Asymmetric Information and Distributional Impacts in New Environmental Markets

Brett Close[1] Corbett Grainger[1] & Linda Nøstbakken[2]

[1]University of Wisconsin - Madison

[2]Norwegian School of Economics

Questions

Transition from Common Property to Property Rights

- Despite large gains in resource rents, often resistance from incumbents.
    - Study consolidation and price discovery
- Concerns about consolidation, fairness (policies include embargo on sales, community-based quota, owner-operator restrictions, etc.)

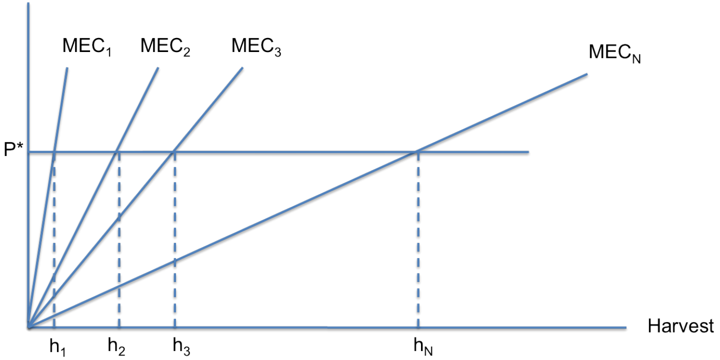
Two main questions:

- How are prices "discovered" in a newly-created environmental market?
- What are the distributional impacts of the transition?

Stylized Facts

- Some concerns about distributional effects (small vs. large)
- Limited empirical studies; some experimental work
- Where there are data, volatility in new markets drops quickly over time

Heterogeneous Marginal Extraction Costs



ITQs

- Fishermen granted shares of the overall harvest, Q
- Relax constraints on number of permits, season length
- Each fisherman's costs are defined as before
- Incentives change–less investment in "racing capital"

Model Results: ITQs

- Assume fishermen pay τ for each unit of harvest.
- Output price may change (denote by $\tilde{p}$).
- Fishermen respond to price $(\tilde{p} - \tau)$, not the nominal price $\tilde{p}$
- Can calculate quota price in the model
- So, inframarginal rents change

ITQs Cont.

- Given tradable and divisible shares, the marginal extraction costs across fishermen will be equalized
- Resource Rents determined by the value of the marginal unit of harvest.

ITQs

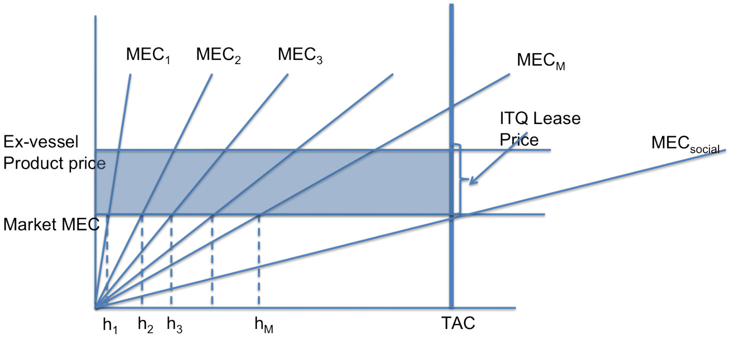


Figure: Individual Transferable Quotas

Market Structure (also see Grainger & Costello 2016)

- There is a group of N active agents in the market, indexed by i with skill parameter α_i drawn from a distribution F.
- A regulator is able to set the season length T and the total allowable catch, Q, subject to the stock of fish, X.
- Each agent in the market is able to purchase a quantity of fishing capital k_i, with the cost of capital c giving total cost ck_i^2, and sell his or her catch h_i at a price p for a profit of π_i.
- Each agent's catch is determine by the skill parameter, level of capital, and the season length and stock of fish: $h_i = \alpha_i k_i TX$.

Mkt Structure Cont

- Under the base case of limited entry, each agent takes the other agents' choices of capital and the season length as given and maximizes profit $\pi_i = ph_i - ck_i^2$.
- Solving for the optimum, assuming an interior solution, each agent will then harvest

$$h_i = \frac{p(\alpha_i TX)^2}{2c}. \tag{1}$$

- The regulator can then set season length so that the sum of each agent's catch is equal to the total catch Q, yielding

$$T = \sqrt{\frac{2cQ}{pX^2 \sum_{i=1}^{N} \alpha_i^2}}. \tag{2}$$

- From this it is clear that each agent's share of the total catch is $\alpha_i / \sum_{i=1}^{N} \alpha_i^2$ and each agent earns profit $\pi_i = \frac{1}{2} ph_i$.

Mkt Structure Cont

- the regulator can set the season to the maximum possible length, $\bar{T}$.
- Because the price received by each agent is simply shifted down by the "tax" amount (the price of the ITQ), the overall structure of the market changes little and each agent still will harvest the same proportion of the catch, now harvesting quantity

$$\tilde{h}_i = \frac{(\tilde{p} - \tau)(\alpha_i \bar{T} X)^2}{2c}, \tag{3}$$

and the market will clear at a permit price of

$$\tau = \tilde{p} - \frac{2cQ}{(\bar{T}X)^2 \sum_{i=1}^{N} \alpha_i^2}. \tag{4}$$

Bargaining Model

- What happens in the early stage of the ITQ regime, when information about the willingness to pay of each agent is scarce and equilibrium has not yet been reached?
- In the case of perfect information on the part of the regulator who allocates each agent share $\alpha_i / \sum_{i=1}^{N} \alpha_i^2$, the market automatically clears as the willingness to pay for ITQs is the same for all agents and each simply harvests the amount allocated to them.
- If, on the other hand, there is noise in the allocation, an interesting distributional question arises.
- We model this case as a game of asymmetric information.

setup

- Each agent's skill parameter is drawn from a distribution whose single parameter is unknown, which is know to have strictly positive support bounded below by zero.
- Each agent knows its own skill parameter as well as the allocation and skill parameter order statistic of each other agent (due to knowledge of historical harvests).
- That is, everyone knows who is the best and the worst (and every position in between) at fishing, but no one knows exactly how good anyone else is.

- Each agent has its own well defined willingness to pay (willingness to accept) based on the skill parameter and their ITQ allocation q_i,

$$\tau_i = \tilde{p} - 2\frac{cq_i}{(\alpha_i \bar{T} X)^2}. \tag{5}$$

- Based on the information available to them, they also form expectations about the market structure, using their own skill parameter as a quantile of the total distribution to form beliefs about the distribution of skill parameters, and from there the distribution of any other agent's skill parameter and willingness to pay and the overall market equilibrium rate.

bidding

- Bidding order is random.
- Agents with higher order statistics make offers sequentially to each other agent.
- The offer is the value that maximizes their expected payoff based on their beliefs about the other agent's skill parameter and willingness to pay.
- If the offer is below the recipient's willingness to pay, it is declined.
- If it is above the recipient's estimate of the equilibrium price, it is accepted.
- If it between these values, the two parties "bargain" with the outcome being the average of the offer and the recipient's estimated equilibrium price, weighted by the square of each agent's skill parameter.
- After each agent has had an opportunity to make offers to the agents with ITQs, all the transaction information becomes known to all agents and they update their beliefs.
- Rounds of bidding continue until no transactions occur.

details

For our simulations, we model skill parameters as being distributed uniformly on $[0, A]$, with distribution parameter (unknown to the agents) $A = 1$. Therefore the expected value of an order statistic of this distribution is

$$\mathbb{E}(\alpha_{(k)}) = \frac{kA}{N+1}, \tag{6}$$

implying that each agent's expectation for the maximum value of the distribution is

$$\hat{A}_i = \frac{\alpha_i(N+1)}{i}, \tag{7}$$

where, without loss of generality we have indexed the agents by their skill parameter order statistic.

Each agent's best guess about the sum of the square of the skill parameters is

$$\hat{\sigma}_i = \mathbb{E}(\sum_{j=1}^{N} \alpha_j | i, \alpha_i) = N\mathbb{E}(\alpha_j^2 | i, \alpha_i) = N \int_0^{\hat{A}_i} x^2 \frac{1}{\hat{A}_i} dx = N \frac{\hat{A}_i^2}{3}, \tag{8}$$

and the expected equilibrium market price is

$$\tau_i^* = \tilde{p} - \frac{2cQ}{(\bar{T}X)^2 \hat{\sigma}_i}. \tag{9}$$

The payoff for the offer-maker k for an offer to i is given by

$$\rho_k(T) = \begin{cases} 0 & \text{, if } T < \tau_i; \\ \tau_j - \dfrac{T\alpha_j^2 + \tau_i^2\alpha_i^2}{\alpha_j^2 + \alpha_i^2} & \text{, if } T > \tau_i \& T < \tau_i^* \\ \tau_j - T & \text{, if } T > \tau_i \& T > \tau_i^* \end{cases} . \tag{10}$$

Based on the information available to the offer-maker, the distribution of the offer-receiver's skill parameter, given their order statistics and the offer-maker's skill parameter, is

$$f_{\alpha_i}(\alpha|\alpha_j, j, i) = \frac{1}{\alpha_j} \frac{(N-j-1)!}{(i-1)!(N-j-i)!} \left(\frac{\alpha}{\alpha_j}\right)^{(i-1)} \left(\frac{1-\alpha}{\alpha_j}\right)^{(N-j-i)} . \tag{11}$$

The expected payoff for a given offer is then the Stiltjes integral of the payoff function over the support for α_i with respect to the distribution of α_i, where τ_i and τ_i^* are known functions of α.
Therefore, the offer maker j will select offer value to agent i as,

$$T_{ji}^* = \underset{T}{argmax} \int_0^{\alpha_j} \left(\mathbb{1}\{T > \tau_i(\alpha) \& T < \tau_i^*(\alpha)\} \left(\tau_j - \frac{T\alpha_j^2 + \tau_i(\alpha)^2 \alpha_i(\alpha)^2}{\alpha_j^2 + \alpha_i(\alpha)^2} \right) + \mathbb{1}\{T > \tau_i(\alpha) \& T > \tau_i^*(\alpha)\} \left(\tau_j - T\right) \right) df(\alpha) , \tag{12}$$

where

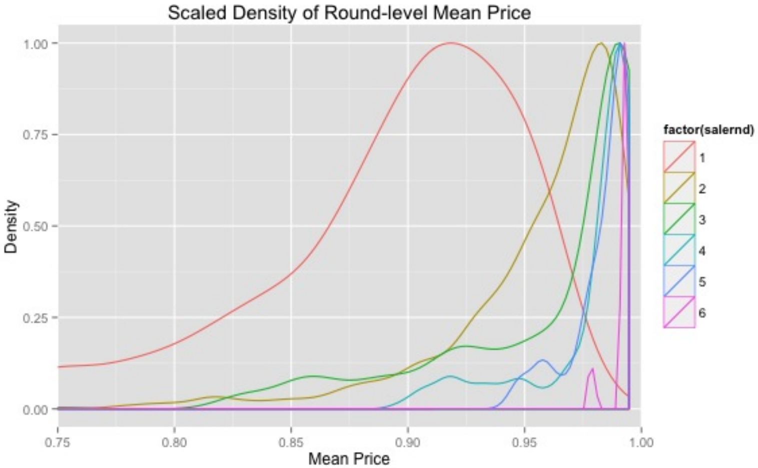
$$df(\alpha) = \frac{1}{\alpha_j^2} \frac{(N-j-1)!}{(i-1)!(N-j-i)!} \left[(i-1) \left(\frac{\alpha}{\alpha_j}\right)^{(i-2)} \left(1 - \frac{\alpha}{\alpha_j}\right)^{(N-j-i)} + (N-j-i) \left(\frac{\alpha}{\alpha_j}\right)^{(i-1)} \left(1 - \frac{\alpha}{\alpha_j}\right)^{(N-j-i-1)} \right] d\alpha. \tag{13}$$

Simulations

We simulated market dynamics

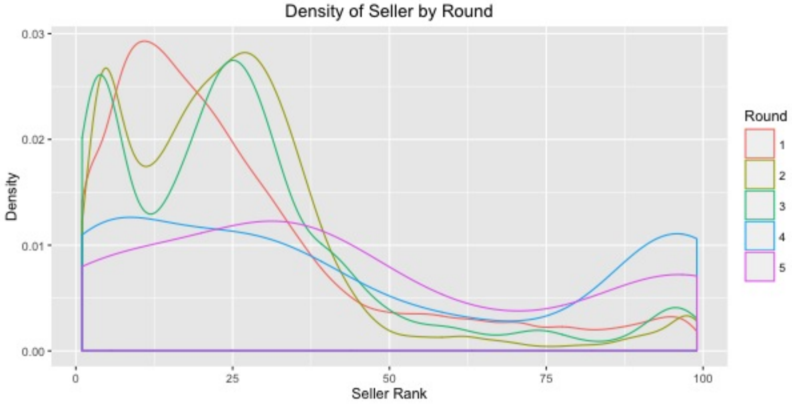
- skill parameters drawn from $\mathit{Unif}(0, 1)$
- grandfather 90% based on limited entry harvest
- season length, price of fish, cost of capital, and total fish mass, were normalized to one.
- A sale is considered to have occurred whenever a offer is accepted.

Results


Scaled Density of Round-level Mean Price
Density
1.00
0.75
0.50
0.25
0.00
0.75
0.80
0.85
0.90
0.95
1.00
Mean Price
factor(salernd)
1
2
3
4
5
6

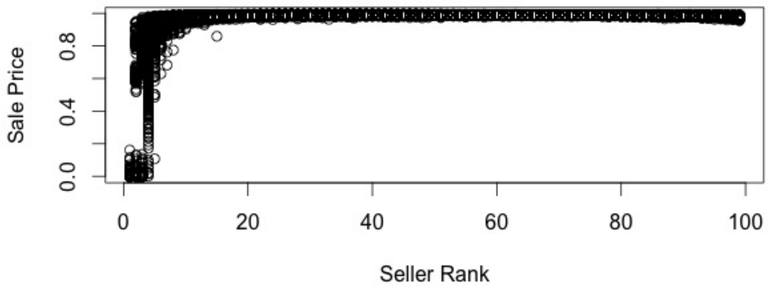
Results Cont.

Higher skill agents tend to be selling in later rounds, rejecting earlier offers as too low.



Results Cont.

Only low-skill agents are selling for low prices; story less clear for buyers.
The very lowest-price sales primarily go to very low-skill agents (due to better estimates of the skill of their nearest neighbors).



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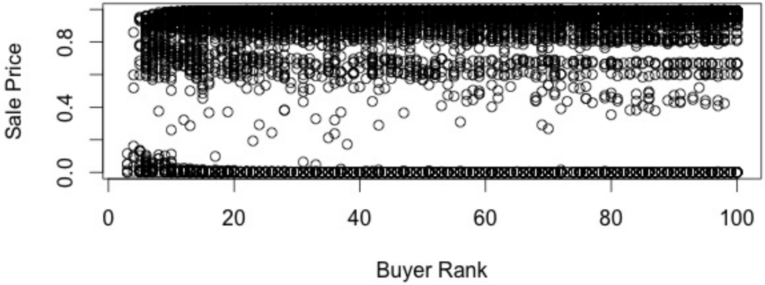

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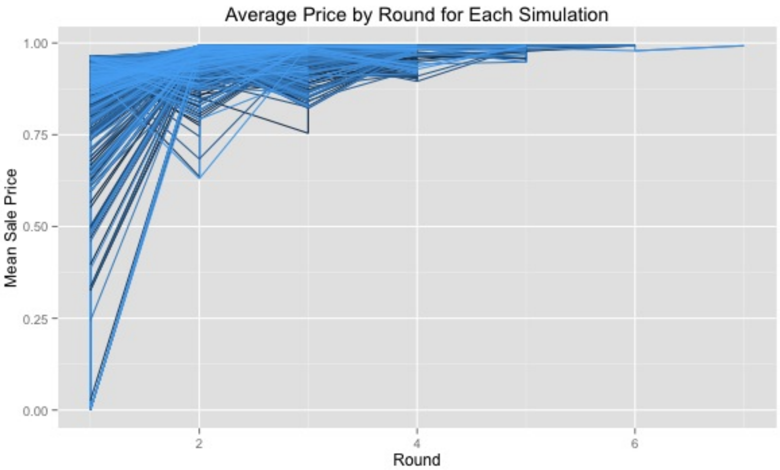

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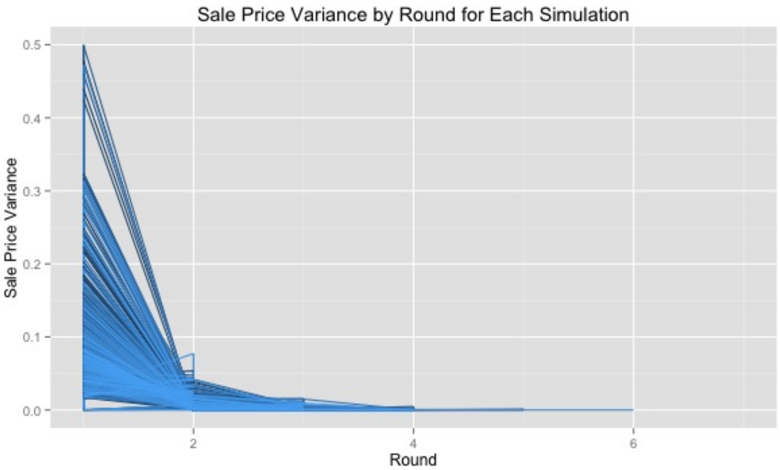

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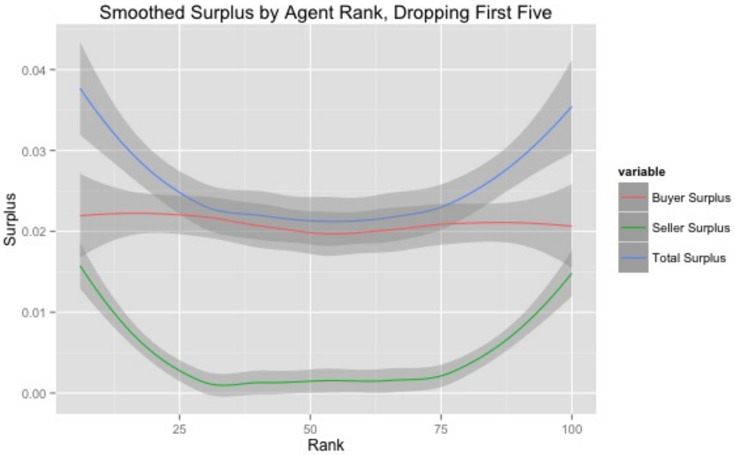

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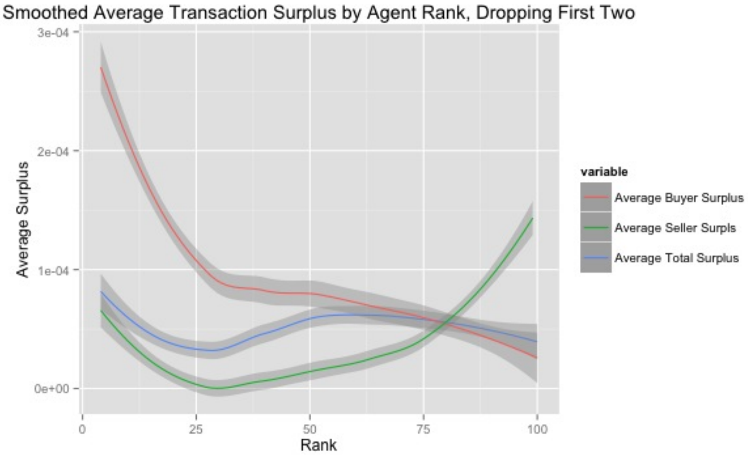

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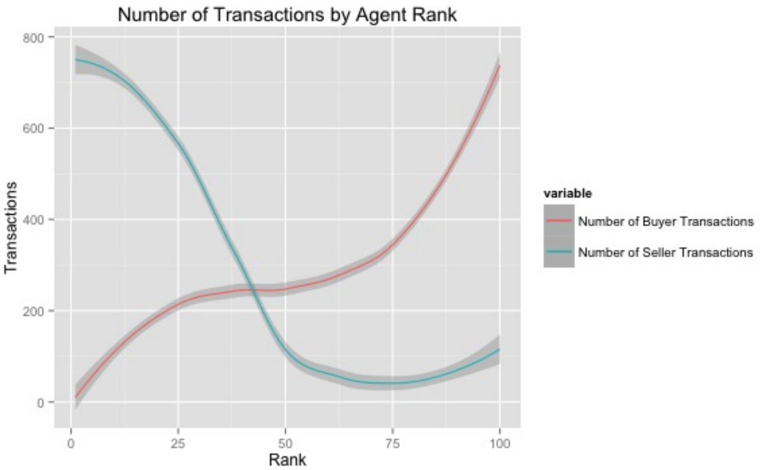

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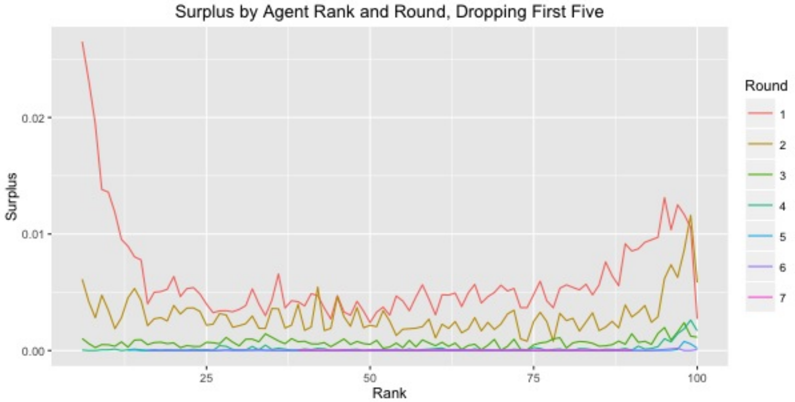
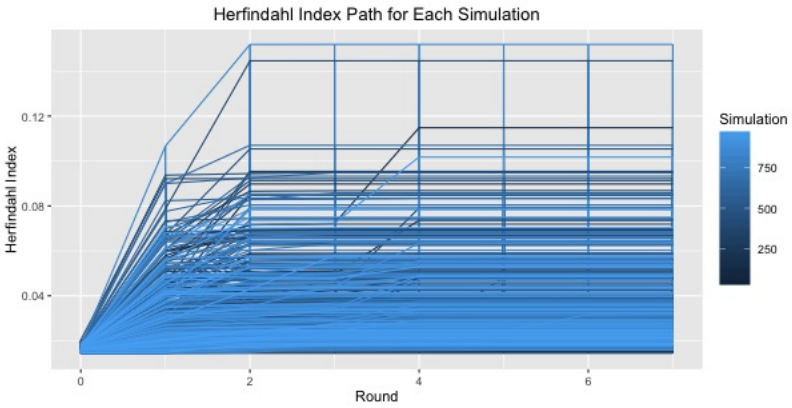


Consolidation



Next Steps?

- Individual-level data?
- Please?!

Price discovery and consolidation in new ITQ market

- Do small-scale operators get "taken advantage of"?
  - While the quota purchase price is often lower than the eventual market price, the small sellers tend to get more surplus from the transaction than the buyer.
  - The smallest and the largest market actors do the best, with the differential gains coming from being sellers; buyer surplus is roughly constant across skill ranks.
- Consolidation driven largely by the level of inequality, as measured by the initial Gini coefficient.
- Information asymmetries play a role; as more information enters the market, the distribution of gains becomes flatter with less of an advantage from information asymmetry.

Thanks!

corbett.grainger@wisc.edu
www.aae.wisc.edu/cagrainger