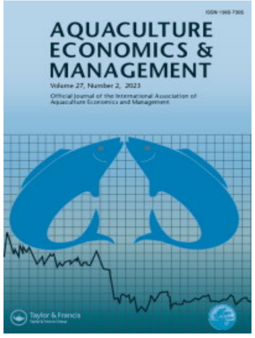

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Determinants of investment behavior in Norwegian salmon aquaculture

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ABSTRACT
The aquaculture industry has experienced substantial growth for many years. Moreover, high growth rates are projected to continue into the foreseeable future. Compared to other aquaculture species, salmon farming is one of the most capital-intensive seafood industries, requiring substantial investments in working capital, fixed assets, intangible assets (i.e., licenses), and innovation. Meanwhile, this industry is exposed to both production risk and demand uncertainty. Surprisingly, investment behavior in the salmon farming sector has attracted very little research. In this study, we examine how investments in the Norwegian aquaculture sector are affected by macroeconomic and industry-specific uncertainty, cash flows, and leverage. In line with studies in other sectors, we find that cash flows are a significant determinant of investment behavior. However, our results on the relationship between uncertainty and capital formation contrast similar studies on natural resource-based industries.

KEYWORDS
Aquaculture; salmon; investment; uncertainty

Introduction

The aquaculture industry has experienced substantial growth for many years. Moreover, high growth rates are projected to continue into the foreseeable future (Garlock et al., 2020, 2022; Naylor et al., 2023). Innovation is a key driver for this development (Afewerki et al., 2023; Asche, 2008). However, less attention has been given to what it takes for innovations to be used (Kumar et al., 2018). This paper seeks to investigate the relationship between uncertainty and investment behavior in the Norwegian salmon aquaculture industry, one of the most innovative and capital intensive aquaculture species.

According to theory and empirical evidence, the impact of uncertainty on firm investments is complex. On the one hand, standard neo-classical theory of producer behavior tells us that the convexity of the profit

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function increases the value of investment since price variations can be exploited for optimization, which means that uncertainty will increase investments (Abel, 1983; Hartman, 1972; Oi, 1961). Modern theories of irreversibility based on real option theory, on the other hand, suggest an opposite effect (Bernanke, 1983; Cukierman, 1980; Dixit & Pindyck, 1994; McDonald & Siegel, 1986). Decision flexibility embedded in investment projects provides management with opportunities to make new decisions after the initial investment decision has been made. Uncertainty will increase the value of these real options, and management will therefore postpone the investment decisions. Real option theory therefore suggests a negative impact of uncertainty on investment behavior. However, more recent research on the impact of real options on investments suggests a more complex relationship. In this approach, investments entail a "basket of options", where some options, such as the investment postponement options as described above, lead to a negative relationship between uncertainty and investment behavior, but other options, such as "strategic options" can lead to increased investments when uncertainty increases (Folta & O'Brien, 2004; Henriques & Sadorsky, 2011; Kulatilaka & Perotti, 1998; Sarkar, 2000). The empirical evidence is also mixed (Carruth et al., 2000). Hence, the relationship between uncertainty and investment behavior is not clear-cut, and therefore warrants more research.

A study of capital formation in the salmon aquaculture is warranted for several reasons. First, the sector is capital intensive, compared to more extensive or semi-extensive aquaculture (e.g., carp, shrimp, etc.).[1] In the early stage, the development of salmon industry regarding reduced production costs and optimal ration size were attributed to technological improvement and innovation (Afewerki et al., 2023), which depended on capital inputs. In response to production risk and market uncertainty, salmon farming firms have become more internationalized through the global supply chain and overseas investment. Recently, the demand for capital expenditures has risen due to severe biophysical risk such as sea lice and stringent environmental regulations. Overseas investment and going public for fundraising have changed the capital sources and ownership structure of the salmon farming companies (Sikveland et al., 2022).

Second, salmon farming companies face numerous sources of risk, such as disease, sea lice infestations, algae blooms, regulatory uncertainty, and price uncertainties (Anderson et al., 2019; Asche, Garlock, et al., 2022; Asche et al., 2017, 2019; Asche, Yang, et al., 2022; Fischer et al., 2017; Iversen et al., 2020; Oglend, 2013, 2020; Oglend et al., 2022; Osmundsen et al., 2021; Pincinato, Asche, Bleie, et al., 2021; Pincinato, Asche, & Roll, 2021; Straume et al., 2022; Torrissen et al., 2013). Markets for risk management instruments exist for some of these risks (Asche, Eggert, et al., 2022; Asche et al., 2016a, 2016b; Ewald & Zou, 2021; Haarstad et al., 2022; Misund & Asche, 2016; Misund & Nygård, 2018; Oglend & Straume, 2020; Schütz & Westgaard, 2018),[2] while other risks require other mechanisms for mitigation, e.g., innovation (Cojocaru et al., 2021).

Third, due to the negative environmental externalities of salmon aquaculture (Abolofia et al., 2017; Anderson et al., 2019; Oglend & Soini, 2020), this sector is facing increasing demands from society for further investments to reduce the environmental footprints, for instance investments in new technology such as semi- or fully closed production technology. Meanwhile, some self-regulated initiatives such as the Aquaculture Stewardship Council's (ASC) salmon standard (Luthman et al., 2019) also demand capital expenditures.[3]

Finally, the amount of fish meal and fish oil available for fish feed production is limited (Misund et al., 2017), and further growth requires new feed ingredients. For many years, soy meal has been used to replace marine ingredients, but increasing pressure from environmental NGOs is forcing salmon farmers to invest in research for alternative ingredients, such as insects, lumber, etc.

To investigate investment behavior we operationalize the Q model of investment behavior. In line with Mohn and Misund (2009), we augment the standard model with measures of uncertainty, both industry-specific and broader-economy measures of uncertainty. We collect annual aggregate investment data (1986–2018) from the Norwegian Directorate of Fisheries. We use an autoregressive model with exogenous variables such as cash flows, leverage, and measures of macroeconomic and industry-specific risk as the explanatory variables. In line with previous research on other commodities, we find that investments are positively associated with cash flows, suggesting that profitability is a determinant of investment behavior in the Norwegian salmon aquaculture sector. Contrary to studies in the energy sector (e.g., Mohn & Misund, 2009), we find that macroeconomic risk (general stock market volatility) is positively associated with investments, but industry-specific risk is negatively related to changes in investments. Our results suggest that both neo-classical theory of producer behavior and modern theories of irreversible investments can be used to explain our results. However, the exact mechanism through which these uncertainties affect investments in the salmon aquaculture sector is an avenue for future research. Moreover, although we measure the industry-specific risk through salmon price volatility reflecting both production risk and market uncertainty, how those particular types of uncertainties, such as regulatory, biological, and environmental risks, affect investment is another direction for future research.

The rest of the paper is organized as follows. In the next section, we provide a background on the development of the Norwegian salmon aquaculture sector, focusing on the changes in capital intensity. "Methodology" section describes the methodology and "Data" section presents the data. "Results and discussion" section presents and discusses the results, and the final section concludes.

Background

Atlantic salmon aquaculture is different from the farming of other aquaculture species in many respects (Asche, 2008). Traditional aquaculture primarily uses semi-extensive and extensive rearing methods, and the farmer has significantly less control over the production process compared to salmon farming with an intensive rearing method. A more intensive production method provides the farmer with larger control over the production process reducing the risk level, but the technology is also more expensive.

While there are higher investment and production costs in salmon aquaculture as compared to species cultured with semi-extensive and extensive rearing methods, Atlantic salmon is also obtain a higher price. Atlantic salmon and rainbow trout aquaculture comprise only 3% of the total quantity of production from aquaculture worldwide; however, in terms of sales value, the proportion is approximately three times the proportion of volumes. Globally, this makes salmon the second most valuable aquaculture species after shrimp (Garlock et al., 2020). As Figure 1 shows, the price of

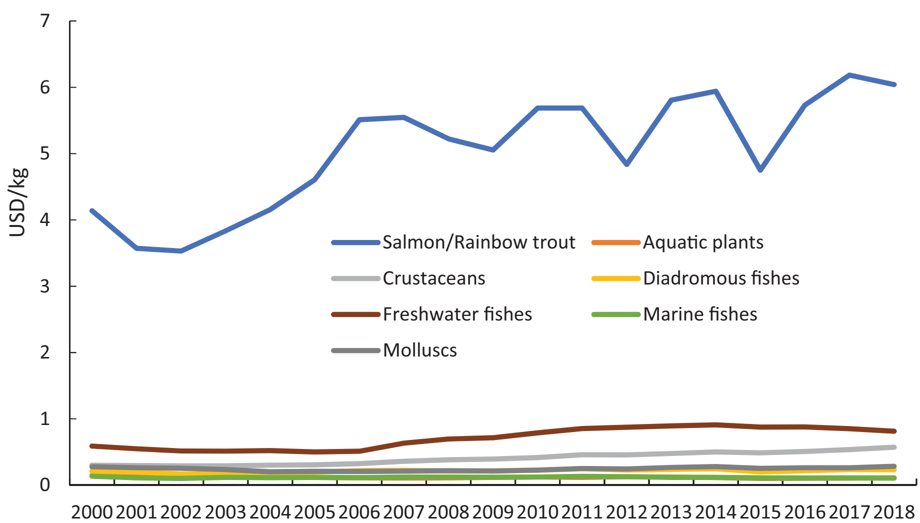

Figure 1. Price of Atlantic salmon and rainbow trout versus prices of various categories of aquaculture 2000–2018 (in USD per kilo, real prices). *Note:* Price = value/quantity (source: FAO), adjusted by consumer price index from the St. Louis Fed.

farmed Atlantic salmon and rainbow trout is approximately 5–10 times the average price of primary aquaculture products.

Modern salmon aquaculture had its commercial breakthrough in the late 1960s/early 1970s (Afewerki et al., 2023). Between the early 1970s and up to around 2012, the annual global production growth of Atlantic salmon was 23% but has since then dropped to approximately 3% per annum between 2012 and 2017. The strong growth of salmon farming until 2012 was driven mainly by productivity growth and technological changes (Asche, 2008). In the first stage, productivity gains were a result of learning-by-doing and scale economies (Bjørndal & Salvanes, 1995; Salvanes, 1993), while in the 1990s technological changes, feed improvements, supplier specialization, new regulations, and better management techniques allowed production costs to fall further (Guttormsen, 2002; Tveterås & Heshmati, 1999).

However, since 2005, the industry has witnessed a slow-down in the productivity growth and a substantial increase in production costs (Aponte, 2020; Asche, Guttormsen, et al., 2013; Vassdal & Holst, 2011). Meanwhile, the industry has also become more concentrated (Asche, Roll, et al., 2013; Tveterås & Battese, 2006).

In 2005, a new regulation system was put in place, whereby a maximum limit restricts the amount of biomass (maximum allowed biomass, MAB) that salmon farming companies can have in their sea pens at any point in time (Hersoug, 2021). Since the industry's biomass levels were substantially below this new limit, the change in the regulation ultimately led to a rapid increase in production between 2005 and 2012. Salmon production per license increased by approximately 85% over the 8-year period between 2004 and 2012 (Figure 2). In 2012, the biomass limit was reached and production per license has since stagnated and even slightly decreased.

Since 2012, the industry has been allowed very little growth in production. There are several reasons for this, such as increasing concerns about the environmental impact of aquaculture[4] (Misund, 2019; Olsen & Osmundsen, 2017; Osmundsen et al., 2017; Osmundsen & Olsen, 2017; Torrissen et al., 2013; Young et al., 2019) and increasing conflicts with other users of the marine space (Hersoug, 2013; Hersoug et al., 2021; Sandersen & Kvalvik, 2015). Since 2017, the Norwegian government has incorporated measures of environmental impact into the aquaculture regulation. According to the current regime, production growth is only permitted in geographical areas where the impact of sea lice on wild salmonids does not exceed the acceptable level.

The above analysis shows that the salmon farming industry has witnessed substantial production growth. So, what about capital intensity? Capital intensity can tell us something about the investment patterns over time.

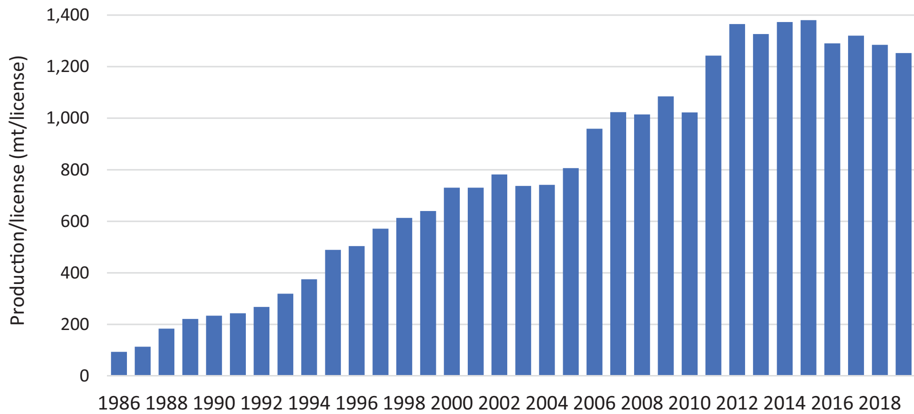

Figure 2. Production per license (metric tonnes (mt) per license). source: Norwegian directorate of fisheries.

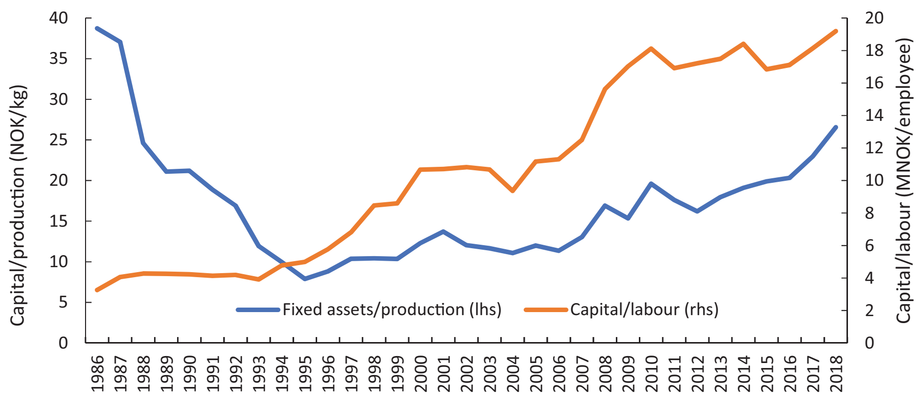

Figure 3. Capital intensity, measured as fixed assets/production and capital/labor. *Source:* the Norwegian fisheries directorate.

For instance, the capital-to-labor ratio provides information on the amount of fixed or real capital relative to labor, which is an important factor of production. Another measure of capital intensity is the ratio of fixed assets to production. This ratio tells us something about the amount of capital needed to sustain a certain level of output. The latter ratio has decreased since 1986 (Figure 3). The largest decrease was seen during 1986 and 1995, when larger volumes led to scale economies. The ratio of capital to labor costs has increased since 1994. Both curves suggest that the industry has become more capital intensive since the mid-1990s, probably due to new regulations, technological improvement, increased uncertainty, and increased profitability.

Capital intensity is also attributed to uncertainty embedded in salmon farming. There are several sources of risk in salmon aquaculture, such as biological factors (e.g., diseases, environmental, parasite infestations), market-based factors (e.g., price dumping allegations and market collusion), regulatory risks, and production risks. Among these, diseases, market access, and market price risk are perceived to be the most important challenges that salmon producers face (Bergfjord, 2009). Several studies have demonstrated a substantial increase in salmon price risk in the last decades (Asche et al., 2018; Bloznelis, 2016; Misund, 2018; Oglend, 2013). An important reason can be found on the supply side (Asche et al., 2019), following the falling long-term elasticity of supply resulting from regulations.

On the other hand, the tighter supply side has also resulted in higher profitability. Oglend and Sikveland (2008) document that price volatility is higher in periods of high salmon prices. Higher profitability is expected to increase investments. However, the empirical results are mixed (Andrén & Jankensgård, 2015; Fazzari et al., 1988). So are the impacts of uncertainty on investments (Carruth et al., 2000). Hence, it is a priori challenging to hypothesize the impact of both profitability and uncertainty on investments.

Methodology

To test the impact of uncertainty on investments in the salmon farming industry under neo-classical theory (Abel, 1983; Hartman, 1972) or real option theory (Dixit & Pindyck, 1994; Henriques & Sadorsky, 2011; McDonald & Siegel, 1986), we need control other factors influencing investments. First, investment follows a dynamic pattern, which is implicitly or explicitly incorporated in the investment literature (Chirinko, 1993). Second, a firm's investment is mostly affected by its cash flow (Quader & Taylor, 2018). Third, a firm's financial leverage affects the risk and growth rate, influencing investment considerations (Aivazian et al., 2005).

To investigate the relationship between investments and cash flow, leverage, and macroeconomic and industry-specific uncertainty, we apply an autoregressive model with exogenous variables.[5]

$$I_t = \alpha_0 + \sum_{i=1}^{p} \beta_i I_{t-i} + \gamma_1 CF_t + \gamma_2 LEV_t + \gamma_3 Vol(macro)_t + \gamma_4 Vol(industry)_t + \gamma_5 Trend_t + \epsilon_t \tag{1}$$

where I_t is investments at time t; CF_t is cash flows; LEV_t is leverage (total debt/total assets); the variables $Vol(macro)_t$ and $Vol(industry)_t$ are the macroeconomic and industry-specific uncertainties (volatilities), respectively; the variable *Trend* catches changes in investment overtime holding other factors constant. The coefficient α_0 is the intercept, $\beta_1, \ldots, \beta_p$ are parameters on lagged investments, γ_1 is the coefficient on cash flow, γ_2 on leverage, γ_3 on macroeconomic risks, γ_4 on industry-specific risk, and γ_5 on the trend variable. The random variable ϵ_t is an i.i.d error term.

To avoid potential heteroskedasticity and scaling effects, investment and cash flow are scaled with the previous year's total asset. Moreover, standard stationarity and unit root tests are applied to examine stationarity. If the variables are non-stationary, first differencing will be used. Serial-correlation in the error terms is examined by visual inspection of autocorrelation plots, which determines the number of lags in the empirical model.

Data

We collected aggregate annual data from the Directorate of Fisheries, 1986–2018. The dataset is based on an annual survey among Norwegian salmonid aquaculture firms. The sample includes a substantial proportion of the salmon farming data (60–90% of licenses). For example, the share of licenses owned by firms included in the surveys out of the total number of licenses is approximately 88.2% in 2018, 62.5% in 2017, and 68.3% in 2016. Salmon farming is the primary business for those sample firms, although some of them operate rainbow trout farming as well. For the sample firms as a whole, the sales volume share of rainbow trout is approximately 5.5%, 7.0%, and 9.1% in 2018, 2017, and 2016, respectively.

Since the proportion and composition of responding firms vary from year to year, all data are therefore divided by the number of licenses in the sample to normalize the observations. Moreover, the data are adjusted for inflation using the Norwegian consumer price index.

An investment variable is not directly available in this database but can be estimated from fixed assets and depreciation data. Investments in fixed assets (I_t) were estimated as the difference in fixed assets (FA) from year $t-1$ to year t, plus depreciation in year t (DEP_t), $I_t = FA_t + DEP_t - FA_{t-1}$.

Figure 4 shows the development in investments in fixed assets per license from 1987 to 2018. Since 2012, there is a steady upward trend in investments per license despite of a stabilized production as shown in Figure 3. The reasons behind this development could be many. First, since 2012, company biomass has been very close to MAB capacity limits (Oglend & Soini, 2020). Companies, therefore, have very limited growth opportunities within the existing regulatory framework. The companies can increase capacity utilization further by using postsmolts which have substantially shorter production cycles in the sea (Bjørndal & Tusvik, 2020), and investments in postsmolt production have increased in recent years (Blomgren et al., 2019). Investments in alternative production technology, such as

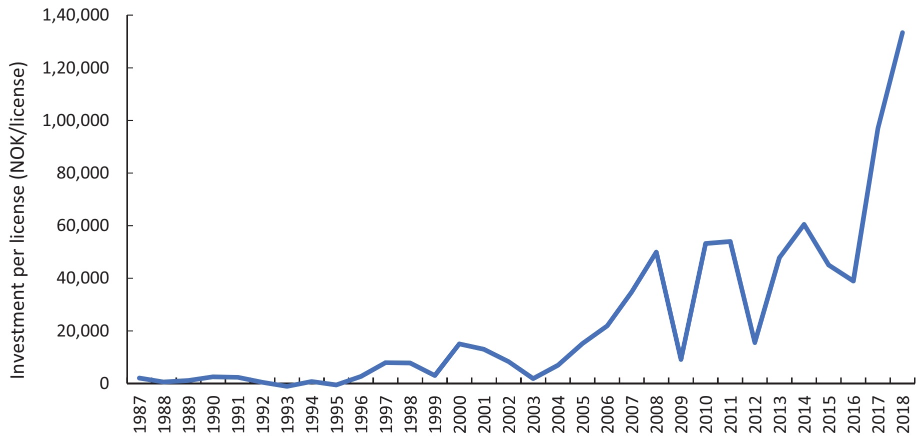

Figure 4. Investments in fixed assets per license 1987–2018. *Source:* Norwegian directorate of fisheries.

offshore aquaculture, semi-closed cages, and submerged pens is seen as an avenue for future aquaculture growth, and has attracted substantial investment (Føre et al., 2022). More stringent environmental regulations have also been a factor driving investments (Afewerki et al., 2023).

As a proxy for cash flow, we use EBITDA (earnings before interest, taxes, depreciation, and amortization). EBITDA has been widely used by investors and lenders as a measure of cash flow (Akron et al., 2020; Godwin & Jones, 2002). In addition, EBITDA affects investment through its impact on cash flow fluctuations (Sheikh, 2022), although it does not consider the tax liabilities and interest costs. Leverage is calculated as the ratio of debt to total assets.

Macroeconomic uncertainty is represented by the volatility of logarithmic returns on daily values of the S&P500 stock index, since this index is often treated as a proxy of the global market (Mohaddes & Pesaran, 2017). Most salmon produced in Norway is exported to the global market and then the salmon industry is exposed to world stochastic macroeconomic factors. Industry-specific uncertainty is represented by the volatility of monthly salmon prices. Both volatilities are estimated with a GARCH (1, 1) model. Annual volatilities are calculated as the annual average of the output from the GARCH (1, 1) models. Figure 5 shows the development of macroeconomic (S&P500 volatility) and industry-specific (salmon price volatility) uncertainties over time. Macroeconomic and industry-specific uncertainties seem to be roughly on the same levels but vary over time. Macroeconomic uncertainty peaks in 2007/2008 during the financial crisis. Salmon price volatility has approximately doubled from around 13–14% in the mid-1980s to around 20–25% in the last 10–15 years.

The descriptive statistics are provided in Table 1. During the whole sample, the average annual aggregate investment is approximately NOK 23

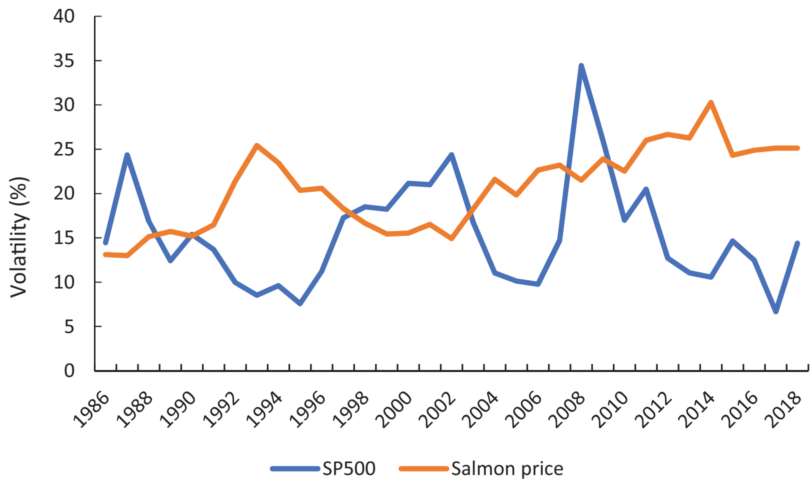

Figure 5. Macroeconomic and industry-specific uncertainties. *Sources:* authors' own calculation with data from datastream (S&P500) and FAO (salmon price).

Table 1. Descriptive statistics.

Variable	Mean	St.dev.	25 percentile	Median	75 percentile
I (NOK/license)	23,485	31,219	2,292	8,738	40,461
CF (NOK/license)	59,821	94,693	4,531	12,613	63,250
LEV	0.758	0.151	0.662	0.742	0.859
Vol (macro)	0.154	0.060	0.110	0.145	0.182
Vol (industry)	0.206	0.046	0.165	0.214	0.243

Note. I = investments in capital expenditure, normalized by fixed assets in the models, CF = cash flow represented by earnings before interest, taxes, depreciation and amortization, LEV = Total debt divided by total assets, Vol (macro) = volatility of the S&P500 stock index, and Vol (salmon) = salmon price volatility.

thousand per license, on average less than half the annual average cash flow. Cash flows follow the same trend as investments, but CF has a much bigger standard deviation than investments in fixed assets, indicating the volatile profitability of this industry, as also suggested by Figure 2.

Results and discussion

Before proceeding with estimating the autoregressive model, we tested the variables for stationarity using a Phillips-Peron test. As expected, given what is commonly reported in the literature (Landazuri-Tveteraas et al., 2021), all variables were non-stationary.[6] We therefore calculated first differences, which in turn were stationary. The variables in the final model therefore represent *changes* in the original variables.

Serial-correlation in the error term was examined by visual inspection of autocorrelation plots. With 2 lags, the autocorrelation of the lags was below the significance lines and determined the number of lags in the final model. In our case, we achieved this result with 2 lags.

Table 2. AR-model with exogenous variables.

Variable	Coefficient	*p* Value
Intercept	0.0422	.0371**
dI_{t-1}	−0.0945	.1385
dI_{t-2}	−0.6966	.1240
Trend	−0.0016	.0018***
dCF	0.3382	.0992*
LEV	0.3369	.3117
dVol(macro)	0.0075	.0053***
dVol(industry)	−0.0293	.0108**

Note: dI_{t-1} and dI_{t-2} = change in investments in capital expenditure (I) divided by fixed assets (FA) for two lags, dCF = change in cash flow, LEV = total debt divided by total assets, dVol(macro) = change in volatility of the S&P500 stock index, and dVol(industry) = change in salmon price volatility.
$^*p < .10$, $^{**}p < .05$ and $^{***}p < .01$.

Table 2 presents the estimates of the final model. The results suggest that changes in investment levels have a tendency to be mean reverting. An increase in investments in year *t* would be followed by reduced investments the next two years. Likewise, a reduced investment in year *t* would lead to increased investments in the two following years, suggesting cyclical investment patterns, as also suggested by Figure 5. However, the coefficients on the lagged investment variables are not significant at conventional significance levels, so the parameters should be interpreted with caution.

Corrected for the autoregressive lags and changes in profitability and volatilities, the model suggests a negative trend in investments over time. The parameter on the trend variable is significant at the 1% level. Thus, the upward trend as shown in Figure 5 is explained by other variables included in the model.

Our results suggest that changes in cash flow have a significant impact on investment levels, at the 10% significance level. This suggests that the increased investment levels in the Norwegian salmon industry can be explained by increased profitability. Since 2016, the industry has witnessed exceptionally high profit margins, and our results suggest that part of these extraordinary profits have been retained for investments. There are several reasons for the increased investment levels (see e.g., Blomgren et al., 2019). First, new regulations for smolt production, escapees, and sea lice quotas have resulted in investments in improved production technology to meet the new requirements. Second, increased problems with sea lice and diseases have stimulated investments in new technology to combat these biological issues, as well as bigger and more specialized well-boats. Third, the high profits have encouraged investments in technology to improve efficiencies, for instance post-smolt production (Bjørndal & Tusvik, 2020).

For uncertainty variables, the primary concern of this study, our estimation results indicate that increases in general market volatility lead to increased investments, while increases in salmon market volatility lead to decreased investments. The aquaculture and oil and gas industries are the primary sectors for Norway, both of which are natural resource-based and export-oriented. Investment behaviors in those two industries are probably subjected to the same macroeconomic uncertainty in the global market. However, our results for the aquaculture industry reflect the opposite effect to what has been seen in the oil and gas industry. Mohn and Misund (2009) find that macroeconomic uncertainty creates a bottleneck for investments among oil and gas companies, while industry-specific uncertainty has the opposite effect. The former result is in line with the literature on both neoclassical theory of producer behavior and the presence of compound options. However, macroeconomic risks are inherently different from industry-specific risks. One reason for the positive relation between macroeconomic risks and investments might be that the salmon industry is a sector that has a low beta (Misund, 2018; Misund & Nygård, 2018; Steen & Jacobsen, 2020), and the firms' profits less influenced by the business cycle than other sectors with higher betas.

A negative impact of industry specific risk on investments is in line with the real option theories of capital formation (e.g., Bernanke, 1983; Cukierman,1980; McDonald & Siegel, 1986), whereby higher price uncertainty leads to increased value of waiting options. The finding is also supported by Bergfjord's (2009) research suggesting that salmon price risk is considered the most important risk faced by salmon farmers.

Investments are not affected by leverage, suggesting that increases in debt relative to total assets do not lead to increased investments. A recent study finds that profitability is negatively linked to short-term and total debt in the salmon industry (Sikveland & Zhang, 2020), suggesting that the effect from leverage might already be captured by our profitability measure.

Conclusion

This study provides an analysis of the drivers of investment behavior in the Norwegian aquaculture sector. As far as we know, this is the first of its kind. Using aggregated data in investments, we examine the impact on investments of changes in macroeconomic and industry-specific uncertainties, cash flows, and financial leverage. Our results suggest that increased profitability has a positive effect on investments, while the impact from uncertainty is mixed. We find that macroeconomic uncertainty has a positive, while industry-specific uncertainty has a negative impact on investments.

The negative relation between salmon price uncertainty and investments should be of interest to salmon farmers, banks, investors, and risk managers. In 2005, the Fish Pool was established as a marketplace for buying and selling financial salmon price contracts, such as futures contracts that can be used to mitigate salmon price risk. Despite the increasing price uncertainty and its negative impact on investments, the Fish Pool has attracted very little interest from salmon farming companies (Asche et al., 2016a, 2016b; Benth et al., 2021; Ewald et al., 2016; Ewald & Ouyang, 2017; Misund, 2018; Misund & Asche, 2016; Oglend & Straume, 2020). This is surprising given that futures contracts are instruments designed to hedge price uncertainty.

A limitation of our study is that it does not capture the variation in firms. Previous research suggests that fundamental such as profitability varies with company size (Asche et al., 2015; Sikveland et al., 2022). Further research should investigate impacts of firm-level variation, firm size, geography, etc. on investment behavior. Another avenue for further research is to examine the dynamics of the uncertainty-investment relationship. Our results were opposite from what was found in the energy industry (Mohn & Misund, 2009, 2011). Further research needs to be carried out to unearth the reasons why. The presence of compound options and u-shaped relationships is probably one of the reasons (Henriques & Sadorsky, 2011).

Notes

1. However, capital structure is important also for other species (Ankamah-Yeboah et al., 2021).
2. Recent evidence suggests that the Fish Pool derivatives market could also be used for risk management of price volatility of other salmonid species such as rainbow trout (Landazuri-Tveteraas et al., 2021).
3. However, this can be at least be somewhat mitigated by the fact that ASC-labeled fish obtains a price premium Asche et al., 2021).
4. Recent research suggests that attitudes toward aquaculture differ among those who live closer to aquaculture and those who live further away (Krøvel et al., 2019).
5. We also considered and ARMAX model (autoregressive moving average model with exogenous variables), but the coefficients on the moving average variables were not significant.
6. The test results are available from the authors upon request.

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