Comments on

M.L. Weitzman:

Landing Fees vs. Harvest Quotas with Uncertain Fish Stocks

Ragnar Arnason

This is a useful paper because it provides the fisheries economics profession with a reason to re-examine certain elements of the currently accepted fisheries management theory. As a result, this contribution may lead to a more solid theoretical foundation for fisheries management. This, of course, is the way any science is supposed to proceed. Theories should be forwarded, challenges made and examined and theories modified or abandoned as necessary. This paper is useful as a part of this process.

Having said this I should add that I don't think the paper, in spite of some interesting points and valuable insights, manages to undermine the current fisheries management theory in any significant way.

Correction of facts

The paper contains a number of statements concerning historical facts. Obviously, the accuracy of these statements is of some consequence. Therefore a few corrections are in order.

The paper asserts (p.2) that ITQs in Iceland were allocated to vessel owners free of charge on the basis of the historical catch record 1981-3. This is very imprecise. The allocation of ITQs for the various species in Iceland has been taking place since 1975 and the process is still going on. Several considerations in addition to historical catches have been used as allocation criteria. While it is true that in the demersal fisheries, which Weitzman probably has in mind, an important stage in the ITQ allocation process occurred in 1984 on the basis of the catch record 1981-3, the allocation and reallocation of ITQs for the same species continued on a very substantial scale until 1990 based on established catch record from 1984 onwards as well as other considerations. Finally, although it is formally true that the allocations as such have generally been free of charge, ITQ-rights have been subject to annual renewal charges that have been rising over time and are currently in excess of 1% of the fisheries gross revenues.

The paper says (p.2) that TACs in Iceland are set and, consequently, ITQs allocated for species found within the 200 mile zone. This is not accurate. TACs are set for a number of very important fisheries outside the 200 mile zone even in distant waters and ITQs allocated for these fisheries.

The paper somewhat mysteriously asserts (p.2) that "Iceland has over ten times more fisheries income per capita than the second largest such fishing-industry dominated nation in the world." This is far from the truth. Several nations have similar or higher fisheries income per capita than Iceland. Among such nations are the Falklands, Faroe Islands, Greenland, Namibia and a number of Pacific Island states. Many more have fisheries income per capita well in excess of 1/10 of Iceland's (where fisheries incidentally account for about 8% of the GDP).

These inaccuracies are, of course, of minor importance for the main message of the paper. Nevertheless, I suppose everyone agrees it is preferable to keep facts as straight as possible.

Weitzman's comments regarding the existing fisheries literature are somewhat more disconcerting. On page 4, he mentions that as far as he knows his model is the first to examine analytically the regulatory issue of instrument choice when there are severe informational constraints about the fisheries environment. There are actually many papers dealing with the issue. Several good references may be found in Smith et al. (1993). Pitcher et al. (1998) also contains a number of useful references. I have myself written a couple of articles dealing with this very issue (Arnason, 1990 and 1993).

Neither is it true, as the paper (in the introduction) seems to suggest that management of fisheries by means of taxes (or prices) has somehow been ignored or undersold in the literature. Indeed one of the first fisheries management suggestion was precisely to tax the fishery (Smith, 1968). This is

natural since the fisheries problem may be regarded as an externality problem and since the work of Pigou (1911), the standard economic response to externalities has been to impose the appropriate corrective taxes or subsidies. During the past three decades most writers discussing fisheries management have included taxes in their suite of fisheries management tools. Prominent examples are provided by such influential books as Clark (1976), Dasgupta and Heal (1979), Anderson (1986), Neher et al. (1989) and Hannesson (1993) as well as several of my own papers even the ones extolling the virtue of the ITQ system (e.g. Arnason 1990). So, contrary to what the paper seems to suggest, management by means of prices (or taxes) is by no means an ignored idea in the theory of fisheries management. What is new is Weitzman's assertion of "the generic superiority of landing fees over harvest quotas in the presence of stock uncertainty".

Finally, and most importantly because it has a bearing upon the relevance of the analysis in the paper, it is quite misleading to assert that the model used in this paper is the standard fisheries model. The model on which the analysis in this paper is based is a discrete time, linear model. This is merely a simple variant of the standard fisheries model which is a continuous time, nonlinear one. In addition, the model Weitzman bases his analysis on has certain worrisome peculiarities. For instance, in his model, profits will always be positive even in a completely open access and unmanaged fishery provided only that the fishery exists. This follows immediately from his equation (5) supplemented only with the very reasonable assumption that the fishermen stop fishing when marginal profits fall to zero.

The use of the simple models is justified if the simplifications do not generate the results. I very much doubt that this is the case here. In fact, I believe that Weitzman's main results are totally dependent upon the particular model he has chosen to use.

The Analysis

Let's now turn to the analysis itself. The fundamental ideas are quite simple. Within the confines of Weitzman's model, the control variable is the escapement, s. Weitzman proves that an optimal level of escapement, s^*, exists. At this level of escapement, marginal profits are $\pi(s^*)$. Therefore, the optimal tax rate is simply:

(1) $\theta = \pi(s^*)$

By comparison, the optimal quota, q^*, is given by:

(2) $q^* = R - s^*$,

where, using Weitzman's notation, R is the size of the fish stock at the beginning of each control period. A crucial feature of Weitzman's model is that R is stochastic. He refers to this as the ecological uncertainty.

Now Weitzman's argument is that s^* is nonstochastic (independent of ecological shocks) and constant (constancy is actually not important for his logic). Therefore, the tax rate, θ, is independent of ecological stochasticity and can be set without errors. Therefore, in principle, management by taxes can achieve optimality.

The quota management on the other hand (equation (2)) depends on the stock size at the beginning of the quota period, R, which is stochastic and, more importantly, unobservable. Therefore, the quota management is subject to errors and cannot on average achieve optimality. *Ergo*, management by taxes is superior.

All this is pretty clear and, I think, logically consistent. However, the result depends crucially on certain highly questionable assumptions.

Assumption 1. s^* is nonstochastic.

The first and most crucial assumption is that the optimal escapement, s^*, is non-stochastic. This is an assumption because this is not argued or even discussed, let alone proven, in the paper. In any case, this immediately seems peculiar because s^* is the fish stock at the end of the control period and the fish stock at the beginning of the period, R, is stochastic. How can it be that the optimal escapement, which is really just the target stock at certain time point, is independent of the stock size one time unit earlier? After all, every fisheries economist steeped in the tradition of dynamic analysis knows that next periods optimal stock normally depends on the current stock size. Thus, if, by some coincidence of nature, the current stock happens to be unusually great or small, the next period's (or next second's) target stock will have to be modified accordingly and is therefore just as stochastic. More precisely, as a general rule of optimal dynamics:

$s^*(R)$,

i.e. the optimal escapement depends on the current stock.

Weitzman manages to bypass this by implicitly assuming that the target stock is always the optimal

equilibrium stock, which, of course, is independent of the current stock. Within the structure of his model this is not as outrageous as it may seem. Remember, the model is linear in the control variable and in discrete time. Hence, if harvesting capacity is sufficiently high it would not only be possible but optimal to reduce the stock to the equilibrium escapement level in every period. Interestingly, even, if capacity were insufficient to bring the stock to the optimal escapement level within the period, Weitzman's tax rule would still be optimal. The crucial point, however, is that in a nonlinear model this would not be the case. In the nonlinear case, the optimal escapement every period would be a function of the stock size at the beginning of the period in accordance with the general rule of optimal dynamics. Hence, the linearity of Weitzman's model is fundamental to the tenability of his implicit assumption that s^* is nonstochastic. It is in this sense that I said his results depend crucially on the structure of his model.

However, linearity is not really sufficient for s^* to be nonstochastic. Within the framework of Weitzman's model the optimal equilibrium escapement level, s^*, would typically be defined by an expression like the following (Clark 1976):

$$F'(s^*)\cdot\frac{p-c(F(s^*))}{p-c(s^*)}=\frac{1}{\alpha}, \tag{3}$$

where $c(s^*)$ represents the first period's harvesting costs and $c(F(s^*))$ harvesting costs in subsequent periods.

But, according to Weitzman's equation (1), the biomass growth function depends in general on the stochastic errors, i.e.

$$F(s_{t-1}|\ \varepsilon_t),$$

where ε_t represents the stochastic parameter, the ecological uncertainty, revealed in period t. It immediately follows that the optimal equilibrium escapement level according to equation (3) or a similar kind of a function will generally depend on the same stochastic parameter as the recruitment itself.

Thus, it appears that even with a linear model and discrete time, Weitzman's assumption 1, is not tenable. s^* will in general be a function of the same stochastic process as R. So, the appropriate taxation depends on the same stochastic process as the optimal quota. Consequently, Weitzman's basic result does not really apply.

Assumption 2. The aggregate profit function $\pi(.)$ is known.

Weitzman's second implicit assumption is that the aggregate profit function $\pi(.)$ is known. This is very optimistic. Of course, no fisheries authority can ever know the industry's profit function. Not only is the required data necessary for such a knowledge immense, but usually the industry and its constituent firms regard their profit functions as a competitive secret and will not want to reveal it to the fisheries authority any more than to anyone else. It doesn't help in this respect that the information is going to be used for taxation purposes. o make matters even worse, it is highly unlikely that an aggregate industry profit function of the form presented by Weitzman even exists in which case the search for such a function is bound to be fruitless.

So, we can take it for granted that Weitzman's profit function $\pi(.)$ is not known and cannot be known. The crucial implication is that the taxation scheme he proposes can only be implemented with errors, errors whose influence is very much like a stochastic term.

This is pretty damaging, for it implies that far from being riskless the tax management is actually subject to stochastic measurement errors (this time of the function $\pi(.)$, just as the quota management. So, again the question of superiority cannot be answered in general terms.

Assumption 3. The fishing firms are identical

Weitzman's third implicit assumption is that all the fishing firms are of identical sizes. If they are not, the optimal tax would have to differ across firms. (Arnason 1990). Consequently, Weitzman's analysis in terms of a single taxation rate becomes inadequate. His fundamental result may, however, still apply.

Which management is really superior

On the basis of the above it appears that Weitzman's three implicit assumptions are not tenable. This implies that, just as the current stock, the optimal escapement and the profit function can only be known with errors. As a result, both the quota management and the taxation management will be subject to stochastic errors and a theorem of the type Weitzman proves is not available.

Under these circumstances, there are good reasons to expect that fisheries management with the help of quotas can do better than management by taxation. In fact, there are several arguments for this. However, the most fundamental one and one that fits

very well into Weitzman's framework of management under uncertainty is the following.

Under ITQ management, market prices of permanent share quotas will provide a measure of the appropriateness of the total quota (q is Weitzman's notation) set by the fisheries manager. More precisely, the higher the market price of permanent share quotas, the closer is the total quota to the optimal in the view of quota market players. Quota market players, on the other hand, while not infallible, are, for well known reasons, precisely the group of agents that will have the most accurate and up to date information about the fishery. This information is revealed to the rest of the world by their supply and demand for permanent share quotas in the quota market and encapsulated in the quota price.

So, acting on this revealed information, the quota authority can simply adjust the quotas until the quota market price is maximized. Although, due to the inherent uncertainty of the fishery, this will not be ex post optimal, it is (on the usual economic assumptions) the best total quota that is possible.

Even more interestingly, under an ITQ regime, the industry itself could set the total quota. There is no fundamental need at all for a fisheries manager under and ITQ system. This, of course, stems fundamentally from the property rights features of the ITQs.

The taxation regime proposed by Weitzman does not offer any such information revealing or self-management features. Hence, if only for this reason (and there are others) the quota management seems economically preferable as a general rule.

Conclusion

The whole set up of Weitzman's model seems rigged to produce the results he seeks. By choosing the appropriate model, by defining the required functional forms by specifying the necessary stochastic structure and by assuming the right knowledge by the fisheries authorities, he can obtain the result that a taxation management is at least as good as quota management.

This approach is reminiscent of O.Lange (1942) and A. Lerner's (1944) proof that a command economy could work just as well as the market economy, if only he prices were set correctly. The approach is, of course, is far from worthless. It defines certain conditions (hopefully the minimum necessary conditions) under which management by taxation will be superior to management by quotas. However, just as in the case of Lange and Lerner, the crucial question is how realistic are these conditions or assumptions. Above, I have argued that these assumptions are very restrictive, indeed. Hence, if I am right, the real thrust of Weitzman's paper is to provide further evidence for the superiority of fisheries management by quotas over fisheries management by taxes. For he has only been able to prove the reverse for a very restrictive type of a model, not really acceptable as an analytic description of any real fishery.

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