, there is a substantial variability in industry profit levels (Tveterås 1999)and an important part of this variability is due to fluctuation in prices (Oglend and Sikveland 2008). This has led to increase the speculative activity around commodities in recent years (FishPool 2013). Such variability is also reflected on Oslo Stock Exchange (OSE) which has become the world's largest and most important financial marketplace for the seafood sector (OSE 2013).

The aim of this study is to determine whether this fluctuation in salmon prices affects the prices in the stock market for salmon companies or, on the contrary, if share prices are sensitive by changes in the salmon farming price. In order to so, I have analyzed four different companies listed in OSE (SalMar ASA, Marine Harvest ASA, Cermaq ASA and Lerøy ASA).Finding the causal relation between both prices could allow for possible adoption of economic policies or regulations that could control the fluctuations. "It is also relevant to control this

volatility, specifically in commodities, since repercussions can be of great importance to food security, financial markets, trade flows, as well as distortions in the overall development of the exporting and importing economies of these commodities" (Doporto and Michelena 2011).

The results could also provide valuable information to stakeholders of the salmon industry (farming companies, investors, seller and buyers) and could help researchers to find better econometric specifications for the salmon price–stock price relationships. The price information could also be used for further studies in analyzing future stock price movements or price forecasting.

Some international organizations (OECD, FAO, IOSCO[1], and European Commission) have already studied the relationship between commodities and stock market prices, but the review of the literature is inconclusive. Some studies indicate that the volatility in commodity prices is due to speculative activity around them, some studies argue that speculative activity has not been decisive for this and other studies argue that the speculative activity is a symptom of price volatility and not its cause. In addition, in some studies the correlation is confused with causality (Doporto and Michelena 2011) .

As it is said *"Cum hoc ergo propter hoc",* this means, correlation does not imply causation. The fact that there is a correlation between A and B it does not mean that A causes B or vice versa. There may be other possibilities, such as: a third unknown factor that is the cause of the relationship between A and B, the relationship could be so complex and numerous that the facts are just coincidences or even B might be the cause of A and at the same time A is cause of B.

This study uses an econometric model in order to evaluate the causality between both prices. The analysis was performed using the Granger causality test.

The paper is organized as it follows: in the next section, I presented some theoretical considerations about the behaviour of salmon prices and stock prices. Section three consists of a brief description of the companies where the prices have been examined and information related to the data used for the analysis. In the

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[1] OECD, Organisation for Economic Cooperation and Development.
  FAO, Food and agriculture organization of the United Nations.
  IOSCO, International Organization of Securities Commission.

fourth section I present the econometric model carried out for the study. The results of the analysis are presented in section five and discussed in section six.

2. THEORY

2.1. Behaviour of Salmon prices

Norway has become the leading producer of salmon, with around the 40% of the total world production. Despite the impressive growth, the farming industry has experienced a high degree of turbulence and large variation in profitability. This has been manifested itself in many bankruptcies and a restructuration of the industry (Tveterås 1999). One important cause of this variability is fluctuation in prices Another factors could be: output price, stochastic shocks, firm heterogeneity in terms of the farm location and quality of management (Oglend and Sikveland 2008).

In the farming industry, when prices increase, farmers seek higher profits by boosting production and sales and the opposite when prices decline, in an attempt to wait for prices to increase. Salmon prices are determined (like all prices) by the law of supply and demand. There are periods of over and under supply which will cause prices to fluctuate. However, this is not always easy to control, since it depends on biological factors, such as: diseases or escapes. Biophysical conditions change during the year and between years and it can also affect the growth of the fish. For example, in average temperature, growth is best in August-September, but in warm summers, fish stop feeding and tends to a halt of the growth. The timing of production is particularly important (Forsberg and Guttormsen 2006). The farmer has to evaluate whether to harvest at that moment to sell the fish at a known price , or to maintain the production in order to get larger salmon, making a risk but not knowing the future price. Salmon in Norway usually reach sexual maturation during August-September and then their quality deteriorates rapidly (Oglend and Sikveland 2008). Stocking and harvesting decisions influence growth and profits. (Forsberg and Guttormsen 2006). Some at the factors that affect the demand are seasonality, changes in preferences and changes exchange rates in different markets, that will also contribute to the volatility of prices (Kinnucan and Myrland 2001). The lack of predictability makes it difficult for the buyers and sellers to plan their investments and operational activities in a longer time perspective. Hence, all the information that improves the decisions of the producers will have an important

value to make the production more profitable and increase the value of the company.(Forsberg and Guttormsen 2006)

The weekly trend of salmon prices used for this study can be observed in Figure 1.Measured week by week the spot price fluctuated between NOK 18, 17 per kg and NOK 44,60 per kg. The average price over these five years was NOK 29, 56. During the 2007-2009 period, salmon prices followed a rising trend, reaching a peak, at NOK 41, 38, during the last week of May 2009. After this period, the prices showed a decreasing trend, dropping to 25, 29 NOK by the middle of October 2009. Such trend fluctuates in an irregular way throughout the year 2010, reaching the maximum point (NOK 44, 60) in the end of December. In spring 2011, prices started to go down until plummeting to a minimum price of NOK 18, 17 in late October. From then on, prices have been swinging around an average of NOK 26, 81.
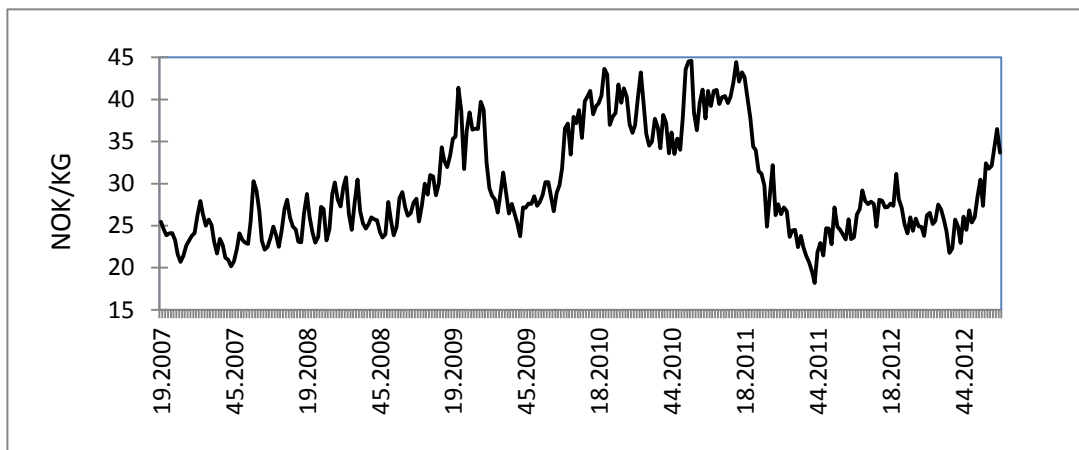
Figure 1. Weekly salmon prices, 19.2007- 5.2013.
*From week 19 in 2007 to week 5 in 2013

2.2. Efficient market hypothesis

"To what extent can the past history of a common stock price be used to make meaningful predictions concerning the future price?" As Eugene Fama wrote, this question has been contemplated for many years a source of controversy to academics and business circles. History repeats itself in that "patterns" of past price behaviour will tend to recur in the future (Fama 1965).

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According to the efficient market hypothesis (EMH), an "informationally" efficient market is one in which information is rapidly disseminated and reflected in prices (Fama 1969). The stock price incorporates all the information that is available about the company that issued them and about the market in general. If we assume there is a model that can predict future stock prices, investors would have countless benefits by buying the stocks which price will increase and by selling the ones will decrease. For example, if the model predicts that there will be a 10% increase in the price of the stock; all investors would buy these stocks. The effect would have an "instantaneous" jump in the price to 10%, so the stock price will immediately reflect the "good news" implicit in the model's forecast (Bodie, Kane and Marcus 2007).

Any information, new and unpredictable, that could be used to predict stock performance should already be reflected in the prices, which will also move randomly and unpredictably. If the information is positive, the price will rise and if it is negative, the price will go down. For this reason investors cannot "beat" the market consistently. Although economic agents had all the information to predict future movements the market will incorporate the information, leading to a state of equilibrium. Therefore the movement of security prices should be unpredictable in an efficient market. If stock prices movements were predictable, that would evidence stock market inefficiency, because the ability to predict prices would indicate that all the available information was no already reflected in stock prices (Bodie, kane et al. 2007) .

There are three versions of the EMH, depending on the type of information to be considered: the weak, semi-strong, and strong forms of the hypothesis:

- Weak form: stock prices already reflect all the information based in historical prices.
- Semi-strong form: Prices efficiently adjust to all public available information regarding to a firm (past prices, earning forecast, balance sheet).
- Strong-form: Stock prices disclose all information relevant to the firm, including the one only available to the company (Fama 1969).

3. DATA AND DESCRIPTION OF THE COMPANIES

3.1. Data

The data used in this study include historical information in both salmon farming prices and stock market prices which is available to public access. Some annual reports from 2012 were also used to describe the companies.

The data set include 300 weekly observations for salmon farming prices and for share prices of SalMar, Marine Harvest, Cermaq and Lerøy in Norwegian Kroner. Those have been measured over a period of time, from the week 19th in 2007 to week 5th in 2013. The weekly salmon prices were compiled by NOS Clearing[2] , a specialist clearing provider to the commodities markets. The daily share prices were taken from the OSE (Table 2). Those prices have been transformed by converting the daily stock data to a weekly average using IBM SPSS Statistics 21.

The company's ticker on this study is the same used in OSE: SALM for SalMar, MHG for Marine Harvest, CEQ for Cermaq and LSG for Lerøy.

Table 1. Minimum, maximum and average for Salmon prices and share prices 19.2007-5.2013

Prices	Minimum Value (NOK)	Maximum value (NOK)	Average (NOK)	Coefficient of variation (%)
P	18.17	44.60	29.56	21.22
SALM	22.40	67.50	45.55	22.97
MHG	0.95	7.10	5.76	26.28
CMQ	22.86	113.40	96.90	21.55
LSG	41.50	193.25	139.85	23.49

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[2] Historical data previous to week 18 in 2008 was calculated and set by FHL and NSL. Some of these older data is not 100% consistent. From week 18 in 2008, all prices have been calculated by NOS Clearing. From week 47 in 2009 a minor modification was done in the calculation procedure.

In the previous table is also showed the coefficient of variation, which measures the variability of a series of numbers and it is useful to compare distributions obtained with different units (Abdi 2010). All the prices fluctuate around 23% in average, compared to its mean. The company who has the highest volatility in share prices is Marine Harvest, followed by Lerøy, Salmar and Cermaq.

The descriptive statistics for share prices of the companies is shown in Figure 2. All the time-series appear to be wandering around a sample average which is nonzero with no discernible pattern or trend. The correlation between salmon price and every company is measured in a correlation matrix in table number 3 (Results, page 23).
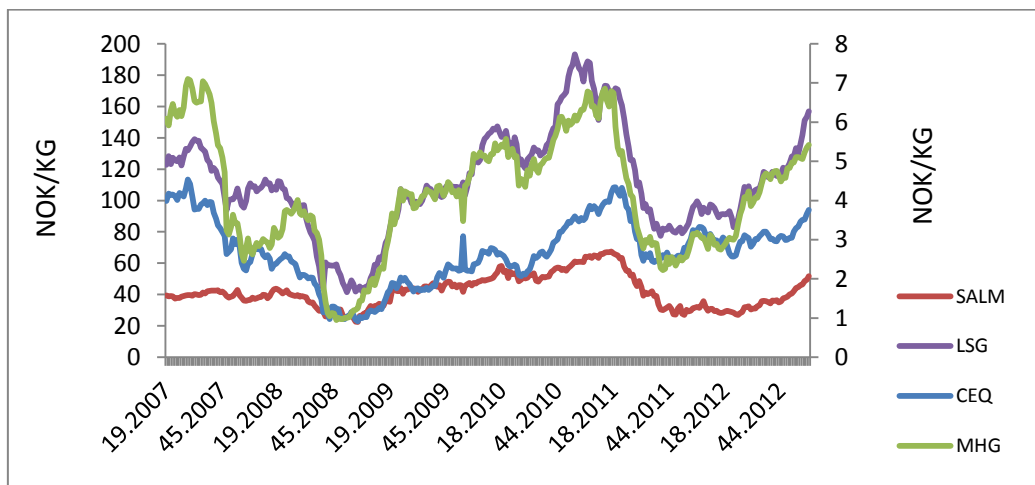
*MHG is represented in the secondary axis

Figure 2.Combined share prices for SALM, MHG; CEQ, LSG. 19.2007- 5.2013

3.2. Companies

The Oslo Seafood Index comprises a large number of companies with different characteristic and business concepts, from small businesses to the world's largest fish farming companies (OSE 2013). These companies have been chosen for being the most active and representative firms in the Oslo Seafood Index.

A brief description of the company is presented in the next section, referring to main activities, products and figures from financial reports of 2012 year.

3.2.1. Salmar ASA

Salmar is Norway's third largest producer of farmed Atlantic salmon. Since its fundation in 1991 Salmar has developed into a vertically integrated aquaculture enterprise. The firm has grown from a single company with a single licence to an international enterprise with 81 fish farming licences in Norway.

The activities of the company include hatchery production, farming, harvesting, processing of salmon and sales and distribution (SalMar 2013).

Salmar was listed at OSE on May 8, 2007. Throughout the years under study the value of its shares has been fluctuating between NOK 22.40 and NOK 67.40 with an average value at NOK 45.55 (Figure 3).
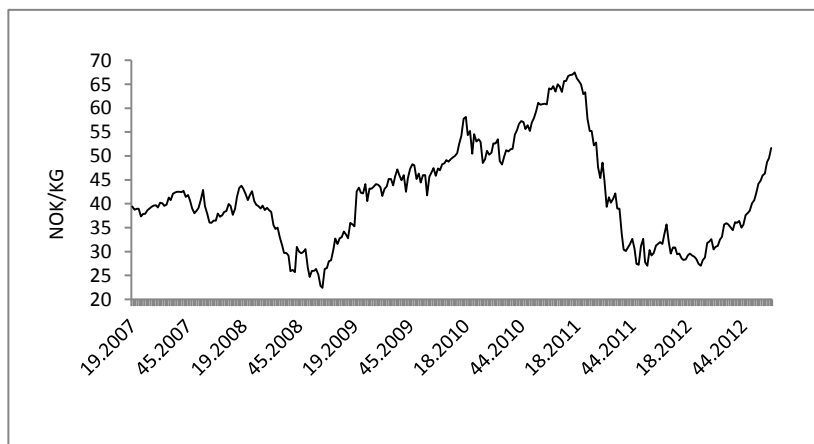
Figure 3. Weekly share prices for Salmar ASA, 19. 2007-5.2013

At the end of 2012 the company had 113 million outstanding shares, rating Salmar at NOK 5 065 million, meanwhile including approximately 1 900 shareholders (OSE 2013) .The Salmar Group generated gross operating revenues of NOK 4 205 million in 2012, a 10% more than in 2011. The Group also enlarged its harvested volume, which increased from 93 000 tonnes in 2011 to about 116 000 tonnes in 2012. The operational EBIT in 2012 (NOK 341 million) was lower than in 2011, largely as a result of lower salmon prices (Salmar, Annual report 2012). The report also reveals that the results of Salmar are closely aligned with movements in the price of salmon.

3.2.2. Marine Harvest ASA

Marine Harvest is the world's leading seafood company, present in 20 countries. It is the largest producer of farmed salmon and processed seafood to customers in more than 50 markets worldwide, yielding one fifth of the global production. The company is the result of the merge between Pan Fish ASA, Fjord Seafood ASA and Marine Harvest N.V. in 2006.

In Norway, Marine Harvest has farming, processing, distribution and sales activities. The main product for the company is salmon but they produce others species as: halibut, trout, haddock, redfish, cod and catfish. Marine Harvest Ingredients as well produce salmon byproducts (MarineHarvest 2013)

The company was listed in OSE in 1997 (as Pan Fish ASA). After week 19 in 2007, the value of its shares stood fluctuating between NOK 0,95 and NOK 7,10 with an average value at NOK 5,76 (Figure 4).
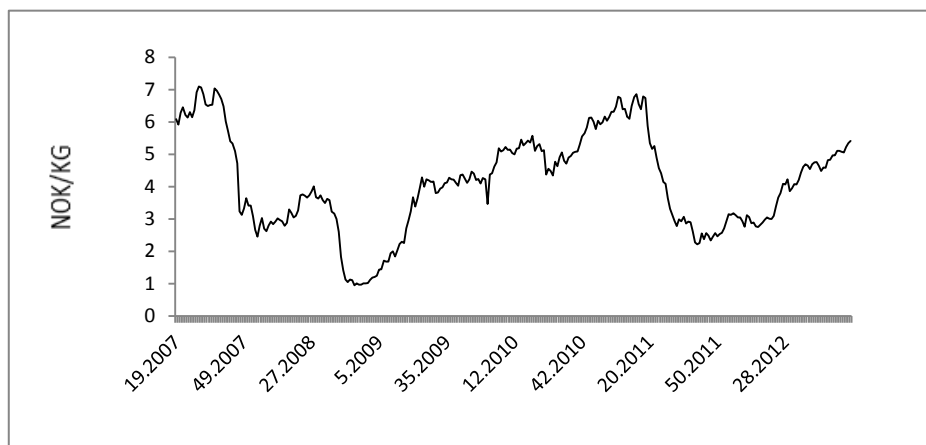
Figure 4. Weekly share prices for Marine Harvest ASA, 19.2007-5.2013

By August, the company had 3 748 341 597 shares outstanding. During 2012, the group had an operational revenue of NOK 15 569,3 millon, with its historical highest recorded harvest volume of salmonids at 392 306 tonnes (OSE 2013).

The operational EIBT was NOK 643 million for 2012 and the profit was NOK 412,6 million, mainly due to low market prices (Marine Harvest, annual report 2012).

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3.2.3. Cermaq ASA

Cermaq ASA was established as a grain trading company. In 1995 it was incorporated to the commercial activities of Statens Kornforretning (present Norwegian agriculture authority, SLF) and was demerged into a separate state-owned limited company then called Statkorn Holding ASA. At the same time Cermaq took over all shares in Stormøllen AS as well as the shares held by Statens Kornforretning in various smaller companies. Today the company is one of the global leading companies in farming of salmonids (Atlantic salmon, large Trout and Coho) and fish feed production[3] and produces (Cermaq 2013).

Cermaq has investments in companies which are not regarded as core business. It is incorporated and domiciled in Norway whose shares are publicly traded on OSE since 2005 (OSE 2013). Through the years under study the minimal value of its shares prices was NOK 22,86 with the maximum being NOK 113,40 and an average of NOK 96,90 (Figure 5).

Figure 5. Weekly share prices for Cermaq ASA, 19.2007-5.2013
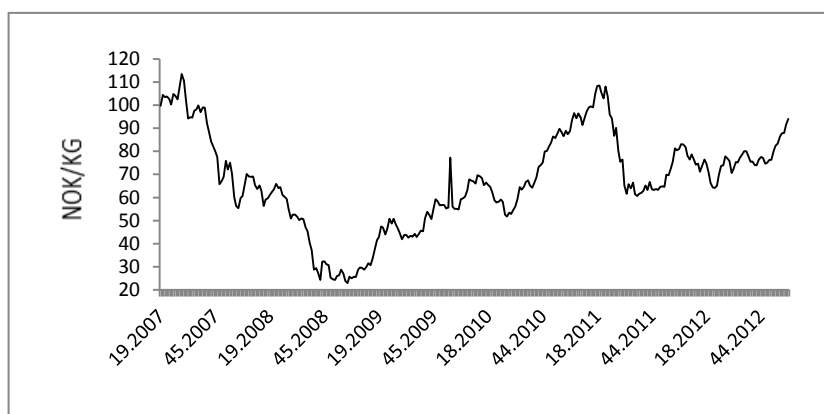
Currently the total number of shares issued by the company is NOK 92 million, By December 31, 2012 Cermaq ASA had 2.518 shareholders. The Norwegian State, represented by the Ministry of Trade and Industry, is the largest shareholder with a 43.5% stake, 32.6% of the shares are held by foreign investors.

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[3] The feed section of the company was sold in July 2013.

The operational revenues increased and for 2012 were NOK 11.781 millon. Operational EBIT has suffered a significant drop from the previous year from NOK 1 004 696 000 to NOK 308 769 000 in 2012 (Cemrmaq, annual report 2012).

3.2.4. Lerøy ASA

Lerøy Seafood Group is the leading exporter of seafood from Norway and the world's second largest producer of Atlantic salmon and Trout, and one of the world's largest seafood exporters. The Group's core activities are distribution, sale, marketing of seafood, processing of seafood, production of salmon, trout and other species, as well as product development. Until to 1997, the company was a traditional family company. In 1997, a private placing with financial investors was carried out for the first time and the company was reorganized as a public limited company and was listed on the Oslo stock exchange in June 2002 (Lerøy 2013). Since week 19 in 2007 the average value of its shares was NOK 41.50 with a maximum of NOK 193 and a minimum NOK 139.85 (Figure 6).
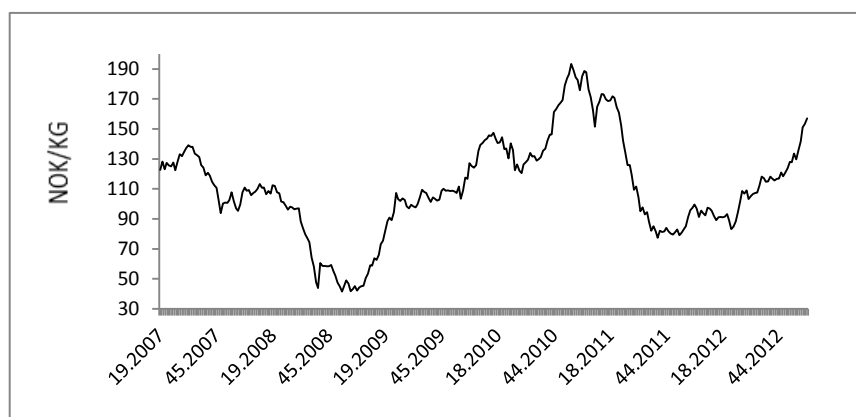
Figure 6. Weekly share prices for Lerøy ASA, 19. 2007- 5. 2013

In 2013 the number of shares outstanding is 54 millons with 1 344 shareholders. By the year 2012 Lerøy reported a turnover of NOK 9 102 million. The harvested volume increased by 11% from the previous year, reaching 153 000 tonnes (OSE 2013).

A summary of the main data of the companies is shown in table 1, highlighting the core business, main product, harvest volume, EBIT and operational revenues. All data has been reviewed in the last annual report provided for each company. Looking at the figure, Marine Harvest is by far the largest company, followed by Lerøy, Salmar and Cermaq. It should be noted that Salmar is the only company harvesting exclusively Salmon.

Table 2. Core business,product, havest volume, EBIT, operational revenues for Marine Harvest, Lerøy, SalMar and Cermaq.

	MARINE HARVEST	LERØY	SALMAR	CERMAQ
Core Business	Farming Harvesting Process Sales Distribution	Farming Harvesting Process Sales Distribution	Farming Harvesting Process Sales Distribution	Farming Feed production
Products	AtlanticSalmon Halibut Other species	AtlanticSalmon Trout Other species	AtlanticSalmon	AtlanticSalmon Trout CohoSalmon
Harvest Volume (GWT)	392 306	153 000	116 100	120 000
EBIT (NOK)	643,4	443,7	341	308
Operational revenues (NOK)	15 569	9 102	4 205	3 300 11 781*

*11.781million for fish farming and feed production, 3.300 million only for fish farming.

4. ECONOMETRIC PROCEDURE

Economic theory suggests many relationships between variables. Economist try to quantify such relationship by using a regression model. In a single equation regression model, the dependent variable (Y_t) is related to only one explanatory variable (X_t). Although this model is useful for a range of situations, in most economic models, there are two or more explanatory variables that influence the dependent (Y_t). This is called multiple regression model. (Hill, Griffiths et al. 2012) Even though regression analysis deals with the dependence of one variable on other variables, it does not necessarily imply causation (Domodar and Dawn 2009). It is important to highlight that "the dependence of a variable Y_t on another variable X_t ,rarely happens instantaneously, it is very often distributed over the time and Y_t responds to X_t with a time-lag (Domodar and Dawn 2009).

In our model of regression analysis involving time series data, it includes not only the current but also lagged (past) values of the explanatory variables. This is called an autoregressive distributed lag model (ARDL) (equation 1). That combines a lagged dependent variable (Y_{t-1}) as one of the explanatory variable and past values of an explanatory variable (X_{t-1}) (Hill, Griffiths et al. 2012)

(Eq.1) $$Y_t = f\left(Y_{t-1}, X_t, X_{t-1}, X_{t-2}, \dots\right)$$

In its general form, with p lags of Y_t and q lags of X_t, and ARDL (p,q) can be written as equation 2:

$$(Eq.\,2) \quad Y_t = \delta + \theta_1 \, Y_{t-1} + \cdots + \theta_p \, Y_{t-p} + \delta_0 X_t + \delta_1 X_{t-1} + \cdots + \delta_q X_{t-q} + \mu_t$$

Where, $\quad \delta = \beta_1(1-p)\,, \quad \delta_0 = \beta_2 \quad, \quad \delta_1 = -p\beta_2\,, \quad \theta_1 = p$

The number of lagged terms to be introduced in the model is an important practical question. There are a number of different criteria for choosing p and q. It is important to notice that the direction of causality may depend critically on the number of lagged terms included (Domodar and Dawn 2009).

We have used the Akaike Information Criteria (AIC) to make the choice of optimal lag (Stone 1979). Choosing p and q to minimize the sum of squared error (SSE) is subject to a penalty that increases the lag lengths as the number of parameters increase. So care must be taken to use the same number of observations. Unless special provision is made, the number of free observations used will typically decline as the lag length increase (Hill, Griffiths et al. 2012).

4.1. Granger causality

According to Granger, 1969, "a variable X_t causes a variable Y_t, if this variable Y_t can be predicted with greater accuracy by using past values of a variable X_t than by not using such past values, while all the others terms remain unchanged". Francis Diebold prefers use the term predictive causality and he explains: "Y_i contains useful information for prediction Y_j", over and above the past histories of the other variables in the system (Diebold 2001). As we have said before, the existence of a correlation between variables does not prove causality or the direction of influence. But, in regression involving time series data the situation may be different. If an event A happens before event B, then it is possible that A is causing B, but not the opposite. So event happening today could be caused by past events, that means past variables can contain useful information for predicting other variables (Domodar and Dawn 2009) This is the main concept behind the Granger causality test. The test is a statistical concept of granger- causality that is based on prediction. The analysis will be run in Shazam Environment 11.0[4] (Whistler, White et al. 2011).

The results from the estimations will indicate which factor determines the direction of the causality. There are three types of causality (Domodar and Dawn 2009):

-   If changes in salmon prices (share prices) granger- cause changes in stock prices (salmon prices), then a directional causality exists.

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[4] Software for econometrics, statistics and analytics.

- If changes in salmon prices granger- causes changes in stock prices, and vice versa, then a bilateral causality exists.
- The direction of granger-causality cannot be determined; in this case the time-series are independent of each other.

Therefore, I performed the test in two directions, stating two different null hypotheses and estimating the following regressions (equation 3 and equation 4):

(Eq. 3)
$$P_t = \sum_{i=1}^{n} \alpha_i \, X_{i,t-j} + \sum_{j=1}^{n} \beta_j \, P_{t-j} + \mu_t$$

H_0 *: Share prices do not Granger-Cause salmon prices*
H_1 *: Share prices Granger-Cause salmon prices*

(Eq. 4)
$$X_t = \sum_{i=1}^{n} \delta_i \, X_{i,t-j} + \sum_{j=1}^{n} \lambda_j \, P_{t-j} + \varepsilon_t$$

H_0 *: Salmon prices do not Granger-Cause share prices*
H_1 *: Salmon prices Granger-Cause share prices*

Where X_i is the share price for *i= SALM, MHG, CEQ, LSG* and *P* the salmon price.

Equation 3 postulates that current salmon price is related to its past values, and also to past values of share prices for Salmar, Marine Harvest, Cermaq and Lerøy respectively.

Equation 4 state that current share prices for Salmar, Marine Harvest, Cermaq and Lerøy are related to its past values and also to past values of salmon prices.

Before running the Granger test, a unit root test was used to determine whether the economic variables are stationary or non-stationary. Non-stationary

nature of the variables imply that they have means that change over time. If variables do not have unit roots, it is possible to conduct the Granger test. However, if the variables have unit roots, one can make the data stationary by taking the first-difference, as is shown in equation 5 (Hill, Griffiths et al. 2012).

$$(Eq. 5) \qquad \Delta P_t = \sum_{i=1}^{n} \alpha_i X_{i,t-j} + \sum_{j=1}^{n} \beta_j \Delta P_{t-j} + \mu_t$$

In the case that the data are non-stationary, one can also transform the variables into natural logarithms, because the transformation tends to produce constant variances when the variables have exponential growths and the variability increases over time (Lütkepohl and Xu 2012). We should note that if we use non-stationary variables, spurious relationships may occur.

In this study I have tested the unit roots with both level data and data transformed into natural logarithms. Once the Granger-causality test has been run, I have performed the test of stationary of the residuals, to check if the model was well specified.

4.1.1. Unit root test

There are several tests for determining stationary. The most popular and the one used here is the Dickey-Fuller (D-F) test. There are three variations of the test depending weather the stochastic process include or exclude a constant term or a time trend (Hill, Griffiths et al. 2012):

- Dickey-fuller Test 1; no constant and no trend.
- Dickey-fuller Test 2; with constant but no trend.
- Dickey-fuller Test 3; with constant with trend.

Based on a visual inspection of the time-series in the figures 1,3,4,5 and 6 in the data section, we can assume for the D-F test, a test with constant but no trend (Equation 6).

Eq. 6 $$\Delta Y_t = \alpha + \gamma Y_{t-1} + \nu_t$$

Our null and alternative hypotheses for the D-F test are:

$$H_o = The\ series\ is\ nonstationary\ (\gamma = 0)$$
$$H_1 = The\ series\ is\ stationary\ (\gamma > 0)$$

If we do not reject the null hypothesis that $\gamma = 0$, we conclude that the series is stationary. If we reject the null hypothesis that $\gamma = 0$, we conclude that the series is stationary.

The results of the test with level data are shown in table 4, in the next section. The same test was carried out with data transformed to natural logs, but the series also had unit root. Therefore we run the test again by taking the first difference; the results are shown in table 5.

4.1.2. Granger causality test

For the Granger test, time lags were chosen based on AIC. In general terms, the model with the smallest AIC is preferred (Hill, Griffiths et al. 2012). However, all the p-values for the F-test were checked for each variable and the lowest p-value were chosen, prevailing above the lowest AIC. In this case, it has been searching along 20 different lag structures. The numbers of lags are shown in Table 6 with the results for the Granger causality test.

4.1.3. Cointegration

The test for cointegration is a test of the stationary of the residuals. As I have mentioned earlier, if the time-series are nonstationary, it should not be used in the regression model, to avoid spurious relations. But there is an exception, if Y_t and X_t are nonstationary I(1) , then we expect a linear combination of them from a long term relationship. Therefore, if the residuals are stationary I(0), then Y_t and X_t are said to be cointegrated; if the residuals are nonstationary, then Y_t and X_t are not cointegrated and any apparent regression relationship between them is said to

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be spurious (Domodar and Dawn 2009).The results for the cointegration test is shown in Table 8.

The null and alternative hypotheses for the cointegration test are:

H_o = The series are not cointegrated → residuals (e_t) are nonstationary.
H_1 = The series are cointegrated → residuals (e_t) are stationary.

5. RESULTS

Correlation expresses the strength of the relationship between two variables on a scaling ranging from -1 to 1. "A strong correlation indicates a strong positive relationship, in which a increase in the value of one variable implies an increase in the value of the second variable. A negative correlation indicates that an increase in the first variable signals a decrease in the second variable" (Berk and Carey 2010).

In table 3 we can see the Pearson's correlation between salmon prices and share prices for the companies and the descriptive statistic is shown in Figures 7,8,9 and 10. For all the companies the correlation is positive. The highest correlation happens for Salmar (0,735). For Lerøy and Marine Harvest the correlation is lower but strong (0,57 and 0,43 respectively). On the contrary, salmon prices and share prices for Cermaq are weakly correlated (0,076). If we look at the relationship between companies, we can confirm that all of them are quite correlated, as we observed in figure 2. The values of Pearson's show that there is a high correlation between the prices of the shares of all companies, varying between 088 and 0.73, except between Salmar and Cermaq (0.459) for which the relationship is not as strong.

Table 3. Values of Pearson's correlation for all the variables.

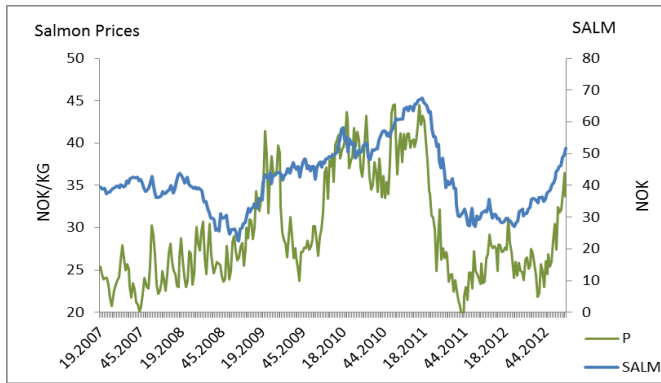|	P	SALM	MHG	CEQ	LSG
P	1,000	0,735	0,435	0,076	0,579
SALM		1,000	0,739	0,459	0,869
MHG			1,000	0,755	0,884
CEQ				1,000	0,751
LSG					1,000

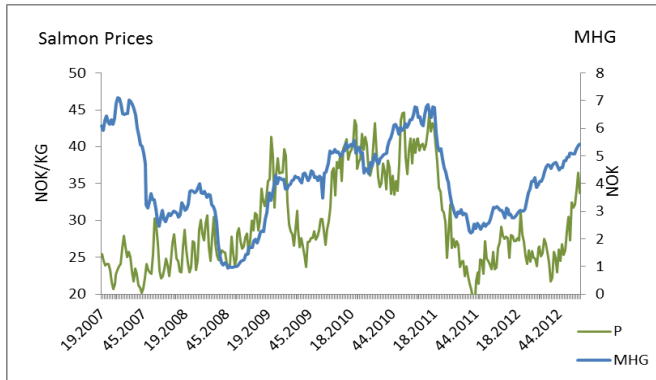Figure 7. Time - series of stock prices for Salmar and salmon prices.

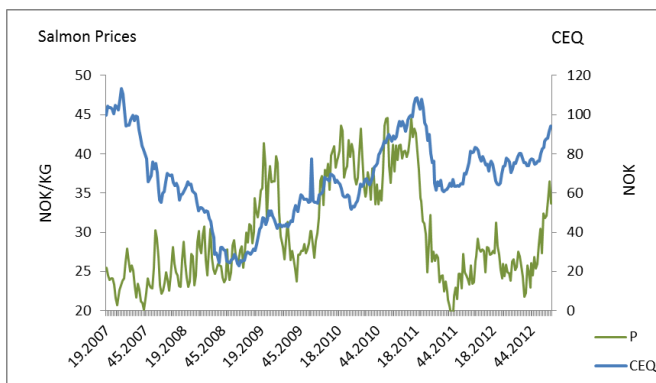Figure 8. Time - series of stock prices for Marine Harvest and salmon prices.

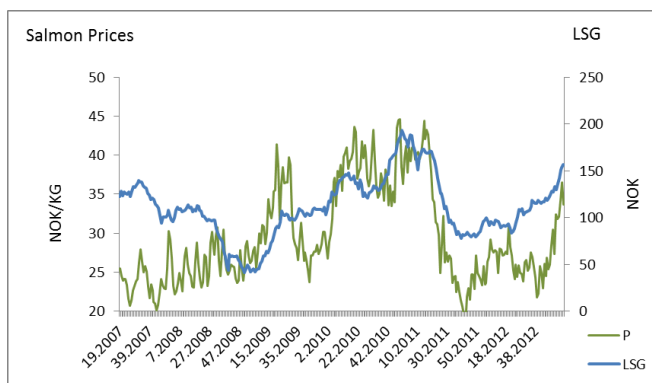Figure 9.Time - series of stock prices for Cermaq and salmon prices

Figure 10.Time - series of stock prices for Lerøy and salmon prices

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The results for D-F test, conducted with level data, are reported in Table 4. I do not reject the null hypothesis of nonstationary at the 10% significance level; the series has unit root.

Table 4. Results of unit root test with level data.

Variables	τ (tau)	Critical value	Unit Root
P	-2.25	-2.57	Yes
SALM	-1.59	-2.57	Yes
MHG	-2.33	-2.57	Yes
CEQ	-1.59	-2.57	Yes
LSG	-2.36	-2.57	Yes

Note: 10 % of significant level

Therefore, I cannot perform the Granger-test, so I run the test again by taking the first difference (Table 5). In this case our time series did not has unit root, hence we can reject our null hypothesis of nonstationary at the 10% significance level. Granger causality test can be performed at first difference I(0) (equation 5).

Table 5. Results of Unit Root Test with First-Differenced DataTable 5: Results of Unit Root Test with First-Differenced Data

Variables	τ (tau)	Critical value	Unit Root
P	-5.10	-2.57	No
SALM	-3.95	-2.57	No
MHG	-4.17	-2.57	No
CEQ	-4.25	-2.57	No
LSG	-3.50	-2.57	No

Note: 10 % of significant level

Once I made the variables stationary by taking the first difference, the Granger test was performed. Table 6 shows the results for granger-causality between both series, reporting the null hypothesis for the variable under considerations, the lagged terms introduced in the causality test for the dependent (Y_t) and independent variable (X_t).

Table 6. Results of the Granger causality test

Hypothesis	Lags (Y_t)	Lags (X_t)	F-value	Decision
H_o :SALM does not GC P	4	4	4.91	Reject H_o
H_o : P does not GC SALM	2	2	5.27	Reject H_o
H_o : MHG does not GC P	3	3	5.65	Reject H_o
H_o : P does not GC MHG	6	2	2.16	Do not reject H_o
H_o : CEQ does not CG P	3	2	1.88	Do not reject H_o
H_o : P does not GC CEQ	1	1	2.01	Do not reject H_o
H_o : LSG does not GC P	3	2	6.84	Reject H_o
H_o : P does not GC LSG	8	16	1.77	Reject H_o

Note: 5 % of significant level. GC: Granger-Cause

In the case of Salmar, the result provides an evidence of a strong relationship between both prices, revealing bidirectional Granger-Causality. The causality flows from salmon prices to share prices and from share prices to salmon prices. For Marine Harvest, the results show that there is Granger-causality from stock prices to salmon prices, but not the opposite. There is no causality between salmon prices and stock prices for Cermaq in none direction. The set of series are not statistically significant in either of the regressions for this company. In case of Lerøy, there is also a strong relationship between both time-series. The result reveals a bilateral granger-causality for the prices. Table 7 shows a summary of the causalities between the series.

Table 7. Summary of Causality test

	SALM	MHG	CEQ	LSG
Share prices GC Salmon prices	✓	✓	✗	✓
Salmon prices GC Share prices	✓	✗	✗	✓

Note: GC= Granger-cause

The results for the cointegration test (Table 8) show the residuals are stationary. The null hypothesis of no cointegration at 10% level of significance has been refused. This implies that the series, Y_t and X_t are cointegrated, so they share similar stochastic trends. It means that estimated regression relationship between salmon prices and share prices is valid and not spurious (Hill, Griffiths et al. 2012).

Table 8. Results for cointegration test

Variables	$\tau\ (tau)$	*Critical value*	*Cointegration*
P= f(SALM,P)	*-4.96*	*-2.57*	*Yes*
SALM=f(SALM,P)	*-3.13*	*-2.57*	*Yes*
P=f(MHG,P)	*-5.08*	*-2.57*	*Yes*
MHG=f(MHG,P)	*-4.30*	*-2.57*	*Yes*
P=f(CEQ,P)	*-5.23*	*-2.57*	*Yes*
CEQ=f(CEQ,P)	*-4.53*	*-2.57*	*Yes*
P=f(LSG,P)	*-5.35*	*-2.57*	*Yes*
LSG=f(LSG,P)	*-4.61*	*-2.57*	*Yes*

Note: 10 % of significant level

6. DISCUSSION

Changes in share prices may be caused by several factors: political factors, economical events, company earnings reports, transactions conducted by largest banks, changes in economic policies, etc. But how does the salmon price affect to share prices? As it has been mentioned earlier, the fluctuating commodity prices could have an impact on corporate profits.

In this section, I discuss how salmon prices can affect share prices and vice versa, based on the results obtained in the previous section.

As it has been explained on the efficient market hypothesis (EMH), stock prices seems to follow a "random walk", with no predictable patterns for investors to follow, and they include information about the company. According to the results, the share prices have some influence on salmon prices for Salmar, Marine Harvest and Lerøy. However, I did not find a clear influence in the case of Cermaq. This can be related with the size of the companies; Marine Harvest is Norway's largest producer of Atlantic salmon, yielding one fifth of the global production; followed by Lerøy, Salmar and Cermarq respectively. This can also be confirmed by looking at their operating revenues. The bigger the company, the more stakeholders will be watching the information belonging to the company. Investors will buy or sell shares depending on the information concerning to it. This will cause the share prices to fluctuate and consequently the company profits. As has been demonstrated in this study, largest companies also happen to be the most volatile companies, Marine Harvest being the most variable, followed by Leroy, Salmar and Cermaq. It could be illustrated in the next example; supposing that there is an outbreak of an infectious disease in a minor fish farming company, which forces them to slaughter a substantial percentage (if not all) the individuals. In order to account for the economic loss this might cause, there will be a drastic increase in prices. As it is explained on the EMH, the stock price changes in response to the new information, but being a small company with little repercussion (referring to stakeholders) the change taking place in the whole stock market would be inconsiderable. Therefore, according to the results we can conclude that large companies in the stock market could have capabilities to influence commodity prices, causing them to follow the same trend, bearish or bullish. On the other hand,

Cermaq has a more reduced ability to influence the market, resulting in a more random stock market fluctuation.

If we analyse the other direction of causality, we see that salmon prices only have influence on the share prices of Salmar and Lerøy, However, Marine Harvest and Cermaq are not as strongly affected by the salmon prices. Returning to the topic of the size of the company, and having said that within the analysed companies, Marine Harvest is the company with the biggest weight in global production of salmon, and therefore with more stakeholders interest in it, I can guess that the fluctuations in share prices are not going to be just causes by salmon price, but also for others factors affecting the company.

A possible explanation that can be given to this result in Cermaq is the diversification of the company's activities. Whilst the main activity for Salmar, Lerøy and Marine Harvest is farming salmon, Cermaq is also dedicated to fish feed production. These two activities make up the value of the enterprise and this is reflect in the stock market, but on the other hand, we are just analysing the salmon price, so this could make the result not be very representative or the link between the two prices to be weak. Therefore it is logical that the price does not impact equally on the share price.

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