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Abstract

This paper establishes an ecotourism model to analyze the role of local residents and government in achieving sustainable development. By incorporating into the model the properties of common-pool resources to which the tourism activities are linked, we prove that ecotourism cannot guarantee sustainable development for a rural area unless it is accompanied by suitable policies to reduce firms numbers and/or a tourist tax. More specifically, we find two stable equilibria: one characterized by low or even a zero level of natural resources, and the other a high level. In the low equilibrium, extinction or zero stock of natural resources occurs under open access to zero transport cost and marginal environmental maintenance cost. The high equilibrium corresponds to higher social welfare, and that can be assured by policies of a tourist tax, license fee, limiting the number of firms and restriction on the population of potential tourists. More importantly, we prove that although the high equilibrium is better than low equilibrium, it may not be optimal. The optimum welfare can only be achieved by a direct tax on tourists, not solely by policies controlling the number of firms.

Classification : Q01, Q57, L83

Key Words : Ecotourism, Common-pool Resources, Sustainable Development, Tragedy of Commons

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1 Introduction

Most remote and undeveloped areas are economically impoverished but biologically and environmentally rich, with clean air, water, charming landscapes, forests, wildlife, lack of noise etc.. The combination of economic growth, progress in information and transportation technology, excessive urban growth and environmental consciousness elevates the attractiveness of rural areas. Thus ecotourism is often considered as a suitable development strategy for the rural areas.

However, the natural resources upon which tourism relies are a typical type of common pool resources (CPRs) as addressed by Hardin (1968) and later by Ostrom (1990,1999), characterized by the non-exclusiveness from one user to another. In addition, tourism activities are to some extent detrimental to the environment resources. As a result, the overuse due to the common pool property of the resources will inevitably lead to a higher depletion rate than its intrinsic recovery rate. Thus, the natural resources begin to decline, and finally are fully exhausted extinct unless the visitation rate of tourism can be controlled to a certain degree below the limit of the environmental carrying capacity.

In sum, the natural resources behind ecotourism, like all types of CPRs, are inherently subject to reciprocal externalities in the form of short-run congestion and long-run depletion. How to manage the natural resources and protect them from extinction is the key to making ecotourism for local development sustainable.

How to manage common pool resources is a classic and important issue. Several approaches have been raised in the literature. Firstly, as advocated initially by Hardin (1968) and most recently by Holden (2005), there is a moral or environment ethic approach calling for the requirement of morality consciousness to make CPRs sustainable. However, in an experimental study, Osése-Eraso et al. (2008) shows that that ‘concern’ for resource scarcity is not enough to prevent resource depletion. Once the players believe some others may not have the concern and anticipate the likely of depletion in the future, the extraction activities will be speed up and lead to earlier depletion.

Secondly and not surprisingly, there is a “fences and fines” approach, calling for the regu-

lations to restrict access and thus to protect the natural resources. Typical examples are the establishment of national park and reservation areas. However, the fences-and-fines method is well documented in many regions and cases as having failed to stop the human behaviors of poaching, illegal logging, mining and destructive development activities such as land clearing.¹ Consequently, we observe a significant decline of wild life population, forest areas, etc..

Finally and probably the most debated in the literature is the market approach. The approach calls for designing a market-based measure to provide economic incentive, especially for the indigenous community, to protect the common pool resources. It is hoped that through the market mechanism we can integrate harmoniously the conservation of natural resources and local community development. In this regard, ecotourism is often raised as one of the most popular and promising strategies in the last several decades, as addressed by Holden et al. (2014). However, as noted by Coria and Calfucura (2012), the success of ecotourism depends on three complicated aspects, i) distribution of benefits, ii) community control over land and resources, and iii) power relations between the stakeholders. Thus, how effective is the ecotourism seems to be dubious.

Firstly, due to the involvement of many stakeholders, including not only the local residents but also outside investors and government, and lack of a fair distribution mechanism², only a very small portion of the tourism benefit goes to the local communities, thus contributing very little incentive for local residents to protect the common resources. Examples are the integrated conservation-development projects (ICDPs) widely established in Africa and other areas, as described in Barrett and Arcese (1995).

Secondly, there is an inherent income effect on resources conservation in the ICDPs. More specifically, there are two basic instruments in the ICDPs for the purposes of development and conservation: benefit-sharing of game meat distribution and the monetary transfer from tourism to local residents. However, as analyzed in Barrett and Arcese (1998) and Johannesen (2006) in a bio-economic model, both the instruments may in the first step increase the income of local residents, which will in turn induce more demand for the game meat. Consequently,

¹See Barrett and Arcese (1995) and the references therein.

²See Coria and Calfucura (2012).

the illegal hunting becomes more severe, under the weak linkage between money transfer from tourism and fines for illegal hunting.

In addition to the small-portion reward problem and negative income effect, an important element, that is not considered in the above mentioned articles but should play a key role in the failure of ecotourism strategy, is the market failure due to the common-pool property. Thus, the theme of this paper is to illustrate that the inherent properties of common goods can lead to market failure of the ecotourism, even if all the tourism benefit goes to the local community. In other words, this paper is to show that, while ecotourism is a commonly suggested strategy for a form of economic development in harmony with conservation the natural resources, the market mechanism itself cannot guarantee success without a suitable policy design.

As mentioned earlier, the natural resources behind ecotourism are in general characterized by common pool properties. More specifically, the local residents can operate tours and compete with each other to serve as many tourists as possible to maximize his/her earning. Thus intuitively, the common pool theory in the existing literature on renewable resources such as the fishing industry can be applied directly.³ However, there are some unique features of tourism products in contrast to other renewable resources, and thus tourism deserves a special treatment in the modeling. First of all, since the consumption of the tourism products requires personal arrival, transportation cost is borne by the tourists. Thus, accessibility of the area, mainly the transport cost and/or regulation by the government, becomes an important factor in determining the market equilibrium. Secondly, demand for ecotourism service varies from individual to individual depending on the level of income, wealth, education and other personal features. In other words, visitors are heterogeneous in preference on tourism; more specifically, people usually gain different utility levels from visiting the same natural resort. In this regard, the tourism product is different from other renewable resource products, and thus deserves different treatment, considering the degree of accessibility and the heterogeneous consumers.

The rest of this paper is organized as follow: Section 2 establishes the model, and solves for

³Basically, we will borrow the approaches commonly adopted in fishing economics, i.e., optimal catching problem as in the related literature of Gordon (1954), Clark and Munro (1980), Clark (1990), Berck and Perloff (1984), Neher (1990), Fan and Wong (1998) etc. to build our model by considering the unique properties of ecotourism to be discussed later.

equilibrium under a free market. It will be shown that the opening up of tourism resources may lead to low- or high-level resource equilibrium, depending on the accessibility cost, number of operators and population of potential tourists. In extremes, under zero access cost and when the tourist population size is too large or local operators are too numerous, the tourism resources will become extinct, an ecotourism version of the tragedy-of-commons. Section 3 conducts comparative statics to analyze the roles for access cost, number of operators, and tourist population in affecting the equilibrium, upon which the policy implications for how to achieve high equilibrium through either a tax on tourists, imposing operation licenses or direct firm-number controls, will be discussed during the analysis. Section 4 turns to the welfare for the local community as a whole. And we prove that even though the high-level equilibrium is better than the low-equilibrium, it may not be optimal; the optimal level of welfare cannot be achieved by merely the firm-number control policy without the tourist tax.

2 The model

Consider a biological resource, a newly discovered ecological resource in a village. With the advantage of better information on the resource, the local resident can operate a service business for tourists to earn extra income. Assume each of the tourists pays a price of P to receive the tour service. The price level will negatively affect the potential number of tourists as generally reflected in a demand function which we now turn to.

2.1 Demand for ecotourism

Tourists attending an ecological tour are not homogeneous in general, due to the different education levels, cultural backgrounds and/or income levels. To model this feature of heterogeneous consumers, we follow the setup by Gayer and Shy (2003). Assume that those who decide to be ecotourists will have to pay a given amount of direct or indirect transport cost τ to reach the destination. In addition, he/she also has to pay to the local resident operator fee P for the service to visit the ecological place. As a result, only the people with positive utility from attending the tour after paying the total costs of $\tau + P$ will visit the ecological site. For convenience we use index x to represent a potential tourist. Assume x is a random variable

of uniform distribution with range of $[0,1]$, with p.d.f. $g(x) = 1$. Obviously, $G(1) = 1$ and $G(0) = 0$, where $G(\cdot)$ denotes the accumulated p.d.f. of x . Let the total number of potential tourists be N , which can be interpreted as the population size of the underlying economy if every person is allowed to visit the ecological area, or as the population of the legally permitted group. His net utility of attending the tour can be described as follows:

$$U(x) = \begin{cases} S \cdot x - \tau - P, & \text{if attending the tour} \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

where S represents the current stock of the natural resources in the ecological site. Equation (1) denotes the net utility of a potential tourist from attending the tour, which is equal to the utility earned from visiting the ecological site minus total cost of transport and service fee.

Clearly, under this set-up, different tourists have different levels of net utility earning, depending on his/her preference represented by x . Higher x represents higher preference in the ecological tour, and thus, a tendency to earn higher utility and a higher likelihood of attending the tour. Theoretically, there exist a marginal tourist, denoted as x_0 , to whom attending the tour or not makes no difference in net utility. That is,

$$S \cdot x_0 - \tau - P = 0,$$

hence, the marginal tourist can be denoted as

$$x_0 = \frac{\tau + P}{S}. \quad (2)$$

There are two factors determining the marginal consumer: the total cost of attending the tour, i.e., transport cost and service charge ($\tau + P$), and the stock of natural resources S . The discussion can be illustrated geometrically by Figure 1. The horizontal axis in the figure represents x , individual index, ranging between 0 and 1. And x_0 represents the marginal tourist. A potential tourist on the left-hand side of the marginal individual x_0 earns a negative net utility from the tour, and therefore will not join. Consumers on the right-hand side of x_0 , i.e., $x \in (x_0, 1]$, earn a positive net utility of $S \cdot x - \tau - P > 0$ from the tour, and hence will decide to join.

[Insert Figure 1]

By the assumption of the uniform distribution of x and population size of N , x_0 equals the share of the population not taking the tour, and $(1 - x_0)$ the share taking the tour. Let n be the total number of tourists; then accordingly $n = N(1 - x_0)$. Thus, x_0 can be solved as follows:

$$x_0 = \frac{N - n}{N}.$$

Substituting x_0 into equation (2) yields

$$P = \left[S \left(\frac{N - n}{N} \right) - \tau \right]. \quad (3)$$

Equation (3) is obviously the inverse function of demand for ecotourism, reflecting the negative relationship between the service fee P and number of tourists n . Clearly, the higher the P and/or τ , the lower the number of tourists n . In addition, the higher the S or N , the larger the number of tourists n . Note that incorporating the heterogeneous consumers and the population size N allows us to analyze the population growth effect of depleting the common resources as frequently mentioned in the literature, e.g. Hardin (1998).

2.2 The dynamics of natural resources

Let $f(S)$ be the reproduction function of the natural resources, for example a forest, meadow, special variety of fishes or some particular natural scenery,⁴ which is a function of the current level of stock S and the carrying capacity K . The function takes the following form as below:

$$f(S) = r \cdot S \left[1 - \frac{S}{K} \right]. \quad (4)$$

The function contains some important ecological sense. Firstly, r represents the ‘intrinsic’ growth rate of the natural resources. In addition, the constant K represents the carrying capacity⁵ of the natural resource. As $S = K$, the natural resource reaches the maximum capacity, and the amount of reproduction equals zero. Thus, the resource will not grow anymore. It will be easy to see that $S = K/2$ corresponds to the turning point of the reproduction curve and is the maximum value of $f(S)$ for equation (4). That is, when $S = K/2$,

⁴The Logistic functional form, which is widely adopted in the field of resources economics, can be traced far back to the ecological economist, P.F. Vorhulst (1838).

⁵The carrying capacity for land is the largest number of living animals (number of tourists in our case) which it can support. If the population of its supported animals is beyond (below) the capacity, then the living environment would begin to decline (increase). See Salerno et al. (2013) and Libosada (2009) for the similar concept of carrying capacity in the tourism industry.

the amount of reproduction reaches the maximum level, i.e., the maximum sustainable yield (MSY) of the ecosystem.

$$S^{MSY} = \frac{K}{2}. \quad (5)$$

If the resource stock is less than one half of the carrying capacity, that is, $S < K/2$, then the amount of reproduction will increase as shown by $f'(S) > 0$. On the contrary, when the current stock is greater than one half of the carrying capacity i.e., $S > K/2$, then the amount of reproduction will decrease ($f'(S) < 0$), although the stock still increases ($f(S) > 0$).

The change rate with respect to time of the natural resources, denoted as \dot{S} , can be defined as below:

$$\dot{S} = f(S) - \theta \cdot n, \quad (6)$$

where θ is a constant and represents the average amount of resources depleted by a tourist. Thus, $\theta \cdot n$ is total depletion amount of the natural resources when there are n visitors. In other words, there are two factors determining the change rate of the natural resources level: one is the amount of reproduction; the other the depletion effect arising from visitors. At equilibrium, the change rate of the natural resources is equal to zero ($\dot{S} = 0$), and the amount of reproduction should equal the total amount of depletion by visitors. That is,

$$f(S) = \theta \cdot n. \quad (7)$$

In fact, (7) is essentially the same as the equilibrium of the “predator-prey” model of Lotka-Volterra, in the sense that tourists are the predator while the natural resources are the prey. Thus, if the total amount of depletion $\theta \cdot n$ is greater than the amount of reproduction $F(S)$, that is, $\theta \cdot n > F(S)$, then the level of natural resources will decline ($\dot{S} < 0$). On the contrary, if the amount of depletion is less than the amount of reproduction, then the stock will increase, i.e., $\dot{S} > 0$.

Furthermore, according to the equations representing the balance of the ecosystem, (4) and (7), we can derive the number of tourists which will keep the ecological system at balance, n , as below:

$$n = \frac{1}{\theta} \cdot f(S) = \frac{r \cdot S}{\theta} \left[1 - \frac{S}{K} \right]. \quad (8)$$

Obviously, factors affecting the equilibrium number of n include the intrinsic growth rate of the natural resources, r , the carrying capacity of the environment, K , the average depletion rate by a visitor, θ , and the stock of natural resources, S .

Graphically, the relation between n and S indicated by equation (8) can be depicted as the SS -line in Figure 2. All the points above the SS -line imply too many visitors for the current stock of S , thus $\dot{S} < 0$, S must decline, as shown by the leftward arrows. On the other hand, any point below the SS -line implies the number of visitors is low enough that the resource stock will grow, i.e., $\dot{S} > 0$, as indicated by the rightward arrows.

Simple algebra on equation (8) yields

$$\frac{\partial n}{\partial S} \gtrless 0, \text{ if } S \gtrless \frac{K}{2}, \text{ and } \frac{\partial^2 n}{\partial S^2} < 0.$$

That is, the SS -line is concave and passes through the origin $(0,0)$ and point $(K,0)$. In addition, n reaches the highest value $rK/4\theta$ at $S = K/2$, the most sustainable yields as defined in the literature, denoted as n^{MSY} hereafter.

[Insert Figure 2]

2.3 Supply of ecotourism

Let m be the number of operators organized by the local residents. Each operator under the given demand function of equation (3) decides the number of tourists to maximize his profit or utility. We also assume that operators are identical in terms of the cost structure and the service provided. In addition, we assume that there is Cournot-Nash competition between them, that is, each operator takes the other's amount of service supply as given. Let n_i be the total tourists served by operator i ; thus the total number of tourists n is:

$$n = \sum_{j=1}^m n_j.$$

Let c be the marginal service cost, and F be the fixed cost, including an established cost and/or license fee, for each operator to run the business legally. Then, the operator's profit can be written as

$$\pi_i = (P - c) n_i - F.$$

By using the demand equation (3), π_i can be rewritten as

$$\pi_i = \left[S \left(\frac{N-n}{N} \right) - \tau - c \right] n_i - F. \quad (9)$$

Under Cournot-Nash competition ($\partial n_j / \partial n_i = 0$, $j \neq i$), solving the representative operator, i 's, maximization problem yields the first-order condition as below:

$$\frac{\partial \pi_i}{\partial n_i} = \left(S \cdot \frac{N-n}{N} - \tau - c \right) + n_i \left(\frac{-S}{N} \right) = 0.$$

At equilibrium, identical cost structure will assure that an equal amount of tourists will be served by each operator, that is, $n_i = \bar{n}, \forall i$. Thus, $n = \sum n_i = m\bar{n}$, or $n_i = n/m$. Consequently, the first order condition can be simplified further as

$$n \cdot \left(1 + \frac{1}{m} \right) = N \left(1 - \frac{\tau + c}{S} \right). \quad (10)$$

This is the equilibrium relation between n and S under a given m , to be represented by the nn -line in Figure 2. Simple algebra on equation (10) shown that $\partial n / \partial S > 0$, and $\partial^2 n / \partial S^2 < 0$, indicating the concave property of the nn -line. And obviously, $S = \tau + c$ at $n = 0$.

In addition, any point above the nn -line indicates that the operator is serving too many visitors, and will reduce the number of tourists to raise profit, as is shown by the downward arrows. On the other hand, any point below the nn -line means increasing visitors will increase the operator's current profit, and thus more tourists will be served, as shown by the upward arrows.

According to equation (10), factors affecting the number of tourists that the operators are willing to serve can be classified into two groups as below: Firstly, there are positive factors, including m (number of operators), S (the stock of natural resource) and N (population of potential tourists). Secondly, there are negative factors including the sum of $\tau + c$, where τ represents all the direct and indirect access cost borne by each tourist; and c the environmental maintenance cost per tourist borne by the operator.

2.4 Equilibrium

At equilibrium, equations (8) and (10) should hold simultaneously. Let S^* and n^* denote the equilibrium value. Clearly, the solution of S^* and n^* can also be represented graphically by the

cross points of the SS - and nn -lines of Figure 2. According to the properties of the SS - and nn -lines, there are at most three equilibria which are depicted as E_L (noted as low equilibrium hereafter), E_1 and E_H (noted as high equilibrium hereafter) in Figure 2. Obviously, the number of solutions can be reduced to one or even zero, depending on the relative position and shape of the two lines. Clearly, in the three-equilibrium case, the corresponding stock of resources S_H^* at E_H is higher than S^{MSY} , while both S_1^* at E_1 and S_L^* at E_L are less than S^{MSY} . As indicated by the directional arrows, both points E_L and E_H are stable, while E_1 is not. See appendix 1 for mathematical proof of stability conditions. In addition, if the operators can instantaneously adjust the number of tourists, then the adjustment path would coincide with the nn -line, indicating also the property of stability for E_L and E_H and instability for E_1 .

3 Comparative Statics

We are now ready to conduct the comparative statics analysis to see how the equilibria are affected by the parameters, especially those policy-related ones. By totally differentiating equations (8) and (10), we have

$$\begin{bmatrix} S\left(\frac{m+1}{m}\right) & \frac{n(m+1)}{m} - N \\ K\theta & 2rS - Kr \end{bmatrix} \begin{bmatrix} dn \\ dS \end{bmatrix} = \begin{bmatrix} -Nd(\tau + c) + [S - (\tau + c)]dN + \frac{n}{2m^2} dm \\ -nd\theta + (rS - n)dK + (K - S)Sdr \end{bmatrix} \quad (11)$$

By Cramer's rule, we can derive

$$\begin{aligned} dn &= \frac{1}{\Delta} \{ (2Sr - Kr)[-Nd(\tau + c) + (S - (\tau + c))dN + \frac{n}{2m^2} dm] \\ &\quad - [\frac{n(m+1)}{m} - N][-nd\theta + (rS - n)dK + (K - S)Sdr] \}, \\ dS &= \frac{1}{\Delta} \{ S\left(\frac{m+1}{m}\right)[-nd\theta + (rS - n)dK + (K - S)Sdr] \\ &\quad - K\theta[-Nd(\tau + c) + (S - (\tau + c))dN + \frac{n}{2m^2} dm] \}, \end{aligned} \quad (12)$$

where

$$\Delta \equiv S\left(\frac{m+1}{m}\right)(2rS - Kr) - K\theta \left[\frac{n(m+1)}{m} - N \right] \gtrless 0, \text{ and}$$

the stability condition requires $\Delta > 0$, implying that the slope for the nn -line should be greater than that of the SS -line, as derived in Appendix 1. Since E_1 is an unstable equilibrium, we will focus on the effect of the comparative statics for E_L and E_H .

Factors affecting the state of equilibrium include not only the nature-determined elements of K , r and θ , but also the policy-related factors such as τ , c , N and m . Policies should aim at the high equilibrium, which obviously represents higher welfare. To guarantee high equilibrium, several policies can be suggested by changing the access cost $\tau + c$, population size N , and the number of operators m , which we now discuss in the following.

3.1 Access costs effect ($\tau + c$)

Transport cost τ reflects the fact that the degree of accessibility and the marginal maintenance cost c , are borne by the tourist and the operators respectively, and thus should affect the equilibrium. By the results of comparative statics of equation (12), the effects of an increase in τ and c on S^* and n^* are mathematically expressed as:

$$\frac{dS^*}{d(\tau + c)} = \frac{1}{\Delta} K\theta N > 0, \quad (12a)$$

$$\frac{dn^*}{d(\tau + c)} = \frac{-1}{\Delta} N(2Sr - Kr) \gtrless 0, \text{ if } S \gtrless \frac{K}{2}. \quad (12b)$$

This means that an increase in τ and c always leads to a higher S , while its effect on n is ambiguous, depending on whether the initial state is low or high. At the low state of $S < K/2$, the number of tourists will increase, while at high equilibrium, i.e., $S > K/2$, the number of n will decrease. Geometrically, an increase in the access cost will only move the nn -line rightward, as indicated by equation (11) and shown in Figure 3. In the figure, the cross point of nn -line on the S -axis moves to a ($a = \tau + c$) and further to a' as the cost increases more. With a small adjustment of $\tau + c$, the E_L will move upward along the SS -line, while E_H will move downward.

[Insert Figure 3]

In the extreme, if the access cost keeps increasing, then as is clearly shown in the figure only the high equilibrium of E''_H will exist. In this case, even if the initial state is at the low equilibrium E_L , we can still reach the high equilibrium, as shown by the dynamic path along the nn'' -line, that is, an instant drop of n from E_L to the corresponding level on the point vertically down to the nn'' -line and then gradually moving upward to E''_H .

Policy implications from the results are clear, knowing that the access cost can be raised by imposing a tax either on the operator (raising c) or on the tourist (raising τ). Accordingly, the government can raise the tax level to increase the natural resource stock and importantly can avoid the low level equilibrium by levying a high tax.⁶

On the other hand, policies reducing the access cost, such as improving the road condition and subsidy to the operator, will lead to a lower level of the ecological resources in the end. An extreme case occurs when the access cost is zero, i.e. open access. In this case, the low equilibrium E_L coincides with the origin, that is, the extinction of the resource. And, unfortunately, the E_L will become the unique equilibrium when N the population and/or the number of operations m is large enough, which as will be analyzed in the section of 3.4 is the case of the classic “tragedy of commons”.

3.2 Number of operators m

By equation (12), the effects of an increase in m on S^* and n^* can be expressed mathematically as below:

$$\frac{dS^*}{dm} = \frac{-1}{\Delta} K\theta \left(\frac{n}{2m^2} \right) < 0, \quad (12c)$$

$$\frac{dn^*}{dm} = \frac{1}{\Delta} (2Sr - Kr) \left(\frac{n}{2m^2} \right) \geq 0, \text{ if } S \geq \frac{K}{2}. \quad (12d)$$

This states that an increase in the number of operators, m , will certainly decrease the equilibrium level of the resources; however its effect on the number of tourists n^* is ambiguous, depending on whether the initial state is low ($S < K/2$) or high ($S > K/2$). Graphically, an increase (decrease) in m will only move the nn -line counter-clockwise (clockwise) on the center of point a , as shown in Figure 4. Thus, if m increases then the equilibrium shifts from E_L to E'_L or from E_H to E'_H . At low equilibrium, both n and S will decline. However, if high equilibrium is the case, then S will still decline but n will increase.

It is worth noting that if the number of operators m keeps increasing, then the nn -line will continue to rotate upward, and the high equilibrium E_H will no longer exist in the end, left only with the low equilibrium as is shown in the case of the nn'' -line in Figure 4. This is more

⁶This policy-related result is essentially similar to that raised in the articles of Morey (1980), Clark (1990) and Tietenberg (1996); that is, the purpose of preventing the fish stock from extinction can be reached by increasing any kind of catching cost, for example, the fee for fishing licenses. See also in Barala et al. (2008) for the similar argument of raising entry fee for helping preserve the Annapura Conservation Area, Nepal.

likely to occur if the current operator's profitability is higher and free entry is permitted.⁷ Note that the larger the population size, N and/or the smaller the establishment cost F , the higher the profitability. The implication is clear; that is, the higher the population size and/or lower the establishment cost, the more likely it is that the tragedy of low equilibrium will occur to the common pool of ecological resources under free entry.

[Insert Figure 4]

3.3 Population growth and 'tragedy of commons'

The effect of population size is similar to that of the operator numbers. As can be derived from equation (12), the population effect is mathematically as below:

$$\frac{dS^*}{dN} = \frac{-1}{\Delta} K\theta[S - (\tau + c)] < 0. \quad (12e)$$

$$\frac{dn^*}{dN} = \frac{1}{\Delta} (2Sr - Kr)[S - (\tau + c)] \gtrless 0, \text{ if } S \gtrless \frac{K}{2}, \quad (12f)$$

Again the effect on S^* is certainly negative; however the effect on n^* can be positive or negative depending on whether the initial state is high ($S > K/2$) or low ($S < K/2$).

Graphically, the change in N only makes the nn -line rotate on the center of a (by of equation (11)), and again like that of the change in m it will move the nn -line counter-clockwise (clockwise) as N increases (decreases) as shown in Figure 5. And, in the extreme case, the high equilibrium will disappear, left only with the low equilibrium, as show by the nn'' -line.

[Insert Figure 5]

3.4 Open access and the 'tragedy of commons'

The unique low equilibrium due to high population size or too many operators will become a serious problem, if the access is free for both the tourists and operators, that is, $\tau = c = 0$.

Figure 6 depicts the case when $\tau + c = 0$. In this case the nn -line is horizontal with $n = mN/(1 + m)$, for equation (10) now becomes

$$n^* = \frac{m}{1 + m} N. \quad (13)$$

⁷The theoretical result in principle supports the argument by Kilipirisa and Zardava (2012), the necessity of control over the tourism firms especially the micro tourism enterprises like travel agents and tour operators etc..

It can be easily seen that if m or N is large enough then E_L will become the unique equilibrium, and more importantly, the equilibrium is characterized with $S^* = n^* = 0$, i.e., an extinction tragedy. More specifically, the threshold for the tragedy to occur can be derived as

$$\frac{m \cdot N}{1 + m} \geq n^{MSY} = \frac{rK}{4\theta}. \quad (14)$$

This states that other things being equal, the lower the intrinsic growth rate, the lower the environmental capacity and the higher the average depletion rate of tourist, the more likely the extinction tragedy will occur.

[Insert Figure 6]

3.5 Policy implications

Policy implications can be drawn upon the above results. It is straightforward that state E_H is better than E_L which in turn is better than the state of extinction. To maintain the high equilibrium of E_H , policies should aim at reducing the potential population size N , decreasing the number of firms m and raising the access cost for tourists τ and marginal cost for operators c . If possible, the policies should also aim at raising the environmental capacity K , intrinsic growth rate of the ecological resource r (to which scientist can contribute), and decreasing the depletion rate of each tourist suitable ecotourism education can help by enhancing the environmental ethic of the tourist (and here as discussed by Holden (2003, 2005); see also references therein).

4 Welfare and optimal policies

Ideally, the aim of a policy should not be confined to avoiding the extinction tragedy or low equilibrium only. Instead, it should actively target maximization of the social welfare for the community as a whole. Let w denote the welfare, which in this case of ecotourism should contain three components: the overall profit earned by the local operators $m \cdot \pi$, tax revenue and the environmental amenities. Suppose each operator is subject to pay a fixed license fee of L to run the business, and each tourist has to a tax of t . Thus, the total tax revenue equals

$t \cdot n + m \cdot L$. Then, the welfare function can be written as

$$w = m\pi + tn + mL + v(S), \quad (15)$$

where $v(S)$ is the environmental amenity welfare from having the ecological resource of stock S , assuming that the marginal welfare of S is positive and decreasing, i.e., $v' > 0$ and $v'' < 0$.

With the tax structure, the profit earned by each operator has to be revised from equation (9) to

$$\pi = \left[S \left(\frac{N-n}{N} \right) - \tau - c - t \right] \frac{n}{m} - (F + L), \quad (9')$$

therefore the welfare function can be rewritten as

$$w = \left[S \left(\frac{N-n}{N} \right) - \tau - c - t \right] n - mF + v(S). \quad (15')$$

Analytically, we can add an iso-welfare curve on the (n, S) space to compare the relative welfare levels under different equilibrium positions, and, more importantly to pin down the optimal level of welfare that can be reached for the ecological economy. To draw the iso-welfare curve on the (n, S) space, note that

(i) $\partial w / \partial S > 0$, and $\partial^2 w / \partial S^2 < 0$.

(ii) $\partial w / \partial n = 0$, at $n^* = N/2[1 - (\tau + c)/S]$, and $\partial^2 w / \partial n^2 < 0$.

These properties can be depicted in Figure 7. That is, at any given level of S , there exists a maximum w at $n^*(S) = N/2[1 - (\tau + c)/S]$ (to be denoted as the ridge-line of welfare hereafter), and $\partial w / \partial S > 0$, that is, $w(n, S_1) > w(n, S_0), \forall S_1 > S_0$.

[Insert Figure 7]

4.1 Iso-welfare curve

Obviously from Figure 7, we can see that at any given level of welfare, say w_0 , there exists a level S_0 of S , and a corresponding $n^*(S_0)$ such that for all $n < n^*(S_0)$, a lower n must be accompanied by a higher S , in order to maintain the same welfare level of w_0 ; while for all $n > n^*(S_0)$, corresponding to a higher n , a higher S is required to make w indifferent. Thus, the corresponding welfare indifference curve through point $(S_0, n^*(S_0))$ can be drawn as the

w_0 in Figure 8. By the same rationale, we can derive a higher welfare indifference curve as w_1 , corresponding to $(S_1, n^*(S_1))$, with $S_1 > S_0$ in the same figure. And, as shown earlier, the ridge line that links all the points of $(S, n^*(S))$ is $n^*(S) = N/2[1 - (\tau + c)/S]$, which coincides with the nn -line at $m = 1$ before tax. As will be shown later, this property plays some role in the content of policy design.

[Insert Figure 8]

4.2 Optimal policies

We are now ready to analyze the optimal ecotourism policies. To do so, the iso-welfare curve is drawn in the equilibrium diagram as in Figure 9.

In the figure, the nn -line is drawn under the case of $m > 1$ and tax free status. The n^* -line is the ridge line of the welfare, which as noted before coincides with the nn -line with $m = 1$ and $t = 0$.⁸ Several interesting and important properties can be drawn from the figure:

1. High equilibrium is better than low equilibrium

The iso-welfare curve through the high equilibrium point, E_H , represents a higher welfare of w_H than that of E_L . This confirms the previously mentioned direction of policy design, that is, aiming at approaching the high equilibrium. And as illustrated before, the high equilibrium can be attained by charging an adequate tourism tax t , reducing m and/or increasing the license fee L .

2. High equilibrium of E_H is not necessary optimal

Although E_H has higher welfare than E_L , it is not optimal, as shown by E_0 in Figure 9, leaving more room for policy to play a role.

3. Policies toward the maximum welfare

The iso-welfare curve w^* , tangent to the SS -line at point E^* , represents the highest welfare value that can be reached for the ecotourism community, at a given level of K , r and θ . Correspondingly, point E^* indicates the target of an optimal policy. How can one reach the optimum by using the policies available? Conceptually, the optimal policy

⁸Note that the license fee does not affect the n^* -line.

should be designed so as to move the nn -line to cross the SS -line through point E^* , such as the nn^{**} -line. For this purpose, as analyzed before and knowing that the nn -line lies always above the n^* -line under $m > 1$, we can (i) raise the license fee of L to decrease the operator's profit to reduce the number of operators m , or simply control directly the number of m , or (ii) raise the tourist tax t , collected from either the tourist or the operator n . Both policies will move the nn -line to the "right" direction toward higher welfare. However, as will be shown in the following, the license fee or reducing m itself will not successfully reach the maximum welfare, without the imposition of the direct tax policy of t .

(a) Effectiveness of the license fee or controlling m

As shown earlier, raising L or reducing m in the extreme will only shift the nn -line clockwise to coincide with the welfare-ridge n^* -line, and correspondingly can only reach the equilibrium point of E_0 with welfare level of w_0 . In other words, w_0 is the greatest possible welfare level that can be obtained through the policy of license and/or firm number control. And clearly, there still exists a distance between w_0 and the optimum of w^* .

(b) Effectiveness of tourist tax, t

By the properties of the nn -line, a tourist tax either on the tourist or on the operator will move the nn -line rightward, changing the intercept in the S -axis from $\tau + c$ to $\tau + c + t$. As a result, there exists a tax rate, say t^* , by which the the nn -line will move to nn^{**} -line, thus reaching the optimal equilibrium point of E^* and welfare level of w^* .

[Insert Figure 9]

5 Discussion and Concluding Remarks

Ecotourism has been suggested recently in many studies as a promising strategy for sustainable development for an ecologically rich but economically poor rural area. The confidence lies

basically in the efficiency of the market mechanism to provide incentives for local people to protect the natural resources on which the tourism is based. In this paper we prove that although ecotourism can prevent the ecological resources from being depleted in the short run, the tragedy of extinction may still be inevitable in the long run, without the support of a proper policy design. This is because the common-pool properties of the ecological resource will make the local people receive too many tourists, exceeding the sustainable level.

By incorporating the factors of access cost, number of operators among the local residents, license fee and tourist tax into the model, the major results are: Firstly, the greater the number of operators, the smaller the equilibrium stock of the ecological resources will be. In the extreme, it may end up at a low level of equilibrium, which is far below the maximum sustainable yields, and may even result in the extinction of the resources if the access cost is zero, an ecotourism version of the ‘tragedy of the commons’. Furthermore, if the population of potential tourists keeps growing, the extinction tragedy or low equilibrium will certainly occur.

Ching-jing area and the Mugumuyu are two contrast examples in Taiwan. The Ching-jing resort area, where the household-hotel was permitted to operate since the early 1990s, represents the case of no access fee (except the transport cost), no limit on the number of operators (household-hotel, m), and potentially numerous visitors (n). On the contrary, for the Mugumuyu reserve area, rich in ecosystem but hard to reach for its rural mountain location in East Taiwan, each tourist has to pay an access fee of 350 NT\$, in addition to a relatively higher transport cost. Furthermore, the daily allowance for visitors is confined to 600 persons, with 300 in the morning and the rest of 300 in the afternoon. Consequently, as implied by our model, the results are opposite for the two areas. The Ching-jing area now has been occupied by overwhelming number of house-hold hotels along with over-constructions; the landscape quality is dramatically damaged, as shown in the record movie of “Beyond Beauty - Taiwan From Above”. On the other hand, the Mugumuyu area retains its attractiveness for the tourist via successfully reserving its natural resources.

To avoid the occurrence of the tragedy of low equilibrium or even extinction, we suggest the following policies: (1) controlling the number of operators, which can be achieved either

by issuing a small number of license or by charging a higher licenses fee; (2) raising the access cost by either imposing a tourist tax on each visitor or charging a ‘sales tax’ on the operators; (3) reducing the population size of potential visitors.

We also prove that although a high level equilibrium can be reached either by reducing the firm numbers or by charging a tourist tax, the former instrument is less efficient. More specifically, there exist an optimal equilibrium which can only be reached if the direct tourist tax is applied. In other words, the maximum level of welfare that can be achieved by the indirect tax of licenses fee is smaller than that which can be obtained through the direct tax on tourists.

In sum, we have shown that ecotourism itself cannot avoid the occurrence of the tragedy of commons, unless it is accompanied by suitable policy interventions, such as reducing the number of operators and population size, and/or increasing the access cost for tourists. We have also shown that the direct tax policy of a tourist tax is better than the indirect tax policy of license control.

Some other polices that are not addressed in the comparative static analysis but are crucial for improving sustainability include: (1) reducing the reward by tourists which can be attained by education, and (2) increasing the environmental capacity of the ecological resource and/or its intrinsic growth rate, which may be possible through the efforts of interested scientists. These policies are obviously worth pursuing in any situation.

Appendix 1

1. The slopes of the nn -line and SS -line:

According to equation (10), the slopes of the nn -line and SS -line can be solved as follows:

$$\begin{aligned} \left. \frac{dn}{dS} \right|_{nn} &= -\frac{\frac{n(m+1)}{m} - N}{S\left(\frac{m+1}{m}\right)} = -\frac{n(m+1) - Nm}{S(m+1)} > 0, \\ \left. \frac{dn}{dS} \right|_{SS} &= -\frac{2rS - Kr}{K\theta} \geq 0, \text{ if } S \leq \frac{K}{2}. \end{aligned}$$

2. Stability condition:

Let Δ be the determinate of the equation, that is,

$$\Delta \equiv S \left(\frac{m+1}{m} \right) (2rS - Kr) - K\theta \left[\frac{n(m+1)}{m} - N \right] \geq 0.$$

By the properties of the stability condition, Δ must be greater than zero. Hence, the stability condition can be represented as

$$-\frac{n(m+1) - Nm}{S(m+1)} > \frac{-(2rS - Kr)}{K\theta}.$$

That is, the slope of the nn -line must be greater than that of the SS -line for the system to be stable.

Appendix 2: Properties of the iso-welfare curve

The welfare function, for convenience, is rewritten as below:

$$\begin{aligned} w(S, n, N, \tau + c, F, m) &= m\pi + nt + mL + v(S) \\ &= \left[S \left(1 - \frac{n}{N} \right) - (\tau + c) \right] n - mF + v(S). \end{aligned} \quad (15')$$

The partial derivatives of the function with respect to each argument, $w \equiv \partial w / \text{over} \partial i$, are listed as

$$\begin{aligned} w_S &= n \left(1 - \frac{n}{N} \right) + v'(S) > 0, \\ w_n &= 2S \frac{n}{N} - (S - \tau - c) \geq 0, \text{ if } n \geq \frac{N}{2} \left[1 - \frac{\tau + c}{S} \right], \\ w_N &= \frac{Sn^2}{N^2} > 0, \\ w_\tau = w_c &= -n < 0, \\ w_F &= -m < 0, \\ w_m &= -F < 0. \end{aligned}$$

1. By total differentiation, $dw = w_S dS + w_n dn = 0$, the slope of the iso-welfare curve is thus

$$\frac{dn}{dS} = -\frac{w_S}{w_n} = \frac{(1 - \frac{n}{N}) + v'(S)}{2S \frac{n}{N} - (S - \tau - c)} \geq 0, \text{ if } n \geq \frac{N}{2} \left(1 - \frac{\tau + c}{S} \right).$$

2. And, a simple algebra yields

$$\frac{\partial(\frac{dn}{ds})}{\partial n} < 0, \text{ and } \frac{\partial(\frac{dn}{ds})}{\partial N} > 0.$$

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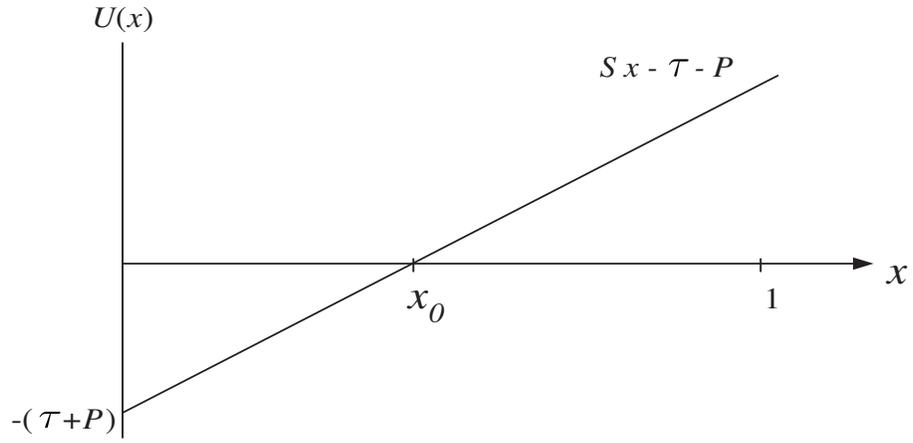


Figure 1: Distribution of heterogeneous tourists

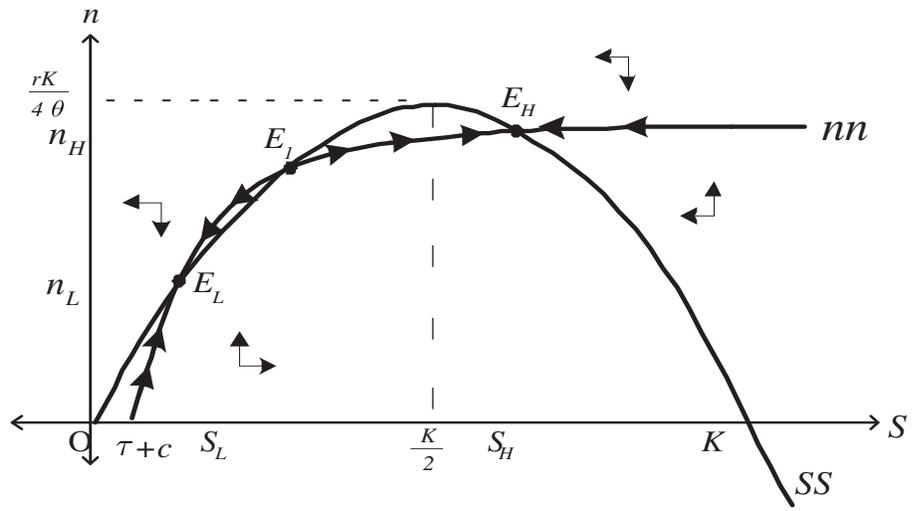


Figure 2: Ecotourism equilibrium

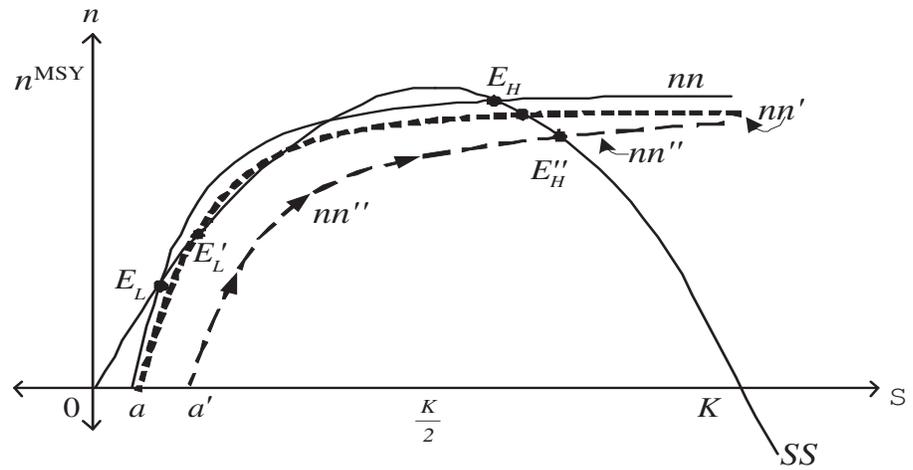


Figure 3: Effect of ecotourism Tax

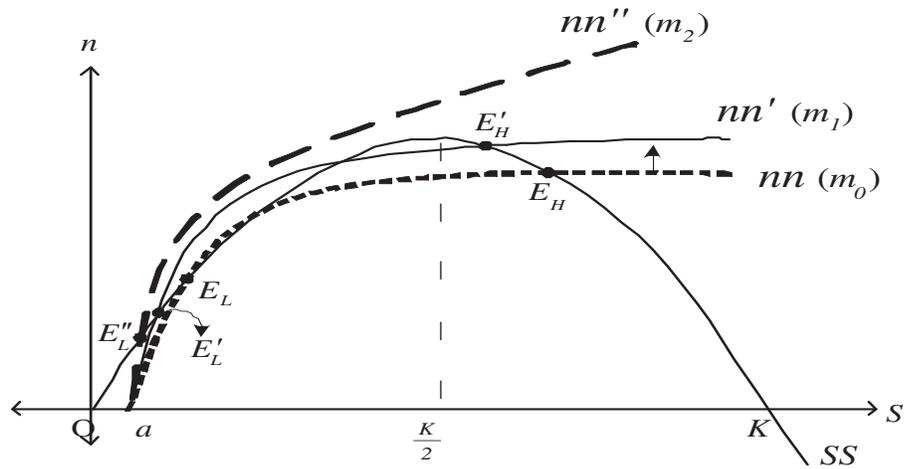


Figure 4: Effects of more operators ($m_2 > m_1 > m_0$)

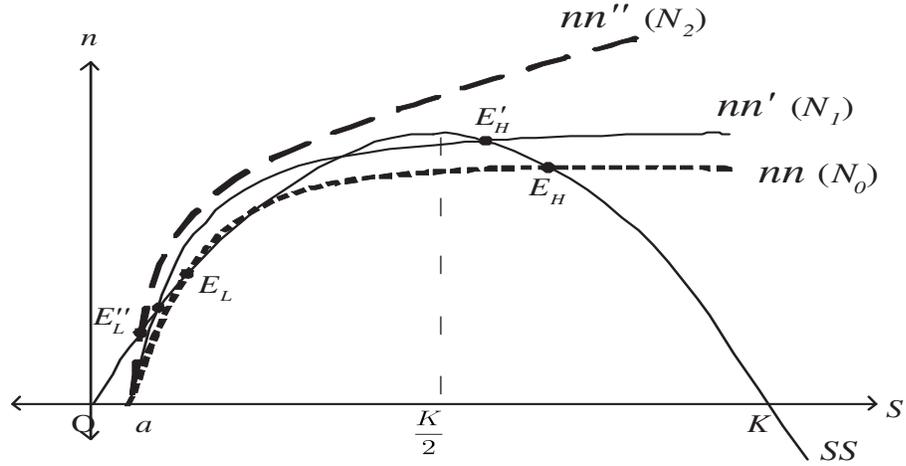


Figure 5: Effects of population growth ($N_2 > N_1 > N_0$)

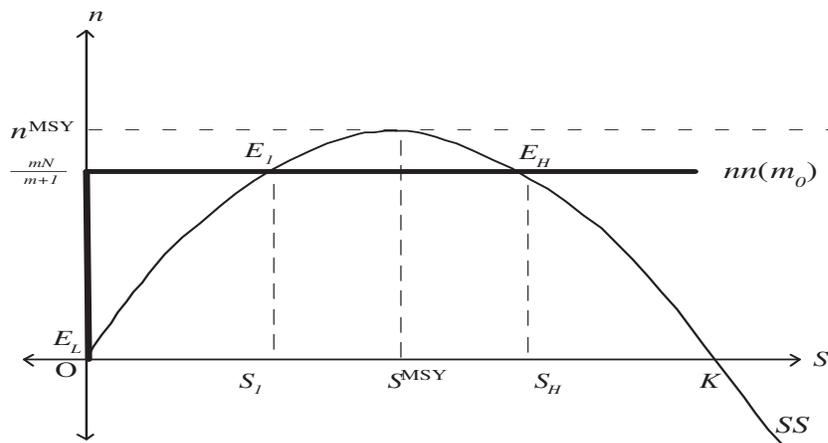


Figure 6: Equilibrium under open access ($\tau + c = 0$)

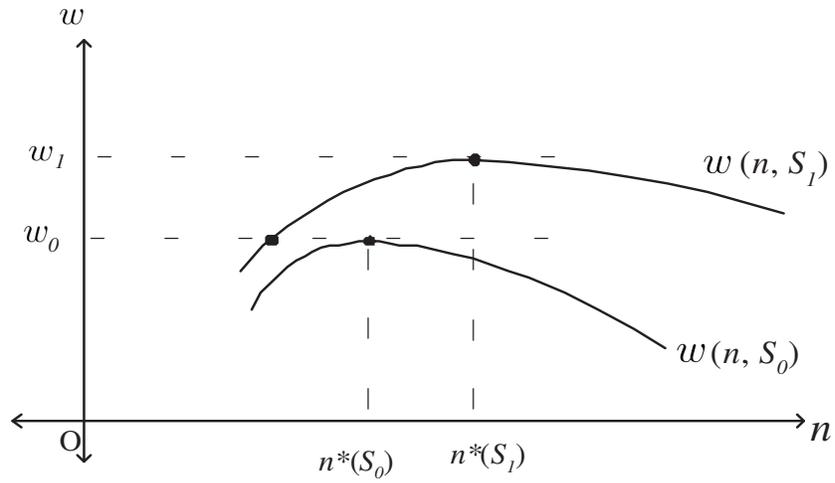


Figure 7: Social welfare of the local community ($S_1 > S_0$)

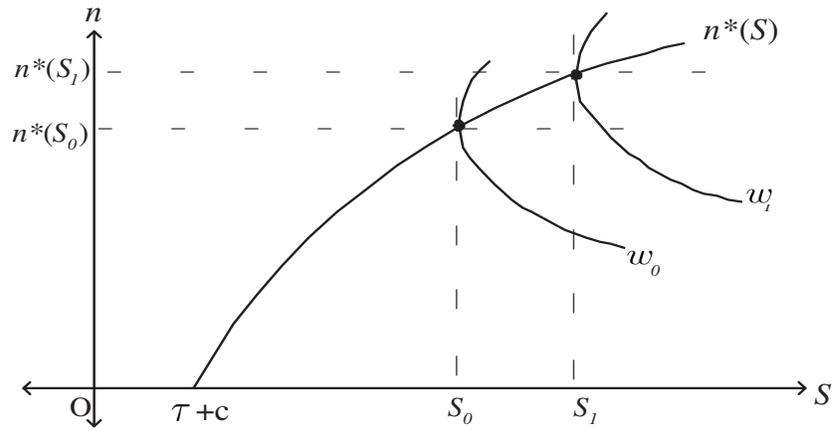


Figure 8: Iso-welfare curve $n^*(S) = \frac{N}{2} [1 - \frac{\tau+c}{S}]$, and $w_1 > w_0$

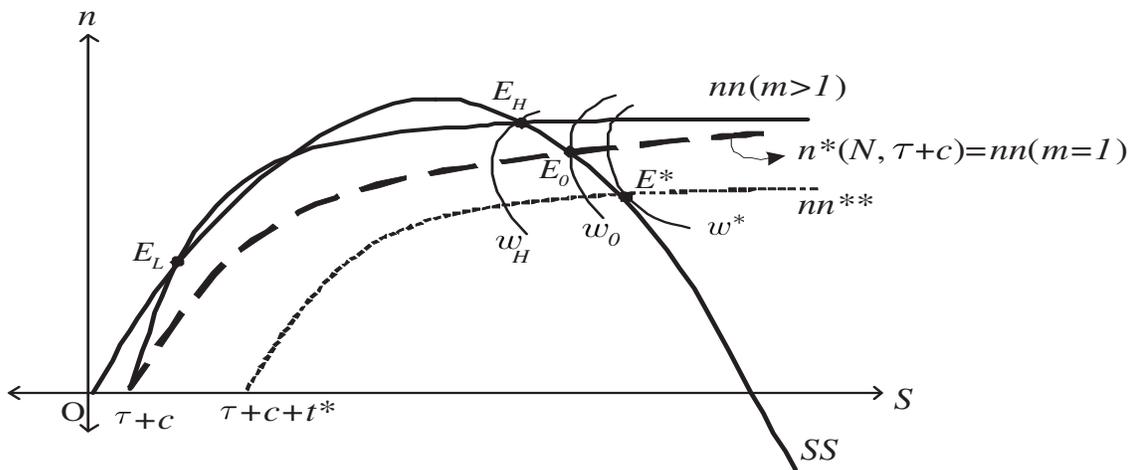


Figure 9: Equilibrium and welfare

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