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Environmentally Conscious Fishing Communities and Fishing Quota Negotiations: The Impact of Environmental Externalities

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ABSTRACT

This paper uses a Nash bargaining model for analyzing negotiations between a fishing community and a vessel over fishing quotas and wages, for a given Total Allowable Catch imposed by the regulator. The analysis considers the environmental awareness of the community and whether the entire quota allotment is being leased, to examine how environmental externalities, unrelated to fishery sustainability, affect wages, employment, and social welfare. It is argued that if the maximum number of quotas is leased to the vessel, a system of transferable fishing rights is a vehicle for pure transfer payments from the vessel to the community, in the form of higher wages and leased quota revenues. In this context, employment level and social welfare are not affected by the fishing communities' environmental consciousness. However, if less than the maximum number of quotas is leased to the vessel, both wages and revenues from leased quotas are higher, while employment is lower when the community is environmentally conscious compared to when it is not. In such case, social welfare is higher when the community is environmentally conscious provided that the inverse demand for fish does not decline too sharply relative to the rate at which marginal pollution damages increase. Finally, it is shown that the strictness of the **Total Allowable Catch** regulations impacts both the community's well-being and the vessel's profitability.

JEL Classification: C78, Q5, Q13, Q22

1 | Introduction

The fisheries industry is linked to the exploitation of open-access renewable natural resources and, ever since Hardin published "The Tragedy of the Commons," in 1968 fisheries' sustainability has been the focal point of numerous studies that analyze the fisheries policy instruments and management. The prime external cost of fishing is the dynamic stock externality linked to the sustainability of a fishery. The purpose of a Total Allowable Catch (TAC) being set by the regulator and the introduction of a fishing quotas system is to internalize this externality by managing fishing activities. However, as noted by Waldo and Paulrud (2017), policy instruments for fisheries management concentrate on fisheries' sustainability and do not consider other external costs. Such external costs include, among others, pollution from the engines (*e.g.*, oil spills), lost fishing gear, causing ecosystem damage from ghost fishing and plastic pollution, habitat damage from bottom trawling, and greenhouse gas emissions.

Recently, reducing emissions from fishing vessels and advancing the decarbonization of the fishing sector have attracted significant attention from authorities such as the European Parliament (European Parliament 2023), as well as ocean conservation organizations such as Oceana (Alma-Maris 2023). However, there are limited number of environmental economic studies addressing CO_2 emissions reduction from fishing vessels in the presence of already established quota systems.[1]

The present paper is addressing this gap by evaluating the efficiency of existing fishery management tools with respect to the reduction of vessel emissions. Our approach considers the environmental concerns of fishing communities, which influence their decisions when negotiating the leasing of allocated quotas to industrial fishers. According to our findings, the environmental concerns of the fishing community, along with the stringency of the TAC, significantly influence the determination of wages, employment, and social welfare, as well as the distribution of economic surplus between the community and the vessel.

One commonly used policy tool for regulating the fishing industry is Individual Transferable Quotas (ITQs), which involves a regulating authority setting a TAC for one or more species (*e.g.*, pollock, cod, halibut, crab) and distributing quota shares to individuals that can be bought, sold, or leased. Community Fishing Quotas (CFQs) are a type of ITQ system, often used in practice, where quotas are initially given free-of-charge to a fishing community organized in the form of a fishing cooperative (henceforth, fishing community and fishing cooperative will have the same meaning), which can then lease them to fishing vessels. Therefore, the responsibility of managing the fisheries and protecting the environment is shared by the regulator and the community (Pomeroy and Berkes 1997; Baland and Platteau 1996). Pomeroy and Berkes (1997) recognize that prerequisite for effective fisheries management is the involvement of members of the local fishing communities in the legislative process. These co-management systems are a natural outgrowth of the realization that the capacities, capabilities and interests of the local fishers are relevant to the prosperity of the fisheries. These systems are rooted in the fishing communities' commitment to environmental preservation, encompassing the four essential aspects of sustainability: ecological, socioeconomic, community, and institutional sustainability (Charles 1994)

It is not uncommon that fishing communities are environmentally conscious[2] and they consider the external cost imposed upon society in the form of environmental damage even if the policy instruments for the management of the fisheries do not. Besides, as noted by Criddle (2012), the fisheries and communities' sustainability is closely associated with the characteristics of the current socioeconomic and legal systems. CFQs systems have been applied in Alaska, USA[3] as well as in various developed and developing countries like Germany, Norway, Iceland, Japan, Chile, Philippines, Malaysia, Vietnam, Cambodia, Namibia, *etc*.[4] Although the same policy instrument is applied by various countries, fishing communities in these countries seem to adopt different strategies. For example, Benkenstein (2014), notes that in Namibia the quota owners, to avoid engaging into risky production activities, prefer to directly lease their quotas in exchange for risk-free cash. On the other hand, Alaskan fishing communities often invest in vessels and processing facilities.

The aim of the present study is to analyze the efficiency of CFQs systems in reducing the environmental harm caused by the fishing industry emissions, in the context of environmentally conscious fishing communities. In this spirit, we explore the bargaining process over fishing quotas between the fishing community and the vessels focusing on two cases: (a) the fishing community is not environmentally conscious and disregards the external damage resulting from the fishing industry emissions, and (b) the fishing community is environmentally conscious, and the external damage caused by the fishing industry's emissions affects their bargaining position in the fishing quotas market. Furthermore, these two cases are examined and compared across scenarios in which fishing communities lease either all or only a portion of the quotas to the vessels. Although there is a plethora of studies about agricultural and fishing cooperatives, the bargaining between environmentally conscious communities and firms for the sale of quotas has been overlooked despite its importance from an environmental, economic and regulatory perspective.[5] We cover this gap in the literature by analyzing this case from both an economic and regulatory perspective.

We follow the Efficient Nash Bargaining model (e.g., Espinosa and Rhee 1989; McDonald and Solow 1981; Vannini and Bughin 2000) between a fishing community and a vessel and we examine how the community, through the bargaining process, can influence the output and employment levels, the firms' profits, and the wages. Our analysis considers the alternative scenarios discussed above and the possible outcomes are explored under different behavioral assumptions about the members of the fishing community (Oczkowski 2006; Batenan et al. 1979). Such behavioral differences can be justified on the grounds of differences in the stage of economic development. The game is simultaneous where both the vessel and the community decide the number and price of the fishing quotas exchanged, the employment level, and the wages.

Between others it is argued that, if the maximum number of quotas is leased then, the community's degree of environmental awareness has no effect on social welfare. However, if only a portion of the quotas is leased then the social welfare is higher when the fishing community is environmentally conscious provided a slow decrease in consumption's marginal utility relative to the rate at which the marginal environmental damage increases. Finally, the community's utility and the vessel's profits depend on the strictness of the TAC.

2 | Background

2.1 | Fishing Communities and Fishing Quotas

The interesting characteristic of the CFQs, and the main difference from the ITQs,[6] is the leading role of the community in the final allocation of the fishing quotas. Fishing communities are traditional fishing villages that are organized into fishing cooperatives, and they are the owners of the quotas. Ginter (1995) note that the CFQ programs are built on the understanding that fishing communities are entities with characteristics and needs that differ from those of individual fisher and fishing businesses. For example, according to Strehlow (2010) in Germany the quotas are initially allocated among fishing cooperatives who are then responsible for the final distribution of the quotas among their members. According to the National Oceanic and Atmospheric Administration (NOAA) the CFQ systems applied in Alaskan fisheries aim to support the economic and environmental sustainability of the local economies.[7] Given that the CFQ systems allow negotiations between a fishing community and a third party (*i.e.*, a non-community vessel) for fishing quotas, the fishing community could earn additional income by leasing unused quotas to the non-community vessel. Mansfield (2007) argues that quotas are structured as marketable assets, with fishing communities in the early 2000s deriving much of their income (approximately US$70 million annually) leasing them rather than directly fishing.

2.2 | Fishing Communities, Fishing Quotas and Employment

The fishing communities do not have the power to influence the price at national level (at least directly) since they will not use the quotas for fishing but for revenues from leasing. This approach is in line with the assumptions and the analysis in Oczkowski (2006) and Helmberger and Hoos (1962). Specifically, the above studies have assumed that the fishing community does not make profits but "*only exists for the members*" (Oczkowski 2006). Therefore, the community cares for the well-being of its members implying a community interest about employment level and wages.[8] In addition, the revenues from the leasing of the quotas could be re-allocated between the members which could be the community's surplus according to Oczkowski (2006).

The employment level in fishing communities is strongly and directly connected to the number of the quotas the vessels will lease from the local fishing communities. The question is if and how the environmental concern that characterizes some fishing communities could have an impact not only on the vessels' profits but also on the employment level as well. Although we explore this question and we build the model based on the above characteristics it is interesting to mention that in collective quotas system in Chile the quota distributed to guilds, trade unions, communities and cooperatives (Castillo and Dresdner 2013). Thus, the relation between unemployment and quotas could be strongly connected through the allocation of the quotas but could be more complex since there are more players in the market with different characteristics.

In what follows, Section 3 presents a theoretical model to outline the different scenarios. In Section 4 we compare the results from each case to focus on the regulators' preferences, and we include results from comparative statics. Finally, Section 5 concludes.

3 | The Basic Model

3.1 | General Framework and Assumptions

This section introduces a general framework of the model, based on fairly general functional forms, and key underlying assumptions. These assumptions align with the characteristics of the fish and quotas market outlined in the previous section and are consistent with what is adopted in the relevant literature. In the following section, specific functional forms are adopted to obtain closed-form solutions.

We examine a scenario in which the regulator has already established the TAC and issued a corresponding number of quotas, $\bar{q}$. Subsequently, all fishing quotas for a particular fishery have been allocated to a local fishing community free of charge—a practice typically referred to as grandfathering. This is commonly observed in the context of CFQs. Thereafter, the regulator will not intervene in the trading of the quotas market or in the negotiations between the interested parties following the principles of the Coasian theory (1960).

The fishing community consists of experienced fishermen and their families and is assumed to have a low capacity of fishing fleet. On the other hand, there is a non-community firm (vessel) that it needs to lease quotas, q, and hire labor, L, to operate. To simplify our analysis, we assume that each quota corresponds to a unit of fish. Furthermore, the production of fish, besides the vessel and its equipment, requires only labor, thus the production function is denoted by $q = f(L, \overline{K})$, where $\overline{K}$ denotes the fixed capital (*i.e.*, the vessel). Assuming that this is a one-to-one function with $q_L > 0$, $q_{LL} \leq 0$, we denote labor requirement per unit of output as $L = f^{-1}(q)$, or to simplify notation, $L = L(q)$ with $L_q > 0$, $L_{qq} \geq 0$.

As in Oczkowski (2006), the fishing community and the vessel negotiate over wages, w, and quotas. We adopt the Nash Bargaining approach to describe the negotiation. As in Hatcher (2005b), the analysis is based on a simple and given -short run-period model under a single species fishery. Therefore, by denoting the revenues as $R = p(q)q$ and the costs as $C = wL(q) + rq$, the short run profit function of the vessel is given by

$$\Pi = R - C = p(q)q - wL(q) - rq, \tag{1}$$

where $p(q)$ denotes the inverse demand for fish with $p' < 0$, $p'' \leq 0$, and r denotes the price of a quota.[9] At national level the price of fish depends on the quantity that will be harvested by the vessel. Thus, contrary to Hatcher (2005a), that examines the effects of non-compliance on quotas and the equilibrium quota price in an ITQ fishery under the assumption that the vessel is a price taker in both the quota and the output market, and closer to Anderson (1991), where the vessel has market power in the output market with one dominant price maker firm in the quotas market, we assume that both the vessel and the fishing community have power in the quotas market while the vessel is a price maker in the output market. The strictness of this assumption is justified on two grounds: first, it is a simplifying assumption allowing us to focus on the negotiation process between the community and the vessel without being concerned about any competition effect in the output market. Second, there are fisheries with unique species where exclusive fishing rights grand monopoly power in the market, as demonstrated by the Maori's exclusive rights to paua (Guth 2001) and the Aboriginal Peoples' exclusive rights to the Tasmanian giant freshwater crayfish (Clark 2017).

Since the harvested quantity of fish depends on the number of the fishing quotas leased to the vessel, the harvested quantity can be lower or equal to the TAC (i.e., $q \leq \bar{q}$; see also Arnason 2009). As in Huggins (2011) and Benkenstein (2014), we consider this to be a representative example of how communities trade fishing quotas in some countries.[10]

To avoid complications related to how benefits are distributed within the community, and to focus solely on the negotiation process between the community and the vessel, we assume, as in Roberts (2007), that all members of the community have identical preferences and share the same outside options. Moreover, community members share the same level of environmental awareness. These assumptions are in the spirit of Solstad and Brekke

(2011), where in a model of resource extraction a clearly defined group of people collectively own and use a natural resource, and in line with Damania and Fredriksson (2000) that assumes a collective action without free riders.[11] Following Oczkowski (2006) we assume zero payoffs for disagreement point. Finally, it is assumed that, independently of reaching an agreement or not, there is no fixed bargaining cost.

It is assumed that the community derives neither income nor utility from its own fishing activities; its primary concerns are wages, employment levels, and the revenue obtained from leasing quotas at price r. Following Lommerud et al. (2005), Mukherjee et al. (2007), Mukherjee (2008) and Asproudis and Gil Molto (2015), we set the reservation wage to zero, implying cooperative members lack alternative employment opportunities. Moreover, a reservation wage of zero[12] is assumed. Finally, the inclusion of a damage function in the utility function, when relevant, reflects the environmental concerns of the community. The damage function, $D(\cdot)$, quantifies the adverse effects on the environment resulting from external costs such as the discharge of CO_2 from the combustion of fossil fuels and, as in Chen et al. (2022), it depends on the quantity of harvested fish, that is, $D = D(q)$, with $D_q > 0$, and $D_{qq} \geq 0$. Consequently, the utility function of the fishing community is described by

$$U^i = u(w, r, L(q)) - i \times D(q), \tag{2}$$

where the superscript $i \in \{0, 1\}$ indicates whether the fishing community is indifferent to ($i = 0$) or concerned with ($i = 1$) the preservation of the environment. We assume that the community's marginal utilities of the wage, the revenues from quotas leased, and the employment level are all increasing at a non-increasing rate while the marginal disutility from the emission damages is increasing at a non-decreasing rate, *i.e.*, for $i \in \{0, 1\}$ we get $U_w^i, U_r^i, U_L^i > 0$ and $U_D^1 < 0$, with $U_{ww}^i, U_{rr}^i, U_{LL}^i \leq 0, U_{DD}^1 \geq 0$, and all the mixed partial derivatives non-negative.

We follow the Nash bargaining approach to describe the negotiation process between the fishing community and the vessel over the quantity of fishing quotas, price of quotas and wages. Note that, based on our assumptions above, the outside option for either party is zero. Denoting by $m \in (0, 1)$ the bargaining power of the vessel, the maximization problem for $i \in \{0, 1\}$ is expressed as

$$\max_{w,r,q \leq \bar{q}} \{NB = \Pi^m U^{i(1-m)}\}. \tag{3}$$

First order and Kuhn-Tucker conditions can be derived from (3) to characterize the optimal values of the model's variables. These optimal values for the two different scenarios regarding the community's environmental consciousness are denoted as $\{w^i, r^i, q^i\}$ where $i \in \{0, 1\}$.

Finally, provided our definitions of the community's utility, the firm's profits, and the damage function, the social welfare can be derived as the sum of the vessel's profits (*PS*), the community's utility (u), the environmental damage, and the consumers surplus (*CS*) in the product market. Therefore, the social welfare, for each type of the fishing community, $i \in \{0, 1\}$, is given by

$$\mathrm{SW}^i = \mathrm{PS} + \mathrm{CS} + u - D. \tag{4}$$

3.2 | Specific Functional Forms

To proceed with our analysis, we adopt specific functional forms, and we calculate the Nash Bargaining solution for both scenarios regarding the community's environmental consciousness. We assume a linear inverse demand for fish, that is, $p = a - bq$, where $a, b > 0$ denote the size of the market and the slope of the inverse demand, respectively. Furthermore, we assume that the labor requirements to produce q units of output are given by $L = kq$ with $k > 0$ being the marginal labor requirement, that is, the inverse of the marginal product of labor.[13] Given these specifications the profit function of the vessel becomes

$$\Pi = (a - bq)q - (wk + r)q. \tag{5}$$

To model the community's preferences, a standard Stone-Geary function is used, with a reservation wage of zero. Additionally, the damage function is assumed quadratic, that is, $D = \mathrm{eq}^2$ where $e > 0$ is the damage parameter. Therefore, the community's utility function for $i \in \{0, 1\}$ becomes

$$U^i = (wk + r)q - i \times D(q). \tag{6}$$

Finally, given these specifications, social welfare becomes

$$\mathrm{SW} = (a - (1/2)\mathrm{bq} - \mathrm{eq})q. \tag{7}$$

In what follows, we use the superscript $i \in \{0, 1\}$ on the model's solutions to indicate whether the community is environmentally conscious ($i = 1$) or not ($i = 0$). Additionally, we use a bar notation over a variable to represent the solution corresponding to the case where all quotas are leased to the vessel, that is, $q = \bar{q}$.

3.2.1 | *The Benchmark Case: Non-Environmentally Conscious Fishing Community*

The community's utility function is

$$U^0 = (wk + r)q.$$

Therefore, the maximization problem is given by[14]

$$\max_{w,r,q \leq \bar{q}} \{NB = [(a - bq)q - (wk + r)q]^m [(wk + r)q]^{1-m}\}.$$

Case 1. Assume that the TAC is not too strict and not all the available community quotas are leased to the vessel, *i.e.*, $q < \bar{q}$. In summary, we get the following results about output, wages, profits and utility:[15]

$$\begin{aligned} q^0 &= \tfrac{a}{2b} < \bar{q} \\ w^0 &= \tfrac{a(1-m) - 2r}{2k} \\ \Pi^0 &= \tfrac{a^2 m}{4b} = mb(q^0)^2 \\ U^0 &= \tfrac{a^2(1-m)}{4b} \end{aligned}.$$

Moreover, the output price, labor, damage and social welfare are:

$$\begin{aligned} p^0 &= \frac{a}{2} \\ L^0 &= \frac{ak}{2b} \\ D^0 &= \frac{a^2 e}{4b^2} \\ \mathrm{SW}^0 &= \frac{a^2(3b-2e)}{8b^2} \end{aligned}.$$

Comparative statics reveal that wages, output, the vessel's profits, and the community's utility are all increasing in the market size. This is intuitive as an increased market size implies increased value added which is then shared between the firm and the community. However, social welfare is increasing in the market size if the rate of increase in environmental marginal damage is not too big compared to the slope of the inverse demand ($\partial \mathrm{SW}^0/\partial a = a(3b-2e)/4b^2 \gtreqless 0$). Moreover, wages and the community's utility are decreasing, while the vessel's profits are increasing in the vessel's bargaining power. On the other hand, output and social welfare are not affected by the vessel's bargaining power.

Case 2. Assume that TAC is too strict so that all the available community quotas are leased to the vessel, that is, $q = \bar{q}$. In summary, we get the following results about output, wages, profits and utility:[16]

$$\begin{aligned} \bar{q}^0 &= \bar{q} \\ \bar{w}^0 &= \frac{(1-m)(a-b\bar{q})-r}{k} \\ \bar{\Pi}^0 &= m(a-b\bar{q})\bar{q} \\ \bar{U}^0 &= (1-m)(a-b\bar{q})\bar{q} \end{aligned}.$$

Furthermore, the price of output, the number of workers, the pollution damage, and the social welfare are:

$$\begin{aligned} \bar{p}^0 &= a - b\bar{q} \\ \bar{L}^0 &= k\bar{q} \\ \bar{D}^0 &= e\bar{q}^2 \\ \bar{\mathrm{SW}}^0 &= [a-(b/2-e)\bar{q}]\bar{q} \end{aligned}.$$

Similarly to Case 1, comparative statics reveal that wages, the vessel's profits, and the community's utility are all increasing in the market size a. Moreover, in this case social welfare is also increasing with the market size. Additionally, the vessel's bargaining power has no impact on social welfare, implying that the bargaining power and its distributional effects play no role on creating value added. Finally, wages and the community's utility are decreasing, while the vessel's profits are increasing in the vessel's bargaining power.

3.2.2 | Environmentally Conscious Fishing Community

When the fishing community is environmentally conscious its utility function is given by

$$U^1 = (wk + r)q - \mathrm{eq}^2.$$

Therefore, the maximization problem is given by

$$\max_{w,r,q \le \bar{q}} \{\mathrm{NB} = [(a-bq)q - (\mathrm{wk}+r)]^m [(\mathrm{wk}+r) - \mathrm{eq}^2]^{1-m}\}.$$

Case 3. Assume that the TAC is not too strict and not all the available community quotas are leased to the vessel, that is, $q < \bar{q}$. It can be shown that output and wages are:

$$\begin{aligned} q^1 &= \frac{a}{2(b+e)} < \bar{q} \\ w^1 &= \frac{(1-m)a-2r}{2k} + \frac{ae}{2(b+e)k} \end{aligned}.$$

Furthermore, profits, utility, output price, labor, environmental damage, and social welfare are:

$$\begin{aligned} \Pi^1 &= \frac{a^2 m}{4(b+e)} \\ U^1 &= \frac{a^2(1-m)}{4(b+e)} \\ p^1 &= \frac{a(b+2e)}{2(b+e)} \\ L^1 &= \frac{ak}{2(b+e)} \\ D^1 &= \frac{a^2 e}{4(b+e)^2} \\ SW^1 &= \frac{a^2(3b+2e)}{8(b+e)^2} \end{aligned}.$$

Comparative statics reveal that wages, output, the vessel's profits, the community's utility, and social welfare are all increasing in the market size. Moreover, wages and the community's utility are decreasing, while the vessel's profits are increasing in the vessel's bargaining power. However, output and social welfare are not affected by the vessel's bargaining power. Furthermore, wages are increasing, and the output is decreasing with the rate at which marginal damage increases ($\partial w^1/\partial e = ab/(2k(b+e)^2) > 0$ and $\partial q^1/\partial e = -a/2(b+e)^2 < 0$).

Case 4. Assume that TAC is too strict so that all the available community quotas are leased to the vessel, *i.e.*, $q = \bar{q}$. It can be shown that output and wages are:[17]

$$\begin{aligned} \bar{q}^1 &= \bar{q} \\ \bar{w}^1 &= \frac{(1-m)(a-b\bar{q})-r+em\bar{q}}{k} \end{aligned}.$$

Therefore, profits, utility, output price, labor, environmental damage, and social welfare are:

$$\begin{aligned} \bar{\Pi}^1 &= m(a-(b+e)\bar{q})\bar{q} \\ \bar{U}^1 &= (1-m)(a-b\bar{q})\bar{q} + em\bar{q}^2 \\ \bar{p}^1 &= a - b\bar{q} \\ \bar{L}^1 &= k\bar{q} \\ \bar{D}^1 &= e\bar{q}^2 \\ \bar{\mathrm{SW}}^1 &= [a-(b/2-e)\bar{q}]\bar{q} \end{aligned}.$$

Comparative static results are qualitatively similar to those in Case 2.

4 | Comparisons

In this section we compare the results derived under different assumptions about the community's environmental concerns, and the stringency of the TAC. Note that according to our findings in cases 1 and 3 we get

$$q^1 = \frac{a}{2(b+e)} < q^0 = \frac{a}{2b}$$

implying three possibilities about the stringency of the TAC:

- the TAC being "too stric,t", that is, $\bar{q} < q^1 < q^0$,
- the TAC being "too loose," that is, $q^1 < q^0 < \bar{q}$, and
- the TAC being "moderately strict," that is, $q^1 < \bar{q} < q^0$.

Hence, depending on the stringency of the TAC the optimal values of quotas leased to vessel are *(i)* $\bar{q}^1 = \bar{q}^0 = \bar{q}$, *(ii)* $q^1 < q^0 < \bar{q}$ and *(iii)* $q^1 < \bar{q}^0 = \bar{q}$. It is then straightforward to note that output and employment are not affected by the environmental consciousness of the community when the TAC is too strict, *i.e.*, $\bar{q}^1 = \bar{q}^0 = \bar{q}$, and $\bar{L}^1 = \bar{L}^0 = L(\bar{q})$. However, output and employment will be greater when the TAC is moderately strict or too loose, that is, $q^1 < q^0 \leq \bar{q}$, and $L^1 < L^0 \leq L(\bar{q})$.

In the following subsections we calculate, for each of the three scenarios, the differences in wages, output/quotas, employment, profits, utilities, prices, damages, and social welfare resulting from the difference in environmental consciousness of the community.

4.1 | Wages, Output and Employment

For each of the three scenarios *(i)-(iii)*, the differences in wages, output, and employment resulting from the difference in environmental consciousness of the community have been calculated. We state the following:

Lemma 1.

i. *If* $\bar{q} < q^1 < q^0 \Rightarrow \bar{w}^1 > \bar{w}^0, \bar{q}^1 = \bar{q}^0 = \bar{q}$, *and* $\bar{L}^1 = \bar{L}^0 = L(\bar{q})$

ii. *If* $q^1 < q^0 < \bar{q} \Rightarrow w^1 > w^0, q^1 < q^0$, *and* $L^1 < L^0$

iii. *If* $q^1 < \bar{q} < q^0 \Rightarrow \bar{w}^1 > w^0, q^1 < \bar{q}^0$, *and* $L^1 < \bar{L}^0$

According to Lemma 1, the fishing community always receives higher wages when it is environmentally conscious compared to when it is not. On the other hand, output and employment are not affected by the environmental consciousness of the community when the TAC is too strict, but output and employment are always lower when the community is environmentally conscious if the TAC is not too strict. Intuitively, an environmentally conscious community can address the negative effects of the environmental damage through two mechanisms: first, by partially internalizing the externality into the wage; and second, by leasing fewer quotas to the vessel compared to the case where the community is not environmentally conscious. Community members may appreciate that overfishing will have a negative impact not only on the environment but also on their jobs since environmental degradation could be a threat to the sustainability of the future jobs in the fishing sector of the area. Thus, a higher wage can be viewed as the premium or implicit cost that a vessel must incur to employ green workers. Alternatively, it may reflect workers' willingness to trade off environmental concerns—accepting employment on fishing vessels that contribute to ecological damage—in exchange for higher compensation (see Asproudis and Gil Molto 2015, for a related case).

4.2 | Profits and Utility

For each of the three scenarios *(i)-(iii)*, the differences in profits and utilities resulting from the difference in environmental consciousness of the community have been calculated. We state the following:

Lemma 2.

i. *If* $\bar{q} < q^1 < q^0 \Rightarrow \bar{\Pi}^0 > \bar{\Pi}^1$ *and* $\bar{U}^1 > \bar{U}^0$

ii. *If* $q^1 < q^0 < \bar{q} \Rightarrow \Pi^0 > \Pi^1$ *and* $U^0 > U^1$

iii. *If* $q^1 < \bar{q} < q^0 \Rightarrow \bar{\Pi}^0 > \Pi^1$ *and* $\bar{U}^0 > U^1$.

According to Lemma 2, the firm always earns higher profits when the community is not environmentally conscious. Conversely, an environmentally conscious community attains greater utility when the TAC is too strict but attains lower utility when the TAC is not too strict. Intuitively, when the community is environmentally conscious will tend to lease fewer quotas to the vessel and this will lower the vessel's profits and the community's utility. This result agrees with the claim of Besley and Ghatak (2005), suggesting that environmentally conscious communities are mission-driven and willing to sacrifice some material benefits to safeguard the environment. However, according to Lemma 1, the environmentally conscious community is "rewarded" with higher wages. The effect of increased wages along with reduced employment explains why the vessel is always worse off when the community is environmentally conscious. Yet, when the TAC is not too strict the increased wages have a detrimental impact to the community's utility since this increase cannot offset utility losses from both the environmental damage and the reduced employment.

4.3 | Prices and Damages

For each of the three scenarios *(i)-(iii)*, the differences in prices and damages resulting from the difference in environmental consciousness of the community have been calculated.

First, it is straightforward to show that when the TAC is too strict the environmental awareness of the fishing community does not affect either the price of fish or the environmental damage. Since all the quotas are leased the level of the damage, $D = D(\bar{q})$, and the price, $p = a - b\bar{q}$, are the same independently of the community's environmental consciousness. On the other hand, when the TAC is not too strict, the price will be lower and the damage will be higher when the community is not environmentally conscious. These results are not surprising since the community leases more fishing quotas to the vessel when the community is not environmentally conscious. However, this result also indicates that an environmentally friendly fishing community will affect the production cost of the vessel and therefore the marker price of the product. A similar result, but with a different mechanism, is derived in Anderson (1991) where a dominant fishing vessel "*...[i]t can simply not use some of its production rights. Total output in the market will fall and market price will increase. This can be called output price manipulation.*"

4.4 | Social Welfare

For each of the three scenarios *(i)-(iii)*, the differences in social welfare resulting from the difference in environmental consciousness of the community have been calculated. We state the following:

Proposition 3.

i. *If* $\bar{q} < q^1 < q^0 \Rightarrow \bar{SW}^0 = \bar{SW}^1$

ii. *If* $q^1 < q^0 < \bar{q} \Rightarrow SW^0 \gtreqless SW^1$ *if* $b \lesseqgtr (\sqrt{17} + 1)e/4$.

iii. *If* $q^1 < \bar{q} < q^0 \Rightarrow \overline{SW}^0 \gtreqless SW^1$ *if* $\bar{q} \lesseqgtr q^1[1 + 2b/(b + 2e)]$.

Hence, according to Proposition 3 when the TAC is too strict, environmental consciousness is not an important determinant of social welfare. This is an interesting result from the regulators perspective: fishing communities' environmental preferences are irrelevant when deciding the allocation of quotas and/or the maximum TAC (provided that the TAC the regulator chooses will remain "too strict," i.e., $\bar{q} < q^1$). On the other hand, when the TAC is too loose, the social welfare depends on the community's environmental behavior. Specifically, if the slope of the inverse demand (i.e., the rate at which the consumer's willingness to pay for fish decreases) is not too steep compared to the rate of increase in environmental marginal damage, e, the social welfare is higher when the community is environmentally conscious compared to when it is not. Finally, when the TAC is moderately strict, social welfare under an environmentally conscious community increases with the TAC. Specifically, for a sufficiently high TAC, that is, $\bar{q} > q^1[1 + 2b/(b + 2e)]$, social welfare will be greater when the community is environmentally conscious compared to when it is not.

Proposition 3 provides key insights into potential social welfare outcomes and suggests that policymakers should consider the environmental attitudes of the fishing community (whether environmentally conscious or not) to achieve optimal results. The results are reported in the following tables. Table 1 presents the outcomes for the scenario in which the TAC is considered overly restrictive (i.e., $\bar{q} < q^1 < q^0$). Table 2 summarizes the findings for the scenario where the TAC is overly permissive (i.e., $q^1 < q^0 < \bar{q}$). Finally, Table 3 displays the results corresponding to a moderately restrictive TAC (i.e $q^1 < \bar{q} < q^0$).

5 | Conclusions

In this study, we utilize a Nash bargaining approach to analyze the negotiation process between two parties involved in fishing quotas: a fishing community and a noncommunity vessel. Our analysis is based on the application of the Community Fishing Quotas (CFQs), which is a co-management system aimed at protecting fisheries and ensuring ecosystem sustainability. However, the involvement of local communities in the fisheries management has generated extensive debate and criticism regarding the effectiveness of such programs. This criticism is evident in various studies such as Jentoft (1989, 2000), Jentoft et al. (1998), Pomeroy and Berkes (1997), and McCay (2004).[18]

This research aims to investigate the bargaining process from the perspective of a regulatory authority and contribute to the ongoing debate regarding the effectiveness of the co-management systems. To achieve this, we examine two real market-based scenarios, relevant to both the efficiency of the CFQs and the regulator's policy. In the first case, the fishing community demonstrates no interest in environmental protection. In the second, the community is characterized by environmentally conscious objectives and a commitment to preserving environmental quality. Furthermore, our analysis incorporates different levels of environmental stringency pertaining to the TAC. This distinction highlights differences between cases where all quotas are leased and cases where only a portion is leased.

It is argued, among other things, that if the maximum number of quotas is leased, CFQs can serve an additional purpose beyond preserving local fisheries sustainability. In the case of environmentally conscious fishing communities, CFQs can function as a mechanism for pure transfer payments, enabling a welfare-neutral trade-off where community members experience higher levels of utility and increased wages, while the vessels earn lower profits. On the other hand, if less than the maximum number of quotas is leased the social welfare is higher when the fishing community is environmentally conscious provided that the rate at which the consumer willingness to pay for fish is not too high compared to the rate of increase in environmental marginal damage. Moreover, the wage is higher if the community is environmentally conscious. Additionally, wages are higher in environmentally conscious communities.

TABLE 1 | Summary of the results and comparison for $\bar{q} < q^1 < q^0$.

	Non-environmentally conscious community		Environmentally conscious community
$\bar{\Pi}$	$m(a - b\bar{q})\bar{q}$	$>$	$m(a - (b + e)\bar{q})\bar{q}$
$\bar{U}$	$(1 - m)(a - b\bar{q})\bar{q}$	$<$	$(1 - m)(a - b\bar{q})\bar{q} + em\bar{q}^2$
$\bar{w}$	$\frac{(1-m)(a-b\bar{q})-r}{k}$	$<$	$\frac{(1-m)(a-b\bar{q})-r+em\bar{q}}{k}$
$\bar{q}$	$\bar{q}$	$=$	$\bar{q}$
$\bar{L}$	$k\bar{q}$	$=$	$k\bar{q}$
$\overline{SW}$	$[a - (b/2 - e)\bar{q}]\bar{q}$	$=$	$[a - (b/2 - e)\bar{q}]\bar{q}$
$\bar{p}$	$a - b\bar{q}$	$=$	$a - b\bar{q}$
$\bar{D}$	$e\bar{q}^2$	$=$	$e\bar{q}^2$

TABLE 2 | Summary of the results and comparison for $q^1 < q^0 < \bar{q}$.

	Non-environmentally conscious community		Environmentally conscious community
Π^*	$ma^2/4b$	$>$	$ma^2/4(b+e)$
U^*	$(1-m)a^2/4b$	$>$	$a^2(1-m)/4(b+e)$
w^*	$\frac{(1-m)(a-2r)}{2k}$	$<$	$\frac{(1-m)(a-2r)}{2k} + \frac{ae}{2(b+e)k}$
q^*	$a/2b$	$>$	$a/2(b+e)$
L^*	$ak/2b$	$>$	$ak/2(b+e)$
SW^*	$a^2(3b-2e)/8b^2$	$\gtreqless$	$a^2(3b+2e)/8(b+e)^2$
p^*	$a/2$	$<$	$a(b+2e)/2(b+e)$
D^*	$a^2e/4b^2$	$>$	$a^2e/4(b+e)^2$

TABLE 3 | Summary of the results and comparison for $q^1 < \bar{q} < q^0$.

	Non-environmentally conscious community		Environmentally conscious community
Π^*	$m(a-b\bar{q})\bar{q}$	$>$	$a^2m/4(b+e)$
U^*	$(1-m)(a-b\bar{q})\bar{q}$	$>$	$a^2(1-m)/4(b+e)$
w^*	$\frac{(1-m)(a-b\bar{q})-r}{2k}$	$<$	$\frac{(1-m)(a-2r)}{2k} + \frac{ae}{2(b+e)k}$
q^*	$\bar{q}$	$>$	$a/2(b+e)$
L^*	$k\bar{q}$	$>$	$ak/2(b+e)$
SW^*	$[a-(b/2-e)\bar{q}]\bar{q}$	$\gtreqless$	$a^2(3b+2e)/8(b+e)^2$
p^*	$a-b\bar{q}$	$<$	$a(b+2e)/2(b+e)$
D^*	$e\bar{q}^2$	$>$	$a^2e/4(b+e)^2$

However, utility, vessel profits, production, and employment are greater when the community is not environmentally conscious.

These findings regarding the efficiency of CFQ systems are significant for policymakers. Regulators allocating quotas to fishing communities may need to consider the communities' environmental interests and concerns, since these preferences affect the distribution of economic benefits, environmental outcomes, and overall social welfare.

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Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

Endnotes

[1] Tyedmers et al. (2005) estimated that fisheries consumed almost 1.2% of global oil, emitting 130 Mt CO_2. Greer et al. (2019) reported higher emissions: 207 Mt CO_2 in 2016 (up from 47 Mt in 1950), with the industrial sector contributing 159 Mt (77%) and small-scale fisheries 47 Mt.

[2] See for example https://www.coastalvillages.organd https://www.alaskapollock.org/sustainabilty.html.

[3] http://alaskafisheries.noaa.gov/cdq/(date access 05.02.2019).

[4] For more details see Strehlow (2010), Castillo and Dresdner (2013), Jentoft and McCay (1995), Evans et al. (2011), Huggins (2011), Kirchner and Leiman (2014).

[5] For further analysis on fishing cooperatives see Barrett and Okudaira (1995), Baticados et al. (1998), Deacon (2012), Unal et al. (2009).

[6] For an extensive analysis on the Individual Fishing Quotas and for the application of rights for the management of fisheries in various countries see Emery et al. (2012), Hannesson (1991), Huppert (2005), Kristofersson and Rickertsen (2009), Laxe (2006), Newell et al. (2005), Yagi and Managi (2011), and Walden et al. (2012).

[7] For more information see https://www.fisheries.noaa.gov/alaska/sustainable-fisheries/community-development-quota-cdq-program (date access 04/05/2023).

[8] Similar with the trade unions' targets and in line with the National Research Council's (1999) statement.

[9] Given this setup, it is straightforward to confirm that $C_w, C_q, C_r > 0$ with $C_{ww}, C_{qq}, C_{rr}, C_{wq}, C_{rq} \leq 0$ and $C_{wr} = 0$.

[10]In Namibia, rights are often leased under vessel-chartering arrangements, with processing and marketing included, leaving quota holders uninvolved (Huggins 2011). Likewise, Benkenstein (2014) notes that although rights are formally non-tradeable, beneficiaries frequently lease quotas to established firms rather than invest in costly vessels and infrastructure, creating a risk-free cash-for-quota system.

[11]For further analysis on the collective action problems see Ostrom (2010).

[12]Introducing a positive reservation wage does not qualitatively affect our results.

[13]For a similar approach with $k = 1$ see for example Asproudis and Gil Molto (2015), and Manasakis and Petrakis (2009).

[14]The wage and the price of quotas can be thought of being negotiated as a package, *i.e.*, as if the two parties negotiate over q and $(wk + r)$.

[15]Non-negativity constraint implies that $m < (a - 2r)/a$.

[16]Non-negativity constraints imply that $2q/a < b < a/2q$.

[17]Non-negativity constraint requires that $a > (b + e)\bar{q}$.

[18]See also Bowles and Gintis (2002) for a more general analysis and review of the role of the communities in governance*e*.

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