How Can Community-Based Management Improve an Outcome? The Effects of Revenue Sharing and Social Capital in a Fishery

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Abstract

We empirically estimate the effects on management outcomes in common-pool resource management into three: the direct effect of management systems, the direct effect of social capital, and the indirect effect of management systems and social capital interacting each other to influence the outcomes. In particular, we focus on revenue sharing arrangement as a possible management tool in a fishery, in which a group of harvesters shares catch and/or revenue among the members of a fishery cooperative. In addition to each of revenue sharing and social capital influencing a fishery independently we hypothesize the synergy between revenue sharing and social capital. Social capital potentially affects the efficiency that revenue sharing brings while revenue sharing can foster social capital, which eventually leads to better management outcomes. An important intermediary between the two factors and the outcomes is collective efforts performed as a group often in a community-managed fishery. We quantified social capital using controlled economic experiments with fisherman subjects as well as surveys. Using the data collected from ten Japanese fishery groups and wild cluster bootstrap for small sample inference, we find evidence that revenue sharing and social capital interact to affect the fishery in information network. However, we find no robust evidence of the direct effect of revenue sharing improving an outcome in a fishery. The results also show that fishery groups achieving economic success are comprised of fishers with higher general trusting attitudes and fishery groups achieving better stock conditions consists of fishers having similar information network size.

Introduction

The importance of community-based management has been long recognized for successful governance of common pool resources (1). Contrary to Hardin's Tragedy of the Commons, empirical research has found many successfully self-governing communities through extensive case study (2,3). This is no exception in fisheries. Fishery cooperatives, where fishermen collectively manage the fishery, has been garnering much attention from both regulators and academics as a way to complement and/or supplement existing management systems such as rights-based management (4). In fact, Northeast multispecies groundfish fishery in US has implemented a sector management system, in which voluntarily formed sub-groups of harvesters may manage their collective total share of the harvest as a group right. Thus, understanding how and why fishery cooperatives succeed is not only important but also timely in terms of policy relevance.

Revenue sharing arrangement is a type of management rule in a fishery, in which harvesters share catch and divide equally the resulting revenue among the members of a fishery cooperative, regardless of how much each harvester contributed. Employment of such arrangement is a collective action that a group of harvesters takes. The role of revenue sharing in fisheries management has been examined in the literature (5–7), but less studied are the quantitative effect of revenue sharing and its mechanism, through which revenue sharing arrangement attains success. In this paper we hypothesize the interaction between revenue sharing and social capital; revenue sharing augments social capital in a community, and social capital also influences various incentives possibly induced under revenue sharing and the efficiency that such arrangement brings.

This paper provides the first rigorous analysis on measuring the direct effects of revenue sharing and social capital in a community-managed fishery, and identifies the indirect effects resulting from the interaction between revenue sharing and social capital. An important intermediary between the two factors, revenue sharing arrangement and social capital, and the outcomes of a fishery is collective efforts defined as any efforts performed as a group to increase harvesting performance of a fishery. The efforts include stock enhancement, rotation of fishing grounds, collective search for schools of fish, exchange of information, and collective use of fishing boats and/or fishing gear. Revenue sharing arrangement and social capital enhance the effect of the collective efforts, which leads to efficient and sustainable use of resources in the long run. Contribution to the group efforts aligns with self-interest when a group of harvesters shares revenue and harvesters are devoted to collective value due to social capital in a community.

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. Social capital can sustain individual fishers' contribution to the collective efforts. Among many aspects of social capital the focus in this paper is on cooperation, trust, and information network.

Empirical findings identified the important roles of the collective efforts in revenue sharing groups (6,7). The collective efforts are a source of efficiency that can be brought by revenue sharing because they are expected to generate synergies, which is key in a partnership structure such as revenue sharing arrangement (8). By aligning self-interest with a group interest revenue sharing supports an incentive to contribute to the collective efforts, which bring synergies and lead to successful management of a fishery.

Not only do these two factors, revenue sharing and social capital, support an incentive to contribute to the collective efforts separately, but also through the interaction with social capital revenue sharing further enhances the effect of the collective efforts, and through the interaction with revenue sharing social capital strengthens a team for the collective efforts. The collective efforts motivated by revenue sharing and social capital bring synergies in fishing, which reinforces the indirect effect of both of revenue sharing and social capital.

Utilizing both numeric data and perceived scales for measurement of the outcomes this paper achieves comprehensive analysis of management outcomes. Four measurements of the outcomes are ex-vessel price per kilogram (economic outcome), resource stock density measured per squared meter (biological outcome), economic success perceived by fishers, and resource conditions perceived by fishers. The data were collected in Japan. Many Japanese fisheries operating under revenue sharing have been successfully managing the resources as well as generating resource rents (6,7,9). To quantify cooperation controlled economic experiments with fisherman subjects were conducted. As for trust and information network indices are constructed from survey responses of the same fisherman subjects. Using wild cluster bootstrapped p-values for small sample inference, we rigorously quantify the effect of revenue sharing and social capital and explore the mechanism, through which those factors interact with each other and affect the outcomes in a fishery.

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. No member can fish independently; every member must operate as a member of the group.

There are several reasons for choosing Japanese/Sakhalin surf clam (*Pseudocardium sachalinensis*) fishery, known as Hokkigai in Hokkaido Prefecture, for this study. A sufficient number of groups engage in this fishery in the same Hokkaido Prefecture. These groups have adequate variation in with or without revenue sharing while relatively homogeneous in other operational rules including engagement of the collective efforts. Focusing on a particular region and carefully selecting groups based on the preliminary data, but without consulting the outcomes, enables us to control many observed and possibly unobserved characteristics at the time of sampling. Harvesting technology is one factor controlled at the time of sampling.

The Hokkaido government requires their FCAs using the jet dredges to impose a minimum catch size of 7.5 cm and closure of fisheries for certain months during the spawning season. In addition, many FCAs in Hokkaido self-impose voluntary Total Allowable Catch (TAC) restriction, landing volume control, and stock enhancement. Individual skippers are required to cooperate for self-regulation including the collective efforts for stock enhancement.

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 coastal Hokkaido in collaboration with 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 seasonal TAC, 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 the other fishery groups and release them in their waters.

The prices not only depend on supply and demand, but also they can vary with shell colors and sizes. The markets generally give higher prices per kilogram for larger sizes. They also value black shells more than brown shells for their beauty although they are an identical species and should taste the same. Difference in colors results from the characteristics of habitats, muddy or sandy, and a choice of the habitats is partly correlated with age.

This market structure of the clams makes the collective efforts for stock enhancement even more important. Stock enhancement can take a form of directly stocking seeds of clams purchased from other FCAs or transplanting younger clams to be harvested in few years later within the same FCA. The purpose and effect of transplanting can be multifaceted; it can simply save traveling time by transporting all at once from distant fishing grounds to the ones closer to the port; it can increase marginal productivity of a fishery by transplanting from densely populated patches to less populated patches; and it can increase marginal revenue of a fishery by changing a composition of black and brown shells. Different types of ocean grounds, specifically whether sandy gravel or mud, create the two colors of the shells. In some FCAs, in which the fishery is composed of different types of ocean grounds, transplanting the clams from sandy sea floor to muddy one can increase value of the clams by turning their shells black.

Well-managed groups can maintain higher prices per kilogram in the long run by coordinating harvesting strategies in accordance to the transplanting effort. Location choice in harvesting strategies becomes even more important when the collective efforts for stock enhancement are in place. The cost of stock enhancement needs to be incorporated in a fisher's decision making in selecting a specific fishing location in order to maximize social benefits as a group. For instance, harvesting the clams before their shells turn black ruins the transplanting effort. Thus, harvesting in coordination with the transplanting effort in addition to choosing a location with highest marginal revenue is important.

Revenue sharing arrangement and social capital can also affect the resource stock through the collective efforts. Directly stocking seeds of the clams can increase the stock size; transplanting can enhance growth of the clams; removing predators can help more clams to survive and live longer.

Our hypotheses can be rephrased in the specific context of this Japanese surf clam fishery in Hokkaido. The first hypothesis is that revenue sharing arrangement improves ex-vessel prices as well as perceived income and conserves the resource stock better through coordinating the fishing efforts and the collective efforts for the stock enhancement more efficiently. The second hypothesis is that social capital—cooperation, trust, and information network—improves the same outcomes through uniting fishers without any economic incentives. The third hypothesis is that the interactions between revenue sharing and social capital lead to better outcomes. The hypothesis can be divided into three sub-hypotheses for each social capital element to be examined. The first sub-hypothesis is that revenue sharing fosters cooperation among fishers and the cooperation augmented by revenue sharing further reinforces coordination in a fishery and results in improvements in the outcomes. The second sub-hypothesis is that general trusting attitudes in a community lead to revenue sharing, which further assures coordination in fishing and better outcomes. The third sub-hypothesis is that revenue sharing develops information sharing networks among fishers, which affects efficiency of coordination in a fishery and improves the outcomes. The differences in the causal directions in the three sub-hypotheses will become more plausible when exact definitions of each parameter are introduced below.

Methods

We collected this unique dataset containing group information from the ten fishery groups in a panel format from 1990 to 2012 and individual information on 79 skippers belonging to the ten groups in a cross-sectional format. In what follows we describe construction of four outcome variables—two at a group level and two at an individual level—followed by social capital parameters.

We approximate the group economic outcome in a fishery with yearly average ex-vessel prices per kilogram with shell-on. Thus, fishermen's profit maximization is approximated as revenue maximization by catching higher valued clams. Catch volume is not a good indicator of management in this fishery because all the groups self-impose a TAC in consideration for their resource conditions. The other important aspect of fishery management is the biological outcome in a fishery, which is approximated with resource stock density measured as volume in grams per squared meters of fishing grounds.

In addition to these numerical measures for the group outcomes, fishers' subjective perceptions towards management outcomes will be used to further understand the effects of management systems. These individual outcome variables are constructed from the survey responses; one question deals with an environmental outcome of fishery management while the other question addresses economic performance of fishery management. Specifically these questions are "Resource management in your FCA is successful in increasing and/or maintaining shellfish resources" and "Fishery management in your FCA is successful in increasing and/or maintaining profits from shellfish fishing" respectively. The fishermen responded on a five-point Likert scale from 1: strongly disagree to 5: strongly agree.

The social capital parameters are cross-sectional data measured in either 2013 or 2014, and are aggregated to the group level and assumed to be constant over time when they are regressed on the ex-vessel prices and resource stock density in a panel format, which were collected at a group level along with other fishing operation data. The prices and stock information are time-series cross-sectional data from 1990 to 2012 with some random missing observations in early years, except for two observations of one group that voluntarily closed the fishery for two years because of concern for the resource.

Two of the five revenue sharing groups switched from non-revenue sharing to revenue sharing during the period of the panel analysis. All other groups have been under the same management systems. In addition, all the groups have been performing other relevant fishing practices such as stock assessment, a TAC, and transplanting/stocking for the entire period.

Social capital parameters To measure cooperation among fishermen the standard, repeated Voluntary Contribution Mechanism was conducted (10). Fisherman participants were recruited through the FCAs, and a total of 79 subjects, ranging from 15 to 100 percent of all members, participated. The sessions took place at a conference room at the FCA or at the community center nearby.

We estimated the parameters using Generalized Latent Variable Model (11). 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.

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

where $\beta_{\mathbf{0}}$ 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 $E(y_{ijt}^*|\boldsymbol{u}) = \Gamma^{-1}(\beta_0 + \beta_1 \boldsymbol{X}_{-ij(t-1)} + u_j^1 + u_{ij}^2 + u_{ij}^3 \boldsymbol{X}_{-ij(t-1)})$. (Eq. 2)

The two parameters for cooperation are created: conditional cooperation and unconditional cooperation (9,12). 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. 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 indices for trust and information network are constructed from the survey responses. They are then aggregated into group variables as mean and standard deviation of group members, which are used in main regression to measure their effects on the outcomes. We constructed the measures of information network a skipper has in the shellfish fishery (13). The size of information network is the number of shellfish fishermen with whom to share important information that potentially affected own profits from shellfish fishing during the fishing season in 2012. Normalizing the size by the possible number of relationships (the size of a fishery group) yields density of information network. After listing five names of fishermen with whom a person has most important relationships subjects were asked what kinds of information he shared with each of the relationships. Based on the information provided by FCA staffs 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. Frequency of sharing the six types of information 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. To avoid confusion, the reverse coded index will be used for main estimation for frequency.

Trusting attitudes of skippers were measured from the two questions from General Social Survey (GSS) (14). Subjects responded on a five-point scale from 1: strongly disagree to 5: strongly agree. To avoid confusion, the reverse coded index will be used for main estimation.

Random-effects model with clustered standard errors is used for estimation.

$$y_{it} = \boldsymbol{X}_{it}'\beta + \boldsymbol{Z}_{it}'\gamma + \alpha + u_i + \epsilon_{it}, \qquad \text{(Eq. 3)}$$

where *i* indexes groups and *t* years. Each group *i* contains T_i observations, which sum to *N*. y_{it} is an outcome of interest, either the prices per kilogram or the resource stock density in grams. ***X*** contains the variables of interest, a rarely changing revenue sharing indicator and time-invariant social capital parameters. The two variables of interest can be put together in the same model if the assumption that there is no causal relationship between the two is appropriate. Nonetheless the two will be put together in one model to examine the indirect effects of the two (15). ***Z*** contains control variables that are different for each outcome. u_i is the random, time-invariant heterogeneity specific to the *i*th group and α is the mean of u_i. When the outcome variable is one of the perceptions from the survey responses, the data become cross-sectional with no subscript *t*. For this estimation we use the OLS estimator with clustered standard errors, as there is no benefit of using the GLS. One drawback of relying on the random-effects model instead of the fixed-effects model is that the model imposes a stronger assumption on the data at hand.

One could argue that the estimates suffer from endogeneity. While revenue sharing and social capital parameters can affect the prices and the stock, higher prices and stock abundance could influence the decision to adopt revenue sharing and its stability, and the levels of cooperation, trust, and information network. There may also exist a mechanism that can affect the outcomes while being correlated with decisions to implement revenue sharing as well as the levels of social capital. One possible scenario is a catastrophic event in the shellfish fishery such as depletion of the resource due to overfishing, disease, weather, or all combined. We examined resource stock density over the last 20 years. The mean density of revenue sharing groups was 0.59 kilograms per squared meter of a fishery 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. Thus, a possible catastrophic event like depletion of the resource is less likely to be associated with implementation of revenue sharing arrangement. However, a moderate variation across the groups is found on how many members shares a sense of crisis on their resource conditions. Together with no randomness of occurrence of revenue sharing arrangement, this calls for controlling heterogeneity, observed or unobserved, in the fishery groups that are correlated with implementation of revenue sharing arrangement as well as the levels of social capital.

Causal inference of the estimates crucially depends on how well unobserved heterogeneity is controlled based on the above discussion. The sampled fishery groups have been controlled on some important observables at the time of sampling; some relevant characteristics of the group operation will be controlled in a regression in addition to time-invariant unobserved characteristics by exploiting a panel structure.

Concerns for standard errors still remain. 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 (16,17). 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 is the most appropriate in this study (18); the wild cluster bootstrap can overcome the problems with having a few clusters and invariant variables within a cluster. The wild cluster bootstrap is different from a standard bootstrap method with cluster option commonly implemented by statistical software such as Stata or SAS. The wild cluster bootstrap forms pseudo-samples based on the residuals and uses "asymptotically pivotal" statistic. 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". 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. The wild cluster bootstrap also solves the issue with invariant or rarely changing variables within a cluster. Forming pseudo-samples the wild cluster bootstrap based on pairs of a dependent variable and explanatory variables has a good chance of replicating the same pseudo-samples if explanatory variables do not vary within a cluster. The wild cluster bootstrap can avoid this by sampling based on residuals.

Results

Although the overall direct effect of revenue sharing arrangement on either the economic outcome or the biological outcome is not evident, the indirect effect of revenue sharing affecting the perceived economic outcome through information network seems to exist. This suggests that merely sharing revenue does not necessarily result in a better economic outcome. However, revenue sharing arrangement can augment denser information network, which then affects the economic outcome in fisheries management. In addition, the overall effect of social capital on the outcomes is mixed, and the results highlight important characteristics of a community that is important to success in fisheries management. Tables I and II show selected results.

Estimation of the effects of trusting attitudes suggest that trust is more important to the economic outcome than to the biological outcome. According to the Table I the groups with fishers who are more trusting result in higher prices. A marginal increase in trusting attitudes among fishers raises the surf clam prices by 40 yen. This effect remains significant even with the wild cluster bootstrap (*p*-value = 0.07).

Comparing Columns (5) and (6) in Table I, we did not find existence of the indirect effect of fishers' trusting attitudes on the outcome through encouraging employment of revenue sharing arrangement. Value of the coefficient of trust is unchanged (or slightly increased) after adding revenue sharing in regression. This suggests that the direct effect of trust is the only effect and there is no indirect effect of trust affecting revenue sharing.

The effect of information network is estimated in four aspects: information size, network density, varieties of information shared, and frequency of sharing such information. Among the four, the network size can possibly have some influence on the prices with some ambiguity and the network density is strongly suggested to have a great impact on the resource stock. Greater standard deviation of the network density decreases the resource stock. This suggests that cohesion of a group as having similar network density among the members improves the resource stock density by 136 grams per m^2 at the margin, which remains barely significant with the wild cluster bootstrap (*p*-value = 0.10). Although the absolute level of the network density becomes important when it is explaining the outcome together with its standard deviation, the effect of cohesiveness of the information network is greater than the overall level of information network. Again, the effect of the network density seems to be a sole effect and does not include the indirect effect of revenue sharing interacting with the network density. Whether sharing revenue or not a cohesive network density in a fishery is important in improving the biological outcome.

The results suggest that a higher level of cooperation does not necessarily lead to better perceptions of economic or biological outcomes; neither unconditional nor conditional cooperation shows explanatory power for any outcomes (Table II). While trust seems to matter in the economic outcome, it doesn't influence the biological outcome. Fishers with higher trusting attitudes are more likely to feel that their income has been increasing or at least remaining at a certain level. However, this estimated effect is no longer significant after being corrected for small sample inference (*p*-value = 0.11).

Among the four aspects of information network, the varieties of information shared and frequency of sharing such information seem to influence the management outcomes. First, more varieties of information shared among fishers lead to a better economic outcome, and this effect seems to be interacted with revenue sharing (Columns 5 and 6, Table II). The magnitude of the effect of varieties of information shared decreases but with gain in significance for the effect of revenue sharing while the explanatory power of the model increases. This suggests that fishers are more likely to consider their profits as increasing or at least remaining at a certain level not only when they share more varieties of information—direct effect of information sharing—but also when they pool revenue and exchange more information—indirect effect of revenue sharing through information sharing. These effects remain significant even with small sample inference (all p value < 0.1). Frequency of sharing information also increases fishers' profits, but there seems to be no indirect effect of revenue sharing.

Discussion

The results of the data analysis provide us insights into how management outcomes in a fishery can be improved. The first lesson is that implementing revenue sharing arrangement does not necessarily generate synergies in harvesting efforts and other collective efforts for the stock enhancement. Theoretically revenue sharing arrangement can improve economic and biological outcomes in a fishery and in particular the Japanese surf clam fisheries in Hokkaido can do so by generating synergies because revenue sharing supports their group incentives. However, the data and the results of the analysis did not support this prediction overall; no direct effect of revenue sharing was found. Especially for the effect on the biological outcome it may be suggested that a self-imposed TAC that has been already in place in all fishery groups for many years suffices to ensure the health of the resource stocks. However, this result does not necessarily suggest that revenue sharing arrangement should never be employed; revenue sharing can achieve economic efficiency through other mechanisms such as cost reduction.

Second, indirect effect of revenue sharing and social capital variables was found in the varieties of information shared. Revenue sharing partly contributes to the effect of the varieties of information; the fishers who share revenue are found to exchange more varieties of information, which jointly contributes to the better perceived economic outcome. The effect of sharing information more frequently dominates the effect of sharing more varieties of information, but the effect of frequency is not associated with employment of revenue sharing in such a way to affect the perceived outcomes. Although it is smaller than the effect of sharing information more frequently, the effect of sharing more types of information can be enhanced by revenue sharing arrangement meaningfully. This can be important policy implication for the fisheries that suffer from inefficiency due to a lack of information sharing among fishers. Revenue sharing arrangement can be an effective policy tool to reinforce the information network in a fishery, which generates synergies in fishing operation and leads to better management outcomes. Implementation of this arrangement may need to assure that free-riding is costly. In the case of the Japanese surf clam fisheries in Hokkaido all the revenue sharing groups have collective fishing operation, which makes it easy to monitor the efforts of other members.

Third, among the various aspects of social capital examined in this study the following two lessons are noteworthy; fostering general trust in a community, not necessarily directed towards fellow fishers, is key in economic success and information sharing among fishers is critical in a fishery in both economic and biological terms. The comprehensive analysis using different measures of management outcomes demonstrates a consistent importance of information sharing while different measures of the outcomes highlight different aspects of information sharing (the network density for the resource stock, the varieties of information and frequency for the perceived outcomes). An interesting aspect of the effect of the network density on the stock is that when some fishers in a group exchange information with more fishers than other fishers in the same group do, it deteriorates the resource conditions. Thus, a group with more cohesion in terms of how dense the information network is across its members can achieve better resource conditions over time. More cohesion in terms of the network density can imply more efficient structures of information networks. This implies that with good organization of information network the fishery groups can spread relevant information evenly across the group, which enables the group to more successfully coordinate harvesting efforts or/and stock enhancement efforts as a group. This feature seems to be more important for the health of the stock than the prices.

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Table I Estimated Effect on Price/Stock

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Real price (yen per kg)							***Stock density*** (grams per m2)					
Revenue sharing	2.8 (0.88)			17.3 (0.20)		14.5 (0.27)		38.6 (0.67)			31.9 (0.72)		43.2 (0.64)
Conditional (mean)		9.3 (0.24)							133.6 (0.24)				
Unconditional (mean)			35.7 (0.00) [0.15]	36.5 (0.00) [0.14]						-335.6 (0.00) [0.11]	-336.0 (0.00) [0.15]		
Trust (mean)					40.1* (0.00) [0.07]	40.8* (0.00) [0.07]							
Network size (mean)							25.8 (0.04) [0.11]						
Network density (stdev)												-135.6* (0.04) [0.10]	-142.1* (0.04) [0.09]
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	225	225	225	225	225	225	225	192	192	192	192	192	192
# of groups	10	10	10	10	10	10	10	9	9	9	9	9	9
Wald chi2	14333	14529	2597	3035	6201	6411	15856	509425	82098	695139	683981	510392	528358

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

Notes: GLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. All social capital parameters are standardized. Control variables in the models for the prices include log of the number of months during a fishing season, the landings in kilograms in the other surf clam fisheries in Hokkaido, log of time trend, and a binary variable if the fishery has not switched to jet dredges. Control variables in the model for the resource stock are log of time trend and a binary variable for one fishery group to indicate the years before the area of the fishery changed due to port construction.

Table II Estimated Effect on Perceived Outcomes

Dependent	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Variable:	Perceptions towards ***economic*** outcome								Perceptions towards ***biological*** outcome					
Rev. Sharing	0.18					0.45**		0.23	-0.02					
	(0.39)					(0.04)		(0.26)	(0.94)					
						[0.04]								
Unconditional		0.24								0.05				
		(0.12)								(0.60)				
Conditional			-0.15								-0.13			
			(0.15)								(0.33)			
Trust				0.17*								-0.07		
				(0.09)								(0.65)		
				[0.11]										
Varieties of					0.26**	0.22*							0.32*	
info shared					(0.03)	(0.05)							(0.07)	
					[0.04]	[0.06]							[0.13]	
Frequency							0.38**	0.33**						0.19
							(0.01)	(0.03)						(0.13)
							[0.01]	[0.03]						
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	77	71	71	70	54	54	58	58	77	71	71	70	54	58
F	0.979	2.715	2.219	3.700	3.175	4.886	5.380	5.205	0.730	0.608	2.122	0.468	6.779	1.485
Root MSE	0.857	0.846	0.862	0.842	0.872	0.851	0.810	0.811	0.868	0.892	0.884	0.877	0.881	0.915

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

Notes: OLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. All social capital parameters are standardized. Control variables, all in logarithm, are the number of years in shellfish fishing and the number of months in 2012 season.