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Abstract

This paper presents a model based on the Nash bargaining for fishing quotas and wages between fishing communities and vessels, focusing on two cases: (a) the fishing communities are not environmentally conscious and ignore the external damages caused by the fishing industry emissions, and (b) the fishing communities are environmentally conscious, and the external damages caused by the fishing industry emissions affect their bargaining position in the fishing quotas market. Between other it is argued that, in developing economies, where normally the Total Allowable Catch (TAC) is relatively strict compared to the community's needs, the community's degree of environmental awareness has no effect on social welfare. In developed countries 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 total allowable catch.

keywords: bargaining, fishing quotas, environmental protection, fishing community, vessels, social welfare.

JEL: C78; Q5; Q13; Q22

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1 Introduction

The fisheries industry is linked to the exploitation of open-access renewable natural resources and, ever since Hardin published in 1968 "The Tragedy of the Commons," fisheries' sustainability has been the focal point of numerous studies. However, more recent empirical studies have shed light on a different dimension of the environmental problem facing the fisheries industry: air pollution from internal combustion engines in operating fishing boats. According to Tyedmers *et al.* (2005) "*fisheries account for about 1.2% of global oil consumption, an amount equivalent to that burned by the Netherlands, the 18th-ranked oil consuming country globally, and directly emit more than 130 million t of CO_2 into the atmosphere*", and according to Greer *et al.* (2019) "*Global CO_2 emissions from the main engine combustion of fuel in marine fisheries amounted to approximately 207 million t of CO_2 in 2016, compared to 47 million t of CO_2 in 1950. In 2016, the industrial sector released around 159 million t of CO_2, i.e., 4.1 times more than in 1950 and accounted for 77% of global CO_2 emissions from marine fisheries. In comparison, the small-scale sector released around 47 million t of CO_2 in 2016, 5.8 times more than in 1950.*" Furthermore, Waldo and Paulrud (2016) noted that policy instruments for fisheries management concentrate on fisheries' sustainability and do not take into account other external costs like the fishing boats emissions of CO_2.

A widely used policy instrument to regulate the fishing industry is that of Individual Transferable Quotas (ITQs). In ITQs systems the regulating authority sets a total allowable catch (TAC) of one or more species (e.g. pollock, cod, halibut, crab), divides the TAC into quota shares, and distributes them to individuals. Such quotas are transferable, *i.e.*, can be bought, sold, or leased. In practice, often the regulating authority distributes the fishing rights (quotas) to local fishing communities organized in the form of fishing cooperatives (henceforth, fishing community and fishing cooperative will have the same meaning). Therefore, a Community Fishing Quotas (CFQs) is a special type of ITQs system where the quotas are initially grandfathered, *i.e.*, allocated free-of-charge, to a fishing community. The fishing community may afterwards sell or lease quotas to fishing boats (firms-vessels) or choose not to use them. Therefore, the regulator, along with the community, are managing the fisheries and protect the ecosystem against degradation (*e.g.*, Pomeroy and Berkers, 1997; Baland and Platteau, 1996). The rationale behind such systems is founded in the fishing communities' interest for the sustainability of the environment that, according to Charles, 1994, include the four cores of sustainability, namely, Ecological, Socioeconomic, Community, and Institutional sustainability. It is not uncommon that fishing communities are environmentally conscious (see for example www.coastalvillages.org and www.alaskapollock.org/sustainabilty.html.) and they consider the external cost imposed upon the society in the form of environmental damage even if the policy instruments for the management of the fisheries do not. Besides, the fisheries and communities' sustainability "*depends largely on the intrinsic characteristics of social, economic, and legal systems*" (Criddle, 2012). CFQs systems have been applied in Alaska, USA[1] as well as in various developed and developing countries like Germany, Norway, Iceland, Japan, Chile, Philippines, Malaysia, Vietnam, Cambodia, Namibia *etc.*[2] Although the same policy instrument is applied by both developed and developing countries, fishing communities in these countries seem to adopt different strategies. For example, Benkenstein (2014), notes that in Namibia the quota owners prefer to directly lease their quotas "*to established companies - essentially a risk-free cash-for quota exchange*" than to make *"costly investments in vessels, processing infrastructure and marketing activities."* However, Alaskan fishing communities usually adopt the latter strategy.

Aim of the present study is to analyse the efficiency of CFQs systems with respect to the environmental damage caused by the emissions of the fishing industry in the presence of environmentally aware fishing communities. In this spirit, we explore the bargaining process for fishing quotas between the fishing community and the vessels focusing on two cases: (a) the fishing community is not environmentally conscious and ignore the external damages caused by the fishing industry's emissions, and (b) the fishing community is environmentally conscious, and the external damages caused by the fishing industry's emissions affect their bargaining position in the fishing quotas market. Although there is a plethora of studies with respect to the agricultural and fishing cooperatives, the bargaining between environmentally friendly fishing communities and firms-vessels for the sale of fishing quotas and the possible outcomes have not been explored.[3] We try to cover this gap in the literature and analyse this case from both an economic and a policy/regulator's viewpoint.

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 takes into account two alternive scenarios. In the first -benchmark- case,

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

[2] For more details see Strehlow, 2010; Castillo and Dresdner, 2013; Jentoft and McCay, 1995; Raakjaer Nielsen and Vedsmand, 1995; Nasuchon and Charles, 2010; Evans et al., 2011; Huggins, 2011; Benkenstein, 2014; Kirchner and Leiman, 2014.

[3] For further analysis on fishing cooperatives see Barrett and Okudaira, 1995; Baticados, 1998; Deacon, 2012; Unal *et al.*, 2009.

the community ignores the environmental damage caused by the fishing industry's emissions. In the second case, the communitiy is environmentally aware of this environmental damage and reacts against it. Therefore, the possible outcomes are explored under different behavioural assumptions about the members of the fishing community (Oczkowski, 2006; Bateman *et al.*, 1979). Such behavioural differences can be justified on the ground 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 other it is argued that, in developing economies, where normally the Total Allowable Catch (TAC) is relatively strict compared to the community's needs, the community's degree of environmental awareness has no effect on social welfare. In developed countries 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 total allowable catch.

2 Background

2.1 Fishing communities and fishing quotas

The interesting characteristic of the CFQs, and the main difference from the Individual Fishing Quotas[4], is the leading role of the community in the final allocation of the fishing quotas. Fishing communities are traditional fishing villages, fisheries-dependent communities, that are traditionally organized into fishing cooperatives, and they are the owners of the quotas. For example, according to Strehlow (2010) in Germany the quotas "*... are distributed among the fisheries cooperatives, which in turn distribute their quotas among their members*". As it is noted in Pomeroy and Berkers (1997) "*[f]isheries managers increasingly recognize that a fishery cannot be managed effectively without the cooperation and participation of fishers to make laws and regulations work.... Co-management systems have emerged as a partnership*

[4] There is a large literature for the theory and the application of the Individual Fishing Quotas or Individual Transferable Quotas. For an extensive analysis on the Individual Fishing Quotas and for the application of rights for the management of fisheries in various countries see Clark et al., 1988; Dupont et al., 2005; Emery et al., 2012; Hannesson, 1991; Huppert, 2005; Kristofersson and Rickertsen, 2009; Laxe, 2006; Newell et al., 2005; Yagi and Managi, 2011 as well as Walden et al., 2012.)

arrangement using the capacities and interests of the local fishers and community, complemented by the ability of the government to provide enabling legislation, enforcement and conflict resolution, and other assistance." Ginter (1995) note that the CFQ program "*...is of interest as a form of 'individual transferable quota' management which explicitly recognizes the special needs of communities as distinct from business firms or individual.*" For example, according to the National Oceanic and Atmospheric Administration (NOAA) the CFQ systems applied in Alaskan fisheries aim "*(i) to provide eligible western Alaska villages with the opportunity to participate and invest in fisheries in the Bering Sea and Aleutian Islands Management Area; (ii) to support economic development in western Alaska; (iii) to alleviate poverty and provide economic and social benefits for residents of western Alaska; and (iv) to achieve sustainable and diversified local economies in western Alaska.*"[5]

As mentioned earlier, the fishing communities have the right to sell or lease quotas to vessels operating in the fishing area. Mansfield (2007) claims that the innovative element of the Community Development Quotas[6] (CDQ) systems "*... is that quota is not designed so local people benefit directly by catching and using the fish (ie use value), but instead quota is marketable (ie exchange value). CDQ groups may not sell their quota outright, but the program is designed for them to lease their quota to non-CDQ firms already active in the industry; these firms now pay CDQ groups for the right to catch fish. By the early 2000s, annual revenue for all CDQ groups combined was around US$70 million, with most income from leasing quota...*". Therefore, there can be negotiations between a fishing community and a third party (*i.e.*, a non-community vessel) for fishing quota. The fishing community could earn additional income by selling/leasing unused quotas for a specific period to the vessel. On the other hand, the vessel needs quotas in order to claim fishing rights in a particular fishery.

2.2 Fishing communities, fishing quotas and employment

Members of the fishing community are working on vessels as a crew or in the fishing industry as processors and distributors. According to National Research Council (1999) "*[s]ome residents of the CDQ communities have participated in the halibut, sablefish, crab, and groundfish fisheries as crew members, skippers, or vessel owners*" and according to Lowe (2008) "*[a]lthough some owned their own crab boats, many*

[5]For more information see http://www.alaskafishereis.noaa.gov/fisheries/cdq (date access 15/02/2019).

[6]The CFQ systems applied in Alaskan fisheries are called Community Development Quotas (CDQ) systems.

Aleutian locals worked as deckhands and some eventually as captains on large-boat crab boats that came to the locality from the outside. Large-boat owners never settled in the Aleutians, preferring to fish in the Bering Sea and return home to ports such as Kodiak, Seattle, and Newport, Oregon." Thus, their wellbeing depends on the vessels' wealth, productivity and profitability and as it is mentioned in National Research Council, 1999 "*In addition to money, CDQ groups were also interested in obtaining jobs for residents, given that unemployment is a serious problem.*" Therefore, fisheries sustainability is not a biological problem, it is a social problem (Criddle, 2012).

Hence, it is obvious that the employment level in fishing communities is strongly and directly connected with the number of the quotas the vessels will purchase/lease from the local fishing communities. The question is if and how the environmental concern that characterises 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 the next section we analyse the models for the two cases. In the section 4 we compare the results from each case in order to focus on the regulators' preferences and we include results from comparative statics. Finally, section 5 includes the conclusion.

3 The basic model

We consider a fishing community that has been grandfathered all the quotas in a specific fishery and a non-community firm (vessel) which is a potential buyer of quotas. The vessel is a profit maximizing business while the community acts as a bargaining agent (Oczkowski, 2006). These two parties bargain for wages and fishing quotas following a Nash bargaining approach. As in Hatcher (2005b), the analysis is based on a simple and given -short run- period model under a single species fishery. Therefore, the short run profit function for the vessel is given by

$$\Pi = pq - C \tag{1}$$

where p is the price of the good in the market (the price of the fish) with $p = a - bq$ and a is the size of the market, $a > 0$ and $a > bq$. Also, q ($q > 0$) is the level of the production (quantity of harvested fish) and b the parameter.

Since the harvested quantity of fish depends on the number of the fishing quotas belong to the vessel, the harvested quantity q can be lower or equal to the TAC (see also Arnason, 2009). Hence, noting the TAC as $\bar{q}$ we have $q \leq \bar{q}$. If $q = \bar{q}$ the fishing community will lease all the quotas to the vessel. We consider this to be a representative example of how communities trade fishing quotas in developing countries. For example, for the case of developing economies like Namibia Huggins (2011) claims that "*...[r]ights are leased under the guise of chartering vessels. The services of processing and marketing the catch are also included in the contract. The operating company pays the fee and the quota holder (i.e., small holding company) has nothing to do with the quota for the rest of the year.*" Similarly, Benkenstein (2014) states that "*...[t]he central problem, outlined in 2014 by Kirchner and Leiman, is that, although fishing rights are non-tradeable in Namibia, rights holders are permitted to 'lease' their quota to established firms. Namibians who have been awarded fishing rights and allocated quotas as part of the government's empowerment drive are faced with the choice of making costly investments in vessels, processing infrastructure and marketing activities or directly leasing their quota to established companies – essentially a risk-free cash-for quota exchange. Given these incentives, it is to be expected that many beneficiaries of the Namibianisation policy will opt to lease their quotas or become passive partners in joint ventures with larger, established firms.*"

At national level the price of fish depends on the quantity that will be harvested by the vessel(s). Thus, contrary to Hatcher (2005b) in our model the fishing vessel is a single price making firm. In that case, it is clear that 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/leasing. This approach is in line with the assumptions and the analysis from Oczkowski (2006) and Helmberger and Hoos (1962). Specifically, the above studies have assumed that the fishing comunities do 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.[7] 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 total cost for the vesel is $C = wL + rq$ where w ($w > 0$) is the wage of the workers, members of the community and L the number of the workers. Furthermore, we assume marginal product of labor equal to $L = kq$ with $k > 0$.[8] In addition,

[7] Similar with the trade unions' targets and in line with the National Research Council's (1999) statement as it is described in the previous section.

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

r ($r > 0$) is the price of the quota or the cost for the vesels in order to purchase each fishing quota. Contrary to Hatcher (2005a) and close to Anderson (1991) we assume that both the vessels and the fishing communities have power in the quotas market while the vessels are price makers in the output market. Particularly, in Hatcher (2005a) the vessels are price takers in the quota and in the output market but in Anderson (1991) the vessels have market power in the output market with one dominant price maker firm in the quotas market.

The CFQ community cares for the wages and for the number of the workers as well as for the revenues from the sale of the unused quotas at price r. Since a quota gives the right to the vessel to harvest a specific quantity of a specific fish (species) for a particular period, then quotas and output can be the same. Simply, one quota represents the right to the vessel to harvest one tonne of a fish (*e.g.*, pollock, cod, halibut, crab). Moreover the utility function of the community is based on a typical Stone-Geary function with reservation wage equal to zero.[9] Furthermore, we introduce the income from the sale of the unused quotas to the utility function $U^{NC} = wkq + rq + R$ where the superscript NC indicates that the community does not care for the protection of the ecosystem. The parameter R is the income that the communities have from their fishing activities. Simply, they will rent some of the unused quotas to the foreign vessels and they will use some (used quotas) for themselves in order to catch fish for private consumption or for local trade. For simplification reasons and without lose of generality we normalise this to zero.[10]

The CFQ community's interest for the environmental concern or environmental protection is represented by the introduction of the damage function in the utility function. The damage to the environment which caused by the CO_2 emissions by the use of burning fuels. The damage function is $D = eq^2$ where e is the damage parameter. That is, the utility function for the environmentally friendly community is $U^C = wkq + rq - eq^2$ where the superscript C indicates that the community is environmnetally conscious.

[9] For simplification reasons and without loss of generality we assume that the reservation wage or the wage from a competitive industry is equal to 0 (e.g. Lommerud et al., 2005, Mukherjee et al., 2007, Mukherjee, 2008 and Asproudis and Gil Molto, 2015). In other words, the members of the cooperative cannot find another job and they do not have the skills to work in a different sector. Thus the utility function is $U^{NC} = (w - w_0)L$ where w_0 is the reservation wage equal to 0, Hence, $U^{NC} = wL$. However, the introduction of the reservation wage into the formula does not have any qualitative effect on the results.

[10] A possible extention on this equation is to add the profits from fishing to the utility function and therefore the question for the community/fishing cooperatives will be how much quotas to rent out and how much to retain. However, the model is more complex and the equations are characterised by non-tractability results.

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, the community's utility including the environmental damage, and the consumers surplus in the produt market. Therefore, it is straightforward to show that $SW = PS + CS + U - D = (a - (1/2)bq - eq)\, q$.

Roberts (2007) assumes that the "...workers have identical preferences and identical outside opportunities." In our study the 'outside opportunities' are equal to zero since the reservation wage is assumed to be 0. However, in our study, and in order to focus on the bargaining for CFQs and on the social welfare, it is assumed that all the members of the community care equally for the environmental quality.These assumptions are in the spirit of Solstad and Brekke (2011) "*The point of departure is a traditional harvesting model: a well-defined group of individuals that jointly own and exploit a natural resource*" and in line with the assumption from Damania and Fredriksson (2000) "*Assume that all consumers join an environmental lobby group, and thus all individuals in society are organized*" where in our case the consumers are the members of the community and the environmental group is the fishing community. Hence, there is a collective action without free-riders .[11] Following Oczkowski (2006) we assume zero payoff for disagreement point. Finally, it is assumed that, independently of reaching an agreement or not, there is no fixed bargaining cost.

3.1 The Benchmark case: Non-environmental conscious fishing community

The community's utility function is

$$U^{NC} = wkq + rq \tag{2}$$

Following the Nash bargaining the vessel and the community will decide the amount of the exchanged quotas, the price of quotas, and the wage[12]. Therefore, the maximisation problem is given by

$$\begin{aligned} \max_{q,w,r} \Pi U^{NC} &= Log(pq - wL - rq)^m (q(wk + r))^{1-m} \\ s.t. \quad q &\leq \bar{q} \end{aligned} \tag{3}$$

where $m \in (0, 1)$ is the bargaining power.[13]

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

[12] The wage and the price of quotas can be thought of being negotiated as a package.

[13] Second-order conditions require that $a > bq + r + kw$ and $0 < m < 1 - \frac{r}{p}$.

case 1: Assume that $q = \bar{q}$, *i.e.*, all the available community quotas are leased to the non-quotas holders, as in the case of developing countries (*e.g.*, Namibia). In summary, we get the following results about output, wages, profits and utility

$$\overline{q}^{*NC} = \bar{q} \tag{4}$$

$$\overline{w}^{*NC} = \frac{(1-m)\,(a-b\overline{q})-r}{k} \tag{5}$$

$$\bar{\Pi}^{*NC} = m\overline{q}(a-b\overline{q}) \tag{6}$$

$$\bar{U}^{*NC} = (1-m)(a-b\overline{q})\overline{q} \tag{7}$$

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

$$\overline{p}^{*NC} = a-b\overline{q} \tag{8}$$

$$\overline{L}^{*NC} = k\overline{q} \tag{9}$$

$$\overline{DF}^{*NC} = e\overline{q}^2 \tag{10}$$

$$\overline{SW}^{*NC} = (1/2)\,(3a-(3b-2e))\,\bar{q} \tag{11}$$

Non-negativity constraints imply that $a > 2\bar{q}$, $ab > 2\bar{q}$, $a > 2b\bar{q}$ and $m < \frac{a-b\bar{q}-r}{a-b\overline{q}}$.

Comparative statics reveal that the wages, the vessel's profits, the community's utility, and the social welfare are all increasing in the market size ($\frac{\partial\overline{w}^{*NC}}{\partial a} = \frac{1-m}{k} > 0$, $\frac{\partial\overline{\Pi}^{*NC}}{\partial a} = m\overline{q} > 0$, $\frac{\partial\overline{U}^{*NC}}{\partial a} = (1-m)\overline{q} > 0$, and $\frac{\partial\overline{SW}^{*NC}}{\partial a} = (3/2)\,\overline{q} > 0$). Moreover, the wages and the community's utility are decreasing , while the vessel's profits are increasing in the vessel's bargaining power ($\frac{\partial\overline{w}^{*NC}}{\partial m} = \frac{-a+b\overline{q}}{k} < 0$, $\frac{\partial\overline{U}^{*NC}}{\partial m} = (-a+b\overline{q})\overline{q} < 0$, and $\frac{\partial\overline{\Pi}^{*NC}}{\partial m} = \overline{q}(a-b\overline{q}) > 0$). However, the social welfare is not affected by the vessel's bargaining power ($\frac{\partial\overline{SW}^{*NC}}{\partial m} = 0$).

case 2: Assume that $q < \bar{q}$, *i.e.*, not all the available community quotas are leased to the non-quotas holders, as in the case of developed countries (*e.g.*, USA). In summary, we get the following results about the wages and the output

$$w^{*NC} = \frac{a(1-m)-2r}{2k} \tag{12}$$

$$q^{*NC} = \frac{a}{2b} \tag{13}$$

Additionally, the vessel's profits and the community's utility are

$$\Pi^{*NC} = \frac{a^2 m}{4b} \tag{14}$$

$$U^{*NC} = \frac{a^2(1-m)}{4b} \tag{15}$$

Moreover, the output price, labour, damage and social welfare are

$$p^{*NC} = \frac{a}{2} \tag{16}$$

$$L^{*NC} = \frac{ak}{2b} \tag{17}$$

$$DF^{*NC} = \frac{a^2 e}{4b^2} \tag{18}$$

$$SW^{*NC} = \frac{a^2(3b-2e)}{8b^2} \tag{19}$$

Non-negativity constraint implies that $m < \frac{a-2r}{a}$.

Comparative statics reveal that the wages, the output, the vessel's profits, and the community's utility are all increasing in the market size ($\frac{\partial w^{*NC}}{\partial a} > 0$, $\frac{\partial q^{*NC}}{\partial a} > 0$, $\frac{\partial \Pi^{*NC}}{\partial a} > 0$, and $\frac{\partial U^{*NC}}{\partial a} > 0$). However, the social welfare is increasing in the market size only if the marginal utility decreases faster than the increase in the marginal damage ($\frac{\partial \overline{SW}^{*NC}}{\partial a} = \frac{2a(3b-2e)}{8b^2} \lesseqgtr 0$). Moreover, the wages and the community's utility are decreasing , while the vessel's profits are increasing in the vessel's bargaining power ($\frac{\partial w^{*NC}}{\partial m} = \frac{-a}{2k} < 0$, $\frac{\partial U^{*NC}}{\partial m} = \frac{-a^2}{4b} < 0$, and $\frac{\partial \Pi^{*NC}}{\partial m} = \frac{a^2}{4b} > 0$). However, the output and the social welfare are not affected by the vessel's bargaining power ($\frac{\partial q^{*NC}}{\partial m} = \frac{\partial SW^{*NC}}{\partial m} = 0$).

3.2 Environmental conscious fishing community

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

$$U^C = wkq + rq - eq^2 \tag{20}$$

Hence, the maximisation problem is described as

$$\begin{aligned} \max_{q,w,r} \Pi U^C &= Log(pq - wL - rq)^m (q(wk+r) - eq^2)^{1-m} \\ s.t. \quad q &\leq \bar{q} \end{aligned} \tag{21}$$

Second-order conditions require that $a > bq + r + kw$ and $0 < e \neq \frac{r+kw}{q}$.

case 1: Assume that $q = \bar{q}$. It can be shown that output and wages are

$$\overline{q}^{*C} = \overline{q} \tag{22}$$

$$\overline{w}^{*C} = \frac{(1-m)(a-b\overline{q}) - r + em\overline{q}}{k} \tag{23}$$

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

$$\bar{\Pi}^{*C} = m\bar{q}(a-(b+e)\bar{q}) \tag{24}$$

$$\bar{U}^{*C} = (1-m)(a-b\overline{q})\,\overline{q} + em\overline{q}^2 \tag{25}$$

$$\overline{p}^{*C} = a - b\overline{q} \tag{26}$$

$$\overline{L}^{*C} = k\overline{q} \tag{27}$$

$$\overline{DF}^{*C} = e\overline{q}^2 \tag{28}$$

$$\overline{SW}^{*C} = (1/2)(3a-(3b-2e))\,\overline{q} \tag{29}$$

Non-negativity constraint requires that $a > (b+e)\overline{q}$.

Comparative static results are similar with the benchmark case for $q = \overline{q}$. Specifically, the wages, the vessel's profits, the community's utility, and the social welfare are all increasing in the market size ($\frac{\partial \overline{w}^{*C}}{\partial a} = \frac{1-m}{k} > 0$, $\frac{\partial \overline{\Pi}^{*C}}{\partial a} = m\overline{q} > 0$, $\frac{\partial \overline{U}^{*C}}{\partial a} = (1-m)\bar{q} > 0$, $\frac{\partial \overline{SW}^{*C}}{\partial a} = \overline{q} > 0$). Moreover, the wages and the community's utility are decreasing , while the vessel's profits are increasing in the vessel's bargaining power ($\frac{\partial \overline{w}^{*C}}{\partial m} = \frac{-a+(b+e)\overline{q}}{k} < 0$, $\frac{\partial \overline{U}^{*C}}{\partial m} = \overline{q}(-a+(b+e)\overline{q}) < 0$, and $\frac{\partial \overline{\Pi}^{*C}}{\partial m} = \overline{q}(a-(b+e)\overline{q}) > 0$). However, the social welfare is not affected by the vessel's bargaining power ($\frac{\partial \overline{SW}^{*C}}{\partial m} = 0$).

case 2: Assume that $q < \bar{q}$. Then we get

$$q^{*C} = \frac{a}{2(b+e)} \tag{30}$$

$$w^{*C} = \frac{(1-m)a - 2r}{2k} + \frac{ae}{2(b+e)k} \tag{31}$$

Furthermore,

$$\Pi^{*C} = \frac{a^2 m}{4(b+e)} \tag{32}$$

$$U^{*C} = \frac{a^2\,(1-m)}{4(b+e)} \tag{33}$$

$$p^{*C} = \frac{a\,(b+2e)}{2(b+e)} \tag{34}$$

$$L^{*C} = \frac{ak}{2(b+e)} \tag{35}$$

$$DF^{*C} = \frac{a^2 e}{4(b+e)^2} \tag{36}$$

$$SW^{*C} = \frac{a^2(3b+2e)}{8\,(b+e)^2} \tag{37}$$

Comparative statics reveal that the wages, the output, the vessel's profits, the community's utility, and social welfare are all increasing in the market size ($\frac{\partial w^{*C}}{\partial a} > 0$, $\frac{\partial q^{*C}}{\partial a} > 0$, $\frac{\partial \Pi^{*C}}{\partial a} > 0$, $\frac{\partial U^{*C}}{\partial a} > 0$, and $\frac{\partial SW^{*C}}{\partial a} > 0$). Moreover, the wages and the community's utility are decreasing , while the vessel's profits are increasing in the vessel's bargaining power ($\frac{\partial w^{*C}}{\partial m} = \frac{-a}{2k} < 0$, $\frac{\partial U^{*C}}{\partial m} = \frac{-a^2}{4(b+e)} < 0$, and $\frac{\partial \Pi^{*NC}}{\partial m} = \frac{a^2}{4(b+e)} > 0$). However, the output and the social welfare are not affected by the vessel's bargaining power ($\frac{\partial q^{*C}}{\partial m} = \frac{\partial SW^{*C}}{\partial m} = 0$). Furthermore, the wages are increasing and the output is decreasing with the rate at which marginal damage increases ($\frac{\partial w^{*C}}{\partial e} = \frac{ab}{2(b+e)^2 k} > 0$ and $\frac{\partial q^{*C}}{\partial e} = -\frac{a}{2(b+e)^2} < 0$). Finally, the social welfare is increasing in the size of the market ($\frac{\partial SW^{*C}}{\partial a} > 0$).

4 Comparison

In this section we compare the results from the two models, focusing on differences in prices, damages, profits, utility equations, wages, output/quotas and number of workers as well as the social welfare. Differences in the latter might have important policy implication for the regulator.

4.1 Profits and Utility

For $q = \bar{q}$

Calculating profit and utility differences between the cases of environmental conscious and non-environmental conscious community we get $\bar{\Pi}^{*NC} - \bar{\Pi}^{*C} = emq^2$ and $\bar{U}^{*NC} - \bar{U}^{*C} = -emq^2$ implying that $\bar{\Pi}^{*NC} > \bar{\Pi}^{*C}$ and $\bar{U}^{*C} > \bar{U}^{*NC}$. Intuitively, when the community is environmentally conscious will sell fewer quotas to the vessel and this will lower the vessel's profits while raising the community's utility.

Lemma 1 *When $q = \bar{q}$, the community yields higher utility and the vessel earns lower profits when the community is environmentally conscious.*

This result is in agreement with the claim of Besley and Ghatak (2005) that the environmentally conscious community has a mission oriented character and it is willing to sacrifice part of its materialistic wellbeing to protect the environment.

For $q < \bar{q}$

We calculate $\Pi^{*NC} - \Pi^{*C} = \frac{a^2 em}{4b(b+e)}$ so, $\Pi^{*NC} > \Pi^{*C}$ and $U^{*NC} - U^{*C} = \frac{a^2 e(1-m)}{4b(b+e)}$ then $U^{*NC} > U^{*C} \forall m \in (0,1)$.

Lemma 2 *When $q < \bar{q}$, the community yields higher utility and the vessel earns higher profits when the community is not environmentally conscious.*

4.2 Wages and Quotas - Output - Employment

For $q = \bar{q}$

With proper calculations we get $\bar{w}^{*NC} - \bar{w}^{*C} = -\frac{em\bar{q}}{k}$ thus, $\bar{w}^{*NC} < \bar{w}^{*C}$ but the output/employment level is the same for both cases since $q = \bar{q}$, hence $\bar{L}^{*NC} = \bar{L}^{*C} = k\bar{q}$.

Lemma 3 *For $q = \bar{q}$ the wages are higher if the community is environmentally conscious.*

The explanation is that the green-community could internalise the externalities into the wages. The members may appreciate that the overfishing will have a negative impact not only to the environment but also to their jobs since the environmental degradation could be a threat for the sustainablity of the future jobs in the fishing sector of the area. Thus, the increase of the wages could reflect the 'price or forfeit' that the vessel will pay in order to hire the 'green' members/workers. Additionally, the statement could indicate that the members are willing to accept to work in fishing vessel, which cause a damage to the environment, for better wages (for a similar case see Asproudis and Gil Molto, 2015).

For $q < \bar{q}$

We calculate $w^{*NC} - w^{*C} = -\frac{ae}{2k(b+e)}$ thus, $w^{*NC} < w^{*C}$. Also, for the case of the output/employment the difference is $q^{*NC} - q^{*C} = \frac{ae}{2b(b+e)}$ hence $q^{*NC} > q^{*C}$. Similarly, $= \frac{aek}{2b^2+2be}$ implying that $L^{*NC} > L^{*C}$.

Lemma 4 *When $q < \bar{q}$ the wages are higher if the community is environmentally conscious. However, production and employment are higher if the community is not environmentally conscious.*

4.3 Prices and Damages

For $q = \bar{q}$

It is straightforward that $\bar{p}^{*NC} - \bar{p}^{*C} = a - b\bar{q}$ and $\bar{D}^{*NC} = \bar{D}^{*C} = e\bar{q}^2$.

For $q < \bar{q}$

Proper calculations yield $p^{*NC} - p^{*C} = -\frac{ae}{2(b+e)}$ so, the price is lower if the fishing community is not environmentally conscious and $D^{*NC} - D^{*C} = \frac{a^2e^2(2b+e)}{4b^2(b+e)^2}$ hence, the damage is lower if the community protects the ecosystem. It is not surprising that the price of the fish is lower under the existence of a non- environmentally conscious fishing community. Simply, the community will sell more fishing quotas to the vessel and the quantity of the harvested fish will be larger compared with the analogous results if the community protects the environment.

4.4 Social Welfare

For $q = \bar{q}$

We calculate the difference $S\bar{W}^{*NC} - S\bar{W}^{*C} = 0$.

Proposition 1 *In developing economies, the social welfare is not affected by the fishing community's environmental consciousness.*

Therefore in the case of developing countries the regulator has no clear preference on whether the fishing community is environmentally conscious or not. This is an interesting result from the regulator's perspective: fishing communities environmental preferences are irrelevnat when deciding the allocation of quotas and/or the maximum TAC.

For $q < \bar{q}$

We calculate $S\bar{W}^{*NC} - S\bar{W}^{*C} = \frac{a^2e\left(2b^2-eb-2e^2\right)}{8b^2(b+e)^2}$. Observe that the sign of this difference depends on b,and e. Specifically, this sign is negative provided that $b \in (0, \frac{1}{4}\left(\sqrt{17}+1\right)e)$.

Proposition 2 *In developed countries the social welfare is higher when the fishing community is environmentally conscious provided that the rate at which the marginal* *utility of fish consumption decreases is not too high compared to the rate of increase in environmental marginal damage.*

Contrary to the proposition 1, in the case of the developed countries the regulator needs to take into account the rate at which the environmental marginal damage increases. Both propositions give important information for the possible outcome of the social welfare and furthermore indicate that the policy maker, in order to achieve the optimum result, should take into account the behaviour of the fishing community (environmentally friendly or not).

All the previous results are summarized in the next tables:

	Non-environmentally conscious community		Environmentally conscious community
$\bar{\Pi}$	$m\bar{q}(a-b\bar{q})$	$>$	$m\bar{q}(a-(b+e)\bar{q})$
$\bar{U}$	$(1-m)(a-b\bar{q})\bar{q}$	$>$	$(1-m)(a-b\bar{q})\bar{q}+em\bar{q}^2$
$\bar{w}$	$\frac{(1-m)(a-b\bar{q})-r}{k}$	$<$	$\frac{(1-m)(a-b\bar{q})-r+em\bar{q}}{k}$
$\bar{q}$	$\bar{q}$	$=$	$\bar{q}$
$\bar{L}$	$k\bar{q}$	$=$	$k\bar{q}$
$\overline{SW}$	$(1/2)(3a-(3b-2e))\bar{q}$	$=$	$(1/2)(3a-(3b-2e))\bar{q}$
$\bar{p}$	$a-b\bar{q}$	$=$	$a-b\bar{q}$
$\bar{D}$	$e\bar{q}^2$	$=$	$e\bar{q}^2$

Table 1: Summary of the results and comparison for $q=\bar{q}$

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

Table 2: Summary of the results and comparison for $q<\bar{q}$

5 Conclusions

We analyse the bargaining for fishing quotas between two players (a fishing community and a non-community vessel) following a Nash bargaining approach and based on the application of the Community Fishing Quotas (CFQ) for the protection of the fisheries. The CFQs is a co-management system where the regulator together with the local communities will manage the fisheries and the sustainability of the ecosystem. Nevertheless, the participation of the local communities in the management of the fisheries has triggered a lot of discussion and criticism for the efficiency of the co-management system (e.g. Jentoft, 1989, 1990; Jentoft et al. 1998; Pomeroy and Berkers, 1997; McCay, 2004)[14]

Scope of the research is to explore the bargaining from the regulator's viewpoint and to contribute to the discussion for the efficiency of the co-management system. Therefore, we explore two cases, based on the real market, which are important for the efficient of the CFQs and for the policy of the regulator. Particularly, in the first case we assume that the community does not have any interest for the protection of the environment. In the second case we assume that the fishing community is characterised by environmental friendly objectives and concern for the conservation of the environmental quality. In addition, we explore the application of the CFQs from both developed and developing countries.

Between others it is argued that, for the developing countries the community's degree of environmental awareness has no effect on social welfare but the community yields higher utility, its members earn higher wages, and the vessel earns lower profits when the community is environmentally conscious. On the other hand, in developed countries the social welfare is higher when the fishing community is environmentally conscious provided that the rate at which the marginal utility of fish consumption decreases is not too high compared to the rate of increase in environmental marginal damage. Moreover, the wages are higher if the community is environmentally conscious. However, the community yields higher utility, the vessel earns higher profits, production and employment are higher when the community is not environmentally conscious.

These results are very significant for the decision-maker and for the efficiency of the Community Fishing Quotas system. The regulator, when deciding the allocation of quotas to fishing communities, may need to consider the communities' environmental interests and concerns.

Finally, although this study is based on the application of the CFQs it could be

[14] *See also Bowles and Gintis, 2002 for a more general analysis and review for the role of the communities in governance.*

extended and generalised for the application of the permits market for the reduction of emissions (e.g. CO_2, SO_2) since the two systems (fishing quotas and emission permits) have very similar characteristics.

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