Dynamic Efficiency Costs of Non-Efficiency Objectives in Tradable Permit Programs

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Funding for this research was provided by the Alaska Fisheries Science Center, National Marine Fisheries Service, California Sea Grant College Program Project, NOAA's National Sea Grant College Program, U.S. Dept. of Commerce

Tradable permit programs

- Policy instrument initially designed as a cost effective solution to common-pool resource problems
  - Applications include managing pollution (e.g. air and water), resource use (e.g. catch in fisheries), and production (e.g. dairy quotas)
- Designers of these programs are increasingly introducing restrictions on trading to address:
  - Social
  - Cultural
  - Secondary environmental issues
  - Other non-efficiency/non-economic goals
- Constraints or restrictions on permit trading can reduce economic gains

Research question

What are the economic costs of implementing restrictions in tradable permit programs?

- Specifically:
  - Compare impacts of different types of restrictions
  - Interactions between restrictions
- Use the Alaskan halibut and sablefish ITQ program to develop estimates of these costs

Alaskan halibut and sablefish ITQ program

- Implemented in 1995 to manage the two fisheries
- Limits on transferability
  1. Permits (quota) assigned to vessel sizes
     - Halibut: A (Unrestricted size and type), B (60ft catcher), C (35-60ft), and D (<35ft)
     - Sablefish: A (Unrestricted size and type), B (>60ft), and C (<60ft)
  2. Quota divisibility and accumulation limited by blocking restriction
     - Participants eligible for very small amounts of quota received their quota as blocks - a block of QS must be bought/sold together and participants are limited in the number of blocks they can hold
  3. Quota assigned to biological management areas
- Effectively creates submarkets

Sablefish TAC by restriction category

Vessel Class	*Unblocked*	*Blocked*	**TOTAL**
Unrestricted	20%	2%	**22%**
>60ft	35%	6%	**41%**
<60ft	29%	8%	**37%**
TOTAL	**84%**	**16%**	**100%**

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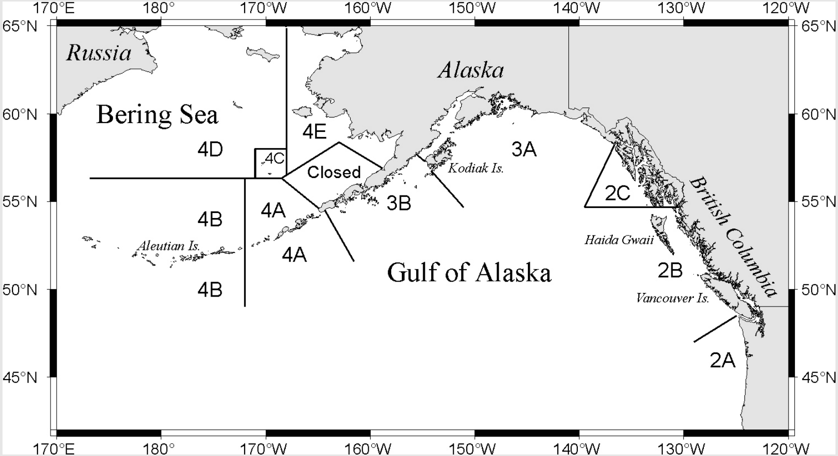
Rationale for restrictions (Pautzke & Oliver 1997)

- Limit "consolidation of ownership"
- "Maintaining diversity in the fleet, and minimizing adverse coastal community impacts"



Model objectives

- Construct a model to conduct policy simulations to evaluate program effectiveness
  - How would the fishery develop with an unrestricted quota market (counterfactual)?
  - Examine counterfactual outcome in terms of:
    1. Number of active vessels
    2. Geographic distribution of vessels
    3. Efficiency losses due to the restrictions

Dynamic decision-making by participants

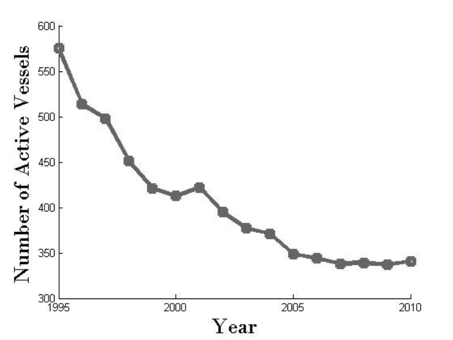
- There may be costs of adjusting capital and labor
- Price of long-term asset should reflect present discounted value of annual catch allowance
- Participants may be hetereogenous (e.g. in terms of capital and individual characteristics)
- Resource stock is also dynamic

E.g. a participant may stay in the program even if their current-period profits are negative, in anticipation of positive profits in the future and positive present discounted value of profit (rational expectations)

Adjustment costs

- How do economic gains during the period following implementation (transition period) depend on restrictions?
- Adjustment may be costly

  E.g. may be due to initially low opportunity costs of less malleable inputs such as capital and labor and therefore may not occur instantaneously (Weninger and Just (1997))
- Dynamic model of adjustment



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Dynamic structural model

- Use to examine development of fishery under counterfactual scenario (unrestricted quota markets)
- Single agent profit-maximization model where fishermen is the decision-maker
  - Fishermen owns the quota and vessel
- Fishermen decides (1) each year whether or not to to exit, which is a function of current and expected profitability and (2) the quantity fished if the vessel remains in the fishery
- Estimate parameters of a single-agent dynamic structural model of the exit decision

Vessel profit

- Profit individual i makes fishing in a given period t:

$$\pi_{it} = p_t q_{it} - C_{it}\left(q_{it}, \mathbf{x_{it}}\right) \;\; s.t. \;\; restrictions$$

- Where we denote ex-vessel price in period t as p_t, the quantity fished by vessel i in time t q_{it}, the cost of fishing q_{it} by vessel i in period t as C_{it}, and $\mathbf{x_{it}}$ is a vector of state variables

State variables ($\mathbf{x_{it}}$)

- *Static*: Vessel length, vessel horsepower, engine-type, hull-type, refrigeration status, tonnage
- *Deterministic*: Vessel age, owner age
- *Stochastic*: Total allowable catch (TAC), stock, ex-vessel price, fuel price, and adjustment costs

Exit decision

- A vessel owner can choose to exit the fishery in any period
- We model this choice using the variable $a_{it} \in 0, 1$
  - $a_{it} = 1$ indicates vessel i remains in the fishery at time t
  - $a_{it} = 0$ indicates vessel i exits the fishery at time t
- With no fishing effort, we assume the owner can rent the vessel out for use in another fishery

$$\pi_{it} = \begin{cases} p_t q_{it} - VC_{it}\left(q_{it}, \mathbf{x_{it}}\right) - FC_{it}\left(\mathbf{x_{it}}\right) & \textit{if } \; a_{it} = 1 \\ OC_{it}\left(\mathbf{x_{it}}, t, N\right) - FC_{it}\left(\mathbf{x_{it}}\right) & \textit{if } \; a_{it} = 0 \end{cases}$$

Choice-specific value function

- The timing of the decision to exit is determined by the current and expected state variables
- In particular, we assume a vessel will remain in the fishery if there are non-negative expected profits to be made
- The choice-specific value function is the sum of the current-period profit and the expected, discounted, future per-period profit

$$V_{it}\left(a_{it}, \mathbf{x_{it}}\right) = u_{it}\left(a_{it}, \mathbf{x_{it}}; \theta\right) + E_t\left(\sum_{\tau=t+1}^{T} \beta^{\tau-1} u_{i\tau}\left(a_{i\tau}, \mathbf{x_{i\tau}}, \epsilon_{i\tau}; \theta\right)\right)$$

Estimation procedure

- Follow previous work on dynamic structural model estimation
  - Match observed (for a given set of state variables) to predicted probability of exit using a 2-step estimator (Hotz and Miller 1993, Hotz et. al 1994)
    - Estimate the parameters of the probit policy function, which can then be used to generate the observed probability of exiting/remaining in the fishery conditional on any set of state variables (Huang and Smith, 2010)
    - Estimate the parameters of the transition equations for the stochastic variables
    - Estimate the value function conditional on parameter vector via Simulation-based Conditional Choice Probability Method
    - Bootstrap to obtain standard errors

Profit models

- **Model I**
  - Valid in the neighborhood of the observed market equilibrium
  - Results indicate restrictions are binding
  - *Benefits:* We can estimate with limited data
  - *Costs:* Does not permit us to develop a counterfactual for a large change
- **Model II (future work)**
  - Estimate a cost function for different levels of fishing (quota ownership)
  - *Benefits:* Permits estimation of a wide-range of counterfactuals (e.g. the impact of removing the vessel class restriction)
  - *Costs:* Requires additional data, which we have, and more auxiliary regressions

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Model I

- We normalize the profit of not fishing to equal zero

$$\pi_{it} = \begin{cases} p_t q_{it}\left(\mathbf{x_{it}}\right) - C_{it}\left(q_{it}\left(\mathbf{x_{it}}\right), \mathbf{x_{it}}\right) & \textit{if} \;\; a_{it} = 1 \\ 0 & \textit{if} \;\; a_{it} = 0 \end{cases}$$

- We use the number of vessels that departed the entire fishery (not just the submarket) the previous year as a measure of adjustment cost
  - Expect the more vessels on the market the lower the opportunity cost of capital/labor
- Linear-in-parameters specification for estimating profit:

$$\pi_{it} = \begin{cases} \theta \left[p_t \; \mathbf{x_{it}}^{'} \right]^{'} + \epsilon_{it}^{\pi} & \textit{if} \;\; a_{it} = 1 \\ 0 & \textit{if} \;\; a_{it} = 0 \end{cases}$$

  - Goal is to estimate $\hat{\theta}$

Preliminary submarket results: Halibut Gulf Class C Blocked

- Blocking is effectively an accumulation limit
- The accumulation limit is on quota share (perpetual right) not the yearly allocation
- Therefore, an increase in the submarket TAC allows fishermen to fish more pounds
- If the accumulation restriction is binding, we expect a positive coefficient on the TAC in the profit equation

Preliminary profit results: dynamic, forward-looking

Variable	**Sign of $\hat{\theta}$**
Vessel year-built	-
Vessel length	-
Vessel length^2	+
Vessel hp	-
Vessel hp^2	-
Vessel diesel engine	+
Vessel hull wood	-
TAC	+
TAC^2	+
Stock	+
Ex-vessel price	+
Fuel price	-
Adjustment costs	+

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Vessel diesel engine	+
Vessel hull wood	-
TAC	+
TAC^2	+
Stock	+
Ex-vessel price	+
Fuel price	-
Adjustment costs	+

Preliminary results cont.

- Preliminary results suggest differences in vessel profitability in restricted and unrestricted markets and economic costs due to restrictions (at the margin)
- For example, in the halibut-Gulf-class C-blocked market we find, holding stock constant, that expansion of available TAC will increase profit
  - This suggests that restrictions are binding in this submarket

Profit Model

- **Model I**
  - Valid in the neighborhood of the observed market equilibrium
  - Results indicate restrictions are binding
  - *Benefits:* We can estimate with limited data
  - *Costs:* Costs: Does not permit us to develop a counterfactual for a large change
- **Model 2**
  - Estimate a cost function for different levels of fishing (quota ownership)
  - *Benefits:* Permits estimation of a wide-range of counterfactuals (e.g. the impact of removing the vessel class restriction)
  - *Costs:* Requires additional data, which we have, and more auxiliary regressions

Model 2

- Vessels in the fishery will maximize profit such that the following FOC holds: $p_t - m_t = VC'_{it}(q_{it})$, where m_t is the quota price at time t
  - Using data on q_{it}, m_t, and $\mathbf{x_{it}}$ we can estimate the variable cost function outside of the dynamic optimization
- Linear-in-parameters specification for estimating the OC function:

$$\pi_{it} = \begin{cases} p_t \tilde{q}_{it} - \tilde{VC} - \theta \left[\mathbf{x}'_{\mathbf{it}} \; N \right]' + \epsilon^{\pi}_{it} & \textit{if} \;\; a_{it} = 1 \\ 0 & \textit{if} \;\; a_{it} = 0 \end{cases}$$

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Counterfactual

- Use $\hat{\theta}$ parameters to simulate counterfactual and then calculate costs of restrictions
  - Group vessel observations by class (size) to estimate $\hat{\theta}$ for each group
    - Use information on cost functions (contained in $\hat{\theta}$) to simulate how the fishery would develop if there were only one quota market in which vessels of all size groups could trade freely
  - Allow for free choice of q_{it} to explore impact of blocking restriction
- How large are the costs relative to the value of implementing a program sooner?

Assumptions about the structure of profit function

- Assume the error structure is that ϵ_{it}^{π} are iid over vessels and time with a Type I extreme value distribution and dispersion parameter σ_{ϵ}
- Assume hetereogeniety is captured via the observed variables in the x_{it} vector
- Under this formulation we assume that in each period the vessel owner observes x_{it} and ϵ_{it}^{π}
- Linear-in-parameters specification for estimating profit:

$$\pi_{it} = \begin{cases} \theta \left[p_t \; x_{it}^{'} \right]^{'} + \epsilon_{it}^{\pi} & \mathit{if} \;\; a_{it} = 1 \\ 0 & \mathit{if} \;\; a_{it} = 0 \end{cases}$$

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