How to Solve the Tragedy of the Commons?
Social Entrepreneurs and Global Public Goods

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Abstract:
We show that when a star type network is formed by an entrepreneur, a non-profit organization run by a social entrepreneur is more reconcilable with the social objective of providing the global public good than a profit organization run by a business entrepreneur. This network formation and efficacy of financing a global public good on a local scale is analyzed in a "selective incentive-cum-global public good" model. Because local networks can play a significant role in preserving the global commons, this finding has important policy implications for global public good provisions such as greenhouse gas abatement and international security.

Key Words:
Global Public Good, Network Formation, Selective Incentive, Non-profit organization, Social Entrepreneur.

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1. Introduction

By taking into consideration the indispensability of network formation and an entrepreneurs' work to form a network in advance of provision stage, we examine the efficacy of financing global public goods such as the global atmosphere, global climate, and bio-diversity by means of an enterprise of "private good-cum-global public good" or by means of a "selective incentive" scheme. In this paper we derive the following main results; (i) that when a star type network[i] must be formed as a precondition for a selective incentive scheme to be carried out, a non-profit organizational form, run by a social entrepreneur, is more reconcilable with the social objective of providing the global public goods than one of for-profit run by a business entrepreneur, and (ii) that the selective incentive schemes proposed by Morgan (2000) and Pecorino (2001), and the voluntary scheme proposed by Ostrom (1990) can accomplish an efficiency only when the cost relative to benefit of network formation is negligible.

A network formed by members of a community is indispensable to any scheme for financing or providing global public goods, firstly because the benefits of those goods are not necessarily recognized by many of the members owing to their uncertain scientific knowledge, and secondly because without solving the problem of high implementation costs including enforcement costs, consumers are not willing to pay for the global public goods, due to lack of confidence in the feasibility of the scheme. When provision or financing of those global public goods is crucially dependent on what type of network should be formed, and on how much it costs, we are faced with the problem of who is willing to bear the cost of network formation, of who can take on the leadership in forming it, and what motivates him to do it.

If consumers are not necessarily conscious of the benefit of a global public good, an entrepreneur undertaking a "selective incentives" scheme is, in advance of providing it, required to form a star network whose center player must be he himself. If the cost to a for-profit firm of forming the network is not negligible, an incentive for a business entrepreneur's work for the network formation must be given by his sharing in the net proceeds of the enterprise. This leads to eroding the sources for financing the global public good, a contradiction to the social objective of providing the global public good. In that case, a non-profit organizational form run by a social entrepreneur may be more reconcilable with the social objective, because he can be compensated for his work through the provision of the global public good, more than a business entrepreneur.

On the contrary, when consumers recognize the benefit of a global public good beforehand, a line type network can be formed with the lowest cost of network formation. In this case, a for-profit organizational form can be reconcilable with the social objective, because the entrepreneur does not need to call for so much compensation for his contribution to the network formation. The problem of network formation can be ignored in this case. This is the situation that previous studies mentioned below have implicitly assumed in examining the efficiency of selective incentive schemes for financing public goods.

Hardin (1968, 1978) insisted the necessity to replace the system of the commons with other political systems, which are enforceable. But he did not examine the cost of collective action and of enforcement. By contrast, Ostrom (1990) took up the case where the negotiations and enforcement to preserve common pool resources can be carried out with a negligible cost compared to the benefit of the preservation, and showed that the local commons can be preserved on a voluntary basis. What happens if those costs are not negligible, however, remains to be answered. On the other hand, Olson (1965) pointed out that collective goods for large groups can be provided only as a by-product of "selective incentives" schemes. Morgan (2000), Morgan and Sefton (2000), and Pecorino (2001) corroborated Olson's by-product hypothesis by examining the effect of "private good-cum-public good" enterprise on the provision of public good.

In examining those selective incentive schemes, however, they assumed as a matter of course that the utility functions of consumers include a public good as an augmenting variable. In other words, they assumed a type of consumer whose utility function has the public good as its augmenting factor from the outset. In the case of global public goods, however, consumers are not necessarily even conscious of the benefits of them. The main reason for this unconsciousness is that scientific knowledge of those global public goods is not certain yet. If that is the case, we have to assume someone with confidence in the scientific knowledge to take the initiative in leading other consumers to have certain knowledge, in advance of assuming the traditional utility functions.

Furthermore, in order for the consumers to participate in the selective incentive scheme by way of purchasing a private good-cum-public good, they must, even if they could be led to confidence in the scientific knowledge, be made confident of the feasibility of the private good-cum-public good scheme. For example, if a consumer is not confident that other consumers also participate in the above scheme under non-refundable conditions, he or she is not willing to pay for the public good. Or, if he or she conjectures that at the stage of implementing the scheme, the cost of communicating between the entrepreneur and consumers is so high, he or she loses confidence in the feasibility of the scheme. In short, they must be confident not only of their own scientific knowledge, but also of other consumers' scientific knowledge, i.e., a sufficiently low cost to implement the enterprise.

All of the above factors require us to take into consideration the indispensability of network formation, more or less led by an entrepreneur undertaking a "private good-cum-global public good" scheme. However, previous studies mentioned above ignored this indispensability. Such ignorance amounts to the assumption that the cost of network formation is negligible, or that the entrepreneur does not mind the cost incurred for forming a network. Based on their neglecting the indispensability of the network formation, Morgan (2000) and Morgan and Sefton (2000) maintained that the "private good-cum-public good" schemes are more efficient in financing public goods than voluntary contribution schemes. However, their conclusions cannot hold in general, if the network formation is an indispensable precondition for those schemes.

In this paper we come up with a three-stage game model to illustrate our logic. At the first stage, an entrepreneur makes a decision on whether to undertake an enterprise of fixed-raffle lotteries, the net proceeds of which must be put into use for financing a global public good. There are two types of entrepreneurs, called business and social entrepreneurs, each of whom is equivalent to the manager of a for-profit firm and a non-profit firm, respectively. It is assumed that the social entrepreneur is compensated for his organizing and managing work not only with a fixed monetary salary but also with the benefit of the global public good, and that the business entrepreneur, on the other hand, must be compensated with a fixed monetary salary and with his sharing in the net proceeds.

At the second stage, a local network must be formed prior to implementing the enterprise. The network is formed through each player's decision-making on direct links with other players. This process of forming a network is viewed as a non-cooperative game. We build it, based on the graph theory developed by Myerson (1977) and Aumann and Myerson (1988). In deciding on direct links with others, each player weighs the benefit against the cost of each link formation. The benefit obtainable from saving on communication costs, but he or she has to pay a link formation cost for forming each direct link, such as time and energy for direct communications. As long as each player has a link with a player in a connected network, he or she can enjoy the full benefit of the network through saving communication costs, i.e., a transaction cost, to transmit information among the connected players, irrespective how much he or she paid for the network formation.

In the case of a community consisting of ecologically unconscious consumers, a star network has to be formed, and someone has to take on the role of the center player who has to bear the heaviest cost for the network formation. As an example of the star network, we can take a hub-spoke type of non-profit organization. On the other hand, in the case of a community consisting of ecologically well conscious consumers, they are ready to positively communicate with others on their common interests, and a line type of network can be formed as the most efficient one. Here the players at the edges pay the minimum cost for network formation. We base the analysis of the cost aspect of network formation on Jackson and Wolinsky (1996), Bola and Goyal (1999), Slikker and Neuweland (2001), and Watts (2001).

At the third stage, the enterprise of a fixed-raffle lottery is undertaken. This enterprise is the same type as that examined by Morgan (2000). The net proceeds of the enterprise is put into use for financing the global public good. From this stage onward, the benefits of the global public good come into being in the utility functions of consumers in a connected network. This scheme is carried out on a local scale, but the supply function of the global public good can be assumed to be a summation type of technology. In this paper, accordingly, it is assumed that each consumer in a connected network obtains the benefit from financing the global public good, even if they contribute to it on a local scale. This assumption can be supported by ubiquitous local experiments with a view to preserving the global commons on a voluntary basis.

By examining that game model, we derive the following main results: (1) that both star and line networks are stable in the sense of their being a strong Nash equilibrium, (2) that when a star network is an indispensable precondition for the selective incentive scheme to solve the problem of uncertain knowledge and communication cost, a non-profit organizational form is more reconcilable with the social objective than one of for-profit, i.e., that in that case, the social entrepreneur can overcome the problem of network formation more efficiently, and (3) that only when the cost of network formation is negligible, do the main results of Morgan (2000), Morgan and Seften (2000) and Pecorino (2001) hold true.

Regarding the concepts of non-profit firm and entrepreneur, we have to mention a difference between the definition used in this paper and that of Hansman (1980), Bilodeau and Slivinski (1998) and Glaeser and Shleifer (2001). In this paper we assume that two types of entrepreneurs, social and business entrepreneurs, exist at the beginning of the game, and that the payoff function of the social entrepreneur is different from that of the business entrepreneur. In this paper, we compare the outcome brought about by the social entrepreneur with that of the business entrepreneur. The entrepreneurs defined in previous studies mentioned above are only one type, whose payoff function has as its augmenting variables both public goods and private goods including pecuniary incomes. They assume that the entrepreneur can choose between the organizational form of a non-profit firm and a for-profit firm so as to maximize his payoff. Their assumption may be suitable to the enterprises, the net proceeds of which are dependent on the choice of an organizational form. On the other hand, as Rose-Ackerman (1996) points out, there are also entrepreneurs with special missions or ideologies, or those who feel that they benefit from a collective good which he himself provides for. The social entrepreneur is a concept abstracting the common characteristics of such entrepreneurs. In fact, we can observe such a type of entrepreneur at an early stage of newly emerging collective interests.

The question of who voluntarily becomes a social entrepreneur must be answered[ii] by recourse to the logic of "waiting game" and "race game," which were put forward by Dasgupta (1988), Baik (1993), Baik et al. (2001), Bilodeau and Slivinski (1996a, 1996b), and Bliss and Nalebuff (1984). The detailed examination of this line of logic is left to Ueda (2002).

This paper is organized as follows: In section 2, the basic model of a non-cooperative game of network formation is presented. In section 3, the fund-raising stage is examined. In section 4, the entry decision of the entrepreneur is examined. In section 5, a brief summary is given. In the appendix of this paper, we give the proof that both star and line network are not only Nash but also strong Nash equilibrium.

2. The Basic Model of Link Formation: A Non-Cooperative Game Approach

The conventional models of public goods implicitly assume that all consumers (or potential beneficiaries) are well conscious of their own benefits obtainable from those public goods. In the case of global common pool resources (hereafter abbreviated GCPR) such as the global atmosphere, however, all of the potential beneficiaries are not necessarily even conscious of the benefit itself, because of their lack of scientific knowledge, or because of uncertainty about it. What is worse, they are uncertain about whether or not other community members are conscious of the benefit, even if they themselves are conscious of their own benefits. It discourages them from giving voluntary contributions, because they are afraid that the feasibility of any measures is groundless owing to huge transaction costs incurred at the stage of implementing it.

Here, we are required to take into consideration the indispensability of network formation prior to the stage of providing GCOR. It further leads us to allow for the cost of network formation as well as the direct cost of provision. Even if selective incentive schemes such as raffle lotteries are regarded as an efficacious means to finance public goods, as proved by Morgan (2000) and Pecorino (2001), even those schemes have to get over the problem of network formation in the case of global public goods.

When consumers are organized in a group where they are confident that they share the same information and therefore that they can save further communication costs by persuading each other into recognizing it and going along with any proposal based on the knowledge, it is called a *network*. Once a network is formed, all members in a network can save any further communication cost indispensable for concerted actions among them. Once it is formed, a social organizer can make any proposal to carry out a selective incentive-cum-GCPR scheme to members in the network with negligible communication cost. Any network is formed through direct links between a pair of players, but it costs each player to form any direct link, whilst he gains the benefit of saving on further communication costs with linked players. Accordingly, he has to weigh the benefit against the cost of his forming direct links. What type of network is formed is dependent on the decisions of the players with the various cost of and benefit from network formation.

In this section, we come up with a non-cooperative game model of network formation making allowance for the cost of forming direct links. It is assumed that once a consumer is connected with a network through his direct links with some members of the network, he becomes confident that he shares certain knowledge on GCPR with other members and therefore the scheme is feasible in terms of the cost of implementing it because of saving on communication cost at the implementation stage.

In the following, we begin the whole process of providing a global public good with investigating the network formation game. After this first stage the stage of financing the public good follows, which is the stage where the participating players decide on their own purchase of the lottery ticket. At the last stage, the public good is financed by a portion of the sales profit and provided by the organizer of the lottery enterprise, who is a social or business entrepreneur depending on his objective functions or organizational forms of enterprise.

Let us begin with explaining the network formation game.

Players: It is assumed that there are $n+1$ potential beneficiaries of GCPR, and the sets of players consisting of them is defined as $N' = (0,1,2,\ldots, n)$ where 0 stands for entrepreneur and the numbers from 1 to n stand for consumers, in the following.

Strategies: The strategies of the players are composed of their decision on direct links with other players. The strategy of i is denoted by g_i, which is defined as:

$$g_i := (g_{i0},\ldots, g_{in}), \qquad i \in N'$$

$$g_{ij} = \begin{cases} c_{ij} \geqq 0, \\ \Phi \end{cases} \qquad j \in N' \setminus i$$

$$g_{ii} = 0$$

$g_{ij}=c_{ij}$ means i would like to form a link with j and is ready to incur the cost of c_{ij} for this direct link. $g_{ij}=\Phi$ means i has no intention of forming a link with j. A n+1-tuple vector consisting of all players' strategies is defined as:

$$g := (g_0, g_1, \ldots, g_n)$$

A link between i and j, denoted by $\{ i, j \}$, is formed, only when $g_{ij}=c_{ij}$ and $g_{ji} = c_{ji}$. A set of links, $l(g)$, formed under a strategy combination, g, is defined as follows:

$$l(g) := (\{ i, j \} \mid g_{ij} = c_{ij}, \quad g_{ji} = c_{ji}, \text{ for } i, j \in N')$$

A connected set including i under a strategy combination, g, is defined as a set of links, denoted by $L_i(g)$, where players in a network are directly or indirectly connected with *i*. It is assumed that when a set of players is connected, they can communicate with others without any further communication cost, because they are confident that they share the same scientific information on causal relations. They can send their messages free of charge. This saving on communication cost is considered as an economic output of that connected network.

The feasible connected set, denoted by $M_i(g)$, is defined as follows:

$$M_i(g) := (\{i, j\} \in l(g) \mid \sum_{\{k,m\} \in l(g), Li(g)} (c_{km} + c_{mk}) \le V(L_i(g))$$

In the above definition, $V(L_i)$ is the output of a network formed by the connected members of $L_i(g)$, which is defined by (1) below. The *feasibility* means that the output of a connected network should exceed or be equal to the total sum of the linkage costs.

Payoff: We define the output of a connected network as saving on communication costs to the players in the network. Denoting by $V(S)$ the output of a connected network formed by a set of players, $S \subseteq N'$,

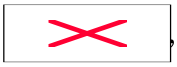
$$V(S) = \begin{cases} \sum_{\{i,j\} \in M_i(g)} c_{ij} + \sum_{\{j,i\} \in M_i(g)} c_{ji} & \text{for } \ni i \in S \\ \left(c_{i_1 i_2} + c_{i_2 i_1}\right) + \left(c_{i_2 i_3} + c_{i_3 i_2}\right) + \ldots + \left(c_{i_{S-1} i_S} + c_{i_S i_{S-1}}\right) & \end{cases} \quad (1)$$

In the second part of (1), $i_S := / S /$, the cardinality of *S*. It is the output of a line network. On the other hand, in the first part of (1), *i* is the center player of a star network. Here, keep in mind that the output is the volume of the saving to be achieved in the most efficient way.

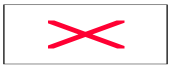
If N' is divided into *m* separated connections, the total output of these *m* connected networks, denoted $V(S_1,\ldots,S_m)$, is defined as follows:

$$V(S_1,\ldots,S_m) = V(S_1) + \ldots + V(S_m) \quad (2)$$

It is obvious that V(N') >V(S_1,…,S_m). Then, the net benefit to *j*, denoted $\Pi_j(g')$, of the network g' is derived as follows:

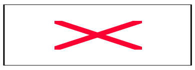
$\Pi_j(g') = V(S_1\ldots,S_m) -$ , $S_h = M_j(g')$ for $\exists h$ (3)

So, when *N'* is connected under *g*,

$\Pi_j(g) = V(N')$ -  $\forall j \in N'$ (4)

When it is assumed that linkage costs are symmetric, it holds that $c_{ij} = c_{ji} = c$ for any $i,j \in N'$. Then, (1) and (4) are simplified as follows:

$$V(N') = 2c\,(\,|\,N'\,|-1) = 2c\;n \qquad (1)'$$

$\Pi_j(g) = 2c\;n -$  (4)'

From the above network formation game, we can derive the following two lemmas, the proofs of which are given in the appendixes of this paper.

Lemma 1. The star and line network of the above network formation game are both Nash equilibrium.

Lemma 2. Both the star and line network are strong Nash equilibrium.

According to Lemma 2, the network formation game has two stable networks in the meaning of their being a strong Nash equilibrium. At this point in time, we cannot say which type is more likely to come into being. In the case of a line type, the players at the end points can gain a larger net benefit than those between them. On the other hand, the net benefit of the center player of a star network is much smaller than those of non-center players. In section 4, it is explained that a star network is formed by community members unconscious of their common interests, but that a line network is apt to be formed by players conscious of their common interests.

3. Fund-Raising Stage[iii]

In the second stage, the entrepreneur who took the leadership in forming a network at the first stage comes up with a selective incentive scheme, *a fixed-raffle lottery*. At the end of the first stage, all players know that not only they themselves but also other players of the network are conscious of the benefits of GCPR, thanks to the network formation. And furthermore, all of them know they belong to the network where they can save any further communication cost borne at the stage of implementing any scheme. At this point in time, they can recognize the global public good as a benefit. That is, at this point in time, the global public good can come into being in their utility functions. In this section we formulate the utility functions of those ecologically conscious consumers.

Players in a connected network obtain benefits not only from private goods but also from preserving GCPR. The private goods are comprised of a numeraire good and the prize of the fixed-raffle lottery. They know at least a portion of the profit of the lottery enterprise is put into use for funding the preservation of GCPR. Although they may not be confident that their fund-raising effort is sufficient to achieve their ultimate goal of preserving GCPR on a global scale, they can obtain a benefit from the belief that their fund-raising activities can contribute to providing the GCPR in spite of being "a bit of", because the supply function of the global public good can be assumed to be an additive type of technology.

The entrepreneur must be compensated not only for his management work required at this second stage but also for his effort to organize a network at the first stage. If he is a business entrepreneur, a portion of the profit of the lottery enterprise is awarded to him at the end of the second stage, in addition to a fixed salary, F, for his management work done at the second stage. His share in the profit is denoted $1-\mu$, $0<\mu<1$. If on the other hand he is a social entrepreneur, he is compensated with F and the benefit of GCPR. It is for the purpose of emphasizing the role of the social entrepreneur at an early stage of collective action that the benefit function of a social entrepreneur is assumed to be so different from that of the business entrepreneur. In what follows, the entrepreneur of any type is denoted 0 player, and N is defined as a set of other consumers, { 1,2,..., n }.

Assuming a quasi-linear utility function, the expected utility of *i* consumer, EU_i, is given by (5) and (5)' for each type of the organizational form of the enterprise.

$$EU_i = I_i - x_i + x_i R / X(N) + \phi_i(\mu (x(N) - R - F)), \text{ for for-profit firms} \quad (5)$$

$$EU_i = I_i - x_i + x_i R / X(N) + \phi_i(x(N) - R - F), \text{ for non-profit firms} \quad (5)'$$

The symbols in the above equations are defined as follows:

I_i := the initial endowment of *i* consumer

x_i := bet of *i* consumer on a fixed-raffle lottery

$x(N) := x_1 + x_2 + \ldots + x_n$

R := a fixed raffle, $0 \leqq R \leqq \mu (x(N) - F)$

ϕ_i := the benefit to *i* consumer, obtainable from the global public good, where it is assumed $\phi'_i > 0$, and $\phi''_i < 0$ as usual.

When the global public good is financed by voluntary contributions, then the utility functions are changed from (5) or (5)' to (6).

$$U_i = I_i - x_i + \phi_i(x(N)), \quad \text{for } \forall i \in N \quad (6)$$

This change in functional form is attributed to change in organizational form from firm organizations managed by an entrepreneur to voluntary actions of all players without leadership or organizing work of an entrepreneur.

Now, for comparison we can derive the first-best and selfish outcome under the conventional assumption of a cost-unconscious social planner. First, suppose the case that each player voluntarily makes a decision on how much to contribute to fund-raising for preserving GCPR, and that those contributions are put into use for it without any additional cost. Then, from the first order conditions for the maximization of (6), (7) is derived.

$$\phi'_i (x(N)) = 1, \qquad \text{for} \quad x(N) = x^V \tag{7}$$

In the above equation (7), x^V is called the selfish level of voluntary contributions as usual.

Secondly, suppose the case that those contributions can be coordinated to achieve the social optimality without any additional cost. Then, the optimal level, denoted by x^*, satisfies the following condition:

$$\sum_{i=1}^{n} \phi'_i (x(N)) = 1, \qquad \text{for} \qquad x(N) = x^* \tag{8}$$

By comparing (7) with (8), it is easily proved that $x^* > x^V$, i.e., the inefficiency of selfish decision-making on public goods.

Next, let us examine the outcome of the fixed-raffle lottery scheme. Assuming the inner solution of the maximization problem of (5), (9) is derived from the first order conditions.

$$\mu \ \phi'_i (\mu (x(N) - R - F)) - 1 + x(N\backslash_i) R / (x(N))^2 = 0, \quad \text{for } x(N) = x^F \tag{9}$$

In (9), x^F is the sum of the expenditures of n consumers on lotteries under the organizational form of for-profit firms, which is managed by a business entrepreneur.

Since $x (N\backslash_i) R / (x (N))^2$ is positive and less than unity, it is easy to prove that $0 < 1 - x(N\backslash_i) R / x (N)^2 < 1$. Because, however, μ is also less than unity, it is not a priori sure whether or not $\phi'_i (\mu (x^F - R - F))$ is larger than unity. It may be larger than unity, if μ is sufficiently small, so that the following inequality, $\mu (x^F - R - F) < x^V$, can hold. In this case, the fund for the global public good financed by a business entrepreneur may be lower than the voluntary contributions. Obviously, this contradicts with the conclusions of Morgan (2000).

On the other hand, if a non-profit firm undertakes the lottery enterprise, and therefore, the payment to the social entrepreneur is assumed to be a fixed salary, F, then μ can be set at unity, and the necessary conditions (9) are changed to (10):

$$\phi_i{}' (x(N) - R - F)^{-1} + x(N\backslash i)\, R / (x(N))^2 = 0, \quad \text{for } x(N) = x^N \qquad (10)$$

In (10), x^N is the total sum of bets spent by n consumers.

By comparing (7) with (10), it is obvious that $x^N - R - F > x^V$. This amounts to the same conclusion as Morgan (2000). It implies that the conclusion of Morgan (2000) is based on the implicit assumption that the manager of the lottery enterprise is a social entrepreneur type.

The social entrepreneur can be compensated for his entrepreneurship with a fixed salary, F, and the direct benefit obtainable from the global public good. Actually, he cannot call for his sharing in the net proceeds of the lottery enterprise, owing to the "non distribution constraint". The non-profit firm pays him only a fixed salary, F. On the other hand the social planner assumed by Morgan (2000) is paid nothing for his coordinating work. This amounts to the case of F being zero in the case of a non-profit firm.

From the above discussions, it is conjectured that the provision of global public goods depends on what type of entrepreneur takes the leadership or what type of organizational form is selected.

4. Who Takes on the Leadership for Network Formation?

In this section, we examine the entry decision of an entrepreneur at the initial stage of the game.

(4-1) Entrepreneur's Belief on Consumers' Types

In this paper we took up two types of entrepreneurs, called social entrepreneur and business entrepreneur. The first type is the organizer and manager of a non-profit firm, and obtains a benefit from the global public good itself that he takes the initiative in providing for. On the other hand, the business entrepreneur is the organizer and manager of a for-profit firm.

He needs not necessarily obtain any benefit from the global public good itself, so that he must be rewarded for his effort with sufficient pecuniary income.

Before launching into a new enterprise, an entrepreneur of any type has to estimate its prospect. In the case of an enterprise of "selective incentive-cum-global public good", he has to expect not only the demand for the private good (selective incentive), but also the demand for the global public good. The state of the demand for the latter influences the cost of network formation. In this paper, we classify these states into two; low and high state, for simplicity.

In the case of a low state, it is assumed the consumers are not even conscious of the benefit of the global public good, for example, for lack of certain scientific knowledge on it and for lack of confidence in the feasibility of schemes for providing it. They are never motivated to positively forming any links with other community members with a view to collective action. Far from that, they have to be persuaded, enlightened, and mobilized to join in a connected network. Such a network, if formed somehow, should be of a star type. If, therefore, the entrepreneur believes that the market of his enterprise is a type of low state, he must be determined to take on the task of the center player of the star network.

In the case of a high state, on the other hand, the consumers are well conscious of their own benefits obtainable from providing the public good. They are motivated to communicate with others in order to confirm mutual consciousness. According to the terminology of this paper, they are motivated to positively form links with other community members. A line network is the efficient outcome of their voluntary link formation. In this case, the entrepreneur can expect the cost of forming a network to be low, and he believes that he can take the initiative in forming a line network by expending the minimum amount of network formation cost, i.e., by taking up his position at a starting edge of the line.

(4-2) Entry Decision and Organizational Forms

If a social entrepreneur is faced with the low state of demand, he has to take leadership in forming a star network as a precondition for the provision of a global public good. The cost of his forming the star network can be compensated both with the benefit of the global public good and with a fixed salary.

If, on the other hand, a business entrepreneur is faced with the same low state of demand, the cost of his forming the star network is not compensated with a fixed salary, because he does not obtain a sufficient amount of benefit from the global public good itself. In this case, his effort to form the network must be compensated by his sharing in the net proceeds of the enterprise.

Here, it should be noted that only the organizational form of a for-profit firm allows an entrepreneur to share the profit, but that the organizational form of a non-profit firm does not. If, therefore, only a non-profit type of organizational form is admitted to the enterprise of a fixed-raffle-cum-global public good, the business entrepreneur cannot be motivated to launch into the enterprise when a star network is indispensable for the enterprise. If that is the case, we come to the conclusion that the social entrepreneur has to take the initiative in forming a star network. In what follows, we also derive a rational foundation of a non-profit organization, from the motivational perspective of an entrepreneur.

Now, let us return to the initial entry stage where an entrepreneur has to decide on whether to enter into the enterprise of selective incentive –cum-global public good. The "selective incentive" is a fixed-raffle lottery. His decision depends not only on the states of the demand for the global public good, High or Low, but also on which type of entrepreneur he is. There are four combinations, as shown in the table below.

	High	Low
SE	1	2
BE	3	4

In the above table, SE and BE stand for social and business entrepreneur, respectively. Assuming that all consumers except for the entrepreneur are symmetric and that the cost of link-formation, c_{ij}, is the same for all players, the payoff functions of SE in cells 1 and 2 are given by (11) and (12), respectively.

$$U_s(|S|; H) = -c + F + \phi_s(|S| x_N(S) - R - F) \quad \text{for } S \subseteq N \tag{11}$$

$$U_s(|S|; L) = -c\ |S| + F + \phi_s(|S| x_N(S) - R - F), \quad \text{for } S \subseteq N \tag{12}$$

In the above equations, ϕ_s stands for the benefit to the social entrepreneur of the global public good, F is a fixed compensation for his management work, and $x_N(S)$ is the maximizer of (5)' with $x_1 = x_2 = \ldots = x_{|S|} = x_N(S)$, for $|S| \leqq n$. Note that $x_N(S)$ is dependent on S.

It is noted that from the maximizing condition of (5)' with symmetric consumers, it is also derived that $d\,(x_N(S)\,|S|)\,/\,d\ |S| > 0$.

Only when $\partial U_s\,(n; L)\,/\,\partial\ |S| = -c + \partial\,\phi_s(x_N(N) - R - F)/\partial\,|S| \ \geqq 0$, can the social entrepreneur form a fully connected star network, subject to his individual rationality. The conventional approach to the scheme of "selective incentive-cum-public good" must have implicitly assumed such a type of social planner, as long as a star network is an indispensable precondition for the selective incentive scheme.

If, on the other hand, $\partial U_s\,(n; L)\,/\,\partial\,|S| = -c + \partial\,\phi_s(x_N(N) - R - F)/\partial\,|S| < 0$, even the social entrepreneur obtaining a benefit from the global public good cannot form a fully-connected network. It reflects the fact that his demand for the global public good is not sufficiently intense relatively to his burden of networking activity.

Let us examine the payoff functions of BE in cell 3 and cell 4, which are given by (13) and (14), respectively. Note that this type of entrepreneur gains no utility from the global public good, based on the assumption made for the sake of emphasizing a difference between a business entrepreneur and a social entrepreneur.

$$U_b\,(|S|;\,H) = -\,c + F + (1\text{-}\mu)\,(\,|S|\,x_F(S) - R - F),\quad S\subseteq N \tag{13}$$

$$U_b\,(|S|;\,L) = -\,c\,\,|S|\,+ F + (1\text{-}\mu)\,\{|S|\,x_F(S) - R - F\},\quad S\subseteq N \tag{14}$$

In the above equations, $x_F(S)$ is derived from (5) with $x_F(S) = x_1 = \ldots = x_{|S|}$ for $S\subseteq N$. Note that $x_F(S)$ is dependent on S.

It is certain that from (5) with the above symmetric conditions $d\,(|S|\,x_F(S))\,/d\,|S|>0$ holds.

If $d^{\,2}(|S|\,\,x_F(S))\,/d\,\,|S|^2< 0$, however, it is possible that $dU_b\,\,(|S|;\,L)\,/\,d|S|=\,-\,\,c\,\,+(1\text{-}\mu)\,\partial\,(|S|\,\,x_F(S))/\partial\,|S|\leqq 0$, for $|S|< n$. In this case, the business entrepreneur is not motivated to form a fully-connected network, even if he can share in the profit of the enterprise.

By comparing (11) with (13), and (12) with (14), respectively, it is easy to show that as μ gets close to unity, and at the same time ϕ's to zero, U_b approaches U_s. When, however, neither type of entrepreneur can form a fully-connected network under the low state condition, μ must be sufficiently small under the condition that $\partial[(1\text{-}\mu)\,\,|S|\,\,x_F(S)]\,/\,\partial(1-\mu)>0$, and / or ϕ's must be sufficiently large. That is, both types must be distinctly different from each other in order for any type of entrepreneur to be motivated to form a fully connected star link.

When, however, the business entrepreneur must be motivated by an increase in his profit sharing, the rest of the funds to be put into use for financing the global public good must be decreased. Accordingly, the selfish objective of the business entrepreneur is not compatible with the social objective of providing global public goods, if a connected star network is an indispensable precondition for the provision.

A Proof of the Logic: The above logic can be illustrated by comparing the first order condition of (5) with that of (5)', with those consumers being assumed to be symmetric. From the first order condition of (5), we can derive (15).

$$\phi_i{}'(\mu\{|S|\ x_F(S) - R - F\}) = 1/\mu\ |S|, \quad \text{for } {}^{\forall}i \in S \subseteq N \tag{15}$$

From (5)', in the same way (15)' is derived.

$$\phi_i{}'(|S|\ x_N(S) - R - F) = 1/|S|, \quad \text{for } {}^{\forall}i \in S \subseteq N \tag{15'}$$

By comparing (15) with (15)' we gain the following inequality:

$$|S|\ x_N(S) - R - F > \mu\,(|S|\ x_F(S) - R - F), \text{ subject to } 0 < \mu < 1.$$

That is, the funds for the global public good is on a more sufficient level financed under the enterprise organized by the social entrepreneur than by the business entrepreneur.

Then, should we have recourses to the social entrepreneurs in order to preserve GCPR? If so, is it assured that that type of entrepreneur exists on a sufficient scale? How is he endowed with such a special type of payoff function as to have global public goods as an augment? It may be suggested that we should set up more institutions and training courses for social entrepreneurship.

5. Conclusions and Implications

The global agreements on stopping global warming tend to be procrastinated, owing to the problem of collective action on a global scale, and to the cost-unconsciousness of the governmental negotiators. Even if it is admitted that intergovernmental negotiations are required for the global community to eventually establish a global constitution, we have to look for alternative or complementary solutions to the “tragedy of the global commons”.

The “selective incentive-cum-global public good” scheme is one of the solutions which can be voluntarily pursued on a local scale. However, so far as a star type of network is a precondition for the scheme to be carried out, the initiative of social entrepreneurs is indispensable. The objective of a business entrepreneur is not necessarily consistent with the ultimate social goal of preserving the global atmospheric quality.

In contrast, the social entrepreneur is a special type of social organizer in the sense that he has to be able to derive a sufficient amount of benefit from the global public good. In addition to business skills, certain scientific knowledge on global eco-systems is a requirement for someone to be a social entrepreneur.

Describing the motivation of an entrepreneur from the perspective of his cost burden, it can be said that in order to motivate him to come into being, the cost of network formation must be sufficiently low relatively to the benefit obtainable from his entrepreneurship. By the way, that cost is dependent on the knowledge and trust prevailing in a community at issue. Those factors underlying the cost of network formation can be considered as an outcome of "social capital".[iv] In this sense, one of our main conclusions can be reformulated as follows; The more insufficient the social capital is, the more indispensable it is for a star network to be formed.

Ecologically conscious communities networked by those social entrepreneurs may be able to discriminate against such consumption goods as to be produced by those companies or imported from those countries, which cannot prove those goods were produced by ecologically friendly technologies. Therefore, if those local networks are formed in many countries, they can motivate the ecologically non-friendly producers or countries to follow the norm of those local networks in the long run. In this sense those local networks can play another significant role in preserving the global commons, such as greenhouse gas abatement and international security, which complements the ongoing intergovernmental negotiations.

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Endnotes

i. As to the basic concepts of the network theory in this paper, refer to Myerson (1977), Aumann and Myerson (1988).

ii. See Ueda (2002).

iii. Refer to Morgan (2000), and Morgan and Sefton (2000) for the details of raffle lotteries.

ⅳ Refer to Svendsen (2003) for the concept of social capital.

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Appendix: Proof of Nash and Strong Nash Equilibrium

It is proved that two sets of strategies bringing about a star and line type of network are not only a Nash but also a strong Nash Equilibrium. In the following, we assume the benefits and costs of the networks are symmetric.

Appendix A: Proof of the Nash Equilibrium:

Let us denote the Nash Equilibrium by g^* for both types of networks to avoid an abuse of terms.

(i) Assume g^* has brought about a line type of network. When $\exists j \in N'$ is located between two players, his payoff under g^* is : $\Pi j(g^*) = 2c\ (n) - 2c$. If he is located at one of the end points, $\Pi j(g^*) = 2c\ (n) - c$. Suppose he deviates from the Nash strategy, and sever one link. (It is obvious that he has no incentive to sever more than two links.) Denoting the deviating strategy by g_j, his payoff is reduced to: $\Pi_j(g_j, g^*_{-j}) = 2c(\ |S_1| - 1) + 2c\ (|S_2|\ -1) - c = 2c\ (n) - 3c$, for the former case. $\Pi_j(g_j, g^*_{-j}) = 2c\ (n-1) = 2c\ (n) - 2c$ for the latter case. In the above, S_1 and S_2 are two connected networks separated by the deviating strategy g_j. Thus the payoffs obtainable from the deviation turn out to be reduced for both cases.

(ii) Assume g^* has achieved a star type of network. When $j \in N'$ is not the center, his payoff is, $\Pi_j(g^*) = 2c\ (n) - c$. If j is the center, $\Pi_j(g^*) = 2c\ (n)\ c\ (n) = c\ (n)$. Suppose j deviates from the Nash strategy and severs one link. Then, his payoff is changed to:

$\Pi_j(g_j, g^*_{-j}) = 2c\ (n-1),$ for the former, and

$\Pi_j(g_j, g^*_{-j}) = 2c\ (n-1) - c\ (n-1) = c\ (n-1),$ for the latter.

For each case, the payoff obtainable from deviation is reduced. (Q. E. D.)

Appendix B: Proof of the Strong Nash Equilibrium:

(i) Let us take up the network type, first. If g^* is not the strong Nash equilibrium, there must exist a coalition S, *S*⊂*N'*, such that *S* satisfies the following condition:

$$\Pi_j(g_s, g^*_{-s}) \geqq \Pi_j(g^*_s, g^*_{-s}) \qquad \forall j \in S$$

and for at least one player, ∃ *k*∈ *S*, a strict inequality holds. In the above, inequality g_s is|S|tuple strategy vector of the deviating coalition *S*, and g_{-s} that of (*N'**S*).

Here we can classify the coalitions made by *S* into two cases. In the first case, *S* does not include the center player *i* of *N'*. If, then, *S* forms a line network, the payoff of *j*∈*S* is:

$$\Pi_j(g_s, g^*_{N\backslash S}) = \begin{cases} V(S) + V(N'\backslash S) - 2c \\ \quad = 2c(n) - 4c & \text{for } j \in S \text{ not at the end points,} \\ V(S) + V(N\backslash S) - c \\ \quad = 2c(n) - 3c & \text{for } j \in S \text{ at one of the end points.} \end{cases}$$

Obviously, both of them are less than $\Pi_j(g^*)$, *which is 2cn* – c.

If, on the other hand, *S* forms a star network, the payoff of *j*∈*S* is :

$$\Pi_j(g_s, g^*_{N\backslash S}) = \begin{cases} V(S) + V(N'\backslash S) - c \\ = 2c(n) - 3c < \Pi_j(g^*) & \text{for the non-center player,} \\ \\ V(S) + V(N'\backslash S) - c(|S| - 1) \\ = 2c(n) - c(|S| + 1) \\ < \Pi_j(g^*) & \text{for the center of S.} \end{cases}$$

Any player of *S* cannot increase his payoff by the coalition *S*, either.

Let us examine the second case that *S* includes the center player, *i* of *N'*. Only the case that *S* is connected by a new star or line network is meaningful. Then, the payoffs of the players of the new star of *S* are:

$$\Pi_j(g_S, g^*_{N\backslash S}) = V(S) + V(j_1,\ldots, j_m) - c$$
$$= 2c(|S| - 1) - c \qquad \text{for } \forall j \in S, j \neq \text{the center of S.}$$

$$\Pi_j(g_S, g^*_{N\backslash S}) = V(S) + V(j_1,\ldots j_m) - c(|S| - 1)$$
$$= c(|S| - 1) \qquad \text{for the center of S.}$$

In the above, $(j_1,\ldots, j_m) = N'\backslash S$, $m = n + 1-|S|$. $V(j_1,\ldots, j_m) = V(\{j_1\}) +\ldots+ V(\{j_m\}) = 0$. All of them are less than $\Pi_j(g^*)$, because $|S| < n$.

On the other hand, the payoffs of the players of the new line of S are:

$$\Pi_j(g_S, g^*_{N\backslash S}) = V(S) + V(j_1,\ldots, j_m) - 2c$$
$$= 2c(|S|- 1) - 2c \quad \text{for the players not at the end points.}$$

$$\Pi_j(g_S, g^*_{N'\backslash S}) = V(S) + V(j_1,\ldots, j_m) - c$$
$$= 2c(|S|- 1) - c$$ for the players at one of the end points. Obviously, all payoffs are less than $\Pi_j(g^*)$, because $|S| < n + 1$.

(ii) We can prove along the same logic for the case of N' being connected by a line network. (Q.E.D)