Do Management Systems Foster Social Capital? Empirical Evidence from Japanese Surf Clam Fisheries

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Abstract

We empirically examine the social effect of management systems. We focus on a particular management practice employed in self-governed coastal fisheries in Japan—revenue sharing arrangement. We hypothesize that management systems affect cooperative relationships and information network in a community; broadly termed as social capital. We quantified social capital using controlled economic experiments with fisherman subjects as well as surveys. Using wild cluster bootstrap for small sample inference, we find evidence of the positive effect of revenue sharing on information network possibly because revenue sharing arrangement provides disincentives to compete and accompanies synchronized collective fishing operation. Interestingly, revenue sharing fishers are no more likely to cooperate unconditionally (i.e., unilaterally) and furthermore they are less likely to cooperate conditionally (i.e., only if others cooperate).

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Introduction

While the primary assumption in economics is that every agent is motivated by self-interest, importance of immaterial motivations such as moral, reputation, and values in economic decision-making has been recognized for a long time. From Adam Smith to Amartya Sen, the vast literature stressing importance of immaterial, unselfish motivations (e.g., so-called 'warm-glow') exists. In fact, many attempts to incorporate immaterial motives in an economic model have been made (e.g., Andreoni, 1989; Bowles & Polanía-Reyes, 2012; Fehr & Schmidt, 1999; Gaspart & Seki, 2003). In what follows, we examine the possibility of nurturing such motivations in a form of social capital. In particular, we focus on understanding how social capital can be fostered in a commons dilemma, a typical example of market failure when the costs and/or the prices do not convey all information. Its understanding is not only important but also relevant in policy discussion to help us achieve ultimately better economic outcomes.

More recent studies on environmental policies highlight the reasons why more attention should be paid to immaterial motives when designing a policy. Behavioral response to monetary incentives sometimes does not align with regulator's intention as referred as crowding out (Cardenas, Stranlund, & Willis, 2000). In the worst-case scenario, economic incentives induced by an institutional setup may undermine individual voluntary motivation to contribute to a better world that would have prevailed otherwise (Bowles & Polanía-Reyes, 2012; Carlsson & Johansson-Stenman, 2012). In particular, in a social dilemma situation such as a fishery each harvester may contribute to the group interest because of moral or reputation among harvesters (e.g. Bénabou & Tirole, 2006; Brekke, Kverndokk, & Nyborg, 2003; Gaspart & Seki, 2003). Trust or reciprocity among members, or social norms can support individual motivation to make sincere commitment to a group interest in a closed society. These studies suggest that non-monetary incentives can play an important role in ensuring success of implementing a policy.

Non-monetary incentives discussed above comprise many aspects of social capital. Social capital is a concept that attributes such as trust, cooperation, and reciprocity among people, and norms and networks in a community are important in improving economic life (Fukuyama, 1996; Putnam, 2001). A stream of the literature on the commons has highlighted important roles of social capital in a community that self-governs a community resource (e.g. Ahn & Ostrom, 2008; Bowles & Gintis, 2002; Gutiérrez, Hilborn, & Defeo, 2011; Pretty, 2003).

Formal economic institutions—markets and property rights—have been recognized as fundamental in determining organizational as well as national economic success (Acemoglu, Johnson, & Robinson, 2005; North, 1973, 2005; Williamson, 1975). As Acemoglu et al. (2005, p. 397) state: "differences in economic institutions are the fundamental cause of different patterns of economic growth." Different economic institutions induce various incentives for people to innovate, to invest, to save for the future, and to provide public goods, which results in differences in economic success. They not only determine the size of a pie but also how a pie should be distributed.

Needless to say the same argument applies to management of the commons. Institutional arrangements inside and outside of the commons influence how successfully resource users can manage the resource and thus benefit from their own resource use (Baland & Platteau, 1996; Ostrom, 1990; Wade, 1989). Whether or not access to the resource is restricted to a limited number of users can alter the incentives for conservation and thus the resulting economic outcomes. Similarly establishment of any types of property rights for resource usage can mitigate some of the externality causing rent dissipation in the commons and improve economic efficiency.

Another stream of the literature suggests that economic institutions do more than changing economic incentives and distributing goods and services; they also affect the accumulation of social capital. Bowles (1998, p. 75) argues that they "also influence the evolution of values, tastes, and personalities" based on cases drawn from experimental economics, history, and other social sciences. Bowles (1998) also points out that moral, ethics, or personality matters especially in the cases of incomplete contracting and asymmetric information, which are prevalent in the real world including many commons situations.

The hypothesis that economic institutions affect social capital can provide important policy implications, because the level of social capital has been shown to be associated with economic performance. In fact, Carpenter and Seki (2011) showed a strong correlation between fishermen's propensity to cooperate (one aspect of social capital) and fishing productivity. Social capital is also found to be empirically associated with economic productivity in other workplace (e.g. Barr & Serneels, 2009; Bouma, Bulte, & van Soest, 2008; Carter & Castillo, 2002; Karlan, 2005; Knack & Keefer, 1997).

In this paper we empirically test the hypothesis that social capital can be fostered by formal economic institutions. In other words, differences in the levels of social capital in a fishing community can be explained by differences in management systems governing fisheries. In so doing we rigorously quantify the effect of management systems on accumulation of social capital.

To test the hypothesis, we focus on a particular management system employed in a fishery—revenue sharing arrangement—as our empirical case study. Revenue sharing arrangement is a type of management rule in a fishery, in which harvesters share catch and/or profits among the members of a fishery cooperative. Employment of such arrangement is a collective action that a group of harvesters takes. The economic roles of revenue sharing in fishery management have been examined in the literature (e.g. Gaspart & Seki, 2003; Platteau & Seki, 2001; Uchida & Baba, 2008). To our knowledge this study is the first to investigate the consequence of revenue sharing arrangement on social aspect of a community and empirically quantify the effects.

This paper provides the quantitative effect of management systems—whether the group has employed revenue sharing or not—on the social aspect of a community (social capital). In particular, this paper asks whether a difference in management systems can result in different cooperative relationships and different information networks in a community. This paper provides the first rigorous analysis to measure the effect of different management systems on social capital and provides insights into an effective policy that can be employed for development of social capital.

The data were collected from Japanese fisheries, many of whom operating under revenue sharing have been successfully managing the resources as well as generating resource rents (Platteau & Seki, 2001; Uchida & Baba, 2008). For the purpose of this paper, social capital is narrowly defined as cooperation and information network, as these are most relevant to fishing operation as a community. To quantify cooperation, controlled economic experiments with fishermen subjects were conducted. As for information network, indices are constructed from survey responses of the same fisherman subjects. Wild cluster bootstrapped p-value method for small sample inference was then used to rigorously quantify the effect of revenue sharing.

Revenue sharing arrangement can be an alternative management practice to solve problems in common-pool resource management that cannot be resolved by other emerging management tools such as Individual Transferable Quota (ITQ). While it can mitigate the externality in a fishery resulting from the common property nature, the ITQ, which was first suggested by Christy (1973), often fails to overcome excessive competition across spaces and times, let alone political difficulty in implementation (Boyce, 1992; Copes, 1986). Revenue sharing arrangement can be one of a few systems to foster cooperation and information sharing in a fishery; it can provide cause for a group and can encourage a cooperative environment for fishing rather than competitively fishing only for self-interests.

Japanese surf clam fishing in Hokkaido Prefecture

Any entities that conduct commercial fishing in Japan's coastal waters must belong to a local Fishery Cooperative Association (FCA). These FCAs not only enforce national and prefectural regulations but also self-regulate the resources tailored to local conditions. Within an FCA many groups of fishers are formed mainly based on the species they target and/or the fishing gear they use. Each group has their own rules of regulation and management and can decide whether to share revenue.

Based on the data provided by Uchida and Wilen (2007), many of the revenue-sharing groups are concentrated in the northeastern Japan, target sedentary species, and use small-scale trawl or gillnets. The coastal fisheries in southern Japan are characterized with fishing many species with the same fishing technology, which complicates the process to share revenue. Many sedentary species fisheries are required to employ small-scale trawl and gillnets by regulation, which results in relatively smaller heterogeneity in fishing skills and outcomes compared to other migratory species or other fishing technology such as fishing bonito. According to Fishery Census of Japan, the fishing groups that share revenue accounted for 11 percent of all groups in Japan in 1988 and the percentage increased to 17 percent until 1998, in which consistent data are available.

We chose the Japanese/Sakhalin surf clam (*Pseudocardium sachalinensis*) fishery, known as Hokkigai in Hokkaido Prefecture, for this study for several reasons. There are a sufficient number of groups engaged in this fishery in the same Hokkaido Prefecture. There are also sufficient variations in with or without revenue sharing while relatively homogeneous in other operational rules.

Focusing on a particular region and carefully selecting groups based on the data from Uchida and Wilen (2007), but without controlling the outcomes, enables us to control many observed and possibly unobserved characteristics at the time of sampling. Harvesting technology is another factor controlled at the time of sampling. For many years all sampled fishery groups employ the jet dredges, by far the most common and the most advanced technology for harvesting the surf clams.

The way the FCAs in Hokkaido organize their shellfish fishery is practically identical. It involves (1) stock assessment conducted by the staff members at Fisheries Extension Offices located all over Hokkaido in collaboration with the local skippers and FCAs, either prior to or after every fishing season; (2) all skippers are called to gather for a pre-season meeting to hear the results of the stock assessment from the local Fisheries Extension Office, to decide a Total Allowable Catch (TAC) for the coming season, and to review operational rules and policy for the season; and (3) during the season a leader and sub-leaders closely watch the market prices (mostly by directly talking with the middlemen) and decide whether to go fishing on the day and if so how much to land subject to the seasonal TAC. Each group usually has an elected leader and multiple sub-leaders for the groups of a significant size. Finally, (4) during and/or after the season whether they share revenue or not all skippers in all FCAs are required to contribute to the collective efforts to make the fishery favorable for growth of the Japanese surf clams although how much to contribute can vary across the FCAs. These efforts include cultivating ocean beds, removing predators, and transplanting clams. Many FCAs also buy juvenile clams from other fisheries and release them in their waters.

The sample consists of ten fishery groups, five of which are under revenue sharing and the other five are not and have never been under such arrangement. They all engage in a small-scale trawl fishery, targeting the Japanese surf clams, and are located in Hokkaido prefecture (eight of them are in Kushiro/Nemuro region, eastern Hokkaido), which means facing the same market, biological conditions, and historical backgrounds. All the groups self-manage the resources of the Japanese surf clams as detailed above; they voluntarily set a TAC based on the stock assessment; they perform the collective efforts for stock enhancement such as stocking and transplanting. All fishers, regardless of management systems, depart from their ports at the sunrise (regulation set by the government), but only revenue sharing fishers return to the ports all together at the same time. Some revenue sharing fishers designate themselves to specific fishing grounds prior to departure and communicate over the radio on the sea about who catch how much in where, further adjusting effort allocation on the sea. In other words, the sampled groups are only different in a decision to employ revenue sharing arrangement accompanied by collective fishing operation in major management/operational rules, but the degree of self-regulation can differ across the FCAs.

The fishers under revenue sharing are financially motivated to coordinate allocation of fishing efforts in both spatial and temporal dimensions; collective fishing operation financially supported by revenue sharing arrangement can further facilitate development of social capital in a fishing community. On the other hand, the non-revenue sharing fishers do not have such an incentive because their profits solely depend on their own catch and the benefits of effort allocation may not accrue to all the fishers equally. The non-revenue sharing fishers do still need to interact with each other in fishing operation as a member of the FCA, but the interaction is not financially motivated.

Methods

We collected this unique dataset containing 79 observations from ten fishery groups in Japan. The dataset consists of individual social capital parameters, each of which will be regressed on a group management indicator—whether sharing revenue or not—and other individual demographic variables for controls.

Although social capital involves various attributes, the focus in this study is on cooperation measured by controlled economic experiments with fishermen subjects and information network measured by the survey. Use of experimental method to measure traditionally hard-to-measure variables such as social capital has been advocated in previous studies (Camerer & Fehr, 2004; Cardenas & Carpenter, 2005; Carpenter, 2002), and in fact many applications exist (e.g., Barr & Serneels, 2009; Bouma, Bulte, & van Soest, 2008; Carpenter, Bowles, Gintis, & Hwang, 2009; Carpenter & Seki, 2011; Carter & Castillo, 2002; Karlan, 2005). Glaeser et al. (2000) carefully compared the experimental method with the survey method and concluded that experiments could be combined with surveys to supplement to each other.

First we detail construction of cooperation parameters with the experiment and then construction of information network indices with the survey. Then, we introduce empirical strategy to estimate the outcome variables (social capital parameters) with our variable of interest (a group management variable).

Cooperation parameters

To measure cooperation among fishermen the standard, repeated Voluntary Contribution Mechanism (VCM) was conducted (Camerer & Fehr, 2004; Carpenter, 2002). Participants were recruited through the FCAs, and many of them held some executive positions in the fishery groups at the time of recruitment. A flyer was provided with the FCAs to make general calls for the experiments and the surveys, and the flyer indicated that the volunteers would be asked to participate in economic experiment (play a simple game) in addition to a survey on fishing operation and they would be paid in cash fixed participation fees plus the earnings from the experiment.

Before the experiment began participants were randomly divided into groups of four persons that were sustained for an entire session. The participants were not told whom they were playing with.[1] The participants were given 3,000 yen (roughly US$30) worth of coins as an endowment every round and asked how much to contribute to a public good from his endowment. Once all the participants made their decision the total contribution of each group was calculated, doubled by the experimenter, and then distributed equally among the group members. The amount not contributed to a public good was kept to the participants. The participants earn a sum of the dividends from a public good, regardless of their own contribution to a public good, and the money kept to themselves for a round. The dominant strategy in the game is to contribute nothing because marginal return from a public good is smaller than the one from a private account regardless of total group contribution. The game was repeated ten times with the exception of one session.[2] At the end of the experiment two of the ten rounds were randomly drawn as a binding round and the participants were paid the average of the payoffs from the two rounds plus a participation fee of 3,000 yen.[3]

All the sessions took place in a conference room at the FCA or at the community center nearby. The participants were seated facing the wall, and in between the participants portable blinds were constructed (Figure 1). At the beginning of every round the participants were given three boxes in different colors. In a yellow box were 3,000 yen worth of coins—real money—as an endowment, a red box was intended for a private account, and a green box was for public good contribution. The participants were asked to move all the coins from the yellow box to either the red box (to keep) or the green box (to contribute), which made it difficult to guess what other participants were doing based on the amount of the noise made from moving coins. Once

[1] In case that the number of participants was not multiple of four, which happened at most sessions, the contribution amounts of some participants were counted twice in multiple groups to avoid the effect of varying group size as in Carpenter and Williams (2010).

[2] The last five rounds were conducted with social disapproval treatment introduced by Carpenter and Seki (2011). However, in this study we do not consider the parameters obtained by this treatment although the observations during these rounds are used for estimation. The session at one FCA repeated the standard VCM for six times with another version of social disapproval for the last two rounds.

[3] A participation fee was set high in this experiment to mitigate concern expressed by many FCA staffs for performance-based payment. The experiment accommodated two more games for different research and thus the session lasted between 2.5 hours and 3 hours. The voluntary contribution mechanism lasted less than 1.5 hours and the average earning from this game was 4,700 yen.

all the participants made their decision the experimenters collected all the boxes and calculated the total contribution of each group and the dividends from a public good. These results were written down on a sheet of paper and distributed to the participants with the three boxes and the coins for the next round.

A total of 80 fishermen participated in the experiment; two subjects were excluded from the analysis. Table 1 shows summary statistics of participants. One to 16 skippers from each FCA that ranges from 12 to 100 percent of all member skippers participated in a session (Table 2). As expected, the smaller the FCAs are the more comprehensive the sampled participants are. How representative the sample is uncertain because of unavailability of information on non-participants in the same FCA. The FCAs greater than ten targeted the skippers who held some positions in the group at the time of the experiments in addition to general calls directed towards all members because these skippers would feel more obligated to cooperate for research. The bottom line is that selection of the participants was done similarly across the FCAs of a lower participation rate.

The mean contribution of all participants is 1,635 yen (55% of endowment) with individual contribution ranging from zero to 3,000 yen (0-100% of endowment). Revenue sharing fishers on average contributed 1,600 yen (53%) to a public good, compared with the average contribution by non-revenue sharing fishers of 1,762 yen (59%). The difference is statistically significant at *p-value* = 0.004 (Mann-Whitney-Wilcoxon test). However, this does not necessarily imply that revenue sharing-fishers cooperate less because in the sample they are statistically significantly younger than non-revenue sharing fishers, which is a very important demographic characteristic that can affect how much to contribute (Aswani, Gurney, Mulville, Matera, & Gurven, 2013). In fact, significant difference between the two groups disappears after controlling for age. For comparison, the same experiment by Carpenter and Seki (2011) with fisherman subjects yielded the overall average contribution of 49% (N = 27) with revenue sharing fishers contributing 51% and non-revenue sharing fishers contributing 46%. This suggests that the fishermen in our study contributed slightly more overall regardless of management systems and the difference in contribution between revenue sharing fishers and non-revenue sharing fishers went in the opposite direction.

The observed amount contributed to a public good, y, in round t by subject i in session j is censored between zero and 3,000 and is related to a latent variable, y^*, as follows.

$$y_{ijt} = \begin{cases} 0 & \text{if } y^*_{ijt} \leq 0 \\ y^*_{ijt} & \text{if } 0 < y^*_{ijt} < 3000. \\ 3000 & \text{if } y^*_{ijt} \geq 3000 \end{cases}$$

The amount contributed to a public good, y, is regressed on a sum of contribution made by other members in the previous round, $\boldsymbol{X}_{-ij(t-1)}$. The model needs to allow individual variation for this coefficient for the reason to be apparent later and thus accommodates a random parameter for $\boldsymbol{X}_{-ij(t-1)}$. In addition, it is likely to be correlated within the same subject nested within the same session and thus the two random effects for subjects and for sessions are also estimated.

We estimated this model using Generalized Latent Variable Model (Skrondal & Rabe-Hesketh, 2004). This model is very flexible that it estimates multi-level random effects as well as one random parameter while allowing the Tobit specification simultaneously. The model is estimated with the following specification.

$$\Gamma\{E(y_{ijt}|\boldsymbol{X}, \boldsymbol{u})\} = \beta_0 + \beta_1 \boldsymbol{X}_{-ij(t-1)} + u^1_j + u^2_{ij} + u^3_{ij}\boldsymbol{X}_{-ij(t-1)},$$

where β_0 and β_1 are parameters to be estimated, $\boldsymbol{X}_{-ij(t-1)}$ is a vector of a sum of contribution made by other members in the previous round, u_j^1 and u_{ij}^1 are random effects for sessions and subjects, u_{ij}^3 is a random parameter, $\Gamma(\cdot)$ is a link function (the identity or the probit function), and y_{ijt}^* is distributed as Gaussian or Bernoulli. We assume

$$E(y_{ijt}|\boldsymbol{u}) = \Gamma^{-1}(\beta_0 + \beta_1\boldsymbol{X}_{-ij(t-1)} + u_j^1 + u_{ij}^2 + u_{ij}^3\boldsymbol{X}_{-ij(t-1)}).$$

Table 3 shows estimation results of the model. An average participant contributes 1,272 yen and an individual variation is in a range of 998 yen standard deviation, which is both economically and statistically significant. An average participant contributes 0.06 yen (the average marginal effect on the observed distribution) more to a public good after observing a marginal increase in the contribution by the other members, which is statistically significant but not economically significant. This varies across individuals in a 0.08 yen standard deviation at a statistically insignificant level.

The results suggest that the participants care about what the others' contribution is and do respond to it cooperatively. The positive coefficient for β_1 implies that they do not shirk and cooperate more when the others cooperate more. However, a dominant part of their strategies is their own contribution level determined outside of what the others did in the previous round. The participants are a group of people who interact daily or at least regularly in a fishery regardless of their management systems. It is possible that they decide their contribution based on the relationship they have in a daily life rather than on what the other participants did in this experiment. This is captured in β_0 and its variation across individuals as u_{ij}^2.

The two parameters for cooperation are created: conditional cooperation and unconditional cooperation (Carpenter & Williams, 2010; Carpenter & Seki, 2011). The conditional cooperation parameter takes a value of u_{ij}^3 and measures how cooperative a person is in response to observed cooperativeness of the other members. A greater value of this parameter indicates that a person is willing to cooperate more after knowing the others' cooperation than an average subject in the sample. The unconditional cooperation parameter takes a value of u_{ij}^2 and measures general cooperativeness of a person after taking into account conditional cooperation. The greater the value of this parameter, the more cooperative a person is independently from what the others are doing. Table 4 shows summary statistics of the two parameters that are normally distributed by assumption.

Information network indices

Participants completed a survey for demographics and answered questions on information network among fishermen such as the number of other fishermen they exchange information with. The indices for information network are constructed from these survey responses.

Based on the work by Holland et al. (2010) and Holland et al. (2013), we construct the measures of information network a skipper has in the shellfish fishery (Table 5). The size of information network is constructed by the survey response to the question asking the number of shellfish fishermen with whom to have shared important information that potentially affected own profits from shellfish fishing during the fishing season in 2012. An average skipper in these fishery groups shared such information with ten skippers. Normalizing the size by the possible number of relationships (the size of a fishery group) yields density of information network. An average density was about 30 percent, ranging from 0 to 100 percent. This indicates, for example, in the case of the fishery group comprised of ten fishermen an average fisherman would have shared important information with three other fishermen.

After listing five names of fishermen with whom a person has most important relationships, participants were asked what kinds of information they shared with each of the relationships. Based on the information provided by FCA staff, six kinds of information were identified as relevant to the surf clam fishery: market, buyer information, specific hot-spots, market for bycatch and its hot-spots, high gear density areas, and boat and gear. Taking the average of the number of kinds of information a person shared with the listed relationships produces an index for varieties of information exchanged. An average fisher shared about two types of information. Among the six kinds the information on specific hot-spots was shared most, followed by market information (Figure 2). Information on boat and gear is also important in these fisheries as reflected by the rule of many FCAs that more than one skipper are required to fish in one boat. These fishermen regard other fishermen as being close friends (49%) and having common in boat and gear (33%).

Frequency of sharing the six types of information listed above during a 2012 season was asked for each relationship in a scale of one to seven: 1 as frequent as everyday, 2 as every few days, 3 as once per week, 4 as once every two weeks, 5 as once per month, 6 as every two months, 7 as once during the season. An average skipper shared the important information with other skippers at least once a week during the season. To avoid confusion, the reverse coded index will be used for main estimation for frequency.

Empirical estimation

We are interested in estimating the effect of revenue sharing on each parameter/index for social capital defined above. Estimation will provide empirical evidence of how management systems affect social aspect of a fishing community. It will also clarify what aspect of a fishing community management system can and cannot influence.

Each parameter of social capital is taken as a dependent variable in a separate OLS regression. In all regression models, standard errors are estimated with cluster robust variance estimator and then are bootstrapped with the wild cluster bootstrap (Cameron, Gelbach, & Miller, 2008). The variable of interest is a binary variable taking 1 if a fisher is under revenue sharing and 0 otherwise. Other variables for controls in the model include demographic information of fishers: log of age, the number of persons in the household, education levels, and log of the number of years in shellfish fishing.

One may argue that the OLS estimates suffer from selection bias. While revenue sharing can affect social capital parameters, social capital could influence the decision for a fisher to select into a revenue sharing group. Carpenter and Seki (2011) discussed that the selection bias for revenue sharing as an individual decision is not a significant problem in Japanese fisheries because each fisher did not self-select into the system. While individual decisions to adopt revenue sharing may not possess selection bias observed in selecting into job training, adoption of revenue sharing arrangement is possibly nonrandom. Preferences, value, and experience of individual fishers have been likely to affect the group decision to adopt revenue sharing. Suenaga (2008) emphasized the importance of involving fishers in the decision making process in Sandfish fishery in Japan. All the fishers surveyed in the Japanese surf clam fishery who gave valid response (64% of the respondents) suggested some involvement in the process for a change in operational rules in the fishery.

One may also argue that the OLS estimates are biased due to endogeneity. There may exist another mechanism that can influence the decision to employ revenue sharing while correlated with unobservables captured in the error term. One possible scenario is a catastrophic event in a shellfish fishery such as depletion of the resource due to overfishing, disease, weather, or all combined. Careful examination of background information suggests that this is not the case. First, we asked in the survey whether they have seen the shellfish resources depleted or drastically decreased. After dropping 13 individuals who have been in the fishery for less than 10 years, we found 71 percent of revenue sharing fishers answered "yes" to the question while 72 percent of non-revenue sharing fishers did, which is not a statistically significant difference (Mann-Whitney-Wilcoxon test, p value = 0.63). We also examined a numerical measure of resource stock density over the last 20 years or so (Figure 3). The mean density of revenue sharing groups was 0.59 kilograms per squared meter of fishing grounds and the mean density of non-revenue sharing groups was 0.54. We found these distributions between the two groups not statistically significantly different (Mann-Whitney-Wilcoxon test, p value = 0.61). This can be also supported by the fact that all the fishery groups, regardless of management systems, have been self-imposing a TAC for the last 20 years at least.

Causal inference of the estimates crucially depends on how well unobserved heterogeneity is controlled because occurrence of revenue sharing arrangement is possibly nonrandom. The sampled fishery groups have been controlled on some important observables at the time of sampling; some relevant characteristics of individual fishers will be controlled in a regression. Unobservables consist of a part that is correlated with observables and a part that is uncorrelated. The estimates are valid to the degree of how closely related the observables are to the unobservables and thus how well these observables capture unobserved heterogeneity.

Concerns for standard errors still remain. The small sample problem of ten fishery groups can understate the standard deviation of the OLS estimators. The literature has been casting doubts on inference based on cluster-robust standard errors when they are applied to the data containing a few clusters and the invariant variables of interest within a cluster (Angrist & Lavy, 2009; Bertrand, Duflo, & Mullainathan, 2004; Donald & Lang, 2007). Asymptotic justification of cluster-robust standard errors relies on the assumption that the number of clusters goes to infinity. Clearly, the data with ten clusters (groups) do not meet this assumption.

Although several solutions have been proposed, the wild cluster bootstrap analyzed in Cameron et al. (2008) is the most appropriate in this study. The wild cluster bootstrap is different from the standard bootstrap method with cluster option commonly implemented by statistical software such as Stata or SAS. The wild cluster bootstrap can overcome the problems with having a few clusters and invariant variables within a cluster by forming pseudo-samples based on the residuals and using "asymptotically pivotal" statistic. A statistic is said to be asymptotically pivotal if its asymptotic distribution does not depend on any unknown parameters. With a few clusters this feature is crucial. While the standard bootstrap directly evaluates the distribution of the OLS estimates, the wild cluster bootstrap forms the Wald statistics for every pseudo-sample and evaluates the distribution of these Wald statistics, which is asymptotically pivotal.

The wild cluster bootstrap also solves the issue with invariant variables within a cluster, which can be an issue with the standard bootstrap with cluster option. In forming pseudo-samples the wild cluster bootstrap does this based on residuals not on pairs of a dependent variable and explanatory variables, which have a good chance of replicating the same pseudo-samples if explanatory variables do not vary within a cluster.

Cameron et al. (2008) recommend to implement the wild cluster bootstrap with the null hypothesis imposed. Instead of using two-point distribution originally applied by Cameron et al. (2008), Webb (2014) proposes to use six-point distribution, which is recommended especially for the data with a very few clusters, say less than 10 clusters. This can greatly increase the number of possible values of the estimated Wald statistics from pseudo-samples.

Another method, bias-reduced linearization (BRL) originally proposed by Bell and McCaffrey (2002) and applied by Angrist and Lavy (2009), can also achieve asymptotic refinement. However, it is not suitable with the data in this study as underlying heteroskedasticity is likely to be severe due to unbalanced clusters. Monte Carlo simulations in Cameron et al. (2008) show that when there is heteroskadsticity, BRL no longer improves inference whereas the wild cluster bootstrap still does.

Results

Overall we find that the implementation of revenue sharing affects formation of some aspects of social capital (Table 6). In particular, revenue sharing arrangement has a negative impact on conditional cooperation while it has a positive impact on information sharing among fishers.

First, we hypothesized that revenue sharing arrangement enhances cooperative relationship among fishers; the relationship fishers face in daily fishing operation, which can significantly depend on whether fishers are under revenue sharing arrangement, may force the fishers to be unconditionally and conditionally cooperate with each other. Interestingly, the results show that revenue sharing arrangement does not influence unconditional cooperation among fishers but does influence conditional cooperation negatively (Table 6). This implies that revenue sharing fishers are no more likely to cooperate unconditionally although revenue sharing arrangement seems to require greater cooperation among fishers. In addition, the negative sign of conditional cooperation among revenue sharing fishers suggests that the fishers under revenue sharing are not only uncooperative to the group but also they are less likely to cooperate even when they see the others contributing to the group. In addition, the degree of uncooperativeness in conditional cooperation (the conditional average difference in conditional cooperation between revenue sharing fishers and non-revenue sharing fishers) is significant considering the range of the estimated variance of the parameter. However, it should be noted that an overall explanatory power of conditional cooperation was found to be trivial from the earlier examination.

Second, we find evidence of the effect of revenue sharing on information network (Table 6). Although revenue sharing does not necessarily increase or decrease network density and network size, it does increase the varieties of information shared and frequency of sharing such information. The fishers under revenue sharing share on average 0.6 more varieties of information than non-revenue sharing fishers and they share such information much more frequently. The estimated effect of 2.02 in a scale of frequency can be interpreted as an increase in frequency from every two weeks (-4) to every two days (-2). An average fisher in the sample shares two kinds of information about a fishery with information on specific hot-spots being most likely and the market information the second most likely. In addition to these two kinds of information an average revenue sharing fisher is more likely to share the information on boat and gear while non-revenue sharing fisher on average shares two kinds out of these varieties. This may reflect the fact that revenue sharing fishers operate fishing together as a group, which can require more detailed information about what other group members are doing being shared amongst them. The collective daily fishing operation, contribution to which can be aligned with self-interest under revenue sharing arrangement, can motivate fishers to communicate more frequently with each other and to share more information. Interestingly, revenue sharing arrangement does not seem to affect the absolute size of information network or the normalized size of the network.

The wild cluster bootstrap yields the same significance level of the estimates as the cluster robust standard error p value. Thus, the inference of significance of the estimates remains the same even after correcting for the small sample. These results are consistent with the results obtained by BRL, which was discussed as another method to address with small sample inference.

Discussion

Economic institutions can influence what social relationships people in a community have beyond their realm of economic outcomes. In this paper we examine how different management systems in a fishery result in different levels of social capital in a community, focusing on revenue sharing arrangement and an individual fishing quota. The results suggest that revenue sharing arrangement leads to less conditional cooperation among fishers while no impact is found in unconditional cooperation. Revenue sharing arrangement, accompanied by collective fishing operation, changes how fishers communicate with other fishers; revenue sharing fishers exchange more varieties of fishing information more frequently.

The negative effect on conditional cooperation is somewhat contrary to the literature on the VCM (Carpenter, Bowles, Gintis, & Hwang, 2009), which suggested that strong reciprocity was a key in team production. The result in this study implies that a key in team production is not necessarily conditional cooperation or reciprocity at least in a context of revenue sharing arrangement in a fishery. The fishers under revenue sharing, who face the same incentive structure as the VCM, are not necessarily conditional cooperators but rather free-riders. Yet, these fishery groups have been successfully maintaining the revenue sharing arrangement for decades. This can suggest two things. First, the other factor may have been contributing to the maintenance of revenue sharing arrangement in these fishery groups. One possible factor is their operational rules that the fishery groups under revenue sharing arrangement self-impose. Every fishery group under revenue sharing arrangement operates together to ensure equal contribution of labor in days and hours among the member fishers. Contrary to anonymity in the VCM, contribution in fishing operation can be easily monitored in terms of landings at the port. Although the fishers have incentives to free-ride, they may still like to compete in fishing, which can counteract free-riding inclinations exhibited in the VCM. Gaspart and Seki (2003) emphasized fishers' nature for competition as an important driver to maintain the revenue sharing arrangement. Anecdotal evidence also exists to support this claim; we heard from a leader fisherman that his fellow fishers still compete for landings even though they have been under revenue sharing for decades. Second, another possibility is that the estimated coefficient of revenue sharing arrangement may be suffering from endogeneity. If these revenue sharing fishery groups had been particularly struggling with free-riding in collective efforts such as the efforts for the stock enhancement, the groups could have been in a way forced to employ revenue sharing to motivate these collective efforts. If this is the case, the estimate from the model is biased and is not a true effect of revenue sharing on conditional cooperation.

The effect of revenue sharing on information network can be attributable to collective fishing operation as well as revenue sharing arrangement. In daily fishing operation revenue sharing fishers fish together as a group and coordinate their fishing efforts and their stock enhancing activities. This way of operation in fishing requires revenue sharing fishers to communicate more information more frequently because information can help fishers to successfully cooperate in fishing, on which revenue can greatly hinge and fishers are financially bound together by revenue sharing arrangement.

Insignificant estimated coefficients of the size of information network and the density of the network suggest that revenue sharing fishers do not necessarily share information with more people compared with non-revenue sharing fishers although they exchange more varieties of information more frequently. Revenue sharing arrangement can provide disincentive to hold back on sharing sensitive fishing information. For example, sharing information on specific hot-spots can decrease the return from fishing effort at the presence of congestion externality, and thus harvesters may prefer to keep it private. However, it is in their interest for revenue sharing fishers to share such information to allocate their collective fishing effort most efficiently.

This may also suggest that revenue sharing fishers have different structure of communication that do not necessarily change the size of the network. For example, hierarchical structure or centralized structure is more efficient in conveying information from one edge of a person to the other edge; the length of pass and/or diameter of the network can be different when the number of relationships an individual have is different. Investigation of difference in network structure between different management systems is left for future research.

Formal economic institutions are important; not only they determine economic performance of those who are under them but also they affect social aspects of communities, trust, cooperation, other-regarding preferences, norms, and networks. This paper provides empirical evidence for this claim. Social impact of economic institutions can be particularly important in common-pool resource management because resource users in a community are often forced to rely on informal contracting and good governance can greatly depend on social capital (Bowles & Gintis, 2002). For stakeholders and policy makers in common-pool resource management these results can help to understand the effect of management systems currently in place and possibly help to design a policy that incorporates the social effects of management systems.

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Table 1. Summary Statistics of Participants

	N	Mean	Std. Dev.	Min	Max
1 if Revenue sharing, 0 otherwise	79	0.58	0.50	0	1
Age	78	53.24	10.21	26	79
Education (1: Junior high school - 6: Graduate degree)	78	1.73	0.60	1	4
Household size (persons)	77	2.77	1.72	0	6
Shellfish fishing experience (years)	73	23.93	13.87	1	55

Note: Not all participants who participated in the experiment completed all the questions in the survey.

Table 2. Participants and FCA Size

FCA	Participants	FCA Members	Percent (%)
Shiraoi	9	75	12
Akkeshi	11	73	15
Kushiro	1	6	17
Bekkai	8	47	17
Hamanaka	16	90	18
Wanchu	7	32	22
Ochiishi	8	24	33
Tobu	3	5	60
Hiroo	9	10	90
Konbumori	6	6	100

Table 3. Estimating Cooperation Parameters

Dependent variable: Amount contributed by *i* in session *j* at round *t*	
β_0: Constant	1,272.57***
	(0.00)
β_1: Total group contribution excluding oneself in the previous round	0.08**
	(0.01)
Variance of u_j^1 (Random intercept for sessions)	45,915.791
	(0.58)
Variance of u_{ij}^2 (Random intercept for individuals)	996,737.9**
	(0.05)
Variance of u_{ij}^3 (Random slope for individual β_1)	0.007
	(0.63)
Observations	666
Log-likelihood	-4,222.41

Notes: P-value in parentheses. Multilevel Tobit Regression.

Table 4. Summary Statistics of Cooperation Parameters

	N	Mean	Std. Dev.	Min	Max
Conditional cooperation	78	0.00	0.02	-0.05	0.08
Unconditional cooperation	78	0	844	-1,500	2,495

Note: Eighty subjects participated, two of whom were dropped from the analysis.

Table 5. Summary Statistics of Information Network Indices

	N	Mean	Std. Dev.	Min	Max
Network size (persons)	78	10.58	15.03	0	90
Network density (%)	78	31.08	34.50	0	100
Varieties of info (1-6 types)	60	2.05	1.27	1	5
Frequency (1: Everyday - 7: Once in season)	63	2.71	1.93	1	7

Notes: Not all subjects completed all the questions in the survey. The last two rows have a particularly lower response rate because these questions are part of the section that requires personal information.

Table 6. Estimated Effects of Revenue Sharing on Social Capital

	Dependent variable: (1) Un-conditional	(2) Conditional
1 if revenue sharing, 0 otherwise	195.87	-0.01**
	(0.36)	(0.04)
		[0.02]
Control	Yes	Yes
Observations	71	71
F statistics	1.636	9.824***
Root MSE	812.3	0.0234

	Dependent variable: (3) Network density	(4) Network size	(5) Varieties of info shared	(6) Frequency
1 if revenue sharing, 0 otherwise	0.11	203.98	0.60*	2.02***
	(0.36)	(0.19)	(0.07)	(0.00)
			[0.06]	[0.00]
Control	Yes	Yes	Yes	Yes
Observations	71	71	55	57
F statistics	2.162	5.184**	19.43***	6.650***
Root MSE	0.333	747.1	1.276	1.696

*** p<0.01, ** p<0.05, * p<0.1

Notes: Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. BRL yields consistent results.

Figure 1. Setup of the Experiment

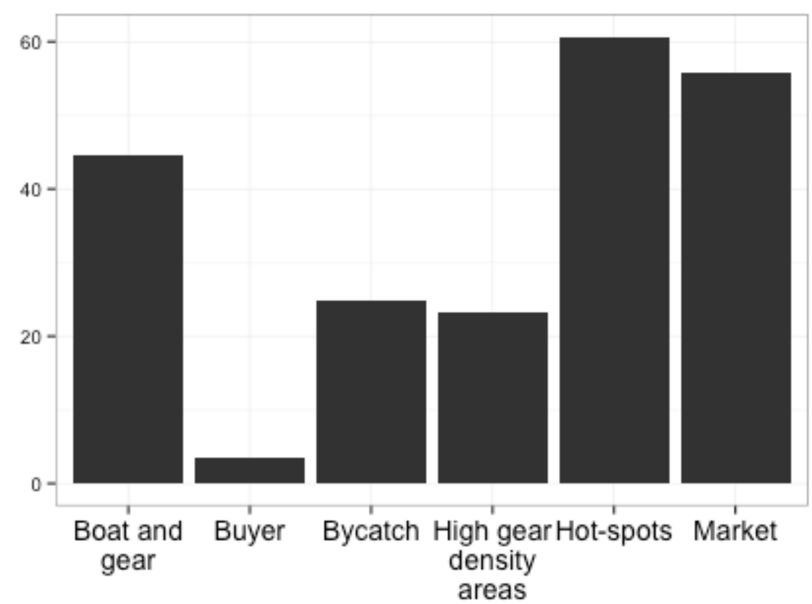

Figure 2. Contents of Information Shared

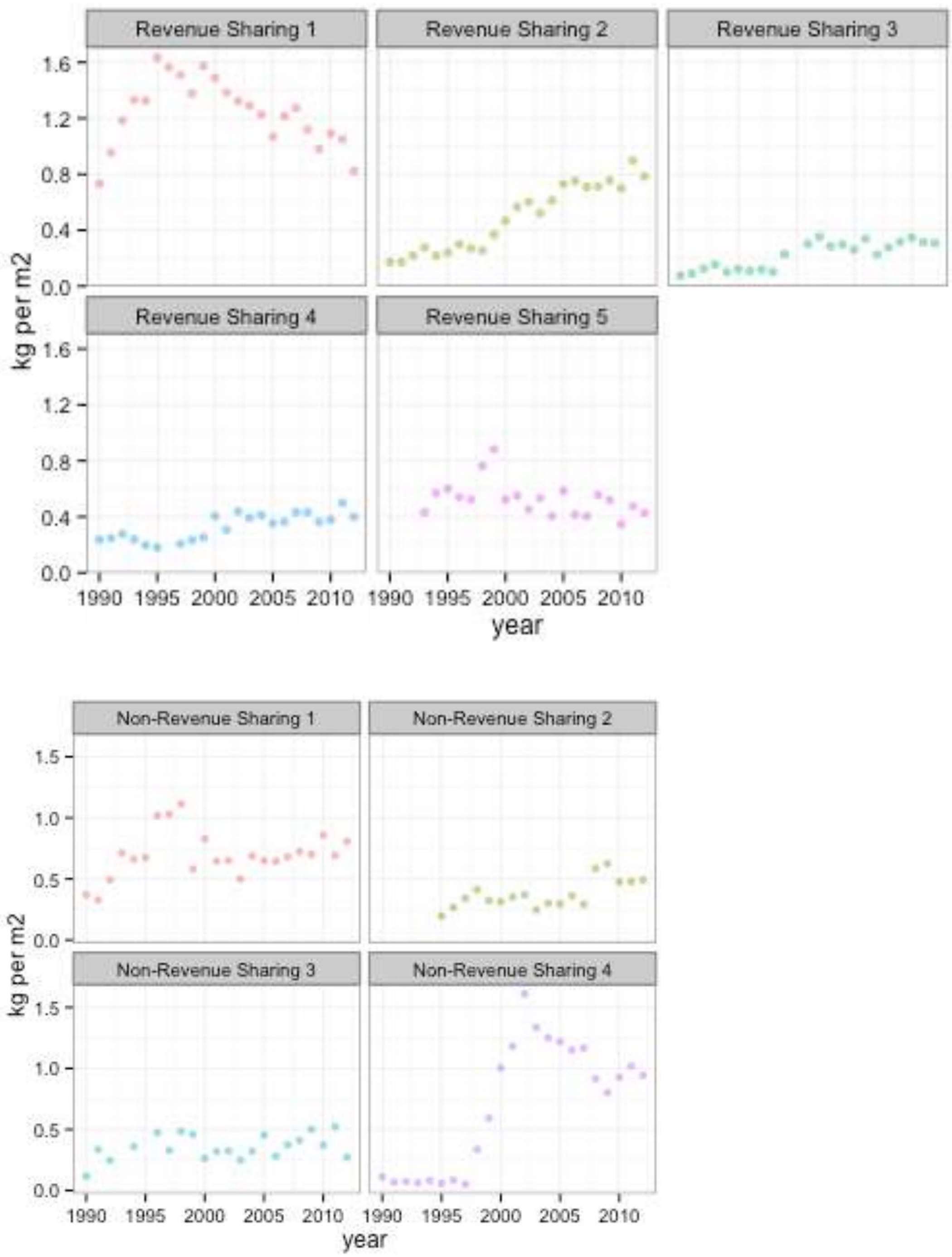

Figure 3. Resource Stock Density over Time