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ECONOMICS OF WILDERNESS RESOURCES

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In 1972 over 16,400 commercial and private users sought the supreme "white water" experience by traversing the Grand Canyon, or a portion of it, by means of inflatable rubber boats. This compares with 372 in 1962 and 70 in 1955. Although Grand Canyon represents one of the most spectacular wilderness experiences, similar explosions in visitor use are reported in the High Sierra, the Salmon and Snake Rivers of Idaho, and hundreds of miles of wilderness trails and rivers in the National Park and National Forest systems. This trend is causing considerable distress for naturalists and environmentalists interested in wilderness preservation, and for National Park and Forest Service administrators caught in the cross currents of political pressure to make public lands freely available to the citizenry while attempting to maintain such lands in some approximation to their natural state.

Visitor use of the National Parks in general, although increasing, has not kept pace with growth in the use of the more primitive areas, as mountain climbing, backpacking and river running have become popular activities that engage remote public lands never previously used for recreational purposes by more than an insignificant segment of the population. The contrast between growth in visits to developed park centers and to more rugged areas is illustrated in Chart 1 for visitor use of Grand Canyon. While total visits to Grand Canyon nearly doubled, 1960-1970, Colorado River excursions increased about 50 times.

Economic analysis of recreational lands has been concerned primarily with the principles (Krutilla, 1967) and techniques (Carlin, 1968;Fisher, Krutilla and Cicchetti, 1972; Hearse, 1968; Hoch,1962) of allocating and valuing land for recreational or preservational as against developed industrial uses. For example, should Hells Canyon or Grand Canyon be flooded behind hydroelectric dams or preserved as scenic resources? Formal treatments of the dynamic and uncertainty aspects of this allocation problem, with particular emphasis on the relative irreversibility of decisions to flood or otherwise destroy whole ecosystems through industrial development, have been provided recently by Fisher, Krutilla, and Cicchetti (1972) and by Arrow and Fisher (1973). These contributions do not deal with the problem of managing, developing,and rationing the use of resources already allocated to recreational uses, although some studies do touch upon the problem (for example, Hoch, 1962, discusses and recommends license fees for park users).

In what follows,the familiar tools of control theory and stationary general equilibrium theory will be used to study a model that captures certain stylized characteristics of public recreational resources. These characteristics include external crowding diseconomies in consumption, deterioration effects of resource use, the capacity of the resource for ecological adjustment to (or recovery from) use, and the public-good aspect of the quality, beauty, or "naturalness" of the resource. Several types of equilibria will be illustrated and compared: An optimal control solution, with and without administrative cost, and a corresponding free use competitive solution; and stationary state competitive solutions for undeveloped and developed access technologies, and an optimal solution with administrative cost. An illustration is given whereby investment in an easier-access technology produces crowding and resource deterioration to the point where all users are made worse off. The administrative cost of overlaying direct controls as a remedy may cause further social losses, or, in any case, be worse than leaving the resource in its orginal state of high-cost access. This suggests the possibility that rationing by deliberately increasing (or not decreasing) the cost of access to scenic resources may be society's best option. Although this appears somewhat counterintuitive there are many institutional examples of a scarce resource being rationed by the imposition of artificial costs. Public toilet facilities nearly always ration tissue paper and towels through dispensers designed to raise the cost of transacting for each unit. One imagines this design evolving from a great deal of experience with excessive waste from simple, more convenient dispensing devices. Similarly, the problem of overfishing for Pacific salmon has been alleviated in part by prohibiting the use of traps that clearly represent the most efficient capture technology. Requirements that oars rather than motors be used on wild river floats, that jeeps and trail bikes be prohibited in wilderness areas, and that certain park roads be left unpaved or restricted to four-wheel drive vehicles, may represent relatively efficient rationing techniques. Such rationing devices not only reduce crowding, and ecosystem damage; they also restrict use to those whose preferences are strong enough to overcome substantial cost of transacting, and in this sense the scarce resource is allocated to its more highly valued uses.

Concepts and Assumptions

Consider a scenic or wilderness recreational resource to be represented in the abstract by a stock, Q, of pleasurable homogeneous services. Real world prototypes would be the Grand Canyon, Yosemite and Glacial National Parks or any of the Wild Areas contained in the National Forest system. In the "natural" state, i.e. "undisturbed" by man, Q is generated by an ecosystem which is boldly assumed to be governed by a differential equation,

$$(1)\ dQ/dt = g(Q)\ ,\ g'(Q) < 0,\ g''(Q) < 0\ ,\ \text{for } Q \geq 0,$$

$$g(\bar{Q}) = 0,$$

where $\bar{Q}$ is the natural state equilibrium. This borders on an offensive oversimplification of reality, but serves to capture the idea that there exist natural biological and geological forces by which a scenic resource develops in the "undisturbed" state. Also, the stage is set for the beauty or wildness of the resource to be modified by man's utilization of it. In particular, if the stock is reduced to some $Q < \bar{Q}$, natural forces will generate recovery so long as the utilization (consumption) rate is below $g(Q)$. Figure 1 illustrates the natural state equilibrium, $\bar{Q}$. At $Q < \bar{Q}$ if the resource is consumed at a rate $q < g(Q)$, it will recover at the net rate $g(Q) - q$ until $dQ/dt = g(Q') - q = 0$.

It is assumed that the natural resource resides in an economy which produces two goods. There is a normal or ordinary good (like corn or meat) produced and consumed at the rate q_1, while consumer exposure to the natural resource is produced at the rate q_2. Exposure to the natural resource affects consumer taste in three distinct ways: (1) q_2 enters the utility function as an ordinary private good just as does q_1. Consumer use of the resource (as measured, for example, in visitor-use days) is variable, controllable, and excludable so that intensity of use is a private activity. (2) Total consumption by all users enters the utility function of each consumer on the assumption that crowding, or merely the presence of other users, even in modest numbers, detracts from the pleasure of scenic or wilderness resources. A dramatic example of external diseconomy on Colorado River excursions is the recent epidemic of dysentery (New York Times, 1972). Thus if q_2^k is the kth individual's consumption, $\sum_{k=1}^{n} q_2^k$ enters the utility function of each of n consumers. Assuming, as we shall, identical utility functions, q_2 is the common consumption rate, and nq_2 is total consumption. (3) The stock of services (Q) represented by the resource enters each utility function as a public good measure of the quality or character of the resource. This is the case whether or not one assumes identical utility functions.

The utility function is then of the form $u^m = u^m(q_1^m, q_2^m, \sum_{k=1}^{n} q_2^k, Q)$ for consumer m,[1] or $u = u(q_1, q_2, nq_2, Q)$ when an economy of n identical individuals is postulated.[2] In the analysis of this paper, u will be assumed to be concave and additively separable,[3]

$$(2)\quad u = u_1(q_1) + u_2(q_2) + u_3(nq_2) + u_4(Q),$$

$$u_1' > 0,\ u_2' > 0,\ u_3' < 0,\ u_4' > 0,$$

$$u_j'' < 0,\ j = 1, 2, 3, 4.$$

A simple homogeneous productive input, available in the amount L, is allocated L_1 units to producing q_1 and L_2 to producing q_2, i.e.

$$(3)\quad L = L_1 + L_2$$

$$(4)\quad q_i = f_i(L_i),\ i = 1,2$$

where the production functions f_i are assumed increasing and concave,

$$f_i' > 0,\ f_i'' \leq 0,\ i = 1,2.$$

The effect of using the resource is assumed to cause deterioration at a time rate which is an increasing convex function of total consumption, $h(nq_2)$, $h' > 0$, $h'' \geq 0$. Hence changes in the net stock of services provided by the resource are described by the differential equation,

$$(5)\quad dQ/dt = g(Q) - h(nq_2).$$

It may be instructive to relate the technology functions, $g(Q)$, $h(nq_2)$ to particular types of recreational resources. A "pure" scenic resource such as the Painted Desert, as viewed from U.S. 66, or the Grand Canyon as viewed from the North or South rims (insofar as they are merely resources viewed at a distance) would not be subject to deterioration, and would therefore be characterized by specifying $h(nq_2) \equiv 0$, and $g'(\bar{Q}) = -\infty$ i.e., $Q \equiv \bar{Q}$. The specification $g'(\bar{Q}) = -\infty$ merely states that geological change in these resources is negligible in contemporary time, and **Q is fixed** and independent of resource utilization. But note that crowding, nq_2, is still in the utility function, and such considerations may detract from the viewing pleasure of a fixed landscape.

The Grand Canyon as viewed from the inner gorge, as part of a Colorado River experience (and similarly for Hell's Canyon on the Snake River), is a scenic resource requiring direct physical contact. One has only to imagine over 16,000 people floating 225 miles of the Colorado River from Lees Ferry to Diamond

Creek in 1972 -- an area totally without sleeping or sanitary facilities -- to appreciate the effect of such use on the terrain, flora and fauna of the River and its immediate environs. Clearly a deterioration function $h(nq_2)$, perhaps with high inelasticity, may apply. Furthermore, the growth or restoration function, $g(Q)$, might be highly elastic for the arid ecosystem of the inner gorge so that recovery from a disturbed state may be very slow. On the other hand, the more lush Allagash region of Northern Maine or parts of the New York State Forest Preserve may recover more quickly from disturbances in their wilderness ecosystems.

A Conventional Control Theory Analysis

If u measures instantaneous social welfare and δ is the social rate of time preference, the standard control problem is to choose

$[L_1(t), L_2(t)]$ so as to maximize $\int_0^{\infty} u e^{-\delta t} dt$ subject to (3)-(5).

The current value Hamilton-Lagrange criterion is

$$H = u_1[f_1(L_1)] + u_2[f_2(L_2)] + u_3[nf_2(L_2)] + u_4(Q)$$
$$+ \mu\Big(g(Q) - h[nf_2(L_2)] \Big) + \lambda(L - L_1 - L_2)$$

and along a maximizing path the conditions

$$\frac{\partial H}{\partial L_i} = 0, \ i = 1, 2, \text{ and } \dot{\mu} = \delta\mu - \frac{\partial H}{\partial Q} \text{ must be satisfied.}$$

By substitution from (3) and (4), the state of the system is described by

$$\text{(6a)} \ \Big(u_2'[f_2(L_2)] + nu_3'[nf_2(L_2)] - n\mu h'[nf_2(L_2)] \Big) / u_1'[f_1(L - L_2)]$$
$$= f_1'(L - L_2) / f_2'(L_2)$$

$$\text{(6b)} \ \dot{\mu} = \mu[\delta - g'(Q)] - u_4'(Q)$$

$$\text{(6c)} \ \dot{Q} = g(Q) - h[nf_2(L_2)]$$

$$\text{and} \lim_{t \to \infty} e^{-\delta t}\mu(t) \geq 0, \ \lim_{t \to \infty} e^{-\delta t}\mu(t)Q(t) = 0.$$

Equation (6a) defines a function $L_2 = L_2(\mu)$ with

$$\text{(7)} \ dL_2 / d\mu = nf_2' h' / J < 0$$

where

$$J = u_1' f_1'' + u_1''(f_2')^2 + (u_2' + nu_3' - n\mu h') f_2'' - \mu h''(nf_2')^2$$
$$+ u_2''(f_2')^2 + u_3''(nf_2')^2 < 0,$$

since $f_i'' \leq 0$, $u_i' > 0$, $u_j'' < 0$, $h'' \geq 0$, and from (6a),

$(u_2' + nu_3' - n\mu h') = u_1' f_1'/f_2' > 0$. Then the differential equations (6b) and (6c), with $L_2 = L_2(\mu)$, describe time paths $Q = Q^*(t)$, $\mu = \mu^*(t)$. The motion of the system in state space (Q, μ) is characterized by the usual phase diagram of Figure 2.

From (6c), the set of points $\{(Q, \mu) \mid \dot{Q} = 0\}$, with the property that the stock of resource services is stationary, is given by

$$(8) \quad Q = g^{-1}(h\{nf_2[L_2(\mu)]\}).$$

This function is strictly increasing since

$$d\mu / dQ \,\big|_{\dot{Q}=0} = g'/nh'f_2' \, (dL_2/d\mu) > 0 \text{, as shown in Figure 2.}$$

Also from (6c), $\partial\dot{Q} / \partial Q = g'(Q) < 0$. At any point to the right (left) of the set $\{(Q, \mu) \mid \dot{Q} = 0\}$ the recovery rate of the resource is below (above) its deterioration rate and the stock of resource services will decline (increase).

Along an optimizing path, (6b) requires the subjective instantaneous unit value of the resource stock, $u_4'(Q)$, to equal total interest on the market value of a unit of the stock, $\mu[\delta - g'(Q)]$, less capital gains on the stock, $\dot{\mu}$. Total interest includes the time preference rate, δ, and $-g'(Q)$, an "own" ecological rate of interest which measures the marginal cost, in terms of reduced natural growth, of consuming the resource stock. The set of points $\{(Q, \mu) \mid \dot{\mu} = 0\}$, with the property that the implicit price of the resource stock is stationary, is given by

$$(9) \quad \mu = \frac{u_4'(Q)}{\delta - g'(Q)},$$

a strictly decreasing function since

$$d\mu / dQ \,\big|_{\dot{\mu}=0} = (u_4'' + \mu g'') / (\delta - g') < 0 \text{, as shown in Figure 2.}$$

Also $\partial\dot{\mu} / \partial\mu = \delta - g' > 0$ and for points above (below) the set $\{(Q, \mu) \mid \dot{\mu} = 0\}$, the price of the resource stock must be increasing (decreasing).

A stationary state equilibrium point (Q^*, μ^*) is shown in Figure 2. If the initial resource stock is $\bar{Q}$, the corresponding optimal initial price is $\bar{\mu}$ and the equilibrium path is along the dashed line passing through $(\bar{Q}, \bar{\mu})$ and (Q^*, μ^*).

If we assume that $\lim_{\mu \to \infty} L_2(\mu) = 0$ in (6a), $\lim_{L_i \to 0} f_i(L_i) = 0$, $\lim_{q \to 0} h(q) = 0$, and $\lim_{\dot{Q} \to 0} g^{-1}(\dot{Q}) = \bar{Q}$, then from (8) $\lim_{\mu \to \infty} g^{-1}(h\{nf_2[L_2(\mu)]\}) \to \bar{Q}$ as shown in Figure 2. If we let $L_2^\dagger = L_2(0)$, where $0 < L_2^\dagger < L$, be the amount of input L_2 used when there is free access to the resource, then we must have

$Q^\dagger = g^{-1}(h\{nf_2[L_2^\dagger]\}) < \bar{Q}$, as shown. From (9) if $\lim_{Q \to \infty} u_4'(Q) = 0$, and since $g'(Q) < 0$ for all $Q \geq 0$, we must have $\mu \to 0$ as $Q \to \infty$; and if $\lim_{Q \to 0} u_4'(Q) = \infty$, then we must have $\mu \to \infty$ as $Q \to 0$, as shown in Figure 2. Thus an intersection point at Q^*, where $Q^\dagger < Q^* < \bar{Q}$, will exist.

Reduction to a Model of Decentralized Competition

The control model reduces to a model of decentralized competition if we set $\mu \equiv 0$, $nu_3' \equiv 0$ in equations (6a) - (6c). That is, there exists no free market price for using the free-access natural resource and each consumer, following his own self-interest, fails to take account of the crowding diseconomies produced by his own consumption of the natural resource.

The competitive time path is then defined by (6c) and

$$(10) \qquad \frac{u_2'[f_2(L_2)]}{u_1'[f_1(L - L_2)]} = \frac{f_1'(L - L_2)}{f_2'(L_2)} .$$

At a stationary competitive equilibrium $\hat{Q}$, $\hat{L}_2$, $\dot{\hat{u}} \equiv 0$, we will have

$$(11) \qquad \hat{Q} = g^{-1}\left(h\,\{n f_2\,[\hat{L}_2\,]\}\right)$$

with $\hat{Q} < Q^{\dagger}$.

Further Analysis of the Stationary State

The stationary state is defined by (6a) - (6c) when $\dot{Q} = \dot{\mu} = 0$. The state of the economy can then be represented in (q_1 , q_2) space in the usual manner of static general equilibrium. This is accomplished by noting that (6b) and (6c) can be combined in the form

$$\mu = \frac{u_4'(Q)}{\delta - g'(Q)} = \frac{u_4'\{g^{-1}[h(nq_2)]\}}{\delta - g'\{g^{-1}[h(nq_2)]\}} .$$

In (q_1 , q_2) space, using (3) and (4), and transforming (6a), equilibrium

is defined by

$$(12) \qquad \frac{-u_1'(q_1^*)}{u_2'(q_2^*) + nu_3'(nq_2^*) - \dfrac{nh'(nq_2^*)\,u_4'\{g^{-1}[h(nq_2^*)]\}}{\delta - g'\{g^{-1}[h(nq_2^*)]\}}} = - \frac{f_1'[f_1^{-1}(q_1^*)]}{f_2'[f_2^{-1}(q_2^*)]}$$

$$(13) \qquad f_1^{-1}(q_1^*) + f_2^{-1}(q_2^*) = L .$$

Condition (12) states the familiar requirement that the social marginal rate of substitution equal the marginal rate of transformation, while (13) requires the economy to operate on its production possibility frontier. The left side of (12) is the slope of an indifference curve adjusted for the external effect of Q and nq_2. This is seen most directly by letting the time preference rate $\delta = 0$. Then the left side of (12) is the slope of an indifference curve defined by

$$u_1(q_1) + u_2(q_2) + u_3(nq_2) + u_4\{g^{-1}[h(nq_2)]\} = \text{constant},$$

where $Q = g^{-1}[h(nq_2)]$ is determined by equilibrium of the resource stock.

However, decentralized competitive consumers of the natural resource do not have private incentive to consider the components u_3 and u_4 when making their consumption decisions. They perceive a substitution rate u_1'/u_2' , and therefore the competitive equilibrium $(\hat{q}_1 , \hat{q}_2)$ as defined by

$$(12) \qquad -\frac{u_1'(\hat{q}_1)}{u_2'(\hat{q}_2)} = -\frac{f_1'[f_1^{-1}(\hat{q}_1)]}{f_2'[f_2^{-1}(\hat{q}_2)]}$$

$$(13) \qquad f_1^{-1}(\hat{q}_1) + f_2^{-1}(\hat{q}_2) = L .$$

In Figure 3 the point C represents a competitive equilibrium, while P represents the social optimum. The indifference curve J_P corresponds to maximum utility, taking full account of all social opportunity costs. At P, the indifference curve I_p corresponds to the set of substitutions perceived by the individual as he views the free-access natural resource. At any point in the commodity space, I will have a greater algebraic slope than J, since $g' < 0$, $h' < 0$, $u_3' < 0$, $u_4' < 0$ implies

$$\frac{-u_1'}{u_2'} > -\frac{u_1'}{u_2' + nu_3' - \frac{nh'u_4'}{\delta - g'}} .$$

In a free market q_1 would exchange for q_2 at the rate $-f_1'/f_2' < -u_1'/u_2'$ at P, and each consumer would substitute q_1 for q_2 -- in the myopic belief that his position would be improved -- until the point C was reached. But at C everyone is worse off than at P.

Optimal Control and the Cost of Administration

Society's choice between P and C in Figure 3, or between stocks Q* and Q† in Figure 2, would be simple if there were no costs associated with achieving the control solution. Everyone would benefit from, and would favor, intervention to impose the allocation represented by P in Figure 3.

But suppose there is a cost to administering this locally efficient allocation. This cost may arise from the need to compute and charge the resource price $\mu^*(t)$ and the congestion charge[4], or to compute and enforce an optimal quota $q_3^*(t)$ for rationing access to the natural resource. In particular, suppose the administrative machinery requires the fixed expenditure of L_a units of the productive input, leaving $L - L_a$ available for direct productive allocation. This will shift the resource stock equilibrium set to the right, say to $\{(Q,u) \mid \dot{Q} = 0\}_a$, as indicated by the broken curve in Figure 2. An equilibrium path will now pass through the intersection at Q^a, the stationary state equilibrium optimal stock, taking into account administrative cost. In Figure 3, the effect of administrative cost is to lower the production possibility frontier from S to S_a, and the optimal stationary state solution is at A. This *may* occur, as illustrated in Figure 3, at a utility level J_a below J_c. Hence the competitive free access solution might be superior to the control solution net of administrative cost. In this interpretation L_a represents cost in excess of any similar cost, such as transactions cost, required to support or maintain free markets.

Rationing by Costly Access or Non-Development

National Park (Forest, Monument) administrators are not normally confronted with a simple choice between optimal controlled access versus free competitive access to a scenic or wilderness resource. Decisions usually take the form of how to permit development or which access technologies are to be permitted. Typically there is the question of whether or not roads to a scenic area are to be paved, or whether trails in a wilderness area are to be closed to motorized traffic. Such decisions can by stylized in our model by asking if it pays society to invest in an easier-access technology. Should a road be built across the Escalante River to Lake Powell permitting automobile access to a hitherto isolated scenic area accessible only by backpacking or horseback? Should jeep trails be closed to all motorized traffic in the Uncompahgre National Forest? Should the use of outboard motors be prohibited on Colorado River excursions through Cataract Canyon or Grand Canyon? These are typical policy decisions facing public lands administrators.

Phrasing the question in this way rather than as a problem concerned only with controlling access is particularly appropriate since the need for limiting access is frequently a consequence of an earlier decision to develop a natural resource by making it more accessible. This raises the question of whether a costly form of primitive access, or non-development in general, is not preferable to overlaying administrative controls upon investment in an easier-access technology as a means of undoing with the left hand that which the right hand has already done.

Suppose that by incurring a fixed input cost equal to L_2^o units per period, the production technology $q_2 = \max [0, F_2(L_2 - L_2^o)]$ can be substituted for the technology $q_2 = f_2(L_2)$, where $F_2(0) = 0$, $F_2' > 0$, $F_2'' \leq 0$ and $f_2(L_2) < F_2(L_2 - L_2^o)$ beyond some level of L_2 (see Figure 4). In terms of production possibilities society can increase its opportunity set over some region by producing less q_1 and investing the input savings in a substitute means of producing q_2. In Figure 5 the frontier of this substitute set is represented by S'.

A possible effect of the investment of L_2^o units of input, or the foregone output, $f_1(L) - f_1(L - L_2^o)$ units of q_1, in developing the natural resource is illustrated in Figure 5. Initially the free access equilibrium is at C. Then society invests in a motorized technology yielding the frontier S'. The resulting sacrifice of q_1 output permits an enlarged set of q_2 consumption opportunities, and society moves to the new stationary state C'. If at C the utility net of external effects is represented by an indifference curve J_c passing to the northeast (southwest) of C' as shown, then society is unambiguously worse (better) off as a result of the development expenditure.[5] Note, however, that at C each consumer perceives that an increase in production possibilities from S to S' will permit him to improve his position by moving to indifference curves above I_c. Myopic consumers may thus press for a change in public land policy that will permit the technological change, but the consequent crowding and deterioration in resource quality may lead to disappointing long-run levels of satisfaction. Such a process seems to portray actual experience in many instances of recreational land development.

After the movement from C to C′, if the public authorities are pressured to intervene and set up the administrative bureaucracy to ration access, this will lower the production possibility set and society ends up at a point such as O_a' which might represent a still lower level of satisfaction even though the point is allocatively efficient. If such be the case it would be preferable, if somewhat paradoxical, to ration access by imposing higher cost access technology, S, and letting competition restore society to the state represented by C.

Footnotes

* I am grateful to the National Science Foundation for research support.

[1]It should be noted that $\sum_{k=1}^{n} q_2^k$ and Q may enter the utility function of consumer m as externality variables with nonzero marginal effects even if $q_2^m = 0$. The Sierra Club member who never climbs Mt. McKinley may derive satisfaction from the knowledge that the largest North American mountain is relatively unspoiled, with few climbers littering its slopes. (He should, of course, also be willing to pay for these satisfactions.)

[2]Alternatively, one could think of u as a welfare function depending on the per capita consumption rates (q_1, q_2), and wilderness quality, Q. In either case, as in most of the growth economics literature, we dodge the whole set of complications introduced by conflicting subjective evaluations of the arguments of u .

[3]Additivity is neither very realistic nor strictly necessary to the analysis, but it very much simplifies the arithmetic by permitting us to deduce that the phase curves of Figure 2 are monotone. Alternatively we could postulate the more general utility function in the text, and then postulate monotonicity for the more general equilibrium state equations corresponding to (8) and (9) and illustrated in Figure 2.

[4] If consumers are required to pay a visitor-use charge, θ_2 per day or other unit of use, then from (6a) and (10) free market allocations will be optimal if $\theta_2 = -\frac{nu_3'}{u_1'} + \frac{nu_1 h'}{u_1'}$, where $-\frac{nu_3'}{u_1'} > 0$ is the congestion or crowding toll, and $\frac{nu_1 h'}{u_1'} > 0$ is the rental rate for the resource services provided by the stock, Q . In Figure 3, θ_2 is measured by the difference between the slopes of I_p and J_p , or between I_p and S , at P , so that for the consumer $\frac{u_2'}{u_1'} = \theta_2 + \frac{f_1'}{f_2'}$, yielding budget equilibrium at P.

[5] This judgment ignores the time path of utility between equilibria and is based entirely on the comparative statics of Figure 5.

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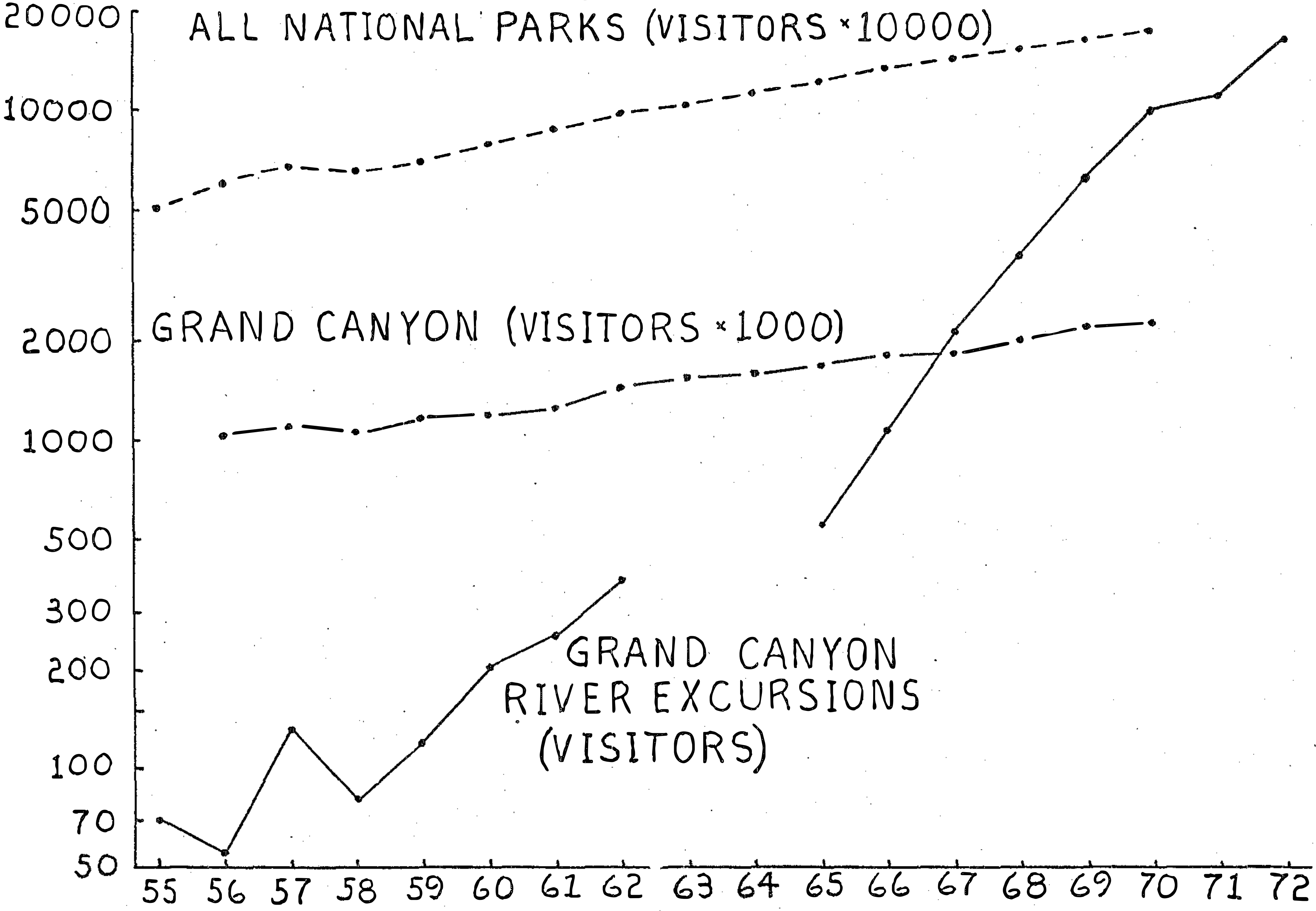
ALL NATIONAL PARKS (VISITORS × 10000)
GRAND CANYON (VISITORS × 1000)
GRAND CANYON RIVER EXCURSIONS (VISITORS)
20000
10000
5000
2000
1000
500
300
200
100
70
50
55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72

CHART 1

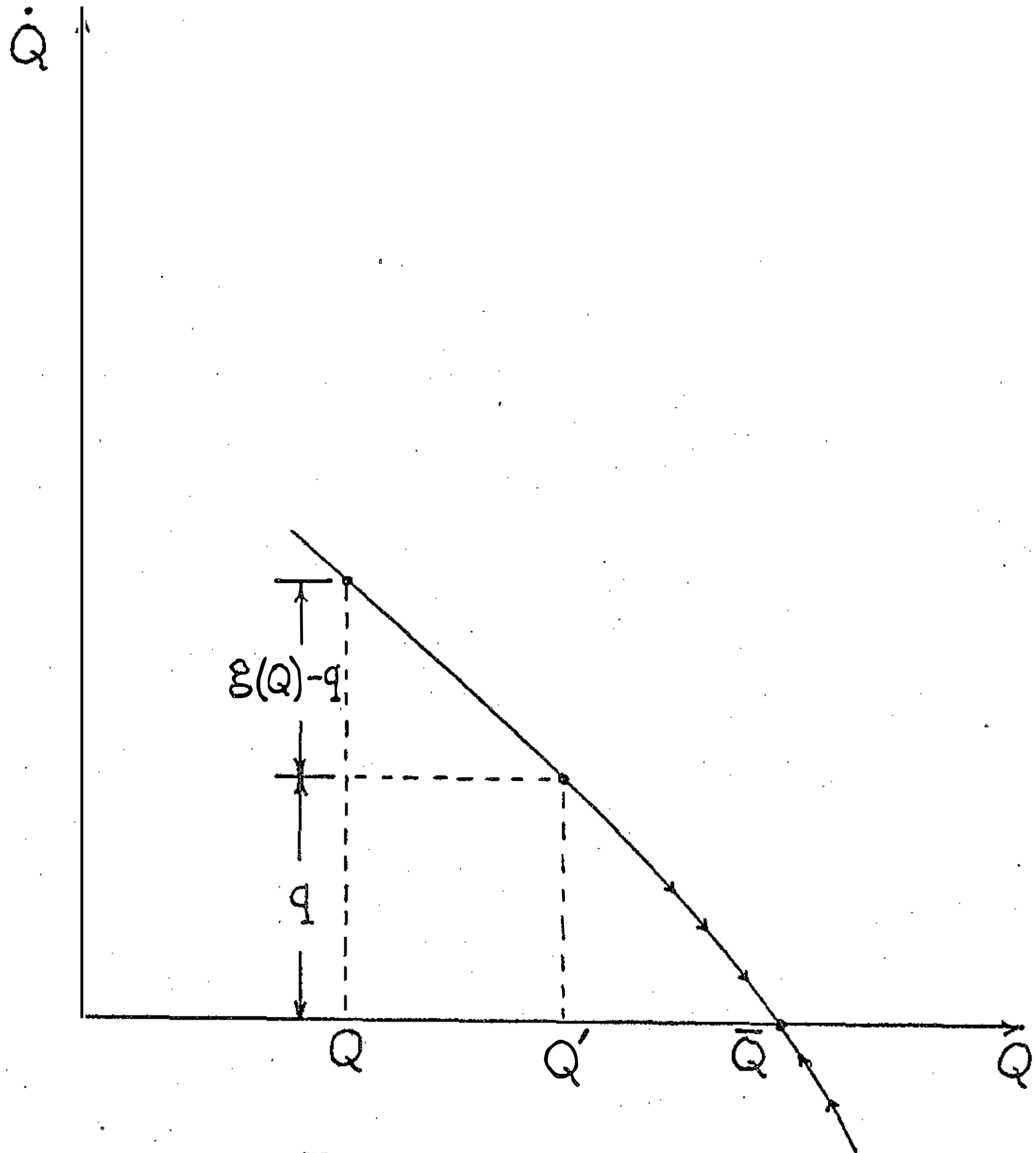

FIGURE 1

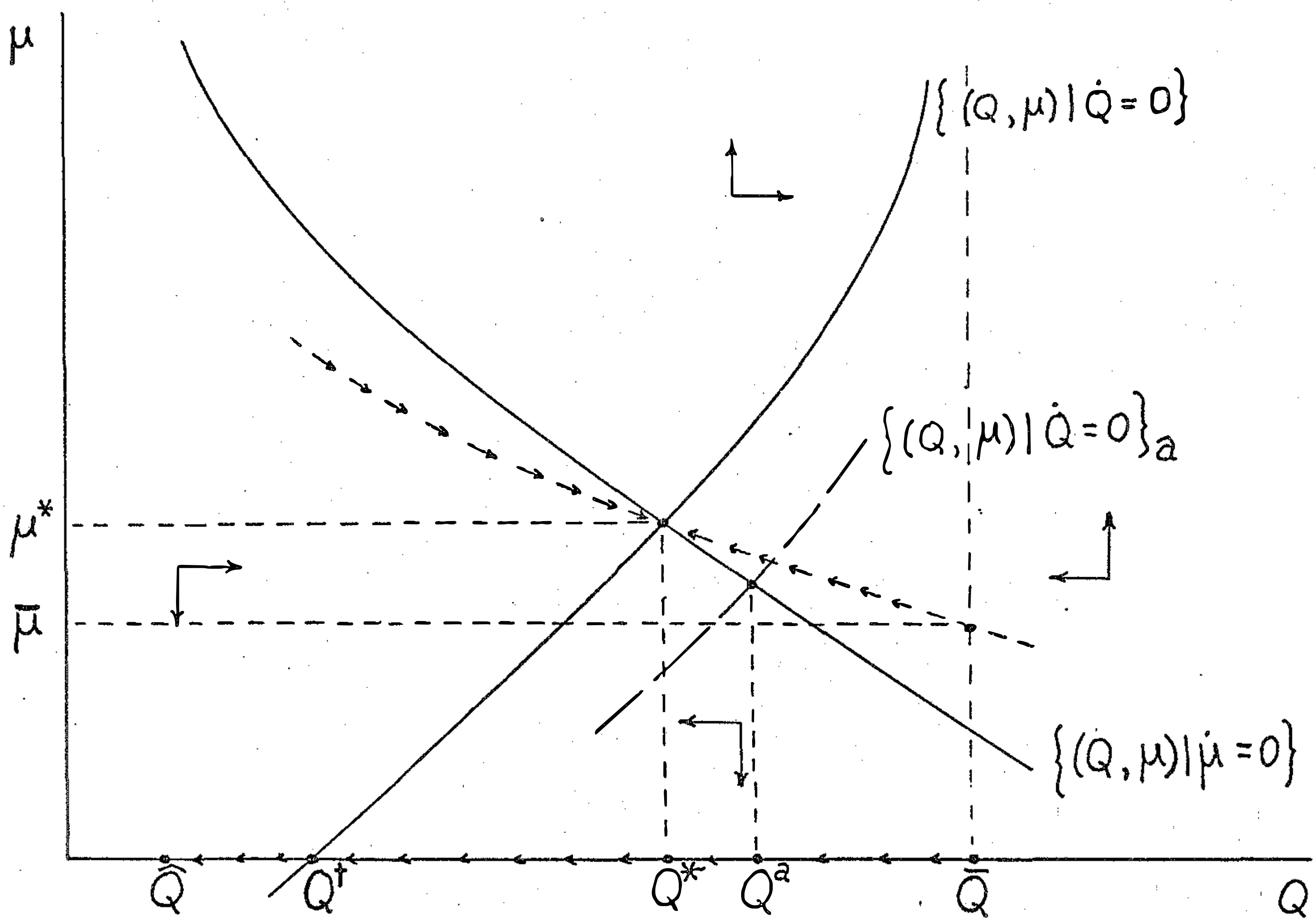

FIGURE 2

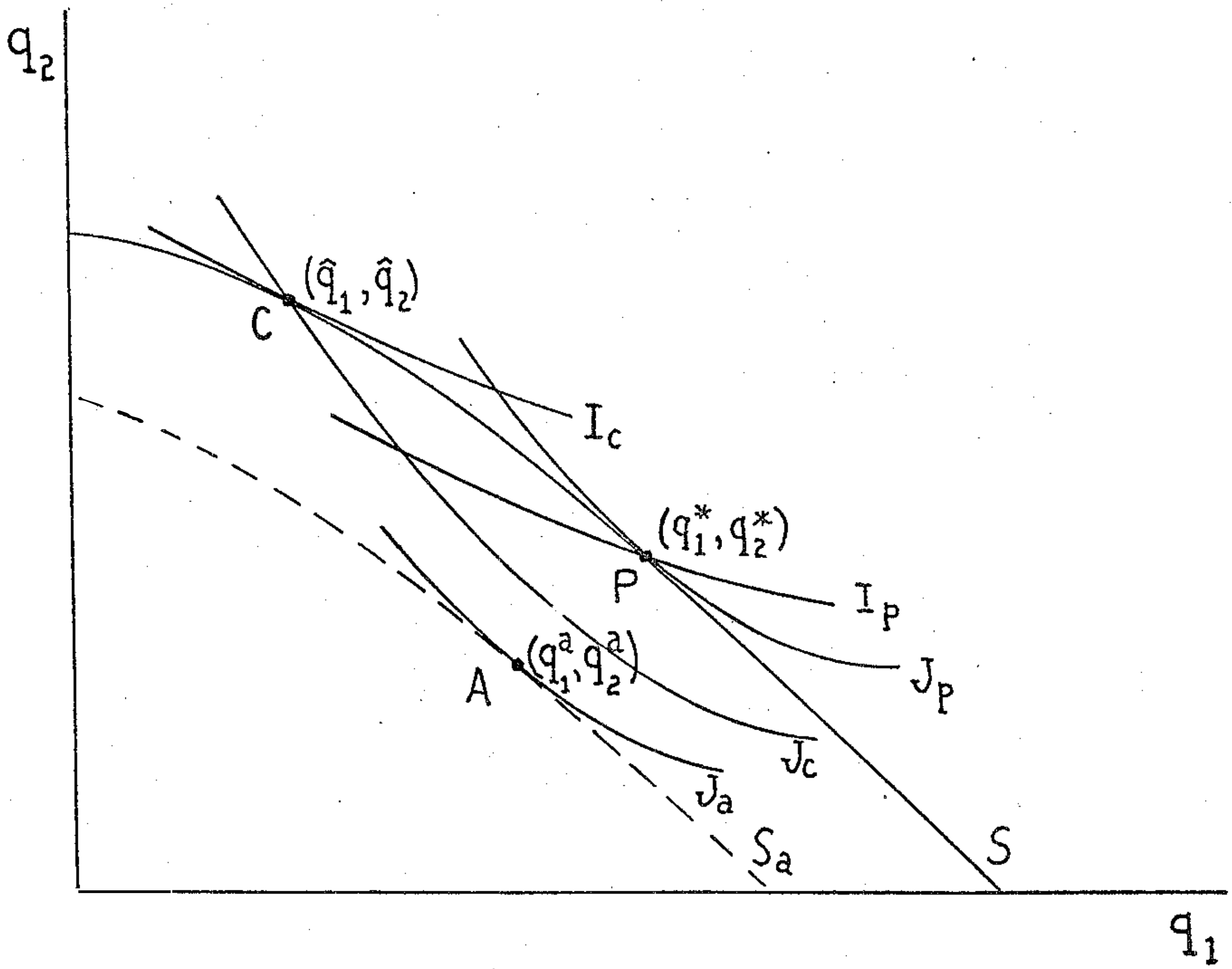

FIGURE 3

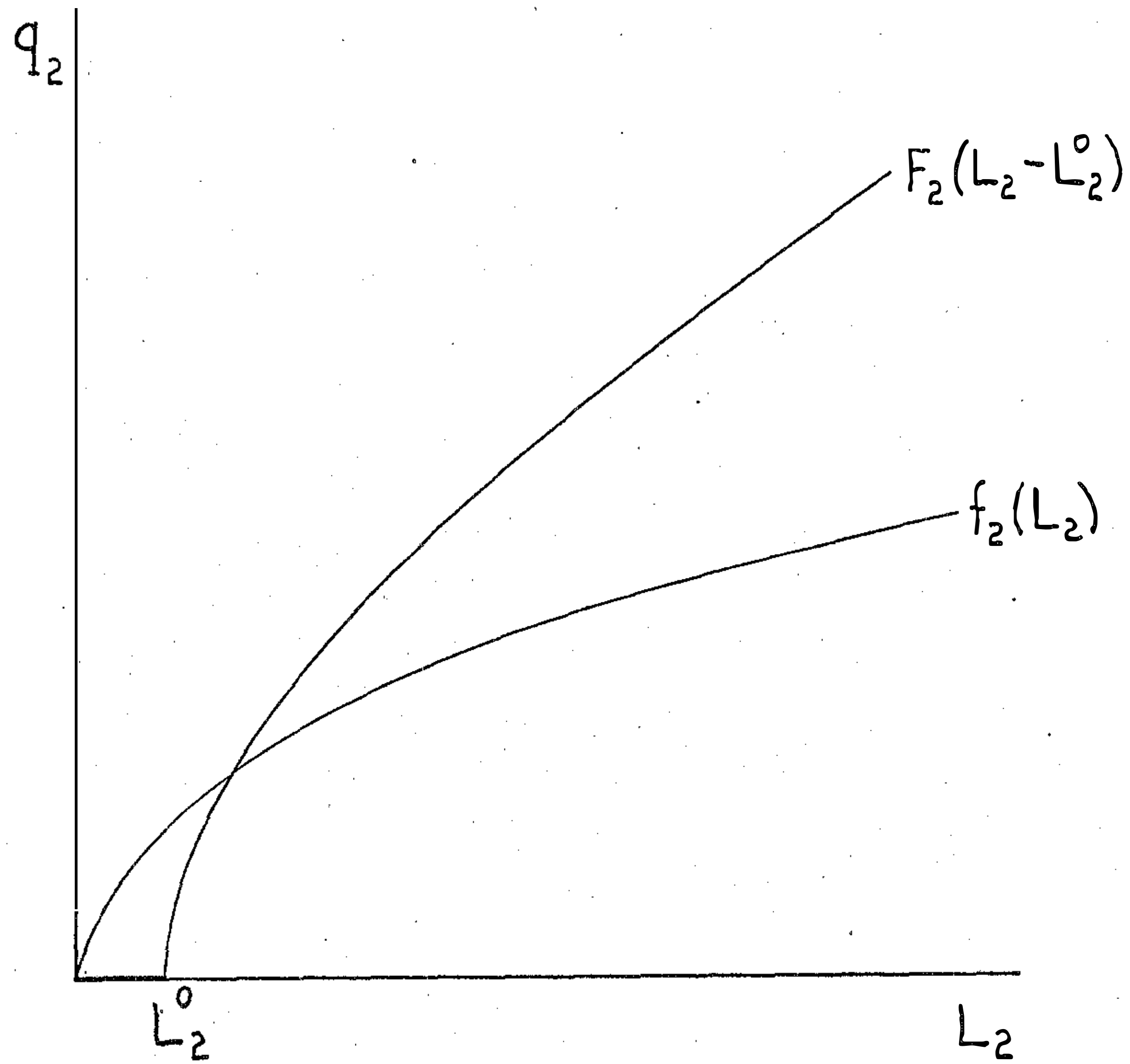

FIGURE 4

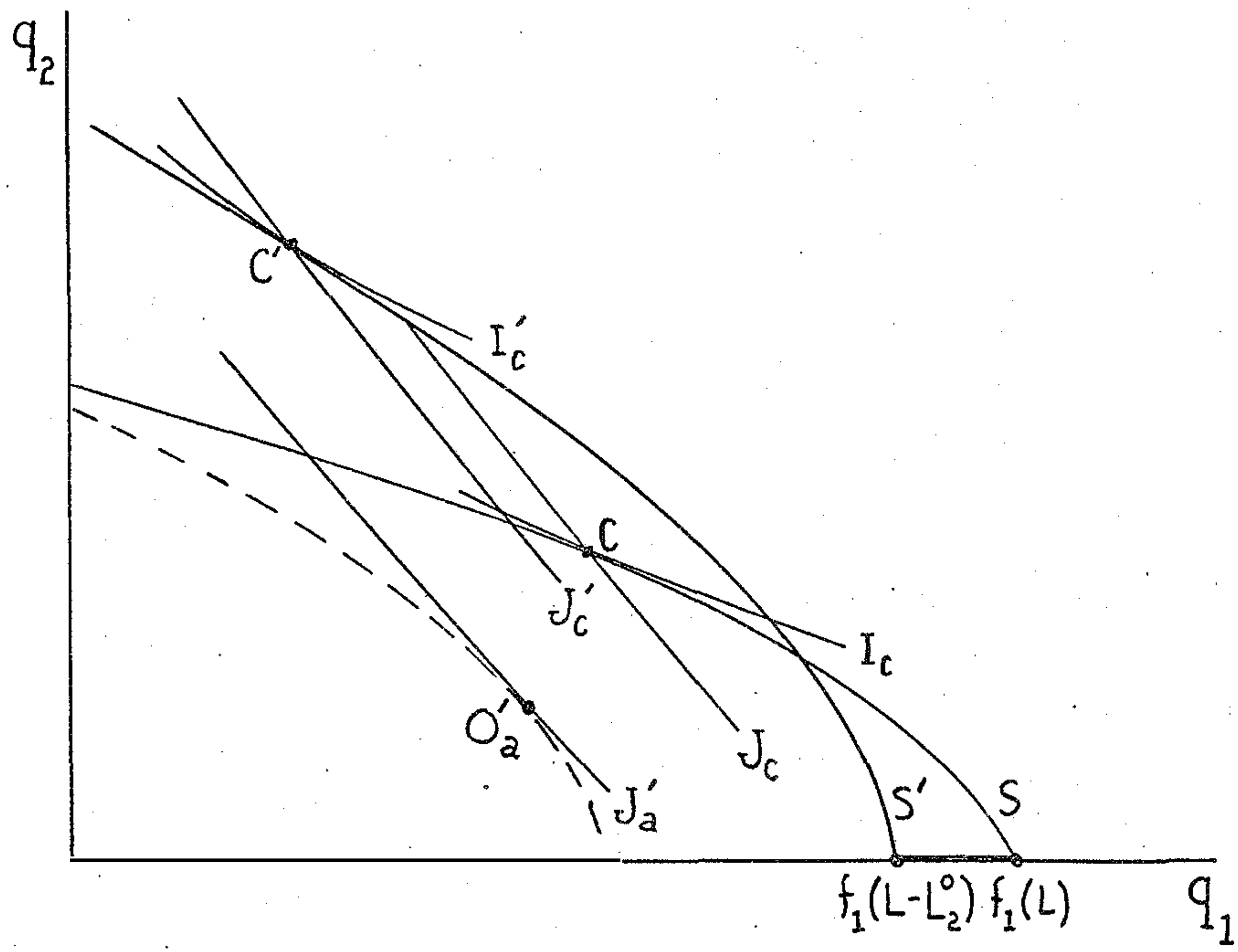

FIGURE 5