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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:

$$p_h = \pi_h(h, x)$$

Marginal profits of fishing

Quota share prices:

$$p_\alpha(t) = \int_t^\infty \pi_h \cdot Q \cdot e^{-rt} d\tau = \int_t^\infty Rents(\tau) \cdot e^{-rt} d\tau$$

In equilibrium

$$p_\alpha = \frac{p_q \cdot Q}{r} \equiv \frac{Rents}{r}$$

What do quota prices tell us?

1. Quantity quota price, p_h , equals current marginal profits of harvesting, π_h .
   - Reveals information about true profit function
   - Duality: Can in principle extract the profit function from quota prices
2. Quota share price, p_α , 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

$$\pi(\boldsymbol{h}, \boldsymbol{x})$$

Depends (in general) on <u>all harvests</u> and <u>all biomasses</u>!

$$\partial^2\pi(i)/\partial h(i)\partial h(j) \neq 0, \qquad \partial^2\pi(i)/\partial h(i)\partial x(j) \neq 0$$

Note: Implicit assumption

Can select all $\boldsymbol{h} \geq \boldsymbol{0}$ vectors, …albeit at a cost!

So, no technical selectivity restriction!

(Analytically convenient and realistic)

Multi-species ITQ-prices

Quantity quota prices:

$$p_{h(i)} = \pi_{h(i)}(\boldsymbol{h}, \boldsymbol{x})$$

Quota share prices:

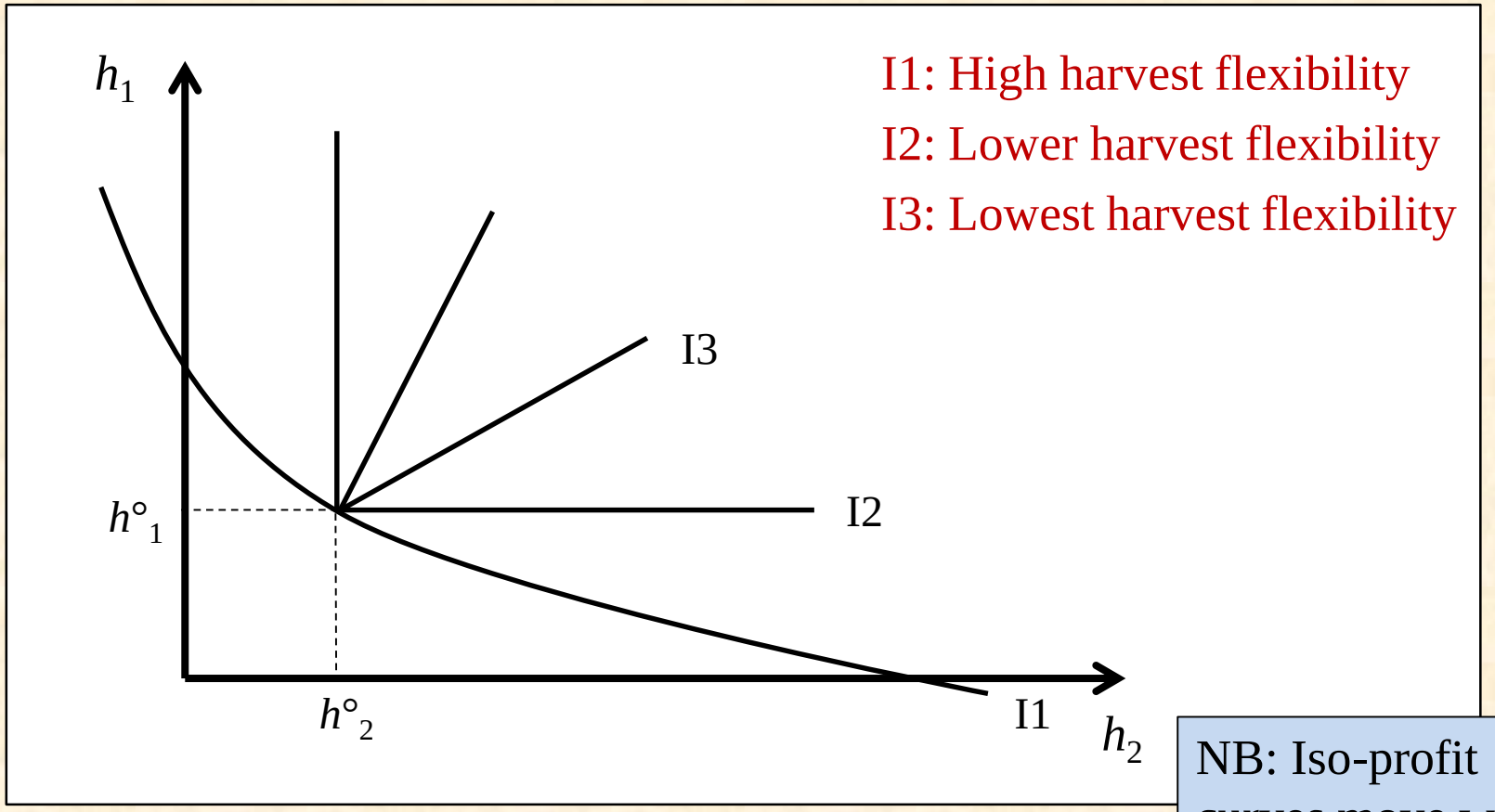
$$p_{\alpha}(i,t) = \int_{t}^{\infty} \pi_{h(i)}(\boldsymbol{h}, \boldsymbol{x}) \cdot Q(i) \cdot e^{-rt} d\tau = \int_{t}^{\infty} Rents(i,\tau) \cdot e^{-rt} d\tau$$

In equilibrium

$$p_{\alpha(i)} = \frac{p_{q(i)} \cdot Q(i)}{r} \equiv \frac{Rents(i)}{r}$$

Profit function in harvest space

Iso-profit curves (harvest flexibility)

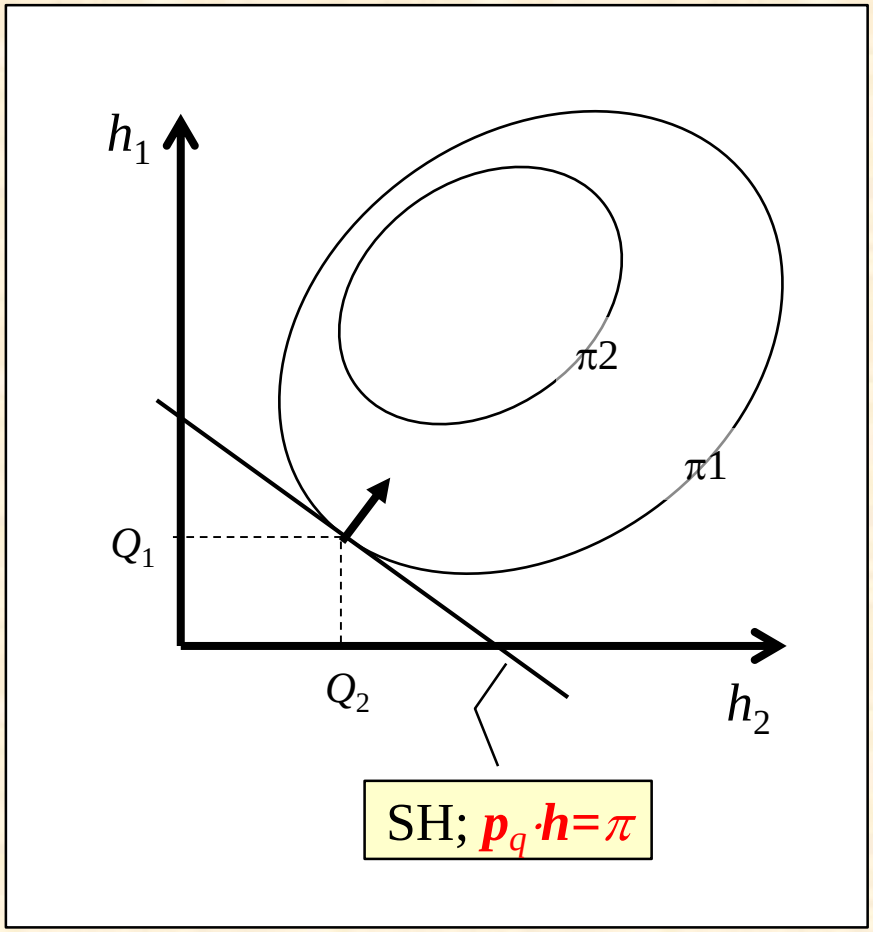


NB: Iso-profit curves move with biomasses, ***x***

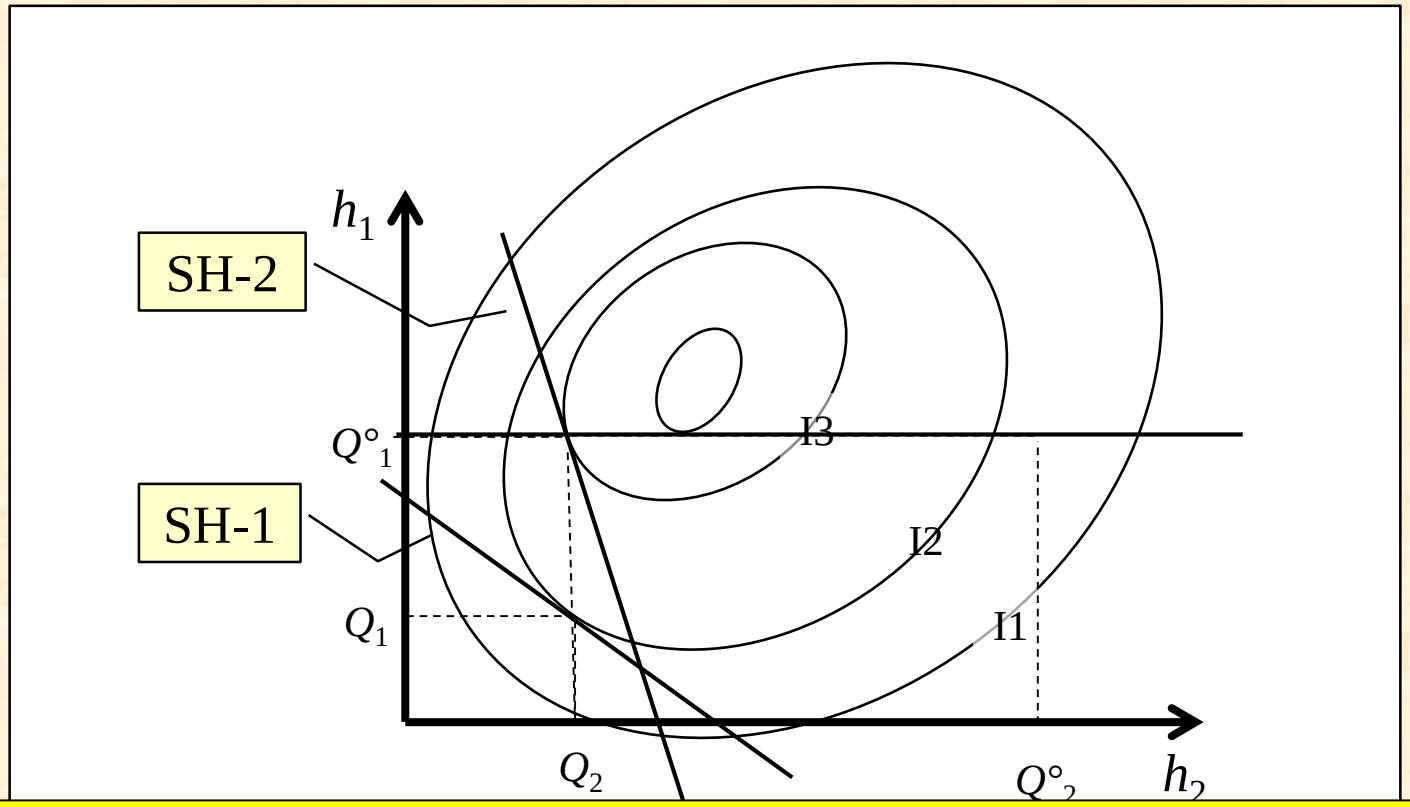
Analytical tool:

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, $\boldsymbol{p_q \cdot h = \pi}$
- 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, $p_{h(i)}=\pi_{h(i)}(\boldsymbol{h},\boldsymbol{x})$, depend on <u>all</u> harvests and biomasses!
   - Reveal information about true profit function, $\pi(\boldsymbol{h},\boldsymbol{x})$
   - 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**!**

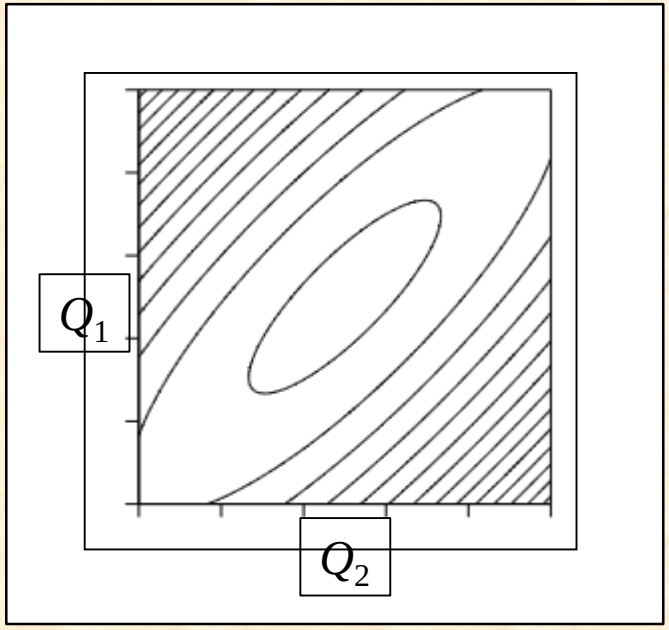
Numerical example

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

Species interaction term

Parameters	Values
p_1	1
p_2	1
c_1	0.2
c_2	0.2
A	0.2
α	1
x_1	5
x_2	5

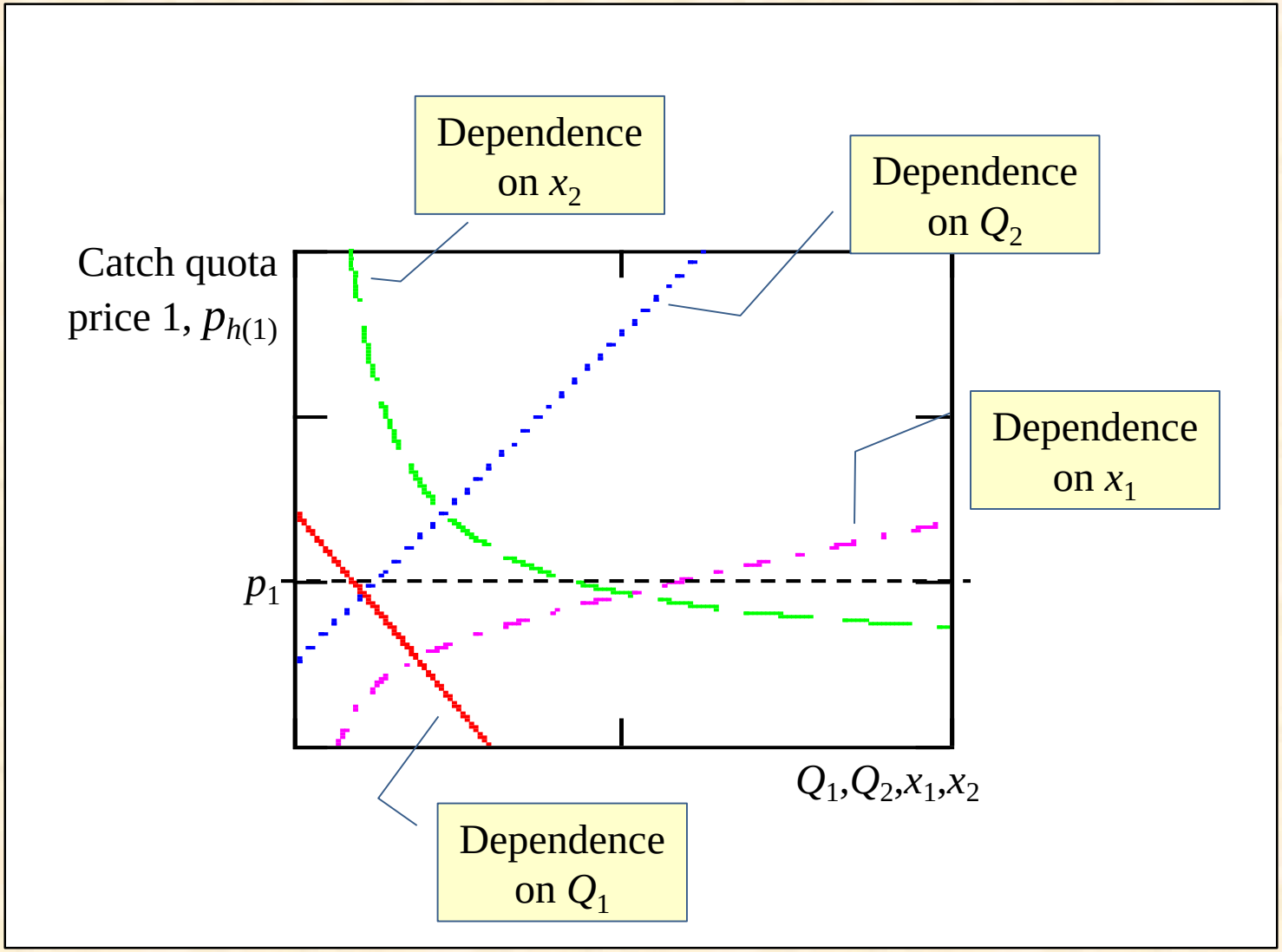
Iso-profit curves



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

Q1	Q2	x1	x2	p_{h1}	p_{h2}
1	1	5	5	0.92	0.92
1	0.7	5	5	0.8	1.06
1	0.7	5	3.5	0.92	0.92

Quantity quota price 1, $p_{h(1)}$



END

Relaxing Assumption A2
(That is, ITQ rules can be violated)

Two types of violations

1. Discarding

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

2. Non-reported landings

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

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_{h_i} reveals information about the (perceived) cost of discarding, $C1_{d(i)}$.

If non-reporting: p_{h_i} reveals information about the (perceived) cost of non-reporting, $C2_{n(i)}$

What do multi-species ITQ-prices tell us?

1. Prices of quantity quotas, $p_{h(i)}=\pi_{h(i)}(\boldsymbol{h},\boldsymbol{x})$, depend on <u>all</u> harvests and biomasses!
   - Reveal information about true profit function, $\pi(\boldsymbol{h},\boldsymbol{x})$
   - 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 ahrvests
   - 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

  $\Rightarrow$ 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

  $\Rightarrow$ 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

    $\Rightarrow$ Reveal information about the true joint profit function
  - ITQ-share prices depend on future expected harvest and biomasses of all species

    $\Rightarrow$ Reveal fishers expectation about the future of the overall fishery (or ecosystem)

END

Icelandic Cod: Landings price vs. quantity quota price

(From Matthíasson 2012)

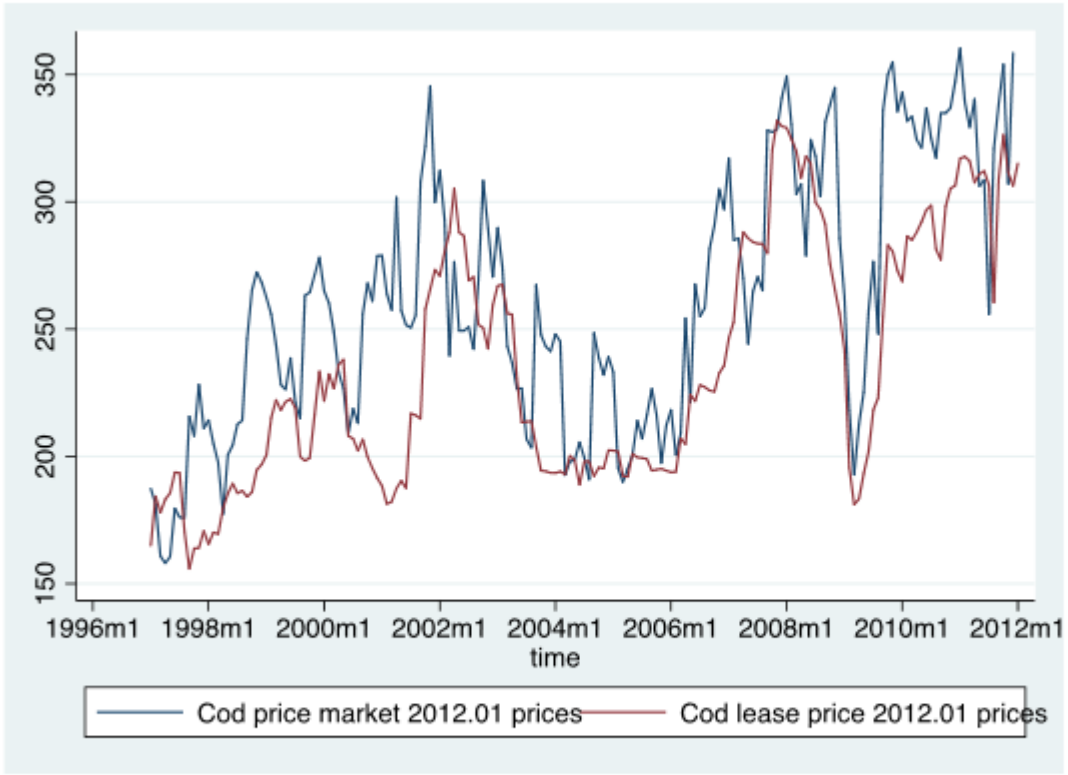


Figure 4 Cod prices at fixed price level ISK, all prices in kronur per kilo, base is January 2012. Source : Directorate for Fisheries

What do multi-species ITQ-prices tell us?
Key findings:

Finding 1

Prices of quantity quotas, $p_{q(i)} = \pi_{h(i)}(\boldsymbol{h},\boldsymbol{x})$, depend on <u>all</u> 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 <u>all</u> current and expected harvests and biomasses!