Developing alternatives to resource extraction: A developmental and environmental win-win?

Days MESSH 2023 - Sète

Michael Tanner[a,c], **Robbert-Jan Schaap**[b]

Cesar Viteri-Mejia[c], Jorge Ramírez-González[c]

A - Department of Socioeconomics, University of Hamburg

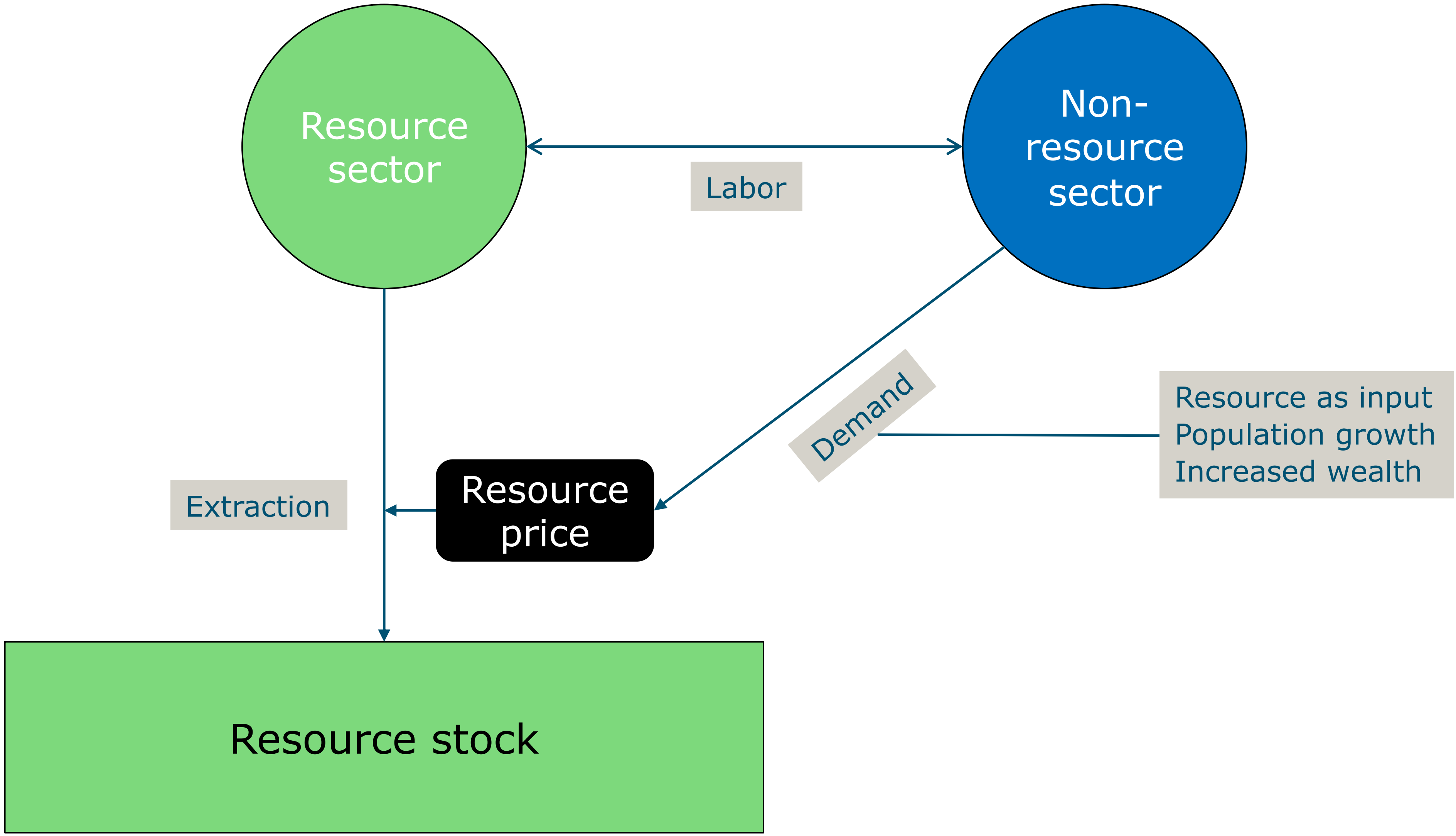
B - CEE-M, Univ. Montpellier, CNRS, INRAe, Institut Agro

C - Charles Darwin Research Station, Galapagos, Ecuador

Motivation

- Developing countries often lack enforcement power for first best quotas (Copeland and Taylor, 2009).
- In lieu second best policies are implemented to protect the resource (MPAs, input restrictions)
- Access to alternative occupations can increasing the opportunity cost of resource extraction (Jayachandran, 2006).
- Net effect of presence alternative occupations on resource extraction depends on complex set of linkages (Gilliland, 2020).

Conceptual example



This paper

- Develop a resource economic model
  - Multiple resources – different dependencies on a non-resource sector
  - Endogenous prices and opportunity costs.
  - Under what conditions does the non-resource sector reduce harvesting effort?

- Assess the causal impact of tourism on resource extraction in the Galapagos islands.
  - Are the conditions from the model met?
  - Does a shock to tourism influence effort?

Theoretical framework

- Starting point: Gordon-Schaefer open-access fishery (Gordon, 1954)
- N identical agents have access to a set of resources ($\boldsymbol{X}$).
- Resources are heterogeneous in prices (P_x), catchability (q_x) and abundance (s_x)
- Agents can distribute 1 unit of effort to harvesting these resources.

$$\sum_{x=1}^{X} e_x \leq 1$$

Theoretical framework

- Agents maximize within period income

$$\max_{e_x} \pi = \sum_{x=1}^{X} h_x p_x - e_x(\bar{c} + T\omega)$$

- Harvest function

$$h_x = e_x s_x q_x$$

- Prices are endogenous and dependent on the non-resource sector

$$p_x = \bar{p}_x + \epsilon_x H_x + \gamma_x T \quad \text{where} \quad \epsilon_x \leq 0, \quad \gamma_x \geq 0$$

Choice of effort – Internal solution

- Case:

$$\sum_{x=1}^{X} e_x < 1$$

- In equilibrium:

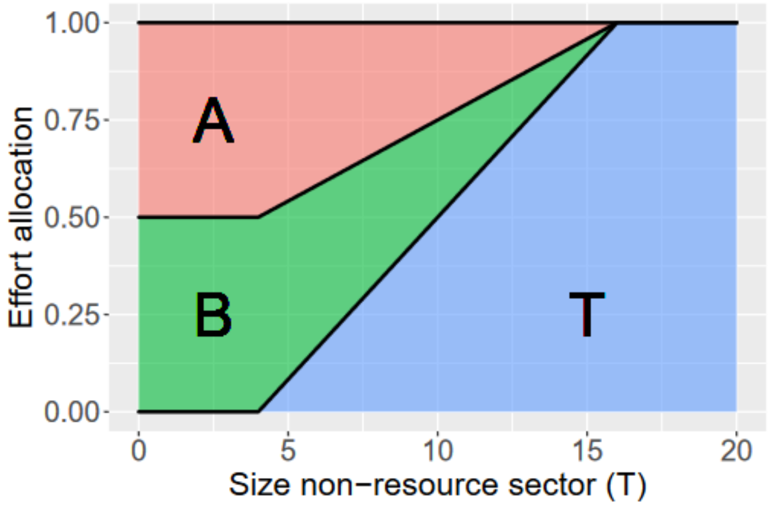
$$\forall e_x > 0, \qquad \frac{\partial h_x p_x}{\partial e_x} = \bar{c} + T\omega$$

- Optimal effort

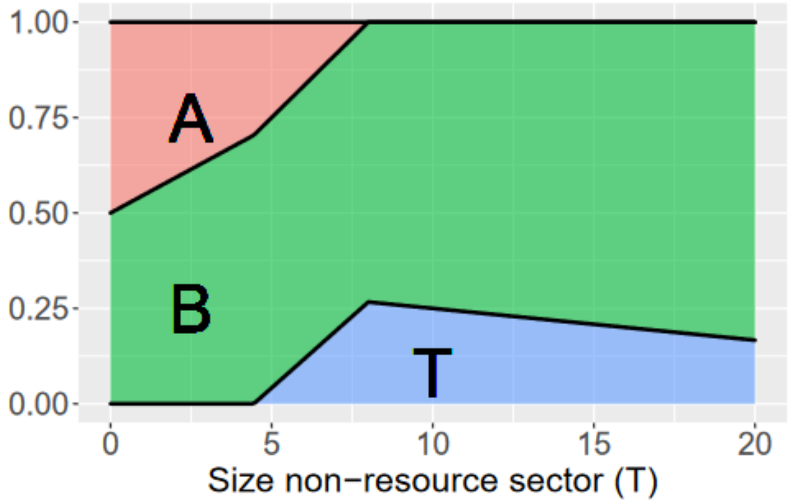
$$e_x^* = \frac{\bar{c} + \omega T - (T\gamma_x + \bar{p}_x) q_x s_x}{2N\epsilon_x q_x^2 s_x^2}$$

Choice of effort – Non-resource sector

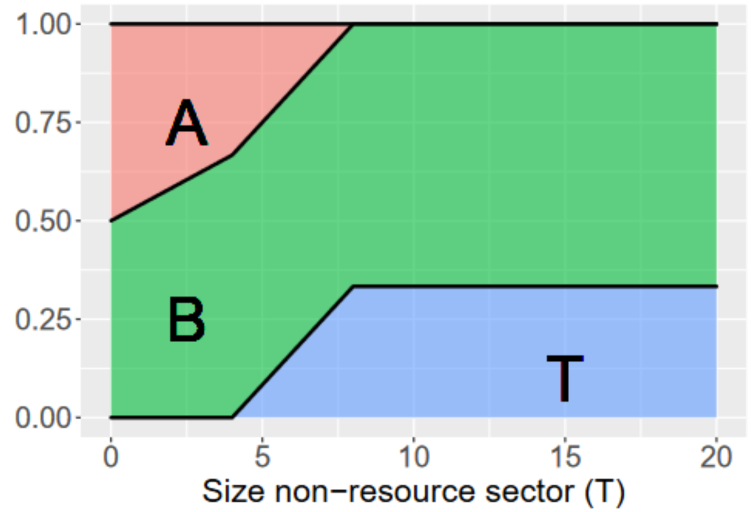
$\omega > q_b s_b \gamma_b = q_a s_a \gamma_a$



$q_b s_b \gamma_b > \omega > q_a s_a \gamma_a$



$q_b s_b \gamma_b = \omega > q_a s_a \gamma_a$



Prediction 1: When the effort constraint is non-binding, harvesting effort allocated to resource x w increases with the size of the non-resource sector when

$$q_x s_x \gamma_x > \omega$$

Choice of effort – Corner solution

- Two resources:

$$X \in (a, b)$$

- In equilibrium:

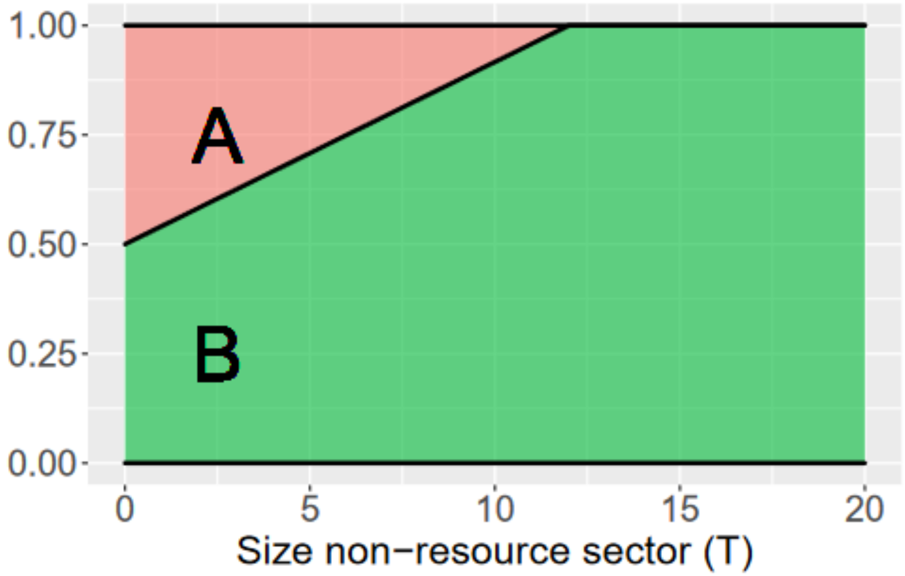
$$e_a = 1 - e_b$$

- Optimal effort

$$e_a^* = \frac{2N\epsilon_b q_b^2 s_b^2 + (p_b + T\gamma_b) q_b s_b - (T\gamma_a + \bar{p}_a) q_a s_a}{2N(\epsilon_a q_a^2 s_a^2 + \epsilon_b q_b^2 s_b^2)}$$

Choice of effort – Non-resource sector

$q_b s_b \gamma_b > q_a s_a \gamma_a$



Prediction 2: When the effort constraint is binding, harvesting effort shifts with the size of the non-resource sector to the resource with the highest marginal gain in productivity $(qs\gamma)$

Resource dynamics

- Simplify to one resource -> study change in steady state when T changes

- Standard resource dynamics

$$s_{t+1} = s_t + G(s_t) - H_t$$

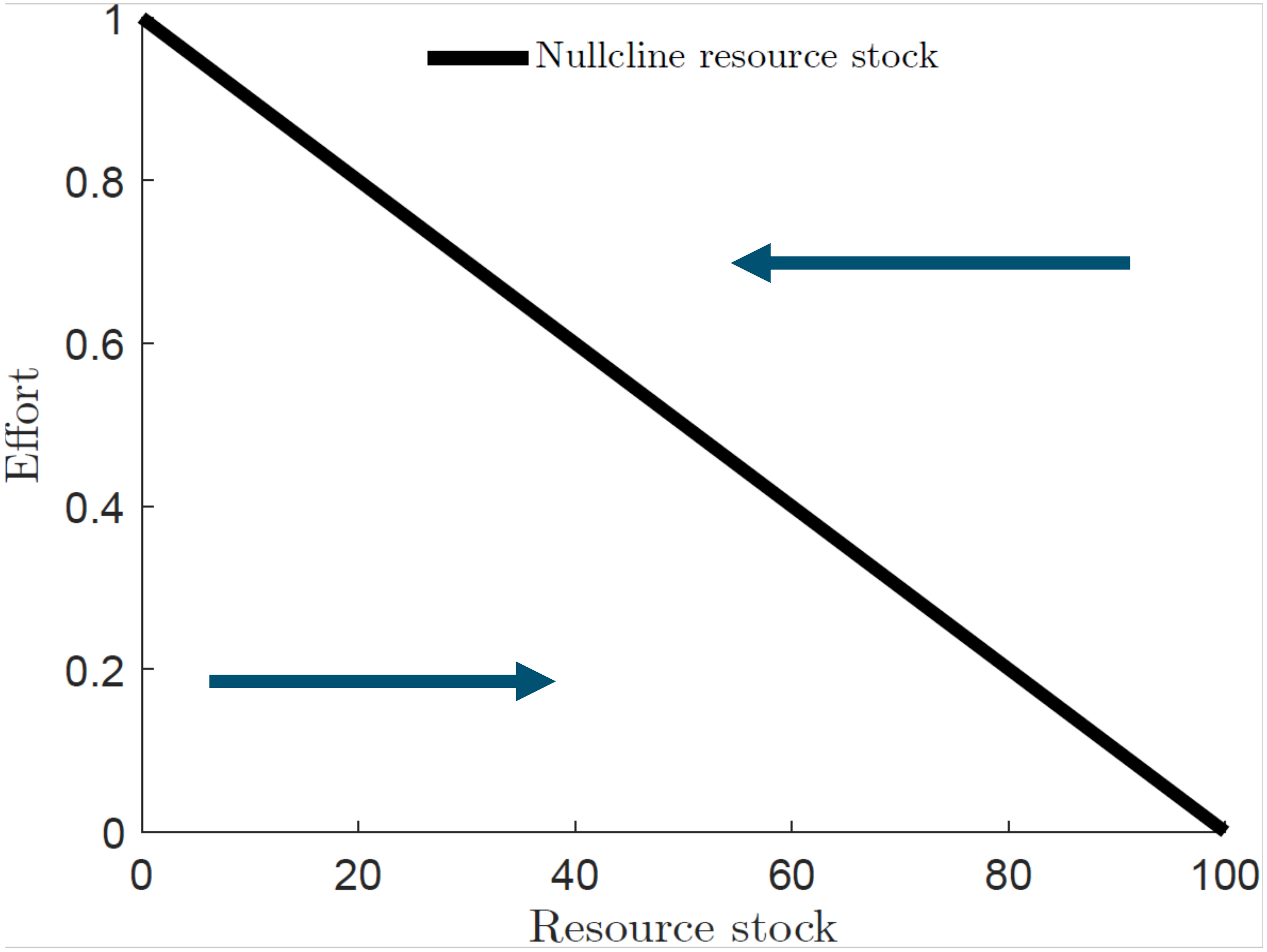
- Logistic growth function

$$G(s_t) = rs_t(1 - \frac{s_t}{k})$$

- Resource stock nullcline

$$\bar{e}(s) = \frac{kr - sr}{Nkq}$$

Steady states $(\epsilon = 0)$

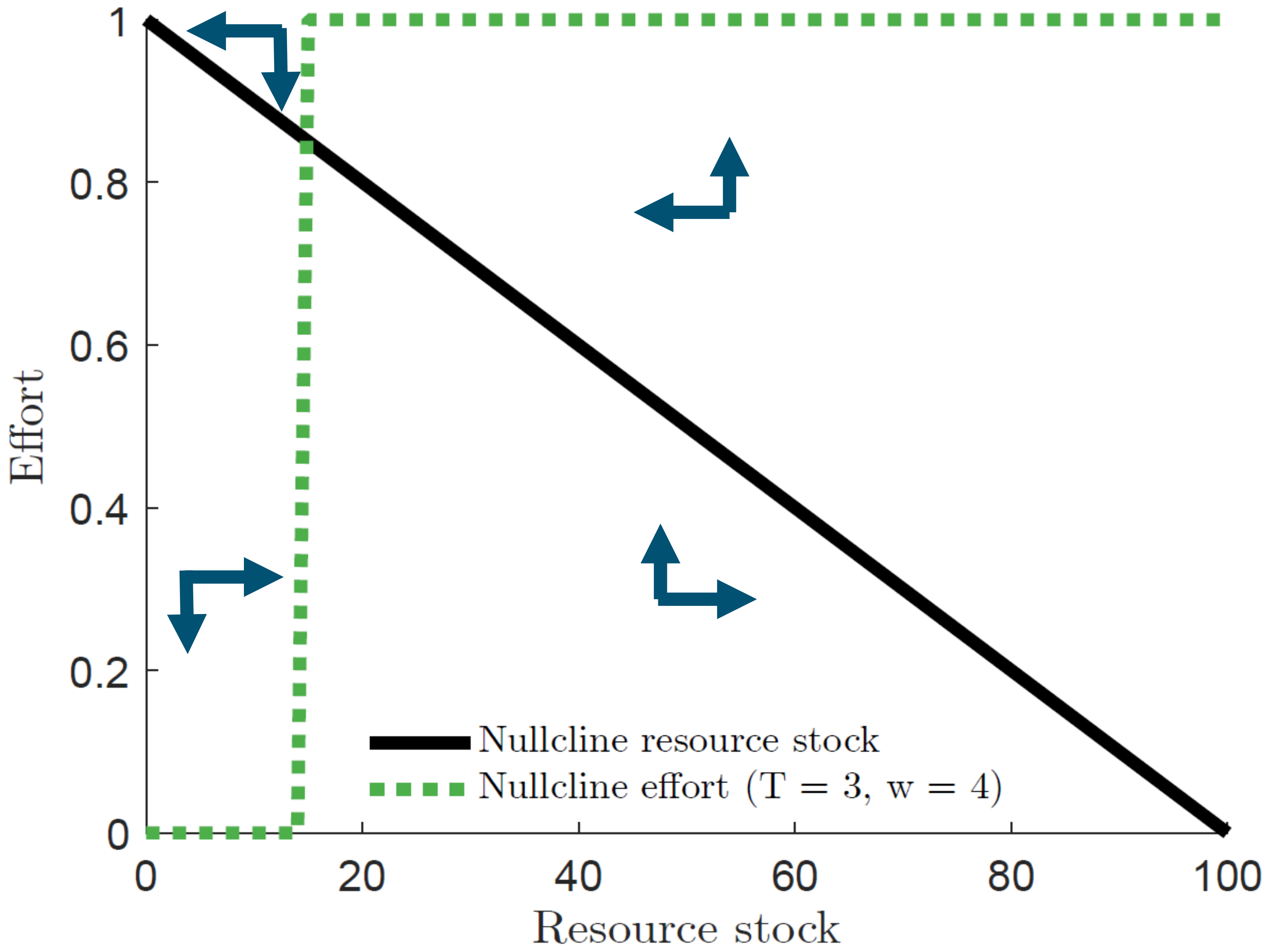


Steady states $(\epsilon = 0)$

Stable steady state is given by:

$$\bar{s}_{ce} = \frac{\bar{c} + \omega T}{q(\bar{p} + \gamma T)}$$

$$\frac{\partial \bar{s}_{ce}}{\partial T} > 0 \;\; if \;\; \bar{c}\gamma > \omega p$$



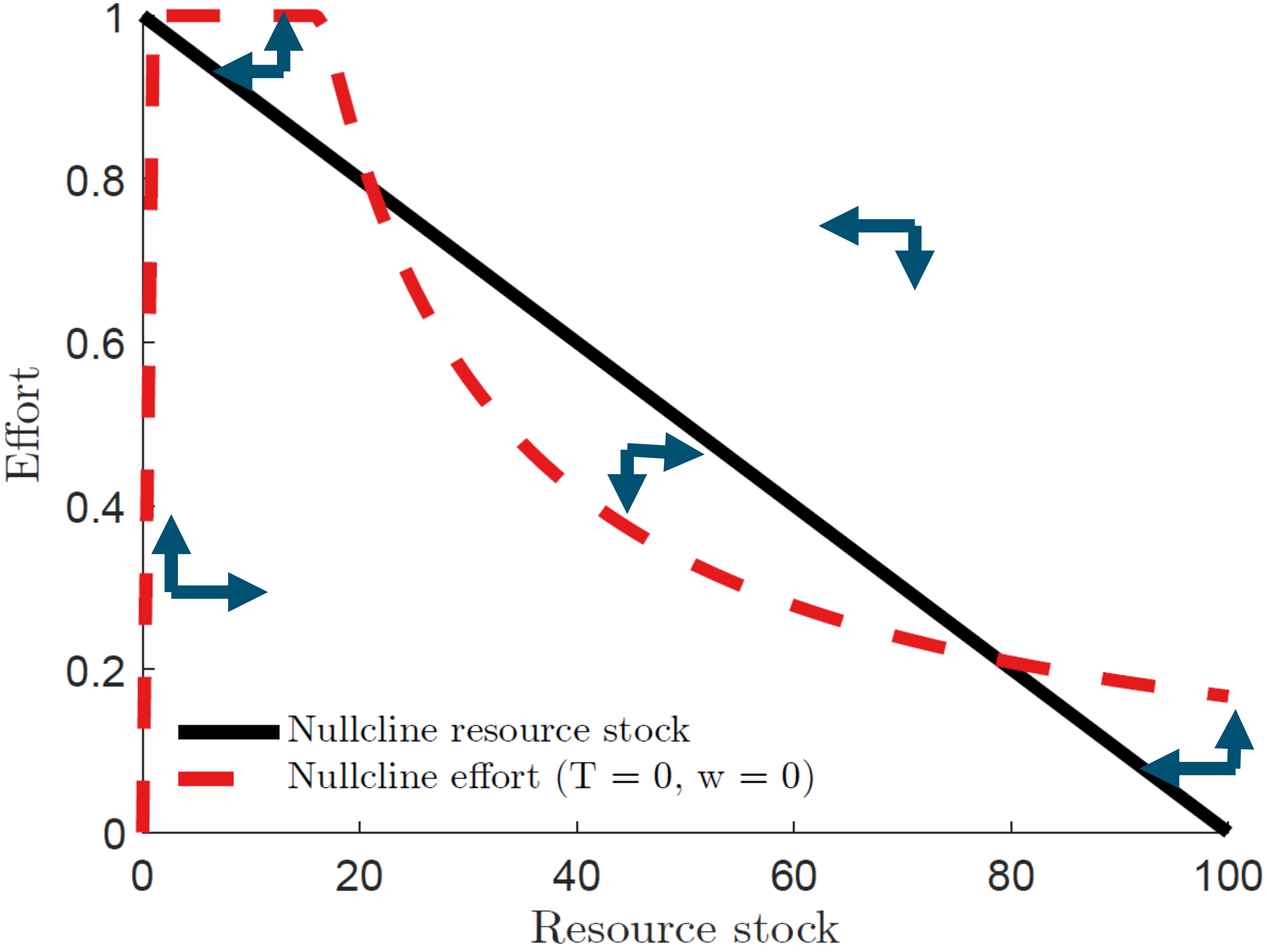
Steady states ($\bar{c} = \omega = 0$)

Steady states are given by:

$$\bar{s}_{pe} = \frac{k\left(r \pm \sqrt{\frac{r(2\bar{p} + 2T\gamma + k\epsilon r)}{2\epsilon}}\right.}{2r}$$

Agents want to supply a constant level of harvest.

Increase in harvest is balanced by decrease in price

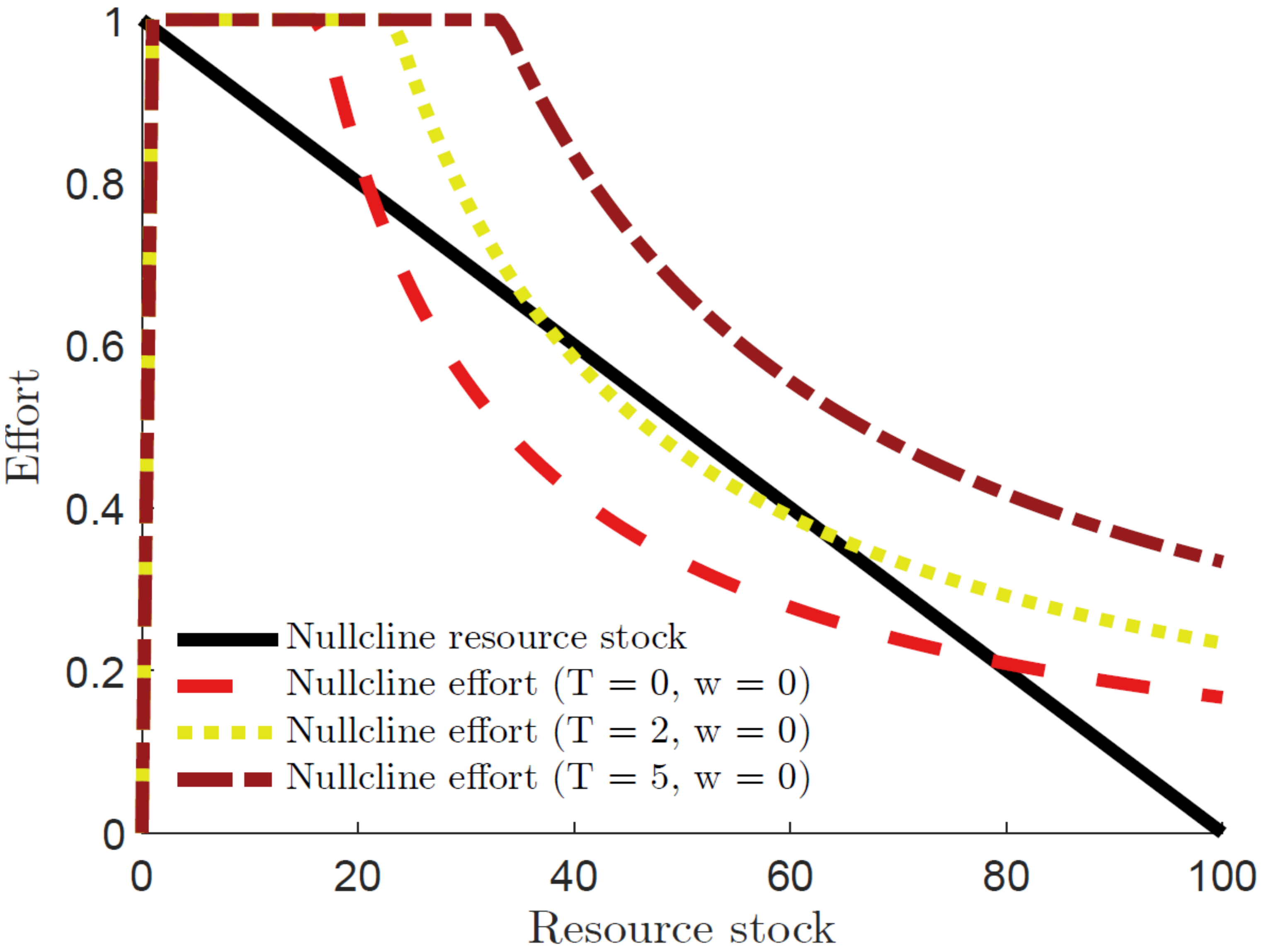


Steady states ($\bar{c} = \omega = 0$)

Optimal effort increases as price increases

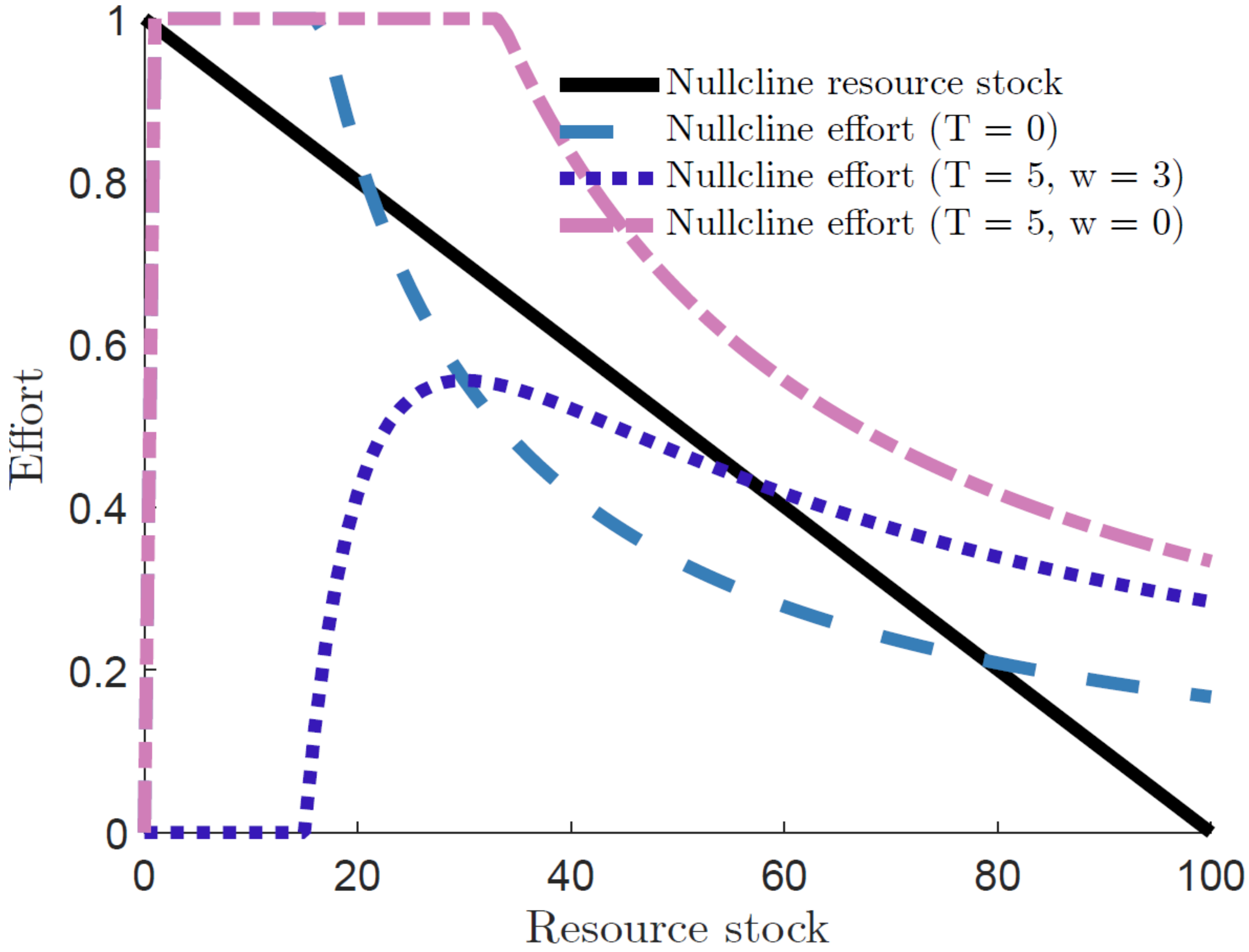
Steady states do not exist exist when

$$2\bar{p} + 2T\gamma > k\epsilon r$$



Steady states ($\bar{c} > 0, \omega > 0, \epsilon > 0$)

Development of steady states as T increases, is dependent on the ratio between ω and γqs

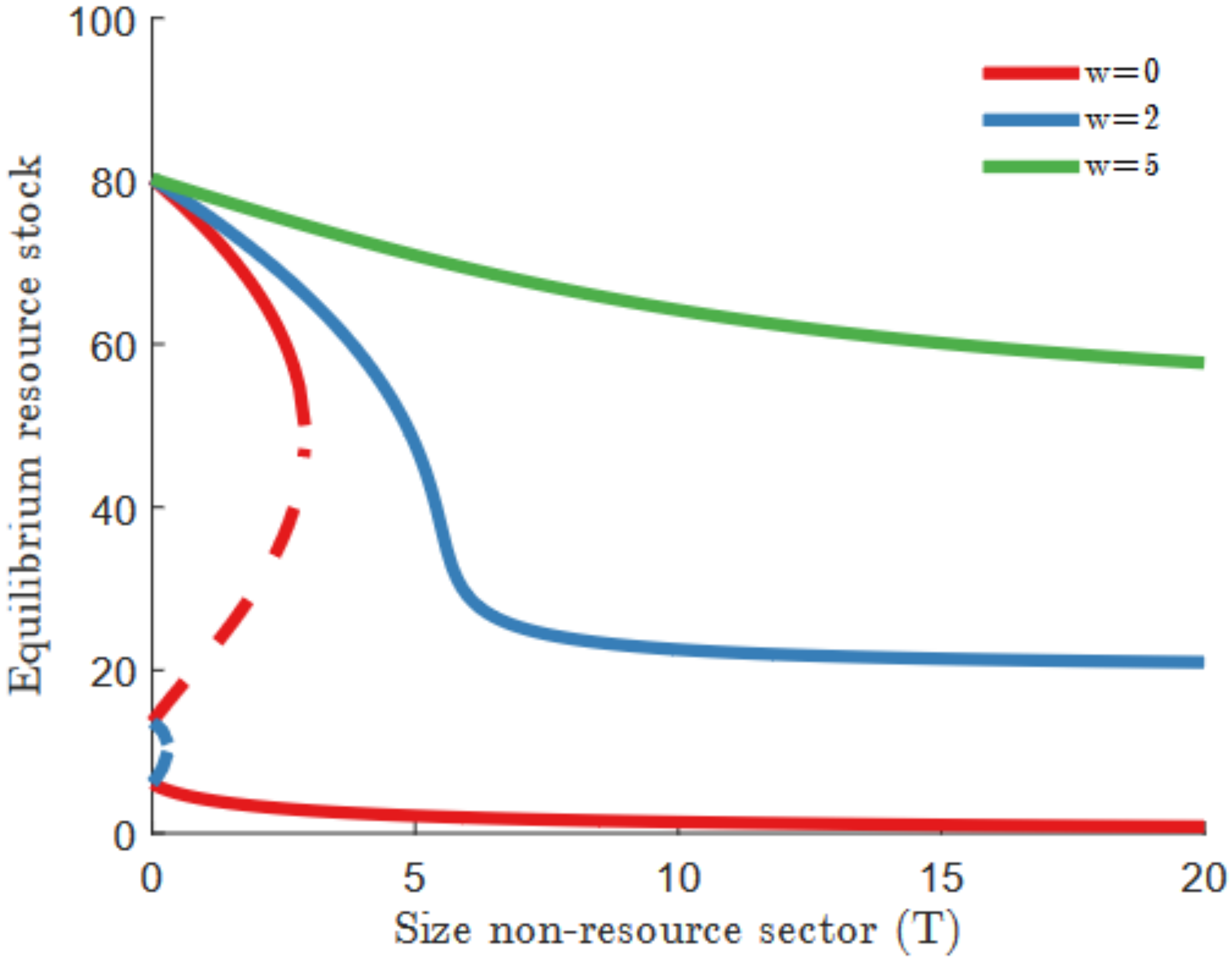


Development of steady states

Development of steady states as T increases, is dependent on the ratio between ω and $\gamma q s$

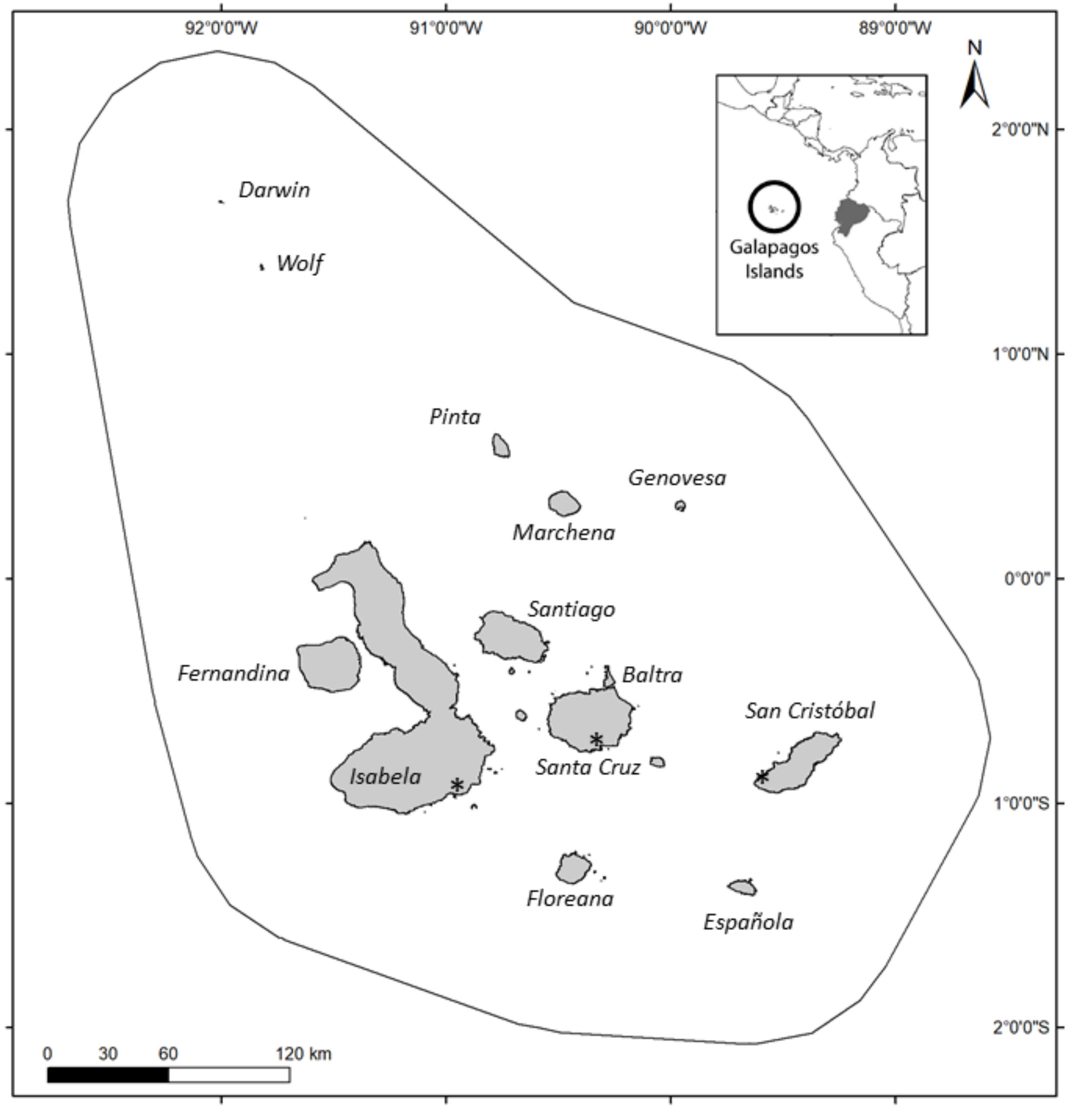
Single steady state converges to

$$\lim_{T\to\infty} \bar{s} = \frac{\omega}{q\gamma}$$



Field setting – The Galapagos Islands

- Hotspot for biodiversity and conservation.
- Multiple fisheries are overexploited due to quotas not being enforceable.
- Galapagos marine protected area (138,000 km2) and input restrictions
- Dual economy, tourism and fisheries.



Testing Hypothesis 1: Two sectors

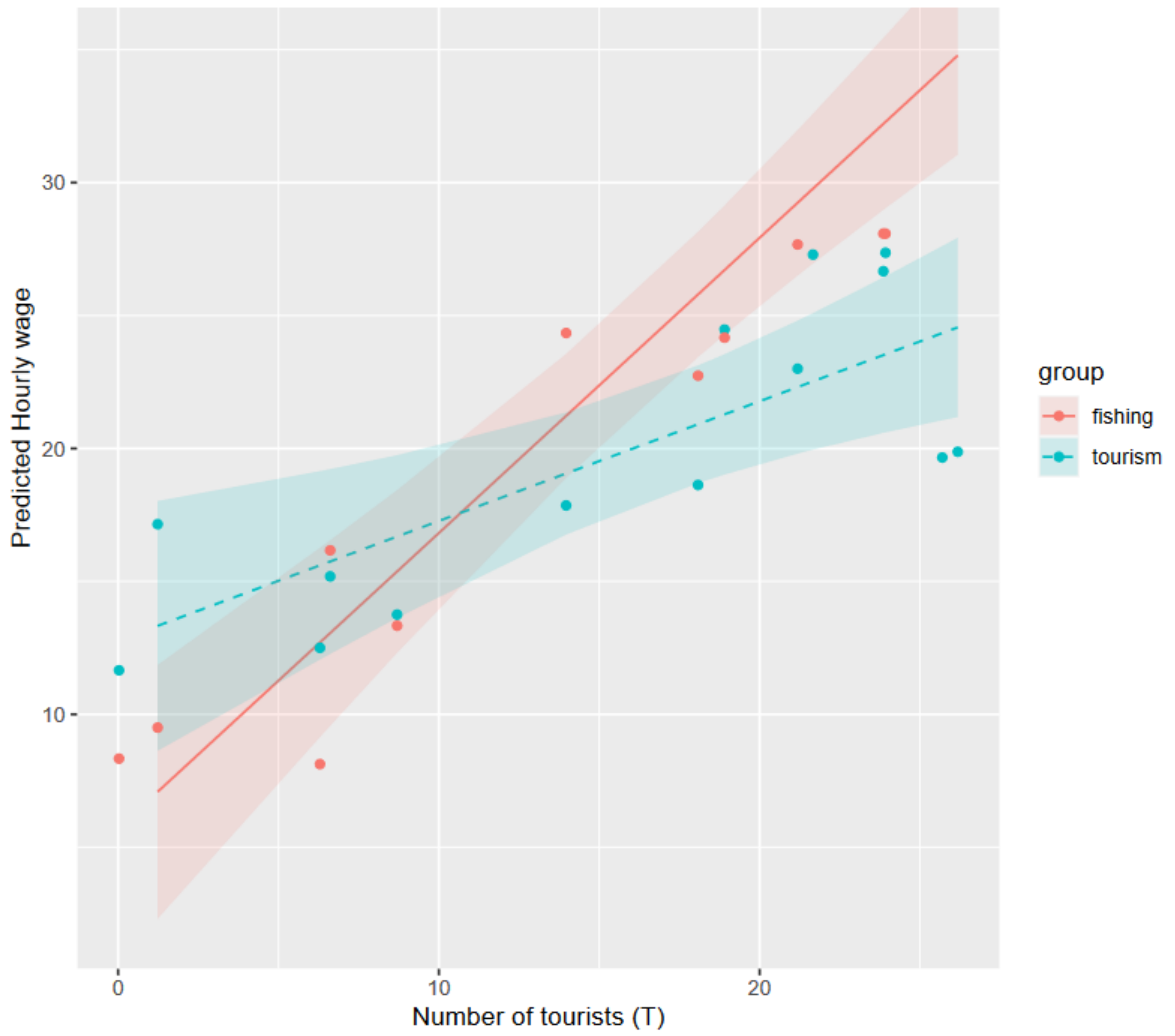
Copyright: CDF

Testing Hypothesis 1: Parameterizing model

Prediction 1: When the effort constraint is non-binding, harvesting effort weakly increases with the size of the non-resource sector when $qs\gamma > \omega$

- Regress hourly wage in fisheries sector and tourism sector on tourist arrivals.
- Data from quarterly national census (2018-2021).

$$qs\gamma = 1.11 \quad \omega = 0.45$$



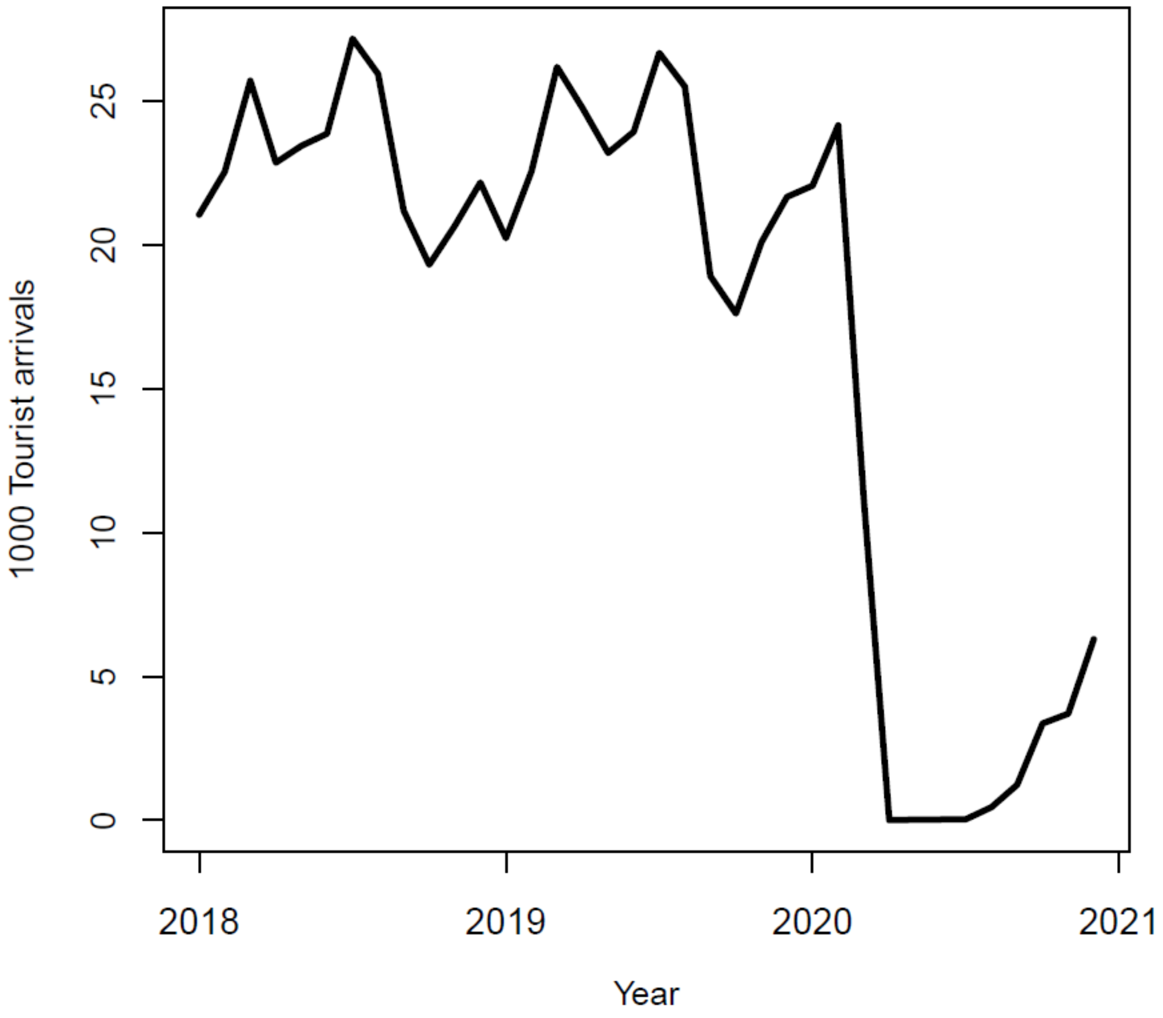
Testing Hypothesis 1: Empirical strategy

- Regression discontinuity in time (RDiT) – Exploit exogenous shock to tourism

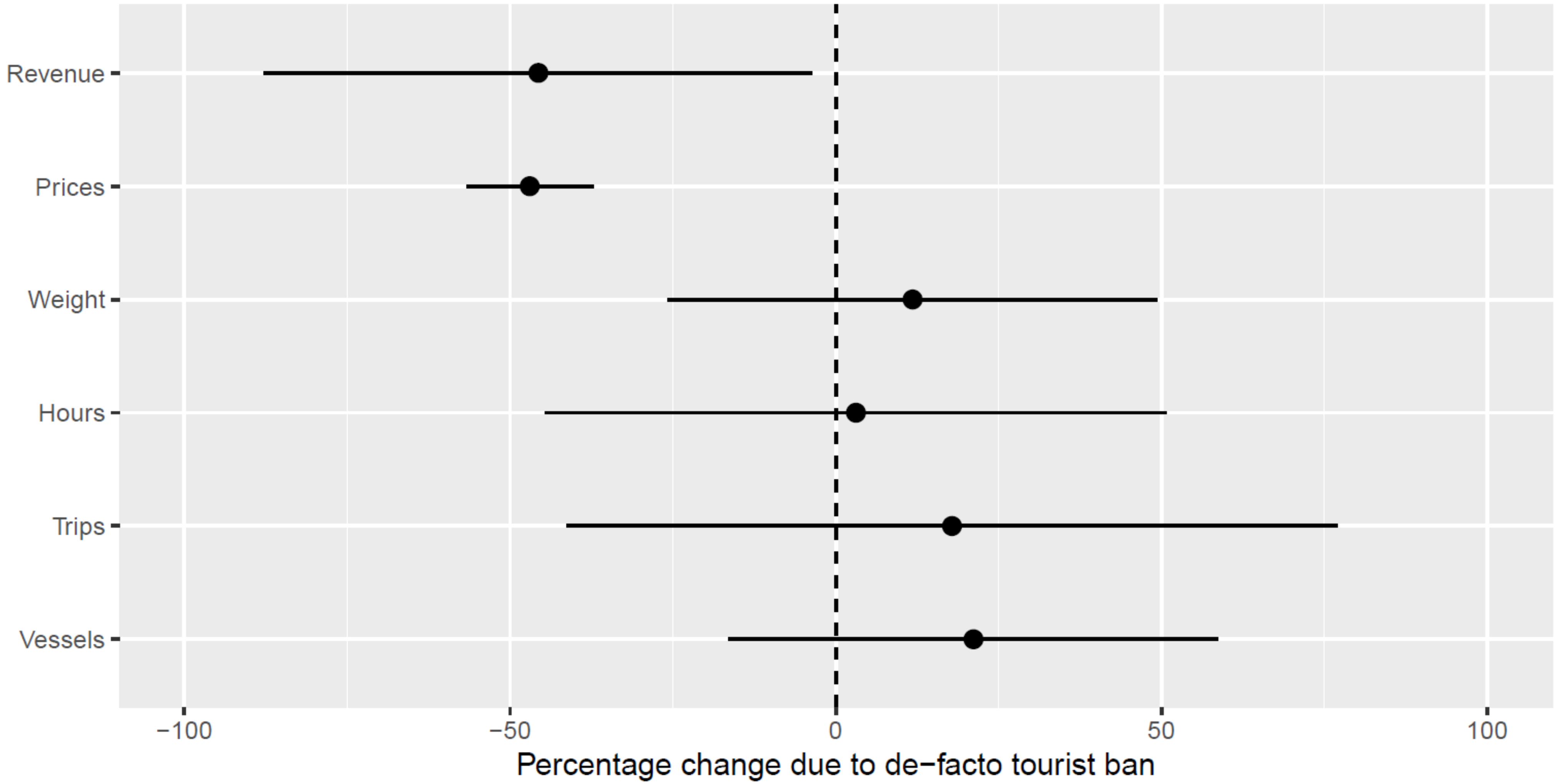
$$y_t = (t > t_{TB})\beta_1 + \boldsymbol{X_t}\boldsymbol{\beta} + \gamma_t + \epsilon$$

- Total changes in effort, weight landed, prices and revenue.
- $\boldsymbol{X_t}$ time-variant controls for seasonality and policy.
- Heteroscadisticy and autocorrelation robust standard errors (Newey and West, 1987)

Testing Hypothesis 1: Shock to non-resource sector



Testing Hypothesis 1: Regression results



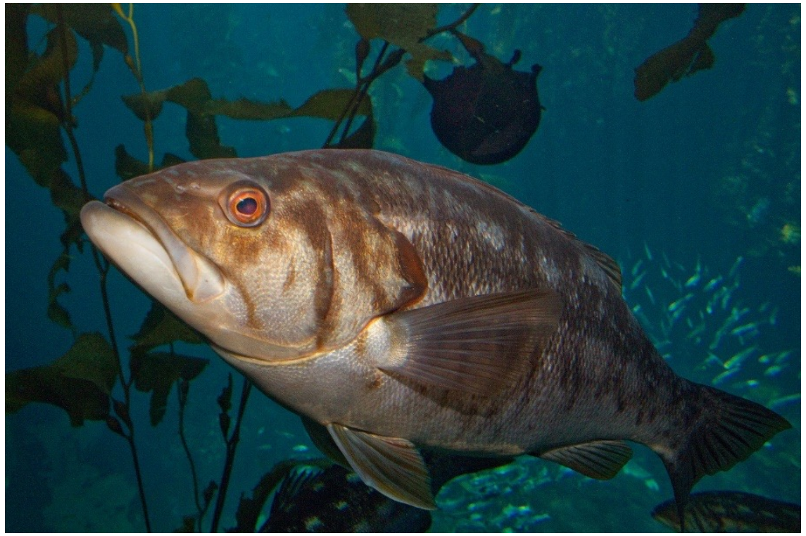
Yellowfin Tuna (*Thunnus albacares*)
ICUN: Near Threatened

+13

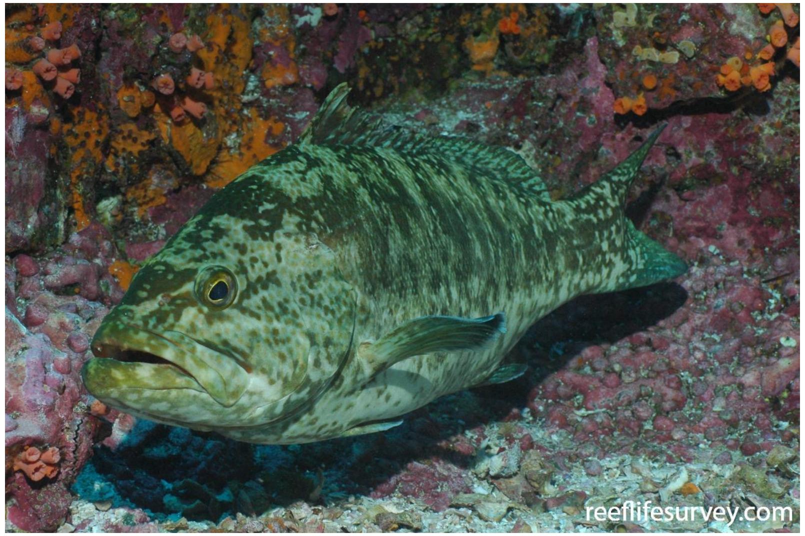
Galapagos slipper lobster (*Scyllarides astori)*
ICUN: Data deficient

+2

Camotillo (*Paralabrax albomaculatus)*
ICUN: Endangered & Endemic to Galapagos



Galapagos Grouper (*Mycteroperca olfax*)
ICUN: Vulnerable & Endemic to Galapagos



+40

Testing Hypothesis 2: Parameterizing model

	Dependent variable: **Price**			
	Pelagic	Finfish	Langosta	Langostino
	(1)	(2)	(3)	(4)
Weight landed (ϵ_x)	−0.03***	0.005	0.03	−0.59*
	(0.01)	(0.01)	(0.02)	(0.32)
1000 Tourists (γ_x)	0.04***	0.05***	0.28***	0.36***
	(0.01)	(0.02)	(0.04)	(0.07)
Time-trend	0.03***	0.03***	0.08***	0.01
	(0.005)	(0.01)	(0.03)	(0.03)
Constant ($\bar{p_x}$)	5.43***	4.97***	6.79***	6.86***
	(0.34)	(0.97)	(1.03)	(1.52)
Observations	60	60	29	19
R^2	0.67	0.66	0.83	0.31
Adjusted R^2	0.57	0.56	0.76	−0.03
Note:		* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$		

Fishery	γ_x	$q_x s_x$	$\frac{\gamma_x q_x s_x}{n_x}$
Pelagic	0.04	25.6	0.24
Finfish	0.05	30.32	0.64
Langosta	0.28	10.2	1.16
Langostino	0.36	8.9	1.24
Fishing			1.11
Tourism			0.45

Testing Hypothesis 1: Per fishery

Prediction 1: When the effort constraint is non-binding, harvesting effort allocated to a resource x is predicted to increase due to a negative shock to T when $\omega > q_x s_x \gamma_x$

$q_x s_x \gamma_x$ Lobster −

$q_x s_x \gamma_x$ Finfish −

ω Tourism

$q_x s_x \gamma_x$ Pelagic +

	Dependent variable:				
	Total	Pelagic	Finfish	Langosta	Langostino
	(1)	(2)	(3)	(4)	(5)
Tourist-Ban	62.00	92.79***	−39.40	−25.11	−22.00***
	(41.68)	(19.74)	(35.81)	(19.30)	(6.46)
longline	161.26*	173.39***	−34.81	37.87	−4.81
	(90.21)	(42.71)	(77.50)	(28.98)	(17.17)
ENSO-index	−16.72	−28.65***	3.53	3.84	−2.89
	(15.20)	(7.20)	(13.06)	(8.77)	(3.90)
Time-trend	1.08	−0.20	0.43	3.38***	0.85*
	(0.74)	(0.35)	(0.63)	(0.75)	(0.46)
Observations	5,432	5,432	5,432	2,910	1,940
R^2	0.01	0.02	0.01	0.02	0.02

Note: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Testing Hypothesis 2: Per fishery

Prediction 2: When the effort constraint is binding, a negative shock to T will shift harvesting effort to resources with lower $(qs\gamma)$

$q_x s_x \gamma_x$ Lobster –

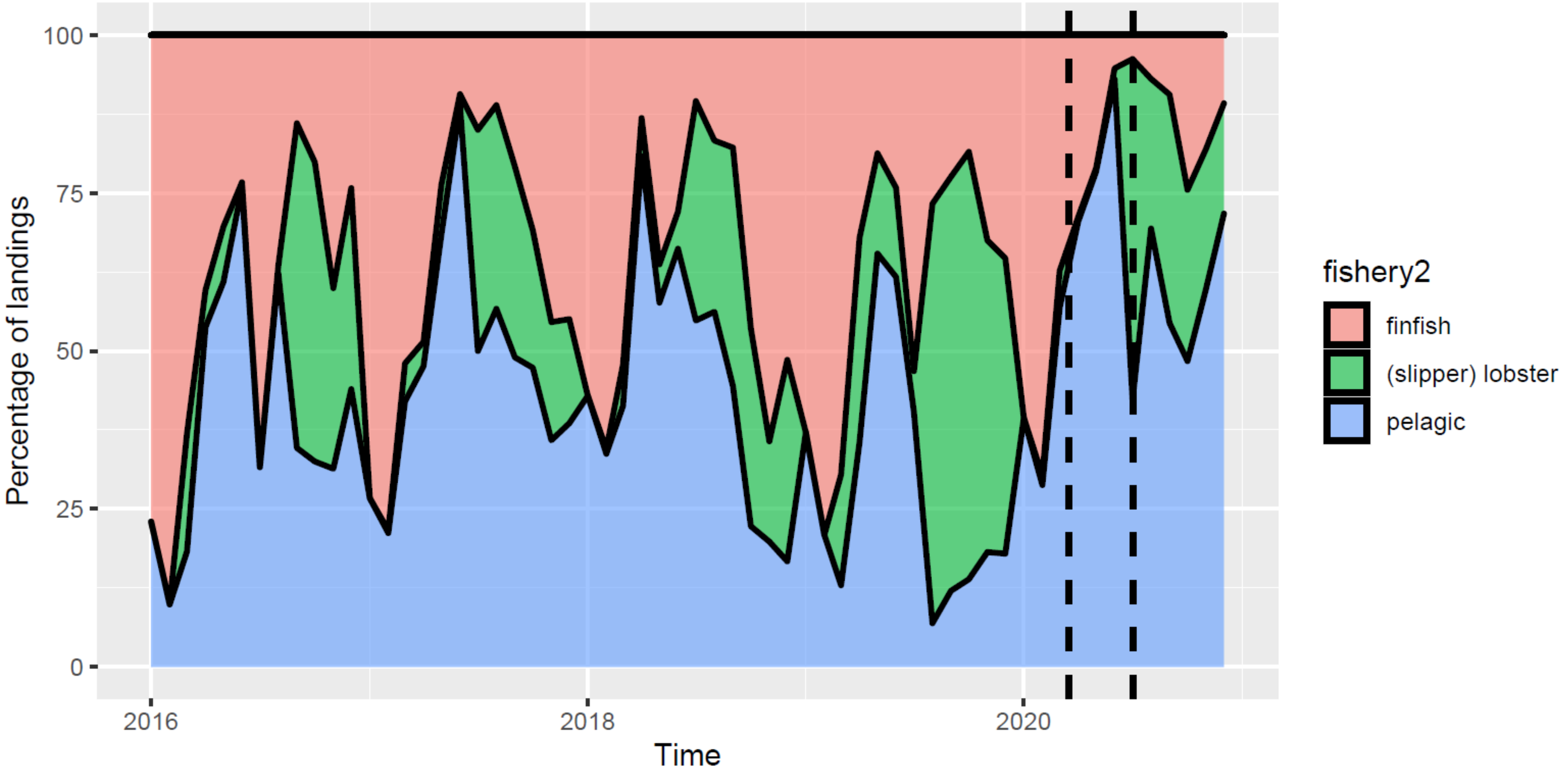
$q_x s_x \gamma_x$ Finfish +/-

$q_x s_x \gamma_x$ Pelagic +

	Dependent variable:				
	Total	Pelagic	Finfish	Langosta	Langostino
	(1)	(2)	(3)	(4)	(5)
Tourist-Ban	18.16	69.61***	−16.98	−62.05***	−28.72***
	(31.63)	(16.97)	(25.55)	(19.02)	(5.58)
longline	347.78***	336.37***	−3.72	20.58	3.57
	(65.60)	(35.20)	(52.99)	(27.37)	(14.21)
ENSO-index	−3.91	−15.26**	1.70	5.37	7.39**
	(11.54)	(6.19)	(9.32)	(8.64)	(3.37)
Time-trend	0.43	0.14	−0.63	3.16***	2.09***
	(0.56)	(0.30)	(0.45)	(0.74)	(0.40)
Observations	4,984	4,984	4,984	2,670	1,780
R^2	0.02	0.03	0.02	0.03	0.02

Note: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Catch composition



Conclusions

- The presence and intensification of an alternative economic sector can increase or decrease harvesting effort.
  - The direction is determined by the responsiveness of the effective wage in each sector to the growing alternative economic sector.

- A shock to the tourism sector in Galapagos had no significant effect on total effort in the fisheries sector, but did shift effort between fisheries.

- Tourism in the Galapagos is likely detrimental to the lobster stocks and potentially the vulnerable finfish stocks