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ECONOMIC THEORY OF COMMONS: REVISITED

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ABSTRACT: The conventional economic theory of commons skipped the fundamental role of institutional structures and associated transaction costs as elements of the set of opportunity choices of resource manager. A empirical economic model of commons which incorporates the role of institutions and associated transaction costs has been proposed. Gordon's theory of commons is a special case of this model. Specific features of the model are - characterisation of transaction function, and incorporation of some social, cultural and obviously economic factors such as homogeneity of user group, type and degree of dependence of user group on resource, and economic status of user group etc.

KEY WORDS: Institutions, Property Rights, Resource Regime, Transaction Function, Transaction Cost.

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ECONOMIC THEORY OF COMMONS: REVISITED

In general, the argument of economic theory has been that natural resources characterised by common property rights can not achieve an efficient allocation of resources without some form of government intervention and/or the creation of private property rights (Gordon 1954, Scott 1955, Hardin 1968, Anderson 1977, p.29 Hartwick & Olewiler 1986, pp.8-9). In contrast, several recent publications summarize a growing and rich body of evidence relevant to successful management of natural resources as common/communal property (National Research Council 1986, Mc Evoy-1986, 88, Wade 1987, Berkes et.al., 1989, Cordell 1989, Pinkerton 1989, Kant et.al., 1991). The conventional economic theory of commons skipped the fundamental role of the institutional structures and associated transaction costs as elements of the set of opportunity choices of resource owner/manager. So, it cannot explain the outcomes of these cases.

Our main argument is that the change of property regime from common/open access resource regime to private or government is not costless. Some times this cost may even be more than the expected rent increment in new resource regime. In such cases this change will be economically inefficient. To overcome this inadequacy of conventional theory, role of institutional structures associated with different resource regimes, and related costs has to be incorporated in the theory of commons.

The purpose of this article is to demonstrate that the role of various institutional structures can be incorporated into traditional economic analysis of resources, and that in the process the scope of economic analysis is broadened.

To this end, a review of literature on conventional economic theory of common resources has been made. Thereafter some concepts of resource, institution, and resource regime have been discussed. Based on these concepts, a general economic model for resources has been developed. It has been shown that Gordon's model is a special case of this general model. The model has been extended to incorporate the special features of a particular resource i.e., forest. The nature of transaction function and transaction cost with reference to forest resource has been discussed. Finally, we conclude with a emphasis on developing a area and resource specific transaction functions, so that an efficient resource management system can be designed to each resource in diverse conditions.

CONVENTIONAL ECONOMIC THEORY OF COMMON RESOURCES

First and most popular economic theory of common property resources was proposed by Gordon (1954). He assumed that relationship between average production and the quantity of fishing effort is uniformly linear, and the costs of fishing supplies, etc., are unaffected by the amount of fishing effort. So marginal costs and average costs are identical, and constant. He observed that rent (profit) will be maximized at a fishing intensity for which marginal revenue is equal to marginal cost. This fishing intensity is less than that which would produce the maximum sustained physical yield. In case of common property the fisherman does not care for marginal productivity but for average productivity, it is the latter that indicates where the greater total yield may be obtained. Thus the rent which the intra-marginal grounds are capable of yielding is dissipated through misallocation of fishing efforts. Further he cited the examples of hunting and trapping, and common pasture; and observed - common property natural resources are free goods for the individual and scarce goods for society. Under unregulated private exploitation, they can yield no rent; and that can be accomplished only by methods which make them private property or public (government) property, in either case subject to unified directing power.

Scott (1955) continued the discussion by taking the Gordon's paper as basis. His observations and conclusions are: " - - as a general rule, the mere fact of sole ownership does not bring about a significant change in the exploitation of the fishery in the

short run. Both the sole owner and the competing fisherman will operate at an output which is theoretically similar (in its equality of marginal cost and marginal revenue) to that in other industries. ----- . In this sense, the social optimum in both the long run and short run would demand that common-property resources be allocated to maximising owners, associations, co-operatives or governments."

The basic difference between two papers is that Gordon's fisherman will fish until his average cost is equal to average revenue, and will be at economically inefficient point, while Scott's fisherman, in short run, can behave like a economic person and will operate at economic efficient point i.e., marginal cost equal to marginal revenue. Surprisingly, in general economists believed and followed the Gordon's approach only. Using the competitive model, Smith (1968) argued in favour of Gordon's conclusions. Plourde (1971) expanded the theory of Gordon, and by considering the problem of optimal exploitation of a common-property natural resource- fisheries, as a control problem advocated for dynamic tax rates in place of quotas. Bell (1972) used Gordon's model for studying the Northern Lobster Fishery, and demonstrated flow of technological externalities from common property resource, which in turn produces a rising cost industry where economic efficiency is not achieved; and advocated government intervention to solve market failure. Haveman (1973) considered decreasing marginal returns, and proved that in common property

entry will proceed until the difference between price and average industry cost becomes zero. Brown (1974) suggested that given the common property aspects of the problem (fisheries), it is necessary to levy a charge per unit extracted; and congestion externality may be accounted for by charging a tax for the use of a unit of variable factor. Anderson (1977, p.29) observed that with no regulation, the equilibrium level of effort in fishery will be where total revenue equals total costs. Hartwick and Olewiler (1986, p.9) concluded that all common property equilibrium are economically inefficient. Bell (1986) also used Gordon's model for craw-fish of Louisiana and shown that even with the existence of pond reared craw fish to reduce social welfare losses, there are additional traps for wild craw fish beyond that necessary to harvest where price is equal to marginal cost. Another stream of economists incorporated some socioeconomic factors in bio economic model (Munro 1976, Smith 1981, Panayotou 1982). Property right school also advocated the superiority of private property (Demstet 1967, North and Thomas 1977, Posner 1977, pp.10-13).

Surprisingly, varied transaction costs in case of different resource regimes could not draw the attention of these economists to significant extent. Beginning with Coase's article on 'The Nature of The Firm', the role of transaction costs that is cost of making exchanges has become more important in explaining the structure of market (Coase 1937, 1960). Alchian and Demstet (1972) took up the problem of coordinating diverse inputs in the production process. Cheung (1969) incorporated the transaction

costs in his paper on the theory of non exclusive resource. He considered three alternative arrangements i.e., a group of individuals forming a tribe, a co-operative, and private property right holder; and observed the costs of exclusion are lowest for the first and highest for the third. The gains are in reverse order. Weighing these gains and costs, the choice of property right arrangement becomes predictable. Recently the property rights and institutions have attracted the attention of a large number of resource economists (Krutilla and Fisher 1975, pp.19-38, Bromley 1982, 1985, 1989, 1991, Scott and Johnson 1985, Bromley and Szarleta 1986, Randall 1987, pp.153-63, Fortmann et. al., 1988, Magrath 1989, Pearse 1990, pp. 173-93). All these economists attempted a comparison of different resource management systems taking resource regime as one of the fixed inputs. Randall (1987, p.159) argues that specification of any possible non attenuated rights would lead to efficiency, but the efficient solution would be different for each different specification of rights. Thus he talks of local optimal outcome limited within a framework of one specified set of non attenuated rights. Economic literature is lacking in a general empirical model which can suggest a global optimal solution. Dahlman (1980, p.138) suggests that it is necessary to show the exact relationship between the productive technology on one hand, and the transaction costs on the other. Both must be accounted for. A model which does so in real sense, should treat both as variable inputs. Such model can offer a global maxima. We develop such model in this paper.

First, we discuss in brief, some concepts involved in such a model.

CONCEPTS AND DEFINITIONS

A resource is something that is useful and valuable in the condition in which we find it (Randall 1987, p.12). A resource is not defined once and for all, but it is defined by two aspects of the particular society under study - its technology, and its institutional structure. The technology represents a combination of the physical capital of an economy and the human capital that operates that asset (Bromley and Szarleta 1986). Institutions are a set of rules, compliance procedures, and moral and ethical behavioral norms designed to constrain the behaviour of individuals in the interests of maximizing the wealth or utility of principals (North 1981, p.201). Technology in the absence of an institutional structure is nothing what matters is the institutional environment within which it operates.

A resource regime, an important aspect of the institutional structure derives its meaning from the structure of rights that characterize relationship of individuals or decision units to one another and to the objects of value. The relationship between two or more individuals or groups can be characterized by stating that one party has an interest that is protected by a right only when all others have a duty. There are other situations in which individual does not have right to undertake certain actions, but instead has only privilege. With a right I am protected against the

claim of another by their duty. With a privilege I am free to do as I wish, since other party has no rights. With this understanding of "right and duty" and "privilege and no right", resource regimes are classified in four classes: (1) Private (2) State (3) Common/Communal and (4) Open-access (Godwin and Shepard 1979, Bromley 1986, 1989, Jacobs and Munro 1987, p.442, Berkes et. al., 1989, p.91, Bromley and Carnea 1989, p.3-5, Gibbs and Bromley 1989, Fenny et. al., 1990). The first three categories have right and duty situation while fourth has situation of privilege and no right.

A resource regime has several dimensions of economic importance i.e., comprehensiveness, exclusiveness, benefits confronted etc. Each of these dimensions varies across a spectrum (Pearse 1990, p.181). Therefore logically it seems more reasonable to treat the resource regime as a continuous variable, instead of treating it as discrete variable. The extreme ends of the variable will be private regime and open access regime. Our this view is supported by a continuous spectrum of resource regimes i.e., free hold, timber lease, forest management agreement, woodlot license, cutting permit etc., between private and state resource regime in case of Canadian forests. The experiment of joint resource management i.e., Joint Forest Management in India (Malhotra and Poffenberger 1989), CAMPFIRE (Community Areas Management Program For Indigenous Resources) of Zimbabwe and ADMADE (Administrative Management Design) for game management areas of Zambia (Forests, Trees and People 1991) also indicate the continuity of resource regime between state and common regime.

Developing, enforcing and monitoring of a resource regime arrangements involve some costs. These costs have been called transaction costs or ICP (Information, contracting and policing) costs. Thus a particular structure of transaction costs is associated with each resource regime (Bromley 1991, p.142).

Once a resource manager or economist realises the role of resource regime, and varied transaction costs associated with each resource regime, the question he faces is not only of optimal quantity to be harvested or the rotation, but also of a optimal resource regime. The answers of these two questions are interdependent, and cannot be answered independently, as neo-classical economists answered. In many situations the answer of neo classical economics may be sub optimal.

With this background, now we develop a required model.

GENERAL MODEL

In general, every economic activity, and in particular economic activity related to natural resources involves elements of transaction and other costs. For segregation of economic activity into different categories the terms 'transformation function' and 'transaction function' can be used. Transformation function is a process of transforming physical inputs into physical outputs. The costs associated with transformation function can be termed as technological or transformation costs (Wallis and North 1986). So produced outputs may not yield any revenue to authorised user/owner

of these outputs, in the absence of transaction function. The production for a resource user/owner will not be complete unless the product yields some economic returns to him. Thus production function will be complete only when transaction function coupled with transformation function has enabled to resource owner/user in obtaining the economic returns. In case of natural resources, the role of transaction function gains a special significance due to its simultaneous operation with transformation function. For example, if a resource owner say state is unable to exclude the local user group from resource use, this group may not allow to complete the transformation process. Thus if we conceptualize the output of natural resource as the quantity which captures the economic return to legal resource owner/user, the resource regime can be treated as one of the variable inputs, obviously the other input is technology. If we assume that the quantity of resource which captures economic returns is denoted as Q , it will be a function of technology and resource regime. So, it can be represented as:

$$Q = F(T, R)$$

The total cost associated with the production process of resource will also be function of technology and resource regime. So, it can be represented as:

$$T.C = F_1(T, R)$$

Total cost will include the costs incurred on transformation and transaction functions. Some times certain operations like exclusion, will be performed by both functions. In such cases the

separation of total cost in two components i.e., technology cost and transaction cost may be difficult. But for ease of treatment, we assume that total cost is separable in two components. So

$$T.C = C_1(T) + C_2(R),$$

where $C_1(T)$ is technology/transformation cost which is function of technology only, and

$C_2(R)$ is transaction cost which is function of resource regime only.

From the individuals point of view, both the functions are 'productive'; that is transaction and transformation costs are incurred only if the expected benefits from doing so exceed the costs of doing so. The behavioural similarity of transaction costs and transformation costs is critical, since it implies that we do not need a new 'transaction costs theory' of human behaviour to deal with transaction costs, simple price theory will suffice (Wallis and North 1986).

A more general theory of utility maximization will be desirable to incorporate different economic objectives like profit, wage or bonus maximization. Precise specification of decision makers utility function being difficult, the theory based on utility maximization runs a danger of losing the operational character. Therefore we will restrict to a model of profit maximization.

Assuming that the quantity Q available to a legal owner/user is sold in open competitive market, at externally determined price P

per unit. Then

$$\text{Profit } Y = P.Q(T,R) - C_1(T) - C_2(R). \quad (1)$$

Necessary conditions for profit maximization are:

$$(\partial Y/\partial T)=0 \text{ or } P.(\partial Q/\partial T)=(\partial C_1/\partial T) \quad (1a)$$

$$(\partial Y/\partial R)=0 \text{ or } P.(\partial Q/\partial R)=(\partial C_2/\partial R) \quad (1b)$$

Thus two necessary conditions for profit maximization are i.e., marginal value of the product with reference to technology is equal to marginal technology/transformation cost, and marginal value of the product with reference to resource regime is equal to marginal transaction cost. These two conditions will give a point/points in two dimensional space which can be tested for sufficient conditions of maxima. The point which satisfy these conditions will give a combination of technology and resource regime for profit maximization. Thus for profit maximization, these two conditions must be satisfied simultaneously. The fulfilment of only one condition with reference to technology, as suggested by neo classical economists need not necessarily give the optimal output, except in special case as shown next:

In a situation as visualised by Gordon (1954), in his famous article, technology is simple and represented by human labour. The technological cost is simply the wages paid to labour. If L represents the units of technology i.e., man days and c is cost per unit of labour, then

$$C_1(T) = c.L.$$

Therefore

$$T.C = c.L + C_2(R),$$

and profit

$$Y = P.Q - c.L - C_2(R). \quad (2)$$

Two necessary conditions for profit maximization are:

$$P.(\partial Q/\partial L) = c, \quad (2a)$$

and

$$P.(\partial Q/\partial R) = \partial C_2/\partial R. \quad (2b)$$

In case of zero transaction cost, the second condition vanishes and hence only necessary condition for profit maximization is:

$$P.(dQ/dL) = c. \quad (2c)$$

Now if we assume that technology is of constant scale of return, then

$$Q = k.L,$$

and if $k=1$, it implies $Q=L$.

Therefore $dQ/dL=1$, and $P=c$ (2d)

Hence condition for profit maximization reduces to marginal revenue equal to marginal cost. This is same as advocated by neo classical economists in their model of common property resource. Thus neo classical model of common resources is a special case of our general model.

Now we modify our model to incorporate the special features of forest resource.

MODEL FOR FOREST

Forest resources differ from other renewable natural resources like fisheries, in terms of long gestation period. Due to this specific feature, 'time' itself acts as a factor of production. Thus forest production process has three inputs i.e., technology, resource regime and time. A single most important decision to be made by a forest manager is the age of harvesting i.e., rotation. A forest firm will decide the rotation in accordance with economic

principle of maximization of present net worth(PNW).

We discuss a general case of infinite rotations, assuming the same rotation is adopted each time. It is also assumed that yield function of tree species under consideration and the stumpage price in constant dollars remain the same in each cycle of harvesting and regeneration.

Suppose that all technological cost incurred during one rotation period is equivalent to $C_1(T)$ incurred in the beginning of rotation period, and similarly all transaction cost is equivalent to $C_2(R)$ in the beginning of rotation period.

Let volume obtained at harvest is represented by V which is a function of time, technology and resource regime ($V=F(t, T, R)$). Externally determined price and continuous real rate of discount are P and r respectively.

Then:

$$\begin{aligned} \text{PNW} &= \frac{PV - C_1(T)e^r - C_2(R)e^r}{e^r} - \frac{PV - C_1(T)e^r - C_2(R)e^r}{e^{2r}} - \dots \\ &= \frac{PV - C_1(T)e^r - C_2(R)e^r}{e^r - 1} \end{aligned} \quad (3)$$

Therefore necessary first order conditions for maximization of PNW are:

$$\begin{aligned} (\partial \text{PNW} / \partial t) &= 0 \\ \text{or } (P \cdot \partial V / \partial t) &= r \cdot PV + r \cdot \frac{PV - C_1(T)e^r - C_2(R)e^r}{e^r - 1} \end{aligned} \quad (3a)$$

$$e^{n-1}$$

$$(\partial \text{PNW} / \partial T) = 0 \quad \text{or} \quad (P \cdot \partial V / \partial T) e^n = \partial C_1 / \partial T, \quad (3b)$$

and

$$(\partial \text{PNW} / \partial R) = 0 \quad \text{or} \quad (P \cdot \partial V / \partial R) e^n = \partial C_2 / \partial R. \quad (3c)$$

The first condition is very well known. It says that for optimal rotation of an even aged crop, meant to be managed on a sustained yield basis, the rate of incremental value growth, $P \cdot \partial V / \partial t$ must be equal to the sum of the rate at which interest would be earned by the crop ($r \cdot PV$) per unit time and the rate of continuous rent earned by the land. This equation is similar to equation corresponding to fundamental theorem of optimal forest rotation except the inclusion of technological and transaction costs in PNW term. But this is only one of the three necessary conditions for optimal forest rotation. The other conditions are as discussed below.

Since it has been assumed that technological and transaction costs are incurred at the beginning of a rotation, and the stumpage revenue is received at the end, these two costs and revenues can not be compared directly. They must be brought to the same point of time. The two equations have achieved it by discounting the revenue.

Equation (3b) indicates that if forest manager is given a choice of selection of technology from a continuous array of different technologies, he must continue to move along this array until the

marginal dose produces the additional growth which is just sufficient to have a discounted value equal to the marginal cost of moving from the just previous option to present option on technology array. Similarly, equation (3c) indicates that a forest manager must select a resource regime arrangement for which the discounted value of additional marginal growth is equal to marginal transaction cost.

In case of naturally growing forests, it can be assumed that transformation cost is incurred only on felling/conversion of growing tress into lumber. This cost will be incurred in rotation year. Therefore PNW will be equal to:

$$PNW = \frac{PV - C_1(T) - C_2(R) e^n}{e^n - 1} \quad (4)$$

In this case the condition corresponding to technology i.e., (3b), for present net worth maximization will change to:

$$\partial PNW / \partial T = 0, \text{ or } P \cdot \partial V / \partial T = \partial C_1 / \partial T. \quad (4b)$$

By taking the transformation cost and returns at same time, we have eliminated the effect of time in this condition. Thus this condition has become same as in general model. The other two conditions corresponding to time and resource regime, will not change.

In case of zero transaction and transformation costs, conditions (3b) and (3c) vanish, and condition (3a) takes the standard form of fundamental equation of forest rotation.

Main challenge in making these models operative is determination of transaction function and transaction cost. Even though the actual shape will vary with each combination of a particular resource and user group, the general nature of these two can be of great help to resource managers and resource economists. The general function can be used by the resource managers to develop the resource specific local transaction functions and transaction costs. Hence the general nature of these two is discussed next:

NATURE OF TRANSACTION FUNCTION AND TRANSACTION COST

The nature of transaction function will depend upon the characteristics of resource, socioeconomic and cultural characteristics of user group, and type and degree of dependence of user group on resource. Since open access resource is under no resource regime, we can safely assume that transaction function is zero at this point. Our transaction function is limited within the range of resource regime from open access to private, it can take either the shape of maxima function or increasing function. Therefore the transaction function can be represented by:

$$F_T(R) = K_T(R-a)^{a1}(b-R)^{a2}$$

where R is a continuous resource regime variable,

a and b are values of R corresponding to two extremes of resource regime i.e., open access and private regime, respectively,

K_T is a constant, let us call it scale factor. The value of this constant will change the function into actual values

of physical product,

a_1 and a_2 are exponents.

The value of a_1 will mainly depend upon the homogeneity of user group, or more exactly the cooperative nature of user group, with reference to the resource. The causative factors for heterogeneity in user group may be caste structure, economic disparity, social and cultural traditions or norms etc. The value of a_1 will be very small for highly homogeneous group, and it will increase with heterogeneity of group. In case of developing economies, even in case of large economic differences and social stratifications, some inherent spirit of cooperation is generally observed. This spirit is almost negligible in developed economies. Normally the man of developed economies is in true sense individual homo-economicus, while the man in developing economies is what Daly and Cobb Jr (1989, pp.159-65) called 'homo-economicus as person in community'. So, in economic terms the value of a_1 will inversely depend on the degree of 'homo-economicus as person in community'.

The value of a_2 will depend upon the economic status, and degree and type of dependence of user group on the resource. In case of poor people who are totally dependent on the resource for their livelihood like tribal people in India, who depend on forests for their vegetable, medicines, fruits and even monetary income from sale of minor forest products, value of a_2 will be very high. In case of poor people who depend on forests only for fuelwood, the value of a_2 will be smaller as compared to the case of tribal. In

case of medium class people who depend on forest for their fuelwood requirement, but have enough buying capacity to purchase other means of fuel, the value of a_2 will be still smaller. If the local people do not depend on forest resource at all, the value of a_2 will be zero. In case, given the choice, the local people would like to convert the existing resource in some other resource i.e., forest to agriculture, the value of a_2 would be negative.

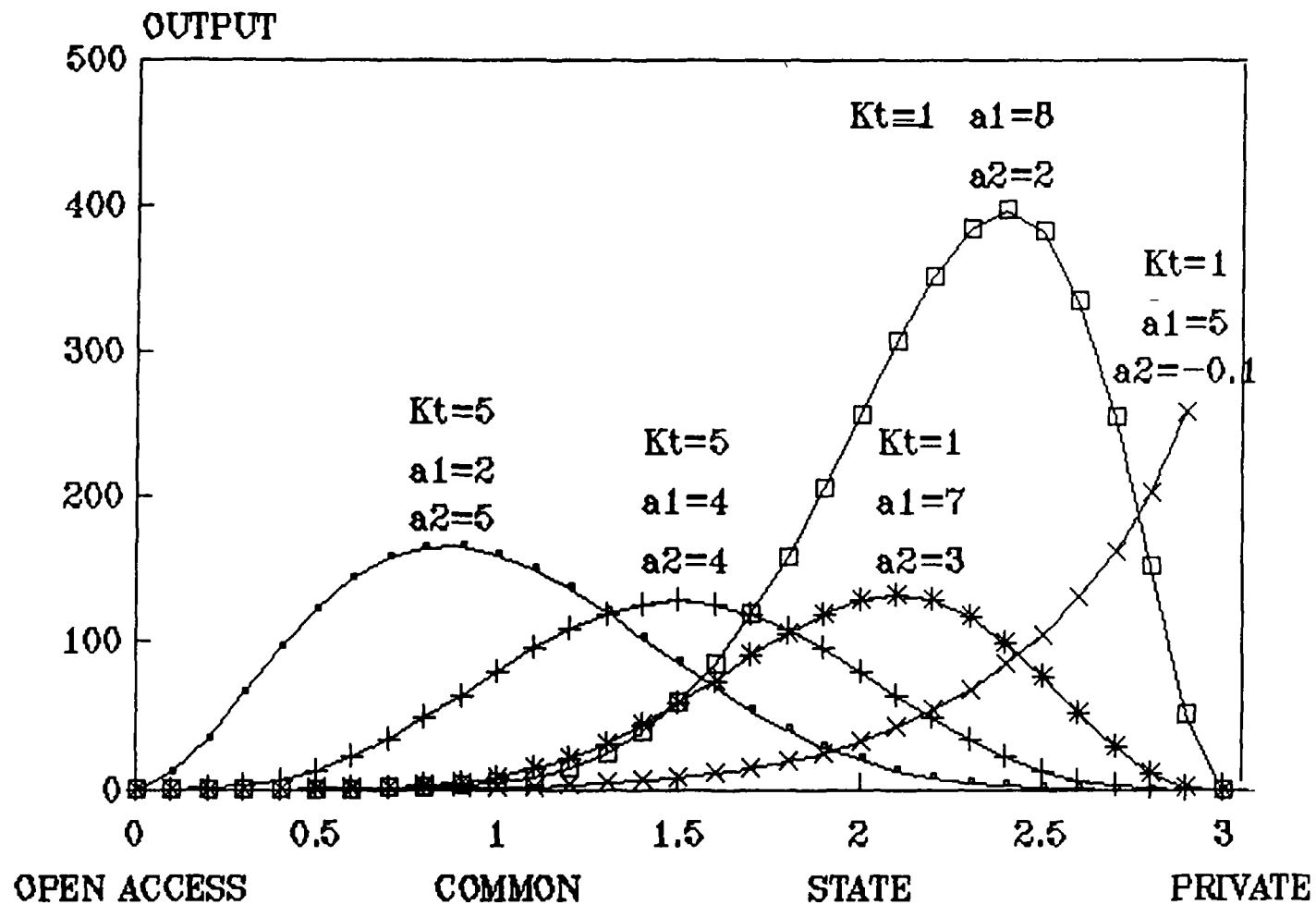
The shape of few transaction functions for different values of a_1 and a_2 are shown in Figure 1. Salient features are described in Table 1.

TABLE 1

Values of a_1 and a_2	Shape	Possible Resource Regime For Optimal Outcome
$a_1 < a_2$ and both > 0	Positive asymmetric with maxima	Depending upon the position of maxima, it will be either some form of common regime or a joint (among local people and state) regime.
$a_1 = a_2$ and both > 0	Symmetric with maxima	Some form of common regime, joint regime or state regime.
$a_1 > a_2$ and both > 0	Negative asymmetric with maxima	Depending upon the position of maxima, it will be either some joint regime among state and local community or among state and private.
$a_1 > 0$ and $a_2 \leq 0$	Increasing	Any regime from common to private

When we speak of transaction cost, we mean the economic value of the inputs used in performing the transaction function. This will

TRANSACTION FUNCTION OUTPUT VS RESOURCE REGIME



include the value of labour, capital and entrepreneurial skill used. The essential duality of general production function and cost function will be applicable in this case also. As in general case, the transaction function will have some extra information on the prices of inputs.

Cost associated with the assignment of resource regime arrangements are one time costs, and can be treated as sunk costs. These costs do not effect the quantities of products available to resource user/owner, once the resource regime is established. Enforcement costs are variable, repeated in each time period. These costs are reduced when the public generally entertains social norms that coincide with the basic structure of resource regime arrangements (Eggertsson 1990, p.35). When either appropriate social norms or subsistence livelihood opportunities are missing, individuals may develop behavioural codes that rival the basic structure of resource regime arrangements. In such cases the enforcement cost becomes enormous. The general shape of transaction cost can also be represented by a similar function as of transaction function:

$$F_c(R) = K_c(R-a)^{a_{1m}}(b-R)^{a_{2m}}$$

Where K_c is a scale factor for cost, and

a_{1m} and a_{2m} are modified values of a_1 and a_2 respectively, we can call these as cost equivalents of a_1 and a_2 respectively.

Finally, we can conclude that the neo-classical economic theory

of commons shut out all of reality which did not fit into its logic, and postulated far reaching conclusions for all common resources only on the basis of one resource i.e., fisheries. This resource is quite different from other common resources i.e., forests and grazing lands etc. The observation of William (1977, p.9)- "conventional economic theory has ignored the institutional field in which our economy functions. It has tried negating the effects of changing field by imposing a prescribed behaviour on individual particles in that field", applies in true sense to economic theory of commons. To set up our theory of commons we must seek in the real world, the influences that are critical for management of resources; and we must consider the exact manner of their interaction. The economic model incorporating a resource regime as one of the inputs and hence transaction costs, is capable of integrating the different socioeconomic and other influences of real world in theory of resources. The need is to develop area and resource specific transaction functions, and then to get a most desirable resource management system.

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