Competitive markets in stochastic environments: Will climate change drive industry consolidation of global fisheries?

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Industry Evolution

What factors influence industry structure?

- Price, profitability, and economies of scale
- History of exploitation and management
- Resource variability, population portfolio effects?

Photos: Paulyfish (top); Hannah Heimbuch (bottom)

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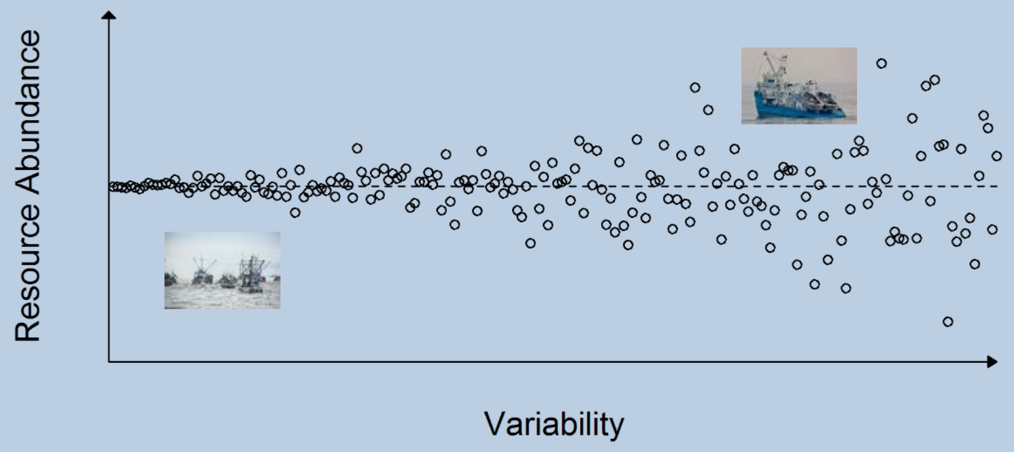
Research Questions

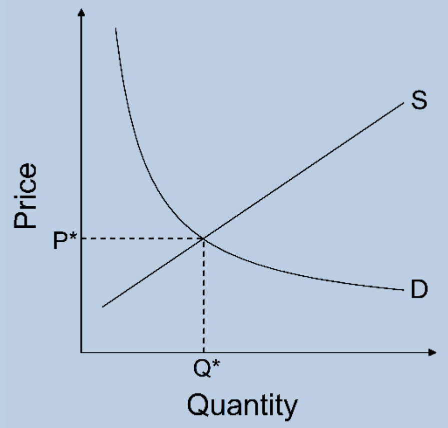
1. Does environmental stochasticity drive industry consolidation?

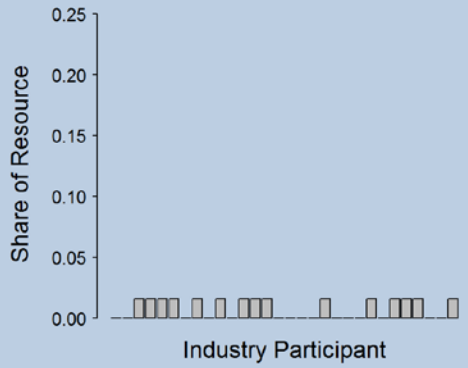
2. Are more consolidated industries found in highly variable environments?



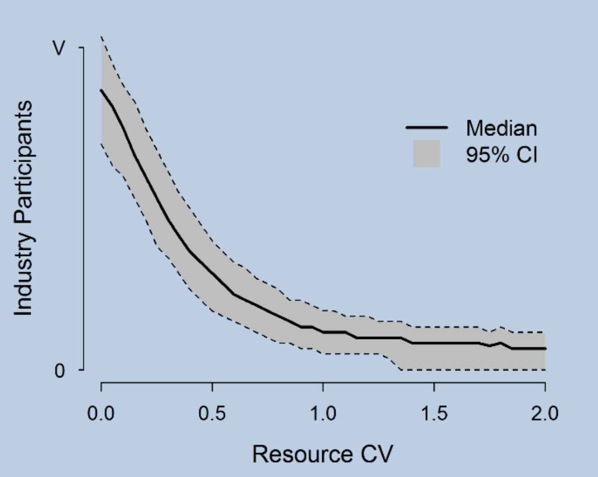
Industry Consolidation Agent Based Model

- Model steps:
  1. Initial participants randomly assigned variable harvest costs
  2. Take random resource draw and determine harvests
  3. Compute price and calculate individual profits
  4. Redistribute market shares of unprofitable participants to profitable participants; if share is < threshold, participant exits; if average profits > 0, new participant enters
  5. Repeat steps 2-4 many times for a fixed level of variability (i.e., standard deviation of random resource draw) and record the final number of industry participants
  6. Repeat steps 2-5 many times and evaluate distribution
  7. Change level of variability, repeat





Results



- Strong relationship between resource variability and the number of industry participants
- Industry growth punctuated by large periodic losses in “bad” seasons
- Most efficient (lowest cost) agents are able to survive

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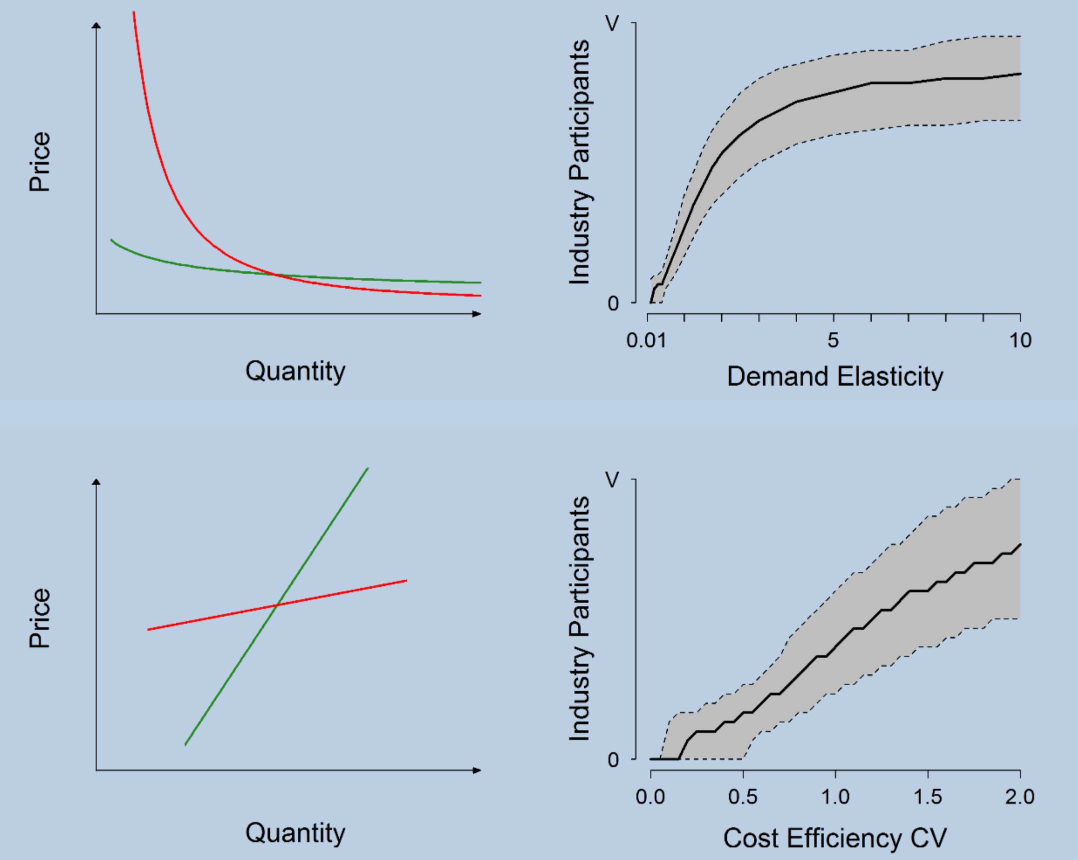
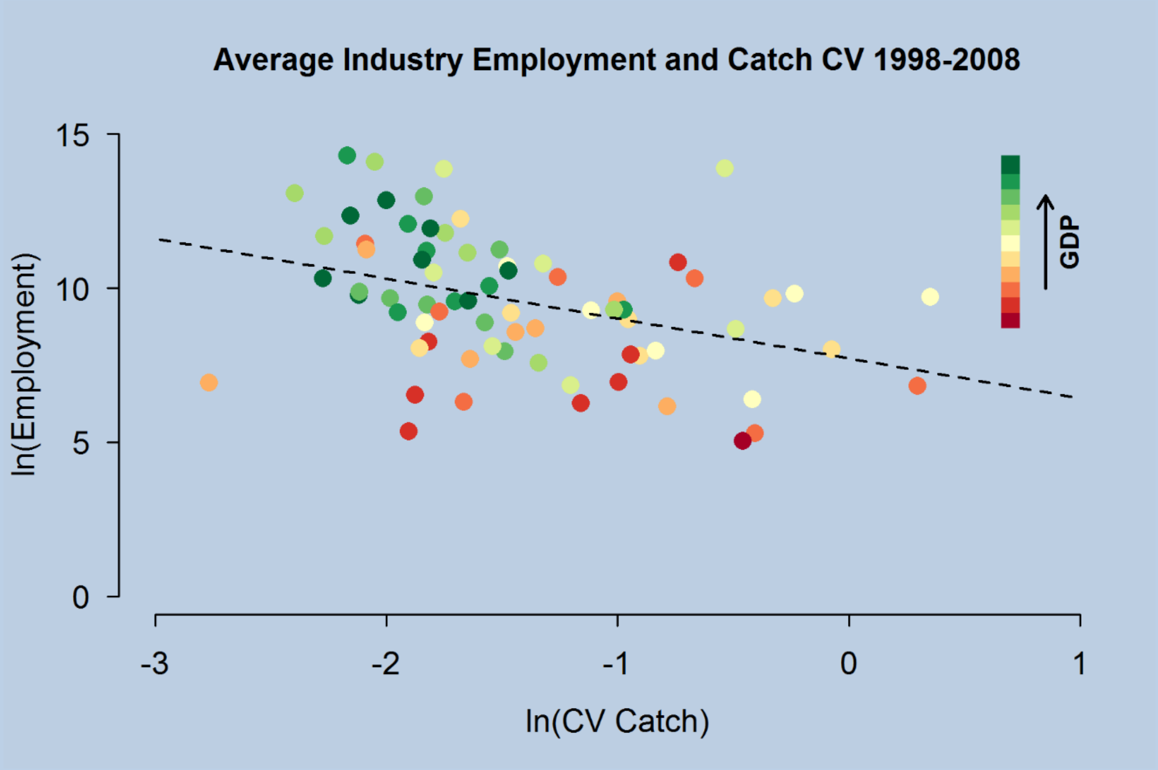
Results

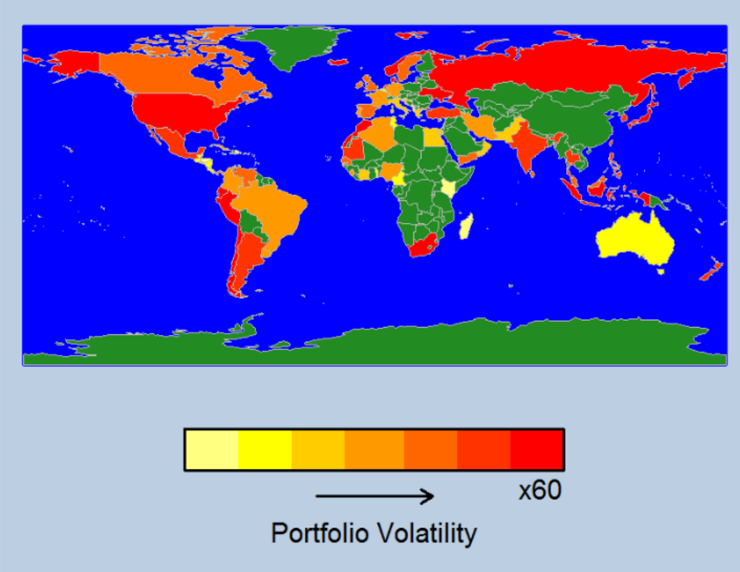
- Several structural components of the model were also deterministic
- Demand elasticity → constant price removes demand side volatility
- Cost heterogeneity → diverse industry better able to withstand large shocks



Empirical Support?



Empirical Support?



$$Volatility_{it} = \sqrt{w^T \Sigma_{it} w}$$

Portfolio weights set to total catch %'ages

Covariance matrix of asset returns for country *i* at time *t*

- Combine FAO catch, ILO employment, and other global data sets to investigate relationship between volatility and employment
- Species groups considered portfolio assets (i.e., pelagic, demersal, crustacean, molluscs, and cephalopods)

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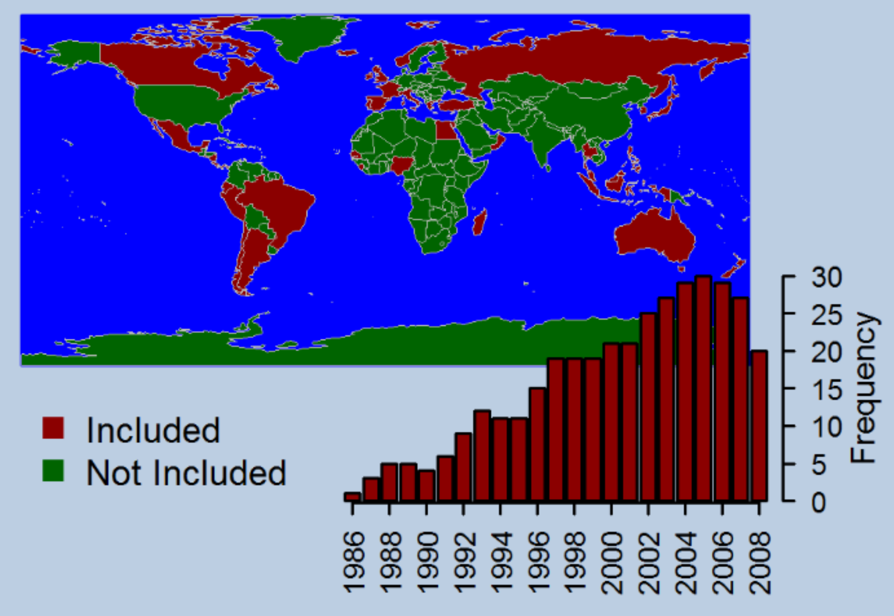
Empirical Model

$$\ln(N_{it}) = \beta_0 + \beta_1 \ln(MTL_{it}) + \beta_2 \ln(GDP_{it}) + \beta_3 \ln(\sum_s C_{sit}) + \beta_4 \ln(\sum_s A_{sit}) + \beta_5 \ln(V_{it}) + \varepsilon_{it}$$



Term	Description	Units
N_{it}	Employment in fishing sector of country *i* at time *t*	People
MTL_{it}	Mean trophic level of catch by country *i* at time *t*	Trophic Level
GDP_{it}	Gross domestic product of country *i* at time *t*	Current US$
C_{sit}	Catch of species group *s* by country *i* at time *t*	Tonnes
A_{sit}	Aquaculture of species group *s* by country *i* at time *t*	Tonnes
V_{it}	Portfolio volatility of country *i* at time *t* (based on current and previous 2 years)	Tonnes

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Preliminary Empirical Results

$$\ln(N_{it}) = \beta_0 + \beta_1 \ln(MTL_{it}) + \beta_2 \ln(GDP_{it}) + \beta_3 \ln(\sum_s C_{sit}) + \beta_4 \ln(\sum_s A_{sit}) + \beta_5 \ln(V_{it}) + \varepsilon_{it}$$

N(Observations) = 362
N(Countries) = 37
R^2 = 0.44

Variable	Coefficient	S.E.
MTL	-2.819***	0.609
GDP	-0.186***	0.054
C_{sit}	0.665***	0.075
A_{sit}	0.372***	0.101
V_{it}	-0.244**	0.041

- Countries/times with more volatile catch portfolios employ fewer people in their fishing industries
- Much more between country variation than within

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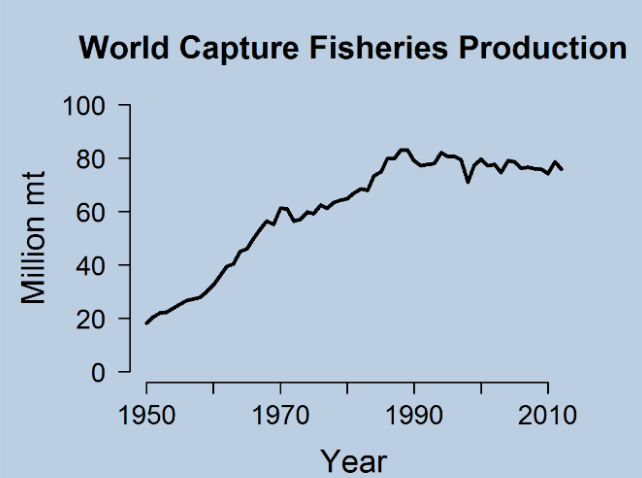
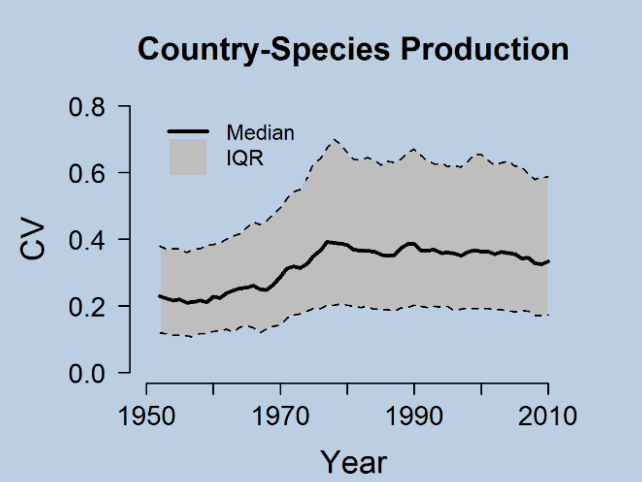
Conclusions





Sustained fishing pressure and climate change are both expected to increase recruitment variability

"Changes in the amplitude of climate variability are very likely to have greater consequences than changes in mean values" (Brander 2007)

Thanks!

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References

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