The Tragicomedy of the Commons: Why Communities Rationally Choose "Inefficient" Allocations of Shared Resources

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Abstract

Open access to a shared resource, or "commons," leads to usage beyond the efficient level. There are essentially two ways for a community to manage a commons to avoid overusage:

- Charge an entry fee that is sufficiently high to restrict usage to the efficient level
- Distribute an efficient number of entry rights entitling owners to use the commons

Either of these methods increases wealth. How will this wealth be distributed? If the first method is used, the community must decide how to distribute the revenue from the entry fee. If the second method is used, the community must decide how to distribute the entry rights. In this paper, I try to answer the following questions:

- When do some communities allow open-access to the commons and forego the wealth creation possible through restricting overusage?

- When communities choose to restrict usage through creating a system of entry rights, how are these entry rights distributed?

- Why do some communities forbid the resale of entry rights and forego the wealth creation from insuring that the users of the commons are those with the highest marginal product of usage?

I answer these questions by building a general model of the commons and examining the distributional consequences of restricted access. It is easy to regulate the commons in a way to make the community as a whole better off. It is surprisingly difficult to regulate the commons to make all or virtually all individual members of the community better off. I assume that because side-payments among individuals are costly and produce rent-seeking, community restrictions on entry are only likely to be adopted and sustained (either voluntarily, or through the political process) when significant numbers of users are better off or at least no worse off after entry is restricted. This assumption allows me to predict the factors that determine when the commons will be used efficiently, and when it will be used inefficiently. I test the predictions on a diverse set of historical examples.

I. Introduction

Open access to a shared resource, or "commons," leads to usage beyond the efficient level. There are essentially two ways for a community to manage a commons to avoid overusage:

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The next section presents a general model of the commons and compares equilibria with open access and restricted access. In section III I look at how difficult it is to assign users a proportion of the total access rights in a way that makes them better off than they were in the open-access equilibrium. In section IV I show the distributional effects of restricting resale of these access rights and why resale may be restricted even though it is inefficient. Section V summarizes the testable implications of the analysis and provides empirical evidence. Section VI seeks to explain why communities give users access rights rather than having a single owner or the government charging efficient. Additional discussion is found in the concluding section VII.

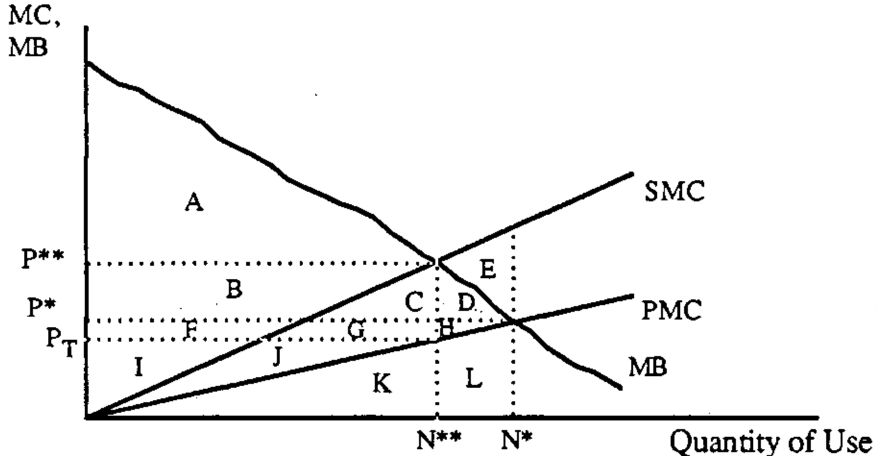
II. A General Model of the Commons

I define a "commons" as a resource shared by many users where a user of the commons imposes externalities on other users. Standard examples of commons include roads, fisheries, grazing areas, and water supplies. All of these examples have the same basic features: either additional users reduce the marginal product of using the resource by other users or additional users increase the marginal cost of other users. In the first case, private marginal product diverges from social marginal product. In the second case, private marginal cost diverges from social marginal cost. Both cases have the same welfare implications—free entry leads to overusage because individuals face average rather than marginal incentives.

In this section I present a general model of the commons where marginal cost diverges from social cost. I assume users impose costs on one another because of congestion. Examples include traffic on a road, power required to pump water from a shared well, and the time it takes to catch fish in a shared fishery. In addition, individual use also degrades the quality and potentially the existence of the commons. For graphical simplicity, I assume that the relationship between quantity and private cost which includes purely private resource costs, as well as the resource costs imposed by others, is a straight line out of the origin.

The Open-Access Equilibrium

In the open-access equilibrium, I assume users ignore the impact of their actions on others and only consider their own costs and benefits.[1] The free entry equilibrium is shown in figure 1:



PMC is private marginal cost as a function of quantity, and MB is private marginal benefit. In equilibrium, quantity is N*. The variable on the horizontal axis, quantity of use, is the characteristic of usage associated with the externality. In the case of the road it might be the number of trips made between two points on a given day. In the case of a common pasture, the characteristic might be the number of sheep grazing per season or day. Each user incurs cost of P* for each use of the commons.

In the open-access equilibrium, the total resource cost of using the resource is the rectangle P*xN* The value to society is the area under the demand curve up to N*. The net gain to society from the resource is A+B+C+D. The equilibrium is inefficient because of the divergence between private and social marginal cost. When marginal cost is linear as assumed, the social marginal cost is linear, but twice as steep, as shown. The value of the quantity

[1] This is a Nash equilibrium as long as users do not feel altruistic towards other users. This is analogous to the Nash equilibrium where individuals make voluntary contributions to a public good without being altruistic towards other contributors.

between N** and N* is D+H+L, while the total cost exceeds the total value by the deadweight loss of E.

Equilibrium When Entry Is Not Free

Society can be made better off by imposing an efficient entry fee, or toll, equal to the size of the externality at the place where SMC = MB, the vertical distance between PMC and MB at N**. The toll of t*, equal to $P^{**}-P_T$, shifts the PMC vertically by t*, and quantity falls to N**. The gain to society is the triangular area, E. This is the standard analysis of how a tax can eliminate a deadweight loss triangle caused by an externality. Holding constant the cost of establishing property rights, the larger the deadweight loss, the larger the gains from establishing property rights and the greater the probability property rights will be established.[2]

The elimination of a deadweight loss makes society better off. Since users suffer from the congestion, one might think that reducing the congestion makes them better off. In fact, all previous users are worse off. Before the toll, each user incurred a cost of P*. With the toll in place, the privately born cost has fallen to below P*, but when the toll is included, the total cost to each individual is higher, P**. The loss to users is B+C+D in figure 1.[3]

Weitzman (1974) also shows that turning a common resource into private property with entry fees reduces the utility of all participants relative to the utility level when there is open-access. His conclusion is that without refunds to users, users prefer the inefficient open-access equilibrium.[4] As might be expected, the revenue from the toll is large enough to compensate

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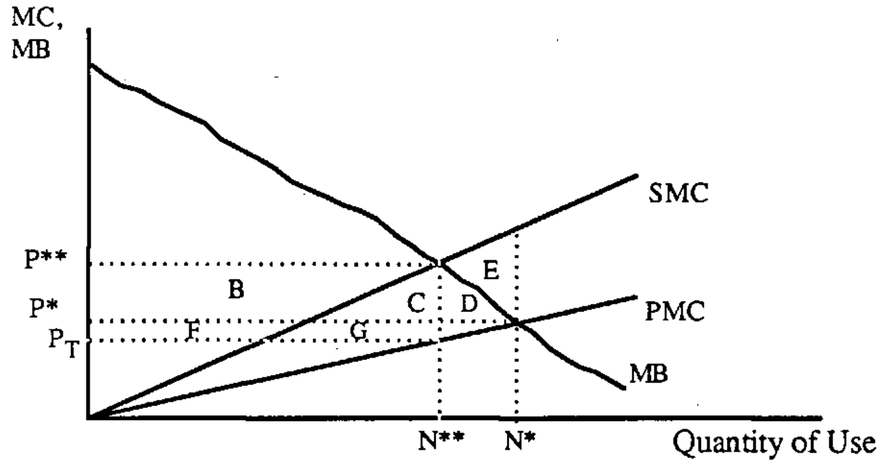
[2]See Demsetz (1972) for a discussion of how property rights evolve as a function of the costs and benefits of establishing them.

[3]This result runs counter to one's usual intuition about rationing via congestion. A price ceiling induces queuing. Eliminating a price ceiling improves welfare and lowers the full price paid by consumers; even though the money price has gone up, the time price has gone down sufficiently so that consumers are better off. It is tempting to apply the same logic here--the toll becomes positive but congestion decreases enough to make users better off. The logic is misapplied in the case of a toll because in the case of a price ceiling, the inefficiency is that quantity is too small, while in the case of the congested commons, the inefficiency is that quantity is too large. When the quantity is too large, the full price, inclusive of toll, must rise to reduce quantity.

[4] De Meza and Gould (1987) dispute Weitzman's pessimistic conclusion that efficient pricing always makes users worse off relative to the situation of free-entry. One example they provide is the case of a bottleneck in a road. It is possible in such a circumstance for the free-entry equilibrium to occur in a region where the supply curve is downward sloping. In this case, there is too little usage of the commons and the imposition of an efficient toll increases usage and makes all users better off. In the case of a bottleneck, all users unanimously prefer pricing even without a refund of the tolls. But such solutions are never seen, suggesting that such cases are the exception rather than the rule.

current users and ex-users for their losses and leave E left over to make them, or another group in society, better off. This is shown below in figure 2:



The toll revenue is equal to B+C+F+G. Because F+G is equal to E+D, toll revenue equals G+H+E+D.[5] Give B+C+D to the original users leaving them indifferent. This leaves E to make current users, ex-users, or other members of society better off.

An alternative method to imposing a toll and revenue refund to achieve efficiency is to give out N** coupons entitling the bearer to one use of the resource per period. Allow resale of coupons. The coupons will sell for t*. The full price of using the commons, inclusive of the opportunity cost of the coupon is again P**--the level of usage is N**, and those with the highest value of using the commons will use the coupons.

The toll/refund and the coupon scheme have identical distributional consequences. Individuals who do not receive tax revenue, or who receive no coupons, are unambiguously worse off by the increase in price from P* to P**. Receiving a proportion of the toll revenue has identical effects as receiving the same proportion of the total number of coupons.[6] Even

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[5] The increase in the total cost to society when quantity increases from N** to N* can be measured in two ways. The first way is the increase in the rectangle whose height is PMC. The height of this rectangle goes from P_T (the congestion cost, when the efficient toll is in place) to P*, while the width goes from N** to N*. The increase is I+J plus the rectangle whose height is P* and whose width is the difference between N** and N*. The alternative measure of the increase in cost is the area under the SMC curve. These two measures have the rectangle under P* between N** and N* in common, so I+J must equal D+E.

[6]Proof: Let n_i* be a user's quantity of use in the free-entry equilibrium. Let n_i** be the level of use when the price is P**. Let TV_i** be i's total valuation (area under the demand curve) given quantity n**. Then i's consumer surplus in the presence of the toll is given by TV_i**- t*n_i**- $P_T n_i$**, where as before, P_T is the private cost to the individual when total usage is N**. The refund for i is given by a_it*N**, where a_i is i's

though both methods seem identical, communities always choose the coupon method rather than the toll and revenue refund. Below in section VII try to explain why this is the case when the effects of the two methods seem identical. In the next section, I discuss problems of implementation with either method, but focus on the coupon method, because of its empirical dominance.

III. Will Users Prefer Restricting Access to Open-access?

As a group, users are better off restricting access to the commons as long as they receive a sufficiently large proportion of the revenue from the toll, or a sufficiently large proportion of the N^{**} coupons. But an increase in wealth need not make all users better off. Without side payments, users who are made worse off will oppose restricting access and.prefer the open-access equilibrium. There are an infinite number of possible distributions of the gains from restricting access. Each individual will wish to maximize his or her own individual share. An explicit prediction about whether access to the commons will be restricted and how the resulting gains are shared among users requires an explicit model of the decision-making process and relative power of different users.

I assume that if some individuals are made worse off by restricting access to the commons, sustaining that regulation via the political process or voluntary action is costly. The implication is that communities will sometimes impose restrictions resulting in a smaller increase in wealth when a larger increase is possible, if the smaller increase raises welfare of all members and the larger increase actually harms some members. Such a result requires the additional assumption that side payments are costly or difficult to administer. The effective cost of making side payments may be high if making of side payments induces entry into the group of potential

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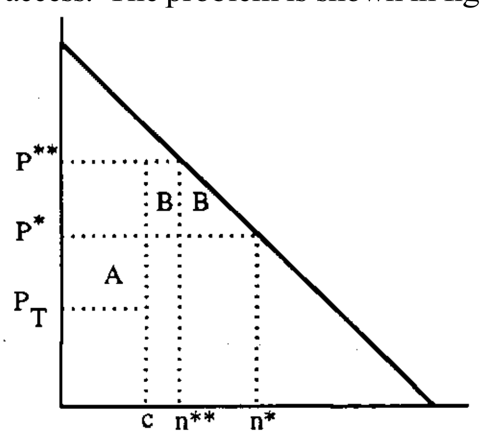
proportion of total revenue, t^*N^{**}. So i's utility from the commons when there is a toll and refund is given by $TV_i^{**} - t^*n_i^{**} + a_i t^* N^{**} - P_T n_i^{**}$. Under the coupon solution, the price of a coupon is t^* so i's quantity is again, n_i^{**}. His total value from using the commons is also the same, TV_i^{**}. What will it cost i to use the commons? He gets a fraction a_i of the N^{**} coupons being distributed. He must purchase the difference between n_i^{**} (his demand for usage of the commons when the price is t^*) and his endowment, and he must pay t^* for each of the coupons he purchases. Total expenditure on coupons is then: $t^*(n_i^{**} - a_i N^{**})$. So total utility from the commons under the coupon scheme is given by $TV_i^{**} - t^*(n_i^{**} - a_i N^{**}) - P_T n_i^{**}$. This is identical to the utility from the toll/refund solution.

recipients, essentially a form of rent-seeking. The rest of this section explores the difficulties of distributing coupons in order to insure all users prefer restricted access to the open-access equilibrium.

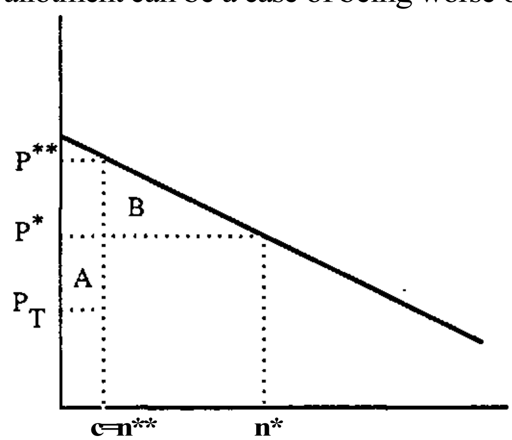
To insure users are made better off, the community of users in the open-access equilibrium must receive the revenue from the tolls or the coupons in the case where users are assigned access rights. This seems obvious, but it may not be easy to determine the users in the open-access equilibrium. Non-users have an incentive to look like users in order to acquire revenue or coupons. Furthermore, after many periods of pricing the commons at P**, there may be individuals without rights to a refund or a coupon who would wish to use the commons if there were free entry. These individuals will favor a return to open-access. So allocating coupons or revenue from the toll requires being able to restrict entry by non-users in determining property rights or that such entry is so costly that it is not profitable.

Even if it is possible to control entry into the population of recipients of the revenue or the coupons, there is an additional problem when usage is non-uniform. Imposing the toll or restricting usage through coupons takes consumer surplus away from the users. An individual's loss is his share of the aggregate loss B+C+D in figure 2~found by integrating along individual demand curves between the prices P* and P**. Users who lose the most consumer surplus when price rises from P* to P** must get a larger share of the coupons else they will be worse off than they were in the open-access equilibrium and will oppose restricting access. The problem is shown in figure 3 below:



The figure shows an individual's demand curve. In the open-access equilibrium, price was P* and usage was n*. The individual is given c coupons. Costs bom by each individual fall to Pj because total usage has fallen to N * * . The equilibrium price of a coupon is P**-Px, established in the market, equal to t*. At the full opportunity cost of P**, this individual's demand for usage is n**, so he will purchase n**-c coupons on the open market. Is the individual better off or worse off than in the open-access equilibrium? On usage between 0 and c, the price has fallen from P* to Pj, an increase in consumer surplus of A. He loses the areas shown as B—a rectangle due to an increase in price on the units between c and n**, and a triangle of lost consumer surplus for the units no longer enjoyed between n** and n*. He is better off as long as A exceeds B. In the figure above, I tried to choose c so as to leave the individual indifferent: A and B are very close in area.

The assignment of coupons and the elasticity of demand determines whether one is a net seller or buyer of property rights. Unfortunately, being content with one's'assignment is not sufficient to guarantee that one is made better off relative to the open-access equilibrium. Figure 4 below shows how if demand is sufficiently elastic, being content with one's coupon allotment can be a case of being worse off relative to the open-access equilibrium:



This individual is given exactly the number of coupon he demands when the full price of usage is P**, yet he is worse off—area B exceeds area A.

The last two diagrams highlight how the variance in elasticity across users affects the success of any property rights solution tied to the level of usage in the open-access equilibrium.

In both cases, the diagrams were drawn with the same level of usage in the open-access equilibrium. But the user in figure 4 loses much less consumer surplus when price rises from P* to P** than the user in figure 3. To insure that both users are better off, the user with the large elasticity must receive a larger share of the coupons. If there were two groups of users, those with large elasticities and those with low, but with equal usage in the open-access equilibrium, an equal division of the coupons is likely to make the users with the low elasticities worse off.

One solution is to assign the coupons in proportion to n_i*, an individual's usage in the open-access equilibrium. As the above diagrams suggest, this only guarantees making individuals better off if demand elasticities are fairly similar. If demand elasticities are similar, then n_i* will be highly correlated with lost consumer surplus, and giving out coupons in proportion to n_i* will make most users better off. But there are two additional problems with using n_i* as the basis for handing out property rights.

The first is that if users anticipate that n_i* will determine property right allotment, then individuals will invest in high usage in the period when n_i* is being monitored in order to receive coupons in the future. In the 1970s, when Canadian fishing authorities asked commercial fisherman to apply for licenses, fisherman rationally anticipated that the goal was to discover how many fisherman there were and to use the population of current fisherman as a way of curtailing entry in the future. Copes (1983), cited in Ostrom (1989) says that the number of registered fisherman rose from 15,531 in 1974 to 35,080 in 1980, when he estimated that only 21,297 were actually fishing. This is not a problem if entry is not possible or if it is costly for the pool of users in the open-access equilibrium to increase their own usage to look like large users.

Even if these problems can be avoided, there is a more serious problem with using n* if the commons is to be regulated for more than one period. What happens as time passes and individual fortunes change? An individual or a family which had a small stake in the open-access equilibrium initially, may turn out to have a large stake later on. Such a family will desire a return to the open-access equilibrium.

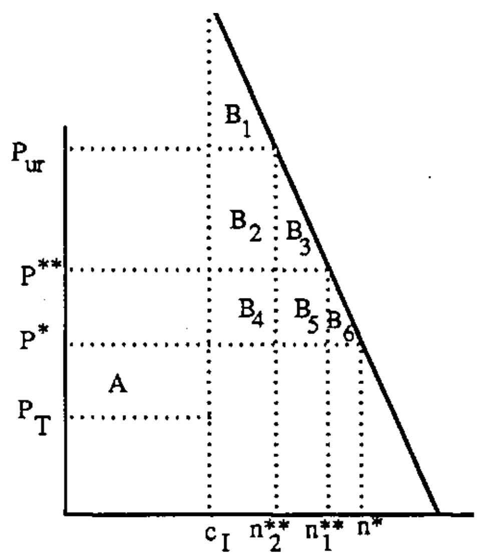
An alternative solution is to link property rights to an observable characteristic other than n* that is positively correlated with current lost consumer surplus as well as future lost consumer surplus. This characteristic cannot be cheaply imitated or acquired by non-users or the benefits to the users in the open-access equilibrium are again diluted. In the case of a commonly held pasture, the characteristic might be land ownership. If land ownership is correlated with consumer surplus, then the solution can make users better off and can endure over time. As long as the variance in elasticity is sufficiently small, the characteristic should be correlated with either n* or n**.

Using land ownership or some other characteristic correlated with demand helps guarantee the stability of the coupon solution for avoiding overusage. If large demanders are given a small proportion of property rights they will prefer a return to a world of open-access. To avoid costly periodic renegotiation, it is important to give out rights in proportion to demand both now and in the future. If there is a characteristic correlated with demand, such a characteristic is ideal for guaranteeing the stability of the solution to avoid overusage.

IV. Restricting Resale of Coupons

Restrictions on resale are inefficient from the perspective of society as a whole. But they may be in the interests of the individual users in the open-access equilibrium. The restriction on resale keeps the price of the property right in the commons lower than it would otherwise be. In the toll/refund solution, this low price leads to overusage. In the coupon solution, overusage is avoided when the price is low, because usage is already determined by the number of coupons. While the low price does not lead to overusage, it does fail to perform the allocative effect of determining the most efficient users of the commons. The result is a capital loss to those who wish to sell their rights, a capital gain to those who purchase rights, and a general loss due to inefficiency.

Consider restricting resale to those endowed with coupons~the users in the open-access equilibrium. Not allowing sales to outsiders harms outsiders and those with an excess supply of rights. But this restriction also avoids a wealth-transfer on the infra-marginal sales within the community of users. If this wealth-transfer had taken place, it could be large enough to make purchasers of rights worse off relative to the open-access equilibrium. This would be true if land-holdings are imperfectly correlated with demand. Consider the situation in figure 5 below:



The figure shows the demand for usage by an individual who receives ci coupons. In the open-access equilibrium, price is P* and usage by this individual is n*. When coupons can be resold within the community, the price of a coupon is P**-PT. The level of usage by the individual shown is ni** at this price—he purchases n1** - cI coupons. His gain relative to the open-access equilibrium is area A on the units between o and cI, while he loses B4+B5+B6 on the units that have gotten more expensive or that he no longer consumes. I have chosen cj. to be a quantity of coupons that leaves him approximately indifferent—A is about equal to $B_4+B_5+B_6$.

But now suppose there is an additional demand from outside the community. This demand drives up the full price of the commons to Pur (for unrestricted resale) so coupons have increased in price to Pur minus PT. (Each individual's cost Pj, may also increase if the outside demand increases N**, but I ignore this to simplify the diagram. Allowing P_T to go up only reinforces the following argument.) At the higher price, usage falls to n_2**. The gain to the individual remains A. The loss is now B_2-B_6. He loses consumer surplus on the units between n_2** and n*. The individual is much worse off than he was before.

Numerous market forces work to allow unrestricted resale. Communities will try to make sure that coupon allotments are tied to lost consumer surplus. Individuals will try to institutionalize side payments to insure that losers from unrestricted resale are net beneficiaries relative to the open-access equilibrium. But if such measures are too costly, communities will outlaw resale to outsiders in order to preserve the support for restricting use of the commons.

The advantages to some users from restricting coupon resale provides another advantage to tying the distribution of coupons to land. Land can be resold even when rights cannot. An inefficient user of the commons who is endowed with a large allotment of access rights can sell his land to an outsider even if he cannot freely sell his rights directly to outsiders. This helps mitigate the loss of wealth to society from restricting the sale of access rights. This can also work to offset the benefits to users from restricting resale. Consider a pasture. An outsider who buys land may wish to buy coupons above and beyond the ones assigned to his land holdings. This will work to bid up the price of coupons as shown in figure 5. The empirical importance of this indirect effect on the price of coupons because land is sellable is a subject for future research.

A necessary condition for it to be rational to restrict resale is the imperfect assignment of access rights relative to lost consumer surplus. Whether communities can allot coupons on the basis of lost consumer surplus depends in a complex way on the elasticity of demand and the variance in the elasticity across users. But holding constant the difficulty of assigning property rights and the costs of establishing effective side payments, the analysis predicts:

> Allowing resale to outsiders is more likely the larger the gains from restricting the commons. The larger is the dead-weight loss in the open-access equilibrium, the larger the gain from restricting entry. As the gains from restricting entry get larger, the greater the leeway in tailoring coupon allotment to individual demand characteristics. So the more crucial it is to regulate the commons, the more likely such regulation will allow resale of rights to outsiders.

In the following section I identify examples of when resale rights are unlimited, when they are restricted to members of the community, and when they are completely circumscribed—no resale at all is permitted. It seems difficult to explain this latter case. Outlawing all resale causes the user in figure 5 to forfeit B1 in addition to B2-B6, seemingly making him even worse off than with unrestricted resale. Yet, as I show below, such restrictions can be rational if it is difficult to eliminate resale to outsiders. In the next section, I show this explicitly for water rights and hunting rights.

V. Testable Implications and Empirical Evidence

Communities gain wealth by restricting access to the commons. I have assumed that in order to generate voluntary or political support for restricting access, communities will structure property rights to insure all or most users of the commons are better off than they were relative to their situation in the open-access equilibrium. The implications of the analysis are as follows:

1. Restricting access is only possible if it is possible to observe the pool of users in the open-access equilibrium and restrict entry into the pool of the recipients of access rights.

2. Rights of access are not divided equally.

3. Rights of access are proportional to foregone consumer surplus due to restricting access.

4. Given sufficient conditions on the variance of elasticity of demand across users, rights of access are tied to characteristics such as usage level in the open-access equilibrium, or land ownership.

5. Resale of access rights may be restricted if the correlation between access rights and foregone consumer surplus is imperfect.

6. Holding constant the correlation between access rights and foregone consumer surplus, unrestricted resale is more likely, the larger the total gain from restricting access.

There are many commons situations where the users of the commons are easily identified and entry is easy to monitor. A medieval village in England or Switzerland has an open meadow for grazing. All of the inhabitants of the village know each other. A group of farmers in India share access to a supply of water. The farmers all know each other. Villagers in Sri Lanka fish the harbor. The village is small; all of the villagers know each other. The analysis predicts that these communities will reduce usage of the commons as long as they can distribute the benefits to make individual users better off. Communities will tolerate a degree of inefficiency in order to benefit each user. The following discussion applies the analysis to both successful and unsuccessful regulation of the commons.

SUCCESSES

I define a success where a community was able to restrict usage to a level below that of the open-access equilibrium avoiding the least-best solution of open-access.

Grazing

In many places throughout history, a community grazes its animals on common pastures. Examples include Japan, India, and the open-field systems in England and Switzerland throughout medieval times even extending to the present. There are many accounts of how usage was restricted. A typical restriction: an owner was not allowed to graze his animals on the common pasture unless he would be able to feed the animal in the coming winter. In the Swiss village of Torbel, in 1517, for example, a regulation said that "no citizen could send more cows to the alp than he could feed during winter.... (Netting (1976, p. 139 quoted in Ostrom (1989, p. 46)." As Picht (1988) points out, this rule ties property rights to the hay-making capacity of the peasant. The analysis here predicts that hay-making capacity is a good proxy for demand.

While this "wintering" condition could reduce grazing from the open-access equilibrium, there is no reason to believe it reduces it to the efficient level. Picht (1988) cites Froedin (1941) that if the meadow could not support the cows that could be wintered, the property right was reduced to a fraction of the number of animals that could be wintered. Other measures used by different villages include a direct measure of haying capacity (measured every 5 or ten years) or the area of owned land. (Picht, 1988, p. 11.)

Dahlman (1980), in his discussion of the open-field system in England reports: "First, in order to prevent the farmers from overgrazing the commons, it would be necessary for the village council to limit the number of animals that each farmer could be allowed to put but on the common grazing area. Usually, the simplest rule was adhered to whereby there was a direct proportional relationship between the number of animals any one tenant could put out in the village herd and the share of the arable land belonging to him." (Dahlman (1980), p. 132. See also McCloskey (1975) p. 85.)

Ault's study of English village by-laws is the most explicit discussion of the restrictions on animal grazing. To protect the harvest, animals were completely restricted from being in the fields on various dates. The number of sheep were restricted as a function of land-holdings. The earliest surviving record is from 1426 in the village of Newton Longville—land-holders were allowed to have 100 sheep per virgate of land (about 30 acres according to Ault, p. 123). In 1509, the village restricted the number to 30 (Ault, p. 137.) Restrictions became common in the sixteenth century. Between one and two sheep per acre of arable land were allowed. Excessive holdings were confiscated by the lord of the manor. Land-owners without sheep could sell their rights to neighbors, but not to "foreners." (Ault, p. 48.)

Slater (1907) discusses how N * * and associated property rights were determined on the commons of the English villages of Laxton and Eakring. In Laxton, sheep grazing on the common land of the village is "stinted," that is, restricted. "Before the stint was agreed to, every commoner had the right of turning out as many sheep as he could feed in winter, the result being that the common was overstocked, and the sheep nearly starved. The stint regulates the number of sheep each commoner may graze upon the common according to the number he can feed on his other land in the parish. It was not adopted without opposition on the part of those whose privileges it restricted. (Slater (1907, pp. 9-10))."

In Eakring, a decision was made as to how many sheep to allow on the commons, then an auction was held to determine the price of allowing one sheep onto the commons. The auction ended when the number of sheep wanting to be grazed at that price equalled the number already decided on by the village—the market cleared. Slater explicitly mentions (p. 13) that "toft-holders," those villagers holding land that entitled the owner to communal rights, who did not plan on grazing any sheep, were thrilled to see outsiders show up to bid in the auction because of the effect on the value of the toft holding. The revenue was divided among the toft-holders. Such rights were immutably tied to the land—if a house were torn down or the land resold, the land-owner retained the rights, guaranteeing the stability of the efficient use of the commons as discussed above.[7]

Eakring allowed outsiders to purchase grazing rights while other villages such as Newton Longville and perhaps Laxton did not The analysis from section IV predicts that the gains from regulating the commons in Newton Longville were not as large as the gains in Eakring. While I do not have evidence on this issue, a similar prediction is found to be correct in the case of water supplies.

Water Supplies

It is likely that the demand for grazing rights is highly correlated with land ownership. Thus the analysis predicts that grazing rights in a community are proportional to land ownership to guarantee the stability of the efficient solution. The relationship between land ownership and the demand for water is also likely to be positive. In fact, the history of allocating property rights in water throughout history has been tied to proportionally to land ownership.

There are numerous cases throughout history where numerous users share access to a source of water, a commons situation prone to overusage. In Assyria, Ancient Rome, medieval Spain and in modem Southern California, users are given property rights in water tied either to land ownership or the level of usage before restrictions are in place. "Mediterranean peoples have consistently adopted certain principles reflecting the need for cooperation. These concepts are found not only in the Code of Hammurabi (Middle Assyrian Laws) but are also characteristic of the medieval Valencian system...The concept of

[7]It is not clear from Slater's account whether the revenue was divided equally or disproportionately according to land. In Laxton, a villagers might have multiple common rights from his farmhouse if it were on "toft" land, his arable holding, and cottages with toft status he might own and sub-let. Each category gave him one voting share and one piece of any revenue. But Laxton did not have an auction like Eakring.

proportional distribution: the cultivator receives water in proportion to the amount of land he works." (Glick p. 187.)

In ancient times, the law recognized the advantage of a stable rights system. Dobkins (1959) quotes an imperial decree from the Theodosian Code (Roman): "...ancient water rights that are established by long ownership remain the property of the several citizens...each man shall obtain the amount that he has received by ancient right and by custom leading to the present day." (Dobkins p. 53 citing Pharr's translation of the Theodosian Code 15.2.7, also found in the Justinian Code 11.43.4.)

In Medieval Spain, we know of regulations for canals going back to the 13th century. Some canals were administered through voluntary associations, while for others, the village or town would establish regulations. In both situations, money was raised for canal maintenance and the hiring of monitors to insure compliance with regulations. Water was allocated according to land ownership using physical structures to insure proportional use as the total quantity to be extracted rose and fell. As Glick describes it (pp. 207-8):

> Proportionality was the organizing factor of the water distributional systems of medieval Eastern Spain. Each irrigator received water in proportion to the land he held. The water to which he was entitled, moreover, was not a fixed amount per unit of land, but rather a proportional one which varied with the volume of the river. All irrigators shared in times of abundance and were equally deprived in time of drought...The proportional quotas for each carrier were expressed in an abstract measurement unit, usually the "thread" of water (fila in Castalan...). A fila thus represented one share of the total amount of water in a given river..., spring, or canal. The abstract unit fila was translated into reality of volumes of water by the dimensions of physical structures—diversion dams, irrigation canals, and divisors—which divided the water that flowed in any channel proportionally among the branches into which that channel divided. In situations during which water was so short that these physical structures could not at the same time preserve the principal of proportionality ***and*** deliver water efficiently, equality was preserved by the institution of a system of turns...whereby the irrigator, instead of drawing water at will, was obliged to irrigate in a specific order and could not irrigate again until his next turn.

Great care was taken to insure that the divisors were accurately constructed to insure a flow of water proportional to land holding. (Glick p. 88).[8]

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[8]The system did not work perfectly but it worked well. Fines for theft of water or taking water out of turn were infrequent. Glick presents data from 1443 and 1486 for the region of Castellon. Of the 910 infractions committed in the two years, 51.4% were for using water one was not entitled to--the rest of the violations are for flooding the fallow field of a neighbor, washing in the canal and so on. While the statuatory level of the

Some water systems allowed resale of water rights, while others did not. According to the analysis in section IV, in regions where water was more plentiful, the total gain to the society of restricting the commons is likely to be smaller, so it is more likely that resale may lead some individuals to be worse off if resale to outsiders is allowed. In general, in systems where water was particularly scarce, such as Alicante, Novelda, and Elche, water rights could be detached from the land and sold. In regions where water was relatively plentiful, such as Valencia and Castellon, water could not be resold.[9]

But how do we explain the seeming irrationality of Valencia and Castellon in allowing no resale at all? According to Maass and Anderson (1978), "...the sale of water or of the rights to water is anathema to Valencians, where water is married to land and cannot be divorced from it Spanish communities that allow divorce are both benighted and immoral in their view." (Maass and Anderson, p. 41.)

A policy of no resale would seem to have large efficiency costs without any of the distributional benefits discussed in section IV. Yet there is a rational explanation. Without resale of any kind, rights do not flow to those who value it the most The Valencians solve this problem by administrative fiat. In times of severe drought, water is no longer given out in proportion to land. Instead, "...preference is given to those priority crops that, based on inspection by canal officers, are in greatest need of water...The crops that traditionally have been given priority vary from community to community, but they include the crops of greatest economic value, meaning that the marginal returns to applying water to these crops and denying it to others are believed to be greater for the canal's service area than if the classes were reversed." (Maass and Anderson, p. 31.

fines was high, the typical actual fine was a penny or pennies, making it unlikely that the fines played the role of marginal cost pricing. Two-thirds of the individuals mentioned were charged only once in the course of a year. The low level of fines suggests the vigilance of the hired monitors who brought 2/3 of all the charges (rather than one irrigator against another) in the two years. These data are taken from Glick (1970) pp. 53-64.
9 For a discussion of the relative abundance of water in the two types of systems, see Glick (1970), p. 12, and Maass and Anderson (1978), p. 106.

But surely this system would function more efficiently if a market for rights were established as it is in other Spanish communities. Is the "immorality" of the market the only factor keeping the Valencians from these efficiencies? In addition, according to Maass and Anderson, the Valencians "fear market imperfections, especially that moneyed men who are not resident farmers could buy sufficient water to control its price and the destinies of irrigators." (Maass and Anderson, pp. 41-42.) So it is the effects of a market, rather than its "imperfections," that keep Valencians from pricing water. A remaining puzzle is why Valencians could not restrict sales to community members only. Perhaps it would be difficult to enforce such a restriction in Valencia, though it is not obvious why.

Ostrom (1989) also recounts how users of water in Southern California used the legal system to avoid the tragedy of the commons. In Southern California, much of the water is pumped from underground basins. It is possible to measure the efficient yield from a particular basin. In 1949, users of the West Basin were using 90,000 acre-feet annually when the efficient yield was only 63,000. They agreed to cut back usage proportionally from the levels at the time, the n_i^* of the discussion in section III, to hit the target level of 63,000.[10] The courts empowered a Water Association to regulate and monitor usage. New users had to purchase rights from the group with rights--the population of users in 1949.[11]

Water users throughout history have avoided the tragedy of the commons by restricting usage. The level of usage allowed depends either on the level acquired in the open-access equilibrium or on land ownership. Canals differ from basins in that downstream users of canals are in an asymmetric position to upstream users, unlike the situation in a basin, or the grazing or fishing case. In the open-access equilibrium for a canal, upstream users are better off than downstream users. Why aren't upstream users treated better in the regulated solution

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[10]As discussed above in section IV, the expectation that rights would be based on usage in the free-equilibrium was anticipated and did stimulate a "pumping race" described in Ostrom (1990). Such a race would have limited long-run dsitributional effects as long as users could all increase their pumping levels proportionally.

[11]Ostrom (1989) describes how the anticipation of a decision allocating property rights on the basis of current use levels induced a pumping race along the lines of the fishing license discussion given above. But as long as outsiders could be excluded and there are not large differences in users ability to accelerate pumping, the court solution makes all users better off.

as we might expect? Downstream users have the threat of violence, theft, and perhaps most importantly, the contribution of funds to maintain the canal. These factors insure that downstream users are treated equally with upstream users in the regulated solution.

Fisheries and "Hunteries"

The previous examples were cases where a group of individuals, well-known to each other for the most part, agreed to restrict group access to the commons in ways that seem calculated to make most if not all users prefer restriction to the open-access equilibrium. In such essentially voluntary arrangements, it is not surprising that a principle of near unanimity is relevant if side payments to compensate losers are difficult to structure. In the cases of fisheries and hunteries, voluntary agreements are difficult to police because of potential entrants, so users turn to the political process to impose regulations. Yet as I show, the principle of making sure that the users in the open-access equilibrium are better off after restriction still has force. It appears however, that because of technological differences betwen hunting and fishing, the distribution of the benefits across users is very different.

Hunting

Consider a state regulating deer-hunting. Allowing free-access to hunters will decimate the population. Public managers choose the number of deer to be killed in a particular year as a function of the current deer population. Let us assume that this number that is allowed to be killed is N^{**}. The state issues N^{**} permits, entitling the bearer to kill one deer. (In fact, they issue a multiple of N^{**}, because not every hunter will kill a deer. But I am told that the relationship between the number of permits issued and the number killed is fairly precise. So I will assume that every permit bearer kills a deer.)

Efficiency requires that the permits be used by those with the highest value. There are two ways this can be done, as discussed above. The state can set a price for the permits so that demand equals N^{**}, essentially an auction. Or the state can hand out the permits randomly, and allow resale. States choose neither method. Instead they set a price for the permits that is well below market clearing, then allow a lottery for the N^{**} permits, but without resale.

The analysis presented above explains why states do not use the auction method of allocating the permits. An auction would result in a price of t* for the permits, and hunters would be worse off unless the proceeds could be refunded to hunters. But why not use a lottery with resale? A lottery without resale seems to redistribute resources from low-income hunters to high-income hunters. It also seems to unambiguously harm hunters. If you have a low value of using the permit relative to others, it would seem that outlawing resale can only lower welfare.

Outlawing resale certainly redistributes hunting privileges from those with higher values of hunting to those with lower. But in fact, this inefficiency is necessary to preserve the gains of hunters as a group from the efficient restriction of hunting to N**. Suppose resale were allowed. Then non-hunters would enter the lottery for a chance to win a valuable asset—the right to kill a deer. Because hunters are a small fraction of the total population, they will get few of the permits and a hunter's expected outcome from this process is very close to having to pay t* for a permit. It is hard to imagine a way of restricting the gains from resale to deer-hunters or even hunters as a group. It is difficult to identify an attribute, such as land ownership in the previous cases, that is correlated with demand for hunting. You could require lottery participants to purchase a rifle, but non-hunters would purchase low-quality rifles to be eligible for the permits.

It is possible for all hunters to be made better off by a restriction on resale, even hunters with high valuations of hunting who do not win the lottery. This is possible if future hunting is a close enough substitute for current hunting. A hunter may lose the lottery today, but he will win in the future and pay a low price for the privilege of using the permit. Forbidding resale insures that the users in the open-access equilibrium benefit from the usage restriction of the commons. The efficient solution would be opposed by many hunters, perhaps nearly all of them, making it less likely to survive the political process.[12]

[12] In some states, even the sale of wild-game meat is outlawed. This restricts the demand for permits to recreational hunters rather than restauranteurs and the commercial hunters they would employ. This may be due to the political power of the recreational lobby, but the analysis here explains the source of this political power:

Fishing

No one owns the whales or the oceans, and so fisheries are prone to overfishing. According to Karpoff (1987), overfishing is avoided by having a fishing "season", as well as by various restrictions on capital-some forms of nets may be outlawed, or there may be a maximum size of boat. The public managers of the fishery adjust these regulations to insure that the total catch maintains the productivity of the fishery, perhaps N^{**}. As in the case of hunting, it is difficult to find a variable such as land ownership to proxy for potential lost consumer surplus when the commons is regulated. Instead capital restrictions such as limiting the size of boats or nets are typically used.

The capital restrictions of fisheries are equivalent to assigning access rights—dividing up the N^{**} fish among the pool of users. The individuals with the highest potential to be skilled fishermen will only become fishermen if the returns to their time and capital are sufficiently large. In the open-access equilibrium, fish are scarce, and the returns to scale are reduced. When fish are scarce, the returns to larger nets and bigger boats goes down. The individuals with the skills to run these larger enterprises go elsewhere. As a result, the efficient scale of boat and net in the open-access equilibrium is small, and the number of fishermen is large. For these individuals to receive the gains from a world of relatively plentiful fish, it is necessary to restrict capital size and reduce the ability of a smaller group of individuals to capture much of the rents in a world of N^{**} fish. This is the source of the political power of the low-skilled fishermen, that Karpoff (1987) argues is decisive for regulating the commons inefficiendy from the perspective of society as a whole.

In the lottery for hunting permits, all hunters may prefer a restriction on resale. But the fabulous hunter who would like to kill many animals within a given year is likely to prefer resale. This phenomenon is much more likely to occur in a fishery—a few superb commercial fishermen with large boats and nets could dominate the restricted season. What is perhaps

in the free-entry equilibrium, hunting for commercial purposes is unlikely to be very important. As a result, the regulated equilibrium provides little benefit to commercial interests.

surprising is that the political process prefers to help a large number of relatively inferior fishermen to helping a smaller number of intensely interested superior fishermen.

FAILURES

The most prominent example of commons where overusage persists is urban roads. The above analysis suggests why pricing urban roads never happens. Efficient pricing makes users worse off.[13] It is too costly to assign coupons or tax revenue in line with demand during the free-access period. Economists argue vigorously for congestion tolls while admitting that automobile users are likely to be made worse off. (See Walters (1961), Vickery (1969?), Small (1983) and others.) Walters (1961), for example, after arguing for congestion taxes concludes (p. 697), "Generally, urban car users will be injured by these arrangements...There could be some simple built-in compensation in the scheme by turning over the taxes collected in urban areas to the local authorities to spend as they think fit." Evidendy, such compensation schemes are not so simple—because users are a small part of society and difficult to identify, it is virtually impossible to design a refund which can compensate them for their losses.[14]

This problem can be avoided if users already contribute collectively to a fund producing a public good enjoyed by users. For example, rather than refund toll revenue to drivers, the money could be used to reduce other fees, say a registration fee, drivers are already paying. In the case of drivers on a particular road, this is unappealing because the reduction in the registration fee will be shared across all drivers, even those on uncongested roads. Even if the redistributive impact is not spread too thinly, the reduction in the registration fee will encourage people to become drivers. If the registration fees are small enough, the net effect is to pay people to register their cars, which again will destroy the effect of compensating the losers. This solution also requires that high demanders get a disproportional benefit from the provision

[13] If individuals have different values of time, and if there is a positive correlation between demand and value of time, the highest demanders may be better off after the toll/refund is in place. Their refund will be less than their toll payments, but their ume savings may be large enough to outweigh this effect.

[14] It is easy to identify who drive after the tolls are in place. The difficulty is identifying drivers in the free-entry equilibrium and the amount they drove.

of the public good aspect or that they have higher values of time sufficient to benefit from the toll/refund solution.

The reduction in registration fees might work in the United States if registration fees had to cover the real resource costs of road construction. Since these are heavily subsidized by jurisdictions other than those of the driver on the road, it is not surprising that the collective action preferred by drivers is to create new roads or to widen existing roads. Similarly, it is not surprising that fishermen oppose private ownership of whales or high license fees. It would be extremely difficult to redistribute the income in a way to compensate the losers from such a policy.

Ostrom (1989) describes a failure discussed in Alexander (1982) that illustrates the . importance of being able to control entry into the commons itself, and not just the pool of those claiming access rights. In a Sri Lankan village, fishermen spread their nets across the mouth of the harbor. Two nets can be deployed in the harbor at the same time. A national 1933 law limited nets to the level currendy existing which at the time was 32 nets; with a few exceptions, each net was owned by a single fisherman. By 1946,77 nets were deployed, seemingly well above the efficient level, according to Ostrom (1989, p. 149.) Each net had multiple owners. The fishermen of the village petitioned the national central government to limit usage to this level of 77 nets over the course of the year. This was granted. Each net worked each side of the harbor in sequence. So each net was used approximately 20 times in the course of a year. Between 1946 and 1964, entrants persuaded the central government to allow 7 new nets into the rotation, a small increase in supply compared to the previous time period. In 1964, a single new entrant from outside the village used his political pull to add 16 additional nets. The entry of 16 new nets benefited the new user and harmed existing users. This was only possible because the jurisdiction regulating usage was outside of the village and the group of users.[15]

[15] **Presumably, the villagers in with stakes in the pre-existing 84 nets could have raised sufficient money to bribe the central government not to allow the entry of 16 new nets. Evidently the free-rider problem was too severe.**

VI. Is the Toll/Refund Solution Really Identical to Giving Users the Property Rights?

I argued above that this solution is equivalent to charging an efficient entry fee and redistributing the revenue (or the proceeds of the sale to a monopolist) among the users with some users getting larger refunds than others.

Economists typically advocate selling the commons to a monopolist or having the government charge an efficient toll. What is striking about the historical record is that the toll-refund solution is NEVER USED.[16] I do not know of a single example of voluntary or political action where users of a commons turned the commons over to a private or public owner who then charged a toll to restrict usage. Instead, the users of the commons are endowed with property rights in the commons and sometimes, but not always, allowed resale of those rights. This suggests that the two methods though seemingly equivalent, are different in some way.

One difference is that the coupon solution does not require a forecast of the relationship between price and demand. A community may know the right number of sheep to graze, or how much water is available for usage. By using coupons, the community knows the usage level with certainty. An exception to this principle would be the case where the community knew the gap between private and social cost and could choose the efficient toll without knowing demand. But this latter case seems unlikely.

Another more important difference may lie in the cost of monitoring usage under the two systems. Consider a stylized version of the sheep auction in Eakring described above. In the open-access equilibrium, 1000 sheep graze per year. The efficient level is 500. Under the toll-refund solution, the village appoints a toll collector who will set a price per sheep such that

[16] **A typical textbook quote is found in Pindyck and Rubinfeld's (1989, p. 636) example of an overfished fishery: "There is a relatively simple solution to the common resource problem-let a single owner manage the resource. The owner will set a fee for use of the resource that is equal to the marginal cost of depleting the stock of fish." Evidently, such a solution is not even relatively simple.**

over the course of a year 500 sheep will graze. At the end of the year, the revenue is refunded to land owners in proportion to the amount of land they own.

The observed alternative solution is the auction where land-owners are endowed with coupons in proportion to their land-holdings. Under both systems, there has to be a method to keep people from using the commons without payment. Fencing is expensive. Monitoring may be done formally by someone hired to to so, or it may be done informally by villagers keeping their eyes open.[17] But monitoring is likely to be much easier under the auction system than under the toll/refund system. Under the auction system, the purchasers of coupons in the auction are observed by the villagers who have sold their rights. It is known who belongs on the commons and who does not It is therefore fairly easy to spot a cheater over the course of a year. But under the toll/refund system, someone must be hired to collect the tolls. Who will monitor the monitor?[18]

The coupon solution is also superior to the toll/refund solution when entry is a problem. In the case of hunting permits, a lottery without resale concentrates the benefits from restricting the commons among users. Even though such a solution is inefficient, it may be superior to allowing resale because of the threat of entry. There is no way to replicate this solution in the case of the toll/refund unless you can identify hunters ex ante. What is required is having an attribute tied to hunters but that cannot be imitated. The coupon solution does this by tying the property right to using it. Only individuals who enjoy hunting enter the lottery. You could tie the refund to being a hunter, but defining a hunter, as discussed above will be impossible to

[17] Ault (1972) provides two examples of this type of monitoring in the open-field system of agriculture. The lack of fences in the open-field system made it difficult to prevent theft. Evidently, most monitoring was done by land owners keeping their eyes open to prevent theft In one town, it was illegal to carry a hatchet at night So if you saw someone with a hatchet, you you didn't have to follow him around or detect theft in some other way. Another example was that day laborers were often paid in kind. Land owners were not allowed to pay day laborers in the field but had to pay them outside the field instead, say at the threshing hall. This way, if you saw a stranger carrying harvest from the field, you knew he was a thief. You didn't have to worry about whether he had been paid.

[18] Communities do use ingenious ways of monitoring the monitor. Ostrom (1989) tells the story of the canal divided into three areas. Each member of the community was given a strip in each section to insure community interest in having water get to the end of the canal. The individual hired to monitor compliance with restrictions on usage was given a piece of land farm at the very end of the canal. Thus the monitor's self-interest is also to assure water gets to the bottom of the canal.

define. The only possible alternative is to give the refund to individuals who successfully kill deer, but as before, this offsets the disincentive effect of the toll.

The advantages of the coupon solution are lost if demand for usage is difficult to anticipate and has large random components. Imagine implementing a coupon solution for daily trips on an urban highway. A regulator would have to know who are the current users of the highway and in what quantity. Any solution would be prone to manipulation by entry during the period where usage was being observed. Current users are likely to be harmed and will oppose intervention.

VII. Conclusion

Throughout time and place, groups able to restrict entry have solved the problem of the commons by choosing a level of usage less than the open-access equilibrium, and giving out the right to use the commons in a way that is proportional to the level of usage in the open-access equilibrium. Resale of these rights is allowed as long as the gains from resale can be concentrated among the initial users.

An efficient solution to the problem of the commons requires

1. Reducing quantity to N^{**}.
2. The quantity N^{**} is used by those who value it the most.
3. Minimizing the monitoring costs of the solution.

Satisfying these criteria produces rents. For the users of a commons to implement an efficient solution voluntarily, the rents must flow to the users such that most if not all of the users are made better off relative to the open-access equilibrium. A political agency with jurisdiction beyond the users of the commons may give these rents to members of society outside the commons, but such a solution will be opposed by the users of the commons, and the intensity of the opposition may be larger than the gains to the winners unless the group of winners is very concentrated.

I have tried to show how societies use property rights to satisfy the three criteria listed above and at the same time insure that each user in the open-access equilibrium is made better off. As long as the users of the commons in the open-access equilibrium can be identified, the commons can be used efficiently by giving the users in the open-access equilibrium property rights in the commons that are proportional to their lost consumer surplus from pricing entry. Making these property rights tradeable insures that users with the highest valuation will use the commons. If entry cannot be controlled, or if it is difficult to tie rights precisely to lost consumer surplus, users will be willing to sacrifice efficiency to insure that individual users in the open-access equilibrium benefit from the regulation of the commons. Investing users with property rights rather than turning the commons over to a single owner may also minimize monitoring costs.

This paper leaves numerous questions unanswered and numerous testable implications unexplored. Are the restrictions in common pastures tied to land because of the efficiency considerations discussed above or because of the political strength of land holders? What are the incentive effects of the allocation of entry rights for determining the efficient overall level of usage? Those with large stakes in the commons should favor expanding usage past N^{**} to maximize their personal gain. How efficient is the level chosen? Do restrictions on resale produce sufficiently large benefits to users to offset the losses from no giving rights to users with the highest valuations as in the case of hunteries? Does the analysis presented here apply to other empirical evidence on the commons? I hope to explore some of these questions in future work.

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