Journal of Rural Development 15(1992):57-76

IMPACTS OF NONMARKET GOOD POLICIES ON MARKET GOODS: A GENERAL EQUILIBRIUM ANALYSIS

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Abstract

Most nonmarket valuation procedures have emphasized estimating values in a partial equilibrium context. However, changes in the nonmarket good sector are likely to affect individual's market good consumption choices. Therefore, when there is a change in the nonmarket good sector, based on the assumption of nonseparability between market and nonmarket goods, the changes in the competitive equilibrium state with respect to market goods are examined. Analysis of policy impacts indicates that competitive equilibria change depending upon the nature of substitution and complementary relationships between market and nonmarket goods, and the degree of those relationships.

I. Introduction

Pareto optimality provides a definition of economic efficiency that serves as the basis for much of welfare economics. Pareto optimality is defined as a situation where no individual can be made better-off without making some other individual worse-off. Pareto optimal states are also referred to as Pareto efficient states, defined to encompass Pareto efficiency in production and consumption. Pareto efficiency in production implies that the marginal rate of technical

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substitution between any two inputs is the same for all industries that use both inputs. Pareto efficiency in consumption implies that the marginal rate of substitution between any two goods is the same for all consumers.

Rival and exclusive goods may be provided by a decentralized pricing mechanism and voluntary exchange, and Pareto optimality can be achieved. However, if goods are nonrival and nonexclusive, e. g., good quality of the environment (air), a decentralized market cannot achieve Pareto efficiency. Many natural resources are nonrival in consumption and nonexclusive in provision, for example, unique environments and the existence of endangered wildlife. To deal with nonmarket goods we need to measure their value because they are not exchanged in the marketplace and thus, fail, to have explicit relative value indicators. There are considerable empirical analyses valuing nonmarket goods. But the emphasis has been placed on estimating values under narrowly defined partial equilibrium conditions as though individual utility functions are strongly separable in both types of goods. General equilibrium demand analysis has not been attempted. However, if utility functions are not separable in both market and nonmarket goods, marginal rates of substitution between any pair of market goods depend on the quantity of nonmarket goods in existence. Nonmarket goods cannot be properly dealt with by considering them in isolation from the rest of the economy. Partial equilibrium analysis may result in error because they assume other markets are characterized by equilibria which are separable from the nonmarket good of interest.

Ayres and Kneese argued that the production of residuals is an inherent and general part of production and consumption processes. The environmental media which receive and assimilate residual wastes are not free goods but natural resources of great value. Also, they provide a formal mathematical framework for tracing residual flows in an economy and relate it to a general equilibrium model of resources allocation, containing unpriced sectors, to represent the environment. The authors warned that partial equilibrium approaches, while more tractable, may lead to serious errors. The basic premise of this paper is that the value of nonmarket goods and analysis of policy impacts on nonmarket goods should be considered in a general equilibrium context instead of from a partial equilibrium perspective.

This allows the price of market goods to adjust to changes in nonmarket goods provision and costs. Isolated, ad hoc taxes and other restrictions are not sufficient. Public investment programs in nonmarket goods provision must be planned in recognition of the general equilibrium context in which they exist. The main purpose herein is to conceptually define a system where market and nonmarket goods are simultaneously accounted for and to identify the impact of alternative nonmarket goods provision policies on market goods.

A general equilibrium analysis of market and nonmarket goods provides more information for valid cost benefit analysis of a policy than partial equilibrium analysis of nonmarket goods (Randall 1983).

II. Concept of Nonmarket Goods

The term nonmarket good is used as an expression to cover a wide variety of goods for which markets are non-existent or incomplete (Randall and Peterson). Types of goods based on concepts of exclusion and rivalry are classified in Table 1 (Randall 1983). Goods are defined as nonrival goods if person A's consumption of the good does not reduce the availability of that good by all others (Musgrave and Musgrave). Nonexclusiveness is an attenuation of property rights and results in inefficiency. Typical allocative results of nonexclusiveness are the underprovision of goods; overexploitation of natural resources; underinvestment in management relative to the efficient level.

TABLE 1 A Classification of Goods Based on Rivalry and Exclusion

	Nonexclusive	Exclusive	Hyperexclusive
Nonrival	type 1	type 4	type 7
Congestible	type 2	type 5	type 8
Rival	type 3	type 6	type 9

The term hyperexclusion is used to denote discriminatory pricing which is required to achieve Pareto efficiency in the case of nonrival goods. Goods of type 6 are market goods. Goods of types 1 through 8 except type 6 may be included in the category of nonmarket goods. Goods of types 1 and 5 are the two types of nonmarket good to be considered in this paper. Throughout this paper, the term nonmarket goods is used to express goods of types 1 and 5. A public sector could provide goods of type 1 in efficient quantities but not at efficient prices, financed from general revenues such as lump-sum tax. Goods of type 5 could be provided by the private sector or by the public sector financing them with user fees.

III. Analysis of Nonmarket Good Policy Impacts

1. The Model

We consider a case of a vector of market goods and a nonmarket good (N) directly included in the utility function with all market goods being produced from marketable factors. Assume there are K firms, each purchasing factors to produce outputs sold in product markets and maximizing profits subject to the technology embedded in their production functions. The firm's production function is given by:

$$f^k(Y^k) = 0$$

where,

$Y^k = (y_1^k \ldots y_h^k,\ y_{h+1}^k, \ldots y_J^k)$
$y_1^k, \ldots y_h^k$ = output quantities
$y_{h+1}^k, \ldots y_J^k$ = quantities of production factors

Following a netput[1] concept, outputs are positive and factor inputs are negative (Varian). Prices in an economy are summarized as a price vector:

[1] Suppose a firm has J possible goods to serve as factors and/or outputs. We can represent a specific production plan by a vector Y where y_j is negative if the j^{th} good serves as a net input and positive if the j^{th} good serves as a net output. such a vector is called a netput vector

$$P = (p_1,...p_h,p_{h+1},...p_J)$$

The profit of firm k is given by the inner product of price and netput vectors.

$$\pi^k = PY^k = \sum_{j=1}^{J} p_j y_j^k \qquad k = 1,...K$$

The solution to this profit maximization problem for producers is a vector of supply and factor demand functions $Y^k(P)$ for all firms k = 1,...K. Each consumer in this system is assumed to own certain endowments and a share (S_{ik}) of the firms' profit. The budget constraint of the i^{th} consumer is:

$$M^i = Pr^i + \sum_{k=1}^{K} S_{ik}\, \pi^k(P)$$

where,

r^i = the i^{th} consumer's endowment vector

$\pi^k(P)$ = the k^{th} firm's profit

An individual's utility level depends on the vector of market and nonmarket goods consumed. Assume an individual has following utility function:

$$U^i = U^i(Y^i, N)$$

where,

Y^i = vector of market goods consumed

N = quantity of a nonmarket good

Assume that the utility function is non-separable in Y and N and that each of I consumers maximizes utility subject to a budget constraint. Also, assume that these consumers behave competitively - that is, they take prices as given. Consumer i's market good consumption bundle will be denoted as:

$$Y^i = (y_1^i...y_h^i)$$

The amount of good j that consumer i consumes is indicated by y_j^i. The consumer's utility maximization problem yields the individual consumer's demand function for a vector of market goods as:

$$Y^{di}(P, N, Pr^i + \sum_{k=1}^{K} S_{ik} \Pi^k(P))$$

Thus, N becomes an argument in the demand function for market goods. Since profits may be expressed as a function of output and input prices, the i^{th} consumer's demand function for market goods can be expressed as a function of prices and the quantity of nonmarket good, assuming the consumer chooses a utility maximizing bundle that satisfies the budget constraint (Henderson and Quandt; Varian). From now on, the income term in demand functions will be ignored. The aggregate demand function for market goods in the economy is obtained by horizontally adding the individual consumer's demand functions (Evans) and is expressed as:

$$Y^D(P, N)$$

where, $Y^D(P, N) = (y_1^D, \ldots y_h^D)$ is a vector of aggregate demand functions for market goods. The aggregate supply of market goods is composed of aggregate supply from consumers, $\sum_{i=1}^{I} r^i$, and the aggregate net supply of producers, $\sum_{k=1}^{K} Y^k(P)$. Total market goods supply is $Y(P) = \sum_{k=1}^{K} Y^k(P) + \sum_{i=1}^{I} r^i$. The supply of a nonmarket good is viewed as an endowment N^o. A competitive general equilibrium is defined as a situation in which there is no excess demand in any market and all prevailing market prices are nonnegative (Quirk and Saposnik). All markets must clear to have equality of demand and supply (Varian; Chiang). Thus, final equilibria in goods markets are characterized by equality of aggregate demand and total supply in every market.

Suppose the nonmarket good which is an argument in the utility function is environmental quality which is nonrival and nonexclusive. Environment yields a flow of services to the consumers such as clean air. Assume wastes generated in the consumption activities are disposed into the environment and decrease environmental quality. In this case, nonexclusiveness does not permit the market to allocate resources efficiently and prevents achievement of Pareto efficiency. This type of nonmarket good may be provided by a public sector in efficient quantity, financed from general revenues. Thus, a lump-sum tax policy could be considered to finance the provision of an efficient quantity. Impacts of intervention in the nonmarket good sector upon the market goods sector will now be analyzed.

2. A Lump-sum Tax Policy

Nonexclusiveness causes market overexploitation of environmental quality relative to the efficient level of provision, as well as underinvestment in the conservation of a good quality environment. Where exclusion of resources is not feasible, the attainment of Pareto efficiency is not possible (Randall 1987). In this case, the government can directly provide an efficient level of environmental quality financed by general revenue (Randall 1972). Suppose the government produces (or manages) environmental quality and the production (management) costs are financed by a lump-sum tax. The lump-sum tax is imposed equally on all consumers regardless of the level of environmental quality they consume. For simplicity then, the government's production function for environmental quality is assumed a function of lump-sum tax revenue collected. After the lump-sum tax, a consumer's budget constraint would become:

$$M^i = Pr^i + \sum_{k=1}^{K} S_{ik}\Pi^k(P) - T$$

where T is the lump-sum tax.

Even though the competitive equilibrium under this policy is not Pareto efficient, it is possible to provide what would have been Pareto efficient quantities. The consumer's utility maximization problem yields new demand functions, $Y^d(P; N, T)$, for the market goods given the new quantity of N provided and a lump-sum tax. Then, aggregate excess demand functions for market goods, factors, and the environmental quality are written as:

$$
\begin{aligned}
E_j &= y_j^D(P; N, T) - y_j(P) - r_j && j = 1,\dots h \\
E_j &= - y_j(P) - r_j && j = h+1,\dots J \qquad (1) \\
E_N &= N^D(P; T) - N^o
\end{aligned}
$$

where,

E_j = excess demand function for market goods and inputs $j = 1,\dots J$

E_N = excess demand function for environmental quality

r_j = supply of inputs which are assumed to be fixed as endowments

N^D = demand for environmental quality

N^o = endowment of the environmental quality (which is the total supply of the nonmarket good)

First, totally differentiate each excess demand function with respect to T to know the effect of a lump-sum tax policy on market good equilibrium. This yields:

$$
\begin{aligned}
\frac{dE_1}{dT} &= \frac{\partial E_1}{\partial p_1}\frac{dp_1}{dT} + \frac{\partial E_1}{\partial p_2}\frac{dp_2}{dT} + \cdots + \frac{\partial E_1}{\partial P_J}\frac{dp_J}{dT} + \frac{\partial E_1}{\partial N}\frac{dN}{dT} + \frac{\partial E_1}{\partial T} \\
&\vdots \\
\frac{dE_h}{dT} &= \frac{\partial E_h}{\partial p_1}\frac{dp_1}{dT} + \frac{\partial E_h}{\partial p_2}\frac{dp_2}{dT} + \cdots + \frac{\partial E_h}{\partial P_J}\frac{dp_J}{dT} + \frac{\partial E_h}{\partial N}\frac{dN}{dT} + \frac{\partial E_h}{\partial T} \\
\frac{dE_{h+1}}{dT} &= \frac{\partial E_{h+1}}{\partial p_1}\frac{dp_1}{dT} + \frac{\partial E_{h+1}}{\partial p_2}\frac{dp_2}{dT} + \cdots + \frac{\partial E_{h+1}}{\partial p_J}\frac{dp_J}{dT} \\
&\vdots \\
\frac{dE_J}{dT} &= \frac{\partial E_J}{\partial p_1}\frac{dp_1}{dT} + \frac{\partial E_J}{\partial p_2}\frac{dp_2}{dT} + \cdots + \frac{\partial E_J}{\partial p_J}\frac{dp_J}{dT}
\end{aligned}
$$

By Walras' law, if $\sum_{j=1}^{J} p_j E_j = 0$ then $E_N = 0$, i.e., if all other markets except one market in an economy are in equilibrium, the remaining one market will also be in equilibrium. Thus, given any price vector P, excess demand for the nonmarket good (N) is determined by the levels of excess demands for the remaining market commodities. One equation is deleted from the system of excess demand functions and $\frac{dE_i}{dT}$ is set equal to zero for every i assuming that the system is at some equilibrium after the change in exogenous variable, T. Expressing the system of equations, in matrix notation, it becomes:

$$H \left[\frac{dp}{dT}\right] = - \left[\frac{\partial E}{\partial T}\right] \tag{2}$$

where,

$$H = \begin{bmatrix} \frac{\partial E_1}{\partial p_1} & \frac{\partial E_1}{\partial p_2} \cdots \frac{\partial E_1}{\partial p_J} \\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot \\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot \\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot \\ \frac{\partial E_J}{\partial p_1} & \frac{\partial E_J}{\partial p_2} \cdots \frac{\partial E_J}{\partial p_J} \end{bmatrix} \quad \left[\frac{dp}{dT}\right] = \begin{bmatrix} \frac{dp_1}{dT} \\ \vdots \\ \frac{dp_h}{dT} \\ \vdots \\ \frac{dp_J}{dT} \end{bmatrix} \quad \left[\frac{\partial E}{\partial T}\right] = \begin{bmatrix} \frac{\partial E_1}{\partial N}\frac{dN}{dT} + \frac{\partial E_1}{\partial T} \\ \vdots \\ \frac{\partial E_h}{\partial N}\frac{dN}{dT} + \frac{\partial E_h}{\partial T} \\ 0 \\ \vdots \end{bmatrix}$$

Equation 2) is solved for $\frac{dp_j}{dT}$ to yield:

$$\frac{dp_j}{dT} = - \frac{1}{|H|} \left\{ \left(\frac{\partial E_1}{\partial N}\frac{dN}{dT} + \frac{\partial E_1}{\partial T}\right) H_{1j} + \ldots + \left(\frac{\partial E_h}{\partial N}\frac{dN}{dT} + \frac{\partial E_h}{\partial T}\right) H_{hj} \right\}$$

$j = 1,\ldots J$

where $|H|$ is the determinant of matrix H and H_{ij} is the cofactor associated with the element in the i^{th} row and j^{th} column of the H matrix (Silberberg).

To determine the sign of $\frac{dp_j}{dT}$ consider a simple economy which has two inputs (J-1, J), two market goods (y_1 and y_2) and one nonmarket good which allows the existence of both complements and substitutes to N. Assume y_1 and N are complements, y_2 and N are substitutes and y_1 and y_2 are substitutes[2]. Excess demand functions are normalized by the price p_{J-1} and rewritten as:

$$
\begin{aligned}
E_1 &= y_1^D(p_1, p_2, p_J; N, T) - y_1(p_1, p_2, p_J) - r_1 \\
E_2 &= y_2^D(p_1, p_2, p_J; N, T) - y_2(p_1, p_2, p_J) - r_2 \\
E_J &= - y_J(p_1, p_2, p_J; N, T) - r_J
\end{aligned}
\qquad (3)
$$

Since the excess demand for N is determined by the level of excess demands for the remaining three goods, only three excess demand functions need be considered to determine the effects of the lump-sum tax, T. Normalizing the three excess demand functions and totally differentiating with respect to T, the result is written in matrix form:

$$
HS \left[\frac{dP}{dT}\right] = - \left[\frac{\partial E}{\partial T}\right] \qquad (4)
$$

where,

$$
HS = \begin{bmatrix} \frac{\partial E_1}{\partial p_1} & \frac{\partial E_1}{\partial p_2} & \frac{\partial E_1}{\partial p_J} \\ \frac{\partial E_2}{\partial p_1} & \frac{\partial E_2}{\partial p_2} & \frac{\partial E_2}{\partial p_J} \\ \frac{\partial E_J}{\partial p_1} & \frac{\partial E_J}{\partial p_2} & \frac{\partial E_J}{\partial p_J} \end{bmatrix} \left[\frac{dp}{dT}\right] = \begin{bmatrix} \frac{dP_1}{dT} \\ \frac{dP_2}{dT} \\ \frac{dP_J}{dT} \end{bmatrix} \left[\frac{\partial E}{\partial T}\right] = \begin{bmatrix} \frac{\partial E_1}{\partial N}\frac{dN}{dT} + \frac{\partial E_1}{\partial T} \\ \frac{\partial E_2}{\partial N}\frac{dN}{dT} + \frac{\partial E_2}{\partial T} \\ 0 \end{bmatrix}
$$

[2] Complements and substitutes are defined as:
If $\frac{\partial y_i}{\partial p_j} < 0$, then i and j ($i \neq j$) are complements. If $\frac{\partial y_i}{\partial p_j} > 0$, then i and j are substitutes. Following this, if $\frac{\partial y_i}{\partial N} > 0$ (<0), then y_i and N are assumed to be complements (subsitutes).

Solving equation 4) for $\left[\frac{dP}{dT}\right]$ gives:

$$\frac{dp_1}{dT} = -\frac{1}{|HS|}\left\{\left(\frac{\partial E_1}{\partial N}\frac{dN}{dT} + \frac{\partial E_1}{\partial T}\right)HS_{11} + \left(\frac{\partial E_2}{\partial N}\frac{dN}{dT} + \frac{\partial E_2}{\partial T}\right)HS_{21}\right\} > 0$$

$$\text{if } \frac{\partial E_1}{\partial N}\frac{dN}{dT} > \frac{\partial E_1}{\partial T}$$

$$\frac{dp_2}{dT} = -\frac{1}{|HS|}\left\{\left(\frac{\partial E_1}{\partial N}\frac{dN}{dT} + \frac{\partial E_1}{\partial T}\right)HS_{12} + \left(\frac{\partial E_2}{\partial N}\frac{dN}{dT} + \frac{\partial E_2}{\partial T}\right)HS_{22}\right\} < 0$$

$$\text{if } \frac{\partial E_1}{\partial N}\frac{dN}{dT} > \frac{\partial E_1}{\partial T}$$

$$\frac{dp_3}{dT} = -\frac{1}{|HS|}\left\{\left(\frac{\partial E_1}{\partial N}\frac{dN}{dT} + \frac{\partial E_1}{\partial T}\right)HS_{13} + \left(\frac{\partial E_2}{\partial N}\frac{dN}{dT} + \frac{\partial E_2}{\partial T}\right)HS_{23}\right\} > 0$$

$$\text{if } \frac{\partial E_1}{\partial N}\frac{dN}{dT} > \frac{\partial E_1}{\partial T}$$

where $|HS|$ is determinant of the HS matrix and assuming Hicksian perfect stability of aggregate excess demand curves for each good, $\partial E_i / \partial p_i < 0$ and principal minors of the HS matrix have alternative signs (Quirk and Saposnik) thus, $HS_{11} > 0$, $HS_{21} < 0$, $HS_{12} < 0$, $HS_{22} > 0$, $HS_{13} > 0$, $HS_{23} < 0$.
$\frac{\partial E_i}{\partial T} = \frac{\partial y_i}{\partial T} < 0$, i = 1,2, $\frac{\partial E_1}{\partial N} = \frac{\partial y_1^D}{\partial N} > 0$ because y_1 and N are complements ; $\frac{\partial E_2}{\partial N} = \frac{\partial y_2^D}{\partial N} < 0$ because y_2 and N are substitutes; and $\frac{dN}{dT} > 0$ because the supply of a nonmarket good is increased by the government's production.

The lump-sum tax itself does not affect demand for the environmental quality because environmental quality is still nonexclusive and unpriced. However, since the government is assumed to produce (manage) environmental quality, an increase in its supply results in a reduction of its excess demand. The level of environmental quality may be provided at (what would have been) an efficient level but not at an efficient price.

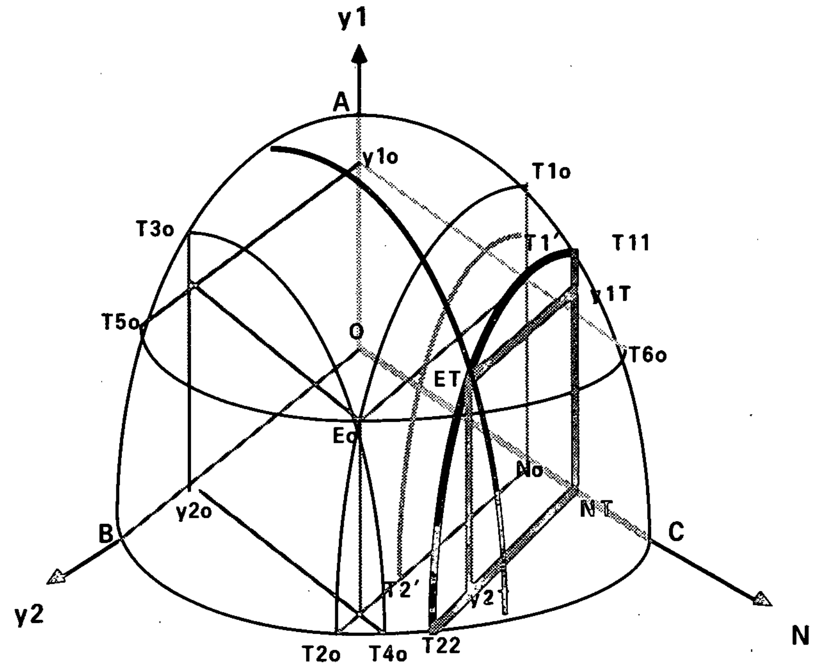
The lump-sum tax has a negative income effect on market goods. It will reduce the demand for market goods if market goods are normal goods ($\frac{\partial y_i^D}{\partial T} < 0$). An increase in supply of environmental quality would have an impact on the demand for market goods, in turn causing prices of market goods to change. Thus, the impact of a lump-sum tax policy in this case is composed of a negative income effect and an increased supply of environmental quality. Comparative static results for the lump-sum tax policy show that the price of complementary market goods increases and the price of substitute market goods falls if the complementary effect is greater than the negative income effect.

If the utility function is separable in both goods and demand functions do not have environmental quality as an argument, then $\partial E_i / \partial N$ becomes zero for all i. The policy has a negative income effect only. Therefore, $\partial p_i / \partial T < 0$ for all i.

An illustration of the analysis is shown graphically as ABC in figure 1. A three goods economy is assumed, and a three-dimensional production possibility surface is drawn for the economy. Points on the surface, denoted as a ABC, represent the various combinations of y_1, y_2 and N which are potentially available to the economy. Assume the economy is initially at the point Eo where the distribution of goods is (y1o, y2o, No). At point Eo with given level (No) of a nonmarket good, curves T1oT2o, T3oT4o and T5oT6o are production possibility curves between the goods y_1 and y_2, y_1 and N, y_2 and N, respectively given a fixed level of the third good. Slopes of curves T1oT2o, T3oT4o and T5oT6o represent marginal rates of product transformation between the goods y_1 and y_2, y_1 and N, y_2 and N ($MRT_{y_1y_2}$, MRT_{y_1N} and MRT_{y_2N}), respectively.

The lump-sum tax initially causes the production possibility curve between market goods y_1 and y_2 to shrink to T1'T2' inside of plane T1oT2oNo. This is because a smaller quantity of resources will be available to produce market goods y_1 and y_2 after a lump-sum tax, i.e., the tax revenues finance resources are employed to produce (manage) a nonmarket good. Resources remaining in the market goods sector can produce the output combination along curve T1'T2' (Browning and Browning). However, since government produces a nonmarket good using lump-sum tax revenues, if total supply of the nonmarket good is increased to NT, the production possibility curve between y_1 and y_2 becomes T11T22. This shift of the production possibility curve from T1oT2o to T11T22 can be expressed as a reduction in supply of market goods but an increase in a nonmarket good availability for the economy. With an increased provision (supply) of N, the subsequent market good equilibrium will be represented as a point along the curve T11T22. As discussed, if the complementary effect is greater in absolute value than the income effect, then the new equilibrium will be at a point such as ET. At the point ET, subsequent prices and outputs are (p1T, p2T) and (y1T, y2T, NT).

FIGURE 1 Effect of a Lump - Sum Tax Policy in Multi - Dimensional Production Possibility Surface



3. A Unit Tax Policy

Assume the nonmarket good consumption in an economy is a natural scenic view instead of environmental quality, e.g., Grand Canyon, which is congestible and excludable (for a detailed expression of categories of wildland benefits and characteristics, see Randall and Peterson). This type of good is nonrival goods until a capacity constraint is approached. Pareto efficient provision of this type of good is not possible without perfectly discriminatory pricing which requires hyperexclusion (Table 1). Since exclusion is possible although hyperexclusion is not, the government can charge a unit tax for access to the natural scenic view or regulate access to it. In this way, excess demand by potential users can be reduced, and an efficient quantity can be provided. Another approach to resolve congestion would be to provide the good using tax revenues. However, this case focuses upon reducing excess demand (congestion). It is assumed, therefore, that the government charges unit taxes to consumers and tax revenues are returned to consumers in the form of lump-sum transfers. From the consumer's utility maximizing problem, individual demand functions for Y and N are obtained as functions of a price vector and the unit tax:

$$Y^d(P, t) \text{ and } N^d(P, t)$$

As stated above, aggregate demand functions for both goods are obtained by aggregating individual demand functions:

$$Y^D(P, t) \text{ and } N^D(P, t)$$

Aggregate excess demand functions for market goods, factors are defined, respectively, as:

$$\begin{aligned} E_j &= y_j^D(P, t) - y_j(P) - r_j & j &= 1,\ldots h \\ E_j &= - y_j(P) - r_j & j &= h+1,\ldots J \end{aligned}$$

Assume that all prices of market goods change after imposition of the unit tax policy. Each excess demand function can be totally differentiated with respect to t and are arranged in matrix form to yield:

$$H \left[\frac{dp}{dt}\right] = - \left[\frac{\partial E}{\partial t}\right] \tag{5}$$

where,

$$H = \begin{bmatrix} \frac{\partial E_1}{\partial p_1} & \frac{\partial E_1}{\partial p_2} & \cdots & \frac{\partial E_1}{\partial p_J} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \frac{\partial E_J}{\partial p_1} & \frac{\partial E_J}{\partial p_2} & \cdots & \frac{\partial E_J}{\partial p_J} \end{bmatrix} \quad \left[\frac{dP}{dT}\right] = \begin{bmatrix} \frac{dp_1}{dt} \\ \vdots \\ \frac{dp_h}{dt} \\ \vdots \\ \frac{dp_J}{dt} \end{bmatrix} \quad \left[\frac{\partial E}{\partial t}\right] = \begin{bmatrix} \frac{\partial E_1}{\partial t} \\ \vdots \\ \frac{\partial E_h}{\partial t} \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

Equation 5) can be solved for $\frac{dp_j}{dt}$ yielding:

$$\frac{dp_j}{dt} = - \frac{1}{|H|} \left\{\frac{\partial E_1}{\partial t} H_{1j} + \cdots + \frac{\partial E_h}{\partial t} H_{Lj}\right\} \qquad j = 1,\ldots J$$

where $|H|$ is the determinant of the matrix H and H_{ij} is the cofactor associated with an element in the ith row and jth column of the H matrix.

Assuming a four goods economy, the normalized excess demand functions are written as:

$$\begin{aligned} E_1 &= y_1^D(p_1, p_2, p_J, t) - y_1(p_1, p_2, p_J) - r_1 \\ E_2 &= y_2^D(p_1, p_2, p_J, t) - y_2(p_1, p_2, p_J) - r_2 \\ E_J &= - y_J(p_1, p_2, p_J) - r_J \end{aligned} \tag{6}$$

Totally differentiating these functions with respect to t and rewriting in matrix form yields:

$$H \left[\frac{dp}{dt}\right] = - \left[\frac{\partial E}{\partial t}\right] \tag{7}$$

where,

$$HS = \begin{bmatrix} \frac{\partial E_1}{\partial p_1} & \frac{\partial E_1}{\partial p_2} & \frac{\partial E_1}{\partial p_J} \\ \frac{\partial E_2}{\partial p_1} & \frac{\partial E_2}{\partial p_2} & \frac{\partial E_2}{\partial p_J} \\ \frac{\partial E_J}{\partial p_1} & \frac{\partial E_J}{\partial p_2} & \frac{\partial E_J}{\partial p_J} \end{bmatrix} \quad \left[\frac{dp}{dt}\right] = \begin{bmatrix} \frac{dp_1}{dt} \\ \frac{dP_2}{dt} \\ \frac{dP_J}{dt} \end{bmatrix} \quad \left[\frac{\partial E}{\partial t}\right] = \begin{bmatrix} \frac{\partial E_1}{\partial t} \\ \frac{\partial E_2}{\partial t} \\ 0 \end{bmatrix}$$

Solving equation 7) for $\frac{\partial p_i}{\partial t}$ via Cramer's rule:

$$\frac{dp_1}{dt} = -\frac{1}{|HS|}\left\{\frac{\partial E_1}{\partial t}HS_{11} + \frac{\partial E_2}{\partial t}HS_{21}\right\} < 0$$

$$\frac{dp_2}{dt} = -\frac{1}{|HS|}\left\{\frac{\partial E_1}{\partial t}HS_{12} + \frac{\partial E_2}{\partial t}HS_{22}\right\} > 0$$

$$\frac{dp_J}{dt} = -\frac{1}{|HS|}\left\{\frac{\partial E_1}{\partial t}HS_{13} + \frac{\partial E_2}{\partial t}HS_{23}\right\} < 0$$

where $|HS|$ is the determinant of the HS matrix and has a negative sign; $HS_{11} > 0$, $HS_{21} < 0$, $HS_{12} < 0$, $HS_{22} > 0$, $HS_{13} > 0$, $HS_{23} < 0$.

$\frac{\partial E_1}{\partial t} = \frac{\partial y_1^D}{\partial t} < 0$ because y_1 and N are complements.

$\frac{\partial E_2}{\partial t} = \frac{\partial y_2^D}{\partial t} > 0$ because y_2 and N are substitutes.

As a result of this analysis, the price of the market good which is a complement to the natural scenic view decreases when the consumption of the natural scenic view is taxed. The price of the market good which is a substitute for the natural scenic view increases. After the unit tax is imposed, equilibrium prices of market goods change depending upon their complementary and/or substitution relationship with the natural scenic view. Therefore, the unit tax upon consumption of the natural scenic view results in changes not only in its consumption level but also in the competitive equilibria for market goods.

Effect of the unit tax policy is drawn in figure 2. With the unit tax on N, the economy would move to a point along curve T3oT4o or a point along the curve T5oT6o in figure 2. A post-tax equilibrium is represented by the point Et with prices (p1t, p2t) and the output distribution (y1t, y2t, Nt).

IV. Summary and Conclusion

Government Intervention is discussed to resolve inefficiency from two types of nonmarket goods, nonrival and nonexclusive goods; congestible and exclusive goods. Overall comparative static results indicate that competitive equilibria of market goods are related to nonmarket goods. Equilibria of market goods change when there is a change in the nonmarket goods sector.

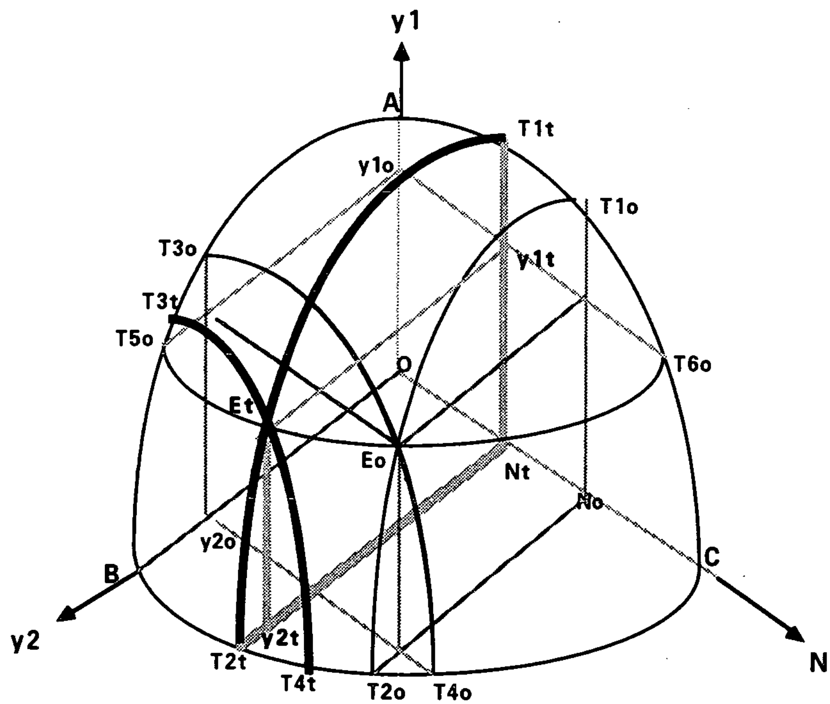
The lump-sum tax policy is applied to a nonmarket good which is nonrival and nonexclusive (a Samuelsonian pure public good). A lump-sum tax policy (if used to provide greater quantity of the nonmarket good) could provide an efficient level of environmental quality. The lump-sum tax policy causes the price of complementary market goods to rise and the price of substitute market goods to fall if complementary effects are greater than income effect.

A unit tax policy can induce competitive equilibria to maintain a Pareto efficient level of the natural scenic view because the unit tax could cause excess demand for N to fall to zero if the tax is high enough. In terms of impact on the market goods economy, the unit tax policy causes the price of complementary market goods to fall and the price of substitutes to increase.

An implication of this analyses is that the true net benefit measure for policy evaluation purposes is the one which includes both the market and nonmarket goods sectors. If market and nonmarket goods are substitutes, policy benefits in a general equilibrium framework will be smaller than the benefits in a partial equilibrium view. If market and nonmarket goods are complements, then the opposite conclusion would hold. This suggests that omission of general equilibrium effects could result in errors previously undiscussed in this branch of valuation literature.

In conclusion, the results of this research can serve as a basis for constructing correct benefit cost analyses and nonmarket valuation instrument designs. As with any other economic decision, invalid nonmarket goods provision decisions should be avoided.

FIGURE 2 Effect of a Unit Tax Policy in Multi-Dimensional Production Possibility Surface



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