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COMMON PROPERTY, RESOURCE RENT AND UNCERTAINTY: WITH AN APPLICATION TO THE NEW ENGLAND GROUNDFISH FLEET

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ABSTRACT

This paper investigates the conditions for private resource equilibrium in an industry exploiting competitively a common property resource when private returns are uncertain. When firms display risk aversion it is argued that the compensation for risk bearing should be viewed as an appropriable resource rent. This rent is not fully dissipated when private resources have no incentive to either exit or enter as it would be when returns are certain. The magnitude of uncertainty in the New England groundfish fleet is investigated, and the level of rent appears to be consequential.

COMMON PROPERTY, RESOURCE RENT AND UNCERTAINTY: WITH AN APPLICATION TO THE NEW ENGLAND GROUNDFISH FLEET

More than a quarter century has passed since Gordon noted the tendency for private users of renewable, common property resources to exhaust or dissipate the rent which the resource is capable of producing. Rent, in this context, is the difference between what users would pay and what they must pay for the use of common property. Since users pay nothing for the use of common property, rent measures the value of the flow of services provided by the resource. Gordon's proposition implies that the common property resource is destined to a state of worthlessness despite its potential value. This implication offers a powerful rationale for management of the resource. It follows that the long run benefits of management may be found by measuring the potential managed rent, since, in the absence of management, long run rent would be fully dissipated. This is the comparison that Gates and Norton made when estimating the benefits of regulation in the yellowtail flounder fishery. If rent is not fully dissipated in the long run, this measure will overstate the benefits by the amount of long run rent. The presence of a positive, long run rent does not affect marginal management decisions; however, the total costs and benefits are relevant in the decision of whether to manage or not. This paper develops the proposition that, when private returns are uncertain, competitive exploitation of a fishery resource (an archetypical common property resource) does not lead to the full dissipation of rent.

Some Premises

The rent, which an item of common property is capable of producing, is fully dissipated when the value of output is just equal to the cost of the private resources used in conjunction with the common property. If one assumes that private resources will be added when revenue exceeds private costs, and will be withdrawn when the reverse is true, then it follows that the only prospect for a private resource equilibrium occurs when the values of output and private resources are identical, or in other words, when all rent is dissipated.

These entry assumptions are central to Neoclassical theory, but they may be generalized, and when uncertainty is present, they must be. A more general assumption is that private resources will flow into an industry when resource owners regard the flows as being privately advantageous. Resources will stop flowing into an industry when the marginal resources may be used to equal advantage elsewhere. Therefore, the owner of the marginal private resource is not willing to pay anything for the use of the common resource. Clearly, the users would not regard themselves as earning any resource rents.

The remainder of this paper is divided into three parts. In the first the optimal participation in an industry with uncertain returns is considered and in the second the entry decision is considered. It is, of course, possible to treat these simultaneously; however, it is useful to separate the marginal decision and the total decision. In the third section the nature of risk in the fishery is considered and the magnitude of rent in the New England otter trawl fleet is explored.

Optimal Participation in a Risky Fishery

The uncertainty of returns in the fishery is so great that institutions, rites and superstitions have evolved to aid in its control. Fishermen are commonly paid shares of the net revenues which has the effect of sharing the uncertainty between vessel owner and crew. Blessings of fleets are annual events in many harbors. While it is unfair to generalize, there are a number of commonly held superstitions.

Assume that a resource owner has decided to enter the fishery and must decide the level at which to participate. Let P(k) be capital inputs k's quasi-rent in the fishery. The resource owner has K units of capital at his disposal. Some fraction may be invested in the fishery and the remainder may be invested with a certain return of b$ per unit invested. The owner's income would be P(k) + b(K-k). To simplify the notation, let $P(k) - bk = \Pi(k)$ where Π is the amount by which quasi-rent exceeds the opportunity cost. In a certain world, a positive value of $\Pi(k)$ would imply the existence of a pure rent; however, the intrinsic uncertainty of the fishery demand that it be recognized that $\Pi(k)$ is stochastic. Therefore, let $\Pi(k)$ have the expectation $\overline{\Pi}(k)$ with variance σ^2. This variance may also depend on k.

If a positive entry decision is made, income is $\Pi(k) + bK$ which produces utility equal to $U[\Pi(k) + bK]$. The owner is presumed to be interested in selecting k* which maximizes the expectation of utility. Identifying E as the expectations operator, the decision problem may be presented as:

$$\text{MAX } (k) \; E[U(\Pi(k) + bK)]$$

$$\text{subject to } 0 \leq k \leq K$$

With knowledge of the functional forms of U and Π, including the probability density function of Π, this problem may be addressed directly. In the absence of this knowledge, a useful approach is to first expand U with a McLaurin's series about an arbitrary value of income, a, yielding:

$$1. \quad U[\Pi(k) + bK] = U(a) + U'(a)[\Pi(k) + bK - a] + 1/2\, U''(a)[\Pi(k) + bK - a]^2 \ldots$$

where the series is written in an abbreviated form. Since $E\Pi, = \overline{\Pi}$ and $E\Pi^2 - \overline{\Pi}^2 = \sigma^2$,

$$\begin{aligned} 2. \quad E[U(\Pi(k) + bK)] &= U(a) + U'(a)(\overline{\Pi} + bK - a) \\ &+ 1/2\, U''(a)(\overline{\Pi} + bK - a)^2 \\ &+ 1/2\, U''(a)\sigma^2 \ldots \\ &= U(\overline{\Pi} + bK) + 1/2\, U''(a)\sigma^2 \ldots \end{aligned}$$

As Loistl has pointed out these steps require that the functions be bounded. If an interior solution exists, a necessary condition for maximization is

$$3. \quad U' \overline{\Pi}_k + 1/2\, U'' \sigma_k^2 \ldots = 0$$

where the subscript k indicates the first derivative.

Alternatively,

$$4. \quad \overline{\Pi}_k = 1/2\, R\, \sigma_k^2 \ldots$$

where R is $-U''/U'$. R is known as the Pratt-Arrow measure of absolute risk aversion. When R is positive, the individual is said to be risk averse, since, when R is positive, an individual will not entertain a fair bet. For the case where σ_k^2 is positive, the marginal expected return on capital is greater than the riskless return. The difference is necessary to compensate for the additional risk with additional investment. When $\sigma_k^2 = 0$, the optimal level of participation for those who decide to participate is invariant with respect to tastes for risk. When σ_k^2 is less than zero, the marginal expected return on fishing capital is less than the riskless alternative rate. One implication of this case is that the risk averse would invest more than the risk neutral. The additional investment reduces risk and is a form of insurance. It is not uncommon to find vessels equipped with redundant gear. The important finding is that there is a level of participation which is privately optimal.

In this analysis, U" is treated as a constant since it is evaluated at the arbitrary value a. The solution appears to depend on this arbitrary value; however, this appearance is an illusion which stems from the nature of the approximation. It is reasonable to select a meaningful value for a, and the most logical value is the optimal value.

This section has presented a methodology for converting a difficult problem into a simpler problem; this methodology is used in the following section as well. Moreover, it has been shown that there is, in general, an optimal level of participation in a risky fishery when the decision to enter has been made. When $\sigma_k^2 = 0$, the optimal level is independent of the owner's tastes for risk; the separation of the entry/exit and participation decisions is most clear in this case.

The Entry/Exit Decision

When should one enter the fishery or when should one in the fishery exit? One should enter if one perceives it to be advantageous. The advantage is gauged by comparing the expected utility with optimal participation with the utility available outside the fishery. If the former is greater than the latter, one should enter. One is indifferent when

5. $E\,[U(\pi(k^*) + bK)] = U(bK)$

where k* satisfies 4. The long run equilibrium is characterized by 5 when

5 refers to the most risk averse fisherman or the least risk averse non-fisherman. The expected difference in utility may be expanded about an arbitrary a, and collecting terms will yield

$$6.\quad E\,[U'(a)\,\Pi + 1/2\,U''(a)\,(\Pi^2 + 2bK\Pi - 2a\Pi)]$$

or

$$7.\quad [U' + U''\,(1/2\,\overline{\Pi} + bK - a)]\,\overline{\Pi} + 1/2\,U''\,\sigma^2$$

Since this expression is of interest when it equals zero, we find that

$$8.\quad \overline{\Pi} = \frac{1/2\,R\,\sigma^2}{1 + R\,(a - 1/2\,\overline{\Pi} - bK)}$$

Since b, K and $\overline{\Pi}$ (k*) are known, it is only reasonable to set <u>a</u> equal to the average of the expected income levels, in which case

$$9.\quad \overline{\Pi} = 1/2\,R(a)\,\sigma^2$$

In the case where $\sigma_k^2 = 0$, all firms have the same k*, $\overline{\Pi}$. In equilibrium $\overline{\Pi}$ is $1/2\,R\,\sigma^2$ for all, where R is the risk aversion for the most risk averse fisherman who is in this sense the marginal fisherman. The expression $1/2\,R\,\sigma^2$ is the cost of risk bearing to the fisherman and the expected quasi-rent must at least cover it. The less risk averse earn an intra-marginal rent since the equilibrium $\overline{\Pi}$ exceeds their cost of risk bearing. This rent is earned by their tolerance for risk.

The intra-marginal rent to risk bearing is somewhat analogous to the rents which accrue to the better skippers and crews. When someone bears risk for someone else, as when one insures another, the former is providing a service to the latter. Fishermen bear risks that others would not, and thus they provide a service to the larger society. The expected rent they receive ($\overline{\Pi}$ in equilibrium) is simply the compensation for this service. The intra-marginal rent is earned by the ability of some to provide the service at lower cost than others.

This reasoning suggests that while in equilibrium expected quasi-rents are greater than zero, these are not resource rents. If a lump sum tax on participation were imposed, the equilibrium would change, and therefore it may be argued that the quasi-rent is not a pure resource rent. However, there is a flaw in this reasoning. Fishermen, as a group, provide a risk bearing service to the larger society to be sure, but this service is available more cheaply elsewhere. Arrow and Lind suggest that society should behave as if it has a risk neutral attitude. In the fisheries this means that society can at essentially no cost guarantee fishermen $\bar{\Pi}$, the expected quasi-rent, in which case society would bear the entire risk. The larger society divides this risk so many ways that it essentially disappears. When a gamble is divided two ways each participant bears only a quarter the income variance of a single participant. Fisher has pointed out that some risks are not divisible in this fashion, and there may be important applications of his theorem to fisheries, as for example when there is a risk of extinction of a species. In most cases the risks are divisible, however.

If society guarantees $\bar{\Pi}$ when a private equilibrium exists it may at the same time impose a lump sum tax of $\bar{\Pi}$ on each fishermen without altering the equilibrium. The guarantee makes the compensation for risk bearing superfluous. While $\bar{\Pi}$ may be viewed privately as a necessary compensation for risk bearing, it is legitimate for society to regard it as an appropriable rent. Since society offers no such guarantees and imposes no lump sum taxes, society is in effect imposing a risk tax and offering a lump sum subsidy in return.

An attempt to capture the rent would certainly run into the problem of "moral hazard," and thus it is perhaps not practical to attempt the capture of this rent. The presence of "moral hazard" does not alter the finding of rents in open access fisheries under conditions of uncertainty, rather it merely suggests that the imposition of a risk tax and subsidy is more practical than a guarantee and lump sum tax.

The Nature of Risk in the Fishery

Fishermen face many risks; vessels and crews are lost at sea, for example. Financial risks are also present and may be divided into those that are vessel specific and those that are industry specific. If industry catch is given, vessels would face uncertainty as to their respective shares of the catch. This is what is meant by a vessel specific risk and these risks average out when viewed at the fleet level. It should be immediately clear that guaranteed shares of a given total involves no social risk. One advantage of owning more than one vessel is that the combined returns are less risky than the individual returns when returns are subject to vessel risk. An industry specific risk would involve fixed shares of a stochastically varying industry catch. In order to guarantee each fisherman a fixed catch when industry landings are uncertain, society would have to shoulder some risk. In practice both sources of risk will be present. The variance of returns at the vessel level is a combination of the vessel and industry risks.

To estimate the vessel variance, data would have to be collected at the vessel level; aggregate or fleet data permit an estimation of the industry variance only. Since monthly observations of revenue for the

New England otter trawl fleet by vessel class for the period 1973-1978 were readily available, the industry variance was estimated. The fleet was divided into six size categories, and in each category the mean revenue was regressed upon a set of monthly dummies to remove any seasonality. The unexplained variance is estimated, and this is an estimate of industry variance. While there may be some factors which account for this unexplained variance, it appears legitimate to suggest that the estimated variance is an appropriate measure of an individual's perception of the riskiness of the industry. One problem that arose in the estimation is that the error terms are positively correlated. A first order correction for autocorrelation removed this problem, but added some complexity. If monthly disturbances are uncorrelated, the variance of annual revenues is simply the sum of the monthly variances; however, when the monthly disturbances are correlated computation of the variance of annual revenues is more complicated since many covariance terms are non-zero. For the largest category of vessels mean annual revenue was $404,505, and the standard error was $59,900 when the ramifications of autocorrelated errors were accounted for. The equation itself is not reported; eight of the eleven months were significantly different than the excluded month, R^2 was .169, and rho was .76. If the vessel's share of the catch is 40% of net revenue, the vessel owner's variance of returns from industry risk is $574,080,000. This figure would have to be multiplied by 1/2 R to gauge the equilibrium rent if this were the only source of risk. Clearly there are other sources of uncertainty as well. If the most risk averse fisherman had an R = .00001, expected rent would have to be $2,870 to keep him in the fishery. An R = .0001, would require that expected rent to be ten times as great. Someone with R = .0001 would be willing to pay $1,000 for a gamble with equal probability of paying nothing and paying approximately $2,111. Someone with R = .0001 would be willing to accept such a gamble if the gain from winning were approximately $2,010.

The partial estimate of the historical variance of returns indicate that with modest risk aversion substantial quantities of rent would have to be present in a state of economic equilibrium. It is possible that a fishery could exist in which the tax imposed by risk was nearly optimal. Likewise, it is possible to imagine that a fishery could exist in which an optimal policy would be one which had the effect of reducing risk. More likely, however, would be fisheries in which the optimal policy would supplement the taxes imposed by risk. In this context an optimal policy is that for which the marginal benefits just equal the marginal costs of the policy. Since the fixed costs of fishery regulation are large, in some of these cases the gains from optimal regulation would not justify the costs.

This paper hardly begins to deal with the consequences of risk in the fishery. The analysis has investigated the equilibrium conditions, yet has not considered whether equilibrium is a relevant concept when industry specific risk is present. Nevertheless, the analysis does indicate that the inclusion of risk in fishery models may profoundly effect policy recommendations. A management policy that seeks stability may accelerate over-capitalization for example. The major implication of this analysis is not that regulation offers no rewards but rather that there is no assurance that regulation will offer rewards. Moreover it is likely that the form optimal management takes is substantially different from that which is proposed in certainty models; however, the development of this notion will have to wait for another paper.

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