A Model of Fishing Conflicts in Foreign Fisheries

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A Brief History of Fisheries Exploitation

- Until the later half of this century most marine fisheries were accessible to DWFNs
- The Extended Fisheries Jurisdiction created 200 mile Exclusive Economic Zones (1982)
- Many of the world fisheries are now under the control of developing nations
- Some developing nations permit DWFNs to exploit their fisheries for a fishing fee

Example: Parties to the Nauru Agreement charge a 5% fishing fee (Campbell, 96)
Exploitation of Foreign Fisheries

- Without regulation dynamic externalities will lead firms to over-fish the stock *(Levhari & Mirman, 80)*
- Coastal nations may choose domestic exploitation, foreign exploitation, both or neither by splitting a Total Allowable Catch between fleets *(Charles, 86)*
- Coastal nations benefit from using a dual-tax system, but can not simultaneously maximize their revenue and net return from fishery *(Clarke and Munro, 87 & 91)*
- With domestic exploitation, coastal nations will use taxes to induce a common equilibrium *(Raissi, 01)*
Contributions to Literature

- Base model generalizes the interaction to \( n \) fishing firms (to see how changes in \( n \) affect behavior)
- Extension of model allows the fishery owner to select the number of firms that exploit the fishery
- **Objective 1:** Characterize the fishing fee and whether it is socially optimal *(use non-cooperative game theory to find the subgame perfect equilibrium)*
- **Objective 2:** Determine the number of firms that the fishery owner admits to the fishery and whether the arrangement is socially optimal
A Model with Exogenous Firms

(1) \[
\frac{dx}{dt} = \gamma x \left(1 - \frac{x}{K}\right) - \sum_{i=1}^{n} h_i \quad \text{(Logistic Growth Function)}
\]

(2) \[
h_i = qxe_i \quad \text{(CPUE Production Function)}
\]

(3) \[
\dot{x}(e) = K \left[1 - \frac{x}{\sum_{i} x_i}\right] \quad \text{(Biologically Steady Stock)}
\]

(4) \[
\text{Max} \prod_{e_i} \equiv (1 - r)p \times qx(e)e_i - ce \quad \text{(Steady-state Profit)}
\]

(5) \[
e_i(e_j) = \frac{1}{2} \left[\frac{(1 - r)b - c}{(1 - \hat{b})} \right] (n - 1) \hat{e} \quad \text{(Reaction Function)}
\]
Interaction Between Firms

Firm 1’s Effort

Firms

2’s Effort

$e_1(e_2, r^0)$

$e_1(e_2, r^1)$

$e_2(r^0)$

$e_2(r^1)$

$e_2(e_1, r^0)$

$e_2(e_1, r^1)$

$e_1(r^1)$

$e_1(r^0)$

Firm 1’s Effort
Bionomic Equilibrium

(6) \[ e_i(r) = \frac{\gamma}{(n+1)q} \left(1 - \frac{c}{(1-r)b}\right) \] (Equilibrium Effort)

(7) \[ r_{\text{MAX}} = (1 - c/b). \quad b = pqK \] (marginal benefit of effort)

If \( r \geq r_{\text{MAX}} \) then there will be no exploitation

- The total equilibrium effort, \( E(r) \), decreases in \( r \)
- The bionomic equilibrium stock increases in \( r \)
- Total bionomic harvest, \( H(r) \), is concave in \( r \)

(8) \[ H(r) = K\gamma \left( \frac{n}{n+1} \right) \left(1 - \frac{c}{(1-r)b}\right) \left[1 - \left(\frac{n}{n+1}\right) \left(1 - \frac{c}{(1-r)b}\right)\right] \]
Owner’s Objective: (9) $\operatorname{MAX}_r r pH(r)$

Proposition 1: There exist at least one fishing fee, $r^*$, that maximizes the owner’s revenue function.

$0 < r^* < r_{\text{MAX}}$

The socially optimal fee maximizes the net return from the fishery: (10) $\Pi(r) = pH(r) - cE(r)$

Proposition 2: If the concavity condition holds (and in most other cases), then $r^*$ is higher than the socially optimal fee.

Firms exert less effort than is socially optimal.
A Schaefer Representation

Net Return & Revenue

\[ \Pi(r) \]

\[ E(r^*) \quad E(r) \quad E(r_{MSY}) \quad E(0) \]

Effort as a Function of \( r \)
A Model with Endogenous Firms

- The Extended Fisheries Jurisdiction allows the fishery owner to choose the number of firms

The Effects of an Increase in the Number of Firms

- Each of the firm’s effort and profit will fall
- Total effort will increase reducing the stock’s size
- Total bionomic harvest will increase if $b/c < 2$.
  (If $b/c < 2$ then the owner will set $n = \infty$)
- **Owner’s Objective:** $(11) \ \text{Max} \ n, r = rpH(r, n)$
The Owner’s Revenue Function
Results of Extension

- The owner does not restrict access to the fishery
  The only feasible interior solution yields less revenue than free access for all values of the parameters
- The owner will set $r_{OA} = (b - c)/(b + c)$
  $r_{OA}$ Solves for the owner’s revenue under open access

$$
R(\infty, r) = rp \times K\gamma \left( 1 - \frac{c}{(1 - r)b} \right) \left( \frac{c}{(1 - r)b} \right)
$$

- The open access solution maximizes net return
  $E(\infty, r_{OA})$ is socially optimal
Welfare Implications

When the Number of Firms is Exogenous
- The coastal nation charges a fee that is too high
- If the number of firms is sufficiently small then nationalizing the fishery may reduce welfare

When the Number of Firms is Endogenous
- Owner does not restrict entry to the fishery
- The owner maximizes its revenue and net return
- Firms do not earn any profit
Why Owners Restrict Access

- To protect domestic fishing firms
- Out of environmental concerns (worries about spillover and production externalities)
- Out of political considerations (support one DWFN in exchange for aid or technology)
- Because monitoring cost increases as the number of firms increases
- Because they must charge a low fishing fee
- Owner may be able to extract the rent from the fishery using a two-tier tariff
The End

Questions?

Comments!

Suggestions?