Environmental Economics and Policy Studies (2000) 3: 291–309

Environmental Economics and Policy Studies

Articles

Property rights and contractual approach to sustainable development

Ben T. Yu[1], Daigee Shaw[2,3], Tsu-Tan Fu[2], and Lawrence W.C. Lai[4]

[1] Department of Economics, California State University, Northridge, California 91324, USA
[2] Institute of Economics, Academia Sinica, Nankang, Taipei, Taiwan
[3] Institute of Natural Resource Management, National Taipei University, Taipei, Taiwan
[4] Department of Surveying, University of Hong Kong, Hong Kong

Received: February 6, 1999 / Accepted: June 23, 2000

Abstract Sustainable development is argued to exist in weak and strong versions. Although the use of a property rights and contractual approach has been well understood in the case of weak sustainable development, the approach has been virtually ignored in the strong version. This paper formulates a property rights and contractual approach for the strong version of sustainable development. By reference to an analytical model and examples from Hong Kong and Taiwan, a Schumpeterian process and the institution of resource entitlements are shown to be the necessary ingredients to promote the strong version of sustainable development.

Key words Sustainable development · Property rights and contractual approach Schumpeterian process · Resource entitlements · Coase theorem

1 Introduction

Sustainable development is the most significant concept of the green movement that has become politically increasingly assertive during the last decade of the twentieth century. It is likely that the concept will dominate the policy agenda of most pluralist countries during the twenty-first century. This paper is an attempt to contribute to the articulation of the concept from an economic point of view, bearing in mind that the "received views" of sustainable development seem often hostile to economic inquiry.

A convenient starting point for articulating the concept is a definition provided by The World Commission on Environment and Development, often referred to as the Brundtland Commission. This commission defined the sustainable development in a 1987 report, *Our Common Future*, as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

It is clear that the heart of the matter is a normative duty of the present generation owed to the next generations to conserve certain needs. Unfortu-

nately, the Brundtland definition is too ambiguous and elusive. What are the needs? Who is to decide the needs? To conservationists, this definition may be seen to embrace the perpetual preservation of all existing genes and other natural resources. To hedonists, however, it is the maximum possible flow of consumption and enjoyment that matters. The elusiveness of this statement also suggests no unique guidelines for sustainable development. As the *UN Chronicle* (June 1992, p. 46) explained, "Sustainable development is a complex concept more easily defined by what it is not, than by what it actually is. Fundamentally, it is not based on the conventional belief that economic progress and environmental protection are mutually opposing goals."

Indeed, the subject of sustainable development is going through a stage of metamorphosis.[1] It is now a multidimensional concept involving issues such as conservation or preservation, substitutability of manmade versus natural capital, uncertainty, irreversibility, intergenerational equity, resilience within an ecosystem, biodiversity, population growth and investment in human capital, decentralization, and community-based conservation, among others. These issues are often discussed in conceptual terms, which are not necessarily consistent with the tools or languages commonly used in neoclassical economics.

The divergent discussions of the concept of sustainable development can be said to be roughly divided into two schools of thought: a neoclassical economic school and an ecological school. The neoclassical school takes welfare or consumption per capita being sustainable or the total capital (manmade, human plus natural capital)[2] being maintained intact as the goal of development with an implicit assumption of the substitutability of all forms of capitals. The writers in this school usually prefer to rely on voluntary exchange and market-based incentives to achieve the goal.

The ecological school (Barbier 1987; Barbier and Markandya 1990; Callicott and Mumford 1997) has a more conservative goal of keeping the stock of natural capital constant or nondecreasing in addition to the goal of sustainable total capital stocks, as they are highly skeptical of the assumed substitutability of capital stocks. The writers in this school can be sub-divided into those who prefer an authoritarian approach and those who favor a voluntary approach to achieve their normative ends. The authoritarian variant tends to rely on the conventional government command and control policies. This in turn implies that they would welcome an ultimate wise man or woman and a highly planned and centralized decision-making process to achieve its goal. The voluntary variant

---

[1] For references on the meaning of this term, see Batie (1989, 1992), Pearce, Markandya and Barbier (1989), Pearce and Atkinson (1998), Daly (1989, 1990, 1991), Daly and Cobb (1989), Dasgupta and Maler (1990), Norgaard (1991, 1992), Howarth and Norgaard (1990, 1992), Tietenberg (2000), and Veeman (1989).

[2] Manmade capital is the classical capital of produced goods. Human capital refers to the skills and knowledge embodied in humans. Natural capital is the sum of traditionally defined natural resources and stocks of assimilative capacities in the environment. See Solow (1992) and Pearce and Atkinson (1998).

includes considerations of communal property rights as the alternative to state regulation or the free market to the "tragedy of the commons."[3]

There is a heavily nostalgic if not utopian sentiment among advocates for communal rights. Both variants, like most other ideas arising from the green movement, involve a profound skepticism or, to some extent, even hostility to the use of economic analysis (and, in extreme cases, even technology) when dealing with ecological issues.[4] It is true that they do use concepts also of perennial interest to the economist, but they generally argue that the market mechanism, or "capitalism," is the culprit of the world's ecological crisis. In their opinion, the price mechanism does not respect the innate significance of natural resources. Development, they tend to believe, always leads to a reduction in "biodiversity" as well as a fall in the stock of natural resources.

In this paper, we set aside the debate on which is a better goal of, and a better approach to achieve, sustainable development. According to Daly and Cobb (1989), an important goal of the ecological school is to keep the stock of natural capital and each component of it constant or nondecreasing. We take that as the strong form of sustainable development, hereafter referred to as "strong sustainability." On the other hand, the goal of the neoclassical economics school is referred to as "weak sustainability."[5] We wish to examine the extent to which strong sustainability may be compatible with voluntary exchanges.[6] This focus of the problem is arguably important because if they were compatible the conflicts between the two schools would be diminished when the infrastructure required to support the two approaches is the same.[7]

Our objective here is first to formulate a definition of strong sustainability. Based on this definition, we examine to what extent the concept may be compatible with voluntary exchanges. An important insight from the discussion is that

---

[3] The thesis of the tragedy of the commons was developed by Hardin (1968). He argued that "Freedom in a Commons brings ruin to all," as anyone who asserts his entitlements in a commons would choose to use more rather than maintain the status quo. His solution was to have government controls to limit access to the commons or to privatize common-pool resources.

[4] See Batie (1989) for a clear exposition of this position, see also Daly (1989) and Ostrom (1990). On the other hand, Dasgupta and Maler (1990) demonstrated how economic analysis can clarify some of these issues. In particular, they argued that the idea of constancy of natural capital "confuse(s) the *determinants* of well-being for the *constituents* of well-being."

[5] Daly and Cobb (1989, p. 72) defined "weak sustainability" as maintaining the total capital intact, and "strong sustainability" as maintaining both manmade and natural capital intact *separately*.

[6] To be sure, the range of objectives considered by the ecological approach can be broad (see Daly 1990). In our theoretical discussions, we use a narrower description as a representation of this more general approach.

[7] Indeed, it can be argued that the distinction between weak and strong sustainability becomes less valid the more we know about the world. For example, if there is unambiguous evidence that a resource is critical (i.e., it provides life support functions that are compromised if the stock falls below a threshold level), weak sustainability does not suggest that the asset should be driven below this threshold. A reviewer of this paper suggested that depletion of the ozone layer probably approximates this situation.

strong sustainability under voluntary exchange must be contingent upon a set of (however incomplete) resource entitlements.[8] The idea of resource entitlements has its origin in the writings of Knight (1924), Coase (1960), Demsetz (1967), and Alchian and Allen (1969). These writings have often been interpreted as advocating selling the environment, which may not be compatible with the ethics of strong sustainability.[9] However, it can be demonstrated that there are exchangeable resource entitlements that, in the long run, can achieve both forms of sustainable development. As a result, biodiversity and the stock of natural resources may be enhanced or expanded. There seem to be conflicting opinions on the usefulness of the property rights approach to environmental issues. Our minds can be easily confused. To help clarify competing and sometimes conflicting concepts, we develop a theoretical framework that can help ascertain the role of resource entitlements, and in so doing it is perhaps useful for defining a viable concept of environmental rights as well.[10]

The organization of this paper is as follows. In section 2 we develop a model that formulates the interaction between a developer and a group of fishermen as an illustration of the possibility of strong sustainability. Cheung (1973) studied the contractual interaction between apple growers and honey bee farmers of Washington State. Cheung's study verified the Coase theorem but did not include a discussion of the impact of such interaction in terms of enhancing biodiversity. This model incorporates environmental conditions and the innovation of fishermen, unlike the conventional treatment of private property over fisheries (Angello and Donnelley 1975, 1976a, 1976b; Lai and Yu 1992, 1995; Lai and Lam 1998). Section 3 argues that, from an economic perspective, strong sustainability should be treated as an ideal and can be stated only in a probabilistic sense rather than as a principle of development that must be followed. Discussion of strong sustainability therefore should investigate as to what types of institution are most likely to emerge to facilitate such positive interactions. Section 4 points out that strong sustainability is possible; some examples in Asia are provided as illustrations. The paper concludes in section 5.

---

[8] As Calabresi and Melamed (1972) indicated, "the first issue which must be faced by any legal system is one we call the problem of "entitlement." Whenever a state is presented with the conflicting interests of two or more people, or two or more groups of people, it must decide which side to favor. Absent such a decision, access to goods, services, and life itself will be decided on the basis of "might makes right." Hence the fundamental thing that law does is to decide which of the conflicting parties will be entitled to prevail. The entitlement to make noise versus the entitlement to have silence, the entitlement to pollute versus the entitlement to breathe clean air."

[9] The objection to selling the environment has been raised in a compensation case in Taiwan (see Yeh 1992). Some argue that the resource entitlement is "inalienable."

[10] The application of transaction cost and institutional economics on development can be found in Nabli and Nugent (1989).

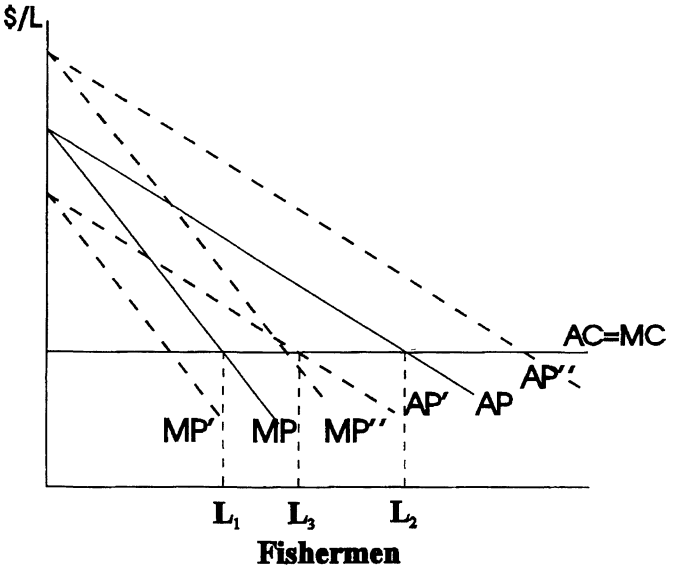

Fig. 1. Power station in an open-access fishery. *MP*, marginal product of fishermen; *AP*, average product of fishermen; L_1, efficient number of fishermen; L_2, open-access equilibrium; L_3, open-access equilibrium with a power station; *AC*, average cost of fishermen; *MC*, marginal cost of fishermen

2 Economic analysis of sustainability

Suppose the natural resource of interest is under an open-access regime in which there are no property rights, as in the case of ocean fish.[11] The marginal product of fishermen is denoted as MP in Fig. 1. Efficient allocation of resources entails only L_1, fishermen, but nonexclusive entitlements or common property will result in overfishing (i.e., L_2 fishermen). The rent of fishing ground is totally dissipated at L_2. The net benefit to fishermen is zero (i.e., fishermen receive a return covering their next best alternatives). A fisherman in the industry, in principle, may be indifferent to being in the industry or out of the industry (Gordon 1954; Cheung 1970).

Suppose now that a power station moves into the fishermen's neighborhood. For the time being, set aside the question of how the power station can come about in this neighborhood, and concentrate first on the effects that the station imposes on the fishermen. Suppose the power station output (Q) affects the environment (e) (e.g., the water temperature) where the fishermen operate. A conventional way to view the problem is to shift the MP curve to MP′. The social

[11] Fish in the ocean are often mistakenly thought of as a good example of "common property" since Hardin's (1968) "tragedy of the commons" paper. Bromley has pointed out the mistake and clarified the confusion about open access and common property. See Bromley (1991) for his argument.

damage caused by the thermal water pollution is denoted by the area between MP and MP′. However, the damage suffered by the fishermen is *zero* because the rent to fishermen, after the AP curve has shifted to AP′, is still zero. With or without pollution, the return to the fishermen covers its next best alternative. The only effect is an exit of fishermen from the industry with L_3 fishermen remaining in the industry.

The above example illustrates an important point. The alleged damage of thermal water pollution to the fishermen does not exist if the fishermen do not have prior entitlements established on the fishing ground to begin with.[12] This does not mean that the social cost of water pollution does not exist.[13] It exists in terms of a shifting of the MP curve, but the damage imposed on the fishermen cannot be "internalized" unless there is a concept of resource entitlements owned by the fishermen.[14] The exposition so far does *not* entail the concept of sustainable development in its strong or weak sense. The environment may deteriorate, and the output of fish is reduced.

One may think that if the actions of the polluter (the power station) are curbed, sustainable development can be achieved. This is not true. A Pigovian tax on thermal emission can curb the emission of the station based on marginal benefit and cost consideration; the MP curve of the fishermen is then higher, but it does not shift back to the original MP position. In other words, the environment continues to deteriorate and the output of fish continues to decrease.[15] However, economists in general are not overly critical about this scenario. The reason is that even though the natural resource in this case has deteriorated, it is considered to be an optimal deterioration in the sense that the value of the output of the power station may exceed the loss in the fishery output and stock of natural capital.

The strong form of sustainable development, the ecological sustainable development, refers to a different type of interaction. Suppose as a result of the station's thermal water pollution certain dimensions of the ecosystem have been altered. This alteration may be in the form of displacement of preexisting fish species by the emergence of certain underwater vegetation and fish species that

---

[12] When the supply curve is upward sloping, fishermen can claim damages. The proposition is also true when the fishing ground is small compared to the size of the fish market. If the price of fish does not change, there is no basis to claim damages. We thank Ronald Johnson for pointing this out to us. See Johnson and Libecap (1982).

[13] This point is also related to the issue of making imputations for the social costs of environmental pollution in the Green national accounting exercises. Although no one owns the entitlement to the ozone layer, and thus no one can claim damage compensations, there does exist the social cost of the depletion of ozone layer that should be estimated for Green national accounts.

[14] Resource entitlement is only an emerging concept. In many countries, resource entitlements do not exist. In countries where explicit regulation is difficult (either because of high enforcement cost or citizens' lack of understanding of what is considered a good environment), the establishment of resource entitlements can reduce state enforcement costs on the one hand and increase citizens' sensitivity toward polluting effects on the other.

[15] Indeed, as discussions in section 3 indicate, a Pigovian tax to curb externality without an institutional determination on the use of tax revenue does not capture the essence of strong sustainability.

prefer a warmer habitat. These changes in the ecosystem would induce a change in the production function of fishermen.[16] It is not far-fetched to suppose that the MP curve of the fishermen, as a consequence of the introduction of the power station, will in fact be higher than the original MP curve (e.g., MP″ in Fig. 1). This is the meaning of strong sustainability as used in this paper. The stock of fish not only does not decrease but in fact increases (though the species and value of the fish may be different). The power station output increases. It clearly satisfies the criteria of Pareto optimality.

That the MP curve of fish can shift to MP″ of course depends on a bit of luck and what can be called a "Schumpeterian" effort. A Schumpeterian effort ventures into an area of uncertainty and entails a willingness to experiment.[17] However, note that this Schumpeterian effort is not rewarded even if there are laws on intellectual property rights. The shifting of the AP curve to AP″, analogous to the case of a negative response, does not result in an increase in rent. All it does is increase the employment of L. Thus, the reward of this Schumpeterian effort requires an extra dimension of rights in addition to intellectual property rights. For the lack of a better term, we call this a "resource entitlement."

A corollary of the "Schumpeterian" effort is that strong sustainability must be stated in terms of a probabilistic area of sustainability. A four-quadrant diagrammatic exposition describing the interaction between the power station and the fishermen can serve to illustrate this corollary in Fig. 2. The southeastern (SE) quadrant of the figure denotes how power station output, Q, affects the environment, e, as given by the function $e(Q)$. The northeastern (NE) quadrant denotes the labor-adjusting fish production as a function of e. F_0, F_1', and F_1 correspond to MP, MP′, and MP″ technological shifts in Fig. 1. Labor-adjusting fish production means a production function, with the optimal labor input substituted for labor; thus, production function becomes a function of several exogenous parameters, including e. For example, in the absence of the power station (i.e., $Q = 0$), the environment is the "purest" at e_0; fish production is at $F[L^*(w, e), e]$, where e is at a maximum value. The maximum environmental index, e, can also be interpreted as a preexisting environment *prior to development*. However, as we show by the end of this paper, there may not be such a thing practically speaking, even though it may exist theoretically as formulated here. For all three functions (F_0, F_1', F_1) we assume the functions to be increasing but only up to a certain level. The output of fish for the "purest" environment e_0 is f_0.

The remaining two phases of the Fig. 2 are for the purpose of identifying the remaining adjustment and equilibrium. The adjustment process starts once the

---

[16] There are cases in Taiwan and Japan during the last few years where free warm water from power stations has been used to supply heat to off-shore marine products cultivating stations, large-scale greenhouses, and seedling production stations. See Tanaka (1999) for the development of "symbiotic power stations" in Japan that aim at build symbioses between power stations and local people and industries by utilizing natural resources cooperatively and flexibly. See Mendelsohn, Nordhaus, and Shaw (1993) for an exposition of this idea. Similarly, Lai and Yu (1992) asserted an adjustment in the production function of culture fish in Hong Kong.

[17] Schumpeter (1934) has referred to these activities as "outside the normal circular flow."

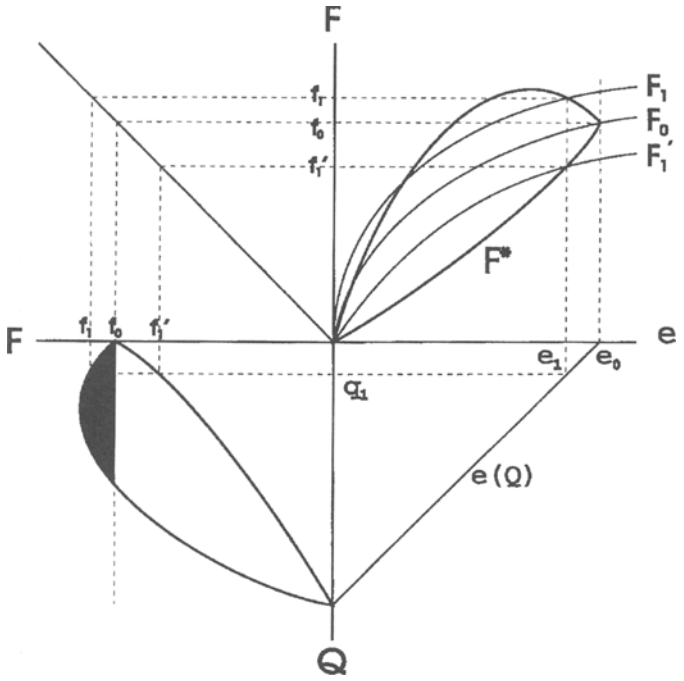

Fig. 2. The interaction between the power station and the fishmen without entitlements. F, fish production; Q, power station output; e, the environment

power station has entered the neighborhood. The relation between the power station and the fishermen can be described as follows. At power station output q_1, the environment is changed to e_1. The ecological system, and consequently the fishermen, can respond positively or negatively to the change in the environment by adjusting the fish production technology. A positive reaction shifts the labor-adjusting fish production function from F_0 to F_1. A negative reaction shifts F_0 oppositely to F_1'. These two quantities via the 45-degree line in the NW quadrant of Fig. 2 can be projected as f_1 and f_1' in the southwestern (SW) quadrant of Fig. 2.

It would be unreasonable to assume that shifting F_0 to a higher position can be realized without any limit. Indeed, the more drastic the change in e, the less likely is there to be a positive reaction. This implies a Schumpeterian production frontier of the shape of a long balloon in the NE phase, denoted by F^*. Projected via the 45-degree line in the NW phase, the trade-off between fishery output and power station output can be described by a similar frontier of the shape of a balloon in the SW phase. This implies that the output of fish, F, and the output of power, Q, can only be defined *probabilistically*, in terms of F^* and Q^*.

The balloon in the SW phase can be separated by the vertical line at fishery output f_0. Although the fishermen may suffer a loss equaling, for example, f_0–f_1',

along the frontier to the right of the vertical line, they have the possibility of gaining f_1–f_0 along the frontier to its left. The black area to its left represents the possible gain. Thus, the frontier to its left is the region of strong sustainability, as it has more fishery output and more power station output. The frontier to its right involves a trade-off between fishery and power station output. It would not satisfy strong sustainability but would have potential gains from trade if the increase in the value of the power station output is higher than the loss in the value of fish. In other words, the frontier on both sides satisfies weak sustainability,[18] but only the shaded area in the SW phase denotes strong sustainability. Overall, fishermen may not find the power station entering the neighborhood to be unwelcome.

Recall the analysis in Fig. 1, which stated that intellectual property rights are not sufficient to provide optimal trade-off in the reduction of pollution damages; examine now how the quantity of resource entitlements may have changed the interaction.[19] Suppose the fishermen have the resource entitlements. The immediate reaction is that they will attempt to negotiate with the power station owner for compensation because of the possibility of less fishery output in the right-hand side region, but they will also try to improve the fishing technology, as they now own the environment. This would increase the probability of the upward shifting of the F_0 curve. The effects of granting the resource entitlements, therefore, is to tilt the balloon in the NE phase to the left, which implies a corresponding tilt of the balloon in the SW phase to the left (Fig. 3). The region of strong sustainability in terms of the frontier in the left-hand side, and its corresponding power station output (Q) and the environmental quality (e), is larger. On the other hand, the trade-off region in terms of the frontier in the right-hand side, and its corresponding Q and e, may be smaller.

It is useful to elaborate further on the significance of the resource entitlements. The effects of the fishermen's negotiation with the power station would prompt the power station owner to participate in the fishermen's adjustment process. This is because the distance between the vertical line and the frontier to its right poses a threat of tax, whereas the distance between the line and the frontier to its left suggests a reward the power station owner can receive. The increase in strong sustainability also implies an increase in the potential gain from cooperation (i.e., area A in the SW phase in Fig. 3) that can be shared between the power station owner and the fishermen. Likewise, the expected value of areas B and C in Fig. 3 is the potential saving in tax if the power station owner also participates in the fishermen's Schumpeterian efforts.[20]

---

[18] The frontier on both sides satisfies weak sustainability, as welfare, consumption, and total capital are kept intact or even increase. Thus, strong sustainability is a subset of weak sustainability.

[19] Coase (1960) argued that the fishermen need not have such an entitlement. So long as someone has the entitlement, negotiation can take place.

[20] In the limiting case, the factory owner can buy the entitlements completely from the fishermen.

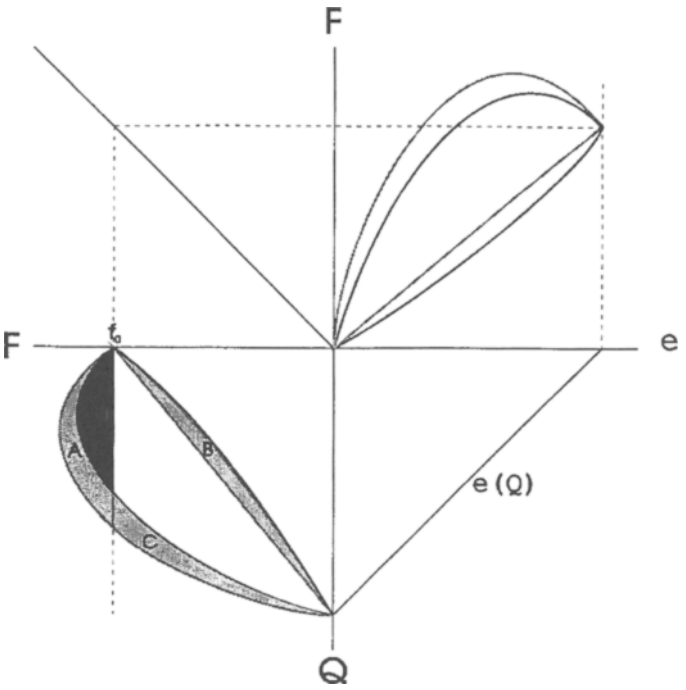

Fig. 3. The interaction between the power station and the fishermen with entitlements; F, fish production; Q, power station output; e, the environment

3 Voluntary exchange and sustainability

The contractual approach to development described above, by virtue of the fact that it expands the areas of both strong and weak sustainability, can also satisfy several characteristics of sustainable development. As emphasized in the previous section, these trading possibilities are contingent on a set of resource entitlements. If such entitlements exist, the owners of the entitlements have an incentive to consider their future actions, just as the owner of a plot of land has the incentive to plan crop rotation for future actions. Owing to the existence of tradable entitlements, negotiation between developers and holders of entitlements in effect can take the future generation into account, satisfying to some extent the "Brundtland" requirement of Pareto optimality between present and future generations.

In essence, our formulation explicitly allows the possibility of a change in production function in an *evolutionary*, *Schumpeterian* manner. In normative terms, such a change may be described as an enhancement of the original production function. In practice, technology (a production function of fish) not only is affected but also can be chosen for a given environment. In other words, technol-

ogy not only affects environment, it can be affected by the environment as well. Presumably, a social planner with perfect foresight would have been able to pick the technologies of the polluter and the polluted at the same time. However, decentralized production entities in the real world cannot perfectly foresee the joint maximization possibility. The choice of a technology or a development process therefore is likely to be sequential; it affects and is affected by environmental changes. A pragmatic approach to the development problem therefore is to ask the developer to accept the environmental consequences (i.e., accept the concept of resource entitlements) without necessarily relying on an ex ante or ex post effluent charge to achieve optimality. In other words, the institution of resource entitlements, to the extent that it can be defined, internalizes a joint maximization process that would not have occurred if decisions were made sequentially and independently, even if remedied by effluent charges or some sort of market mechanism that involves trading among polluters.

The evolutionary, Schumpeterian experiment and the interaction between the polluter and the polluted in our formulation can be contrasted with the traditional formulation of the externality problem where production functions are assumed to be *given*. The typical formulation has the output of the polluter (which assumed to have a *given* production function) entering the *given* utility or production function of the polluted. The externality is captured by a negative derivative of the action chosen by the polluter that enters into the utility or production function of the polluted. Within the context of this formulation of the problem, optimal conditions can be defined by maximizing one's utility or production function subject to the constraint of the other's utility or production function. If information cost is zero, efficient outcome in the context of the model can indeed be achieved by requiring the polluter to pay a pollution tax with the tax rate equal to the marginal damages at the optimum.

This method of interaction, however, does not achieve the "mutually resource enhancing" condition as advocated by the notion of strong sustainability described in the formulation here. The choice of technology (production function) is the essence of a Schumpeterian experiment. Technically, when a polluter generates an action, what he or she is generating is a *set* of marginal external products (some positive, some negative.) Out of this set of marginal products, the Schumpeterian experiment may result in one that is positive, or less negative. Our point is that it takes the acceptance of a resource entitlement to increase the chance of this happening.

The conventional formulation of an externality interaction necessarily involves a trade-off between two outputs characterized by the region to the right of the vertical line at f_0 in Fig. 3. The strong sustainable development version, on the other hand, would require an outcome with more fish and more power in contrast with the "pollution-free" technology of f_0. The idea that strong sustainability can be enlarged implies that the natural capital asset should not aim only at preservation but at expansion. Such an expansion is achieved via a process of voluntary exchange, thus satisfying the conservation or preservation requirement of strong sustainability.

We visit several examples illustrating the Schumpeterian process and note how institutionalizing entitlements can help facilitate this process. Before that, we highlight several theoretical implications of this approach: First, strong sustainability is not necessarily in the realm of state actions. Although defining the environment is a collective action (i.e., involving fishermen and possibly recreation users), the state can be quite passive, taking merely an advisory role or acting as an enforcer of contracts. It is commonly thought that the granting of property rights may lead to a weak form of sustainability, although the state can assist in reducing transaction costs.[21] However, the need for state intervention is much stronger when it comes to strong sustainability. Indeed, the granting of property rights is often considered to be ineffective and insufficient to support strong sustainability. This is clearly demonstrated to be false in terms of the formulation in this paper. An institution that facilitates a bargaining process between the developer and the holder of the resource entitlements can in principle achieve the strong form of sustainable development.[22]

Second, development activities are not necessarily the exclusive territory of big enterprises. The fishermen in our example can take the initiative to subsidize the power station owner in order to have strong sustainability. This is nothing but the "no free lunch" principle in economics. Although an increase in stock due to positive spillovers may come as a "surprise" initially to the fishermen, and they may very well be given a free ride on the benefit without paying the cost, this "trickling down" philosophy of development need not result in the first best situation. Mutual contributions can result in mutual benefits. In addition, transaction cost problems such as moral hazards constitute a requirement for joint contributions from the power plant investor and the fishermen, particularly for maintenance of the new technology resulting from the development. Indeed, critics of the ecological school of sustainability have raised the question of cost when satisfying all criteria. There are clear benefits to strong sustainability, but one cannot ignore the costs, which involve infrastructure and maintenance costs.

Third, strong sustainability in this formulation is treated as a desirable outcome but not a guideline. It would be rare to think of all development instances to be of this category (state or private actions included). The more frequent cases are those where a change in an ecosystem in fact leads to changes in natural stock, outputs, and life styles. In principle, there are mutually beneficial arrangements that can be worked out even among these cases. Ultimately, development cannot be devoid of values. Sharks, mosquitoes, flies, and certain bacteria may not in our current generation be considered to be "worth sustaining," but who can foresee the preferences of future generations? From an economic perspective, a more

---

[21] For example, designing certain "rules of thumb" such as "invest resource rents" for compensation via public saving can reduce transaction costs across generations.

[22] When the scope and magnitude of the affected area is large, local definition of the natural capital, although it alleviates the local conflicts, may impose an effect on its neighbor and the neighbors of the neighbor. In that case, state actions may entail a lower transaction cost than those that evolve via a succession of private contracts.

realistic guiding principle in these cases is to look at the aggregate net benefit of all parties affected. In our example, the reduction in the value of fishery output must be balanced against the increase in the value of the power station output. Development policies overemphasizing the preference of future generations can run into the danger of having a hypothetical future preference dominating the current preferences.

4 Examples and propositions

A contractual approach to strong sustainability of development suggests the following two key components: (1) a structure of entitlements must somehow, directly or indirectly, be defined; and (2) a Schumpeterian process of discovering new technology or production functions must be encouraged. Several propositions can be made more explicit.

Proposition 1. *Resource entitlements force environmental considerations as an internal decision of the polluter*

Polluters anticipate paying a "tax" in the case of a negative adjustment but can receive a "subsidy" in the case of positive interactions. In the illustration used in this paper, it is not only in the interest of the fishermen to ask the power plant to reduce pollution, it is also in the interest of the power station to participate in the Schumpeterian process of seeking new production functions. Indeed, in Taiwan, lengthy negotiations between the Taiwan Power Company and several fishermen associations on compensation and fishery investments often take place. The legitimacy of these negotiations was found to be based on the Fishing Act of 1985, which gives fishermen associations such an entitlement.[23] The Act does not explicitly state that the fishermen associations are entitled to resource entitlements. Nevertheless, the fishing entitlements can be interpreted to be a partial form of resource entitlements. At least, the Act provided a basis for negotiations. Through these negotiations both the power company and the fishermen would gain knowledge of the environment within which they operate.

The format of negotiation in Taiwan is an ongoing process subject to changes and revisions (Shaw 1996). The breadth of the dimensions of negotiation can sometimes turn a negative sentiment of NIMBY (not-in-my-backyard) into a positive sentiment of YIMBY (yes-in-my-backyard) (Koo 1996). For example, the Suao Cement Factory, owned and run by Taiwan Cement Corporation (TCC)

[23] See Articles 15–35 of Chapter 2 of the Fishing Act, especially Article 29, which states that a negotiated compensation package must be reached between the fishing entitlements holder and the developers who apply for the development of the fishing ground for the purpose of, for example, navigation lanes, port usage, national defense, and environmental protection before the agency can grant a development permit thus canceling the fishing entitlements. The Fishing Act was first promulgated in 1929 and has been revised several times. The latest revision was in 1985.

has successfully entered into an "Environmental Protection Agreement" with the Ilan County government, the local community where the factory is sited. The sequential rounds of negotiation of this agreement is a good illustration of how a joint decision on production functions have been made.[24]

A contractual approach to resolving environmental conflicts in Taiwan can be costly and lengthy. It is sometimes due to special interest groups disguised as environmentalists in the negotiation or to the shirking of prevention measures and cost exaggeration of the polluted. However, the contractual approach has indeed pointed to factors beyond the mere negotiation of monetary compensation. For example, in the case of joint capital investment in changing the production functions, the polluters generally pay a higher percentage of this investment, reflecting the ex ante expected damages to the polluted; the contract would stipulate a percentage of return to the polluter if the new production function turns out to be successful. Under this form of contract, the worst scenario is where the new production chosen is ex post inefficient, and the polluted shirks in providing defensive measures. However, this scenario poses no further tax liability on the polluter, as the original percentage of capital investment has already reflected the ex ante compensation. The only effect is a lack of further cooperation. The best scenario is where the new production function is ex post efficient, and the fishermen (or the retrained workers) do not shirk averting activities. In that case, of course, the polluter also shares the benefit. Therefore, it is possible to work out a contract where there can be more outputs to both the polluter and the polluted, thereby satisfying the strong version of sustainability.

Proposition 2. *Resource entitlements provide the incentive to experiment in addition to the right to negotiate*

Marine culture fish farms are common in Asia. Fish farming is usually supported by some sort of institutional entitlements, such as the fishing entitlements in Japan or Taiwan. The original intention of implementing these entitlements might have been to manage the open-access property of fishing resources. However, without a willingness on the part of the fishermen to experiment, it is arguable whether the success of culturing fish in Asia would be so prominent. Asian fishermen's willingness to experiment is in sharp contrast to the rigidity reported among fishermen in the West (Johnson 1990). Indeed, as reported in recent Organisation for Economic Cooperation and Development (OECD) findings, institutional structure alone, such as those that "limit the total catch, or

[24] In one round of the negotiation, for example, it was suggested that "TCC would set up an integrated belt conveyor system to move coal, gypsum, limestone, and cement so as to reduce impacts on traffic and to meet the requirements set by the Ilan County government." In other words, the Suao Cement Factory changes its production function while expecting the county government to alter its production function as well. These decisions and outcomes are not likely to be coordinated by a set of taxes and subsidies.

the number of fishing vessels . . . including technical measures and TACs, have generally yielded poor results" (OECD 1997).

The example of the Marine Fish Culture Zone (MFCZ) in Hong Kong may be illuminating on this issue. In 1980 the Hong Kong government passed a Marine Fish Culture Ordinance. The experience of the cultured fish production in Hong Kong suggested that certain species of fish were not only immune to changing water characteristics in the area but could adapt to such characteristics in a positive way. The MFCZ is an example of how the environment can be defined (i.e., designating part of an open access area as a number of private areas). Within a given private area, its owner has the incentive to seek the type of fish or mix of species most suitable for a given water quality. Indeed, the variety of live seafood in restaurants in Hong Kong, many of which have a vertical relation with fish farms, has visibly increased since the institutional entitlements of cultured fish have been established (Lai and Lam 1998).

Institutionalizing marine resource entitlements in Hong Kong has provided two insights. First, it demonstrates how the resource entitlements of a common property (sea district) can be partially defined. In some way, one can think of the cultured fish as a way to measure the environment. In the absence of such institutional features, there is no way to assess the damage of environment deprivation (e.g., red tide). Thus, the resource entitlements on fish have provided the basis by which some "Coasian" form of bargaining is possible. However, as argued in the theoretical section of this paper, it does not satisfy the strong version of sustainability.

Sustainability, in terms of more fish and higher industrial outputs, can be achieved. This is because institutionalizing resource entitlements can provide incentives for the fish farmers to experiment with species and develop methods to increase their growth rate. This economic consequence of the MFCZ has seldom been stated in the previous literature or among the policymakers (Lai and Yu 1992; Lai and Lam 1998). Instead, most attention has been paid to the resource entitlements implicit in MFCZ regarding water pollution (i.e., a pure bargaining exercise, as described in the previous paragraph). We propose that the real economic significance of the MFCZ is that it induces the fish culturists to search for production functions that adjust to the environment. Moreover, looking ahead to the future, it may also provide a political base that influences development activities leading to a change in environment, thereby satisfying the requirement of strong sustainability.

Proposition 3. *Resource entitlements are not natural rights. The concept of entitlement itself evolves from a Schumpeterian process*

The Schumpeterian process in sustainable development advocated in this paper casts doubt as to whether the resource entitlement concept is a static one the present generation can define at the outset for the future generations. Environmentalists often view technology as encroaching on their natural rights. However, if the environment is itself the result of technology, the conflict of

development and environment is merely a conflict between sets of old and new technologies. Resource entitlements provide a mechanism by which the technologies can be developed as mutually enhancing rather than necessarily competing.

An example is the bird conservation area at the northern border of Hong Kong called the Mai Po Marshes. Designated a "site of special scientific interest" (SSSI), its land-ward surrounding areas have been prevented from being used for housing or golf course development. However, the rapid urban development at its northern border, the Shenzhen Special Economic Zone (SSEZ) in Mainland China, is not subject to control by the Hong Kong government. In this respect, any conservation efforts by the Hong Kong government will be rather ineffective, as it is likely to be overwhelmed by the development efforts coming from the north (i.e., the SSEZ).

The property right approach proposed in this paper suggests the following: If the environment of the marshes is not defined in terms of area (emphasizing preservation) but in terms of the quantity of birds, it is possible to develop a neighboring natural park with similar ecological conditions that may attract the birds to fly there instead of remaining in their old habitat. In other words, the production function (living habits) of the birds may be changed in such a way that it might be able to be partially domesticated (similar to cultured fish). Thus, having more birds and more houses is not inconceivable. In fact, strong evidence is provided by the fact that trees planted as "fung shui woods" in the villages that used to derive much income from gei weis and fishponds in the marshes have also been designated SSSIs for their value as breeding grounds for local birds.

The developmental history of the gei weis and fishponds, as manmade habitats, serve to illustrate the arguments how development can be compatible with the environment, although in a somewhat *accidental* and *serendipitous* way. The gei weis were developed in the old days by villagers who constructed their settlements near the marshes. Fish farmers cleared natural mangroves or deepened some gei weis to form deepwater fishponds to ensure the supply of wild shrimp and foods for the gei weis. Had the strong sustainable development vision of the ecologist prevailed during the 1940s, Mai Po and the sites of the present villages would have been a pure mangrove area that never would have attracted to it so many bird species. The message is that production activities are not inherently contradictory to biodiversity.

5 Conclusions

Sustainable development is ideal, but there is no consensus on the best way to achieve this ideal. Some prefer to rely on voluntary exchange and market-based incentives to achieve weak sustainability. Others prefer the traditional command and control policies and therefore would rely on ultimate wise individuals and a highly planned centralized decision-making process to achieve strong sustainability. Others fall back on communal property rights without explaining whether such a property rights system can itself be sustainable when confronted

by population growth or increased competition. The property rights and contractual approach described in this paper suggests that it is possible to have voluntary exchanges result not only in weak sustainability but also in strong sustainability. It relies on a concept of resource entitlements and mutual contributions between parties. The role of the state is to assist the defining process and to enforce contracts.

Acknowledgments. We thank two anonymous referees and the editor of this journal for helpful comments and suggestions. We are grateful to the National Science Council in Taiwan for financial support.

References

Alchian A, Allen W (1969) Exchange and production: theory in use. Wadsworth Publishing, Belmont, CA, USA

Anderson L (1976) The relationship between firm and fishery in common property fisheries. Land Economics 52:179–191

Angello R, Donnelley L (1975) Property rights and efficiency in oyster industry. Journal of Law and Economics 18:521–533

Angello R, Donnelley L (1976a) Externalities and property rights in the fisheries. Land Economics 52:519–529

Angello R, Donnelley L (1976b) Prices and property rights in the fisheries. Southern Economic Journal 42:253–262

Barbier E (1987) The concept of sustainable economic development. Environmental Conservation 14:101–110

Barbier E, Markandya A (1990) The conditions of achieving environmentally sustainable development. European Economic Review 34:659–669

Batie S (1989) Sustainable development: challenges to the profession of agricultural economics. American Journal of Agricultural Economics 71:1083–1101

Batie S (1992) Sustainable development: concepts and strategies. In: Peters G, Stanton B (eds) Sustainable agricultural development: the role of international cooperation. Dartmouth Publishing, Watertown, MA, USA

Bromley D (1991) Environment and economy: property rights and public policy. Blackwell, Oxford

Calabresi G, Melamed D (1972) Property rules, liability rules, and inalienability: one view of the Cathedral. Harvard Law Review 85:1089–1128

Callicott J, Mumford K (1997) Ecological sustainability as a conservation concept. Conservation Biology 11(1):32–40

Cheung S (1970) The structure of contract and the theory of a non-exclusive resource. Journal of Law and Economics 13:49–70

Cheung S (1973) The fable of the bees: an empirical investigation. Journal of Law and Economics 16:11–33

Coase R (1960) The problem of social cost. Journal of Law and Economics 3:1–44

Daly H (1989) Steady-state and growth concepts for the next century. In: Archibugi F, Nijkamp P (eds) Economy and ecology: towards sustainable development, Kluwer, Boston

Daly H (1990) Toward some operational principles of sustainable development. Ecological Economics 2:1–6

Daly H (1991) Steady-state economics, 2nd edn. Island Press, Washington, DC

Daly H, Cobb J (1989) For the common good. Beacon Press, Boston

Dasgupta P, Maler K (1991) The environment and emerging development issues. Proceedings of the World Bank Annual Conference on Development Economics 1990, World Bank, Washington DC, pp 101–131

Demsetz H (1967) Toward a theory of property rights. American Economic Review Proceedings 57:347–359

Gordon H (1954) The economic theory of a common property resource: the fishery. Journal of Political Economy 62:124–142
Hardin G (1968) The tragedy of the commons. Science 13:1243–1248
Howarth RB, Norgaard R (1990) Intergenerational resource rights, efficiency, and social optimality. Land Economics 66(1):1–11
Howarth RB, Norgaard R (1992) Environmental valuation under sustainable development. American Economic Review Proceedings 82:473–477
Johnson R (1990) Commercial wild species rearing: competing groups and regulation. Journal of Environmental Economics and Management 19:127–142
Johnson R, Libecap G (1982) Contracting problems and regulation: the case of the fishery. American Economic Review 72:1005–1022
Knight F (1924) Some fallacies in the interpretation of social cost. Quarterly Journal of Economics 38:582–606
Koo L (1996) Transforming NIMBY into YIMBY: the siting experience of Taiwan Cement Corporation in Ilan, Taiwan, ROC. In: Shaw D (ed) Comparative analysis of siting experience in Asia. Institute of Economics, Academia Sinica, Taipei
Lai W, Lam K (1998) Pond culture of Snakehead in Hong Kong: a case study of an economic solution to common resources. Aquaculture International 6(1):67–75
Lai W, Yu B (1992) The effects of water pollution in the fishing industry of Hong Kong. Department of Surveying, The University of Hong Kong
Lai W, Yu B (1995) The "Hong Kong" solution to the overfishing problem: a study of the cultured fish industry in Hong Kong. Managerial and Decision Economics 16:525–536
Mendelsohn R, Nordhaus W, Shaw D (1993) The impact of global warming on agriculture: a Ricardian analysis. American Economic Review 84:753–771
Nabli M, Nugent J (1989) The new institutional economics and its applicability to development. World Development 17:1333–1347
Norgaard R (1991) Sustainability: three methodological suggestions for agricultural economics. Canadian Journal of Agricultural Economics 39:637–645
Norgaard R (1992) Sustainability: the paradigmatic challenge to agricultural economists. In: Peters G, Stanton B (eds) Sustainable agricultural development: the role of international cooperation. Dartmouth Publishing, Watertown, MA, USA
OECD (1997) Towards sustainable fisheries: economic aspects of the management of living marine resources. OECD, Paris
Ostrom E (1990) Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge
Pearce D, Atkinson G (1998) Concept of sustainable development: an evaluation of its usefulness 10 years after Brundtland. Environmental Economics and Policy Studies 1:95–111
Pearce D, Markandya A, Barbier E (1989) Blueprint for a green economy. Earthscan Publications, London
Schumpeter J (1934) The theory of economic development. Harvard University Press, Cambridge, MA, USA
Shaw D (1996) An economic framework for analyzing facility siting policies in taiwan and Japan. In: Kleindorfer P, Kunreuther H, Hong D (eds) Energy, environment and the economy: Asian perspectives. Edward Elgar, Aldershot, UK
Solow R (1992) An almost practical step toward sustainability. Resources for the Future, Washington, DC
Tanaka Y (1999) Is the NYMBY syndrome a universal phenomenon: symptoms and remedies. Presented at a workshop on challenges and issues in facility siting, Institute of Economics, Academia Sinica, Taipei, January 7–9, 1999
Tietenberg T (2000) Environmental and natural resource economics, 5th edn. Addison Wesley Longman, Reading, MA, USA
UN Chronicle. June 30, 1992
Veeman T (1989) Sustainable development: its economic meaning and policy implications. Canadian Journal of Agricultural Economics 37:875–886
World Commission on Environment and Development (1987) Our common future. Oxford University Press, Oxford

Yeh J (1992) Environmental entitlements for sale: the 1.5 billion dollar payment for the establishment of the fifth naphtha-cracking plant (in Chinese with English abstract). Proceedings of the National Science Council, Republic of China. Part C: Humanities and Social Sciences 2(1): 17–34