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# Strategic investments in catch capacity and quotas: How costly is a mismatch for a firm?

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ABSTRACT

Despite improved fisheries management, overcapacity is still a major issue in fisheries worldwide. This study investigates the economic effect of a mismatch between catch capacity and quota holdings on the economic performance of fishing boats operating in a system of Individual Fishing Quota (IFQ) system. Based on the data of 71 fishing vessels, which constitute the entire fleet of Norwegian seagoing purse seiners, an ordinal least squares model is applied by including the vessel's catch capacity, quota holding, and return on invested capital (ROIC) along with several control variables. The estimated results suggest that the key factor affecting ROIC is overcapacity. Specifically, when the relative ratio of capacity and quota holding increases by 1%, a vessel's ROIC decreases by 0.692%. This finding indicates that the overcapacity problem in the Norwegian seagoing purse seine fleet still exists even more than a decade after an IFQ regime was introduced. The paper concludes by discussing implications of the findings.

## 1. Introduction

Following "the tragedy of the commons" [1], in open-access fisheries, boat owners often overinvest in capacity, which causes fish stocks at risk to be depleted. As a consequence, authorities have taken an overall responsibility to regulate fishing to avoid losing significant socioeconomic values. The regulation often taken by many countries in the world is combining a total allowable catch (TAC) system with an individual fishing quota (IFQ) system. The TAC secures biological sustainability, and the IFQ avoids the race for fish and reduce overcapacity and therefore ensures economic sustainability for players (e.g., Refs. [2–5]).

For fishing vessel owners, wild fish represents a critical part of their business. In limited-entry and quota-managed fisheries, fishing rights give a firm access to valuable natural resources (e.g., Ref. [6]). Therefore, fishing rights are intangible threshold resources that qualify a firm to participate in the industry. Accordingly, investments in fishing rights are considered to be of strategic importance. Moreover, to exploit the fishing rights on hand, a firm must invest in physical assets, such as catch capacity, fishing vessels, and fishing gears. Finally, human capital from the perspective of a skipper and a crew is needed to efficiently operate a vessel. Therefore, in an investment decision, adjusting investments in the interrelated asset classes to maximize the profit of a firm is critical [47].

Nøstbakken et al. [7] provided a survey of the literature on investment behavior and capacity adjustment in fisheries. She highlighted the sparsity of empirical contributions, although several theoretical studies have been conducted on the investment behavior of fishing vessel firms. Moreover, most of the available empirical studies discuss how decommissioning arrangements, buyback programs, subsidies, and tax interventions affect business investments (e.g., Refs. [8–10]). Some empirical studies are also concerned with entry and exit issues in open-access fisheries (e.g., Ref. [11]). Nøstbakken et al. [7] underlined the need for more empirical studies on investment strategies at the firm level based on adequate financial data. Moreover, Iversen et al. [12] claimed that there is a knowledge gap on how businesses strategically adapt and financially perform under different institutional frameworks.

The main objective of the present study is to empirically investigate the relationship between firms' investments in vessels and quotas and their subsequent financial performance under an IFQ regime. Table 1 provides an overview of the most significant modifications of Norway's IFQ regime in relation to a "pure" IFQ system. Specifically, this study investigates whether Norwegian seagoing purse seiners have been able to adjust their catch capacities to their available quota holdings by using firm level data. This is a vital strategic decision for firms as a mismatch is expected to inflict economic losses on the company. Consequently, the research issue raised in this study is, *how costly is a mismatch between a*

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**Table 1**
The IFQ regime implemented in Norway's purse seine fleet[a].

| No | Modification | Motivation |
|---|---|---|
| M0 | Only active Norwegian fishermen are entitled to own fishing rights and quotas. | To secure national ownership of valuable natural resources |
| M1 | Quota can only be bought together with a vessel in the same group. The bought vessel has to be scrapped. | To remove excess catch capacity from the vessel group |
| M2 | Whenever the quota is traded, at least 5% will be returned to the vessel group, so the buyer retains a maximum of 95%. | To let firms that do not directly participate in the quota transactions reap benefits as there are fewer vessels to share the TAC. This rule also helps to reduce quota prices |
| M3 | If the quota is traded across a county border, then it will be reduced. The largest reduction will take place if the quota is traded from a county in the north to a county in the south (45%). | To reduce the tendency to the regional concentration of quotas |
| M4 | Each vessel has a quota ceiling on 850 tons at present, which represents approximately 2% of the vessel group's TAC share. | To prevent overconcentration of quotas on a few vessels |
| M5 | Each firm has a quota ceiling, which corresponds to approximately 6% of the vessel group's TAC share. | To avoid overconcentration of quotas on a few firms |
| M6 | Tradable quotas (structural quotas) are time-limited. When they expire, they will be returned and allocated to the remaining vessels in the group. | To keep the community's ability to govern fisheries and express that the fish resources are a common property |
| M7 | Trade is only permitted to take place within the same vessel group. | To prevent large vessels from outcompeting small vessels |
| M8 | Quota leasing is not permitted. | |

[a] Adapted from Johnsen and Jentoft [13]; and Standal and Asche [5].

*fishing vessel's catch capacity and its quota holding?*

The validity of the comparison of firms' performance is highest when firms are similar [14]. When analyzing the financial consequences of quota and vessel investments, isolating the financial performance of the catch business unit of a firm from other business units is methodologically significant. Accordingly, the Norwegian seagoing purse seine fleet is selected as an empirical case because this industry is made up of quite similar firms in terms of species caught, catch technology applied, and catch capacity of the vessels. None of the firms are vertically or horizontally integrated with other business units, such as processing, sales, or non-fisheries. Moreover, each seagoing purse seiner in Norway is formally organized as a limited liability company. Thus, the information in the firms' public financial statements only includes data related to the catch business unit. In addition, the purse seine fleet is part of a subsidy-free, limited-entry industry that is subject to a TAC and a IFQ management regime, which has been in work for more than a decade.

In the following section, investment theory related to fisheries, and the economic importance of adjusting catch capacity to the quota holding is presented. Next, the context of the study, the Norwegian seagoing purse seine fleet, is described. After that, the research method is outlined, followed by the presentation of the estimated results. Finally, the findings are discussed.

## 2. Theory

Economic theory assumes that the motivation for any firm to invest is to maximize its wealth (e.g. Ref. [15]). Conventional investment theory states that a firm should invest as long as the net present value of the future cash flow of the investment is positive. The opportunity cost of capital is critical when analyzing the profitability of investments. An economic rational investor will only invest more as long as the expected return overrides the cost of capital [16]. Within IFQ management systems, ship owners can buy and sell not only vessels but also quotas (e.g., Ref. [17]). These are strategic decisions that can significantly affect the scale, scope, and profitability of the business activities [18].

When investing in quotas and vessels, the time perspective is normally long [19]. As a result, future expectations can be of great importance to the investment decisions taken. Annual fluctuations in the biological resource base and uncertainty related to product prices, exchange rates, and oil prices can lead to considerable uncertainty about the future cash flow. If the investment is wholly or partly irreversible, for example, in the form of a specialized vessel with a limited secondhand value, the risk of the investment increases. An uncertainty about the size of the investment expense and required rate of return (RRR) is also existent [20]. The greater the uncertainty, the less willingness to invest [21]. Empirical studies estimate a fishing vessel firm's RRR to be very high relative to the expected return on alternative investments [22]. However, RRR can be reduced by introducing property rights systems, such as IFQ in fisheries (ibid.). When a fishing is closed, intangible assets, such as quotas, are valued in the market. Thus, ineffective and unprofitable vessels are given an incentive to withdraw from the industry by disinvesting. This may especially be the case if alternative income opportunities exist outside the industry [9]. After an exit, the released quotas will be available on the market for the remaining players.

Nøstbakken [19] found that firm-specific variables have a greater impact on the investment behavior of the Norwegian purse seine fleet than economic factors. She argued that two owners with equal productivity and profitability can choose widely different investment strategies. For example, one firm may choose to invest in quotas, whereas another may choose to sell. A reason for this is that the investors can have different expectations of the future profitability. However, it may also be due to different attitudes toward risk among the players. Another explanation is that the Norwegian purse seine fleet was composed of some "old school" fishing vessel owners with lower growth ambitions than their more modern peers, which were governed by a professional organization. The findings indicate, according to Nøstbakken [19] that the economic explanation that the resources (in this case, tradable quotas) are acquired by the most productive and profitable actors in the industry is not necessarily valid. Instead, firm-specific factors (e.g., prestige, generation change, and mimetic behavior) are decisive for firms, which invest in quotas and vessels.

In her review on investment behavior and capacity adjustment in fisheries, Nøstbakken et al. [7] point out four distinct types of capital that can be encountered in economic studies of marine fisheries: natural, physical, human, and intangible. Natural capital is commercial fish stocks produced by marine ecosystems and harvested by commercial fishing firms. Intangible capital describes the need for a fishing firm to own fishing rights and quotas in regulated fisheries. Physical capital includes infrastructure in the form of a vessel and gear that is required for the operation of the vessel. Finally, human capital comprises skilled management and the crew required to catch and process fish. As an individual firm usually have no noticeable impact on fish stock size, natural capital is usually taken as given. Accordingly, this study explores firms' investments in physical capital, human capital, and intangible fishing rights only.

### 2.1. Intangible capital

Intangible capital investments includes transferable licenses and quotas. The main motive for introducing fishing rights, in addition to the need to protect fish stocks, is to reduce the race for fish. When investing in quotas, costs, and revenues are affected. Specifically, if rights are bought in the market, then they will be introduced in the accounts of the firms as an intangible asset in the balance sheet and as depreciation in the income statement. Other relevant variables being equal, a larger quota results in a larger catch, which gives rise to higher revenues. Larger catches may also enable a firm to better exploit economics of scale [23] and reduce transaction costs [24].

Nevertheless, the effect of investing in quota on a firm's profit is an empirical issue depending on the net effect of increasing revenue and costs given by the quota purchase. In strategic factor markets, firms can buy and sell resources [25]. If the markets are perfectly competitive, then firms will only obtain normal returns from purchasing strategic resources, such as quotas, in an efficient market place [19].

### 2.2. Physical capital

To exploit available fishing rights, a firm must also invest in physical capital, such as vessels and gears. A firm can invest in new vessel technology to become more efficient and profitable. Townsend [26] found that access restrictions on fishing can lead companies to invest more in physical capital. Shipping firms can invest in high-quality technology to improve the working days and safety of the crew and attract more skilled fishermen. This situation can, however, lead to overinvestment in capital. The effect may be reinforced if the investment is subsidized by public tax incentives (ibid.). Nevertheless, the technology available and purchased in an open market can hardly give a firm any competitive advantage as it can easily be imitated by its rivals [25].

The most efficient purse seiners are those who use the shortest time to fill their quotas, considering that this does not impair product quality and market price. To achieve this aim, a vessel is expected to have a large catch capacity, modern capture technology, and a powerful engine. Such a vessel can also have lower transaction costs [27] than a vessel based on old and less efficient fishing technology. For a boat owner harvesting a natural resource only seasonally available, the possibility of cost-effective fishing will only exist for brief periods [28]. In this case, firms should have sufficient catch capacity to exploit the short time windows for fishing when they are open.

### 2.3. Human capital

The resource-based view (RBV) of strategy examines potential sources of economic rents internally in the firm (e.g., Refs. [29,30]). Thus, efficiency is primarily driven by resources and capabilities, which are built within the boundaries of the firm. Resources that are owned or controlled by the firm, such as fishing rights, vessels, and gears, are assets [30]. Capabilities, on the other hand, are described as socially complex procedures that determine how efficient a firm is able to transform inputs into outputs. Properties of the accumulation process can make resources and capabilities valuable, rare, inimitable, and non-substitutable and thus hard to acquire for competitors [29]. This is in contrast to resources that are bought in strategic factor markets [25]. Hence, RBV claims that the basis for competitive advantages and superior performance is grounded in resources and capabilities that are heterogeneously distributed between firms and are immobile and hard to imitate. Accordingly, the way a vessel is applied to harvest the available quota can give rise to a competitive advantage and above-normal profit. The same argument goes for the culture of the crew, their fishing practices, and the relationships between fishermen and the skipper [31].

Within an IFQ management system, adapting the physical catch capacity to the quota holding is a central strategic decision for the management of the individual fishing vessel firm [12,32]. The size of the quota and catch capacity of the vessel must be aligned for a firm to operate efficiently. Consequently, quota investors are expected to follow up with more vessel investments so that the intangible and physical capital investments support each other in a balanced way. In theoretical works, capital invested in vessel, and quotas is often considered perfectly malleable [33]. However, the more common situation in fisheries is that investments in quotas and vessels have a degree of non-malleability. Accordingly, investment decisions become more complex as they are separable but related [7].

## 3. Empirical context

Norwegian seagoing pelagic seiners constitute the empirical context of this study. The most valuable pelagic species fished is herring, mackerel, and capelin. After the national TAC is set, it is distributed to different pelagic vessel groups as group quotas. In addition to seagoing purse seiners, groups of pelagic trawlers, coastal pelagic boats, and purse seiners without concession also exist. The group quotas are further distributed to the vessels within the groups based on their quota holdings. Approximately 2/3 of the TAC goes to the group quota of seagoing purse seiners. This group consists of purse seiners over 90 feet or has a load capacity over 1500 hl. The entire population of the seagoing purse seiner group in 2017 including 71 fishing vessels is covered in this study.

### 3.1. Norway's IFQ system

Norway does not manage her fisheries by an individual transferable quota system (ITQ) officially, but in reality, the applied IFQ system has many similarities with an ITQ system (e.g., Refs. [2–5,13]). A purse seine owner with Norwegian citizenship (M0 in Table 1) can buy another vessel, but only in the same vessel group, transfer the quota from the bought vessel, decommission the bought vessel, and keep the transferred quota for 20 years (M1 in Table 1). Quotas sold are curtailed by a certain proportion (M2 and M3 in Table 1). The truncated portion is redistributed to the vessel group. A vessel owner can buy and transfer quotas only up to a certain limit (M4 and M5 in Table 1). If an owner has more quotas than he can fish with his active vessel, then he can apply for a permit to split and sell it. Once the 20-year period is over, the quota goes back to the group (M6 in Table 1) and redistributed on a permanent basis to the remaining vessels in the seagoing purse seiner group. Thus, all vessels in the group will get more quotas.

Table 1 shows that in the seagoing purse seine group, one national market with regional boundaries and restrictions is involved [4]. There is a certain curtailment of the quota depending upon, which county the quota is transferred to. This measure is intended to limit regional concentration of fishing capacity and operations.

### 3.2. Quota holdings

A pelagic quota consists of a quota package that gives a vessel the right to catch a certain volume of herring, mackerel, and capelin. After the collapse of the herring fishery about 50 years ago, the vessels were allocated with vessel quotas. As of 2005, quotas have been tradable, provided that the vessel selling the quota exits the fishery. Quotas that have been traded are referred to as structural quotas (SQ), whereas the original quota of the vessel, which were received free of charge from the state, is described as base quotas (BQs).

As presented in Fig. 1, the majority of boat owners in Norway's purse seine fleet have purchased quota shares. Standal and Asche [5] found that approximately 19% of the total group quota had been sold within the seagoing purse seiner vessel group between 2006 and 2015.

### 3.3. Catch capacity and quota holdings

The total quota holding of a seagoing purse seiner includes the BQs, SQs, and other quotas (OQs). Some purse seiners have other fish quotas than herring, mackerel, and capelin. These species are, however, less valuable, including sand eels, Norway pout, brisling, and blue whiting. Accordingly, the economic effect of OQs is less significant.

Fig. 2 shows the relationship between the vessels' quota holding (BQ + SQ) and their catch capacity. Physical catch capacity is measured in vessel capacity units (VCU), formulated as vessel length (meters) x vessel width (meters) + .45 × engine power (for more details, see Data and Methods section). As illustrated in Fig. 2, a great variety is found among the vessels with regard to how well the catch capacity is adjusted to the vessels' quota holding.

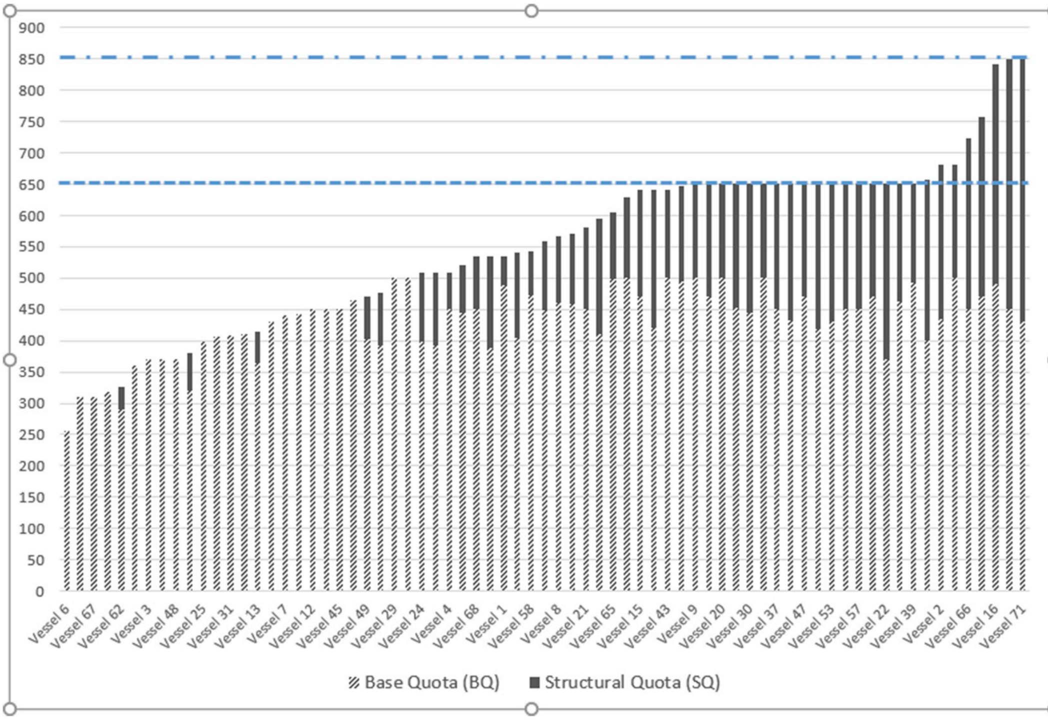


**Fig. 1.** Distribution of Base quotas (BQ) and Structural quotas (SQ) of seagoing purse seiners as of 2017. The two horizontal dotted lines show the quota ceiling before 2015 (650) and after (850).
Source: Norwegian Directorate of Fisheries database of licensed purse seiners (https://register.fiskeridir.no/fartoyreg/)

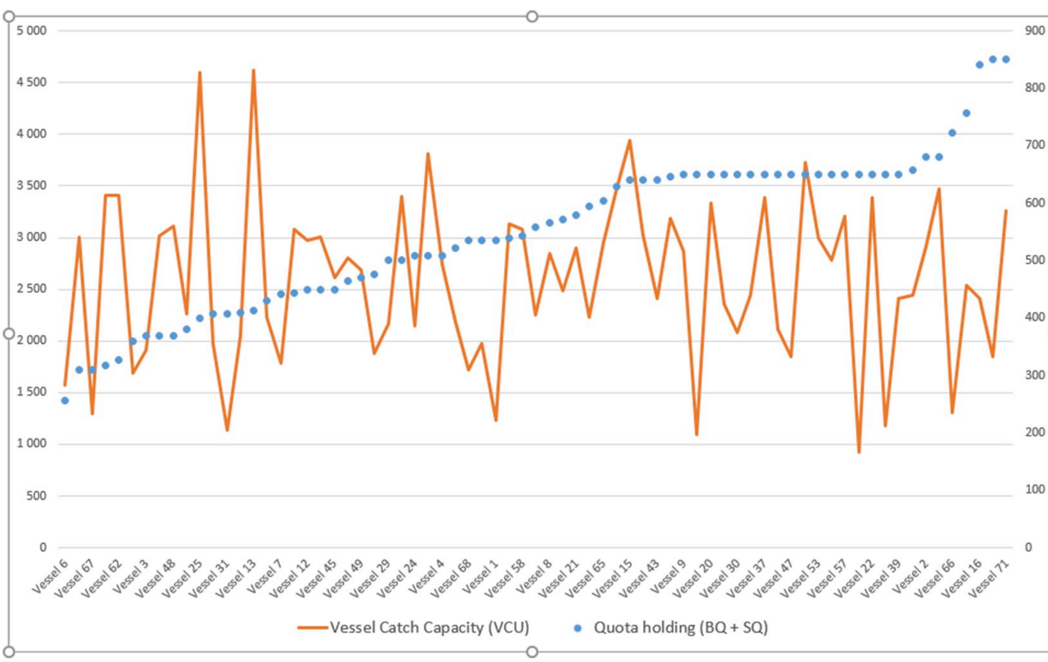


**Fig. 2.** Vessel catch capacity (VCU, left axis) and quota holding (right axis) as of 2017 ($r^2 = 0.64$). OQ is not included in the figure as it uses another unit of measurement than BQ and SQ.

### 3.4. Descriptive data

Table 2 presents the descriptive data of the Norwegian seagoing pelagic fishing fleet, which includes 71 vessels. The mean return on invested capital (ROIC) of these vessels was 11% in 2017, varying from a minimum of 1% to a maximum of 81%. The mean BQ held by a vessel is 431 tons, and more than half of the vessels have a BQ of more than 448 tons. Variations in BQ owned by the vessels is very small as the maximum BQ owned by a vessel is 500 tons, which is only 52 tons more than the mean value. Twenty-one vessels have never bought quotas (SQs) in the market. The remaining 50 vessels have bought SQs with a mean amount of 113 tons. Forty-eight vessels have OQs, which include species of sand eels, Norway pout, brisling, and blue whiting. The average VCU is 2,588, the minimum VCU is 924, and the maximum VCU

**Table 2**
Descriptive data of seagoing pelagic fishing vessels.

| | ROIC | BQ | SQ | VCU | CAQ | Age |
|---|---|---|---|---|---|---|
| Minimum | 1% | 256 | 0 | 924 | 2,65 | 2 |
| Mean | 11% | 431 | 118 | 2588 | 4,76 | 16 |
| Medium | 5% | 448 | 113 | 2608 | 4,73 | 14 |
| Maximum | 81% | 500 | 420 | 4616 | 7,89 | 51 |
| Standard error | 2% | 7 | 12 | 94 | 0,14 | 1 |

is 4616. The average ratio of catch capacity against quota holdings (CAQ; catch capacity/(BQ + SQ)) is 4.76. The variation of the ratio between the vessels is huge. The CAQ varies from 2.65 to 7.89, indicating the existence of a mismatch between catch capacity and quota holdings for many vessels.

The mean age of the vessels is 16 years old, with a relatively even distribution between the young and the old as the medium number (14) is close to the mean value. The information of the attributes of the vessels not presented in the table is as follows: 8 vessels belong to firms owing more than one vessel; 21 vessels belong to larger holding companies; and 49 vessels are located in two regions, namely, Hordaland, and Møre and Romsdal. Those vessels are expected to have high ROIC if they belong to a company owning more than one vessel or a large holding company as they gain advantage in sharing information. For the same reason, it is also expected that the vessels located in the cluster region of Hordaland, Møre and Romsdal have higher ROIC.

## 4. Data and Methods

### 4.1. Data

The accounting data of each of the 72 fishing firms were obtained from the Brønnøysund Register Center (in Norwegian: Brønnøysundregistrene, www.brreg.no) based on industry code and company identification and analyzed. All firms had a positive ROIC except for one (ROIC of −8.56%). This vessel is regarded as an outlier in the econometric analysis and was therefore deleted from the data for further model estimation. The sample size for the final estimation therefore becomes 71. Data on the vessel quota holdings and catch capacity were retrieved from the public database of licensed purse seiners published by the Norwegian Directorate of Fisheries (https://register.fiskeridir.no/fartoyreg/).

### 4.2. Measuring catch capacity

The concepts of capacity and capacity utilizations of fishing vessels are complicated as the most important input factor, fish, is beyond the fishermen's control and can widely vary between years and during the year [34]. Moreover, in most cases, fish is caught free of charge; thus, the input has no cost. Consequently, measuring capacity and capacity utilization in fisheries is not straightforward [20,35].

Gross register tonnage, gross tonnage, or tonnage units are used as a physical measures of the vessel's volume. Furthermore, the age of the vessel may give an indication of the effectiveness of the technological equipment. However, the relationship between the efficiency of the vessel and its age may be weak or nonexistent [12]. Another physical capacity measure used is engine power measured in kW or horsepower. All the above measures help describe different physical dimensions of the capacity of a vessel.

One physical capacity measure that combines some of the aforementioned measures is VCU. This measure originates from English fisheries management and is recommended by FAO [36]. The measure is composed of the length and width of the vessel and its engine power. The formula is as follows:

$$\mathrm{VCU} = L \times W + 0.45 \times \textit{engine power},$$

where $L$ is the vessel length, $W$ is the width (both in meters), and engine power is measured in kW (1 kW ≈ 1.36 hp). For example, following the formula, a vessel that is 73.3 m long and 12.6 m wide and has an engine of 4027 kW has a VCU value of 2736. However, some disadvantages exist with the VCU measurement unit. VCU is a purely physical measure, devoid of economic rationale. Moreover, as the type of fishing gear is not included, a comparison between different fisheries is difficult.

### 4.3. Measuring financial performance

The aim of the present study is to estimate how costly a mismatch is between a fishing vessel's catch capacity and its quota holding. The operationalized dependent variable in the study is the firms' ROIC resulting from the catch business only. The performance measure used is relative and thus enables comparing firms of different sizes [37,38]. There are surprisingly few analyses of accounting data in fisheries, while this has become an active field in aquaculture, e.g. Asche et al. [39]; and Misund and Nygård [40].

However, in traditional financial statements, assets are grouped in relation to their liquidity and debt relative to maturity. Such a format is useful for creditors when analyzing whether a firm is sufficiently liquid to pay its debt on maturity. For the purpose of this study, which is profitability measurement, a standard setup of the income statement and balance sheet was not suitable for further analysis. Therefore, the analysis is based on reorganized income statements and balance sheets given by Penman [38]. The overall purpose is to separate assets and liabilities into one of two categories: 1) operating assets and liabilities and 2) financial assets and liabilities. The same procedure was also applied to the profit and loss accounts. An essential purpose in the study is to calculate the operating results of the core activity, i.e., the catch business only, which is not affected by financial items. Subsequently, the operating profit was calculated after tax in accordance with the net operating profit less adjusted taxes (NOPLAT) as outlined in Table 3.

When separating operating income and expenses and financial income and expenses in the profit and loss account, a corresponding separation was made in the balance sheet when calculating the working capital. Therefore, the operational working capital was allowed to consist of the assets that were regarded necessary for the operation, i.e., receivables (debtors), prepaid expenses, and inventory. Then, financial assets were made up of cash, other liquid funds, and short-term investments. As some cash regarded as financial operating assets is normally needed for transaction purposes, an amount equivalent to 3% of the revenues was taken as required cash for ongoing transactions. The remainder was considered financial assets.

Current liabilities were made up of trade payables, current liabilities due to accrued liabilities and due taxes and fees, and any other short-term liabilities for, which interest is not payable. Deferred dividend, which was not paid but booked as accrued liabilities, was reallocated to equity. In short, debt that did not charge financial expenses with interest or similar payments was regarded as operating debt and included in the operating working capital. The remainder was regarded as short-term operational interest-bearing debt together with long-term interest-bearing liabilities. In sum, these items were considered financial liabilities. Operating assets (property, plant, and equipment), and net working cash and receivables, less operating liabilities, is considered net invested capital (IC). Based on NOPLAT, the firm's ROIC is calculated as

**Table 3**
Calculating NOPLAT from fishing activities.

| | |
|---|---|
| | Sales revenues |
| - | Operating costs |
| - | Labor costs |
| - | Depreciation and amortization |
| = | EBIT (earnings before interests and taxes) |
| - | General taxes on EBIT |
| = | NOPLAT |

$$ROIC_t = \frac{NOPLAT_t}{IC_{t-1}}.$$

### 4.4. Method

An ordinal least squares (OLS) model is applied to investigate the existence of overcapacity at the firm level in the Norwegian seagoing purse seine fleet. The model estimates whether the relationship between the quota holding owned by a vessel and the vessel's catch capacity affect the ROIC. Aside from the key variables of quota holdings (BQ, SQ and OQ) and catch capacity (CAQ), other variables, such as vessel age (Age), if the vessel is part of a multi-vessel firm (MVF), strategic alliance (SA), or co-located (COL), are also included in the model as control variables. The empirical model is specified as

$$lnROIC_i = \propto_0 + \propto_1 lnBQ_i + \propto_2 lnSQ_i + \propto_3 lnOQ_i + \propto_4 lnCAQ_i + \propto_5 Age_i + \propto_6 MVF_i + \propto_7 SA_i + \propto_8 COL_i + \propto_9 D1_i + \propto_{10} D2_i + e_i, i = 1, 2, \ldots \mathrm{N}, \quad (1)$$

Basic quota (BQ) and structure quota (SQ) are separately measured to avoid the measurement of errors as the properties of BQ and SQ are different (i.e., BQ is received for free, whereas SQ is bought in the market). When SQ is equal to zero, it means the vessel has not bought any quota in the market. In these cases, a minimum quota unit (SQ = 1) is provided to take the logarithm. OQ is specified as a dummy variable (1 for vessels having OQ; otherwise, 0). A volume variable for OQ was not used because this quota is measured by different units other than BQ and SQ. Moreover, the economic significance of this quota is modest.

As we have discussed, CAQ presents the ratio of vessel catch capacity (VCU) to the volume of quota holdings (BQ + SQ). CAQ is used instead of catch capacity for two reasons. First, the definition of capacity does not mean the higher capacity, the larger the overcapacity. Overcapacity is defined as a vessel having excessive capacity for catch in relation to quota (e.g., Refs. [20,32]). Second, quota volume is highly correlated with vessel capacity. This argument is intuitive as a large vessel will normally have a larger quota than a smaller one. The correlation between quota volume and vessel capacity is 0.64. When two highly correlated variables are included in the same model, the model will have the problem of multicollinearity.

For the left of the variables, *MVF*, *SA*, and *COL* are all dummy variables. They are 1 when a vessel has this characteristic, otherwise 0. The *MVF* (e.g., Ref. [41]), *SA* (e.g., Ref. [42]), and *COL* (e.g. Ref. [43]) variables are expected to have a positive effect on the vessel's ROIC.

The mean and medium values for ROIC (see Table 2) reveal a considerable asymmetric distribution with a long tail of high ROIC. The estimation model therefore introduces three dummy variables that will control for the effect of ROIC above 20%, between 10% and 20%, and below 10%. The argument is that the asymmetric ROIC can be due to a "skipper effect" or the operation and management of the vessel and/or the firm [31]. Thus, the human capital part of the independent variables can be years of experience or innate skills. The effect of human capital is often ignored in the literature [7]. Accordingly, the operating model captures the effect of heterogenic human capital among the firms by the dummy variables attributed to different ROIC ranges. In Equation (1), dummy 1 (*D1*), and dummy 2 (*D2*) are dummy variables for categories 1 and 2, respectively. To avoid the singularity problem in the estimation, one of the category dummies is excluded from the model. This is the base variable when interpreting the estimated results of *D1* and *D2*.

Consistent with the investment behavior theory discussed by Nøstbakken et al. [7]; the independent variables in the model include three types of capital in fisheries investment. *BQ*, *SQ*, and *OQ* reflect intangible capital, *CAQ*, and *Age* are the physical capital of a vessel, and *MVF*, *SA*, *COL*, and dummies are related to human capital.

## 5. Findings

The estimated results of the model (Eq. (1)) are presented in Table 4. The model well explains the performance of ROIC as R-squared is 0.79. As expected, human capital is important to explain the variation of ROIC between vessels. This finding is in line with the RBV of strategy that examines potential economic rents internally in the firm (e.g., Refs. [29, 30]). This statement is given based on the two category dummies, which are statistically significant at any reasonable level with large magnitudes.

For the key variables of *BQ*, *SQ*, and *OQ*, none of the estimated coefficients of these variables are statistically significant at any reasonable level as suggested by their low *t* values. This finding means that neither the scale of the quota nor the type of quota (BQ, SQ or OQ) is important for the vessel's ROIC. The key factor that significantly influences the vessel's ROIC is overcapacity. This statement is based on the result that the estimated coefficient of CAQ is statistically significant, with a negative sign. The results suggest that when the relative ratio of capacity and quota volume of a vessel increases by 1%, the ROIC of the vessel decreases by 0.692%. This result further indicates that a big overcapacity problem still exists in the Norwegian seagoing pelagic fishing fleet.

For the control variables, the estimated coefficients of *Age* and *SA* are positive but not statistically significant at any normal significance level. This also holds for the estimated coefficient of MVF. The results suggest none of the factors such as age of vessel, whether a vessel is operated by a firm that belongs to a big fish holding company or operated by a firm owning multiple vessels affects a vessel's ROIC. Our result of SA is different from that given by Ref. [42]. They found the average ROIC is higher when a vessel is operated by a firm that belongs to a big fish holding company.

In the sample, approximately half of the vessels are located in the two regions Hordaland and Møre og Romsdal. When looking at the descriptive statistics, the average ROIC for the vessels in the two regions are lower than that of the vessels from other regions. Therefore, univariate studies simply draw the conclusion that COL has a negative effect on ROIC. However, this claim is incorrect. In the model of this study, the effect of ROIC given by COL is isolated from the other factors, including quota, fishing capacity, management, and others. The estimated coefficient of COL is positive and statistically significant, suggesting that being co-located has improved the vessel's ROIC. Thus, the average ROIC for the vessels in the clusters is due to other factors, including the problem of overcapacity and poor management.

## 6. Discussion

Many studies on overcapacity are of a theoretical nature, and industry is used as the unit of analysis. Accordingly, more empirical studies on the economic consequences of overcapacity for firms based on adequate financial data have been called for in the literature (e.g. Refs.

**Table 4**
Estimated results of the model.

| | Estimated coefficient | *t* value |
|---|---|---|
| Intercept | 0.621 | 0.20 |
| BQ | −0.163 | −0.32 |
| SQ | 0.012 | 0.39 |
| OQ | 0.066 | 0.42 |
| CAQ | −0.692 | −2.29** |
| Age | 0.010 | 1.44 |
| MVF | −0.124 | −0.60 |
| SA | 0.238 | 1.56 |
| COL | 0.299 | 1.97** |
| D1 | −2.306 | −11.14** |
| D2 | −1.039 | −4.24** |
| $R^2$ | 0.79 | |

** Significant at the 5% critical level.

[12,19]). In response to these requests, the research question raised in this study is, how costly is a mismatch between a fishing vessel's catch capacity and its quota holding? To investigate the issue, data of 71 Norwegian seagoing purse seiners were collected and analyzed using an OLS model including the vessel's catch capacity, quota holding, and ROIC along with several control variables.

The findings of this study show that the three variables representing the quotas (BQ, SQ, and OQ) all have t values indicating insignificance in explaining the variance of the dependent variable. These findings have important implications. First, the profitability of the players has not been improved by buying quotas (SQ) at a market price. Second, the findings indicate the lack of economies of scale in the seagoing purse seine fleet. As a consequence, the increase in the quota ceiling that took place in 2015 (see M4 in Table 1 and Fig. 1) cannot be expected to have a positive effect on the future profitability of the vessels. This finding is contrasted by Nøstbakken [44] but supported by Bjørndal and Gordon [45] who did not find evidence of large economies of scale in the Norwegian seagoing purse seine fleet, concluding that most of the returns from scale effects have already been captured.

The main variable in the study, *CAQ*, a measure of potential misalignment between an index of physical capacity and quotas (fishing rights and licenses) has a negative elasticity, and high statistical significance. This finding supports the hypothesis that not an optimal alignment of physical capacity and quotas is presently available in the industry. The total quotas (the TAC of the vessel group) has a natural upper boundary within the fishery studied. This finding may then mean that the physical capacity is still too high, in spite of decommissioning of vessels in recent decades.

Moreover, the distribution of quota within the group may not be optimal. If this is correct, then more quotas to the larger vessels relative to the smaller vessels will decrease the CAQ for high-capacity vessels (and increase for small-capacity vessels). The present market for quotas may over time lead to such a redistribution as older and smaller vessels are taken out of active use.

The positive elasticity of age, though not quite statistically significant, merits a comment. The sign of the elasticity may seem counterintuitive. However, we find an explanation in the definition and calculation of ROIC. The value of the denominator, *IC*, is a book value of the vessel, and intangible capital (licenses and quotas). Many high age vessels are almost fully depreciated. Some also fish only on BQs. BQs do have a market price, if sold. For many vessels of high age, a hidden value in their balance sheets is thus present as the market value is higher than the book value of the quotas. If the market value for assets had been available for this study, then the positive value for age would have most likely disappeared.

The dummy for the COL effect is as expected. A steady concentration of purse seiners has been existent in Hordaland and Møre og Romsdal. This study shows that such concentration has resulted in a higher ROIC of the vessels when controlling for the other factors in the model. Being part of an SA or MVF did not have a significant effect on the firms' financial performance.

To conclude, our findings suggest that despite the closure of the commons, the introduction of quota systems, decommissioning programs, market-based structural measures, and detailed control over the fishermen's day, problems created by overcapacity still exist in Norway's fisheries. Overcapacity leads to increased pressure on scarce fish resources and an economic loss to the society as productive resources that could have been used elsewhere get tied up in fisheries. Other negative consequences of overcapacity include high administrative management costs, conflicts in resource allocation, and limited financial return for the players that incur higher fixed costs than necessary [46].

The findings of this study indicate that the most important strategic decision for a firm is not to acquire the largest possible physical catch capacity or quota holding but to achieve the best possible match between two variables. If a mismatch has occurred, then a key question is, which of the two critical variables is most flexible and cost efficient to adjust? Catch capacity is a physical construct, which is not very flexible because it must be adjusted in large leaps. Increasing capacity can either be achieved by extending the vessel or replacing an old engine with a new and more powerful one. The quota holding, however, is an intangible construct that can be adjusted in smaller increments. The use of the quota market is therefore most compelling for a firm to achieve a better fit between capacity and quota holding. This method will require the quota market to work without incurring high transaction costs for the players [24]. However, the modifications made to Norway's variant of the IFQ regime (see Table 1) make the system rigid and costly to apply. As a consequence, aligning the catch capacity to the quota basis becomes more difficult for firms.

### Declaration of competing interest

None.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpol.2020.103874.

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