Common and Fundamental Risk Factors in Shareholder Returns of Norwegian Salmon Producing Companies

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Abstract

Salmon farming companies are increasingly gaining attention from investors and portfolio managers. The last decade has seen a substantial growth in the securitization of salmon farming assets and prices. A growing literature demonstrates that industry-specific fundamental, as well as market-wide risk factors help explain stock returns. However, very little is known about the pricing of salmon stocks and especially the contribution of industry-specific fundamental risk factors. Using a multifactor model, we find that stock returns for salmon farming firms are significantly associated with both common market-wide risks and industry-specific risk factors.

Keywords: Atlantic salmon production, salmon company valuation, stock returns, risk factors, salmon price.

JEL codes: G12, G31, Q02, Q14, Q22

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1. Introduction

This paper examines the determinants of salmon farming company stock prices returns. Knowledge about the risk and return of salmon producers is essential for investors and other stakeholders, and can provide insight into the determinants of the cost of capital, which is a crucial input to any investment decision. Textbook asset pricing models, such as the capital asset pricing model (CAPM), assert that stock returns should only explained by marked-wide common risks. However, a growing literature has demonstrated that industry-specific common factors may also play a role in explaining historical returns (Kavussanos and Marcoulis 1997; Faff and Chan 1998; Henriques and Sadorsky 2001; Sadorsky 2001; Hammoudeh, Dibougloo, and Aleisa 2003; Boyer and Filion 2007; Tjaaland et al. 2016). For instance, Boyer and Filion (2007) find that common market and macroeconomic factors as well as fundamental risk factors are significantly associated with oil stock returns. So what about the salmon industry? Are there fundamental risk factors that can affect the returns on financial salmon securities? A recent study demonstrates that the prices of a different type of salmon market security, namely futures contracts on the Fish Pool Exchange, are affected by industry specific risk factors (Asche, Misund, and Oglend 2016b). Turning to the salmon farming equity market, very little is known about the risk factors that determine the risk and return of salmon equities. An interesting research question emerges: Are the risk factors identified by Asche, Misund, and Oglend (2016b) for a related financial market, also instrumental in determining the return and risk of salmon stock prices? This is important information for investors in salmon stocks, and potentially other seafood stocks as well.

The dataset contains ten salmon companies listed on the Oslo Stock Exchange in Norway, and comprises the majority of listed salmon producing firms globally. Monthly returns, from 2006 to 2016, on both individual salmon farming company stock prices, and on an equally-weighted portfolio, are regressed on a set of market-wide and industry-specific common factors. The market-wide macro factors include the market excess returns, the Fama-French-Carhart risk factors, returns on the NOK/EUR and NOK/USD exchange rates, and changes in the Brent blend crude oil price. In addition, a set of fundamental factors potentially affecting only salmon companies, such as the salmon price and shocks in biomass, harvest and seawater temperature, are included as sources of industry-specific risks.

The results demonstrate that the market-wide macro factors are the most important determinants of salmon firm total shareholder returns. Moreover, our results also suggest that returns are also sensitive to changes in industry-specific risk factors, such as the salmon price and deviations in harvested amounts.

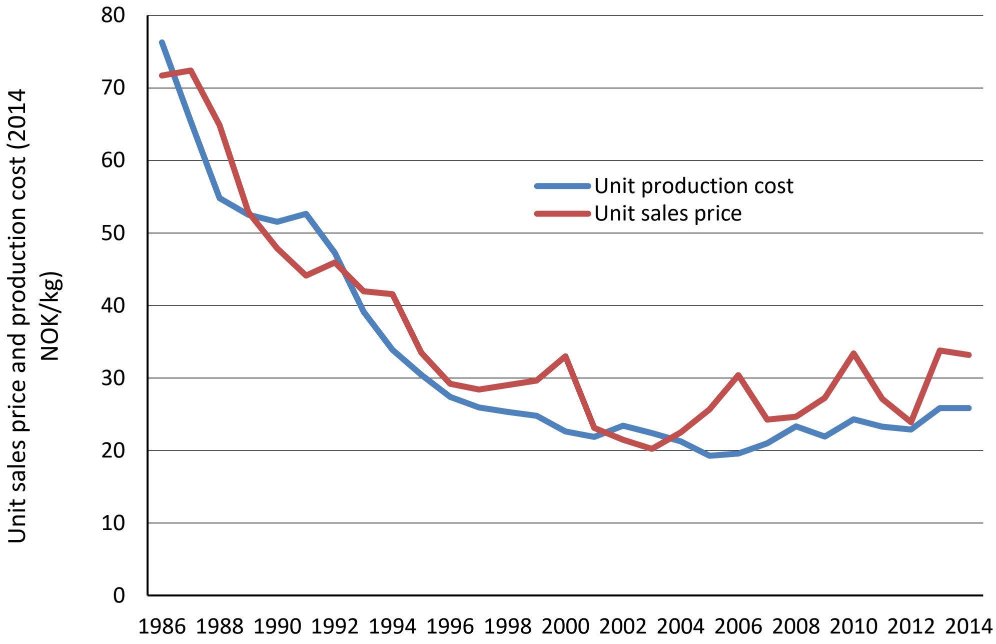
This study highlights the importance of including fundamental factors when examining the drivers of returns of companies in a particular industry. We contribute to a growing literature demonstrating the importance of using industry-specific common factors when assessing the determinants of shareholder returns. The results could be of interest to investors and analysts in the seafood sector in their endeavours to price salmon stocks.

The remainder of the paper is structured as follows. The next section describes the securitization of farmed salmon assets over the last decade, followed by a literature review. Then, we describe the empirical methodology, the variables, and the data sample. This is followed by a presentation of results and discussion. The final section concludes the findings.

The securitization of salmon companies and salmon prices

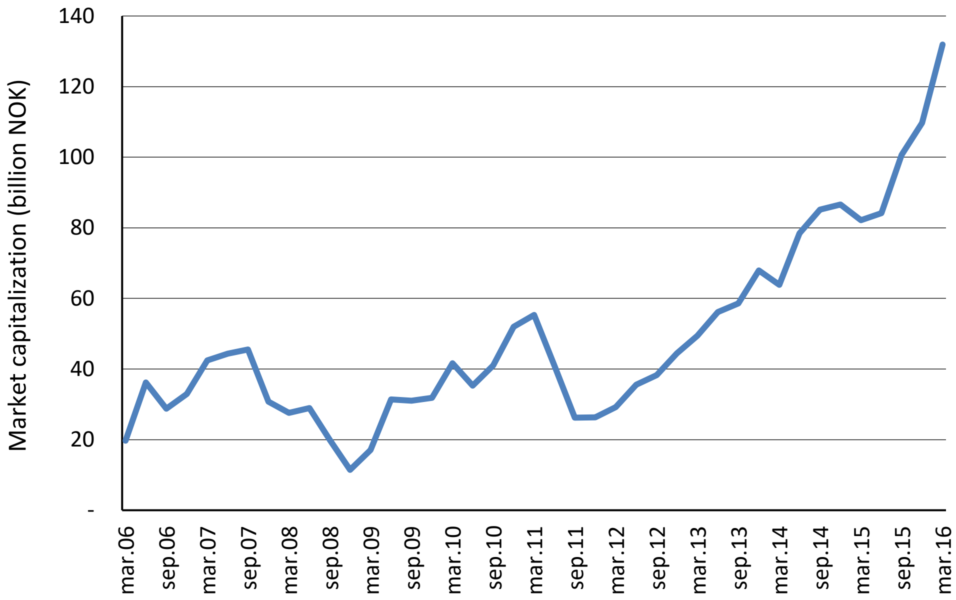
The Norwegian salmon industry has experienced a substantial growth since its inception in the late 1960s. Over the last 25 years, the production of Atlantic salmon (*Salmo salar*) has grown by more than 600% (Marine Harvest 2015), and is expected to continue to grow also in the future (Kobayashi *et al.* 2015). In 2014, the global harvested quantity of Atlantic salmon was approximately 2 million metric tonnes gutted weight. At an average sales price of ~4 EUR/kg for 2014, the monetary value of this production is approximately 8 billion Euros. Substantial productivity improvements during the 1980s and 1990s, resulting in a steady decrease in unit production costs, has laid the foundation for this rapid production growth for farmed salmon (Asche 1997; Guttormsen 2002; Tveterås and Heshmati 2002; Asche, Roll, and Tveteras 2007; Asche 2008; Nilsen 2010; Vassdal and Holst 2011; Asche, Guttormsen, and Nielsen 2013; Roll 2013), in combination with a considerable demand growth (Asche *et al.* 2011; Xie and Myrland 2011; Brækkan and Thyholdt 2014; Brækkan 2014). This period of high productivity growth lasted until the early-2000s. Productivity growth has since slowed down, and the industry has matured, consisting of fewer and larger companies, and the production has become more feed intensive (Kvaløy and Tveteras 2008; Olsson and Criddle 2008; Asche *et al.* 2013). The deceleration in productivity growth been attributed to the assimilation of the most obvious innovations and knowledge transfers, and that the unit production cost and sales price for Norwegian salmon has gone from being productivity driven to input-factor price driven (Asche and Oglend 2016). The impact of the changing productivity growth on production costs and wholesale prices of salmon can be discerned from Figure 1, which clearly shows a shift in the early 2000s. The implications of this development are that the price and risks of input-factors, such as the large global commodities wheat and soybean, which may be affected by common macroeconomic factors, may now to a greater extent influence the price of salmon, and possibly also the valuation of salmon firms.

Figure 1: Development of salmon prices and costs



The recent decade has also seen an increased interest in the salmon farming industry from financial analysts, investors, and portfolio managers. The emergence of market places for risk management and trading of financial securities linked to salmon assets has facilitated this development. The Oslo Stock Exchange has evolved as the major hub for trading of salmon firm stocks and indices, and related financial derivatives. In the recent two decades, several fish farmers have been listed on the Oslo Stock Exchange, with a particular sharp increase in total market capitalization of salmon equities over the last five years, from approximately 20-50 billion NOK in 2006-2012, to above 130 billion NOK in 2016 (Figure 2). The increase can be explained by an increase in the number of listed salmon farmers, as well as the impact on share prices of superior profits in recent years.

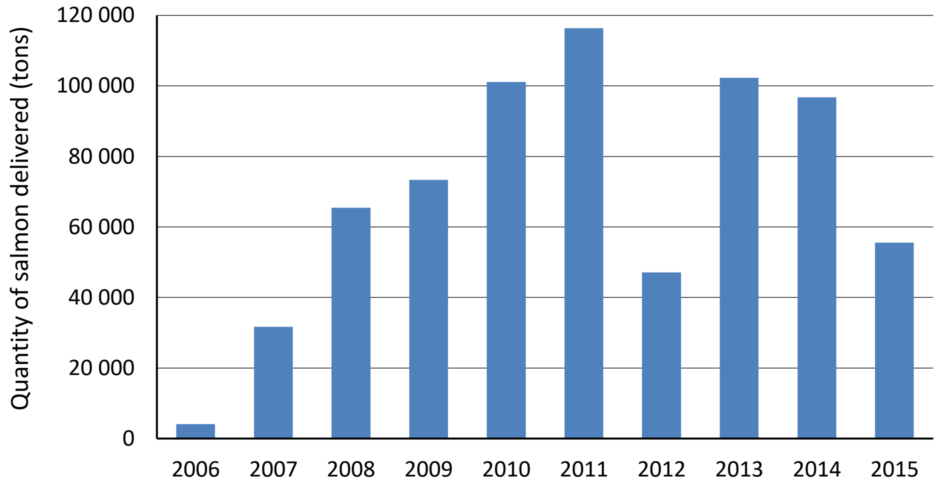
Figure 2: The development of salmon farming firm stock volume, and price of a portfolio of equally-weighted salmon farming firm stocks on the Oslo Stock Exchange.



Note. Data source: Datastream. The total market capitalization is calculated as the sum of the market values of equity for eight of the largest salmon farming firms on the Oslo Stock Exchange from January 2006 to March 2016. The number of companies included in the total has changed as more companies have been listed.

Meanwhile, the Fish Pool exchange has emerged as the primary market place for trading of derivatives on the spot price of salmon. In 2005, the Fish Pool Exchange was established as a market place for the trading and clearing of financial derivatives, such as forwards, futures and options, on the spot price of Norwegian Atlantic salmon. In 2012, the Oslo stock Exchange acquired a major stake in Fish Pool. While trading at Fish Pool grew rapidly in the first six years after inception, the trading volume has since stagnated (Figure 3). Nevertheless, the Fish Pool/Oslo Stock Exchange nexus remains the primary trading place for financial seafood securities.

Figure 3: Development of salmon derivatives traded on Fish Pool.



Note. Trading volume, in metric tons of salmon, for the Fish Pool Exchange 2006-2015. Source: www.fishpool.eu.

Literature

This section describes the relevant literature. First, we review the extant literature on salmon farming risks and economics, as well as insights provided by previous cross-sectional and industry-specific studies in other industries, and discuss how these studies can aid in the identification of relevant fundamental risk factors we can use in the empirical models.

Salmon farming risks: market and operational source of risk

Although the Norwegian salmon industry has been a success story in terms of profitability and growth, production of salmon is still associated with substantial risks, both market risks and operational risks. One thread of the literature has examined issues related to market price risks. Several studies have demonstrated that the salmon price is volatile (Oglend and Sikveland 2008; Solibakke 2012; Oglend 2013, Dahl and Oglend 2014; Bloznelis 2016), contributing substantially to a salmon farmer's risk. Since salmon prices are the main driver for salmon farming profitability (Asche and Sikveland 2015), market volatility should lead to earnings volatility, and ultimately influence the financial status of the salmon producers. A recent study demonstrates that periods of reduced profitability due to lower output prices increases the risk of corporate failure for salmon farming firms (Misund 2016b).

A second thread of the literature investigates a multitude of operational risks that salmon farming firms face. The production cycle for farmed salmonids such as *Salmo salar* (Atlantic salmon) encompasses several stages. First, roe is produced from sexually mature salmon. The roe are hatched, followed by a fresh water juvenile stage. After some months, the juveniles undergo a metamorphosis process called smoltification, which allow the fish to survive in salt water. The smolts are subsequently transferred to sea water pens, whereafter they are intensively fed over a period of 16-24 months until they reach marketable size (3-8 kilogrammes). The fish are starved for a short period of time prior to being harvested, processed, transported, and sold to wholesale and retail markets. The quantity and quality of farmed salmon is highly dependent on key technological, environmental and physiological factors. A strand of the literature has addressed improvements in productivity that the Norwegian salmon industry has witnessed (Guttormsen 2002; Tveterås and Heshmati 2002; Forsberg and Guttormsen 2006; Asche, Roll, and Tveteras 2007; Asche 2008; Nilsen 2010; Vassdal and Holst 2011; Asche, Guttormsen, and Nielsen 2013; Roll 2013). The industry has also become more concentrated through a series of horizontal and vertical mergers (Tveteras 2002; Kvaløy and Tveteras 2008; Olson & Criddle 2008; Oglend and Tveteras 2009; Asche *et al.* 2013). The result is that ~70% of production in the major salmon producing countries is controlled by ~5-10 firms in each country. This asymmetric distribution of production has an impact on the number of exchange listed salmon farming companies we have been able to collect data from.

Moreover, the salmon growth rate is also dependent on factors such as fish size, feed amounts, feed conversion rates, seawater temperature and quality, season, and photoperiod manipulation, topics which have been addressed by biologists (see e.g. Jobling 1994; 2008). In particular, fish health has been highlighted as a substantial key production risk (Asche, Guttormsen, and Tveteras 1999; Tveteras 1999; Torrisen *et al.* 2011; 2013).

Are all risks priced by investors?

Although the salmon farmer is exposed to a wide range of market and operational risks, the investor might not be concerned with the same risks. Recent studies on another financial asset catering to the salmon farming industry, i.e. salmon futures prices, might provide a clue as to which risks inherent in salmon farming are relevant for investors. A recent and growing literature has examined the properties of Fish Pool salmon futures, including volatility modelling (Solibakke 2012), price discovery (Asche, Misund, and Oglend 2016a; Ankamah-Yeboah, Nielsen, and Nielsen 2016), hedging effectiveness (Misund and Asche 2016), convenience yield (Asche, Oglend, and Zhang 2015; Ewald *et al.* 2016), and risk premium (Asche, Misund, and Oglend 2016b). Ewald and Salehi (2015) demonstrate the importance of including salmon price returns when explaining the returns on salmon farming stock prices. They find that changes in the salmon futures price could help explain the returns on two major salmon farming companies. Asche, Oglend, and Zhang (2015) find that the convenience yield for salmon futures is determined by inventory, fish stock growth, and seawater temperature. The influence of inventory, and especially shocks in inventory, on the salmon futures risk premium, is also demonstrated by Asche, Misund, and Oglend (2016b). These studies generally suggest that fundamental risk factors associated with shocks in salmon inventory, as well as product prices, are important for investors in the futures prices. Whether these risk factors are also relevant for investors in salmon stocks is an empirical question.

While some studies address the valuation of the individual fish farms (e.g. Ewald, Ouyang, and Siu 2016), very few studies have investigated the stock market valuation of salmon companies. Misund (2016a) investigates the relationship between accounting information and salmon company valuation and finds that information in financial statements are important determinants of share prices, but did not specifically address the determinants of salmon farming company returns. Zhang, Myrland, and Xie (2016) examined the correlation between salmon firms listed on the Oslo Stock Exchange, and how that correlation was affected by firm size and salmon spot price. Ewald and Salehi (2015) examine the relevance of asset pricing models on Fish Pool futures returns, as well as the impact of futures maturities on the stock of two major salmon farming companies. The latter study applies single- and multifactor asset pricing models (common risk factors) to examine the returns on Fish Pool futures. No study has to date investigated the impact of common and fundamental risk factors and salmon company shareholder returns. Our study aims to fill this gap in the literature. To investigate the determinants of salmon firm returns, our study includes several common risk factors as well as more industry-specific risk factors. The importance of these risk factors have been demonstrated by several researchers, and is the topic of the next section.

The importance of industry-specific risk factors

While the formal asset pricing models such as the CAPM (Treynor 1961, 2008; Sharpe 1964; Lintner 1965a, 1965b, Mossin 1966) and the Fama-French Carhart (Fama and French 1992, 1993; Carhart 1997) model are constructed for the stock market at an aggregate level, a growing literature is also addressing the impact on returns of industry-specific risk factors. Several studies demonstrate that industry-specific information are determinants of stock returns (Kavussanos and Marcoulis 1997; Faff and Chan 1998; Henriques and Sadorsky 2001; Sadorsky 2001; Hammoudeh, Dibooglou and Aleisa 2004; Boyer and Filion 2007; Kretzschmar and Kirchner 2009; Tjaaland et al. 2016). The general impression from these studies suggest that both market-wide macro risks, as well as industry-specific risks are determinants of commodity stock returns. Boyer and Filion (2007) include common and fundamental factors in their analysis of Canadian oil and gas stocks. Their common macroeconomic factors include interest rates, exchange rates, market excess returns oil and gas prices, and among the fundamental factors are fluctuations of proven oil&gas reserves, volumes of production, debt level, operational cash flows and drilling success. They find that increases in the common factors of market return, appreciation in oil and gas prices, appreciating exchange rates, and decreases in interest rates, are associated with increased stock returns. Moreover, growth in internal cash flows and decreases in oil and gas production have a positive impact on stock returns.

The literature suggests that both common macroeconomic and fundamental risk factors should be included in empirical models to uncover the determinants of salmon stock returns. Cross-sectional studies, as research on other commodity stock returns shows, suggest including macro factors such as the market excess returns, Fama-French-Carhart risk factors, the oil price, and exchange rate changes. The review of the literature on salmon economics and market risks suggest including salmon price and currency risks, as well as risks associated with the production process. The next section will in more detail describe the common macro and fundamental risk factors we used in the empirical models.

Method

The point of departure for the empirical regression model is the multifactor model for returns, which describes contemporaneous relationship between the excess returns on a stock (or portfolio of stocks) and a set of risk factors[1]:

[1] This approach is similar to other relevant studies such as Khoo (1994), Faff and Chan (1998), Faff and Brailsford (1999), Henriques and Sadorsky (2001), Sadorsky (2001), and Boyer and Filion (2007).

$$R_{i,t} = \alpha + \boldsymbol{\beta_M R_{M,t}} + \boldsymbol{\beta_F R_{F,t}} + \varepsilon_{i,t}, \tag{1}$$

where $R_{i,t}$ is the excess return on stock *i* at time *t*, measured by subtracting the risk free rate of return at time *t* from the stock return at time *t*. The vector $\boldsymbol{R_{M,t}}$ contains the common macro risk factors affecting all stocks in the market at time *t*, and $\boldsymbol{\beta_M}$ is the vector of sensitivities of returns on stock *i* to the macro risk factors at time *t*. The vector $\boldsymbol{R_{F,t}}$ represents a set of common risk factors only affecting salmon firms (fundamental risk factors), at time *t*. The next sections will in more detail describe the proxies we use for common and macro risk factors, and industry-specific fundamental risk factors.

Before we go on, it is important to note that the specification in Eq. (1) only allows the researcher to investigate the contemporaneous relationship between stock returns and the risk factors. The model does not let us draw any conclusions as to any causal relationships. Neither does the empirical model described above constitute a formal test of asset pricing models. From the results we cannot conclude that the risk factors command a risk premium, we can only deduce that the returns are sensitive to, or associated with, changes in the proxies for risk factors.

Common and macro risk factors

Common and macro risk factors should capture risks that have an impact on all securities in the economy. Examples of macro risks include stock market risks and extra market risks such as oil prices, inflation risk, and interest rate risks.

This study uses the following seven macro common risk factors; the market excess return (*MRP*), the Fama-French-Carhart risk factors (*SMB*, *HML*, and *UMD*), changes in the oil price (*OIL*), and the changes in the NOK/EUR (*NOKEUR*) and NOK/USD (*NOKUSD*) exchange rates.

1. The market excess return (*MRP*). This variables is calculated as the return on the Oslo Stock Exchange all-share index (OSEAX), less the risk free rate (measured as the return on Norwegian government bonds with 1 month left to maturity). *MRP* is a proxy for the market risk premium.

2. The Fama-French-Carhart factors (*SMB*, *HML* and *UMD*). Fama and French (1992; 1993) documented that risk factors calculated from the returns on portfolios of small firms less portfolio returns on large firms (small-minus-big: *SMB*) was a determinant of stock returns. Likewise, the authors also identified the importance on stock returns of the difference in returns on portfolios of high versus low book-to-market equity ratios (high-minus-low: *HML*). Based on the research of Jegadeesh and Titman (1993), Carhart (1997) later identified the momentum risk factor (*UMD*: return on a portfolio of upward trending stocks minus the return on a portfolio of downward trending stocks). The Fama-French-Carhart factors have since been used extensively in multifactor models, applied both by academics and practitioners alike. Since we examine salmon stocks listed on the Oslo Stock exchange, the relevant *SMB*; *HML* and *UMD* factors to use are the ones estimated from returns on stocks listed on OSE.

3. Oil price (*OIL*). Crude oil is a globally traded commodity and changes in its price has profound impact on the global economy (Hamilton 1983; Mork 1989; Jones, Leiby, and Paik 2012), as well as stock markets (Jones and Kaul 1996; Sadorsky 1999; Kilian and Park 2009; Ding, Kim and Park 2016). Due to its importance for the economy, changes in the crude oil price could therefore represent a common risk factor also for salmon farming companies. The literature suggests that the oil price also impacts industries

other than the energy industry. For instance, Nandha and Faff (2008) find a negative effect of oil prices on stock prices in 35 industrial sectors except the oil and gas industries. We therefore include the change (return) on oil prices (*OIL*) as a variable that captures the impact of oil prices on salmon stocks.

4. Exchange rate risk (*EUR* and *USD*). The literature suggests that exchange risk could also have an impact on stock returns (Jorion 1990; Louden 1993; Khoo 1994; Sadorsky 2001; Boyer and Filion 2007), and exchange rate risk is therefore also included in the present study. Exchange risk is captured by two important exchange rates for salmon farmers listed on the Oslo Stock Exchange; the NOK/EUR (*EUR*) and the NOK/USD (*USD*) exchange rates. While costs for Norwegian salmon farmers are mostly incurred in local currency, the sales are usually collected in foreign currency, of which the EUR is the largest. Arguably, exchange rate risk can represent a major source of risk in terms of profitability for salmon farmers. Several studies demonstrate the importance of exchange rates for salmon farmers (Kinnucan and Myrland 2002; Tveterås and Asche 2008; Larsen and Kinnucan 2009; Larsen and Asche 2011; Xie, Kinnucan, and Myrland 2008; Straume 2014; Zhang and Kinnucan 2014). Since many farmers listed on OSE also have subsidiaries in Chile for whom the U.S. is one of the primary markets, we also include the USD/NOK exchange rate (*USD*).

Fundamental risk factors

The next set of risk factors, the fundamental risk factors, proxy for common systematic industry-specific risk factors affecting only the return on salmon farming firms' stock prices, assuming a minimal impact on the returns on stocks in other industries. We include four fundamental risk factors: shock in production (*PROD*), shocks in inventory or biomass (*BIO*) and shocks in seawater temperature (*TEMP*), in addition to changes in the salmon price (*SALMON*). The first three fundamental risk factors were identified in a recent study by Asche, Misund, and Oglend (2016b), and are constructed to capture risks associated with different aspects of the production, and especially the inventory of salmon. To isolate the shocks in production, inventory and temperature from (deterministic) seasonal and trend components we apply a seasonal and trend filtering procedure based on loess, STL (Cleveland *et al.* 1990). The residual is then normalized by subtracting its mean and dividing by its standard deviation.

5. $PROD_t$. This variable captures the shock from harvested volumes of Norwegian fresh salmon, and is calculated as the normalized, seasonal and de-trended deviation in the monthly quantity of harvested salmon in Norway from time *t-n* to *t*. The harvesting of salmon in Norway typically follows a seasonal profile, whereby the amounts of salmon harvested are determined by physical variables such as seawater temperatures, season, photoperiod and seawater chemistry, in addition to biological factors such as size, growth rates, diseases, and sexual maturity. In addition, the optimal harvest time is also determined by size since larger salmon command a price premium over smaller salmon (Asche and Guttormsen 2001). Shocks in harvest volumes can come as a result of unexpected changes in the above physical, biological and management-determined variables. For instance, a widespread salmon disease might lead to accelerated harvesting. An increase in sea lice infection affecting large production areas might reduce the welfare of salmon and decrease their growth as a results, leading to reduced harvesting. These examples illustrate that deviations from expected seasonal harvest volumes might occur, and it is this uncertainty that the *PROD** variable aims to capture. Any shock in harvest amounts will potentially affect future supply and therefore

represent an uncertainty in future inventory. Hence, an upward shock in harvesting might indicate a smaller future inventory.

6. BIO_t : This variable captures shocks in inventory (biomass) of live Norwegian salmon in sea pens. The variable is calculated from quantities of live Atlantic salmon in Norway from time *t-n* to *t*. If the normalized variable is positive, this implies that there is more salmon in stock than expected, and an investor might expect there to be less harvested salmon in the future, which might increase future salmon prices, and therefore profitability and cash flow.
7. $TEMP_t$: This variable represents temperature deviations (shocks in temperature). The variable is calculated from seawater temperature collected at 10 meter depth on the west coast of Norway. Seawater temperature impacts growth rates of fish (Jobling 1994; 2008), and positive shocks in temperature might imply higher growth rates and increased production of salmon in the future.
8. Changes in the salmon price (*SALMON*). We also include the salmon price risk (measured as the return on the salmon price) since the literature suggest that commodity prices are important for stock returns (Boyer and Filion 2007).

Before we proceed, it could be useful to first discuss the differences between the three shock variables. All three of the fundamental risk variables *PROD*, *BIO* and *TEMP*, capture elements of the same common inventory uncertainty. However, they do so with different timing. Gorton, Hayashi, and Rouwenhorst (2012) argues that the information content of inventory data might be affected by potential errors related to the timing of information as well as appropriate definitions of inventory. According to Asche, Misund, and Oglend (2016b), *PROD* contains information as to the change in current inventory due to harvesting of salmon. It is therefore a short-term inventory risk variable. On the other hand, *TEMP* captures uncertainty in future inventory as an upward shock in the seawater temperature increases growth, which will in the medium term lead to increased inventory. Another medium-term inventory risk variable is *BIO*, which measures shocks in the reported biomass. Since the biomass is the aggregate inventory, containing both salmon below and above marketable size, it is a crude inventory measure. Hence, in light of Gorton, Hayashi, and Rouwenhorts' (2012) concerns, we therefore use three inventory risk measures, capturing different timing and types of inventory uncertainty. Including variables for uncertainty about future inventories are included in our empirical models since the biomass, and changes in biomass, can convey information on future cash flows for salmon producers.

The empirical models

For ease of comparing our results other studies on stock returns, we present results from three models. The first model is the classic market model whereby the excess return on a stock (total return including both dividend and capital yield less the risk free rate) is regressed on the market excess return. The market model is a widely-used model for estimating equity betas. The second model is the Fama-French-Carhart model (SMB, HML and UMD) which is an extension of the market model, and is typically used for evaluating portfolio performance. The third model is a combination of the Fama-French-Carhart model and the additional common and fundamental risk factors. The three empirical models are presented in more detail below.

Model 1: The market model. This is the single-index model where MRP is the only explanatory variable. The intercept represents the alpha of the single-index model, a measure of over- or underperformance, after adjusting for the stock's systematic risk. The beta coefficient represents the CAPM beta, a measure of systematic risk.

$$R_{it} = \alpha_1 + \beta_{1MRP}MRP_t + \varepsilon_{1it} \tag{2}$$

Model 2: The Fama-French-Carhart 3-factor model (FF3). This model is an extension of the market model (Model 1), whereby additional market-wide risk factors are included: SMB, HML and UMD.

$$R_{it} = \alpha_2 + \beta_{2MRP}MRP_t + \beta_{2SMB}SMB_t + \beta_{2HML}HML_t + \beta_{2UMD}UMD_t + \varepsilon_{2it} \tag{3}$$

Model 3: Full model (Fama-French-Carhart plus fundamental and common risk factors) The final model, including common macro and fundamental risk factors, becomes

$$\begin{aligned} R_{it} = \alpha_3 &+ \beta_{3MRP}MRP_t + \beta_{3SMB}SMB_t + \beta_{3HML}HML_t + \beta_{3UMD}UMD_t \\ &+ \beta_{3OIL}OIL_t + \beta_{3EUR}EUR_t + \beta_{3USD}USD_t + \beta_{3SALMON}SALMON_t \\ &+ \beta_{3BIO}BIO_t + \beta_{3PROD}PROD_t + \beta_{3TEMP}TEMP_t + \varepsilon_{3it} \end{aligned} \tag{4}$$

In addition, Model 3 (Eq. (4)) is estimated for each individual company in the sample to provide insight into the variation in exposure to the different risk factors.

Data samples

Monthly total shareholder returns (i.e. the sum of capital gain and dividend yield) are calculated from stock prices collected from Datastream (www.thomsonreuters.com). The returns are calculated on logarithmic form. The empirical model in Eq. (4) is estimated on the returns on an equally-weighted portfolio of salmon stocks returns, as well as on the individual stocks comprising the portfolio. Table 1 shows the composition of the portfolio of salmon stocks over the sample period. A total of ten firms have been selected, with the number of stocks vary across time, from two in 2006 to nine in 2016 (Table 1). Ideally, the sample should be larger. However, the vast majority salmon firms are either subsidiaries of larger corporations, or privately owned. This puts a limit on the number of stocks it is possible to include in the sample.

Monthly Fama-French-Carhart risk factors for the stocks listed on the Oslo Stock Exchange are collected from Bernt-Arne Ødegaard's website (http://finance.bi.no/~bernt/financial_data/ose_asset_pricing_data/index.html). The properties of these risk factors are described in Ødegaard (2016).

Changes in the NOK/EUR and NOK/USD exchange rates are calculated as returns on the two exchange rates, collected from the Norwegian Central Bank (www.norges-bank.no). As a proxy for the risk free rate, we use the monthly rate of return on Norwegian government bonds with 1 month left to maturity.

Inventory and production data are collected from the Norwegian Directorate of Fisheries (www.fiskeridir.no). Monthly figures for biomass (harvest) are used to calculate the *BIO* variable (*PROD* variable). Salmon spot prices are collected from Fishpool.eu (NASDAQ spot price index). We calculate monthly changes (returns) in salmon price by taking the last weekly price in month *t*, and dividing it by the last weekly price in month *t-1*, minus one.

Oil prices are collected from the U.S. Department of Energy, Energy Information Agency (DOE EIA). Monthly changes on oil prices are calculated as the monthly return on the front month futures contract (last observation in month *t* divided by last observation in month *t-1*, less one).

Table 1. The number of companies in the portfolio of salmon stocks in the sample period.

Year	Number of stocks in the equally-weighted portfolio
2006	4
2007	3-5
2008	6
2009	6
2010	6-7
2011	6-8
2012	8
2013	8
2014	7-8
2015	7
2016	7

Table 2 presents the descriptive statistics for the data sample. The average monthly excess return on the portfolio of salmon stocks is 1.38%, which is quite high compared to that of the market (0.23%). This suggests that salmon stocks have experienced a substantial price appreciation over the sample period, possibly linked to a substantial increase in salmon prices (0.73% monthly changes).

Table 2. Descriptive statistics for data sample.

	Mean	SD	Min	25 percentile	Median	75 percentil	Max
Portfolio return	1.38	8.67	-23.67	-3.15	3.03	5.39	32.10
MRP	0.23	5.97	-24.45	-2.65	0.95	3.86	14.84
SMB	0.15	4.11	-11.23	-2.56	0.22	2.31	12.82
HML	-0.23	3.57	-7.80	-2.77	-0.43	1.91	9.10
UMD	1.10	4.15	-16.09	-1.18	1.54	3.42	12.05
OIL	0.13	9.99	-35.84	-4.92	0.65	5.52	30.24
USD	0.20	3.66	-7.75	-1.66	0.24	2.62	14.77
EUR	0.38	2.38	-9.91	-1.24	<0.01	1.53	10.59
SALMON	0.73	8.95	-23.42	-4.75	0.51	6.48	29.16
PROD	0	1	-286.07	-73.71	6.76	67.08	231.53
BIO	0	1	-364.93	-64.11	-5.52	65.70	248.93
TEMP	0	1	-301.03	-64.11	-8.05	48.94	266.33

Note. All numbers multiplied with 100. N = 114. PROD, BIO and TEMP have been standardised to have mean = 0 and SD = 1.

Table 3 presents the correlation between the variables. Most of the variables exhibit low correlations with the exception of the NOK/USD exchange rate and the change in oil price. The correlation between *USD* and *OIL* is -0.65, which is high, but not too high as to cause concern. The correlation between SP and the exchange rates, on the other hand, is very low (4-8%).

All variables were tested for stationarity using the augmented Dickey-Fuller test. The null hypothesis of a unit root was rejected for all variables in the dataset. Since heteroscedasticity and serial correlation can be present in the data, the standard errors are Newey-West corrected.

Table 3. Correlations between the variables

	MRP	SMB	HML	UMD	OIL	EUR	USD	SALMON	BIO	PROD	TEMP
MRP	1	-0.13	0.03	-0.25	0.11	-0.02	-0.13	0.06	0.20	0.19	0.04
SMB		1	0.15	0.22	0.06	0.25	-0.02	-0.03	0.02	-0.21	0.05
HML			1	-0.03	0.17	-0.05	-0.10	-0.15	<0.01	0.16	0.14
UMD				1	-0.21	0.09	0.12	-0.03	-0.01	-0.08	-0.03
OIL					1	0.02	-0.65	-0.01	0.14	0.12	0.02
USD						1	0.02	0.08	0.02	-0.14	-0.12
EUR							1	0.04	-0.09	-0.09	0.01
SALMON								1	-0.14	0.07	<0.01
PROD									1	0.03	0.11
BIO										1	0.08
TEMP											1

Results and discussion

This section presents the results from the estimation of the three empirical models in Eqs. (2)-(4), both for the returns on an equally-weighted portfolio, and the returns on individual salmon stocks. First, we present the results from the regression of the monthly return on an equally-weighted portfolio of salmon firm stocks on the set of common macro and fundamental risk factors. Second, the results from the individual salmon firm returns regressions are presented.

The results clearly show that the market risk premium is a major determinant of salmon firm stock returns on a portfolio level (Table 4, column 2: Market model). The beta is 0.8062, suggesting that salmon stocks are slightly defensive compared to the market as a whole (beta of 1). This result indicates that salmon stocks are less risky than the Oslo Stock Exchange in general, suggesting that the superior returns on salmon stocks in recent years is not explained by high market (systematic) risks exposure. Later in this section, we will examine if this is also the case for individual salmon firm stocks.

Table 4: Regression results. The effect of common macro and fundamental risk factors on the return on a portfolio of equally-weighted salmon firms.

Variable	1. Market model	2. Fama-French-Carhart	5. Full model
Intercept	0.0120*	0.0168**	0.0148**
MRP	0.8062***	0.6975***	0.6698***
SMB		-0.6419***	-0.5752***
HML		0.4161***	0.4624**
UMD		-0.2433	-0.2341
OIL			0.0087
EUR			-0.0843
USD			0.0922
SALMON			0.2439***
BIO			-0.0034
PROD			0.0100
TEMP			-0.0022
R2-adj	0.3023	0.4190	0.4726
Ljung-Box	3.648	6.114	0.0152
	(0.056)	(0.013)	(0.902)
Breusch-Pagan	4.157	1.548	9.766
	(0.042)	(0.818)	(0.552)

Note. Significance of the regression coefficients are presented with asterisks: * = p<0.10, ** = p<0.05, and *** = p<0.01. Significance of the Ljung-Box and Breusch-Pagan tests are presented with p-values in parantheses.

Next, turning to the Fama-French-Carhart model (Model 2), we find evidence that additional macro factors also play a role in determining the returns on salmon stocks (Table 4, column 3). Both coefficients on *SMB* and *HML* are statistically significant at the 1% level. Including the new variables affects the coefficient on *MRP*, which drops to approximately 0.7, while the adjusted R^2 increases from 30 to 42%. The change in coefficient on *MRP* can suggest that the market model in Eq. (2) is misspecified, and the coefficient on *MRP* is possibly adversely affected by the omitted variable bias. If this is the case, academics and practitioners attempting to calculate the beta for salmon stocks should consider using a Fama-French 3-factor model as opposed to the popular single-factor market model.

Moreover, the coefficients on the SMB and HML factors can be interpreted economically. A positive (negative) coefficient on SMB indicates that the return on a stock, or a portfolio, is positively associated with a small firm risk premium (i.e. a large firm risk discount). Our results suggest that the listed salmon stock portfolio is tilted towards large stocks. This is not surprising since the sample comprises some of the largest companies on the Oslo Stock Exchange. Several of the firms are among the top 25 largest. Moreover, a positive (negative) coefficient on HML suggests a tilt towards value (growth) stocks. The results in our study suggest that the salmon stock equally-weighted portfolio is tilted towards the risk premium associated with value stocks. In summary, the results of the Fama-French-Carhart regression suggests that salmon stocks are defensive, and tilted towards large caps and value stocks.

In the next model (Model 3) we include the common macroeconomic factors of oil price and the NOK/EUR and NOK/USD exchange rates, and the fundamental (industry-specific) risk factors comprising variation in the salmon spot price and three inventory risk measures (*BIO*, *PROD* and *TEMP*) (Table 4, column 4). None of the coefficients on the common macroeconomic factors are statistically significant, and we conclude that they are not direct determinants of salmon shareholder returns. While the previous literature suggests that exchange rates are important in the salmon industry (Kinnucan and Myrland 2002; Tveterås and Asche 2008; Larsen and Kinnucan 2009; Larsen and Asche 2011; Xie, Kinnucan, and Myrland 2008; Straume 2014; Zhang and Kinnucan 2014), this risk might not be passed through to stock returns. There might be several reasons for this. Firstly, in investor can mitigate the adverse effects of exchange rate exposure using hedging instruments, and the exchange rate risk will therefore not be of much importance. Secondly, a firm’s management can also hedge exchange rate risk. Research suggest that the impact on firm value from exchange rate changes is both economically and statistically small (Griffin and Stulz 2001). Bartram (2008) finds that the insignificance of foreign exchange rate exposures on performance measures such as cash flows, can be attributed to hedging at the firm level. Thirdly, the literature suggests that exchange rates might be passed through to prices (Bodnar, Dumar, and Marston 2002). This could also be a possible explanation for our results for the salmon industry. However, several studies suggest that a mix of spot and contract sales can create additional price volatility, resulting in reduced price transmission (Tveterås and Asche 2008; Larsen and Kinnucan 2009; Larsen and Asche 2011). Additional analysis into the relationship between exchange rate risk on salmon firm cash flow variation and valuation, is left to future research.

We find that the changes in the oil price is not significantly associated with salmon stock returns. A possible explanation could be that changes in oil prices are already captured by the excess return on the Oslo stock exchange market index. The OSE market index comprises many oil and gas companies, the biggest being the oil and gas company Statoil. Several studies demonstrate that oil company returns are affected by the oil price (e.g. Boyer and Filion 2007).

Our results suggest that the most important industry-specific risk factor is the salmon price. This finding is consistent with Asche and Sikveland (2015) who find that variations in operating earnings are driven by variations in the salmon price, and Misund (2016a) who find that operating earnings are value-relevant information for investors in salmon firms.

We find that the coefficient on *SALMON* is very significant, suggesting that the salmon price is an important determinant of salmon stock prices. It is also the only industry-related determinant of salmon stock returns.

Before we go on to the analyses of individual stock returns, it could be worthwhile to assess the importance of the regression intercept. In the framework of both the one factor model (market model) and multifactor models (Models 2 and 3), the intercept represents the ‘alpha’.

The alpha is part of the return that is not explained by the models and the systematic risks. It embodies superior returns. With the exception of the market model (which could be misspecified), all models have a significant alpha coefficient. In an efficient market, stocks should not provide returns above the common, systematic, risk premiums. However, our results suggesting that a portfolio of salmon stocks has indeed provided superior returns, should be interpreted with care. First of all, our dataset is small in terms of number of firm observations (ten), and time (approx. 10 years). Drawing firm conclusions from a small dataset is not prudent. Second, the models can be misspecified as only approximately 50% of the variation in returns are explained by the variables. Third, the salmon industry has over the sample period experienced a substantial increase in output prices, combined with restrictions in supply growth. The result is a major repricing of salmon stocks. However, standard economic theory does not imply that this situation will persist in the long-run, and it is important that our study is replicated in some years' time, perhaps following the end of the current super-cycle.

Next, we turn to the analysis of individual salmon stocks. For ease of exposition we present only the results from a full multifactor model, including all the risk variables. Moreover, the results from the portfolio returns suggest that the coefficients may possibly be adversely affected by the omitted variables bias in the simpler models such as the market model.

The results for the individual regressions are generally in line with that of the portfolio return regressions presented earlier (Table 5). In general, the salmon stocks have lower beta than one (except Grieg Seafood (GSF) with a beta ~1.086, which is roughly in line with the market). The betas (significant) on the market excess return varies between 0.54 to 1.09. The exception is Bakkafrost, with a beta of -0.10, but which is not statistically significant. A possible reason is that the Bakkafrost stock price has a very low correlation with the market return, possibly suggesting an inefficiency in the pricing of the stock.

Furthermore, the coefficients on *SMB* and *HML* on the returns on individual salmon stocks returns seem, in general, to suggest that salmon stock returns are negatively associated with small caps, and positively associated with value stocks.

Table 5: Regression results: The effect of common macro and fundamental risk factors on the return on individual salmon firms.

Variable	MHG	LSG	SALM	NRS	CEQ	GSF	BAKKA	SSC	Pooled
intercept	0.0173	0.0145	0.0167**	0.0247	0.0148	0.0159	0.0362***	0.0052	0.0167***
MRP	0.8999***	0.5440***	0.5830***	0.8574*	0.9101***	1.086***	-0.1012	0.7559**	0.6704***
SMB	-0.6944**	-0.1361	-0.1769	-0.7380	-0.2495	-1.139***	-0.4683	-0.8603**	-0.5140***
HML	0.2075	0.5337*	0.5027**	0.1436	0.7104**	0.4933	0.6385*	0.4843	0.4778***
UMD	-0.3633	-0.1377	0.1499	0.3017	-0.2744	-0.2393	-0.3159	-0.2830	-0.1696
OIL	-0.0784	0.0872	-0.0397	0.0098	-0.2195	0.1173	0.0085	0.2172	-0.0010
EUR	0.3345	-0.0350	-0.0610	-0.7564	-0.2195	-1.2035**	0.4531	-0.2389	-0.4353**
USD	0.2301	0.1755	0.1284	0.0906	-0.2122	0.1686	0.6227*	0.6753	0.0084
SALMON	0.2058*	0.2144**	0.1860**	0.4342**	0.1374	0.4478**	0.1691	0.2170*	0.2711***
BIO	-0.0017	-0.0025	0.0004	-0.0021	-0.0109	-0.175	0.0092	-0.0140	-0.0033
PROD	0.0252**	0.0063	0.0110*	-0.0075	0.0093	0.0158	0.0106	-0.0024	0.0080*
TEMP	-0.0023	0.0091	-0.0032*	-0.0291**	-0.0027	-0.0073	0.0026	-0.0093	0.0003
N	113	113	103	56	99	102	69	56	711
R2-adj	0.3054	0.1492	0.2172	0.1530	0.3077	0.3984	0.0997	0.1932	0.2228
Ljung-	0.298	0.170	0.300	4.369	0.051	7.460	0.352	2.211	0.344
Box	(0.585)	(0.680)	(0.584)	(0.037)	(0.821)	(0.006)	(0.553)	(0.137)	(0.558)
Breusch-	8.045	13.690	9.870	7.260	11.586	16.819	16.857	7.074	8.561
Pagan	(0.709)	(0.251)	(0.542)	(0.778)	(0.396)	(0.113)	(0.112)	(0.793)	(0.662)

Note. MHG = Marine Harvest ASA, LSG = Lerøy Seafood Group ASA, NRS = Norway Royal Salmon ASA, CEQ = Cermaq ASA, GSF = Grieg Seafood ASA, BAKKA = Bakkafrost p/l, and SSC = Scottish Salmon Company plc. Significance of the regression coefficients are presented with asterisks: * = p<0.10, ** = p<0.05, and *** = p<0.01. Significance of the Ljung-Box and Breusch-Pagan tests are presented with p-values in parantheses.

For some of the firms, the coefficients on the exchange rates are statistically significant, but this appears only to be sporadic, and does not leave a general impression that these macroeconomic variables are important determinants of salmon stock returns.

Again, as in for the portfolio returns, the salmon price seems to be a major determinant of individual salmon company stock returns, consistent with the findings of Zhang, Myrland, and Xie (2016). The inventory risk measures seem to be of lesser importance. The adjusted R^2 are lower for the individual firm return regressions as compared to the portfolio models. This is as expected since the former regressions contain more noise than the portfolio regressions. This is one of the reasons for the popularity of using portfolio returns instead of returns on individual securities in empirical studies on returns in the literature.

Since our dataset contains data in both the cross sectional and time series dimensions, we carry out a tests for poolability. This test ascertains if the coefficients on the variables are the same across the companies. If so, then panel data techniques should be applied. The F-value of the poolability test is 1.5548 and the resulting p-value is 0.01298. The null hypothesis that the same slope coefficients apply to each individual is rejected at the 5% level (but not the 1% level). We therefore decide to present both the results of the individual companies and for the panel data (Table 5, last column). The results for the pooled dataset (Table 5, last column) is generally in line with the results from the portfolio returns in Table 4 in terms of magnitude, sign and significance of the coefficients.

To obtain some insight into how the shocks in the market (in aggregate) are transferred to the returns, we can inspect the sum the coefficients on the returns variables (MRP, SMB, HML, UMD, OIL and SALMON). The sum of the parameters are consistently below 1 (range between approx. 0.5 and 0.8), suggesting a low total sensitivity of salmon stocks to the risk factors identified in our paper.

In summary, the results suggest that the major determinants of salmon stock returns, both for individual stocks and for an equally-weighted portfolio, seem to be the three market common factors (*MRP*, *SMB* and *HML*), as well as changes in the salmon price. The results also suggest that inventory risk variables are priced by investors, but the impact on returns seems to be much smaller than the four major determinants. Other macroeconomic risk variables do not seem to determine salmon stock returns. The conclusion of our findings is that salmon stock prices are mainly determined by risk factors that can be considered systematic risks, such as the market risk premium and the additional systematic risk factors identified by Fama and French (1993) and Carhart (1997). Although, the salmon stocks have witnessed a tremendous share price appreciation since 2012, our results provide evidence that some of the price increase is consistent with finance theory. The only industry factor that we identify as a determinant of salmon stock prices is the salmon price. Since there is a strong relationship between salmon firm earnings and the salmon price, we can infer that investors view the current salmon price as a proxy for future salmon prices and therefore affecting both current and future cash flows. Higher expectations of future cash flows should lead to higher valuations and therefore returns. Hence, all the determinants of salmon stock prices identified in our study are consistent with economic theory.

Conclusions

The salmon farming industry in Norway, has since its inception in the 1960s, enjoyed a tremendous success in terms of growth, and recently also profitability. The substantial volume growth has been attributed to high productivity growth as well as demand appreciation. Since the early 2000s productivity growth has slowed, and the industry has matured and consolidated. Concurrently, market places for salmon assets have emerged, facilitating trading of salmon equities, salmon equity derivatives, and salmon price derivatives, and ultimately attracting investors and portfolio managers. Despite the increased importance of the industry, and the increased attention from investors, academic research into the properties of salmon equities has been slight. This paper investigates the contemporaneous relationship between returns on salmon shares and common market and macroeconomic risks, as well fundamental industry-specific risk factors. We find that the salmon equities are significantly associated with changes in common marked-wide risk factors such as the market risk premium and the Fama-French SMB and HML risk factors. Of the fundamental risk factors, we only identify the salmon price as a relevant determinant of stock prices.

A major limitation of this study is the small number of observations. The sample consists of ten salmon farming companies. The small number of observations can have an adverse effect on the estimators from the regressions. Estimators may be biased and standard errors imprecise. Making inferences based on coefficients with borderline significance should therefore be done carefully. The reason for the small sample size is the low number of exchange listed salmon companies. At present, only nine salmon farming firms are listed on the Oslo Stock Exchange. Since the ownership of the farmed salmon production is very concentrated, it is unlikely that there will be a substantial increase in the sample size going forward.

Our research has uncovered some questions left up to future research. Firstly, it is important to examine the relationships between share price returns and risk factors, and how it changes over time, especially after the current super-cycle in salmon prices has receded. Another avenue of research is to try to examine the causal relationship between risk factors and returns, as well as to determine the size of any risk premiums.

Our research adds to the growing literature highlighting the importance of including fundamental risk factors when explaining stock returns. Moreover, our results provides insight into the determinants of salmon company shareholder returns. This information is important for analysts, investors and portfolio managers investigating the pricing and performance of salmon company shares.

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