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ITQ prices: What do they reveal?

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Introduction

• Many ITQ-systems in the world
  – Up to 25% of global harvest
• Can observe ITQ-prices
• What do they tell us?

Observed ITQ-prices often exhibit bewildering (to some) behavior (i.e. very high or low relative to price of fish).
[This has prompted some economists to assert fishers are irrational]

Here show inter alia that such ITQ-prices can be entirely rational!
Premises

**ITQ-system**

**A1.** ITQ-rights are high quality (i.e. secure, exclusive, tradable and permanent)

**A2.** Violations of ITQ rules are impossible – perfect enforcement *[Can relax]*

**A3.** Quotas are binding (at least one company would like to harvest more)
Premises (cont.)

Fishing firms

A4. Maximize profits

A5. Have perfect knowledge of current prices (and their own operating conditions)

Quota market

A6. Transactions costs negligible

A7. No market manipulation (competitive market)
Single species ITQ-prices

Quantity quota (quota rental) prices:

\[ p_h = \pi_h(h, x) \]

Quota share prices:

\[ p_{\alpha}(t) = \int_{t}^{\infty} \pi_h \cdot Q \cdot e^{-rt} d\tau = \int_{t}^{\infty} \text{Rents}(\tau) \cdot e^{-rt} d\tau \]

In equilibrium

\[ p_{\alpha} = \frac{p_q \cdot Q}{r} \equiv \frac{\text{Rents}}{r} \]
What do quota prices tell us?

1. Quantity quota price, $p_h$, equals current marginal profits of harvesting, $\pi_h$.
   - Reveals information about true profit function
   - Duality: Can in principle extract the profit function from quota prices

2. Quota share price, $p_\alpha$, equals present value of expected future rents in fishery
   - Reveals fishers’ beliefs about future (incl. TAC policy, future prices etc.)
   - Duality: Can in principle extract fishers’ PV-function from ITQ-share prices
But…

Many fisheries are multi-species fisheries!

Do these results hold in that context?
A general multi-species profit function

\[ \pi(h, x) \]

Depends (in general) on all harvests and all biomasses!

\[ \frac{\partial^2 \pi(i)}{\partial h(i) \partial h(j)} \neq 0, \quad \frac{\partial^2 \pi(i)}{\partial h(i) \partial x(j)} \neq 0 \]

Note: Implicit assumption
Can select all \( h \geq 0 \) vectors, …albeit at a cost!
So, no technical selectivity restriction!
(Analytically convenient and realistic)
Multi-species ITQ-prices

**Quantity quota prices:**

\[ p_{h(i)} = \pi_{h(i)}(h, x) \]

**Quota share prices:**

\[ p_\alpha(i, t) = \int_t^\infty \pi_{h(i)}(h, x) \cdot Q(i) \cdot e^{-rt} \, d\tau \equiv \int_t^\infty \text{Rents}(i, \tau) \cdot e^{-rt} \, d\tau \]

In equilibrium

\[ p_{\alpha(i)} = \frac{p_{q(i)} \cdot Q(i)}{r} \equiv \frac{\text{Rents}(i)}{r} \]
Profit function in harvest space
Iso-profit curves (harvest flexibility)

I1: High harvest flexibility
I2: Lower harvest flexibility
I3: Lowest harvest flexibility

NB: Iso-profit curves move with biomasses, $x$
Analytical tool: Iso-profit contours, separating hyperplanes and quota prices

- The iso-profit curves define “better than”-sets in harvest space
- These sets are convex
- Each combination of TACs defines a point in harvest space
- Through each TAC point there exists a supporting hyperplane, $p \cdot h = \pi$
- These hyperplanes define quantity quota prices (The normal to the hyperplane)
Now, easy to see graphically how TACs affect quota prices

So obviously;
quota rental price can exceed landings price!
What do multi-species ITQ-prices tell us?

1. Prices of quantity quotas, \( p_{h(i)} = \pi_{h(i)}(h,x) \), depend on all harvests and biomasses!
   - Reveal information about true profit function, \( \pi(h,x) \)
   - Duality: Can in principle extract the profit function from quota prices

Implications

1. Interpreting multispecies ITQ-prices is complicated!
2. Multispecies ITQ-prices can exceed landing prices!
Numerical example

\[ \pi(h, x) = p_1 \cdot h_1 + p_2 \cdot h_2 - c_1 \cdot \frac{h_1^2}{x_1} - c_2 \cdot \frac{h_2^2}{x_2} - A \cdot \left( h_1 - \alpha \cdot \left( \frac{x_1}{x_2} \right) \cdot h_2 \right)^2 \]

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Species interaction term
Iso-profit curves

Stretched because $A \neq 0$
If $A = 0 \Rightarrow$ symmetrical

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<tr>
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Quantity quota price 1, $p_{h(1)}$
Relaxing Assumption A2
(That is, ITQ rules can be violated)

Two types of violations

1. Discarding

\[ \pi(h, x) - p_h \cdot h \rightarrow p_1 \cdot (h_1 - d_1) - C(h, x) - C1(d_1) - p_{h1} \cdot (h_1 - d_1) \]

2. Non-reported landings

\[ \pi(h, x) - p_h \cdot h \rightarrow p_1 \cdot (h_1) - C(h, x) - C2(n_1) - p_{h1} \cdot (h_1 - n_1) \]

Similar, but not identical
Theorem
Discards and/or non-reporting will take place if the price of quantity quota, $p_{h(i)}$ is high enough (critical quota price)

If discards:
$$p_{h(i)} = p(i) + C1_{d(i)}(d(i))$$

If non-reporting:
$$p_{h(i)} = C2_{n(i)}(n(i))$$
What do ITQ-prices tell us under these circumstances?

If discarding: $p_{hi}$ reveals information about the (perceived) cost of discarding, $C_{1d(i)}$.

If non-reporting: $p_{hi}$ reveals information about the (perceived) cost of non-reporting, $C_{2n(i)}$. 
What do multi-species ITQ-prices tell us?

1. Prices of quantity quotas, \( p_{h(i)} = \pi_{h(i)}(h,x) \), depend on all harvests and biomasses!
   - Reveal information about true profit function, \( \pi(h,x) \)
   - Duality: Can, in principle, extract the profit function from quota prices

Implications

1. Interpreting multispecies ITQ-prices is complicated!
2. Multispecies ITQ-prices can exceed landing prices!
What do multi-species ITQ-prices tell us? (cont.)

2. Prices of ITQ-shares, $p_{\alpha(i)}$, equal expected present value of future rents from using this quota-share for fishing
   – Assuming future paths of all biomasses and harvests
   – Can, in principle, extract this PV function from observed ITQ-share prices
Conclusions

• In the multi-species ITQ fishery
  – ITQ rental prices depend on the harvest and biomasses of all species
    ⇒ They can greatly exceed the (apparent) marginal profits and the landings price of any given species
  – ITQ-share prices depend on future expected harvest and biomasses of all species
    ⇒ They can also seem unduly high or low (when considered for individual species)
Conclusions (cont.)

• In the multi-species ITQ fishery
  – ITQ rental prices reveal the marginal contribution of harvest of one species to total fishery profits
    ⇒ Reveal information about the true joint profit function
  – ITQ-share prices depend on future expected harvest and biomasses of all species
    ⇒ Reveal fishers expectation about the future of the overall fishery (or ecosystem)
END
Icelandic Cod: Landings price vs. quantity quota price
(From Matthíasson 2012)
What do multi-species ITQ-prices tell us?

Key findings:

Finding 1
Prices of quantity quotas, \( p_q(i) = \pi_{h(i)}(h,x) \), depend on all harvests and biomasses!

Implication:
In general: \( \partial p_q(i)/\partial h(j) \neq 0 \), \( \partial p_q(i)/\partial x(j) \neq 0 \)

Finding 2
Prices of share quotas, \( p_q(i) \), depend on all current and expected harvests and biomasses!