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A COMMENT ON KLIEVE-MACAULAY'S SOUTHERN BLUEFIN TUNA GAME

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Klieve and MacAulay (1993) (KM) analyse bargaining between the Australian and Japanese Southern Bluefin Tuna (SBT) industries using game theory. The KM model is a Nash equilibrium with symmetrical information, threat functions and a set of biological constraints. When we attempted to include the New Zealand SBT industry as a player in the KM model, we discovered important shortcomings in it. In this comment, we outline three major shortcomings in the KM model and propose an alternative model of a Nash equilibrium for the SBT industry.

Not a Nash Equilibrium

KM simulated a bionomic model over time under a range of arbitrary assumptions about harvest rates. The simulation resulted in profit streams for the Australian and Japanese SBT industries which, after scaling, became inputs into an equation from Intrilligator (1971) describing a Nash equilibrium. However, KM's simulation model does not include any process of optimisation and thus the outcome is not an economic equilibrium, Nash or otherwise. Rather, it is simply a calculation of the expected returns over time from a number of arbitrarily chosen joint Australian and Japanese fishing strategies. One of the requirements for a Nash equilibrium is that the preferred strategies cannot be dominated, preferably globally, but at least in the domain of the feasible negotiation set. Without an explicit optimisation process, this requirement is unlikely to have been met.

Arbitrary Threat Functions

Kennedy and Watkins (1985) recognised that (1) with Australians capturing younger tuna than the Japanese and (2) with biological interdependence between different SBT age classes, SBT management problems could be solved using game theory. That is, negotiations between the Australians and Japanese would have strategic elements which could be expressed as threat functions that reflected the potential damage that one party might do to the other.

Game theory was originally developed in the context of market share problems where extinction was not an issue. However, transferring these concepts to management of natural resources where extinction is possible is not straightforward. It is not clear whether a fishing industry would be willing to threaten extinction and whether such a threat, in the context of the SBT problem, would be credible given the 'green' political constraints on both sides. While there is evidence that industries may at times be indifferent to the possibility of specie extinction, governments have shown a great willingness to intervene in these situations. If threats did not involve extinction, then it is not clear what form they would take. This is an area that requires more research.

KM's choice of threat functions was arbitrary. They chose threat harvest rates that were, in their words, 'very heavy', without providing any theoretical basis for their choices. While KM's threat functions may have been based on sound scientific advice as to what constitutes 'very heavy' fishing levels, there is no reason to believe that they represent the actual threats that would be made in negotiations. It is quite possible that either extinction or some other level of fishing effort would be chosen. From the maximand below, Nash equilibria are sensitive to choice of threat function and thus KM's treatment is unsatisfactory.

Not a Steady State Equilibrium

The central issue in any fishery management problem is sustainability. In essence, the problem is to determine harvest rates that maximise fishing returns without violating a constraint on minimum parental biomass. Rather than constrain parental biomass, KM simply excluded any simulated strategies that resulted in parental biomass of less than 220 000 tonnes during the simulation period. This approach has a number of problems. First, there is no indication whether KM's preferred strategies are 'best possible'. The imposition of a sustainability constraint in an optimisation model could result in solutions which dominate their preferred strategies. Second, since the starting point for KM's simulations is the 'virgin fishery' stage, there is no guarantee that management of the fishery based on KM's simulations but applied to contemporary (or 'non-virgin') starting values would be sustainable. The latter problem would have been overcome with a sustainable equilibrium from a contemporary state of the fishery.

In the model below, we outline a Nash equilibrium for the SBT industry in a non-linear programming framework under KM's bionomic assumptions. The proposed framework deals with the problems of incorporating an explicit optimising component and a sustainability condition.

$$\max_{H} (\pi_J - T_J)(\pi_A - T_A)$$

subject to:

$$T_i = T_i(?)$$

$$\pi_i = \sum_{k=1}^{15} P_{ik} H_{ik} - k_{ik} F_{ik}$$

$$H_{ik} = XNOS_k\,[\frac{F_{ik}}{F_{ik} + M}][1 - \exp(- F_{ik} - M)]$$

$$XNOS_k = XNOS_{k-1}\exp(- M - F_{kJ} - F_{kA})$$

$$XNOS_1 = \frac{\alpha PBIOM}{1 + (\frac{PBIOM}{K})\beta}$$

$$PBIOM = \sum_{8}^{15} (XNOS_k\, WIT_k)$$

$$XNOS_k \geq S_k$$

K, α and § are coefficients and subscript k (k = 1 to 15) denotes tuna age class, and i ($i = A$ or J) denotes Australia or Japan. The other symbols are as in KM except S_k, the minimum levels for each age class needed to ensure a sustainable parental biomass. The threat functions, T_i, are not specified for the reasons outlined above. The model, as specified above, does not provide equilibrium values for the adjustment of the fishery following imposition of management. Rather, it provides long run equilibrium values for sustainable levels of harvest.

In conclusion, while the analysis undertaken by KM contributes to debate on approaches to fishery problems, it has serious shortcomings as an applied piece of research. We have shown that at least two of these shortcomings could have been rectified with relatively minor modifications to the model and have argued that the threat functions are more complicated than proposed in KM and require further research.

References

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