Environment and Development Economics (2020), **25**, 355–377
doi:10.1017/S1355770X20000133

RESEARCH ARTICLE

The impact of collective use rights on share contracts: the case of the Extractive Artisanal Regime (RAE) in Chilean hake fisheries

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(Submitted 24 October 2018; revised 29 October 2019; accepted 28 January 2020; first published online 20 April 2020)

Abstract

Share contracts are the dominant remuneration system in artisanal fisheries. Introducing regulations based on collective use rights may affect the way profits are distributed. The literature on the effect of regulatory reform on factor income distribution, however, is scarce. In this paper, we look at differences in the implementation of the Extractive Artisanal Regime in Chilean hake artisanal fisheries to test its effect on share contracts. We estimated a switching regression model using census data to calculate the average treatment effect. Our results show that crewmembers in communities regulated by some form of collective use rights receive, on average, 6 per cent more of total net incomes compared to those regulated by a limited access with global quota regime. Differences in the relation between crew size and labor rewards, as well as in the negotiating power of crewmembers under different regimes, may explain the results.

Keywords: collective use rights; fisheries; share contracts; switching regression model

JEL classification: Q22; D86; D13

1. Introduction

The use of catch share systems for fisheries management has been broadly advocated in the literature for its efficiency gains compared to open access conditions (Costello *et al.*, 2008; Gutiérrez *et al.*, 2011). However, improvement in efficiency usually implies, among other things, the reorganization of the internal structure of firms, which might lead to important distributional conflicts. These conflicts are mainly related to quota concentration, reduction in employment of fishermen, more competition in the labor market, increased working hours for active fishermen, and/or changes in the remuneration

of fishing jobs (Guyader and Thébaud, 2001). Typically, regulations based on catch shares are designed to give use rights to vessel owners, implying additional distributional conflicts coming from the improved position of capital owners (Copes, 1997; Davidse, 1997). It is likely, then, that catch shares will redistribute bargaining power and, therefore, rents within the firm. Specifically, through the remuneration systems, catch shares can have a direct impact on rent distribution between the vessel owner and the crew.

This paper contributes to understanding how the mechanism by which output or income in fisheries is distributed between labor and capital, is adjusted when a catch shares system is introduced. The most broadly used remuneration system in artisanal fisheries is share contracts. Under a share contract remuneration regime, the crew receives a percentage of either the gross income or profit per fishing trip (Platteau and Nugent, 1992). Given the potential redistribution of bargaining power and the well-known effects of catch share systems on productive efficiency, the introduction of this fisheries management instrument is likely to have an impact on labor costs and crew wages, especially in shared remuneration systems (Guillen *et al*., 2017). This might have important implications on fishermen's expected income. Literature studying the impact of catch share systems on efficiency-related issues is well-documented (see, for example, Copes, 1986; Grafton, 1996; Scott, 2008; Arnason, 2012), but information on remuneration effects is still limited. One exception is Abbott *et al*. (2010) who found an increase in remunerations after the implementation of catch shares in the Bering Sea/Aleutian Island crab fisheries in the USA. The rise was explained by an increase in the base on which the share was calculated, but the authors did not find any clear evidence of changes in crew shares.

We use data on the distribution of fishing net incomes between vessel owners and crewmembers, and geographical differences in the implementation of the Extractive Artisanal Regime (or RAE, its acronym in Spanish) in Chilean hake fisheries to explore changes in crew shares. RAE is a type of cooperative catch shares regulation implemented in Chile with basically two variations: RAE by organization and RAE by area. While RAE by area represents the *status quo* of a restricted access regime with global quota over a specific fishing area, RAE by organization requires artisanal fishermen to build organizations that collectively decide how to organize fishing effort over their common quota. Our empirical strategy takes advantage of the fact that these different varieties of RAE were applied simultaneously in different geographic areas. We combine census data and information from official decrees by the Undersecretary of Fisheries to identify a number of fishing communities that adopted the collective quota systems, namely RAE by organization (treated group) and RAE by area (control group). To assess the effect of this regulatory change on crew shares, we estimate a switching regression model which enables us to account for pre-existing differences between fishing communities and shows differentiated effects on crew net income shares depending on the regulatory regime.

The rest of the article is organized as follows: section 2 reviews the literature on catch shares systems as a fisheries management instrument and its effects on fisheries performance. Section 3 describes the characteristics of the Chilean hake fisheries. Section 4 discusses the implementation of the RAE in Chile. Section 5 presents the empirical strategy and section 6 the data and econometric estimation. Section 7 discusses the main results, section 8 presents a series of robustness controls, and section 9 concludes with the implications of the study.

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

2. Literature review

The use of catch share systems has been advocated in the fisheries literature as a management device that can prevent fisheries from collapsing (Costello *et al*., 2008; Gutiérrez *et al*., 2011), particularly individual transferable quotas (ITQs) as a specific type of catch share regime (Copes, 1986; Grafton, 1996; Scott, 2008; Arnason, 2012). Although ITQs can be an efficient solution, they can fail to enhance efficiency in intra-seasonal or spatial effort allocation (Holland, 2004; Wilen *et al*., 2012) and in multispecies fisheries (Sanchirico *et al*., 2006), and can generate weak incentives for biomass and ecosystem (Arnason, 2012).

An alternative management regime that may hold advantages over ITQs is cooperative catch shares (CCS).[1] In this case, rights are granted to an organized group of fishermen (Poon *et al*., 2013). CCS can improve management when there is some type of externalities between fishermen (Baland and Platteau, 2003; Cheong, 2004; Segerson, 2014; Holland, 2015). In such cases, collaborative action can enhance efficiency through a reduction in monitoring and enforcement costs (Ovando *et al*., 2013), inducing efficient effort distribution between an organization's members (Schlager, 1994; Cancino *et al*., 2007; Deacon *et al*., 2008; Uchida, 2017), reducing site search costs through information sharing (Costello and Deacon, 2007; Knapp, 2007; Deacon *et al*., 2008) and reducing bycatch through cooperation (Ovando *et al*., 2013). However, the effect of CCS on efficiency and resource conservation depends on the regulatory design of the rights, the characteristics of the fishery, the way in which fishermen organize themselves, and the goals and the cooperation tradition of organizations (Heintzelman *et al*., 2009; Holzer, 2010; Deacon, 2012; Castillo and Dresdner, 2013; Ovando *et al*., 2013; Segerson, 2014).

The effect of CCS on share contracts has received little to no attention in the literature. The little existing evidence relates to evaluating individual catch share regimes that are similar to ITQs. Conceptually, we can identify different routes through which the change in the regulatory regime might affect income shares. Which one of these routes constitutes a valid explanation in this case is an empirical question. The change in the regulatory framework is associated with changes in the productive process, altering underlying incentives for economic decision-making, with subsequent consequences on the production function, productivity, bargaining power of factors, and on the characteristics of a 'fishing job', such as duration, safety and content. In order to enhance efficiency in quota markets, fishers are not only encouraged to be more efficient in terms of fishing operations, but are also incentivized to reorganize their internal structure, particularly in terms of contracts between vessel owners and crews (Guyader and Thébaud, 2001).

One way to understand the determination of income shares is a basic negotiation model, in which the shares are determined by the bargaining power of the relevant agents. Brandt and Ding (2008) developed a model to study this new contractual form that emerges between boat and quota owners in an ITQ setting. Basically, individual or collective quotas are considered a new form of capital, distinct from the vessel. As capital, they give rights to catch and reduce the relative importance of labor compared to

[1]We make a distinction between cooperative catch shares that are catch limits granted to a group of individuals, generically called 'cooperatives' (e.g., associations, fisher organizations, producer groups, guilds, unions, communities), and rights over areas, that are generally referred to as Territorial Use Rights for Fishing or TURFs (Poon *et al*., 2013). This study looks at catch limits of specific species bestowed upon associations of vessel owners.

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other inputs (Casey *et al*., 1995). Therefore, the possibility that the crew retains part of the vessel owners' rent and/or agrees to cover the extra costs, depends on the bargaining capacity of each of the parts (Guillen *et al*., 2017). This view seems to be held in most of the literature that has done research on share contracts in fisheries (McCay *et al*., 1995; Squires *et al*., 1995; Abbott *et al*., 2010). In this literature, there is a case when the introduction of individual fishing rights should tend to reduce the crew share. This is when a part of the income is used to pay the cost of the fishing rights. However, this effect could be counteracted if this reform, at the same time, induces the search for more skilled crew with greater labor productivity, augmenting the bargaining power of the crewmembers. This could, in principle, lead to an increase in the crew's income shares. Thus, it is not evident how an efficiency-enhancing change in the fishing rights regime will change income shares among the crewmembers in general. Empirically, Abbott *et al*. (2010) explored the remuneration and employment effects of individual catch shares in the Bering Sea/Aleutian Island crab fisheries in the USA. The authors found an increase in remunerations coming from efficiency gains. These gains were the result of cost reductions and/or increases in live landings per day. There was no clear evidence that crew shares had changed, implying that this increase was founded on a larger income base from which the share was calculated.

A second way to understand the shares system is as a cooperative contract agreement between the vessel owner and the crew, where the distribution of benefits resulting from this coalition is to be determined by a consensual bargaining process. For consent to prevail, a commonly agreed concept of fairness should be adopted which, in turn, will specify how the distribution scheme will work in a consensus (Liang, 1999). The contract agreement between the vessel owner and the crew, in accordance with the multiple crew model (McConnell and Price, 2006), incorporates two parameters that determine the income share and the ex-ante cost share paid by the crew (e.g., fuel). If the cost share for the crew decreases, this will increase the net income share received by the crewmembers. In this model, the cost share depends, among other things, on the reservation utility of the crew. If this reservation utility increases, then the cost share will be reduced in the contract, reducing the vessel owner's net income share.[2] There are several routes in this model, through which a regulatory reform such as the RAE by organization can generate positive or negative impacts on the crew's net income shares. A change in equity considerations of what constitutes a fair share would generate an increment in the reservation utility of the crew, and an increase in its net income share. Moreover, if the regulatory reform induces more cost efficient trips, the percentage of costs per trip required to be shared among the crewmembers will be reduced, having the same effect as an increase in reservation utility.

An additional argument for analyzing the effect of the RAE by organization on income shares is considering the collective nature of the fishing right. Strictly speaking, in the RAE by organization the fishing rights are granted to the organization and not to individual vessels. This, and other features of the specific way in which collective rights were implemented, implied that the artisanal fisher organization (cooperatives) had a great deal of power to influence income shares. Specifically, fairness considerations might be very important for the fisher organizations (McCay *et al*., 2013). Once

[2]The introduction of the cost share and the crew's reservation utility in the model is what, in our opinion, makes the multiple crew model more consistent with a cooperative contract agreement view of the shares system.

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

again, in principle, the shares might change either way, depending on the characteristics of the organization and the manner in which collective action is organized by it.

In summary, we do not have theoretically definite predictions on what we should expect to happen with income shares when CCS are introduced. Nevertheless, the empirical evidence on what the result was on income shares is relevant, because it discards certain outcomes (decrease or increase in crew shares), and allows us to discuss the causes of the observed change.

3. The Chilean hake fisheries

In south-central Chile, there is a traditional fishery industry based on a demersal species, the Chilean hake (*Merluccius gayi gayi*). This species is found between the Coquimbo (29°54′28″S) and Los Lagos (41°28′18″S) regions,[3] primarily located in the first 60 miles off the coastline, and concentrated around 50–500 m depth. The primary spawning period occurs between August and September, not starting until October in the southernmost regions. The recruitment age is two years old, and they can live up to 20 years (Subsecretaría de Pesca, 2011).

Two different fleets operate over the species: the industrial and the artisanal fleets. According to Chilean law (General Fisheries and Aquaculture Law, 1991), artisanal vessels cannot exceed 50 gross tons or a length of 18 m. Vessels that exceed one of these marks are considered industrial. Artisanal fishermen have exclusive rights for fishing within the first five nautical miles off coast. To capture Chilean hake, industrial vessels use bottom trawling or dropline methods, while artisanal vessels are only allowed to use gillnet or dropline. Chilean hake is mainly used for human consumption, both domestic and foreign, in the form of frozen or fresh chilled products (Quezada and Dresdner, 2014).

The distribution of income in the artisanal Chilean hake fisheries is based on a share contracts system, which varies depending on the fishing gear used and the geographical location. As a general rule, trip costs (mainly fuel and food expenses) are discounted from the gross income of a fishing trip. This resulting income, hereafter net income, is then distributed between the vessel owner and crew in fixed percentages. For instance, vessel owners in the Biobío region that do not use trawling receive 40 per cent of the net income, and the rest of the crew receives 60 per cent (Dresdner *et al*., 2005). One particular feature of artisanal fishing's organization is that the total capital required to fish is distributed between the crew. While one of the fishers owns the vessel and, therefore, receives a higher share of the net income, the crewmembers in many locations provide their own fishing gear (H. Arancibia, leader of the Federación de Pescadores Artesanales de la Región del Biobío, personal communication, 16 March 2017); thus, the crew's share does not only reflect labor income, but also capital income. In some fishing coves, the owner of the fishing gear receives a specific share of income for this contribution. The negotiating power of the crew is stronger in these cases where they contribute capital, rather than only contributing labor.

[3]The country is divided into sixteen different regions. The General Law of Fisheries and Aquaculture restricts artisanal fishers to operating exclusively in the region where the vessel is registered. In contrast, industrial fishermen are allowed to move along the entire Chilean coast, outside the five first nautical miles off coast.

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4. Extractive Artisanal Regime in Chile

In 2001, an individual quota system was established and applied for the first time to assign the industrial share of the Chilean hake fisheries' total allowable catch (TAC). In 2004, a special regime called the Extractive Artisanal Regime or RAE was established by the Undersecretary of Fisheries (UF) to allocate the artisanal share of the TAC for those fisheries with restricted access. One of these was the Chilean hake fisheries.

The RAE can be initiated by the Undersecretary of Fisheries or upon request from artisanal fisher organizations (Reglamento del RAE, 2004). It includes different potential assignment forms for the artisanal share of the TAC among fishermen, namely: by geographic area, by fleet, by vessel-type (according to size), by fishing cove, by artisanal organizations or individually. In practice, however, only two of these assignment forms have actually been in force in Chile: RAE by area and RAE by organization.

The RAE by area assignment form can be seen as a system of several different TACs defined over limited areas and subsamples of artisanal fishermen. In fact, the division of the share of the artisanal TAC by regions is a RAE by area assignment form. Thus the status quo, should no one have requested a change in the regulatory regime, was a RAE by area assignment form. However, the RAE by area was applied, in some cases, to geographic areas that were smaller than the regional limits. For the fishermen with access rights to the area, the system worked as a restricted-access common pool regime with a TAC. Thus, the incentive was to fish as fast and as much as possible, before the area was closed.

The RAE by organization form, in contrast, required the formation of a formal fisher organization of vessel owners with legal statutes, member lists, and a democratic election of the leaders. The quota was assigned to the organization. Thus, the individual member did not have legal rights over the quota, but the organization did.[4] Moreover, the application to participate in the RAE by organization mode required a majority decision of the members belonging to the organization. The normative also included the possibility that the organization presented a managing plan for the quota. This plan should identify the rules for internal allocation of the organizational quota, which crewmembers participated in the extraction of the quota, verification mechanisms for the total landings made by the organization, and even organization-specific management and commercialization rules. This plan had to be supervised by the Fisheries authorities. Thus, the regulatory design has several incentives that framed collective action. This may have encouraged fishermen to coordinate in making fishing and income distribution decisions. However, collective catch share systems, *per se*, do not guarantee that fishermen will choose the collective action path (Holland *et al*., 2013).

When the RAE system was first implemented, most artisanal fishermen were not organized. Many artisanal fishers joined or built organizations to secure a quota because of the RAE's specifications. Another consequence of the regulatory change was that

[4]To calculate the organizational quota, the authorities used the share of total artisanal landings during the three years previous to the RAE launching by all the vessels belonging to the organization. This may have incentivized switching between organizations, with a potential significant impact on estimation. However, our data does not allow us to explore this potential switching, unfortunately. We believe that there is little likelihood of switching occurring in our sample period for the following reasons: our sample period is the 2007–2008 season, which is three to four years after the RAE implementation. Calculation of the organizational quota is based on the three previous years of landings. If switching occurred, this was more likely to have happened before the implementation of RAE by organization. This is an interesting research question that is beyond the scope of this paper.

the organizations' leaders obtained a great deal of power because the quota was owned by the organization and its sharing was supposed to be agreed upon by all the members of the organization. According to the Undersecretary of Fisheries, the RAE system in Chile was an effort to organize artisanal fishery, reduce job uncertainty in this activity and improve its management (Subsecretaría de Pesca, 2011). However, depending on the context and some particularities in each fishery, we should expect different effects from introducing these two types of RAE in terms of efficiency and distribution. For example, Chávez Estrada *et al.* (2018) found that RAE by organization reduced the technical efficiency in the common sardine and anchovy fishery in Chile, on average, and that organizations showing cooperative behavior performed better than those that do not. In spite of lack of more empirical evidence, this finding may also apply to other fisheries such as the Chilean hake fisheries. Another characteristic that is context-specific to the fisheries of interest in this study is the potential stronger negotiation power of crewmembers, who provide their own fishing gear. We hypothesize that this feature creates dissimilar effects in terms of distributional impacts of the RAE by organization.

Initially, both the RAE by area and RAE by organization forms were applied simultaneously in different geographic areas.[5] The areas with more artisanal fishermen and a prior history of artisanal organization were the ones that opted for RAE by organization, while the rest remained with the RAE by area form (Dresdner *et al.*, 2005). Since this last group continued to operate in the same manner as it used to before the introduction of the RAE by area, we do not expect to find any effects on the share contracts of their crew, because of the regulatory reform. The fishermen who were authorized to operate in the fisheries in an area regulated by organizational RAE and who decided not to participate in any organization had the right to access a common pool quota of approximately 6 per cent of the total artisanal share of the quota, called 'residual quota' (*cuota residual* in Spanish). They had the right to catch fish until this quota was exhausted in a restricted-access common pool mode.

5. Empirical strategy

To estimate the impact of the regulatory regime on crew net income shares, the following model was used:

$$y_i = \beta' x_i + \delta I_i + \varepsilon_i, \tag{1}$$

where y_i is the crew net income share of vessel i; x_i is a vector of explanatory variables from vessel I; β (a vector) and δ (a scalar) are parameters; ε_i is a stochastic variable; and I_i is a binary variable taking the value of one when the vessel owner operates under RAE by organization, and zero if the vessel owner is regulated under RAE by area. The impact of the regulatory system on net income shares is captured by the δ parameter. One issue with this model is that it might result in inconsistent estimates of the regulatory impact on net income shares if the selection of regulatory system is based on a set of pre-existing observed covariates; that is, if vessel owners' characteristics under RAE by organization differ systematically from those observed in fishing communities under RAE by area, the model might present selection bias (Maddala, 1983). Furthermore, the

[5]In fact, the two forms were introduced within the same regions. This was made possible by separating the regions into different (smaller) geographic areas, some under RAE by organization and others under RAE by area.

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

explanatory variables may have different effects on crew net income shares depending on the regulatory regime.

To deal with these issues, we estimate the switching regression model (Maddala, 1983). In our specification, we closely follow Nguyen and Leung (2009). The selection equation is defined by a criterion function I, determining whether or not the vessel owner operates in a fishing community regulated under RAE by organization:

$$I_i = 1 \text{ if } \theta' x_i + \gamma' z_{ik} + u_i > 0,$$
$$I_i = 0 \text{ if } \theta' x_i + \gamma' z_{ik} + u_i < 0, \tag{2}$$

where $I_i = 1$ if vessel i operates in a fishing community regulated under RAE by organization, and $I_i = 0$ if vessel i is under RAE by area; z_{ik} is a vector of observed variables affecting the probability that vessel i operating in a community k chooses to be regulated by RAE by organization; θ and γ are vectors of parameters; and u is a stochastic term.

The crew net income share equations for each regulatory regime are defined as follows:

$$y_{1i} = \beta_1' x_{1i} + \varepsilon_{1i} \text{ if } I_i = 1\ , \tag{3}$$
$$y_{0i} = \beta_0' x_{0i} + \varepsilon_{0i} \text{ if } I_i = 0\ , \tag{4}$$

where y_{1i} and y_{0i} are the fractions of net incomes allotted to crewmembers of vessel i under the RAE by organization and RAE by area regulatory regimes, respectively. u_i, ε_{1i} and ε_{0i} are the error terms of the selection equation, the RAE by organization and the RAE by area net income share equations, respectively. These are random variables that are assumed to follow a trivariate normal distribution with zero means and variances of σ_u^2, σ_1^2 and σ_0^2, respectively. Equations (2)–(4) form a system that requires a simultaneous estimation approach. Based on this trivariate distributional assumption of the disturbance terms, the switching regression model proposes the maximization of the following logarithmic likelihood function:

$$\ln L = \sum_{i=1} I_i \left[\ln \left(F\left(\eta_{0i}\right) \right) + \ln \left(\frac{f\left(\varepsilon_{0i}/\sigma_0\right)}{\sigma_0} \right) \right]$$
$$+ \left(1 - I_i\right) \left[\ln \left(1 - F\left(\eta_{1i}\right) \right) + \ln \left(\frac{f\left(\varepsilon_{1i}/\sigma_1\right)}{\sigma_1} \right) \right]. \tag{5}$$

$F(\cdot)$ and $f(\cdot)$ are the cumulative distribution and the distribution function, respectively; η_{ji} is defined as follows:

$$\eta_{ji} = \frac{\left(\gamma Z_i + \rho_j \varepsilon_{ji}/\sigma_j\right)}{\sqrt{1 - \rho_j^2}}, \quad j = 1, 2, \tag{6}$$

where $\rho_j = \text{corr}(\sigma_j^2, \sigma_u^2)$, $j = 0, 1$ are the correlation coefficients between the error term in the selection equation and the respective error terms in the net income share equations.

This model allows us to estimate the differences in the net income shares when vessels switch from the RAE by area regime to the RAE by organization regime, and vice versa. To calculate these measures, we first need to compute the conditional expectations of

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the net income shares under the two regimes. The expected outcome of a vessel that is a member of RAE by organization group is defined as follows:

$$E(y_{1i}|I_i = 1,\ x_{1i}) = x_{1i}\beta_1 + \frac{\sigma_1\rho_1 f(\gamma z_j)}{F(\gamma z_j)}. \tag{7}$$

The expected hypothetical outcome of a vessel that is a member of RAE by organization group (since $I_i = 1$) if the 'RAE by organization' regime did not exist (hence y_{0i}) is:

$$E(y_{0i}|I_i = 1,\ x_{1i}) = x_{1i}\beta_0 + \frac{\sigma_0\rho_0 f(\gamma z_j)}{F(\gamma z_j)}. \tag{8}$$

The expected change in the crew net income share of a vessel regulated under RAE by organization if it switches hypothetically to RAE by area is represented by:

$$E(y_{0i}|I_i = 1,\ x_{1i}) - E(y_{1i}|I_i = 1,\ x_{1i}). \tag{9}$$

The expected hypothetical outcome of a vessel that is a member of RAE by area (since $I_i = 0$) if 'RAE by area' regime did not exist (hence y_{1i}) is

$$E(y_{1i}|I_i = 0,\ x_{0i}) = x_{0i}\beta_1 + \frac{\sigma_1\rho_1 f(\gamma z_j)}{F(\gamma z_j)}. \tag{10}$$

The expected outcome of a vessel that is a member of RAE by area is defined as follows:

$$E(y_{0i}|I_i = 0,\ x_{0i}) = x_{0i}\beta_1 + \frac{\sigma_0\rho_0 f(\gamma z_j)}{F(\gamma z_j)}. \tag{11}$$

Finally, the expected change in the crew net income share of a vessel regulated under RAE by area when switching hypothetically to RAE by organization is expressed as:

$$E(y_{1i}|I_i = 0,\ x_{0i}) - E(y_{0i}|I_i = 0,\ x_{0i}). \tag{12}$$

Equation (9) can also be considered as an estimation of the average treatment of the treated. It quantifies how high the crew share is among group organization members compared to what it would have been if they had not become a member (Uchida *et al.*, 2010). In addition, we are interested in the potential impact of the RAE by group organization on the net income share. This is the average treatment effect (ATE) of the new regulation on the distribution of net incomes between vessel owners and the crew. It can be interpreted as the average gains in the crew share from changing all fishermen under RAE by area to RAE by organization. Then, we calculated the ATE as follows:

$$\begin{aligned}\text{ATE} = &(E(y_{1i}|I_i = 1,\ x_{1i}) - E(y_{0i}|I_i = 1,\ x_{1i})) \\ &- (E(y_{1i}|I_i = 0,\ x_{0i}) - E(y_{0i}|I_i = 0,\ x_{0i}))\end{aligned} \tag{13}$$

Or

$$\text{ATE} = (x_{1i} - x_{0i})(\beta_1 - \beta_0).$$

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6. Data and econometric estimation

We used data from the first Fishing and Aquaculture Census in Chile that was conducted by the Statistical National Institute (or INE, its acronym in Spanish). This census spanned the period from the end of 2008 until the first months of 2009 and contains information for the 2006–2007 fishing season (INE, 2009).

The census survey collected information from different economic agents related to the fisheries and aquaculture sectors. We used the census data on vessel owners operating in the artisanal sector.[6] The census consists of information on the fraction of total net incomes (fishing gross income discounting fuel and food expenses) from fishing distributed to each category of dependent workers involved in extraction activities, including vessel owners (namely skippers), fishers, divers, divers' assistants, and others. Our main share contracts' variable represents the sum of the percentages of all crewmembers belonging to these fisher categories. To identify a representative sample of fishers operating in the Chilean hake fisheries, we selected only those vessel owners reporting Chilean hake landings as one of their three main species. Thus, our sample consists of 662 observations of vessel owners operating during the 2006–2007 fishing season across the country under essentially two management regimes: RAE by area and RAE by organization.

In order to distinguish vessel owners operating under one regime or the other (the treated and control groups), we used the RAE regulatory decrees from the Undersecretary of Fisheries (Subsecretaría de Pesca y Acuicultura, 2017). These decrees give information on the distribution of the artisanal share of the TAC for the Chilean hake by area and, in the case of the RAE by organization mode, by organizations. Since this information is gathered at the organization level, we were not able to observe directly whether or not a single vessel owner was a member of an organization participating in the RAE by organization regime; however, we had information about the fishing cove (*caleta* in Spanish) where the organization reported performing its extractive activities and where the individual vessels were registered.[7]

Consequently, we matched organizations under RAE by organization, individualized in the official decrees, with location data of the vessel's registered fishing cove to proxy whether or not each vessel owner operated under RAE by organization, that is, if he belonged to the treated group. In this way, we defined treatment and control groups at the fishing cove level, assuming that all vessels registered in a certain location belonged to the treatment group if the decrees identified at least one organization located in this fishing community settlement operating under RAE by organization. This proxy, though imperfect, is based on the fact that it is not common to find more than one organization representing the same fishing community (Subsecretaría de Pesca y Acuicultura, 2017). Thus, this assumption seems reasonable in the absence of more accurate data. Figure A1 in the online appendix shows fishing coves throughout the study area. Red dots denote fishing coves regulated by organizational RAE. As can be observed, treated fishing communities are mainly located in the Biobío region, followed by Valparaiso.

To estimate the switching regression model, we first need to specify the selection equation outlined in (2). This equation estimates the probability that the community

[6]We excluded vessel owners who: reported that their boat was in maintenance; used their boat to transport passengers or cargo, and did not report crewmembers.

[7]Vessel owners report their base fishing settlement. We use this information to proxy for location.

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

chooses to be regulated by RAE by organization as a function of a vector of observed variables z_j. The probability is estimated by a probit model. The procedure for implementing the RAE regulation allowed this decision to be voluntary, and we hypothesized that it responded to the following observed variables at the fishing community level. First, we introduced a variable that measures the relevance of Chilean hake in the fishing community using the total Chilean hake landings during 2000–2004,[8] the period prior to the regulation. This is a scale variable that might also capture how resource abundance in the fishing area affects the decision to choose RAE by organization. We hypothesized that the communities with larger shares of hake total landings would try to secure these landings by choosing a RAE by organization regulatory form. We also included a variable that captured differences in opportunities across fishing coves. This variable adopted a unit value if the community had access to fishing infrastructure and zero otherwise. Fishing communities lacking infrastructure were assumed to be at a disadvantage, which might strengthen the community perception that a regulatory change was necessary. It is also possible that people living in fishing communities with fewer opportunities might act more conservatively; thus, the expected sign of this variable is ambiguous. Furthermore, it has been suggested that more populated geographical areas and with a longer tradition of artisanal organization were the ones that opted for RAE by organization (Dresdner *et al.*, 2005). Consequently, we controlled for population size and the ex-ante level of organization. The size of the fishing community was measured by the number of fishermen reporting to be living in the fishing community, while the ex-ante level of organization included only those fishermen who reported being members of a fisheries-related organization for at least five years prior to the regulatory reform.[9] We hypothesize that fishing communities with more organizational experience are more likely to choose the RAE by organization form.

To estimate the share contract equations for each regime (equations (3) and (4)), we followed Thuy *et al.* (2013) and Salazar-Espinoza (2015) and considered a vector x_i of explanatory variables characterizing vessel owners, boats and state of resources.

For vessel owner characteristics, we controlled for age, education and experience to proxy for vessel owner's bargaining power. The rationale is based on the bargaining power argument supported by an extensive literature on agrarian contracts (Kvaløy, 2006). We expected that older, more educated and more experienced vessel owners would have an advantage in the bargaining process, resulting in a smaller crew profit share. In addition, we controlled for a dummy variable if the vessel owner had alternative employment in the past year. We assume that supervision costs increase if the vessel owner has less time for monitoring because he partakes in other economic activities; thus, we expect a positive association between this characteristic and the crew profit share.

Regarding boat characteristics,[10] we controlled for vessel size, vessel material, technology and crew size, intended to proxy for catchability and the use of capital-intensive

[8]The census does not collect data on landing per vessel. The available data is the total landing per fishing settlement, which is obtained from the National Fisheries and Aquaculture Service.

[9]Vessel owners report the year in which they registered in the organization.

[10]Some vessel owners declare operating more than one vessel, however, details on characteristics were asked for the two first main vessels. In the case of vessel owners reporting more than one boat, the characteristics correspond to the main vessel used.

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

technology. While vessel size is proxied by including dummies for several categories,[11] vessel material is defined as wood (value equal to one) or other materials (value equal to zero).[12] Differences in technology were proxied by a dummy for the presence of onboard echo sounders and a series of dummy variables that characterize the type of fishing gear, particularly purse-seine net and drift-net fishing technology.[13] In all cases, the variable adopted a value of one when the technology or fishing gear was present on the vessel and zero if not. In addition, we considered the number of crewmembers. We expected that vessel owners operating smaller boats made out of wood with a larger crew size, and using labor-intensive technologies would have a lower catchability coefficient, and would decide to give a larger proportion of total fishing net income to the crew.

In addition, we added a dummy variable named climate shock taking the value of one if the vessel owner reported experiencing an adverse climate event (bad weather or resource scarcity) in the last twelve months, and zero otherwise. We anticipated an increase in crew profit shares in times of resource scarcity, since it is necessary to increase labor effort in periods of difficult weather. Most likely, some absolute crew remuneration level exists under which it is no longer rewarding for the crew to make the trip. Thus, crew profit share should increase in low gross income levels.

Finally, we introduced variables that capture differences in opportunities and outside options across fishing communities. These were the total Chilean hake landings in 2007 of the fishing community, the unemployment rate in the district where the fishing community is located and a dummy variable that adopts the value of one if the fishing community is located in a rural area, and zero otherwise.[14] Table 1 summarizes the descriptive statistics of control and selection variables by different management regimes.

Descriptive statistics show substantial differences between vessel, fishing technology and fishing settlement characteristics in the RAE by organization and RAE by area. For instance, in terms of socioeconomic characteristics, vessels owners operating under RAE by organization are relatively older, more experienced, less educated and devote more time to fishing. In terms of vessel and technological characteristics, vessels under RAE by organization are mainly small motor boats made out of wood, and hire more workers. Finally, we observe that fishing coves under RAE by organization are larger, defined as rural areas, lacking infrastructure, and have historically lower landing volumes and higher levels of organization. All these characteristics suggest that the decision of opting for RAE by organization may first respond to better initial conditions to succeed under a regulation that requires cooperation efforts (i.e., fishing and organizational experience), and second, a low level of development of coves (i.e., less advanced technology, lower landing values, lack of infrastructure) that may see this new regulation as a means to improve their welfare.

[11] The categories that are currently used for administrative purposes by Chilean fisheries authorities are small oar boats, small motorboats, launches less than 12 m in length, and launches between 12 and 18 m. The category of larger launches served as the benchmark in the estimation.

[12] Other materials include fiberglass and steel.

[13] As not all technological categories included in the census qualify for Chilean hake, we only included the relevant technologies: the purse-seine net and drift-net fishing technology. Other categories include long line technology and handline fishing technology, which serves as the benchmark.

[14] For unemployment rate calculations, see Salazar-Espinoza (2015). The variable 'rural status' used in this paper is constructed based on the official definition of rural area suggested by the Statistical National Institute of the Chilean government (INE, 2005). This considers as rural area all the human settlements with a population smaller or equal to 1,000 inhabitants, or between 1,001 and 2,000 inhabitants where more than 50 per cent of the population that declare to have worked, do so in primary activities.

Table 1. Descriptive statistics of treatment and control fishing communities for Chilean hake (*Merluccius gayi gayi*) artisanal fisheries

	Under RAE by organization		Under RAE by area	
Variables	Mean	Std	Mean	Std
Net income share of crew[a]	0.47	0.17	0.37	0.19
Vessel owner's characteristics				
Age[b]	49.37	11.33	46.61	10.96
Education[b]	7.21	2.92	7.82	2.96
Experience[b]	34.74	12.63	28.59	12.41
Another occupation[a]	0.08	0.27	0.15	0.36
Vessel's characteristics				
Small oar boat[a]	0.21	0.46	0.03	0.19
Small motor boat[a]	0.61	0.48	0.94	0.19
Motor launch (length <12 m)[a]	0.10	0.32	0.02	0.16
Motor launch (length >12 m)[a]	0.08	0.24	0.01	0.07
Wood vessel[a]	0.94	0.25	0.29	0.45
Other materiality[a]	0.05	0.22	0.71	0.18
Echo sounder[a]	0.23	0.42	0.19	0.39
Crew size[c]	3.04	2.15	2.27	0.99
Technological and activity characteristics				
Purse-seine net[a]	0.75	0.43	0.73	0.44
Drift-net fishing[a]	0.08	0.27	0.01	0.09
Other technologies[a]	0.17	0.30	0.24	0.22
Climate shock[a]	0.23	0.43	0.17	0.37
Fishing settlement characteristics				
Total landings 2007[d]	41.34	32.31	377.14	458.865
Unemployment rate[e]	0.138	0.014	0.101	0.027
Rural[a]	0.776	0.417	0.327	0.469
Infrastructure[a]	0.68	0.467	0.96	0.191
Total landings 2000–2004[d]	2,422.795	2,675.3	5,044.30	7,445.157
Population[c]	693.941	427.25	307.42	312.285
Population organized[c]	227.446	115.8	125.86	122.328
Number of vessel owners	188		474	

Std, standard deviation.
[a]Dummies.
[b]In years.
[c]Number of persons.
[d]In tons.
[e]Proportion.
Source: Own elaboration based on census data.

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

Despite the above-observed dissimilarities, the switching regression model was designed to account for these differences, and thereby isolates the effect of the new regime on share contracts. First, the model assumes an equation to explain the decision to participate in RAE by organization as a function of fishing settlement characteristics, which allows us to correct by selection into the regime. Second, the set of covariates included in the share contract equations controls for any observed differences in vessel and fishing technology characteristics between the two regimes.

7. Presentation and discussion of results

We estimated the selection and share contract equations together for each regime using the proposed econometric strategy.[15] The selection equation models the choice of management regime by the organization. The results are presented in table 2.

We found that fishing communities reporting historically larger total landings are more likely to implement RAE by organization. They may view RAE by organization as a way of securing these larger potential catches through the allocation of collective catch shares. We also found that fishing communities with less infrastructure are more likely to adopt RAE by organization, suggesting that this regulation can be seen as an opportunity to help overcome disadvantageous conditions. Moreover, the estimations show a positive association between participation in organization and the likelihood of having RAE by organization. This indicates that in places with an existing tradition of fishermen organization, the probability of adopting RAE was greater. Results concerning fishing community size were not statistically significant.

Table 3 shows estimation results of the share contract equations. Column 1 presents the estimated coefficients using the sub-sample of vessel owners operating in fishing communities under RAE by organization, and column 2 shows the ones under RAE by area.

Overall, the fit of the equations is adequate and the signs of the estimated parameters are in line with expectations. Results suggest that vessels' characteristics are more important in explaining share contract decisions than vessel owners' attributes. As share contracts are most often determined by social relations and respond to aspects of productivity (i.e., vessel characteristics, the organization of production, and technology), these results are not surprising.

Net income shares are larger in smaller launches under RAE by organization and in wooden boats under RAE by area. In addition, vessel owners who use purse-seine net are more likely to offer a smaller profit share under RAE by area. These results are consistent with a higher crew bargaining power in more labor-intensive vessels (Salazar-Espinoza, 2015). We found dissimilar results in the association between crew size and share contract decisions depending on the type of RAE. In line with Nguyen and Leung (2009) and Salazar-Espinoza (2015), the results indicate that vessel owners in RAE by area tend to give a higher proportion of fishing returns when they have fewer workers. The authors explain that this negative association comes from a trade-off between the quantity and quality of labor, arguing that fewer crewmembers may lead vessel owners to care more

[15] Results might suffer multicollineality from a potential correlation among several variables. For instance, rural zone can be correlated with unemployment rate, crew size with vessel size, population with landings, etc. We checked this by computing correlation coefficients. They were generally small. Still, we re-estimated the model, removing some potentially collinear variables, and found similar results. These results are available upon request.

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

Table 2. Estimates of RAE by organization treatment by fishing communities for Chilean hake (*Merluccius gayi gayi*) artisanal fisheries using a probit model

Variables[a]	RAE by organization = 1
Infrastructure	−0.853*** (0.259)
Total landings 2000–2004	0.00059*** (8.55×10^{-5})
Population	−0.00045 (0.00045)
Population organized	0.005*** (0.00157)
Constant	−3.908*** (1.070)
Number of vessel owners	662

Notes: Robust standard errors in parentheses.
[a]Vessel owner variables are not shown for space reasons.
***$p < 0.01$.

about labor quality than quantity. Because of this, they are willing to offer a higher profit share to increase labor productivity in each crewmember. Another argument relates to the regulation itself: RAE by area is basically a TAC implemented under restricted-access common pool conditions. This has proven to be inefficient. The marginal productivity of increasing labor is so low or negative that any increase in labor generates null or negative marginal gains. Consequently, the only way that vessel owners are willing to hire an extra crewmember is if they reduce the total crew profit share in order to keep their current gains.

In contrast, we found a positive association between net income shares and crew size in RAE by organization fishing communities. Platteau and Nugent (1992) assert that positive associations between crew size and crew shares are more likely to occur in fisheries with stronger social ties. As a pre-condition to participate in the RAE by organization regime, fishers need to create a legal fisher organization of vessel owners with a democratic election system of the leaders. Thus, legal rights over the quota of individual members were limited, and many decisions required a consensus within the organization. Thereby, it is likely that members of RAE by organization not only consider economic arguments in their decisions, but also income distribution concerns. In contrast to RAE by area, it is expected that this regulation may have contributed to enhancing fishing efficiency and productivity, implying higher labor productivity and fishing gains. Since equity concerns in CCS are also important, vessel owners may decide to give up part of their profit percentage because larger fishing gains with RAE by organization allow vessel owners to keep their absolute gains in spite of a lower share. However, the impact of RAE by organization on fishermen's efficiency can be heterogeneous, depending on the characteristics of the fishermen's organization (Chávez Estrada *et al.*, 2018). A more probable argument that can explain this positive association is the potentially higher bargaining power of labor in Chilean hake fisheries. As discussed earlier, fishing rights under RAE by organization were granted to vessel owners, which strengthened their negotiation position as capital owners. However, in many fishing communities extracting Chilean hake, crewmembers contribute their own fishing gear and, therefore, are reimbursed for more than just their labor effort, increasing their bargaining power.

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Table 3. Estimates of share contract decisions under RAE by organization and RAE by area after the switching regression model for Chilean hake (*Merluccius gayi gayi*) artisanal fisheries

	Share contract decisions	
Variables	(1) RAE by organization	(2) RAE by area
Vessel owner's characteristics		
Age[a]	−0.000855 (0.00252)	0.00116 (0.00133)
Education[a]	−0.00241 (0.00523)	0.00110 (0.00261)
Experience[a]	−0.000225 (0.00250)	0.000892 (0.00108)
Another occupation[b]	0.00645 (0.0467)	0.00613 (0.0213)
Vessel's characteristics		
Small oar boat[b]	0.0388 (0.0359)	0.0111 (0.0497)
Small motor boat[b]	0.0387 (0.0374)	−0.0207 (0.0561)
Launch (length < 12 m)[b]	0.0993** (0.0499)	0.0326 (0.0608)
Wood vessel[b]	−0.0284 (0.0545)	0.0896*** (0.0232)
Echo sounder[b]	−0.0232 (0.0616)	−0.0285* (0.0172)
Crew size[c]	0.016* (0.0095)	−0.0644*** (0.0111)
Technological and activity characteristics		
Purse-seine net[b]	0.0235 (0.0338)	−0.0832*** (0.0307)
Drift-net fishing[b]	−0.00897 (0.0519)	−0.00618 (0.0337)
Climate shock[b]	0.0526* (0.0285)	−0.0438** (0.0197)
Fishing settlement characteristics		
Total landings 2007[d]	−0.000220 (0.000435)	-6.27×10^{-5}*** (1.96×10^{-5})
Unemployment rate[e]	−0.969 (1.018)	1.222*** (0.393)
Rural[b]	−0.00167 (0.0322)	−0.0795*** (0.0215)
Constant	0.602*** (0.194)	0.431*** (0.0871)

(*continued*)

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Table 3. Continued

Variables	Share contract decisions	
	(1) RAE by organization	(2) RAE by area
Log pseudo likelihood	221.98	
Wald χ^2	25.49	
Number of vessel owners	188	474

Std, standard deviation.
Notes: Robust standard errors in parentheses.
[a]In years.
[b]Dummies.
[c]Number of persons.
[d]In tons.
[e]Proportion.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 4. Estimates of RAE per organization treatment in the fishing community for Chilean hake (*Merluccius gayi gayi*) artisanal fisheries

RAE Regime	Difference between counterfactual and expected share
ATE	0.059*** (0.006)
RAE by area	−0.031** (0.012)
RAE by organization	0.069*** (0.007)
Number of vessel owners	662

Notes: Robust standard errors in parentheses.
$^{***}p < 0.01$, $^{**}p < 0.05$.

Another discrepancy between regulatory regimes was the sign associated with climate shock. While vessel owners operating under RAE by organization increase the crew profit share when facing an adverse natural event, we find the opposite result under RAE by area. One well-known negative effect of common property-based fisheries management is that it generates incentives to fish 'as fast as possible' (Pfeiffer and Gratz, 2016). In the case of RAE by area, economic incentives to fish as rapidly as possible may still exist; thus, as the total fishing gains fall during adverse natural conditions, this reduction might be passed on to the crew's profit share. The positive effect found in RAE by organization may also be related to the relatively more balanced negotiation power between the vessel owners and the crewmembers, as the latter provides fishing gear. Thus, it is more likely that losses during climate shock periods are borne by both vessel owners and crewmembers under RAE by organization.

Following the expressions of equations (9)–(13), table 4 presents estimations of RAE by organization's impact on crew net income share. Results support a significant and positive effect of the regulatory reform on this share. We found that the crew profit share is, on average, 6 per cent larger in fishing communities regulated under RAE by organization, compared to RAE by area (ATE in table 4 estimated from equation (13)). The reorganization of Chilean hake fisheries, as a consequence of the CCS, also led to a reorganization of the internal structure of firms, particularly the contractual terms between

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

vessel owners and crews. Results show that we may observe a reduction of 3 per cent in crew net income share in vessels under RAE by organization hypothetically switching to RAE by area (RAE by area in table 4 estimated from equation (9)). Finally, the estimates suggest that a vessel hypothetically switching to RAE by organization from RAE by area would increase the crew share around 6 per cent (RAE by organization in table 4 estimated from equation (12)). This can be interpreted as the average treatment of the treated.

8. Robustness controls and further discussion of results

One concern is the great geographical variation along the Chilean coast and, therefore, among fishing communities. This variable may be driving results. As a robustness check, we replicated the estimations for a more homogenous area comprised of two neighboring regions, the Biobío and Maule regions. While most of the fishing communities in the Biobío region had chosen RAE by organization by the census period, all fishing communities in the Maule region were using RAE by area. Furthermore, focusing on the Biobío region as the treated group makes it less likely that fishers in other fishing communities operate in places regulated under RAE by organization, as the residual quota is relatively smaller in this region. Results are available in tables A1 and A2 in the online appendix. Overall, they confirm a positive association between the crew size and climate shock variables in the share contract estimations under RAE by organization.

We also calculated a positive ATE, although it had a larger magnitude than the whole sample estimate. One of the arguments for a larger positive effect is that crewmembers in some locations contribute their own fishing gear, increasing their bargaining power. To explore this further, in online appendix table A3, we present a two-sample t test for the share given to equipment owners under RAE by organization and RAE by area. This data is available in the census and distinguishes the share of total fishing gains that is given to whoever owns the fishing equipment. Data does not allow us to identify whether this new participant is the vessel owner, a crewmember or another fisher, however. Having these limitations in mind, results indicate that there are not significant differences between regimes when considering the whole sample; however, equipment shares are significantly larger in the treated group when the sample is reduced to the neighboring regions. This characteristic could explain the different magnitudes found in the ATE between the whole and reduced samples.

The increase in crew shares found previously does not guarantee a welfare improvement for crewmembers if the income base from which the share is calculated is reduced as a consequence of the regulatory change. A complementary variable to explore is the absolute crew income. Following this objective, we estimated the model by using the absolute crew income as the dependent variable. To do so, we used information on total net fishing incomes reported monthly in the census from June 2007 until May 2008. Then, we computed the monthly net fishing income by dividing the total income for the number of months that the season lasted. In order to compute the absolute crew income, we multiplied this monetary variable by the crew share. Note that to ensure a cleaner association between reported incomes and hake fishing activities, we selected only those fishers reporting common hake as their main species. This reduced the number of observations to 520. The results are shown in tables A4 and A5 in the online appendix. The main findings remain. Estimations suggest that crewmembers operating under RAE by organization not only received a higher share of incomes but also higher fishing incomes compared with what they would have received under RAE by area.

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

As discussed in section 2, theoretically there is no definite expectation of the effect that the introduction of a collective rights system, such as the RAE by organization, will have on the crew's income share. Our estimation results show that this share increases compared with what would have occurred without this regulatory reform. One factor that could have contributed to this was the rights that were granted without costs to the organizations and that a quota trading between them was not allowed, so no formal market for exchanging rights developed. This fact could help to explain why crew shares did not fall, since there were no requirements to finance the cost of the right. However, the increase in shares could be related to a change in the bargaining power of the crew, the introduction of fairness considerations in the share distribution because of the increased power obtained by organizations, or as a consequence of increased efficiency that decreased cost shares, as discussed in section 2. We do not have conclusive evidence about which of these hypotheses has more explanatory power in this case. However, we have some evidence and we try to make a case for one of these hypotheses.

First, higher crew shares together with an increased crew income, as a result of the change in regulatory regime, do not necessarily mean that the increase in remunerations came from efficiency gains. In other words, a higher crew income was not necessarily the result of cost reductions and/or increases in live landings per day. One alternative explanation is higher crew shares, which was possible due to crewmembers owning fishing gear. This is not contradictory since previous evidence on another fisheries shows that the introduction of CCS did, on average, reduce technical efficiency for artisanal fishers in Chile (Chávez Estrada *et al*., 2018). Unfortunately, we do not have data to properly measure changes in efficiency in the Chilean hake fisheries. Second, we explicitly tested with neighbor regions if equipment owners with RAE by organizations received a higher share than equipment owners with RAE by area, and the results show significant positive results. Third, we interviewed an artisanal organization leader who stressed the importance of crew shared capital as a special feature of this fishery, which made this activity resemble an association of independent entrepreneurs more than a contract between a vessel owner and a crew. Finally, it is not possible to test whether the effect of collective action contributed to this result, but certainly this possibility seems less likely with a crew composed of primarily own entrepreneurs.

9. Conclusions

In this article, we studied the impact of implementing the Extractive Artisanal Regime by organization – a form of CCS – on crew net income shares in Chile. Making use of geographical differences in the adoption of the regulation among fishing communities, we estimated a switching regression model.

Our results suggest that crew net income shares are, on average, 6 per cent larger in fishing communities regulated by 'RAE by organization' as compared to those regulated by 'RAE by area'. The results also show dissimilar effects of crew size and history of climate shock on crew shares, depending on the type of RAE regime implemented. Whereas under RAE by organization both variables increase crew income shares, the opposite result was found under RAE by area. We argue that RAE by area is basically a limited access regime with TAC per area. It incentivizes rapid exhaustion of the quota, implying inefficient catch. Lower fishing rents and environmental problems may imply a lower share for crewmembers as vessel owners try to increase their incomes. The party who must bear a larger fraction of this loss depends on the bargaining power of those involved. Equity concerns may be important in regulatory settings with cooperative principles, as

https://doi.org/10.1017/S1355770X20000133 Published online by Cambridge University Press

an increase in crew share may respond to this characteristic as well. However, the RAE by organization form gives use rights to organizations of vessel owners, suggesting a shift in bargaining power toward capital owners. If this were true, we should observe a tendency to reduce crew shares instead. We argue that specific characteristics of Chilean hake fisheries associated with crewmembers' ownership of fishing gear might have strengthened the negotiation position of the crew. If crew bargaining power increased under RAE by organization compared to the baseline, crewmembers who contributed fishing gear may have received an increase in the fraction of fishing gains. Descriptive comparisons between equipment owner shares under RAE by organization and RAE by area suggest that rewards for gear owners may be larger in the former structure. Results are robust to estimation using a reduced sample of neighboring regions, and focusing on crew incomes instead.

These results have important policy implications. Incentive-based instruments have been criticized for their distributional implications that favor capital owners. This is grounded in a potential increase in their bargaining power. Our findings do not contradict this expectation, as crews in Chilean hake fisheries also own part of the capital. But our results point out that it is not the instrument as such (the rights use system) that generates distributional consequences, but rather the pre-existing factor distribution. Therefore, our results suggest that the potential distributional effect of a right-based system is conditioned on the crew's ability to exert control over the capital, which may respond to particular characteristics of fisheries and social relationships within fishing communities.

There are some limitations to our work. First, our results rely on the assumption that vessel owners operate under RAE by organization if they belong to fishing communities whose organizations appear in the regulatory decrees. Some vessels might be misclassified, leading to less precise estimations. Second, the identification of the effect of RAE by organization relies on cross-sectional variation only. Unfortunately, limitations on share contract data before and after the introduction of the RAE do not allow us to perform a more exhaustive evaluation of the distributional impacts and economic consequences of this regulatory change. Finally, a more formal analysis of the different routes by which catch shares affect income shares is desirable. This is left for future research.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355770X20000133.

Acknowledgements. The authors gratefully acknowledge financial support from project FONDAP, No. 15110027.

References

Abbott J, Garber-Yonts B and Wilen JE (2010) Employment and remuneration effects of IFQs in the Bering Sea/Aleutian Islands crab fisheries. *Marine Resource Economics* **25**, 333–354.

Arnason R (2012) Property rights in fisheries: how much can Individual Transferable Quotas accomplish? *Review of Environmental Economics and Policy* **6**, 217–236.

Baland J-M and Platteau J-P (2003) Economics of common property management regimes. In Mäler K-G and Vincent JR (eds), *Handbook of Environmental Economics*. Amsterdam: Elsevier, pp. 127–190.

Brandt S and Ding N (2008) Impact of property rights on labor contracts in commercial fisheries. *Ocean & Coastal Management* **51**, 740–748.

Cancino JP, Uchida H and Wilen JE (2007) TURFs and ITQs: collective vs. individual decision making. *Marine Resource Economics* **22**, 391–406.

Casey K, Dewees E, Turris B and Wilen JE (1995) The effects of individual vessel quotas in the British Columbia halibut fishery. *Marine Resource Economics* **10**, 211–230.

Castillo C and Dresdner J (2013) Effort optimization in artisanal fisheries with multiple management objectives, collective quotas, and heterogeneous fleets. *Australian Journal of Agricultural and Resource Economics* **57**, 104–122.

Chávez Estrada GA, Quiroga Suazo MA and Dresdner Cid JD (2018) The effect of collective rights-based management on technical efficiency: the case of Chile's common sardine and anchovy fishery. *Marine Resource Economics* **33**, 87–112.

Cheong S-M (2004) Managing fishing at the local level: the role of fishing village cooperatives in Korea. *Coastal Management* **32**, 191–201.

Copes P (1986) A critical review of the Individual Quota as a device in fisheries management. *Land Economics* **62**, 278–291.

Copes P (1997) Social impacts of fisheries management regimes based on individual quotas. Social implications of quota systems in fisheries. In Pálsson G and Pétursdóttir G (eds), *Social Implications of Quota Systems in Fisheries*. Copenhagen: Nordic Council of Ministers, pp. 61–90.

Costello C and Deacon R (2007) The efficiency gains from fully delineating rights in an ITQ Fishery. *Marine Resource Economics* **22**, 347–361.

Costello C, Gaines SD and Lynham J (2008) Can catch shares prevent fisheries collapse? *Science (New York, N.Y.)* **321**, 1678–1681.

Davidse WP (ed.) (1997) *Property Rights in Fishing; Effects on the Industry and Effectiveness for Fishery Management Policy*. The Hague: Agricultural Economics Research Institute (LEI-DLO). Available at https://core.ac.uk/download/pdf/29324226.pdf.

Deacon RT (2012) Fishery management by harvester cooperatives. *Review of Environmental Economics and Policy* **6**, 258–277.

Deacon RT, Parker DP and Costello C (2008) Improving efficiency by assigning harvest rights to fishery cooperatives: evidence from the Chignik salmon co-op. *Arizona Law Review* **50**, 479–509.

Dresdner Cid J, Barriga O, Chávez Rebolledo C, Henríquez Aste G, Cubillos Santander L, González Vallejos N, Hernández A and Baquedano M (2005) Evaluación Socioeconómica de la Implementación del Régimen Artesanal de Extracción (RAE), en la Pesquería de la Merluza Común. Informe Final, Proyecto FIP 2004-49. Available at http://www.subpesca.cl/fipa/613/articles-89080_informe_final.pdf (in Spanish).

General Fisheries and Aquaculture Law (1991) Ley General de Pesca y Acuicultura (texto actualizado incorpora modificación Ley N° 20.925). Available at http://www.subpesca.cl/portal/615/w3-article-88020.html (in Spanish).

Grafton RQ (1996) Individual Transferable Quotas: theory and practice. *Reviews in Fish Biology and Fisheries* **6**, 5–20.

Guillen J, Boncoeur J, Carvalho N, Frangoudes K, Guyader O, Macher C and Maynou F (2017) Remuneration systems used in the fishing sector and their consequences on crew wages and labor rent creation. *Maritime Studies* **16**, 1–36.

Gutiérrez NL, Hilborn R and Defeo O (2011) Leadership, social capital and incentives promote successful fisheries. *Nature* **470**, 386–389.

Guyader O and Thébaud O (2001) Distributional issues in the operation of rights-based fisheries management systems. *Marine Policy* **25**, 103–112.

Heintzelman MD, Salant SW and Schott S (2009) Putting free-riding to work: a partnership solution to the common-property problem. *Journal of Environmental Economics and Management* **57**, 309–320.

Holland D (2004) Spatial fishery rights and marine zoning: a discussion with references to management of marine resources in New England. *Marine Resource Economics* **19**, 21–40.

Holland D (2015) Structuring rights and privileges in catch share systems. In Halvorsen R and Layton DF (eds), *Handbook on the Economics of Natural Resources*. Cheltenham, UK and Northampton, MA: Edward Elgar Publishing, pp. 81–304.

Holland D, Kitts A, da Silva P and Wiersma J (2013) Social capital and the success of harvest cooperatives in the New England groundfish fishery. *Marine Resource Economics* **28**, 133–153.

Holzer JG (2010) An Analysis of Sector Allocations in Commercial Fisheries (Ph.D. thesis). University of Maryland, University Park, MD.

INE (2005) *Chile: Ciudades, Pueblos, Aldeas y Caseríos*. Santiago de Chile: Instituto Nacional de Estadísticas (INE), Departamento de Geografía y Censos, (in Spanish).

INE (2009) *Primer Censo Nacional Pesquero y Acuicultor*. Santiago de Chile: Instituto Nacional de Estadísticas (INE), (in Spanish).

Knapp G (2007) The Chignik salmon cooperative: a case study of allocation to a voluntary self-governance organization. University of Alaska, Anchorage, Alaska. Available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.519.9757&rep=rep1&type=pdf.

Kvaløy O (2006) Self-enforcing contracts in agriculture. *European Review of Agricultural Economics* **33**, 73–92.

Liang KG (1999) Fairness in Chinese Organizations (Unpublished dissertation). Old Dominion University, Norfolk, VA.

Maddala G (1983) *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge, MA: Cambridge University Press.

McCay BJ, Creed CF, Finlayson AC, Apostle R and Mikalsen K (1995) Individual transferable quotas (ITQs) in Canadian and US fisheries. *Ocean and Coastal Management* **28**, 85–115.

McCay BJ, Micheli F, Ponce-Díaz G, Murray G, Shester G, Ramirez-Sanchez S and Weisman W (2013) Cooperatives, concessions, and co-management on the Pacific coast of Mexico. *Marine Policy* **44**, 49–59.

McConnell KE and Price M (2006) The lay system in commercial fisheries: origin and implications. *Journal of Environmental Economics and Management* **51**, 295–307.

Nguyen Q and Leung P (2009) Choice of remuneration regime in fisheries: the case of Hawaii's longline fisheries. *Journal of Agricultural and Resource Economics* **34**, 498–517.

Ovando DA, Deacon RT, Lester SE, Costello C, Van Leuvan T, Mcllwain K, Strauss CK, Arbuckle M, Fujita R, Gelcich S and Uchida H (2013) Conservation incentives and collective choices in cooperative fisheries. *Marine Policy* **37**, 132–140.

Pfeiffer L and Gratz T (2016) The effect of rights-based fisheries management on risk taking and fishing safety. *Proceedings of the National Academy of Sciences* **113**, 2615–2620.

Platteau J-P and Nugent J (1992) Share contracts and their rationale: lesson from marine fishing. *Journal of Development Studies* **28**, 386–422.

Poon SE, Bonzon K and Van Leuvan T (2013) *Catch Share Design Manual, Volume 2: Cooperative Catch Shares*. Environmental Defense Fund.

Quezada F and Dresdner J (2014) The behavior of hake prices in Chile: is the world market leading? *Latin American Journal of Aquatic Research* **42**, 1087–1098.

Reglamento del RAE (2004) Decreto Supremo N° 296 Aprueba Reglamento del Régimen Artesanal de Extracción, Subsecretaría de Pesca, Gobierno de Chile, 20 de diciembre del 2004 (in Spanish).

Salazar-Espinoza C (2015) Share contract choices and economic performance: empirical evidence from the artisanal fisheries sector in Chile. *Marine Resource Economics* **30**, 71–95.

Sanchirico JN, Holland D, Quigley K and Fina M (2006) Catch-quota balancing in multispecies individual fishing quotas. *Marine Policy* **30**, 767–785.

Schlager E (1994) Fishers' institutional responses to common-pool resource dilemmas. In Ostrom E, Gardner P and Walker J (eds), *Rules, Games, and Common Pool Resources*. Ann Arbor: University of Michigan Press, pp. 247–265.

Scott AD (2008) *The Evolution of Resource Property Rights*. Oxford, UK: Oxford University Press.

Segerson K (2014) Collective approaches to fisheries management. In Squires D, Maunder M, Vestergaard N, Restrepo V, Metzner R, Herrick S, Hannesson R, del Valle I and Andersen P (eds), *Effort Rights in Fisheries Management: General Principles and Case Studies from around the World. FAO Fisheries and Aquaculture Proceedings, 34*. Rome: Food and Agriculture Organization of the United Nations, pp. 251–260.

Squires D, Kirkley J and Tisdell C (1995) Individual transferable quota as a management tool. *Reviews in Fisheries Science* **3**, 141–169.

Subsecretaría de Pesca (2011) Cuota global anual de captura de merluza común (*Merluccius gayi gayi*), año 2012. Informe Técnico (R.PESQ.) N° 117/2011. Subsecretaría de Pesca, Valparaíso (in Spanish).

Subsecretaría de Pesca y Acuicultura (2017) Decretos regulatorios del Régimen de Extracción Anual (RAE) para la Merluza Común. Available at http://www.subpesca.cl (in Spanish).

Thuy PTT, Flaaten O and Anh NTK (2013) Remuneration systems and economic performance: theory and Vietnamese small-scale purse seine fisheries. *Marine Resource Economics* **28**, 19–41.

Uchida H (2017) TURFs, collective fishery management, and fishery cooperatives. *Bulletin of Marine Science* **93**, 83–99.

Uchida H, Uchida E, Lee J, Kim D and Ryu J (2010) Does self management in fisheries enhance profitability? Examination of Korea's coastal fisheries. *Marine Resource Economics* **25**, 37–59.

Wilen JE, Cancino J and Uchida H (2012) The economics of territorial Use rights fisheries, or TURFs. *Review of Environmental Economics and Policy* **6**, 237–257.

Cite this article: Salazar C, Dresdner J (2020). The impact of collective use rights on share contracts: the case of the Extractive Artisanal Regime (RAE) in Chilean hake fisheries. *Environment and Development Economics* **25**, 355–377. https://doi.org/10.1017/S1355770X20000133