Quota prices, discarding and rents in a multispecies fishery

Aaron Hatcher
University of Portsmouth, UK

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Quota prices in multispecies fisheries

- Modelling quota prices where there is joint production (limited targeting)
- How can we model a quota market equilibrium *during* a season?
- Species-specific TACs may not correspond to typical catch ratios
- Hence "choke" species and discarding
- How do quota (lease) prices and (inframarginal) rents arise, and change?
- Squires/Kirkley (various), Turner (JEEM, 1997), Vestergaard (CJE, 1999), Singh & Weninger (JEEM, 2009)

Fishing vessel behaviour

- Harvest function:

$$H_i \equiv \sum_j \beta_{ij}\left(k_i, X_1, ..., X_M\right) H_i\left(e_i, k_i, X_1, ..., X_M\right)$$

  where β_{ij} is the proportion of species j in the catch
- Effort decision:

$$E_i \geq e_i^* > 0 : \quad \sum_j \left[p_j - r_j\right] \beta_{ij} H_i'\left(e_i^*\right) - C_i'\left(e_i^*\right) = \lambda_i^* \geq 0$$

  where r_j is the quota lease price for species j
- Discard decision:

$$d_{ij}^* > 0 : \quad r_j = p_j + \theta_{ij}, \quad j = 1, 2, ..., M$$

  where $\theta_{ij} \geq 0$ is a discard cost
- Quota compliance:

$$q_{ij}^* = \beta_{ij} H_i\left(e_i^*\right) - d_{ij}^*$$

Quota market equilibrium model

- Quota price bounds:

$$0 \leq r_j \leq p_j + \theta_j$$

- All quota held by firms (endowments $\neq$ demands)
- Assume quota only placed on market when $r_j > 0$
- All quota markets clear (no excess supply)
- In the case of chokes $r_j = p_j + \theta_j$
- The quota pricing problem in the model is

$$\min_{r_j} \left\{ \sum_i \left[\sum_j \left[p_j - r_j \right] \beta_{ij} h_i - c_i \right] \right\}$$

$$\text{s.t.} \quad \sum_j \left[p_j - r_j \right] \beta_{ij} h_i - c_i = \lambda_i \geq 0, \forall i, \quad r_j \leq p_j + \theta_j, \forall j$$

Quota market equilibrium model

- With harvest and costs linear in effort, the λ_i indicate inframarginal rents
- We have M quota species and N (different) vessels/technologies
- With the λ_i as slack variables, solutions to the quota pricing problem have the equality

$$(\textit{variables}) \quad M' + N' = M'' + N \quad (\textit{constraints})$$

where $M' \leq M$ is the number of *positive* quota prices, $N' < N$ is the number of positive shadow prices (λ_i), and $M'' < M$ is the number of *binding* quota price ceilings

Quota market equilibrium: $M = N$

- We have a set of positive, interior*, quota prices and no vessels earn inframarginal rents
- If one or more of the quota price ceilings binds, as a TAC is exhausted, then one or more of the λ_i will be positive and these vessels will earn inframarginal rents
- *we cannot rule out a quota market equilibrium with corners (0 or $p_j + \theta_j$) even if a TAC is not exhausted (one or more of the λ_i will then be positive)

Quota market equilibrium: $M > N$

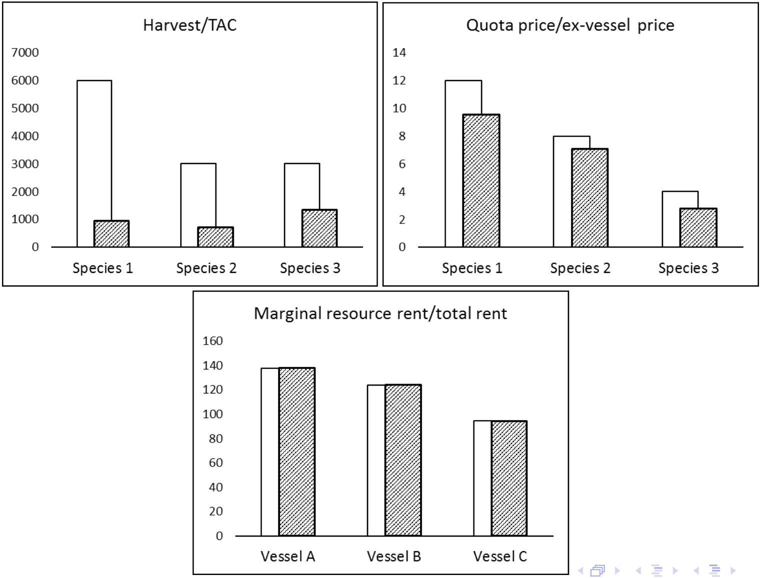
- One or more quota prices must *either* be constrained at its price ceiling (even if the TAC is not exhausted) *or* equal to zero - no inframarginal rents
- If a TAC is exhausted, so that its quota price reaches the price ceiling, vessels earn inframarginal rents only where the total number of vessel constraints plus binding quota price ceilings becomes less than the number of TACs

Quota market equilibrium: $M < N$

- One or more of the λ_i will be positive and these vessels will be earning inframarginal rents
- If a species TAC is then exhausted, so that its quota price is constrained at its price ceiling, this will increase the number of vessels earning inframarginal rents

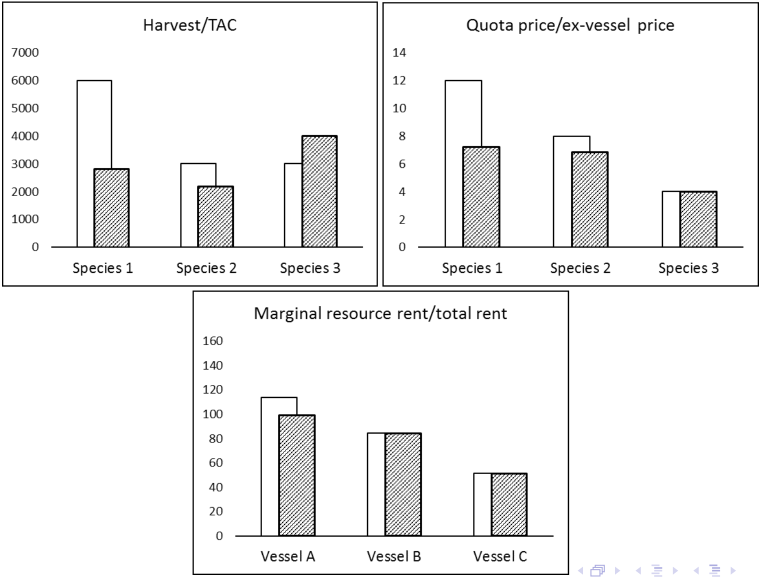
Simulation: 3 species, 3 vessels

$E = 50$ days



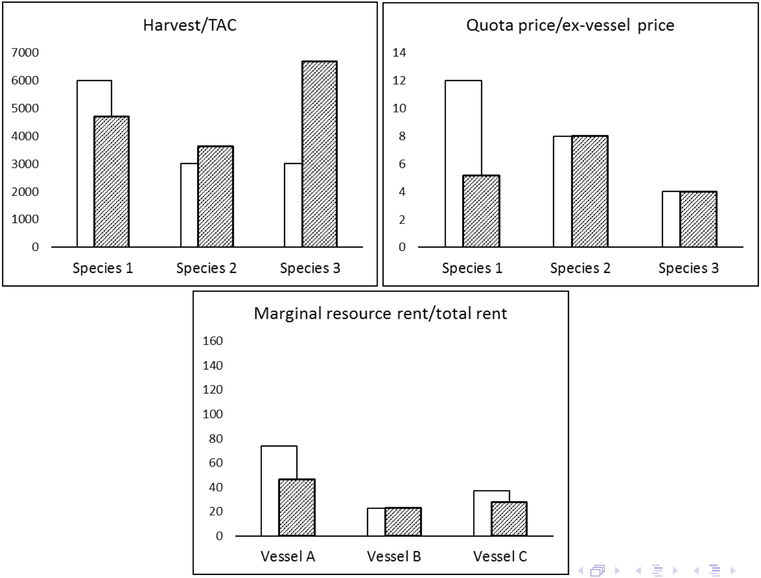
Simulation: 3 species, 3 vessels

$E = 150$ days



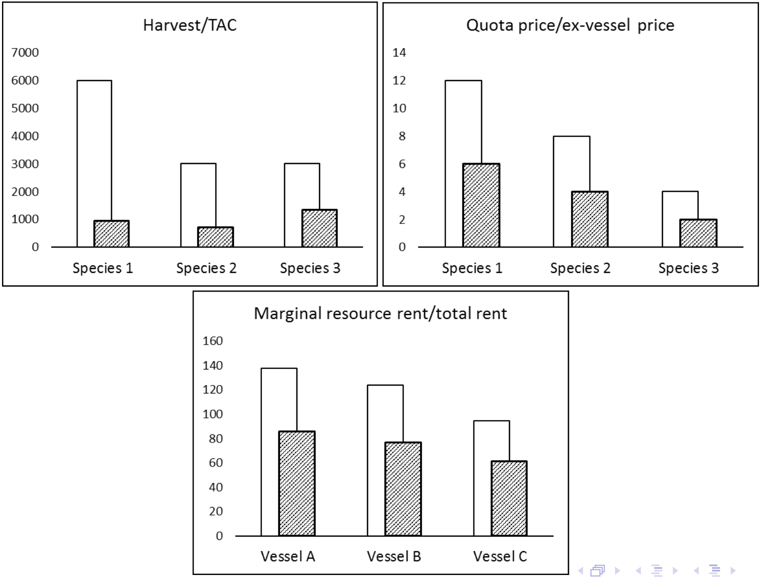
Simulation: 3 species, 3 vessels

$$E = 250 \text{ days}$$



Simulation: "deemed value" (50% EVP)

$E = 50$ days



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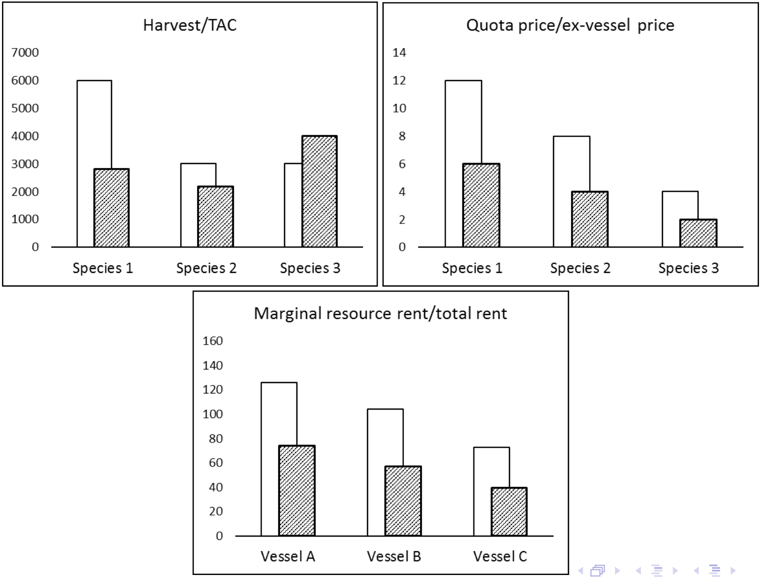

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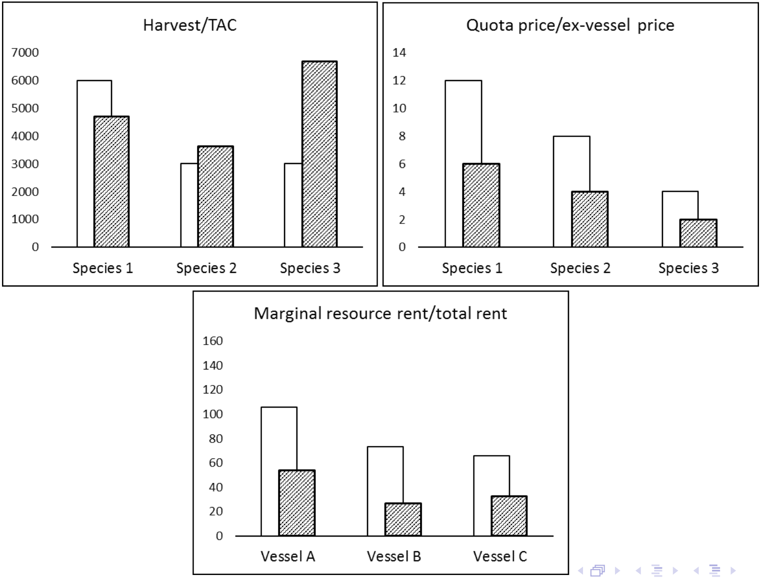

Concluding remarks

- Equilibrium quota prices and rents sensitive to relative numbers of species and vessel technologies
- We should not be surprised to observe corner prices, particularly where the number of quota species is large
- Inframarginal rents increase with fleet heterogeneity
- Impact of chokes and discarding
- Quota price controls can change allocation of surplus