COMMUNITY MANAGEMENT: AN OPTIMAL RESOURCE REGIME FOR FORESTS IN DEVELOPING ECONOMIES?

SHASHI KANT
Faculty of Forestry, 33 Willcocks Street,
R. ALBERT. BERRY
Department of Economics, 150 St. George Street,
and
J. C. NAUTIYAL
Faculty of Forestry, 33 Willcocks Street,
University of Toronto, Toronto.

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INTRODUCTION

An important strand of thinking about efficient use of natural resources is the economic theory of commons. A conventional view is that common property rights are inconsistent with efficient utilization of natural resources in the absence of some form of government intervention, and that given the impediments to effective intervention private property rights are a better bet (Gordon 1954, Scott 1955, Hardin 1968, Anderson 1977, p,29, Hartwick & Olewiler 1986, pp.8-9). Rose (1994) challenges the validity of this proposition for some types of property, and concludes that communal management may be socially wealth-enhancing for properties with certain of the characteristics of public goods, such as roads and waterways. Also calling the conventional theory into question is a rich and growing body of empirical evidence from around the world which points to the successful management of a wide variety of natural resources as common/communal property[1]. Some authors have used game-theoretic frameworks to explain the observed frequency of collective action in natural resource management (Runge 1986, Sethi and Somanathan 1996). While such game-theoretic models, together with the empirical literature, offer important insights into the sustainability of common property regimes, a solid theory of the optimal institutional bases for resource management is necessary both for a fully satisfactory understanding of such regimes and as a basis for policy prescriptions. In this paper, we attempt a more formal theory of optimal resource regimes in which institutional factors are taken account of explicitly.

A valid theory of institutional alternatives must reflect the real world influences critical to effective resource management and take account of the manner of their interaction. In his paper on social cost, Coase (1960) argued that economists had ignored the basic production input, "the right to produce". The still popular economic theory of commons (Gordon, 1954) has similarly overlooked the fundamental role of institutional structures and associated transactions costs *(the* costs associated

[1] These include fisheries in Japan (Kenneth 1989), U.S.A (Acheson 1989) and Mexico (Miller 1989); forests in India (Kant et al., 1991, Poffenberger and Singh 1991, Campbell 1992) and Canada (Brightman 1987); water in the Philippines (Cruz 1989), U.S.A (Ostrom 1990), and India (Wade 1987); grazing lands in Botswana (Peters 1987) and swamplands in Borneo (Vondal 1987).

Thus, though the importance of the relationship between production technology, resource regime, and associated transaction costs has been recognised since the articles of Coase (1937, 1960), resource regime has not been fully incorporated into the economic production models used to identify the most efficient regime from the full set of options ranging from open access to private regime. An adequate economic model of resource regimes—one that can identify a global maximum, must treat both physical inputs and property rights as variables, and should account for variation in transaction costs. Due consideration of the role of transactions costs makes community management look a good deal more promising, at least under certain circumstances. Many local communities possess a wealth of knowledge regarding their environment and how to manage natural resources to meet their needs. Over the centuries, they have developed social and technological strategies to respond to diverse ecological settings. While the viability of many indigenous systems has been eroded with time, some newly emerging organisations are establishing or re-establishing such systems. Their success will depend upon such factors as policy support, the existence of appropriate agencies to facilitate organisational development, and training capacity. In this paper, our emphasis is on identifying the socio-economic conditions under which different resource regimes will be economically efficient, so these issues are left aside.

Our main argument is that the wide range of possible resource regimes between the purely private at one extreme and open access (to anyone) at the other should not be neglected. Transaction costs, associated with the implementation and monitoring of the resource regime, can be a significant component of the total cost of using a resource. They vary with the characteristics of the resources, the characteristics of the regime itself and the socio-economic conditions of the surrounding community, and they constitute one of the factors determining the optimal resource regime. The incorporation of resource regime as a variable in natural resource production models would help to elucidate the reasons for relatively superior performance of community regimes in selected contexts. In this paper, we incorporate institutional structure into a static analysis[3] of optimal natural resource management regimes, thinking in terms of a continuous array of regime possibilities varying from open access to private regime (rather than just the two standard options—state and

[3] The focus being on static analysis, the dynamics of on-going interactions among agents and groups are not discussed here. These issues are addressed in Kant and Berry (1998).

private regimes). We identify the socio-economic characteristics of the resource's "user group" (those receiving some direct benefits from the resource) as the main determinant of the relative efficiency of different regimes.

In the present context of environmental degradation and global warming, issues surrounding the management of forests have received serious attention from every sector of society. Hence, our focus in developing this theory is on the management of forest resources. Forests are a stationary renewable resource characterized by relative indivisibility in the sense that they cannot be divided into small patches of a few hectares without losing some of their silvicultural characteristics, related sources of productivity, and capacity to regenerate. These physical features, together with the frequent non-exclusion of local communities, are the main reasons behind private market failure in the forest management sector in developing economies. Fisheries, underground water, and surface water, for example, are unlike forests in being non-stationary resources, while agricultural production differs in being more highly divisible without significant loss of productivity. Though the concepts we use in incorporating institutional structure into our analysis are general in nature, and can be extended to other similar resources such as pastureland and inshore fisheries, such extension requires careful attention to the physical characteristics of these resources.

The first section of the paper discusses concepts pertaining to resources, institutions, and resource regimes, as well as the social context of forest management in the developing economies. Based on these concepts, Section **II** develops a general economic model for resource use, in which Gordon's (1954) model- appears as a special case. Section **III** focuses on the general nature of the transaction function and the incorporation of resource regime in to economic production models. Finally, we conclude with comments on the need for better understanding of the transaction functions to aid in the design of efficient resource management systems for diverse conditions.

SECTION I: CONCEPTS AND DEFINITIONS

The usefulness of any resource is determined by available technology and institutional structure. A technology is a way in which physical and human capital inputs are converted to outputs. An institutional structure is made up of a set of rules, compliance procedures, and moral and ethical norms which constrain the behaviour of individuals in the interests of maximizing the wealth or utility of principals (North, 1981, 201). A "resource regime" is a structure of rights and duties characterizing the relationship of individuals or decision units to one another with respect to the resource[4]. Institutional arrangements are continually established (and refined) in order to determine (and to modify) the scope and nature of the resource regime (Bromley, 1991, p.22).

The relationship among the individuals or decision units who are somehow related to a given resource can be specified as a set of rights, duties and privileges. In this context a "property" is not merely a physical object (e.g. land) but rather the right to a benefit stream, a right that is only as secure as the duty of others to respect the conditions that protect that stream (Bromley, 1991, p.22). When one's interest is protected by a right to undertake certain actions, one is protected against the claim of others by their duty to respect one's right If the others do not have that duty, then the individual has only a privilege; in that case one has no protection against the claims of others, but as long as one "gets there first" one can do as one wishes with the property in question, since the other parties also have no rights. Based on these concepts, resource regimes have been categorized into four classes: (1) private (2) state (3) common/communal and (4) open-access[5]. The first three categories involve bom rights and duties while the fourth is a situation involving privilege but no rights or duties. Under private, state, and common property regimes, the resource management rights are vested in an individual (or corporate bodies), government, and an identifiable community of resource users, respectively. Open access is characterised by the absence of well-defined property rights; implying free access to anyone. However, physical characteristics of the resource and political and administrative boundaries of village, district, and nation may limit access to a narrower group as in the case of forest resources, grazing land, and inshore fisheries. On the other hand, access may be open to any one in the world as in the case of atmosphere, sunlight, and ocean resources. In the literature these two categories of resources have typically been referred to as

[4] In this paper, resource regime is a broader concept than ownership. The terms "resource regime" and "property regime" are used interchangeably.

[5]Godwin and Shepard 1979, Bromley 1986 and 1989, Jacobs and Munro 1987, p.442, Berkes et al., 1989, p.91, Bromley and Cernea 1989, p.3-5, Gibbs and Bromley 1989, Feeny et al., 1990.

"local commons" and "global commons" irrespective of their resource regimes.

Control of access involves limitations on the rights and privileges of various potential users. Overuse of a resource could come from outsiders—those with no privileges that are recognized by the group in control of the resource, but their attempts to make off with some of the products of the resource will usually be fended off by the latter group. Overuse of the type which plays the central role in the simplest "tragedy of the commons" stories, however, comes from "insiders", that is from members of the local community who start treating their rights as privileges. Hence, the difference between a de jure condition and a de facto condition can be important in the description of resource regimes. In fact, the tragedy of the commons outcome is often the result of conversion of a de jure private, state, or community regime to a de facto open access regime. In some cases a discrepancy between the de jure and the de facto situations can cause conflict Inefficiency in the management of the resource is another frequent result.

A resource regime typically has several economically important dimensions — comprehensiveness, exclusiveness, benefits conferred, responsibilities, managerial system, technologies employed, etc., each of which varies across a spectrum (Pearse 1990, p. 181). For simplicity we focus here only on the dimension of principal interest to us—access or exclusiveness,[6] and we distinguish among resource regimes in terms of a continuous variable, rather than a discrete one, i.e. we think not only of the four discrete regimes just identified but of a multitude of possible options along a property continuum from open access to a purely private regime where access by anyone except the agent who controls and manages the resource is zero (Rohlmann,1992).[7] Hence, in our terminology, a resource regime involving a state or privately owned resource not characterized by

[6] Such variables as technology and managerial style will of course be at least in part a function of the more clearly institutional features of a resource regime (inclusiveness, etc), but they can in principle also be determined exogenously to these particular institutions, in which case they constitute other dimensions or variables helping to define the resource regime in a basic sense. The dimension of primary interest to us here is openness of access.

[7] In forest resource regimes, as mentioned before, open access refers in practice only to members of the identified user group.

exclusion of other potential users (in particular the local community) group will not be described as a state or private regime, respectively, but rather open access, community or joint, depending on who is excluded. For example, in India some state-owned forests are used by communities which have their own set of rules for management and use; such forests are legally under a state regime but de facto under a community regime. In some areas state governments have formally recognised the use and management rights of local communities, and the forests are managed jointly with those communities; we refer to them as "joint regime" forests. Regimes may be joint between:(i) communities and the state government; (ii) the state government and private companies, and (iii) private companies and communities. However, only the first category - between communities and state - is prevalent regime in developing economies, and the other two categories are found in the developed economies.

Under open access there would be no restriction on the use of any output from forests. Under a community regime, the user group is entitled to all the products, and use is typically regulated in terms of harvesting time and quantities to be harvested at a particular time. In the case of a joint regime (between state and community), the user group gets only a fixed share of timber products and of nationalized non-timber products, while getting the full harvest of non-nationalized non-timber products. Under a state regime, the local user group is totally excluded from timber and nationalized non-timber products, but not from the use of some non-nationalized non-timber forest products. Under a pure private regime, the user group is excluded from all products. Hence, on the spectrum defined by degree of exclusion of the local community, the sequence is from open access regime to community regime to joint regime (between state and community) to state regime, and finally to private regime.

The enforcement and monitoring of a resource regime typically involves costs, commonly referred to as transaction costs or information, contracting and policing (ICP) costs. A particular structure of such "transaction" costs is associated with each resource regime (Bromley 1991, p. 142). Developing a new regime is likely to involve additional costs of inducing behaviour patterns which do not yet have the sanction of common practice. The optimal regime for a given resource depends not only on the physical production (transformation) efficiency with which the inputs it provides are converted to outputs, but also on the level of transactions costs (transaction efficiency). Socio-Economic Factors (SEF) will typically be important determinants of the optimal resource regime in a given resource cum "user group" environment[8]. We focus on two such factors: user group heterogeneity with respect to the resource management (a), and the degree of the community or user group's direct dependence on the resource (p).

User group heterogeneity with respect to the resource (a). Members of the user group will often have a range of somewhat differing preferences regarding resource management, or assign different priorities to the various objectives of resource management, either because of differing personal interests in the resource or differing degrees of involvement in the social group. People think of themselves both as separate "individuals" and as "members of a social group". In traditional societies, where people see themselves first as members of the group and only secondarily as independent individuals, an inherent spirit of cooperation is generally present even in the face of large economic differences and social stratification. This spirit is muted in modern industrial societies, where people are first and foremost "individuals". The heterogeneity of individual interest with respect to how a resource is managed reflects both economic differences (e.g. income level) and social and cultural traditions or norms; the extent to which "personal" interest fully determines an individual's behaviour with respect to the resource depends on the degree of "community spirit"; hence, the level of heterogeneity (a, allowed to range between 0 and 1) will vary inversely with the degree of such "community spirit" as well as with economic differences[9] [10].

[8] The "user group" (those receiving some benefits from the resource) is defined somewhat loosely here in the sense that we do not take into account the fact that the resource regime selected will in fact determine to some extent which individuals and families are able to take advantage of the resource. In other words, the composition of the user group is endogenous. One might, alternatively, think of the community which we define as the user group as the "potential user group".

[9] This heterogeneity is the inverse of full agreement on and support for the same resource management regime. The greater it is the less will shared interest in a given regime help to make it work effectively, either in the positive sense of assuring a positive contribution, as necessary, to effective management or in the negative sense of assuring that no members of the group will behave in ways which sabotage or lower the payoff from the resource. At the simplest level, heterogeneity can be

Rose (1994) argues that under some circumstances property might be more valuable as a commons than it would be in individual hands, because the administrative costs of customary management are low relative to those of an individual property system. In so arguing, she cites social or group customs as one of the main factors in the success of commons. Our concept of homogeneity (heterogeneity) of the community is designed to include but go beyond the concept of group

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measured by the share of the total user group which has the same preference on resource management.

[10] It may be useful to consider a hierarchy of levels of heterogeneity. The basic level consists of cultural, economic, ethical and social differences. Due to these basic heterogeneities, the members of the user group may have diverse preferences for timber and non-timber products and hence prefer different product mixes (this could be termed second level heterogeneity). Diverse product preferences will result in different preferences with respect to the resource management regime (third level hierarchy). In summary, heterogeneity with respect to the resource regime can be treated as a function of the product preference differences, which can in turn be treated as a function of cultural, economic, ethical, and social heterogeneity. Researchers appear to have discussed only the first level of heterogeneity; for example, Ostrom (1990, p.89) argues that none of the successful Common Property Regime (CPR) situations involves participants who vary greatly in regard to ownership of assets, skills, ethnicity, race, or other variables that could strongly divide a group of individuals. But, we think that for the success of CPRs, it is the third rather than the first level homogeneity that is the most critical (See Footnote 19).

Normally, homogeneity of preferences on resource management will depend upon first and second level homogeneity. But, sometimes, a strong mutuality of interest may override social, economic, or cultural heterogeneity. For example, when large catches by New Jersey fishermen depressed prices on the New York fresh fish market, they decided to form a local marketing co-operative. The co-operative decided on total catch levels for the fleet, and provided for the sharing of revenues regardless of the catch levels of individual boats (McCay 1980). Thus the marketing co-operative forced homogeneity with respect to resource (fish) management. Similarly, in South India (Wade 1988), Nepal, Indonesia, and the Philippines (Ostrom and Gradnerl993), mutual dependencies among head-end and tail-end farmers of an irrigation system forced homogeneity with respect to resource management among asymmetric (or first level heterogeneous) participants. On this point, see also Footnote 19.

customs. Similarly, Seabright (1993), for example, points out that the degree of trust economic agents have in one another serves a crucial role in common property regimes. He offers a model of "habit forming" co-operation, in which the fact that players' beliefs about each other's trustworthiness are confirmed contributes to co-operative behaviour. Such a "habit forming" process, though, would be less likely to arise in a community that starts with a high level of heterogeneity with respect to resource management preferences. Other factors such as small size of the user group and feelings of mutual obligation can also contribute to the homogeneity of the group and thereby underpin successful common property regimes (Bardhan, 1993; Wade, 1988, p.215).

The degree of direct dependence (3) of the user group on resource. Every one depends on forests in some way. Forests provide many values such as items of consumption, recreation, environmental benefits, and spiritual benefits. In developing economies of South and South-east Asia or Africa, some tribal groups depend heavily on forests located close to their habitation for many consumption items such as food, fuel, medicines, and even monetary income (from sale of minor forest products) that are necessary to their subsistence. In developed economies, the "user groups" mostly depend on forests for derived items, such as pulp and furniture, which may be obtained from forest areas either near or far; similarly, their deriving recreational benefits does not depend only on nearby forests. The relationship between the user group and the forest is both less intense and less specific, in the sense of its linking a particular user group to a particular forest. Though some aboriginal groups do have this sort of "one to one" direct dependency relationship with a particular forest, this is less frequent than in developing economies. Here, we are interested in the degree of one to one direct dependence of the user group on a forest.

The degree of direct dependence by the user group is defined by the importance of direct benefits from forests in the group's total consumption bundle. Its range is here defined as running from 0 to 1. The fraction of the user group's GDP contributed by the forest may be taken as a first approximation of this dependence.[11] Also to be borne in mind is the extent to which the users can,

[11] What Wade (1988, p.215) refers to as the level of users' demand for the success of a common property regime is similar to our concept of degree of dependence. Our concept of

if necessary, substitute away from their direct forest benefits to other sources. This depends both on the utility function itself and on the practical availability of substitutes for forest-derived benefits. If the utility function includes only forest-derived benefits, there is no possibility of such substitution and hence the degree of direct dependence will be equal to one. The case of some subsistence tribal communities approaches this extreme; though in principle there are substitutes for most of the forest-based benefits, the user group is unable to take advantage of them because of its limited monetary income. In the case of some benefits there are no substitutes, e.g. spiritual values. The importance of such spiritual values is hard to quantify, but both its central role in a number of conflicts between indigenous groups (e.g. tribal people of India) and the dominant society and evidence from participatory rural appraisal methods leaves little doubt that they can matter a lot.

The model specified below must be understood in the social context of forest management in developing economies. It is relevant to situations where community involvement in resource management is an interesting option, because there is a community (or communities) with a history of reaping some benefits from the forest or living in sufficient proximity to make that a natural aspiration. Forests in developing economies, which are mostly tropical and subtropical, are also very rich in biodiversity and produce not only timber but also a large number of non-timber forest products (NTFPs) such as fruits, leaves, seeds, flowers, gums, and tubers. Most of these latter items cannot be exploited on a commercial scale due to high extraction costs, but do play a significant role in some rural economies. Neither private nor state regimes will use these products, their management being mainly oriented towards timber production. In the case of community or joint regimes, the local user group tends to exploit all the possible forest products. The argument for community or joint regimes for forest management in developing economies is thus similar to the nineteenth-century doctrine in favour of maintaining public access to locations essential as avenues of commerce, even at the expense of exclusive ownership rights. Any resource regime which excluded this potential user group would likely involve significant costs of exclusion. Often the user group community has experience in collective management which raises the potential

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dependence is somewhat broader than Ostrom's (1992) concept of scarcity, since in cases where the user group is independent or only indirectly dependent on the forest, the scarcity of the resource will not have any impact on the group's perception of and preferences on the forest regime.

efficiency of community control. Our focus is on the attributes of the potential user group which are likely to determine the performance of a community management resource regime.

SECTION H: GENERAL STATIC MODEL

Any economic activity, including those related to the use of natural resources, may usefully be thought of as involving a "transformation function" and a "transaction function". The former describes the process whereby physical inputs are transformed into physical outputs; the costs directly associated with this process can be termed technological or transformation costs (Wallis and North 1986). However, a given set of physical inputs may yield more or less output and that output may yield more or less revenue to the right holder depending on the transaction function, which relates the level of potential physical output achievable given the available resources to the benefits received by the right holders. If we define output as the amount of product that generates economic return for the right holders), and the resource regime is treated together with labour, capital, and technology as a variable, then the production relationship can be expressed as:

$$Q = F(L,K,T,R), \qquad (1)$$

where Q is the output accruing to the right holders), L and K are physical labour and capital inputs[12], while T and R refer to technology and to the resource regime respectively.

As noted, the resource regime selected may constrain and hence determine the range of possible technologies and their productivity, so it may be useful to treat technology (i.e. the set of technological options available) explicitly as a variable. Here, however, our focus is on the optimal resource regime. Accordingly, relationships between regime and technology are not addressed directly and only the resource regime is treated as a variable, along with capital and labour. Equation 1 thus reduces to:

$$Q = F(L, K, R). \qquad (1a)$$

The transformation and transaction functions may be separable or non-separable. In the former

[12] For simplicity, we incorporate the productive potential for the natural resource under the factor of capital.

case, the transformation process is independent of the resource regime, hence total physical output is the same regardless of resource regime arrangements. The process of creating value for the society can be thought of as consisting of two separate stages. The transformation process can then be expressed as:

$$Q_1 = F_1(L, K), \qquad (2a)$$

where Q_1 is physical output produced by transformation process, and F_1 is the transformation function. The transaction function makes available all or part of Q_1 to the right holder(s).[13] It can be expressed as:

$$Q = Q_1.G(R), \qquad (2b)$$

where Q is quantity of product received by the right holder(s), and G is the transaction function. In this simple case, the share of physical output received by the right holder(s) is dependent only on the resource regime.

In the case of forest resources, the surrounding social institutions assume special importance because they affect not only the transaction function but also the efficiency in transformation. For example, if a forest owner (say the state) is unable to exclude a local population (user group) it (the owner) may be unable to complete the transformation process. In this case of non-separability, the transaction and transformation processes interact such that the form of each function depends on the characteristics of the other. In this case, the relationship expressed by Equation (1a), seems the more appropriate one.

For simplicity, consider a situation in which the average transformation cost is linear in output (as assumed by Gordon, 1954) and is independent of the resource regime, i.e. there is separability between the transformation and transactions functions. Figure 1 represents a situation in which average per unit costs rise with output due to increasing scarcity of the resource. The curve $C_PC_{P'}$ is the average cost curve which would obtain in the case of a single constant returns to scale producer in this industry.[14] Under competition, which would occur given open access, this curve becomes a

[13] The part of Q_1 not accruing to the right holder may go to other members of the society (as an externality) or be dissipated in some way such that it does not accrue to anyone.

[14] If there were decreasing returns to scale and the industry were under unified control, it would take

supply curve and equilibrium would occur at point A where this supply curve intersects the demand curve, here assumed to be horizontal at DD'. All producers would have average and marginal cost equal to OD and the total social rents would be zero. In the absence of transactions costs the socially optimal level of output is that at which marginal production cost, given by curve $C_PM_{P'}$ (marginal to $C_PC_{P'}$), equals the price, i.e. point B. A single producer facing the same costs as the open industry would select that "efficient" point and would produce quantity Q_b. Rents accruing to the producer would be the area DBFE. A set of producers induced to produce there by taxes or quotas would do the same as the single producer, as long as those instruments were set at the right level, though social gains would be less if there were significant administrative costs to such intervention.

The relative benefits from different regimes are naturally altered when regime-sensitive transactions costs are taken into account. If the private or state regime mentioned by Gordon faced the average transaction cost functions depicted as $C_tC_{t'}$,[15] then the average total cost curve for this single producer (including production and transactions costs) would be CC' (the vertical summation of curves $C_PC_{P'}$ and $C_tC_{t'}$). The marginal total cost curve CM' intersects DD' at Q_g, a lower output level than Q_b. However, if another resource regime involves lower transaction costs than represented by $C_tC_{t'}$ and this implies a lower total cost curve that regime and its associated output level will be superior. If however the minimum transaction cost is sufficiently high such that the average and marginal cost curves which include both transaction and transformation costs lie completely above the demand curve, no regime based on rights and duties (private, state, joint, or communal) may yield any rent, and the optimal regime could be open access. The transaction costs of different regimes will depend upon the socio-economic factors of the user group, to be discussed in the next section, where we develop a more complete model to determine the optimal resource regime under different socio-economic situations and the correspondingly different transactions

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the form of a number of small producing units under that unified control.

[15] Average transaction cost is assumed invariant to output for simplicity. The analysis would proceed in the same way with any other function. The character of this function could vary widely. In some instances the bulk of these costs might be fixed, in which case the average transaction cost would approximate a rectangular hyperbole.

costs. For the model to have real content, it is essential to know the general character of the transaction function, i.e. the way resource regime arrangements actually function. Though the precise shape of the function will vary with each combination of particular resource and user group, identifying general features constitutes a useful first step.

Insert Figure 1

SECTION III: THE NATURE OF THE TRANSACTION FUNCTION

Costs of coordination and exclusion are the two components of transaction costs. User group heterogeneity and direct dependence are two important socio-economic factors (SEFs) helping to determine, respectively, the costs of coordination and of exclusion. A user group nearly independent of the forest resource (β close to 0) will have little or no interest in forest management, so exclusion of that group poses no problem to a private or a state regime[16]; such regimes have by definition no or very small coordination costs. Hence, user group's independence or very low dependence will improve the relative performance of a state or a private regime. A higher level of dependence will lead to costs/difficulties of exclusion; at a certain level of dependence, exclusion may become prohibitively expensive or impossible, leading to the failure of either private[17] or state

[16] Given the indivisibility of forests, "private regime" means management by a large enterprise with total exclusion of any potential user group; it does not refer to the ownership of small plots of trees by individuals.

[17] A high level of resource dependence is not a sufficient condition for the optimality of a community regime. It raises the costs of exclusion, but the user group may be included either by division of the resource among individuals (de facto a private regime) or through a community regime, with the relative merits of these two options depending on other physical and economic characters of the resource. Thus, of two user groups with equal high dependence on a resource–the forest in one case and agricultural land in the other, a community regime may be optimal for forests but a private one in agriculture. In addition to divisibility, other features such as frequency of production, value of output, the possibility of increasing yields by intensive irrigation, manuring, and crop rotation favour the private regime in agriculture. In the case of forests, private ownership of small patches would interfere with controlled continuous yields and present problems in meeting the minimal needs of each

regimes and leaving the community regime as the only viable one[18]. In the case of community regimes, the group's closeness to the resource and their local information system further reduces exclusion cost.

A main obstacle to an effective community regime is user group heterogeneity. As heterogeneity increases, the chances of reaching a consensus and hence of smooth and effective resource management diminish[19] and at some point the private regime will dominate the community one[20]. In the case of a heterogeneous user group the collection and analysis of information and consensus

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household. A community regime allows annual harvesting to meet the needs of each member. This is the reason for simultaneous existence of a private regime in agriculture and a community regime in forest resources as in Swiss villages of alpine peasants (Netting 1976), rural villages in Japan (McKean 1982), and many villages close to forests in India. Netting's (1976) arguments for this co-existence are somewhat similar to ours.

[18] In this context people tend to be more afraid of government than of private enterprises, but exclusion is not complete in the former case either. Economies of scale do lower the cost of exclusion for state regimes. Hence, at intermediate levels of user group dependence, it may be impossible for private agencies to exclude the user group but still possible for the state to do so; at higher dependence levels the government too will be unable to effect such exclusion.

[19]An example would be a user group composed of the households of different castes where the caste system defines the dominant social distinction in the group. The problems associated with this sort of user group heterogeneity may sometimes be skirted if the user group agrees to divide the total forest resource into parts (not into small patches of a few hectares for each family but into large areas with each group managing one part of the resource independently under a caste-specific community regime, and with boundaries defined by painting of the boundary trees. In the state of Orissa (India), heterogeneity of the user group was seen to lead to either destruction of forests (failure of community regime) as in the case of Joranda village, or to the division of forest amongst different but internally homogeneous groups as in the case of Mahapada village (Kant et al. 1991).

[20] For purposes of this discussion it is convenient to think of all relevant socio-economic factors as belonging to one or the other of two groups, those (like dependence) which favour the communal regime and those (like heterogeneity) which favour the private regime. For simplicity of discussion and of mathematical presentation we assume only those two SEFs.

building on resource management will be more costly because of the diversity involved. In the case of homogeneous groups the information in question and the views will be almost identical so these costs will be low. The rule system designed by the community for forest management has to be incentive-compatible and enforceable. Its design mainly involves incorporation of the economic incentives and enforcement procedures appropriate to the particular user group, and requires discussion with most or all members of the user group to identify incentives and procedures acceptable to the whole group. The cost of this exercise will naturally increase with the heterogeneity of the group. The probability that some members will not follow the system once it is adopted will also increase. A stronger enforcement system will be required, leading to higher enforcement costs. Hence, the costs of information, contracting, and policing will all increase with the heterogeneity of the group. Meanwhile, the policing (exclusion) cost will increase with the dependence of the user group[21].

The nature of the coordination and exclusion costs thus implies that as the homogeneity of the user group increases and/or its dependence level increases the optimal resource regime will shift away from state or private regimes towards communal or joint (between community and state) regimes, an inference supported by field observations[22] (Bundestag 1990, p.262; Kant et al. 1991; Poffenberger, 1990, p.xxi). In addition to these two socio-economic factors, transaction costs will also depend upon the opportunity cost of the time of community people, which itself may depend upon these or other socio-economic factors as well as on the prevailing wage rates in the area.

For simple exposition in what follows, we focus not on these two components of transaction costs but on the transaction function which expresses the ratio of output received by the right holder to

[21] For simplicity of exposition we mainly link group heterogeneity with issues of 'information and contracting' (coordination) and group dependence with policing (exclusion) cost, even though each of these SEFs may have some effect on both coordination and exclusion costs.

[22] A lower level of user group dependency raises the viability of all types of regime by lowering exclusion costs, but since these costs are a bigger problem for private and state regimes than for community managed ones, it raises the relative effectiveness of the former. At the same time, dependency and heterogeneity have to be looked together.

output produced or producible given the physical inputs used or available, and, first, we consider the separability case. The most plausible simple assumption, given the way the two costs are linked to regime, is that the transaction function is either monotonically increasing, monotonically decreasing, or has a single maximum value somewhere in its domain ranging from open access to private regime. The variety of possible shapes of this function reflects those of the total transaction costs curve discussed above. Such a transaction function G(R) can be conveniently expressed by the mathematical form:

$$G(R) = \delta . R^{\alpha}(1-R)^{\beta} \qquad (3)$$

where R is the continuous resource regime variable representing different levels of exclusiveness, scaled for simplicity between 0 to 1 (but excluding the end points [23]). Open access (no exclusion) is represented by a number near zero, and a private regime, which means full exclusion, by a number close to 1. Community, joint, and state regimes can be assigned, in somewhat arbitrary way, values of 0.25, 0.50, and 0.75, respectively. The parameters α and β are the two SEFs defined above.

The maximum possible value of the transaction function is one. In many real life situations that maximum will be approached, as in the case of state-managed forests located far from human habitations and thus under no pressure from a local population. A scaling factor δ normalizes the maximum value of the transaction function.

Under separability between the transaction and transformation functions, the optimal resource regime is the one for which the value of the transaction function reaches its maximum. The first order condition for maximization is:

[23] A quirk of this particular function is that its value becomes zero at both R=1 and R=0. In this it misrepresents the reality we are portraying, but since it provides a valid picture asymptotically close to those limits it is useful. For a highly heterogeneous group (α close to 1) and negligible dependence (β close to zero), the transaction function reaches its maximum close to R=1, but then falls precipitously to zero at R=1. Similarly it has its maximum close to R=0 for a highly homogeneous group, but the value falls precipitously to zero at R=0. Therefore, it is technically necessary to interpret the private resource regime as being represented by $R = 1^-$ (a point very close to 1) and the open access regime at $R = 0^+$.

$$dG(R)/dR = 0 \text{ or } R = \alpha/(\alpha+\beta), \quad (4)$$

and the second order condition at the point given by the first order condition is

$$d^2G(R)/dR^2 = -(\alpha+\beta). \quad (4a)$$

Therefore, for positive values of both the SEFs (α and β), $R = \alpha/(\alpha+\beta)$ defines the resource regime which maximizes the value of the transaction function. It indicates that for heterogeneity (α) > dependence (β), the optimal resource regime will be between a joint one (involving both the user group i.e., the community and the owner, probably the state) and a private one; for heterogeneity (α) < dependence (β), the optimal regime will be between an open access and a joint regime. More precisely, Equation 4 indicates that $R >= 0.75$ for $\beta = 0.1$, $\alpha >= 0.3$ and for $\beta = 0.2$, $\alpha >= 0.6$; and $R =< 0.25$ for $\beta >= 0.3$, $\alpha = 0.1$, and for $\beta >= 0.6$, $\alpha = 0.2$. For all other values of the two SEFs, the optimal value of R lies between 0.75 and 0.25, which means some sort of joint management between government and communities. These results imply that only for a very small range of values of the two SEFs, particularly when the dependence of the user group on the resource is very small, will either a private or a state regime be optimal. In contrast, for a rather wide range of SEFs some sort of joint regime between state and community will be optimal. In the developing economies, the values of both α and β may often fall within the range of 0.4 to 0.6 (Kant 1996); for theses ranges of the two SEFs, the optimal R also varies within the range 0.4 to 0.6, implying that the optimal regime will tend to be some sort of joint regime between the state and communities.

In the case of non-separable transformation and transaction functions, the output accruing to the right holder(s) will depend simultaneously on the factor inputs and the resource regime; the optimal quantity of factor inputs and the optimal resource regime can be determined by static analysis of a production function that includes the transformation and transaction functions. Details of such analysis are given in Appendix A. Even though, the optimality conditions are somewhat more complicated in this case, overall pattern of how optimal resource regime depends on α and β is likely to be similar to the separability case.

CONCLUSIONS

This paper focuses on how such socio-economic factors as degree of user group dependence on a resource and user group heterogeneity help to determine which resource regime, along a spectrum ranging from open access to private property, will be optimal under specific conditions. The concept of the transaction function is developed to express the fact that different resource regimes face different costs of coordination and of exclusion. In the case of separable transaction and transformation functions, the optimal resource regime is determined by the effect of socio-economic factors on the transaction function, while in case of non-separable transaction and transformation functions their effects on the physical production process are relevant as well.

Further research on the coordination and exclusion costs associated with different resource regimes is essential to provide a better feel for the likely range of circumstances under which community resource management may be optimal, and for ways in which those costs may be reduced in the context either of community management or competing management forms[24].

Their quantitative imprecision notwithstanding, the results presented above give some indication that in developing economies the state regime will frequently not be optimal for management of forest resources located near populated areas[25]. Similarly, in the areas where forests are owned by private companies but the local communities are heavily dependent on these forests (e.g for employment), a joint regime between the company and local communities may be optimal. This is not to suggest that all the forests in these countries should be under joint resource regimes. Some large tracts are far from communities and no user group is dependent on them as a resource, and in other cases local communities are not directly dependent on forest resources and/or heterogeneity among the group is pronounced; these can be efficiently managed under state or private regimes.

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[24] A solid understanding not only of the cost and productivity features of alternative resource regimes but also of the process of evolution of resource regimes is necessary for effective policy making, especially when community involvement in management is a serious option. Kant and Berry (1998) presents a more detailed discussion.

[25] In this context, some recent institutional shifts in forest management in India are described in Kant and Nautiyal, 1994.

APPENDIX A

STATIC ANALYSIS FOR NON-SEPARABLE TRANSFORMATION AND TRANSACTION FUNCTIONS

For simplicity, assume that only a given technology, represented by a Cobb-Douglas function, is available to the user group. We wish to identify the optimal combination of resource regime and physical inputs (labour and capital) for this technology. In this case profit can be expressed as:

$$Z = P.L^a.K^b.\delta.R^\alpha(1-R)^\beta - P_l.L - P_k.K - P_r(R) \quad (1)$$

Where L is labour input, K is capital input, P_l is price of labour, P_k is price of capital, and $P_r(R)$ is price of resource regime. The resource regime variable is different from the variables corresponding to the physical inputs - capital and labour. Physical inputs are assumed to be homogeneous, and the number attached to them represents the quantity used. Differences across resource regimes are not necessarily, or generally, interpretable as comparable to quantitative differences in a physical input, though, in this case, we are assuming that they can be thought of as qualitative differences. The resource regime price is defined as the total costs (sum of exclusion and coordination costs) of the regime. The regime price thus varies with the value of the regime variable R.

First order conditions for profit maximization are:

$$a.L^{a-1}.K^b.\delta.R^\alpha(1-R)^\beta = P_{lo} \quad (1a)$$

$$b.L^a.K^{b-1}.\delta.R^\alpha(1-R)^\beta = P_{ko} \quad (1b)$$

$$L^a.K^b.\delta.R^\alpha(1-R)^\beta.[(\alpha/R)-(\beta/(1-R))] = (MP_r(R)/MR)/P \quad (1c)$$

$(MP_r(R)/MR)$ is a marginal resource regime price, and we denote the ratio of the marginal resource regime price to the price of output $(MP_r(R)/MR)/P$ by P_{ro}. Similarly, P_{lo} and P_{ko} are the prices of labour and capital, respectively, in relation to the price of output.

These three equations can be solved to obtain[26]:

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[26]On dividing (1a) by (1b)

$$K = (b/a).(P_{lo}/P_{ko}).L \quad (1e)$$

On dividing (1c) by (1b)

$$K = (b.P_{ro}/P_{ko})/[1/\{(\alpha/R) - (\beta/(1-R))\}] \quad (1f)$$

On dividing (1c) by (1a)

$\delta . R^{\alpha}(1-R)^{\beta}.[(\alpha/R)-(\beta/(1-R))]^{1-a-b} = P_{ro}.(P_{lo}/a.P_{ro})^{a}(P_{ko}/b.P_{ro})^{b}$ (1d)

Equation (1d), subject to the concavity conditions of the profit function, can be solved for R (optimal resource regime) by any non-linear equation solution method. The value of R can be used to obtain the values of L and K.

On simplification, the three first order conditions (1a, 1b, and 1c) will yield the standard marginal condition:

$(MPP_l / P_l) = (MPP_k / P_k) = (MPP_R / (MP_r(R)/MR))$ (2)

A slight difference in this equation from the standard marginal condition is noticeable. L and K represent the units of labour and capital used while R represents a particular resource regime. The prices of labour and capital are constant, hence, the P_l and P_k are average as well as marginal prices of labour and capital, respectively, while the price of the resource regime is a function of R, hence marginal price of R appears distinguishably. The equation can be interpreted as that the optimal condition will be given by the ratio of the marginal product and the marginal price of each input being the same.

The equation can be modified to:

$(L.P_l/a) = (K.P_k/b) = [R.MP_r(R)/MR] / [\{\alpha - (\beta.R/(1-R))\}]$ (2a)

In a Cobb-Douglas function a and b represent the percent change in output due to a one percent change in the input (elasticity of output with respect to the respective inputs), and these are referred to as scale factors; accordingly, we refer to $\{\alpha - (\beta.R/(1-R))\}$ as a shadow scale factor of the resource regime. While a and b appear as powers of the two inputs labour (L) and capital (K), this shadow scale factor does not, nor does it have a constant value like a and b. The production function has two terms related to the resource regime, R and 1-R, which together with their powers α and β produce the scale effect $\{\alpha - (\beta.R/(1-R))\}$. Since this effect is not identical to that implicit in $R^{\{\alpha - (\beta.R/(1-R))\}}$ we refer to it as the shadow scale factor. The shadow scale factor of the resource regime is resource regime dependent, hence the elasticity of output with respect to the resource regime varies across resource regimes, while the elasticity of output with respect to labour and capital is independent of the amount of these inputs used. Since, a and b are positive, $\{\alpha$ - $(\beta.R/(1-$

$L = (a.P_{ro}/P_{lo})/[1/\{(\alpha/R) - (\beta/(1-R))\}]$ (1g)

On substituting the values of L and K from 1g, and 1f, in 1c, we get 1d.

R))} should also be positive; which leads to optimal $R < \alpha/(\alpha+\beta)$. We know that for $P_r(R)=0$, the optimal $R = \alpha/(\alpha+\beta)$. Hence, in the presence of a positive price of resource regime, the optimal R will be less than optimal R in case zero price of resource regime.

The optimal condition can be expressed as the ratio of the input multiplied by its marginal price to the scale factor being the same for each factor.

LITERATURE CITED

Acheson, J. M. 1989. Where have all the exploiters gone? Co-management of the Maine Lobster Industry. In Berkes, F. (ed.) Common Property resources: Ecology and Community-Based Sustainable Development. Belhaven Press, London. pp. 199-217.

Anderson, L.G. 1977. The Economics of Fisheries Management. The John Hopkins University Press. Baltimore and London. 296 p.

Bardhan, P. 1993. Symposium on management of local commons. The Journal of Economic Perspectives. 7(4):87-92.

Bell, F.W. 1972. Technological externalities and common property resources: an empirical study of the U.S Northern Lobster Fishery. Journal of Political Economy. 81:148-158.

Berkes, F.(ed.) 1989. Common Property Resources: Ecology and Community Based Sustainable Development. Belhaven, London. 302 p.

Brightman, R. A. 1987. Conservation of resource depletion: the case of the Boreal Forest Algonquians. In McCay, B. J., and J. M. Acheson. (ed.) The question of the commons. The University of Arizona Press, Tuscon. pp. 121-141.

Bromley, D. W. 1986. Closing comments. National Research Council, Proceedings of the conference on Common Property Resource Management, National Academy Press, Washington, D.C., pp.593-598.

Bromley, D. W. 1989. Property relations and economic development: the other land reform. World Development. 17:867-877.

Bromley, D. W. 1991. Environment and Economy: Property Rights and Public Policy. Blackwell. 247 p.

Bromley, D.W., and Carnea, M.M. 1989. The management of common property natural resources. World Bank Discussion Paper No.57. Washington, D.C. 67 p.

Bromley, D.W., and Szarleta, E. 1986. Resources and people; an economic perspective. In Natural Resources and People. Edited by Datilberg, K.A and Bennett, J.W. Westview Press. pp. 165-84.

Brown, G., Jr. 1974. An optimal program for managing common property resources with congestion externalities. Journal of Political Economy. 82:163-174.

Bundestag, D. 1990. Protecting the tropical Forests. 2nd Report of Enquete Commission. Bonner Universitats. Bonn. 968 p.

Campbell, J.Y. 1992. Joint forest management in India. Social Change. 22(l):36-53.

Cheung, S.N.S. 1987. "Common property rights." In The New Palgrave: A Dictionary of Economics, vol 1. edited by John Eatwell, Murray Milgate, and Peter Newman. Macmillan London. pp. 504-505.

Coase, R.H. 1937. The nature of the firm. Economics 4:386-405.

Coase, R. H. 1960. The problem of social cost. Journal of Law and Economics. 3:1-44.

Cruz, M. J. 1989. Water as common property: the case of irrigation water rights in the Philippines. In Berkes, F. (ed.) Common Property Resources: Ecology and Community-Based Sustainable Development. Belhaven Press, London. pp.218-236.

Dahlman, CJ. 1980. The Open Field System and Beyond: a property rights analysis of an economic institution. Cambridge University Press. New York, 234 p.

Demsetz, H. 1967. Toward a theory of property rights. American Economic Review. 57:347-359.

Feeny, D., Berkes, F., McCay, B.J., and Acheson., J.M. 1990. The tragedy of commons: twenty two years later. Human Ecology 18(1): 1-19.

Fortmann, L. and John, W.b.(eds). 1988. Whose trees? Proprietary Dimensions of Forestry. Boulder, Co. Westview Press. 341 p.

Gadgil, M., and R. Guha. 1992. This Fissured Land: An Ecological History of India. Oxford University Press, Delhi. 274 p.

Gibbs, C.J.N., and Bromley, D.W. 1989. Institutional arrangements for management of rural resources: common property regimes. In Berkes, F.(ed.), Common Property Resources. Belhaven, London. pp. 22-32.

Godwin, R.K., and Shepard, W.B. 1979. Forcing squares, triangles and ellipses into a circular paradigm: the use of commons dilemma in examining the allocation of common resources. Western Political Quarterly. 32:265-277.

Gordon, J.S. 1954. The economic theory of common property resource: the fishery. The Journal of Political Economy 62:124-142.

Hardin, G. 1968. The tragedy of commons. Science. 162:1243-48.

Hartwick, J.M., and Olewiler, N.D. 1986. The Economics of Natural Resource Use. Harper and Row Publishers, New York. 530 p.

Jacobs, P., and Munro, D.A.(eds.)1987. Conservation with Equity: Strategies for Sustainable Development. IUCN, Cambridge. 466 p.

Kant, S. 1996. The Economic Welfare of Local Communities and Optimal Resource Regimes for Sustainable Forest Management. Ph.D.Thesis (Unpublished), Faculty of Forestry, University of Toronto, Toronto. 166 p.

Kant, S., Singh, N.M., and Singh, K. 1991. Community Based Forest Management Systems. Indian Institute of Forest Management, Bhopal, India. 70 p.

Kant, S., and Nautiyal, J.C. 1994. Sustainable Joint Forest Management through Bargaining: A Bilateral Monopoly Gaming Approach. Forest Ecology and Management. 65:251-264.

Kant, S., and R.A. Berry. 1998. Evolution of Optimal Resource Regimes in Forest Management. Faculty of Forestry, University of Toronto, Toronto. Unpublished.

Kenneth, R. 1989. Solving the Common-Property Dilemma: Village Fisheries Rights in Japanese Coastal Waters, In Berkes, F. (ed.) Common Property resources: Ecology and Community-Based Sustainable Development. Belhaven Press, London. pp. 168-184

Krutilla, J.V. and Fisher, A.C 1975. The Economics of Natural Environments: studies in the valuation of commodity & amenity resources. Baltimore. Published for Resources For the Future, Washington D.C. 292 p.

Luckert Martin K. 1992. Property rights for changing forest values: a study of mixed-wood management in Canada. Canadian Journal of Forest Research. 23:688-699.

Magrath, W. 1989. The Challenge of the commons: the allocation of non exclusive resources. World Bank Environment Department Working Paper. 14. 52 p.

McCay, B. J. 1980. A fishermen's cooperative, limited: Indigenous resource management in a complex society. Anthropological Quarterly. 53:29-38.

McKean , M. A. 1982. The Japanese experience with scarcity: Management of traditional common lands. Environmental Review. 6: 63-88.

Meza de David and J. R. Gould. 1992. The social efficiency of private decisions to enforce property rights. Journal of Political Economy. 100(3):561-580.

Miller, D. L. 1989. The evolution of Mexico's Spiny Lobster Fishery. In Berkes, F. (ed.) Common Property resources: Ecology and Community-Based Sustainable Development. Belhaven Press, London. pp. 185-198

Netting, R. M. 1976. What Alpine Peasants Have in Common: Observations on Communal Tenure in a Swiss Village. Human Ecology. 4(2): 135-146.

North, D.C. and Thomas, R.P. 1977. The first economic revolution. Economic History review. 30:229-41.

North, D.C. 1981. Structure and change in economic history. W.W.Norton and Company, New york. 228 p.

Ostrom, E. 1990. Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge. 280 p.

Ostrom , E. 1992. Crafting Institutions for Self-Governing Irrigation Systems. Institute of Contemporary Studies, San Franscisco.

Ostrom, E., and R. Gardner. 1993. Coping with the Asymmetries in the Commons: Self Governing Irrigation Systems Can Work. The Journal of Economic Perspectives. 7(4): 93-112.

Pearse, P.H. 1990. Introduction to Forestry Economics. U.B.C.Press Vancouver. 226 p.

Peters, P. E. 1987. Embedded systems and rooted models: the grazing lands of Botswana and the commons debate. In McCay, B. J., and J. M. Acheson. (ed.) The question of the commons. The University of Arizona Press, Tuscon. pp. 171-194.

Plourde, C.G,, 1971. Exploitation of common property replenishable resources. Western Economic Journal 9:256-266.

Poffenberger, M. 1990. Keepers of the Forest. Kumarion Press, Connecticut. 289 p.

Poffenberger, M. and Singh, C. 1991. Emerging directions in Indian forest policy: the legal framework for joint forest management of forest lands. Ford Foundation Working Paper 14. New Delhi.

Posner, R. A. 1977. Economic Analysis of Law (2nd ed.). Little Brown, Boston. 572 p.

Randall, A. 1987. Resource Economics. John Wiley and Son. New York. 434 p.

Rohlmann, M. 1992. Integrated natural resource management- a question of property institutions? Presented at 3rd Common Property Conference of the International Association for the Study of Common Property, Washington, D.C. 1992.

Rose, Carol M. 1994. Property and Persuasion: Essays on the History, Theory, and Rhetoric of Ownership. Westview Press, Boulder. 372 p.

Runge, F. 1986. Common Property and Collective Action in Economic Development. World Development. 14(5):623-635.

Scott, A.D. 1955. The fishery: the objectives of sole ownership. Journal of Political Economy 63:116-124.

Scott, A. and Johnson, J. 1985. Property rights: developing the characteristics of interests in natural resources. In Natural Resource Economics. Edited by Scott, A. Clarenden press, Oxford, pp.376-421.

Seabright, P. 1993. Managing Local Commons: Theoretical Issues in Incentive Design. The Journal of Economic Perspectives. 7(4): 113-134.

Sethi, R., and E. Somanathan. 1996. The Evolution of Social Norms in Common Property Resource Use. The American Economic Review. 86(4): 766-788.

Vondal, P. J. 1987. The common swamplands of southeastern Borneo: multiple use, management, and conflict. In McCay, B. J., and J. M. Acheson. (ed.) The question of the commons. The University of Arizona Press, Tuscon. pp. 231-249.

Wade, R. 1988. Village Republics: Economic Conditions for Collective Action in South India. Cambridge University Press, Cambridge. 238 p.

Wallis, J.J., and North, D.C. 1986. Measuring the transaction sector in the American economy, 1870-1970. In Long Term Factors In American Economic Growth. Edited by S.L.Engerman and R.E.Gallman, University of Chicago Press. pp.95-161.

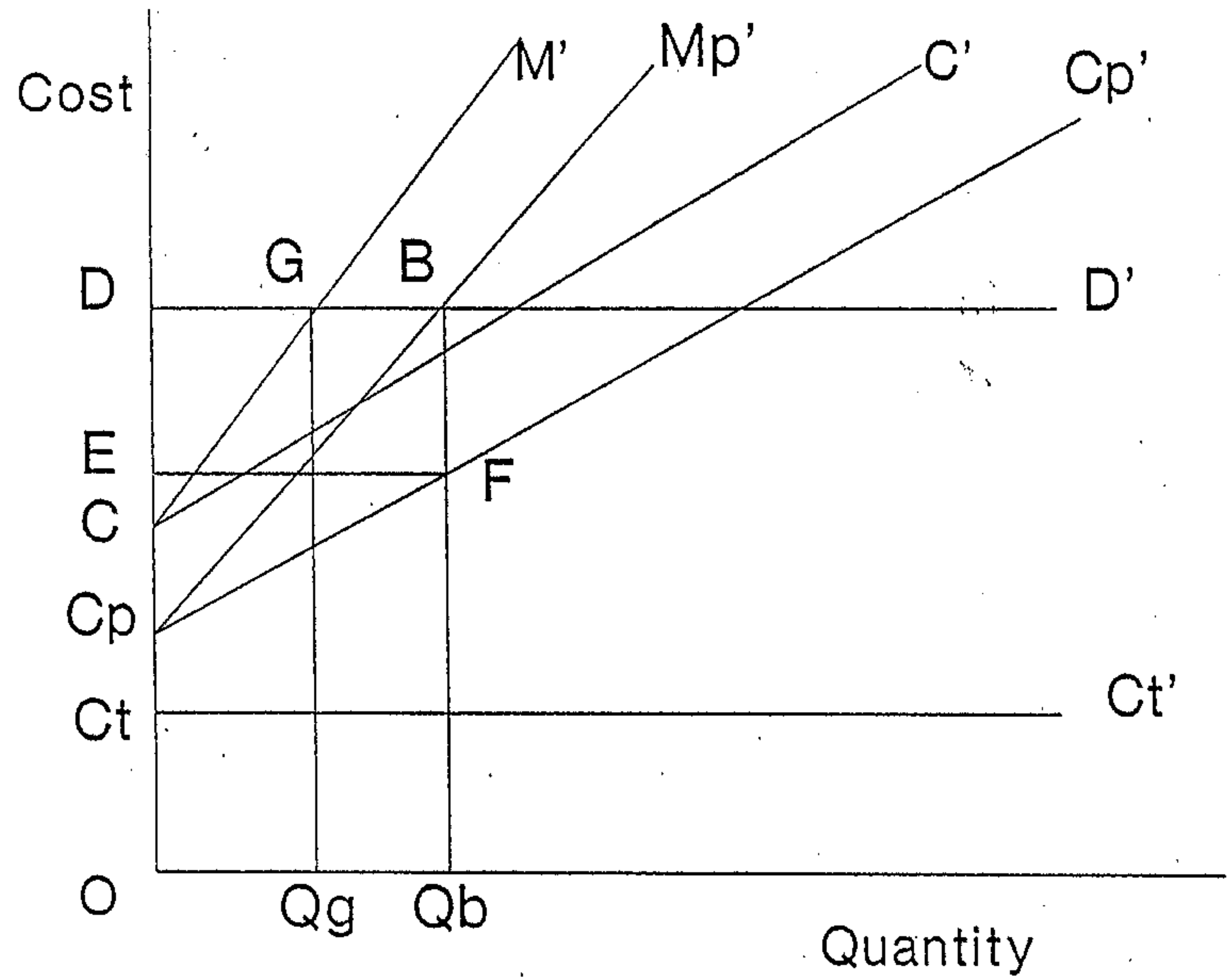

Figure 1