# Incentive Structure of Participation in Community Activity

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**Abstract.** In this paper, we disassemble community mutual aid into two components: providing local public goods and everyday associations with neighbors. If the OFT (Out-For-Tat) strategy is taken, and the benefit of everyday associations with neighbors exceeds the cost, cooperation was demonstrated not only in associations in everyday life but through providing local public goods. To fulfill this condition, it is necessary to lower the participation fees in associations with neighbors, and for all the members to choose the local public goods that receive the benefit. When using ICT (Information Communication Technology) especially, cost cutting for associations with neighbors is expected.

**Keywords:** Incentive structure, Community activity, OFT strategy.

## 1 Introduction

It is said that relationships raise an individual's feeling of happiness. However, relations with the neighborhood have weakened over time, and the community's role as a safety net has also diminished. In this paper, we have clarified, using game theory, the structure of inducements for local residents to join community activities. Using the framework of game theory, we analyzed the conditions for participation in community activities that are possible in the new towns and the surrounding area that have developed during Japan's period of high economic growth.

## 2 Previous Studies

### 2.1 Factors for Happiness

The notion of subjective well-being (SWB) was introduced as an approach from psychology. According to this theory, income and interpersonal relations raise the subjective feeling of happiness. Social capital, an approach from sociology, is the idea of

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increased happiness. It is often said that financial relationships with family, companions, the neighborhood, etc. contribute to happiness. Also, from economics, the significance of social relations is pointed out based on the capability approach. Every theory shows that relationships increase the feeling of happiness.

### 2.2 Game Theory and Social Network Analysis

Previous research shows that association brings about a feeling of happiness. And if the player recognizes that human relations for him/her are being materialized over the long term, this will become a move in an infinitely repeated sequential game. Unlike a one-time game, each player chooses concerted actions from the beginning all the time.

Greif (2006) shows that in the history of trade around the Mediterranean Sea cooperative action occurred when a company began business. This reveals an infinitely repeated game structure of sequential moves in an exclusive network, if a player's traffic is limited within the network, and even if there is a spread spatially. Furthermore, first-time players will care about a subsequent repute and take concerted action.

Aoki (2001) explained concerted action in a rural community in modern Japan using game theory. Homogeneous farming households in Japan have been living for a long time in rural villages. The formation of long-term human relations makes these closed networks. It performs infinitely repeated game in an exclusive network. Using folk theorem, a cooperative relationship is achieved in such a game. However, once somebody betrays deviates, , other villagers stop the association using an Out-For-Tat (OFT) strategy. For many farming households, since a lost association was a matter of life or death, these became societies that supervised, as there were no mutual deviations. Aoki (2001) examined the potential for cooperation under the status of the social dilemma by connecting a joint-work game (social exchange game) and a fellowship game (commons game). Where, since the benefits obtained from joint work were a characteristic of public goods, the member who does not participate in an operation can also enjoy benefits. There exists the joint work which requires the expense, $C_i$ from each member. By participating in these operations, all the members can acquire sufficient results and can get the benefit[1] $B_i$. However, whenever there is a member who does not participate in an operation, the benefit decreases only by $d_i$ .

In this game, although the cost for mutual help including association with neighbors must be paid, $C_s$, if N players participate, they can obtain the benefit, $B_s(n)$. However, to do joint work is a requisite for this game. Therefore, if someone does not perform joint work, other players will lose the benefit annually from the following year, $z = B_S(n) - C_S$.We summarize this in Figure 1.

[1] For example, m persons expense the cost, benefit will be expressed as $B_i - (N-m)d_i$ .

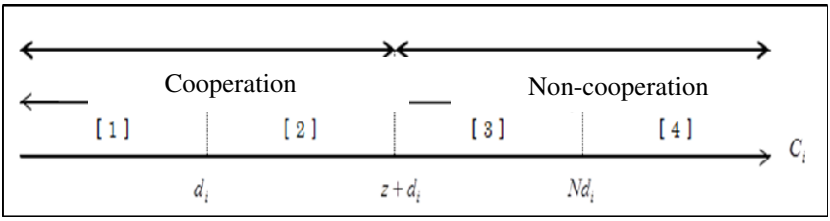


**Fig. 1.** Relationships in the solution for the game

Sphere [1] and [2] show cooperating cases, and sphere [3] and [4] express non-cooperative cases. As the conditions are originally satisfied, in sphere [1] cooperation is carried out. On the other hand, in sphere [2] by connecting games, cooperative behavior occurs. Since the benefit obtained by linking a game is less than the sphere [3] from the cost cutting on which I depend non-cooperative, cooperative behavior does not break out. Since the incentive which I depend non-cooperative exists and a benefit serves as the maximum under the behavior, sphere [4] is a sphere where social dilemma does not exist.

Therefore, even if a social dilemma exists, Aoki has pointed out that there is the potential that cooperative behavior will be performed, when social capital exists. These models assume that society consists of brethren groups, such as trading merchants or farmers only. As a result, social composition members have long-term relationships, and maintain the workplace environment together. Thus, these models are based on a strong relationship of interdependence.

## 3 Model

### 3.1 Features of a Current City Suburb

In current city suburbs, since they are easier to move into than modern rural communities, suddenly an unknown person becomes a neighbor. It is an open network. Since current city suburb inhabitants' vocation and family structure are diversified, community activity consists of the following two types.

**Private Provision of Local Public Goods.** For local residents, broadening sidewalks, and a crime prevention patrol, etc. are common subjects. Two or more persons can improve sidewalks and simultaneously take countermeasures against a suspicious person. However, they cannot completely eliminate [remove] someone who does not pay the cost. Based on these two characteristics, broadening a sidewalk and taking countermeasures against a suspicious person, etc., can be called public goods. In addition, peripheral [other] people can use the sidewalk daily, or can expect crimes to be prevented by the patrol of a specific area. Therefore, broadening sidewalks and countermeasures against a suspicious person can be called local public goods.

There are various kinds of local public goods, and local governments usually provide them. However, when the manpower and financial support of local governments are insufficient, local residents on their own might undertake a crime prevention patrol, etc. as a countermeasure against suspicious people. This case is called the private provision of local public goods.

In this paper, in order to clarify the participating incentive structure to a community activity of a current city suburb, the collaborative activity of an Aoki model is replaced with the private provision of local public goods. But since there is a conflict of interest for local residents about the provision of local public goods, a model is made about this section using the tie-up formation on the basis of a negotiation model.[2]

**Association with Neighbors.** According to Ishida (2011), in the past in Japan, the gender division of labor was not clear, and there was mutual help for nursing, patient care, etc. by the neighborhood. The benefit of the community game in an Aoki model assigns merit to the mutual help of such a community.

In Japan after modernization, with the emergence of an industrial structure, gender division of labor advanced and the number of employees increased. As a result, companies and households started to offer the mutual help function that the community had so far borne. The benefit of association with neighbors assumed by the model of this paper is a residual part of the mutual help which neither the household nor the company can cover. Specifically mentioned are people talking to one another in a neighborhood, confirming their safety following a disaster and taking refuge together, etc. It is assumed that the cost of association with neighbors is dependent on the number of interveners. This is because various types of effort are required in an open network in order to have interpersonal relations.

### 3.2 Model Building

Regional community activities consist of two stages: At the first stage, the members of the community determine by negotiation the type of local public goods that they will provide privately. The model of the game is the sequential style negotiation model of Rubinstein (1981). The second stage is the game where someone communicates with neighbors or does not.

The model consists of two stages: First by an OFT strategy, where only when the participation right to the negotiation of the private provision of local public goods in the first stage is acquired. Also examined is the case where there is participation in association with neighbors at the second stage. Later, when an OFT strategy is not being achieved is also analyzed.

**First Stage: Negotiation/Tie-Up for the Private Provision of Local Public Goods.** We assume the inhabitants of a community, N = {1, --, N}.Cooperative relations is

[2] Aoki (2001) also points out the importance of negotiation as another side of economics.

expressed as the tie-up S. The structure of this tie-up is denoted by $\prod = \{S^k\}_{k=1}^m$ . Moreover, Π is a split ups (partition) of N= {1,--.,N} (i.e. $S^k \neq \varnothing,\ S^k \cap S^{k'} \neq \varnothing,$ for k ≠ k', and $\cup_{k=1}^m S^k = \{1,...,N\}$ ). Each inhabitant supplies local public goods privately. z is the social marginal benefit from the player or inhabitants who cooperated in the private provision of local public goods arbitrarily, and sets the cooperation cost to c(z). When Z is made into the total benefit from a private provision of all the inhabitants' local public goods, a certain inhabitant's gain is defined as Z-c(z).

If it is assumed that when all the people that belong to the tie-up S contribute at the same level, the total of the gain of the tie-up S will become like $s[sz - c(z) + Z_{-i}]$. s is the number of member participants of the tie-up S, and $Z_{-i}$ is the total of inhabitants' contribution that is not included in S. Therefore, the participant in a tie-up will solve the following questions:

$$\max_z sz - c(z)$$

This expresses the kind of cooperation organization on the basis of the private provision relationship of local public goods using a tie-up formation model. The sequence of the suggestion and the response is decided exogenously and the negotiation process of a tie-up formation performs the game according to the sequence. When people of the initiative propose a formation of the tie-up S to which self belongs, a game starts. In proposed tie-up S, each person who has participated answers the suggestion according to the sequence decided. If one refuses a suggestion, the person has to propose S', a counterproposal. A tie-up will be formed if a suggestion is accepted by all the people contained in the tie-up S. And when all the people in the tie-up S are away from the game, the inhabitants of the initiative begin a suggestion out of a set of the inhabitants of N/S which remain. Time is denoted by t=1,2,…. Each inhabitant's strategy, tie-up size which may happen at each term if it is a proposer and which contains self for every history. It proposes, and if it is a response person, it is an acting program which may happen and which opts for "acceptance of order" and "veto" for every history.[3]

A stationary subgame perfect equilibrium (SSPE) is a strategy profile $\mathbf{\Gamma} = \{\Gamma_1,...,\Gamma_m\}$ that fulfills the following two conditions: (1) About all inhabitants, $\Gamma_i$ is a stationary strategy. (2) A strategy is an optimum strategy to other inhabitants' strategy in all the histories in which each acted about all inhabitants.

A strategy profile means that it is dependent only on a suggestion while each inhabitant is running, and the already formed tie-up. That is, in a stationary strategy, inhabitants' behavior is dependent only on the factors relevant to gain. In the game of this paper, this corresponds to the already formed tie-up and the left-behind inhabitant player. In other words, a stationary subgame perfect equilibrium is the profile of a

[3] We call what happened in the past history. So, the history of time t is all the list of behavior.

stationary strategy with the history that inhabitants do not exist for whom gain goes up from the strategy determined by one-sided deviation.

**Second Stage: Association with Neighbors.** The second stage is based on the commons game by Aoki (2001), which is a part of community game connecting the social exchange game and the commons game by Aoki (2001). The participant has to pay the cost $C_s$ for association with neighbors, as in the preceding paragraph. The benefit $B_s(n)$ can be obtained if n person has participated in it among the inhabitants of a certain region.

**When the OFT Strategy Is Achieved.** We calculate the solution of the game by backward induction from the second stage to the first stage. First, we reason from the second stage (association with the neighbors). When an OFT strategy is taken, in association with the neighbors, it will be a requisite that the negotiation for private provision of local public goods has been achieved.

If it is a game only for one time and is $B_s(n) > C_s(n)$, it participates in an association with the neighbors, and mutual help is performed. If it is $B_s(n) < C_s(n)$, it will not participate in an association with the neighbors' game.[4] But since the social interaction in the region is not a one-time limitation, it usually considers repeating a game.

A benefit at each time and the slippage of the cost serve as $B_s(n) - C_s(n)$ . Total benefit which will be obtained by participating in association with the neighbors if the discount rate to the future is set to $\delta_S$ is below. It is set to (1).

$$B_{SC} = \frac{\delta_S}{1-\delta_S}(B_S(n) - C_S(n)) \tag{1}$$

Because the benefit that eq.(1) expresses is considered to also be the benefit obtained only by doing the private provision of local public goods, this can be interpreted as social capital which associates neighbors with each other. So,

$$B_s(n) > C_s(n) \quad \text{or} \quad B_{SC} > 0 \tag{2}$$

As long as it is (2), participate in association with the neighbors at the second stage. Eq.(2) is the participating incentive compatibility condition (IC 1) for association with neighbors.

We consider that, at the first stage, the cooperative relationship to the private provision of local public goods includes the results of the second stage. Each inhabitant's utility function serves as the shape where the gain of the first stage and the second stage was united, and is the following:

[4] We call what happened in the past history. So, the history of time t is all the list of behavior.

$$u = \begin{cases} sz - c(z) + Z_{-i} + B_{SC} & i \in S \\ Z - c(z') & i \notin S \end{cases} \tag{3}$$

***Proposition 1***

1. If $Z - c(z') > sz - c(z) + Z_{-i} + B_{SC}$, the tie-up structure will serve as Singleton.
2. If $Z - c(z') < sz - c(z) + Z_{-i} + B_{SC}$, the tie-up structure will serve as a totality tie-up.

<*Proof*> Here, we use the theorem written by Bloch (1996). "When a player is symmetrical, as for the regular subgame perfect equilibrium of a tie-up formation game, the player 1 chooses whole-number $k_1$ from interval [1,n]. Then player $k_1 + 1$ chooses whole-number k from interval $[k_1 + 1, n]$. The game agrees with the part game perfection balance in the limited procedure game that continues until a style line of the integer $(k_1, k_2, ..., k_n)$ satisfies $\sum k_j = n$.

If $Z - c(z') > sz - c(z) + Z_{-i} + B_{SC}$ is always formed, they are all the suggestions, everyone does not propose several tie-ups, but one proposes the cooperation with only oneself, and it is achieved. For the opposite case, the first proposer proposes totality tie-up, and it is achieved. ■

If the inhabitants who do not cooperate in a tie-up assume that private provision of local public goods is not carried out at all, the conditional expression in which the totality tie-up is achieved will be set to $Z < sz - c(z) + B_{SC}$. Since Z=sz here, it is set to $c(z) < B_{SC}$ and the measurement of the private provision cost of the gain of the second stage of association with neighbors and the local public goods of the first stage serve as a key to whether it is able to produce a cooperation system. But since the cost of association with the neighbors is dependent on the number of people participating in the game, the following corollary is drawn.

***Corollary***

When the number of players who participate with neighbors becomes N→∞,

1. If $B_s(\infty) > C_s(\infty)$, a tie-up structure is the totality tie-up.
2. If $B_s(\infty) < C_s(\infty)$, a tie-up structure is Singleton.

When the cost of association with the neighbors exceeds the benefit, $B_s(\infty) < C_s(\infty)$, or the cost for cooperating in the private provision of local public goods exceeds the gain of association with the neighbors, $c(z) > B_{SC}$, it is difficult to do private provision of local public goods over the long run.

**When the OFT Strategy Is Not Achieved.** We examine the case that even if someone does not cooperate for the private provision of local public goods they still associate with neighbors. In order to find a long-term relationship (following the preceding paragraph), we examine an infinite time repeated game.

***Theorem.*** If the following conditions are satisfied when the OFT strategy is not taken, someone who does not cooperate in the private provision of local public goods and participates in association with neighbors. However, this strategy is not a dominant strategy.

$$c(z) > c(z') - B_{sc} + C_s(n) \tag{4}$$

***<Proof>*** When the OFT strategy is not taken, the first stage and the second stage become independent. Therefore, the utility function of each inhabitant of eq.(3) becomes only a benefit of the first stage.

$$\mathrm{u} = \begin{cases} \mathrm{sz} - \mathrm{c(z)} + Z_{-i} & i \in S \\ sz - c(z') & i \notin S \end{cases} \tag{3'}$$

Proposition 2 is obtained like proposition 1.

***Proposition 2***

1. If $Z - c(z') > \mathrm{sz} - \mathrm{c(z)} + Z_{-i}$, a tie-up structure will be Singleton.
2. If $Z - c(z') < \mathrm{sz} - \mathrm{c(z)} + Z_{-i}$, a tie-up structure will be totality tie-up.

***<Proof>*** which can be proved like proposition 1 ■

The condition is that it is non-cooperative in both of the games to become a dominant strategy when an OFT strategy is not taken is $c(z) > c(z') + \delta_s B_s(n) - C_s(n)$. However, if the participating incentive compatibility condition (IC 1) to association with neighbors of eq.(2) is satisfied, an association with the neighbors nonparticipation will be the dominant strategy, irrespective of a strategy selection for the private provision of local public goods.

## 4 Considerations

When thinking of present-day Japanese society, a community consists in many cases of households that have only an aged single person or an aged couple, especially in the new town of a big city suburb. Because an increase in the aged population will continue and the inhabitants from the former will die in time, the number of private providers of local public goods, like crime prevention patrols and so on, will decrease. If new inhabitants do not come from other places and they try to carry out a crime prevention patrol like before, one's cost of private provision of local public goods, c(z), will increase. Moreover, if it becomes troublesome at an advanced age to go out, going to talk with a person will also become laborious. In this way, cost of association

with the neighbors, $C_s(n)$, cannot but go up. Then, the case that the cost of association with the neighbors exceeds the benefit of association with the neighbors or the case where the cost of private provision of local public goods exceeds the benefit of association with the neighbors will occur. As a result, the continuation of a community activity can become impossible from the propositions and corollary.

Of course, a working population also resides in the region. Considering deleting the time of an occupation or holidays and going out for a crime prevention patrol for the aged (the cost of private provision of local public goods), and the aged's talk (the cost of association with neighbors), $C_s(n)$), they may sometimes feel more satisfaction is obtained from an occupation, housewifery, and leisure than the sense of security that there is a companion nearby. Today, since NPOs or volunteers carry out crime prevention patrols in the region, they take over the cost of private provision of local public goods (c (z')). In this way, if the OFT strategy is achieved, the strategy of cooperation will realize only the private provision of local public goods. Otherwise, the strategy of participating in no community activities is realized. In fact, there are many cases where people only associate with neighbors and are exempt from cooperation in the private provision of local public goods for reasons of being aged or by paying a fee. These are considered to be the cases where the OFT strategy is not achieved.

For the private provision of local public goods at the first stage, the problem is the selection of the kind of private provision of local public goods. In many cases, long-time inhabitants and subjects who have already performed the community activity act as the proposers of the initiative. If the OFT strategy is achieved, from proposition 1 and the corollary (when new inhabitants cooperate in private provision of local public goods), only the old inhabitants form a tie-up and a situation without friendships developing with new inhabitants may also occur in a new residential area.

## 5 Conclusion and Remarks

Two procedures can be considered as solutions to the question raised as the subject in the preceding sections. One is decreasing the cost of the private provision of local public goods or association with neighbors. Another is that the new and the old inhabitants will cooperate to equally enjoy the benefit of community activity.

First, we concretely consider the ways for decreasing the cost of private provision of local public goods or association with neighbors. If you meet and talk with your neighbors, your time with an occupation, or housewifery and leisure will decrease. However, there's some possibility to reduce the troublesomeness of association with neighbors. That is, by using ICT such as a virtual common space composing of virtual plants as users' avatars, a person's movements may be visualized as a plant on a screen, and another person may send a certain signal at his/her slit time.

Similarly, appeals for participation in a crime prevention patrol, etc. by an electronic bulletin board or a discussion in an electronic conference room might also decrease the cost of private provision of local public goods. But, according to the social trial run that Hampton (2007) studied in the Boston suburbs, a big slippage was seen by the occupancy rate of an electronic conference room or an electronic bulletin board

by individual ICT skill and life stage. Kimura (2012) has indicated that a survey in Japan like Hampton's has not been conducted yet but such a measure is required.

Another is that new inhabitants and old inhabitants will enable participation to equally enjoy the benefit of a community activity. What is necessary is, theoretically, just to suppose that a sequential move game with an entry and recession is repeated, in order to raise the benefit of private provision of local public goods. In fact, there is a way to do that. For instance, by using an electronic conference room, everyone could easily make suggestions or confirm participation in activities. Considering regions where the OFT strategy has not already been achieved, this is one of the ways to reduce inhabitants' opportunity cost by collecting the cost of private provision of local public goods in money, and to outsource this to NPOs and so on.

We will do a future trial run to solve these two questions in a specific community by utilizing ICT. The purpose of the trial run will be to see whether or not this contributes to improving the happiness of local residents.

**Appendix.** When the private provision of local public goods and association with the neighbors are restricted only once. Since the benefit to the non-cooperative person of private provision of local public goods is $B_i - (N-n)d_i$ and if it is a game with limitations, un-cooperating is chosen once. Since participation in association with neighbors is refused by an OFT strategy, if one does not cooperate in the private provision of local public goods, the gain from association with neighbors is set at 0.

Suppose all the members other than oneself participate in association with neighbors in cooperation on the private provision of local public goods (n=N-1), the gain for the non-cooperative person of the private provision of local public goods will be $\mathrm{D}(N-1) = B_i - (N-N+1)d_i = B_i - d_i$. The gain of association with the neighbors is set to 0, as mentioned above.

Similarly, the gain for the cooperation of the private provision of local public goods is $C(N-1) = B_i - (N-N+1)d_i - C_i = B_i - d_i - C_i$. In addition, when all other members cooperate in association with neighbors, an association with the neighbors participant's gain is $B_s(N-1) - C_s$.

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