18. Economic Analysis of Organizational Design for Coastal Management

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1. Introduction

Marine protected areas (MPAs) are effective tools for protecting coastal resources ecosystems and the economic and social benefits. In particular, since the World Summit on Sustainable Development in 2002, which resolved plans that include the establishment of MPAs, this kind of opinion seems to be commonly shared. Their management is accompanied by legal enforcement of fishing regulations. However, this requires a sufficient workforce to undertake activities to manage MPAs, such as the surveillance of illegal fishing. Therefore, governments need to implement actions to ensure the effectiveness of many MPAs.

In the Philippines, local government units organize such implementation units to protect MPAs called “Bantay Dagat.” The Bantay Dagat is organized to implement law enforcement and typically consists of residents in regions that include MPAs. The participation of residents is voluntary; they usually receive remuneration in exchange for their engagement. However, some papers and reports criticize that remunerations are insufficient as compensation for engagements, and thus, large parts of activities are supported by voluntary contributions of participants (c.f., Altenburg et al., 2017; Maderazo et al., 2016; Shinbo, Bradecina, and Morooka, 2014; Esmas and Panganiban, 2021). Bantay Dagat’ s activities are supported mainly by funds provided by local government units. According to the dominant view, this financial support seems to be insufficient.

This chapter offers a theoretical framework based on economics to study the organizational design of activities to protect coastal resources. Coastal resources benefit stakeholders, such as the fishers and business parties that use them. In economics, these resources are regarded as commodities. In this chapter, we note that these have an important feature of public goods ― “non-excludability.”[1] Coastal resources are generally available to stakeholders, provided they can reach them. This arises from the difficulty of excluding a certain person from the beneficiaries of resources. In other words, resources are non-excludable. The sustainability of

[1] Usually, public goods are defined as commodities that are not only non-excludable but also nonrival. In the case that commodities are regarded as coastal resources, these might diminish when a lot of stakeholders that access them exists. If so, the coastal resources are non-exclude, but not nonrival. These commodities are often distinguished from public goods and referred as “common-pool resources”. In this chapter, the nonrival property is not essential. Thus, we focus on problems that comes from non-excludability of the resources.

coastal resources requires stakeholders' contributions for maintenance. However, when resources are non-excludable, stakeholders can extract their benefits, even if they do not contribute to sustainability, leading to insufficient stakeholder contributions.

This section examines efficient schedules that protect coastal resources and provide implications for organizational design, such as the Bantay Dagat. Section 2 introduces a theoretical model of public goods provision and confirms the inefficiency of voluntary contributions. Section 3 provides optimal monetary incentives and implications.

2. A Model of Public Good Provision

This section confirms the logic that the supply of public goods tends to be insufficient by employing a formal model of public-good provision. The economic analysis examines stakeholders' decision-making and their consequences as equilibria. Section 2.1 constructs a model by introducing structures of stakeholders' benefits and costs through economic activity. Specifically, we define stakeholders and their utilities and then set their decision-making problems. Finally, in Section 2.2, we confirm that the model illustrates the logic behind the inefficient provision of public goods.

2.1 Basic Setup

There are $n \geq 2$ agents benefit from public goods and extend efforts to build these goods. The number of agents n can be interpreted as the population size of a region in which the agents live. Each agent $i \in \{1,2,\ldots, n\}$ can choose their effort level $e_i \geq 0$ and contribute to public goods. When agent i exerts effort e_i, this burdens agent i with a positive effort cost $C(e_i)$, given by

$$C(e_i) = \frac{c}{2}e^2,$$

where c is a constant and $c > 0$. A point of this effort cost setting is that the cost function $C(e_i)$ is increasing and convex in effort $e_i \geq 0$. To see this, we consider agent i who has already exerted effort $e_i = 1$, thereby bearing cost $c/2$. Note that this cost $c/2$ is also an increment due to an increase in effort from $e_i = 0$ to 1. If agent i tries to increase their effort to $e_i = 2$, then the effort cost increases by $3c/2$, strictly larger than $c/2$. This means that an increase in effort increases the original and additional costs. These efforts are interpreted as working hours. Participation in activities to manage public resources causes participants to spend their time. If a participant only works for 1 hour (h), the additional work hardly interferes with daily life. However, if they work for 5 hours, the additional work might significantly hinder them. In such a situation, the cost of spending working hours can increase and become convex. Theoretically, this assumption ensures solutions to the agent's utility maximization problems and equilibria. In addition to a common economic analysis, we introduce such an assumption into the effort cost $C(e_i)$. Constant $c > 0$ represents the relative size of the cost to the benefit from public goods, defined as follows:

This chapter describes the benefits of public goods as a function $\pi(e)$, given by

$$\pi(e) = \theta\left(\Sigma_j e_j\right) - \frac{d}{2}\left(\Sigma_j e_j\right)^2, \tag{1}$$

where $j \in \{1,2,\cdots,n\}$ and $\Sigma_j\, e_j = e_1 + e_2 + \cdots e_n$. Both θ and a are constant and $\theta > 0$, $d \geq 0$. The first term on the right-hand side of Equation (1) represents the effectiveness of public goods. This increases the sum of all agents' efforts. The second term describes the substitutability between agents' efforts. For a given $d > 0$, if the sum of agents' efforts increases, an additional contribution from an increment in the effort diminishes. The number of essential facilities or equipment may be limited for these activities in actual situations. If so, contributions per agent must become small, even if stakeholders are willing to spend much time and exert much effort on activities. In these cases, the effectiveness of per unit effort can be considered a decrease in the amount of effort. Another interpretation of d is that it represents the degree of diminishability of public resources. If $d = 0$, then the resources are completely non-rival. Otherwise, the greater the number of stakeholders, the smaller the benefits from the resources because these are diminishable. Both coefficients θ and d indicate the relative sizes of the effectiveness of public goods and substitutability between agents' efforts, respectively.

Next, we define the "utility" of agent i and social welfare. Agent utilities are measured by the difference between the benefits of public goods and effort costs. Formally, agent i's utility is given by the function

$$u(e) = \pi\left(\Sigma_j e_j\right) - C(e_i), \tag{2}$$

where e is a vector of all agents' effort $(e_1, e_2, \ldots, e_n)$. Social welfare is given by the sum of the agents' utilities:

$$v(e) = \Sigma_j u(e) = n\pi(e) - \Sigma_j C\left(e_j\right). \tag{3}$$

Utility represents the structure of each agent's benefits and costs. Social welfare provides a measure of the overall benefits to stakeholders.

2.2 Insufficient Contribution to Public Good Provision

This subsection highlights why public goods provision can be insufficient. To observe this, we begin with the case that the public-good provision is "sufficient." According to a common economic analysis, socially efficient effort maximizes social welfare. As the social welfare $v(e)$ given by Equation (3) is quadratic and concave, it has a unique effort level of e_i that maximizes $v(e)$ for each $i \in \{1,2,\ldots, n\}$. In the solution, effort e_i must satisfy the condition that the first-order derivative in e_i is equal to zero for each $i \in \{1,2,\ldots, n\}$. Thus, we have:

$$n\left[\theta - d\left(e_i + \Sigma_{j\neq i} e_j\right)\right] - ce_i = 0$$

for each $i \in \{1,2,\ldots, n\}$. Note that all the agents are identical in terms of utility. This leads to the conclusion that all agents exert equal effort. From $\Sigma_{j\neq i}\, e_i = (\text{n-1})e_i$, we have a socially efficient level of effort e_{fb}, given by

$$e_{fb} = \frac{n\theta}{c + dn^2}. \tag{4}$$

Hereafter, we refer to e_{fb} as efficient effort.

Next, we consider the case in which each agent individually chooses their effort levels and checks the result that the individual choice of effort becomes small compared to the efficient action, thereby being socially inefficient. When each agent exerts effort individually, the effort level maximizes their utility. Economists employ the concept of the Nash equilibrium to explore such effort levels. The Nash equilibrium is given by the following conditions: for all $i \in \{1,2,\ldots, n\}$,

$$e_i \in \max_{e_i} u(e),$$

where $u(e)$ is given by Equation (2). Note that even though agent i's utility is a function of their effort and all other agents' efforts, this equilibrium concept requires that each agent maximizes utility by choosing only their action for the other agents' efforts. If the condition holds for all agents, it means that each agent has no incentive to change their effort level.

We provide the Nash equilibrium. As in the case of an efficient effort, agent i's utility $u(e)$ is quadratic and concave in e_i. Thus, the effort level of agent i maximizing utility $u(e)$ is given by the first-order condition $\partial u(e)/\partial e_i = 0$. From the definition of the Nash equilibrium, the condition must hold for all agents $i \in \{1,2,\ldots, n\}$ in equilibrium. This provided a set of simultaneous linear equations.

$$\left[\theta - d\left(e_i + \Sigma_{j\neq i} e_j\right)\right] - ce_i = 0 \qquad \text{for all} \quad i \in \{1,2,\ldots,n\}.$$

Solving them, we have an equilibrium effort level e_i^*:

$$e_i^* \equiv \frac{\theta}{c+dn} \qquad \text{for all} \quad i \in \{1,2,\ldots,n\}$$

And we have

$$e_{fb} - e_i^* = \frac{\theta c(n-1)}{(c+nd)(c+n^2 d)} > 0 \qquad \text{for} \quad n \geq 2.$$

This result indicates that when agents voluntarily contribute to public goods, their contribution becomes insufficient compared to the socially efficient level. Recall that the benefit from the public good $\pi(e)$ is given by Equation (1). Under these circumstances, all agents' efforts contribute to the benefit. This means that each agent's contribution is distributed among all the agents. As the contribution of a certain agent gives all agents an advantage, it is efficient for each agent to contribute to improving all agents' utility in terms of social welfare. However, each agent is only interested in their utility. Agents recognize only their fraction of total benefits from public goods and do not have incentives to increase their contribution to the socially efficient level. In addition, agents' efforts are substitutable. That is, if an agent reduces their effort levels, the benefit from the public good can be maintained by an increase in other agents' efforts. Thus, agents can maintain their benefits, even if they are unwilling to contribute. This problem is referred to as "free rider." In free-rider problems, agents can benefit from other agents' contributions, thereby weakening their incentives to provide their contributions. Therefore, the contributions of all the agents become insufficient.

3. Monetary Incentives

This section examines the monetary incentives to induce agents' contributions to the public good. Furthermore, by focusing on the implementation costs of hiring agents, we provide implications for financing schemes.

3.1 Setup of an Extended Model

We consider the basic setup and add the following elements: A local government unit (labeled as "LGU") is interested in social welfare v (e). LGU can hire agents to contribute to public goods by remunerating their work hours. We assume that the effort levels e_i are observable. Thus, we can define the remuneration of agent i as a function of e_i. Let w (e_i) = we_i be the remuneration for agent e_i, where constant w represents the payment for hour.[2] Thus, agent i yields w per unit effort. We assume that when the remuneration is transferred from LGU to agent i, the LGU bears transfer costs $\tau \geq 0$ per unit of remuneration (e.g., 1 PHP). Then, if all agents are hired and exert efforts $(e_1, e_2, \cdots, e_n)$, the total cost of remuneration transfer becomes $\tau w \sum_j e_j$. The utility with the remuneration of agent i is given by:

$$U(e, w) = u(e) + we_i = \pi\left(\Sigma_j e_j\right) + we_i - C(e_i). \tag{5}$$

Social welfare under remuneration payment is defined as the difference between the social welfare v (e) provided by Equation (3) and the total payment $B\,\Sigma_j e_j + \tau B\,\Sigma_j e_j$, that is,

$$V(e, w) = \Sigma_j[u(e) + we_i] - \left(w\Sigma_j e_j + \tau w\Sigma_j e_j\right) = v(e) - \tau w\Sigma_j e_j.$$

As the remuneration payment $w\Sigma_j e_j$ is only transferred from LGU to agents, it does not affect social welfare. However, the transfer cost decreases welfare.

The economic activity was implemented in two stages. In the first stage, the LGU decides the payment amount for hour w. In the second stage, after all agents observe w, they choose their effort levels. Agents then yield benefits from both public goods and payments.

3.2 The Optimal Remuneration

We provide an equilibrium remuneration when agents individually choose their effort levels. LGU decides the payment for hour w considering the agents' effort choice under payment B. This requires that, for a given payment B agent i's effort choice e_i satisfies the condition that for all $i \in \{1,2,\ldots, n\}$, e_i maximizes agent i's utility U (e,w). This provides the following equilibrium effort level e (w):

$$e(B) = \frac{w + \theta}{c + dn} \qquad \text{for all} \qquad i \in \{1, 2, \ldots, n\}. \tag{6}$$

Agents' efforts are improved from e_i^* in the case of no monetary transfer, if $w > 0$. LGU chooses payment w so that social welfare $V(e$ $(w),$ $w)$ is maximized by considering that, for all i, e_i = e (w) holds. By some calculation, we have the equilibrium payment w (τ) that maximizes social welfare, as follows:

$$w(\tau) = \frac{\theta[c(n - 1 - \tau) - dn\tau]}{c + dn^2 + 2\tau(c + dn)} \qquad \text{for} \qquad \tau \in [0, \tau^*), \tag{7}$$

and $w(\tau) = 0$ for $\tau \geq \tau^*$, where

$$\tau^* = \frac{c(n-1)}{c+dn} > 0. \tag{8}$$

[2] Potentially, we can of course consider other forms of w (e_i). However, in this model, any kinds of forms of renumerations payment bring essentially different results. In this chapter, we employ a linear function of effort e_i as a simplest form of payment schedules.

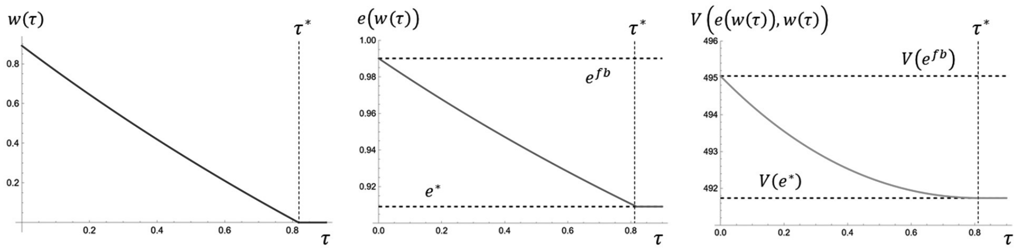

Figure 1 Equilibrium payment $w(\tau)$, effort levels $e(w(\tau))$, and social welfare $V(e(w(\tau)),w(\tau))$, ($n = 10$, $\theta= 10$, $c = 1$, $d = 1$). $V(e^{fb})$ and $V(e^*)$ are social welfare at effort levels e^{fb} and e^*, respectively.

Substituting $w(\tau)$ into $e(w)$ and $V(e\ (w),\ w)$, we obtain the equilibrium effort level $e\ (w(\tau))$ and the corresponding social welfare $V\ (e\ (w\ (\tau)),\ w\ (\tau))$. Appendix A.1 provides details of the derivation of the equilibrium.

We can observe the following properties in equilibrium: payment per work hour, agents' efforts, and social welfare. First, there is a threshold value τ^* of τ, such that if transfer costs τ is larger than τ^*, then payment $w\ (\tau)$ become equal to 0. In this case, the LGU does not hire agents to contribute to public goods. Thus, social welfare is equivalent to that in the no monetary transfer case. However, when τ is smaller than the threshold τ^*, LGU hires agents and pays $w\ (\tau) > 0$ per unit of effort e_i. In this case, the equilibrium payment, agents' efforts, and social welfare decrease in τ. The larger the transfer cost, the smaller the payment, effort levels, and social welfare. Conversely, a reduction in transfer costs increase them. If τ reaches its lower bound of 0, then monetary transfer achieves an efficient effort e^{fb} given by Equation (4). Intuitively, these results were straightforward. When the transfer cost τ is large, monetary transfers are costly. Hence, in those cases, the LGU is reluctant to use monetary transfers to maintain social welfare. Figure 1 describes the fluctuations in equilibrium outcomes caused by an increase in the transfer cost τ. Equilibrium payment $w\ (\tau)$, effort levels $e\ (w\ (\tau\ )$, and social welfare $V\ (e\ (w\ (\tau)),\ w\ (\tau))$ are indicated by the blue, red, and green lines, respectively. The horizontal axis indicates the transfer cost τ. We can see that in equilibrium, payment $w\ (\tau\ )$ decreases in τ and reaches 0 at $\tau = \tau^*$. Thus, the equilibrium effort and social welfare also decrease in τ. Conversely, $\tau = 0$, and the equilibrium payment leads to socially efficient effort and corresponding social welfare. On the other hand, if $\tau \geq \tau^*$, these outcomes reach outcomes in the case of voluntary provision.

3.3 Determinants of Transfer Costs

In the previous section, we see that the transfer cost τ becomes an important factor that induces contributions to public goods by employing monetary incentives. Usually, the transfer cost τ is interpreted as the taxation cost in economic analyses (Laffont and Tirole, 1993). When tax remuneration is provided, governments incur some costs for administration. Even if the remuneration resource does not include tax, it is unavoidable to bear this cost.

This section proposes other transfer cost sources that lead to implications for fundraising to organize the activities for the public good provision. Section 3.3.1 illustrates that the transfer cost can be interpreted as a financial cost. Section 3.3.2 states that if the budget constraints the LGU, such constraints can be virtually rewritten as the transfer cost, introduced in Section 2.1.

3.3.1 Financial Costs

We consider a situation where the LGU accesses outside investors to raise funds to organize activities for the public good provision. Many outsiders have an investment opportunity with a return of $r > 0$. Thus, if investors invest in this opportunity, they yield a return $1 + r$ per one unit of investment amount. We assume that the mass of investors is sufficiently large so that the liquidity demands of the LGU are completely covered. In addition, for simplicity, we assume that the investment opportunity is risk-free. That is, it has no possibility of default. Consider a situation where the LGU tries to collect liquidity from remunerating agents. Therefore, the LGU issues a bond with a face value $R > 0$. This means that the LGU should redeem the bond by repaying the face value R except in the case of default. Let $\epsilon \in (0,1)$ be the default probability. Thus, the expected value of the bond becomes $(1 - \epsilon) R$. Finally, let p be the issue price of the bond. Given the issue price p, LGU yields an amount of liquidity that is equal to p from outside investors and repays face value R to them.

We provide the issue price p. Note that the number of investors is sufficiently large. For a given price p, if investors buy the bond, they yield a return of this bond $r_B = (1 - \epsilon)R/p - 1$ per one unit of the investment amount. Subsequently, the return on the bond becomes $r_B = r$. A reason is as follows. If $r_B > r$ holds, then the LGU can increase issue price p and yield more liquidity. However, if $r_B < r$ holds, then investors prefer an alternative opportunity to the LGU bond issue. In this case, the LGU cannot yield liquidity. Equation $r_B = r$ provides the issue price.

$$p^* = \frac{(1-\epsilon)R}{1+r} < R,$$

where the inequality holds by $\epsilon \in (0,1)$ and $r > 0$. At this issue price, if LGU procures all the necessary liquidity, then LGU should repay $R/p^* = (1 + r) / (1 - \epsilon) > 1$ per unit of money. Recall the definition of the transfer cost τ in Section 3.1. In this case, because LGU procures liquidity $nw(\tau)\, e(w(\tau))$ and repays $(R/p)\, nw(\tau)\, e(w(\tau))$, we can rewrite the transfer cost τ using expressions of the return from investors' alternative opportunity and LGU's default possibility:

$$\tau = \tau_B = \frac{r+\epsilon}{1-\epsilon} > 0.$$

The transfer cost τ_B increases in both r and ϵ. When alternative investment opportunities provide investors a high return, the LGU needs to increase the return from its bond to induce investments. This decreases the issue price of the LGU bond, p^*. However, when the default possibility ϵ increases, the expected value of the bond redemption decreases. Thus, in addition to an increase in r, LGU reduces the issue price. Hence, both the high return from investors' alternative opportunities and the high default possibility of LGU bonds lead to an increased transfer cost.

3.3.2 Budget Constraint

In actual situations, whether the amount of remuneration for agents is sufficient might depend on the financial conditions of local government units. In Section 3.2, our model does not consider the budget constraint of LGU; instead, we consider the transfer cost, such that LGU bears the welfare loss τ per unit of payments. However, both situations can be regarded as equivalent.

We return to the setup in Section 3.2 and consider the case of the budget constraint. Recall that, for a given payment per unit of agent effort B, effort levels become $e\,(w)$ given by Equation (6). Again, we consider an optimal payment w such that it maximizes social welfare. Suppose that the transfer cost τ is equal to zero and the LGU prepares a budget $W \geq 0$ to remunerate agents for their contributions. In addition, suppose there is no fund for remuneration. Then, because the total amount of remuneration should not exceed budget W, LGU faces the following budget constraint:

$$nwe(w) \leq W. \tag{9}$$

From the budget constraint (9), we can first see a trivial case in which the budget W is equal to zero. In this case, because LGU cannot remunerate agents, the effort levels of agents are equal to those of the voluntary provision case in Section 3.1 (i.e., $e_i = e^*$). Thus, social welfare does not improve from voluntary provision. This corresponds to where the transfer cost is sufficiently high, as described in Section 3.2.

Second, when the budget W is sufficiently large, LGU can induce the socially efficient effort-level e^{fb} given by Equation (4). The total payment amount is provided by $nwe(w)$. If the effort level $e(w)$ for a given payment w is equal to e^{fb}, the corresponding payment e^{fb} is given by:

$$e^{fb} = e\left(w^{fb}\right) \qquad \Leftrightarrow \qquad w^{fb} = \frac{\theta c(n-1)}{c + dn^2}.$$

Thus, a sufficient budget is provided by $W^{fb} \equiv nw^{fb}\, e(W^{fb})$. Hence, when budget W is larger than W^{fb}, LGU achieves an efficient effort e^{fb}. This corresponds to the case that $\tau = 0$ in Section 3.2.

In the last case, the budget satisfies $W \in (0, W^{fb})$. In this case, the LGU uses up budget W. This means that budget constraint (9) holds with equality; that is, in the equilibrium, payment w satisfies $nwe(w) = W$. This equation derives the equilibrium payment, $\hat{w}(W)$, where

$$\hat{w}(W) = \frac{1}{2}\left(\sqrt{\frac{\theta^2 + 4nW(c + dn)}{n}} - \theta\right).$$

Let $\lambda(W)$ be a function on the amount of budget $W \in (0, W^{fb})$, such that

$$\lambda(W) = \left(\left.\frac{dV(e(w), w)}{dw}\right|_{w=\hat{w}(W)}\right)\left(\left.\frac{d\{ne(w)w\}}{dw}\right|_{w=\hat{w}(W)}\right)^{-1} > 0.$$

Then, in both cases, $W \in (0, W^{fb})$ and the transfer cost τ is equal to $\lambda(W)$ become equivalent. The value of $\lambda(W)$ is referred to as the "shadow cost." When LGU faces a budget constraint (9) and $W \in (0, W^{fb})$, budget W is too short to induce an efficient effort e^{fb}. Thus, even if the LGU is willing to induce more agents' efforts, it is impossible to raise payment w because of budget constraints. We can regard this situation as LGU choosing payment w so that it balances with the (shadow) transfer cost $\lambda(W)$. [3] Figure 2 shows the relationship between W and $\tau = \lambda(W)$. The horizontal axis indicates budget W. As we can see, the shadow

[3] Theoretically, this λ is a Lagrange multiplier for the budget constraint given by inequality (9) in following constrained optimization problem: LGU maximizes social welfare $V(e(w), w) - \tau nwe(w)$ subject to $nwe(w) \leq W$ and $w \geq 0$.

cost $\lambda(W)$ decreases in the budget W. Although it is difficult to derive from Figure 2, $\lambda(W)$ is not linear, but a convex function of W.

3.4 Timings of Fund-Raising

In the above section, we consider the budget constraint and state that it can be rewritten as the transfer cost using the expression of the shadow cost. This section considers the timing of the fundraising. It is thought that the timing of fundraising is closely associated with budget allocation. Consider the hierarchical structure of an organization that manages its activities. When the upper layer of the organization has authority over budget implementation, the budget is established by the upper layer and allocated to the lower layer. In this case, the lower layer determines the remuneration schedule for agents within the predetermined budget. However, when the authority of budget implementation is delegated, the lower layer can determine remuneration schedules and budget size. In addition, the lower layer could use alternative sources of the budget as typified by donations other than the public finance such as taxation, bank loans, or bond issues. In this case, the budget becomes more flexible because the lower layer can raise funds as needed to remunerate agents by using various ways. This section examines the effect of budget flexibility on contributions to provide the public good. We then offer implications for the authoritative allocation of budget implementation.

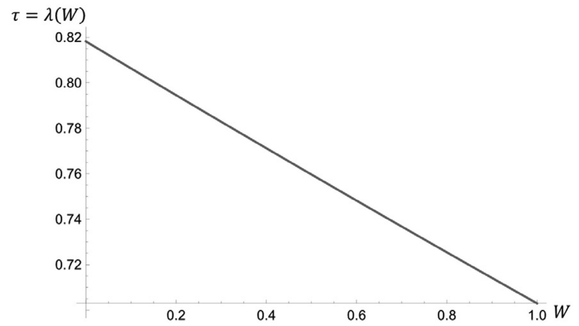

Figure 2 Shadow cost $\lambda(W)$ ($n = 10$, $\theta = 10$, $c = 1$, $d = 1$)

Suppose that transfer cost τ is the financing cost, as discussed in Section 3.1. We compare two cases of fundraising timing. In the first case, the LGU prepares the budget after it decides on the amount of payment w. In other words, the LGU raises funds for a given financing cost τ as much as the total payment $nwe(w)$. In this section, we refer to this case as the noncommitment case. This case is discussed in section 3.2. In the second case, the LGU prepares the budget by ex-ante fundraising. It raises funds W before it decides the amount of payment w. We assume that the LGU cannot collect any supplementary funds. Thus, the LGU commits to the total amount of payment W ex-ante and decides the payment w for the given budget constraint. These two cases differ in terms of the flexibility of the budget. The noncommitment case allows LGU changes the budget at the timing of the decision of payment w. On the other hand, in the commitment case, the budget is fixed.

To consider the difference between both cases, we introduce two additional assumptions. Firstly, we assume that LGU should expend a fixed cost to implement the activity. In addition, the fixed cost in the noncommitment case is larger than the one in the commitment case. Instead of the flexibility of the budget, LGU bears additional costs for budget control. Formally, in the commitment case, LGU bears the fixed cost $f \geq 0$ if it hires agents. In the noncommitment case, the fixed cost becomes $f + \Delta$, where $\Delta > 0$. To exclude a trivial case that LGU cannot hire agents because of a high fixed cost, we assume that f and Δ are sufficiently small. Secondly, we assume that, in the noncommitment case, the lower layer which decides payment w has an endowment. The amount of endowment is equal to $f + \Delta$ and the lower layer can appropriate the fixed cost. The noncommitment case is interpreted as the authority to control the budget being delegated to the lower layer. We consider the situation that the lower layer can access alternative sources for fundraising such as donations from private firms, NGOs, or something. On the other hand, in the commitment case, the budget comes from only the public finance of LGUs.

The timing of the decisions is as follows: At stage 0, only in the commitment case, the LGU decides the budget W given the financing cost τ. At stage 1, in both cases, the LGU chooses a payment per unit of effort w. In the commitment case, the total payment amount is constrained by budget W. In the non-commitment case, the payment is not constrained, but the LGU bears a financial cost τ per unit payment. In Stage 2, LGU expends the fixed cost and each agent exerts an effort.

We begin with the case of non-commitment. Note that, in this case, the fixed cost $f+\Delta$ does not affect effort incentives of agents. Thus, the decision problem of payment w in this case is equivalent to that described in section 3.2. Hence, we have agents' effort $e(w)$ and payments $w(\tau)$ given by Equations (6) and (7), respectively. This leads to the corresponding social welfare, $V(e(w(\tau)),w(\tau))-(f+\Delta)$.

Next, we consider the case of a commitment. In this case, because LGU expends the fixed cost f, the budget that is available to hire agents becomes $W-f$ for given the total budget W. Thus, the LGU faces the budget constraint $nwe(w)\leq W-f$ and chooses payment w within the budget. At stage 2, each agent decides their effort level for a given payment w. Even in this case, the agents' utility maximization does not change. Thus, agent effort leads to the same result in the non-commitment case $e(w)$ given by Equation (6). At stage 1, LGU maximizes social welfare for the given equilibrium agent effort $e(w)$ and budget constraint. Recall that budget $W-f$ can be transformed into the shadow cost $\lambda(W-f)$. Thus, by considering the shadow cost $\lambda(W-f)$ as the transfer cost, we derive the equilibrium payment $w(\lambda(W-f))$. Substituting into the agents' efforts and social welfare, we have the corresponding outcomes $e(w(\lambda))$ and $v(e(w(\lambda)))$, where $\lambda=\lambda(W)$. Note that, in this stage, LGU does not bear the financial cost τ because the equilibrium payment $w(\lambda)$ comes from the given budget. Thus, we use an expression $v(\cdot)$ which represents social welfare without the financing cost. At stage 0, LGU chooses the budget W for a given payment $w(\lambda)$ and agents' effort $e(w(\lambda))$ so that W maximizes social welfare. As LGU bears financing cost τ per unit of budget W, it maximizes the difference between social welfare and financing cost:

$$v\big(e\big(w(\lambda)\big)-f-\tau W \tag{10}$$

where $\lambda=\lambda(W-f)$.

Providing the equilibrium outcome of this maximization problem in both cases, we can characterize a relationship between the financial cost and timings of the fundraising. Let $\tau^{**}=\Delta/k$ be a threshold value of the financial cost τ. We consider the case that τ^{**} is in the interval $(0, \tau^{*})$, where τ^{*} is defined by equation (8). Then, we can derive the result that, for $\tau<\tau^{**}$, social welfare in the commitment case is larger than that in the noncommitment case, and for $\tau>\tau^{**}$, the opposite holds. In other words, when the financial cost τ is relatively small, ex-ante fundraising improves social welfare. Conversely, when the financial cost τ is large, ex-ante fundraising diminishes social welfare. Appendix A.2 presents the derivation of this result.

These results have the following implications. Budget flexibility affects the performance of the activity to contribute public goods. Moreover, the effect of budget flexibility depends on the level of the financing cost. If the financing cost is sufficiently small, the delegation of authority to control the budget hurts the performance of the activity. Hence, it is desirable that the upper layer controls the budget and the lower layer implements the activity within the given budget. This result arises even if the lower layer can use alternative sources to raise funds. However, if not, the budget flexibility expands the performance of the activity. Hence, authority to control the budget must be delegated to the lower layer.

4. Other Related Works

This section introduces some useful theoretical works other than the analysis in Section 2 and Section 3.

4.1 Fund Allocation Within the Organization and Negative Effects of "Winner Picking."

Consider a case in which LGU manages two or more divisions to contribute to coastal management activities. If the LGU pursues a performance or achievement of the activities and expects them, it might concentrate resources on divisions expected to yield better performance. Intuitively, such resource allocation based on the predicted performance seems to be effective because LGU can choose the efficient use of resources by "winner picking," that is, LGU picks up a division that dominates others in terms of performance. However, it is highlighted that winner picking negatively affects the expected performance ex-ante.

Brusco and Panunzi (2005) argue that "winner picking" is inefficient in the literature on internal capital allocation within multi-divisional firms. They consider a firm consisting of two divisions. Each division creates internal reserves through its activities that are reallocated within the firm's projects and investment divisions. As internal reserves are transferred between divisions, another division risks exploitation even if each division gains inner reserves. This harms divisions' ex-ante incentives to acquire internal reserves. Thus, ex-ante, winner picking diminishes the expected internal reserves, decreasing firm value.

In Brusco and Panunzi's (2005) model, headquarters can intervene in divisions' activities through capital allocation. Here, we can regard the headquarters as having the authority to implement the budget. If the organizational structure is multi-layered, the distribution of such authority affects the performance of the activities. Aghion and Tirole (1997) consider a two-layered organization that consists of a boss and their subordinate and argue that the delegation of formal authority induces subordinates' efforts. Dessein (2002) extends the idea of Aghion and Tirole (1997) by considering communication, established as a standard model in Crawford and Sobel (1982) between the boss and subordinate. Prendergast (2002) examined the relationship between the allocation of authority and compensation schemes.

4.2 Performance Measures of Contribution

As Brusco and Panunzi (2005) noted, winner picking might diminish the performance of ex-ante activities. In such a case, it could be desirable that the LGU is insensitive to implementing activities on the premise that it has the authority to allocate the budget.

Amemiya (2019) constructs a model to examine executive compensation in multi-divisional firms by extending Brusco and Panunzi (2005). This study shows that the pay-for-performance sensitivity of the compensation scheme increases with the degree of uncertainty of a project's productivity. In particular, if the degree of uncertainty is sufficiently small, the compensation does not depend on firm performance. Such fixed compensation cannot induce the efforts of executive officers. However, this could mitigate the negative effect of winner picking.

4.3 Alternative Sources of Income

The protection of MPAs prohibits the restriction of fisheries. Thus, establishing alternative sources of fishers' income could be an important issue. The management of coastal resources often includes creating new businesses represented by eco-tourism. However, when the profitability of a new business is uncertain, entry into the industry could result in a loss.

Amemiya, Ishihara, and Nakamura (2021) examine a firm's pre-emptive entry into the market competition.[4] They assume that each firm can gain private information on stochastic demand and consider the effect of pre-emptive entry as a signal of the information. They show that only if the firm is ignorant of the market size compared to the other firm, it tends to enter the market pre-emptively. However, pre-emptive entry diminishes producer surplus in the industry. Although the pre-emptive access of the ignorant firm is relatively worthless for itself and potential competitors, it can enclose many demands by pre-emptive entry.

5. Concluding Remarks

This chapter examines the optimal incentive schemes to contribute to MPA management. In addition, focusing on the costs for the incentive schemes, we imply that delegating authority of the budget implementation is desirable if the cost of fundraising is relatively high. However, several issues must be considered.

First, in this chapter, we have not focused on specific financing schemes and have not designed an efficient way of raising funds to compensate for the cost of activities to protect coastal resources. In the Philippines, under the local government code of 1991, LGUs can use broad discretion to access private capital. Therefore, the analysis must progress according to corporate finance literature that considers the performance of organizations through financing schemes. Second, in addition to common economic analysis, the results of this chapter also depend on some unobservable determinants, especially the benefits from public goods θ and d. If we try to apply this theoretical analysis to the actual management activities of MPAs, we must indirectly estimate the actual benefits realized by stakeholders. For example, Shinbo, Launio, and Morooka (2011) and Ballad, Shinbo, and Morooka (2018) estimate willingness to pay and willingness to "work" to contribute to the management activities of MPAs by using data from the questionnaires and interviews. Even though many issues remain, we hope this analysis provides researchers with a clue to improve organizational structures and institutions for coastal resource management.

Appendix

A.1 Derivation of $w(\tau)$ and Properties of Equilibrium Outcomes

First, we provide $w(\tau)$ and $e(w(\tau))$. Substituting $e(w)$ given by Equation (5) into $V(e,w)$, we have

$$V(e(w),w)= n(w+\theta)\{(dn^2+2ch-c)-w\phi\}\psi^{-1},$$

where $\phi \equiv c+dn^2+2\tau(c+dn)>0$ and $\psi \equiv 2(c+dn)^2>0$. Taking the first-order derivative, we have

$$n\{\theta(c(n-1-\tau)-dn\tau)-w\phi\}\psi^{-1}. \tag{A1}$$

The first-order derivative ($A1$) is negative if $c(n-1-\tau)-dn\tau<0$. In this case, w reaches a lower-bound 0. Otherwise, w satisfies the condition $dV(e(w),w)/dw=0$. So

$$w=\theta[c(n-1-\tau)-dn\tau]\phi^{-1}. \tag{A2}$$

Thus, $w(\tau)=0$ if $\tau \geq \tau^* \equiv [c(n-1)](c+dn)^{-1}$ and otherwise, $w(\tau)$ is given by Equation ($A2$). Substituting w

[4] This paper constructs an extended setup of the Stackelberg competition model with private information established by Gal-Or (1987). Shinkai (2000) and Cumbul (2021) provide other forms of extension of the Gal-Or's model.

(τ) into $e(w)$, we also have $e(w(\tau))$ as follows:

$$e(w(\tau)) = \theta (n + \tau) \phi^{-1} \quad \text{if} \quad \tau \in [0, \tau^*),$$

and $e(w(\tau)) = e^* = \frac{\theta}{c+dn}$ if $\tau > \tau^*$. Similarly, we have $V(e(w(\tau)), w(\tau))$ as

$$V\big(e(w(\tau)), w(\tau)\big) = \begin{cases} \theta^2 n(n+\tau)^2(2\phi)^{-1} & if \quad \tau \in [0, \tau^*), \\ \theta^2 n[(2n-1)c + dn^2]\psi^{-1} & if \quad \tau \geq \tau^*. \end{cases}$$

Next, we present the properties of $w(\tau)$, $e(w(\tau))$, and $V(e(w(\tau)), w(\tau))$. If $\tau \geq 0$, then $w(\tau)$, $e(w(\tau))$, and $V(e(w(\tau)), w(\tau))$ are independent of τ because $w(\tau) = 0$. For $\tau < \tau^*$, taking the first-order derivatives concerning τ, we have

$$\frac{\partial}{\partial \tau}[w(\tau)] = -\theta(c + nd)[(2n-1)c + dn^2]\phi^{-2} < 0,$$

$$\frac{\partial}{\partial \tau}\big[e\big(w(\tau)\big)\big] = -\theta[(2n-1)c + dn^2]\phi^{-2} < 0,$$

$$\frac{\partial}{\partial \tau}\Big[V\Big(e\big(w(\tau)\big), w(\tau)\Big)\Big] = -\theta^2 n[(2n-1)c + dn^2]\phi^{-2} < 0.$$

A.2 Derivation of the Result in Section 3.4

If $\tau \geq \tau^*$, LGU does not hire agents. In this case, social welfare is equal to that by the voluntary provision which is discussed in Section 2.2. In this section, we focus on the case that $\tau^{**} \in [0, \tau^*)$.

In the noncommitment case, equilibrium social welfare V^{NC} is given by

$$V^{NC} = \theta^2 n(n+\tau)^2 (2\phi)^{-1} - f - \Delta.$$

In the commitment case, for given the budget $W - f$ and the equilibrium effort level $e(w(\lambda))$, we can derive the shadow cost λ as follows:

$$\lambda = \{\sqrt{n}\,[dn^2 + c(2n-1)] - \xi(c + dn^2)\}\,[2\xi(c + dn)]^{-1}, \tag{A3}$$

where

$$\xi = \sqrt{4(W-f)(c+dn) + \theta^2 n}.$$

Under λ given by equation (A3), LGU maximizes social welfare given by equation (10) by choosing the budget W. This maximization problem can be solved as

$$W^* = k + \{\theta^2 n(n+\tau)[c(n-1-\tau) - dn\tau]\}\,[c + 2c\tau + dn(n+2\tau)]^{-1}.$$

And we have equilibrium social welfare V^C as follows:

$$V^C = \theta^2 n(n+\tau)^2 (2\phi)^{-1} - (1+\tau)f.$$

Taking a difference between V^{NC} and V^C, we have the result that $V^{NC} \geq V^C$ if and only if $\tau \geq \Delta / f$.

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