



Departamento de
Economía
Universidad de Concepción



The Impact of Environmental Variability on Fishers' Harvest Decisions in Chile

A multi-species structural approach

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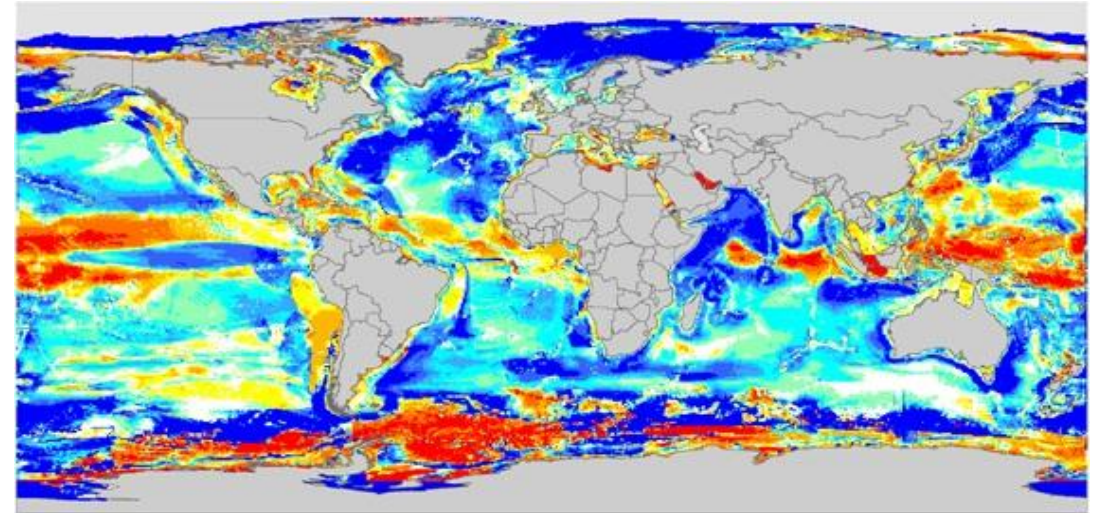
Departamento de Economía, Universidad de Concepción

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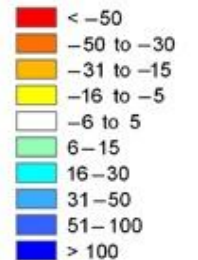
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Motivation

- Small pelagic stocks fluctuate sharply with climate variability.
- Standard projection tools assume **constant fishing rates or full quota uptake** – the human decision is assumed away.
- **But fishers choose** which species to target, how many trips, how much to land.



Change in catch potential
(% relative to 2005)



Source: Cheung et al. (2010)

Project goal: propagate climate-driven biomass shifts into fisher-side responses – participation today (Paper 1), optimal harvest decisions in the full structural model (Paper 2).

The project — two papers, one structural pipeline

Paper 1 (today's results)

Reduced-form effort + identified stock dynamics

- **Negative binomial** trip equation, estimated separately by fleet.
- Bayesian state-space stock dynamics with structural climate shifters (in appendix).
- Comparative statics under future climate scenarios.

Paper 2 (today's roadmap)

Welfare counterfactuals

- Translog **cost** function (trip-level, by fleet).
- **Inverse demand** (IAIDS, 3SLS).
- **Dynamic vessel optimization** \Rightarrow optimal $T_g, h_{g\tau}$ under different climate scenarios.
- Welfare, prices, species substitution.

*The two papers share **the same identified stock dynamics**. Paper 1 stops at participation; Paper 2 closes the loop through prices, cost, and profits to estimate optimal harvest and quota allocation.*

Setting and observed heterogeneity

Chile's Small Pelagic Fishery (Centro-Sur)

Stocks & sectors

- **Anchoveta** (*Engraulis ringens*), **sardine** (*Strangomera bentincki*), **jack mackerel** (*Trachurus murphyi*).
- ~94% of national landings; mostly purse seiners.
- Two sectors: **artisanal** (ART), **industrial** (IND).

Quota regime

- TAC split between sectors with **limited cross-sector transferability**.
- IND quotas partially tradable within sector; ART under spatial collective-property rights (i.e., **RAE**).

Fleet portfolios are very different

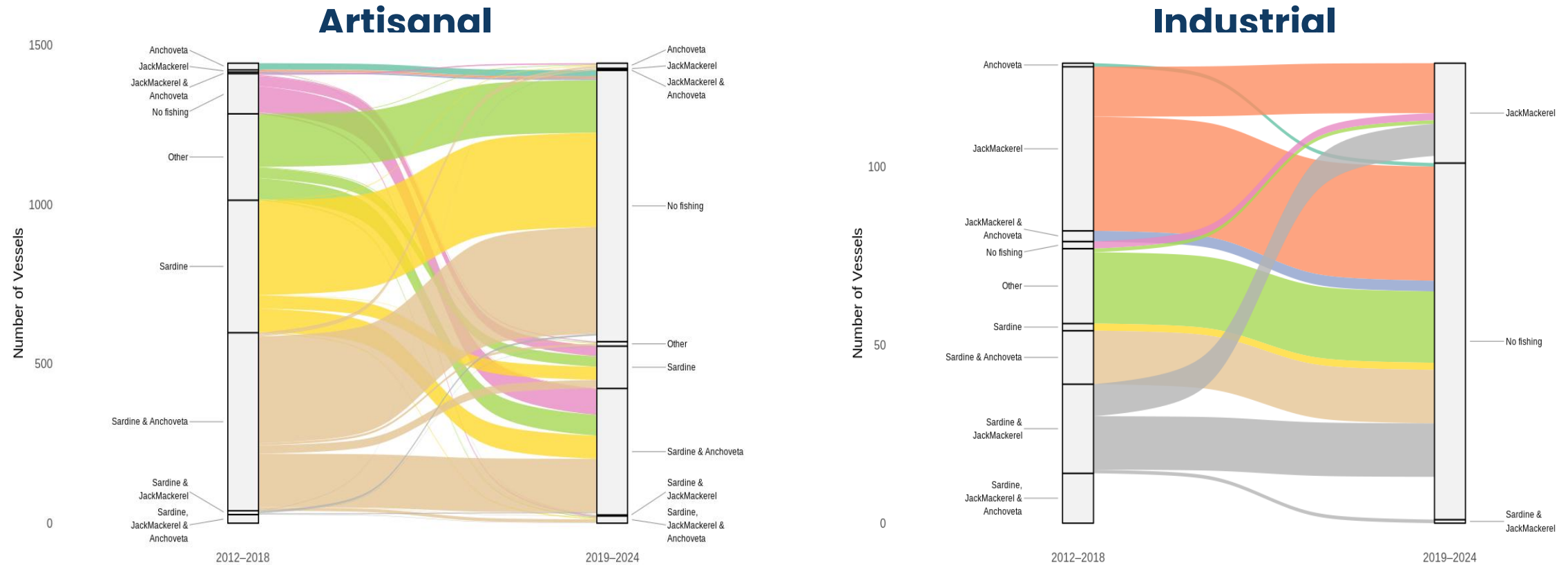
- ART: ~ {anchoveta, sardine}. Concentrated.
- IND: ~ 95% jack mackerel + 5% sardine.

Mobility

- IND: offshore purse-seiners.
- ART: port-anchored, RAE binds spatially.

⇒ **Same shock, different choices.**

Observed strategy switching — ART vs IND



Trip-level target-species transitions, IFOP logbooks 2013–2024.

ART: anchoveta ↔ sardine dominates; jack mackerel essentially absent. **IND:** rotation across all three. Same fishery, very different revealed choice sets.

Paper 1 — The NB trip equation

A negative binomial model of annual trips

Specification, by fleet g (ART, IND)

$$T_{vy}^g \sim NB(e^{U'_{vy}\beta_g + \alpha_y^g}, \theta_g)$$

with $U_{vy} = [p_{sy}, H_{vy}^{alloc}, Z_v, O_{vy}]$:

- p_{sy} : ex-vessel prices, by species.
- H_{vy}^{alloc} : vessel-level quota allocation.
- Z_v : hold capacity, vessel type.
- O_{vy} : bad-weather days, closures.
- α_y^g : **year FE** (absorbs 2019–22 shocks).
- Vessel-clustered robust SEs.

Why NB by fleet?

- Overdispersion σ^2/μ : 22.4 (ART), 4.9 (IND). Poisson rejected at $p < 0.001$.
- Two fleets, two technologies, two choice sets – no pooling.

Two channels to projections

- **Indirect**: structural shifters $\rho_{SST}, \rho_{CHL} \rightarrow B_{i,t} \rightarrow H_{vy}^{alloc}$.
- **Direct**: vessel-specific Δ bad-weather days from CMIP6 winds.

Extend the model with endogenous effort shares responsive to relative profitability and an endogenous quota-binding regime.

What drives fisher participation?

Variable	Industrial	Artisanal	Reads as
H^{alloc} (quota allocation)	(+) ^{***}	(+) ^{***}	Quota = binding budget constraint, both fleets.
Price – jack mackerel	(+) ^{***}	0	IND oriented to jack mackerel; ART has no exposure.
Price – sardine	0	(+) ^{***}	Sardine is ART's primary target.
Price – anchoveta	0	(-) ^{***}	Simultaneity sign.
Hold capacity (log)	0	(+) ^{***}	Heterogeneity is within the artisanal fleet.
Bad-weather days	0	(-) ^{***}	ART vulnerable; IND insulated by vessel size.
Closure days	(-) ^{***}	(+) ^{***†}	IND: largest single coef. ART: zone FE collinear (†).

Negative binomial with year FE, vessel-clustered robust SEs. Sign and significance shown. *** $p < 0.01$. † zone-FE collinear (not causally interpretable).

Two fleets, completely different participation models.

Comparative statics — the fleet asymmetry

Fleet	Counterfactual	%ΔT marginal	%ΔT conditional	Pr(portfolio loss > 50%)
Artisanal	mid-century, moderate (SSP2-4.5)	-8.1%	-2.1%	0.95
	end-century, severe (SSP5-8.5)	-10.2%	-2.7%	0.99
Industrial	mid-century, moderate (SSP2-4.5)	-0.7%	-0.7%	0.12
	end-century, severe (SSP5-8.5)	-0.9%	-0.8%	0.12

%ΔT: change in annual trips vs baseline. Marginal averages over all posterior draws. Conditional restricts to draws with $f^H_v > 0.5$. Cross-median across a 6-model CMIP6 ensemble. NB with year FE.

- Marginal asymmetry ~**11:1** ART:IND; conditional ~**3.4:1**.
- ART portfolio collapse near-certain by SSP5-8.5 end.
- ⇒ Asymmetry runs through **probability of portfolio collapse × direct weather** ($\beta_w^{ART} < 0, \beta_w^{IND} \approx 0$); quota cross-sector limits lock it in.
- IND's protection rests on jack mackerel — **long-run shifter n.i. at both local and basin scales** (App. D-ter).

Two channels: direct vs indirect

Decomposition

Indirect (biomass → allocation):

$$\Delta SST, \Delta \log CHL \xrightarrow{\rho_i^{SST}, \rho_i^{CHL}} B_{i,t}^* \rightarrow H_{vy}^{alloc}$$

Jurel: ρ_{ENSO} over Niño 3.4 also not identified (App. D-ter).

Direct (weather → trips):

$$\Delta \text{wind} \xrightarrow{\text{vessel CDF}} \Delta \text{bw-days} \xrightarrow{\beta_w^g} T_{vy}$$

End-century SSP5-8.5

Fleet	Indirect	Direct	Total
Artisanal	-9.0 pp	-1.2 pp	-10.2%
Industrial	-0.8 pp	-0.1 pp	-0.9%

Indirect (biomass) carries **most** of the asymmetry; direct (weather) reinforces it where vessels are exposed (ART). Both channels point the same way.

Opinion: Climate effects on jurel operate on margins (location, behaviour, range) – **NOT on annual productivity elasticity at this aggregation** → Justification for expanding model using discrete choice model instead NB

Paper 2 — closing the loop

Three structural extensions \Rightarrow welfare

What gets added on top of Paper 1

- (i) **Trip-level cost function** – translog $C_{vg}(w, h, x, Z, Env)$, SUR by fleet. Recovers **input demands** (fuel, labor, ice) and elasticities of input substitution under climate shocks.
- (ii) **Inverse demand (IAIDS)** – $\ln p_{iy}$ as a function of all species' landings, instrumented by SST, CHL, fuel prices. Resolves the simultaneity observed in Paper 1.
- (iii) **Vessel dynamic optimization** –
$$\max_{T_g, h_{g\tau}} \sum_t \delta^T [P(h)h - C_g(h)] \text{ s. t. quota cap } (T_g^*, h_{g\tau}^*)$$
under each scenario.

Optimization model allows for

- (i) **Prediction under a changing climate of:**
Equilibrium prices and species substitution
- (ii) **Define optimal quota allocation**
- (iii) **Study policy reforms (counterfactuals) as adaptation:**
 - (i) Cross-sector quota transferability.
 - (ii) RAE redesign (multi-zone permits).
 - (iii) State-contingent TACs.

Takeaways

1. **Paper 1:** fleet-specific NB model of annual trips reveals **two completely different participation technologies** in the same fishery.
2. **Paper 1:** under counterfactual shocks, the marginal ART:IND participation asymmetry is **~11:1** (conditional **~3.4:1**), running through (i) the **probability of portfolio collapse** in the indirect biomass channel and (ii) **direct weather** exposure ($\beta_w^{ART} < 0, \beta_w^{IND} \approx 0$); quota cross-sector limits lock it in.
3. **Paper 2:** closes the loop – **input demand, inverse demand, vessel × social-planner joint optimization** – to deliver welfare counterfactuals: equilibrium prices, species substitution & optimal quota allocation, and policy reforms.

*Adaptive capacity is not a property of fishers; it is a property of the **bundle (portfolio × permit × institution × market)** they sit in. Identifying adaptation requires modeling all four dimensions jointly – pooling, fixed prices, or aggregate effort all bias the answer.*

¡Gracias! / Thank you

Questions?

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