Regional and sectorial impacts of cost allocation rules & impacts of ecological restoration schedule : input-output/system dynamics modeling

Mateo Cordier, Takuro Uehara

M

Regional and sectorial impacts of cost allocation rules & impacts of ecological restoration schedule : input-output/system dynamics modeling

Mateo Cordier
Université de Versailles Saint-Quentin-en-Yvelines

Takuro Uehara
Ritsumeikan University

September 2018

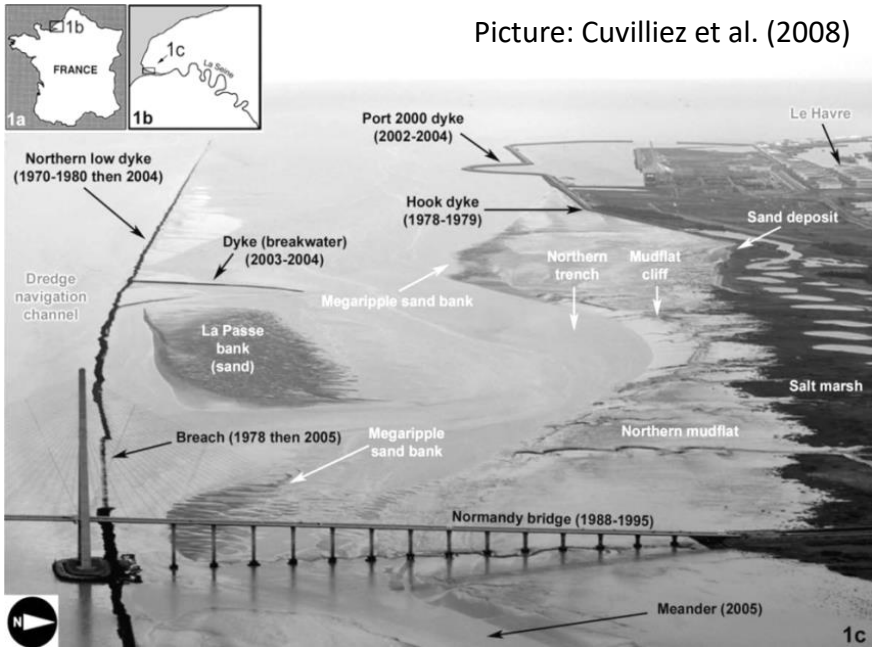
M

Method and study area

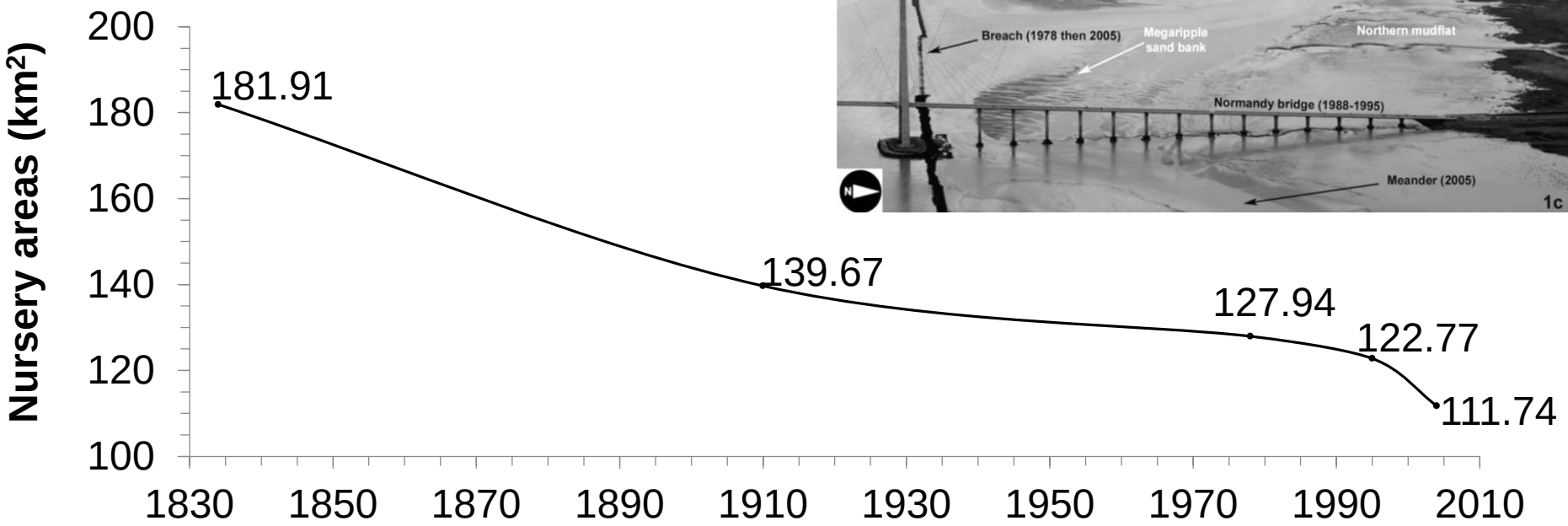
M

Study Area: The Seine Estuary (France)

- **Nursery areas for sole have decreased due to harbour infrastructure expansion**



Picture: Cuvilliez et al. (2008)

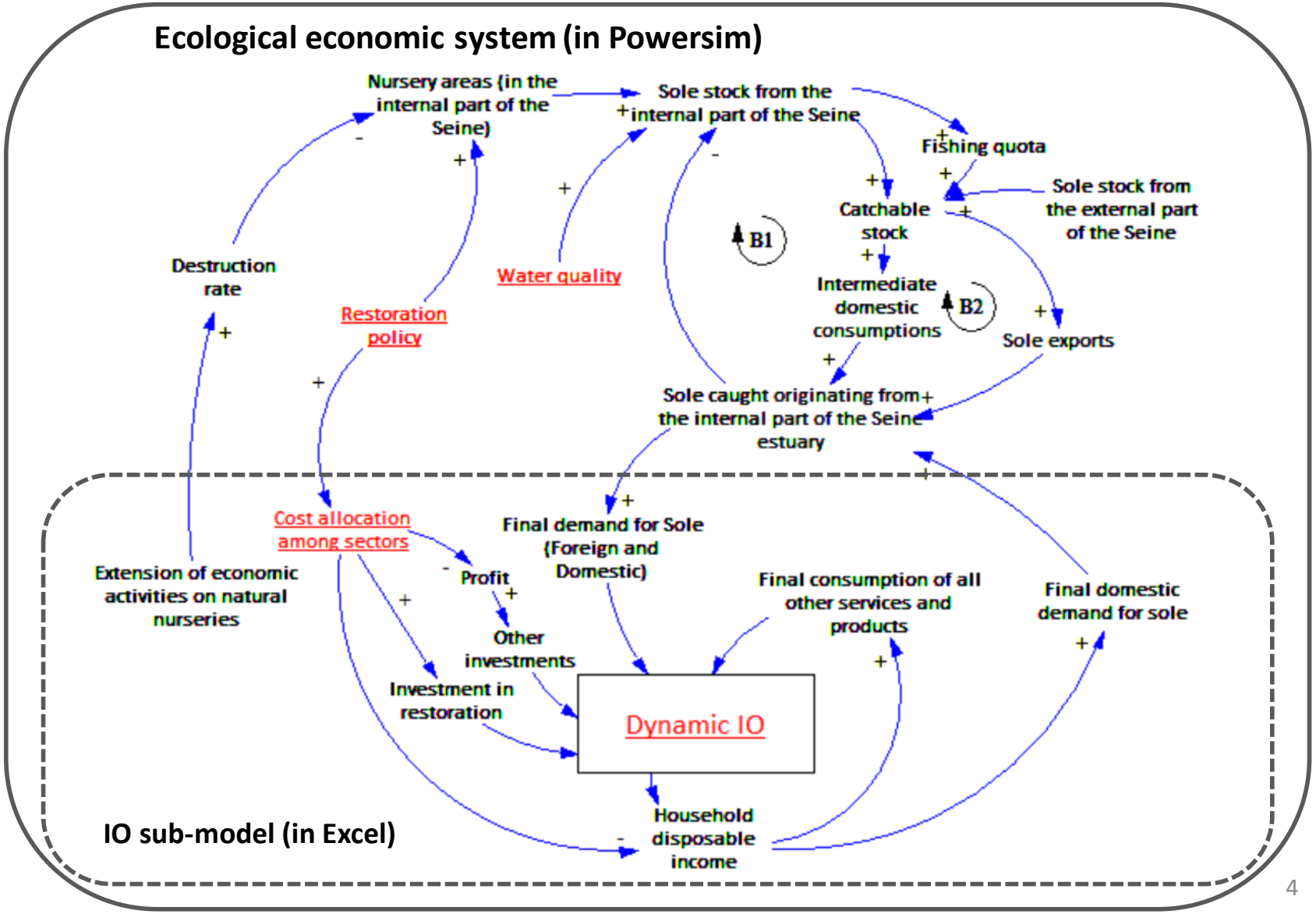


Evolution of nursery areas of the internal part of the Seine estuary.

Source of data: Rochette et al. (2010)

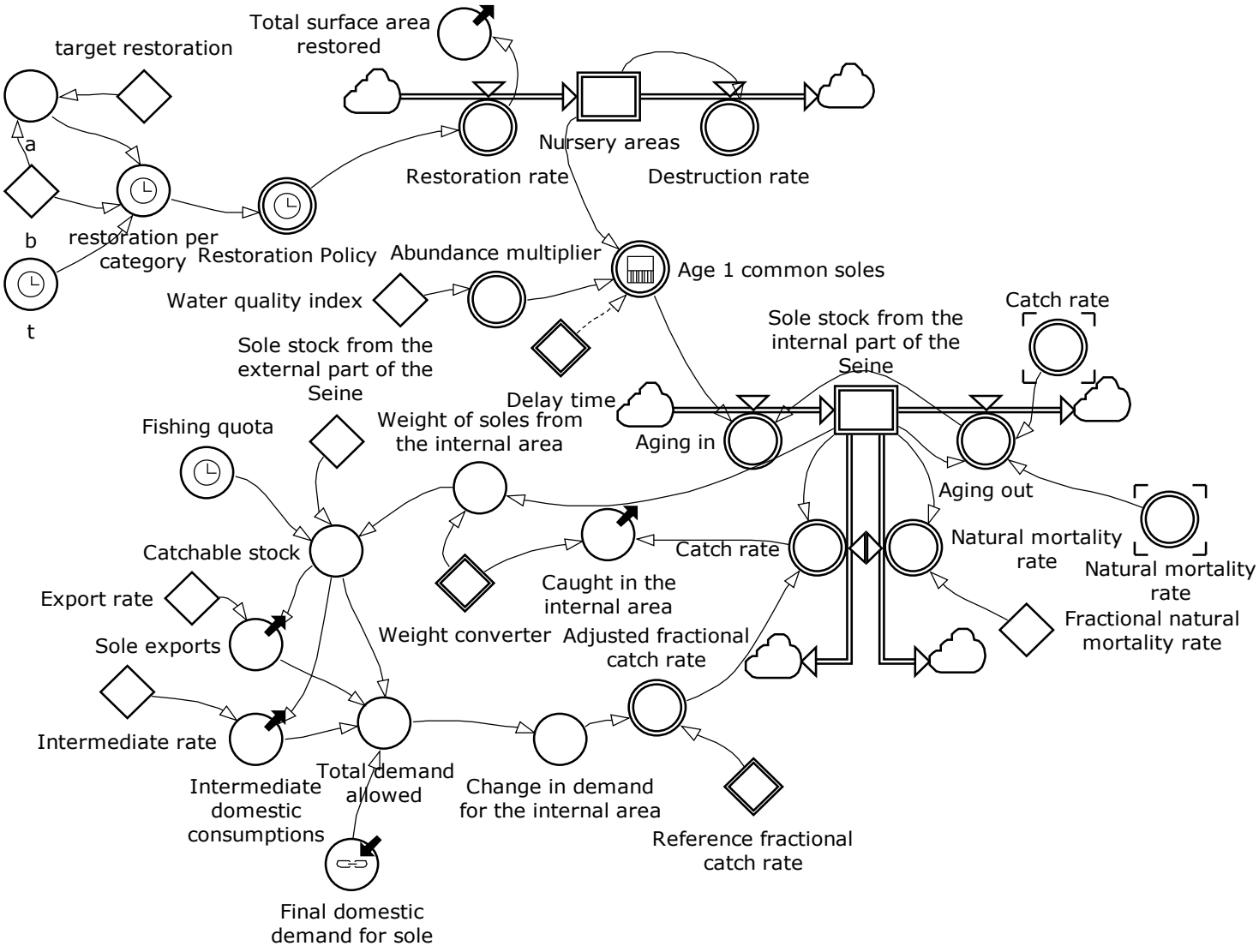
T

Conceptual scheme of the IO/SD model



T

The SD ecological-economic model



M

The IO sub-model

	Buying Sector $(j = 1, \dots, n; n = 37)$	Final Demand $(k = 1, \dots, f; f = 8)$	Total Output
Selling Sector $(i = 1, \dots, n; n = 37)$	$\mathbf{X}$ x_{ij}	$\mathbf{F}$ f_{ik}	$\mathbf{x}$ x_i
Imports	$\mathbf{mi}'$ mi_j	$\mathbf{mf}'$ mf_k	m
Value Added $(l = 1, \dots, p; p = 3)$	$\mathbf{V}$ v_{lj}		$\mathbf{v}$ v_l
Total Outlays	$\mathbf{x}'$ x_j		

M

Dynamization of the IO sub-model

$$\mathbf{x}_t = \left[\left(\mathbf{I} - \widehat{\boldsymbol{\beta}}_t \mathbf{A}\right)^{-1} \widehat{\boldsymbol{\beta}}_t\right] \mathbf{f}_t \qquad \forall t = 1, \ldots, T$$

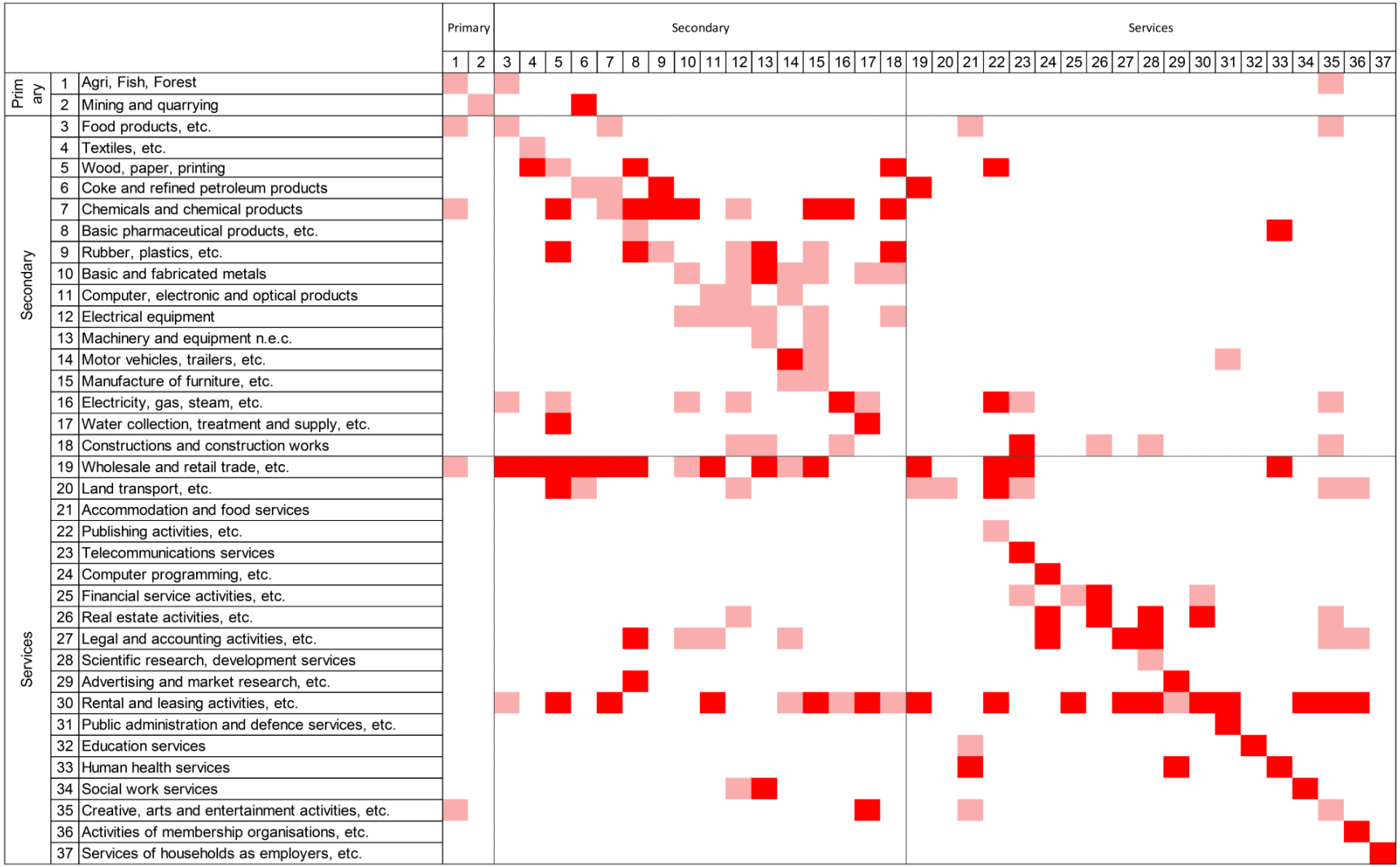
where $\widehat{\boldsymbol{\beta}}_t$ is a diagonal matrix with the elements, $\widehat{\boldsymbol{\beta}}_{i,t}$, computed as:

$$\widehat{\boldsymbol{\beta}}_{i,t} = \exp\left[\alpha_0 + \alpha_z \log\left(\frac{x_{i,t-1}}{z_{i,t-1}}\right) + \alpha_g g_{i,t}\right] \qquad \forall i = 1, \ldots, n$$

M

Changes in IO technical coefficients over the period 2012-2032

Positive changes: dark color. Negative changes: lighter color. No changes: white cells



T

Scenarios simulated

T

Scenario development

- Exploring the dynamic behaviors of the model

Scenarios	Policy impact Assessment
	Restoration schedule
Business as usual (BAU)	No restoration
Restoration scenarios	1. Increasing 2. Constant 3. Decreasing

M

Scenario development

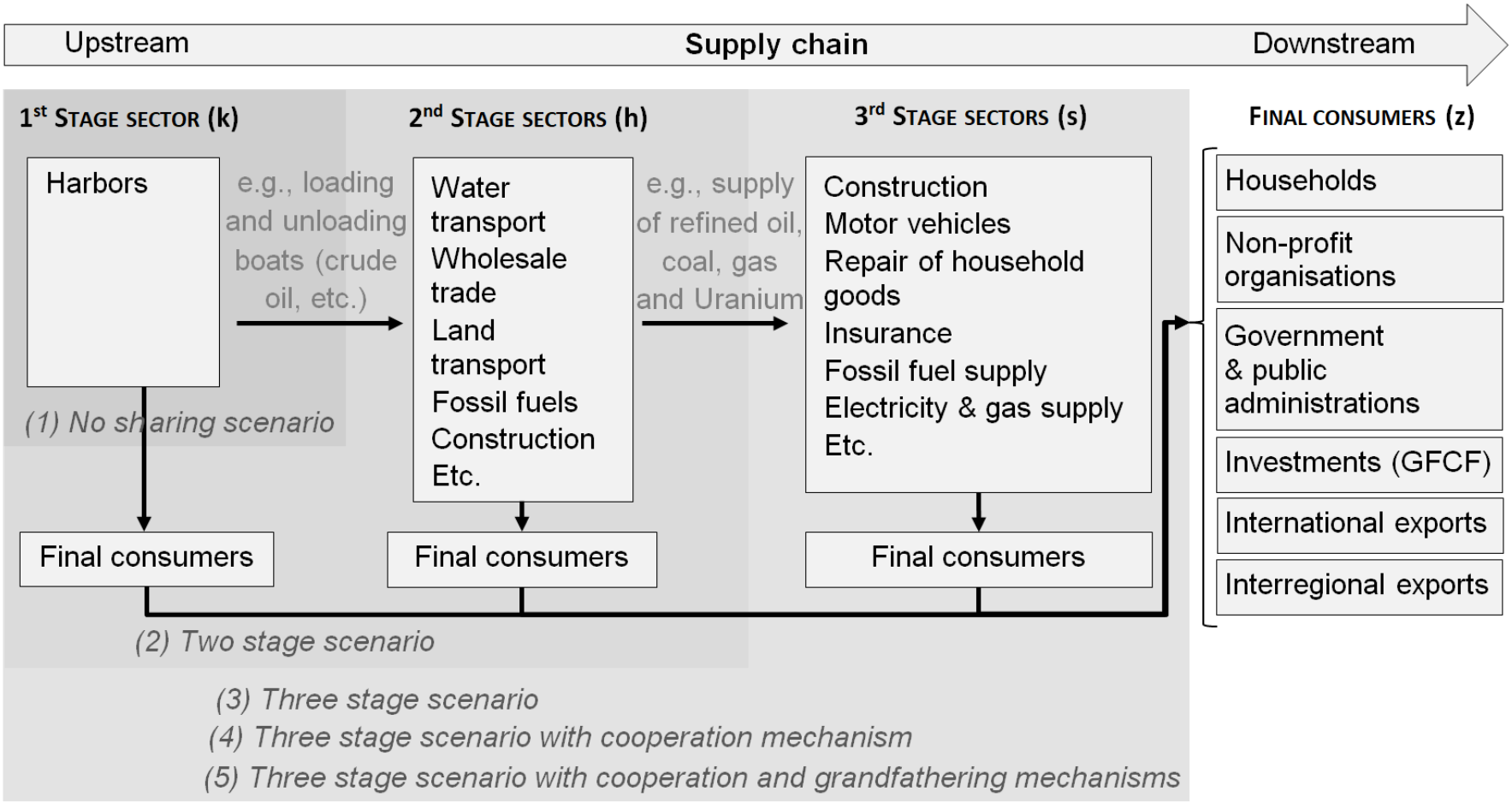
- Exploring the dynamic behaviors of the model

Scenarios	Policy impact Assessment	
	Restoration schedule	Cost allocation
Business as usual (BAU)	No restoration	
Restoration scenarios	1. Increasing 2. Constant 3. Decreasing	Rule 1: No sharing Rule 2: Two stage sharing Rule 3: Three stage sharing Rule 4: Three stage sharing with cooperation mechanism Rule 5: Three stage sharing with cooperation and grandfathering mechanisms

M

Cost allocation rules

The cost allocation rules are, *inter alia*, based on the **shared environmental responsibility principle***



* Gallego and Lenzen (2005), Lenzen et al. (2007), Lenzen and Murray (2010), Cordier et al., (2018)

M

Scenario development

- Exploring the dynamic behaviors of the model

Scenarios	Policy impact Assessment	
	Restoration schedule	Cost allocation
Business as usual (BAU)	No restoration	
Restoration scenarios	1. Increasing 2. Constant 3. Decreasing	Rule 1: No sharing Rule 2: Two stage sharing Rule 3: Three stage sharing Rule 4: Three stage sharing with cooperation mechanism Rule 5: Three stage sharing with cooperation and grandfathering mechanisms

M

Scenario development

- Exploring the dynamic behaviors of the model

Scenarios	Policy impact Assessment		
	Restoration schedule	**Cost allocation**	**Restoration responsibility**
Business as usual (BAU)	No restoration		
Restoration scenarios	1. Increasing 2. Constant 3. Decreasing	Rule 1: No sharing Rule 2: Two stage sharing Rule 3: Three stage sharing Rule 4: Three stage sharing with cooperation mechanism Rule 5: Three stage sharing with cooperation and grandfathering mechanisms	Stage responsibility calculation: 1. Value added/Net output 2. Gross operating surplus (GOS)/output 3. Return on investment (ROI)

T

Scenario development

- Exploring the dynamic behaviors of the model

Scenarios	Policy impact Assessment			Policy sensitivity analysis
	Restoration schedule	Cost allocation	Restoration responsibility	Water quality
Business as usual (BAU)	No restoration			0.77
Restoration scenarios	1. Increasing 2. Constant 3. Decreasing	Rule 1: No sharing Rule 2: Two stage sharing Rule 3: Three stage sharing Rule 4: Three stage sharing with cooperation mechanism Rule 5: Three stage sharing with cooperation and grandfathering mechanisms	Stage responsibility calculation: 1. Value added/Net output 2. Gross operating surplus (GOS)/output 3. Return on investment (ROI)	[0.50, 1.00]

T

Scenario development

- **Inputs** entered to feed the IO/SD model and **outputs** delivered by the model:

Model inputs	Model outputs (outcome indicators)
Economic inputs entered in the model: 1. Exogenous annual economic growth (%) 2. Investments required for the restoration of nurseries (M€/year) ***Ecological inputs entered in the model:*** 1. Nursery area restored (km^2/year) 2. Exogenous water quality (%)	***Economic outcome indicators:*** 1. Gross Domestic Product (GDP) (M€) 2. Disposable income (M€) 3. Gross Operating Surplus (GOS) (M€) ***Ecological outcome indicators:*** 1. Sole caught originating from the internal area of the estuary (tons) 2. Nursery areas - Km^2 - Total Economic Value (TEV, M€) excluding food and nursery services

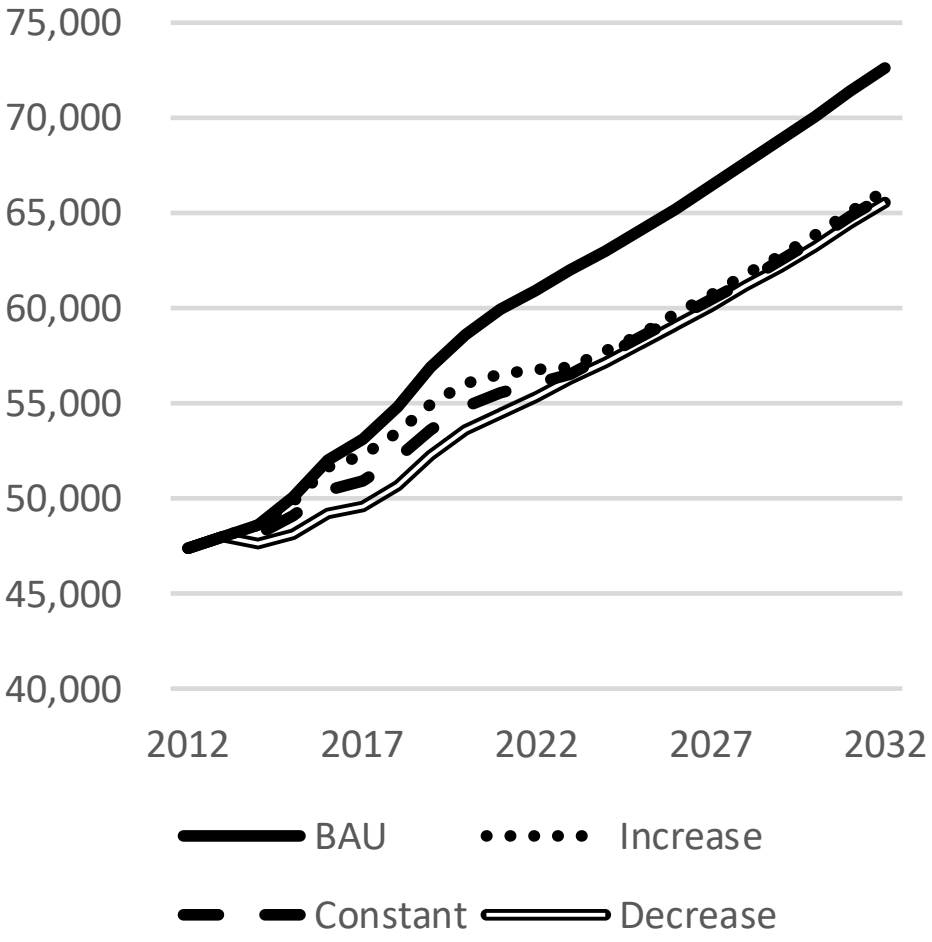
T

Results

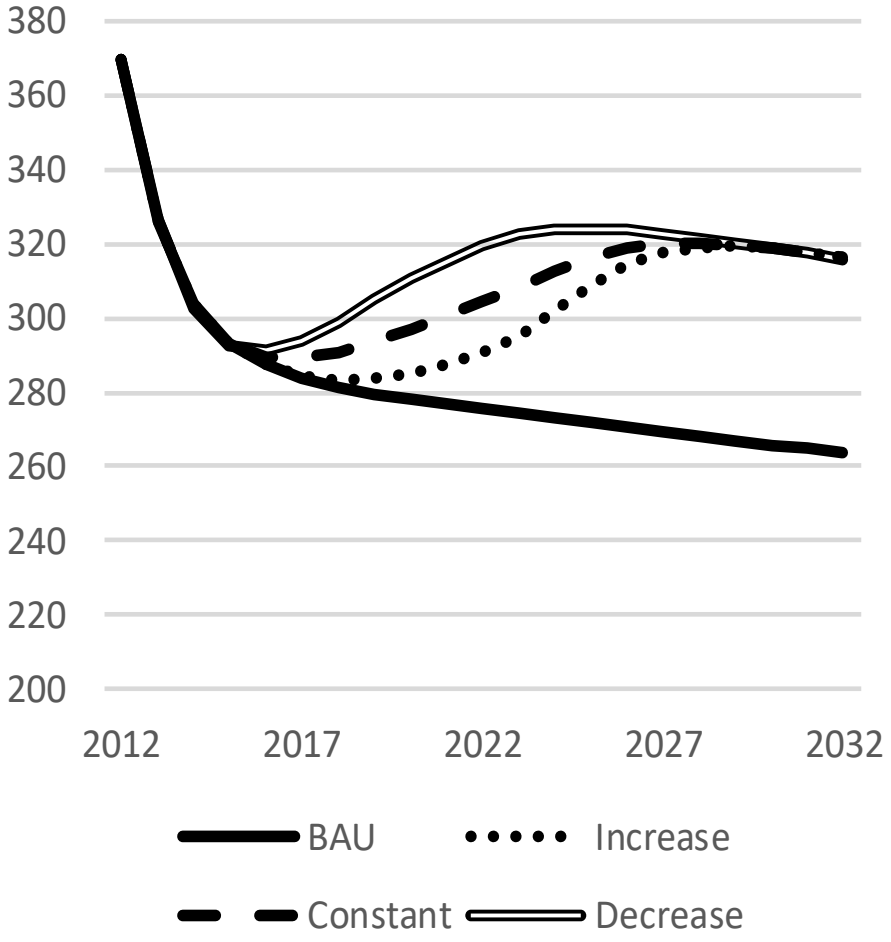
T

Regional impacts of restoration schedules

GDP (Million €)



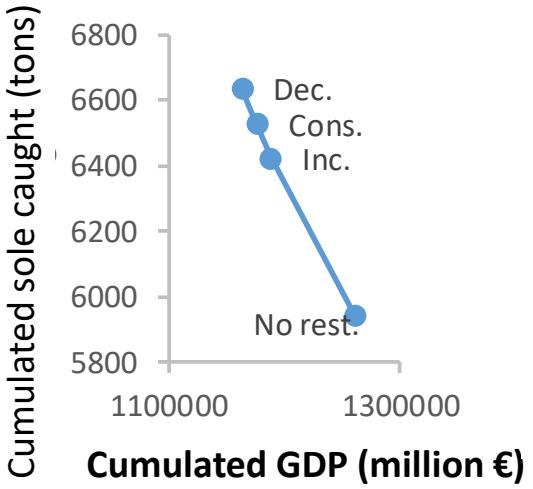
Sole caught in the internal area (tons)

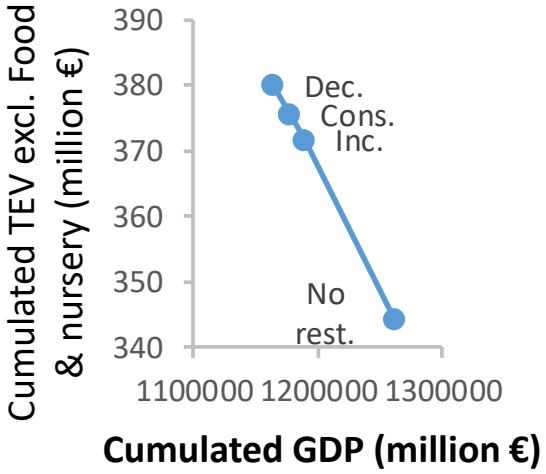


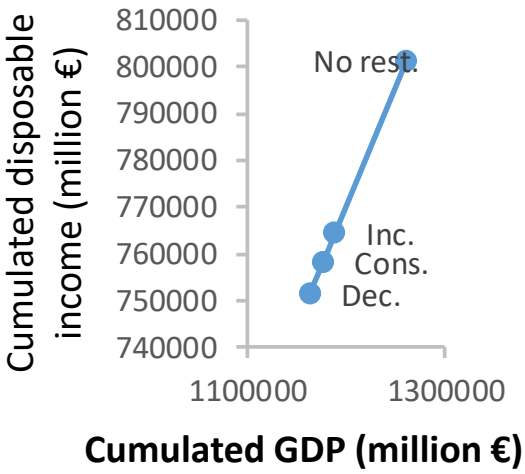
T

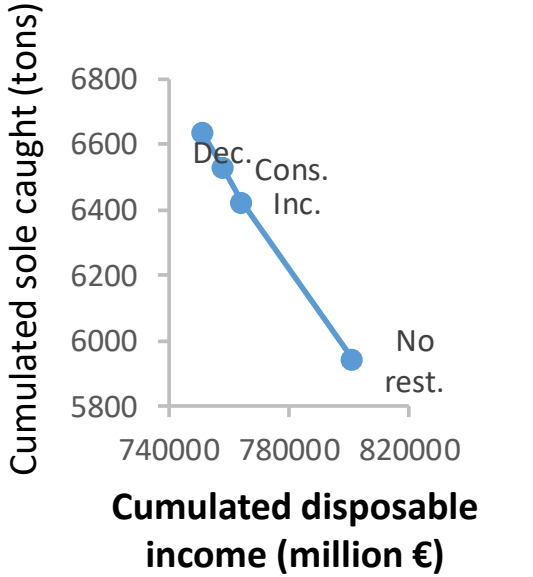
Relationships between key outcome indicators

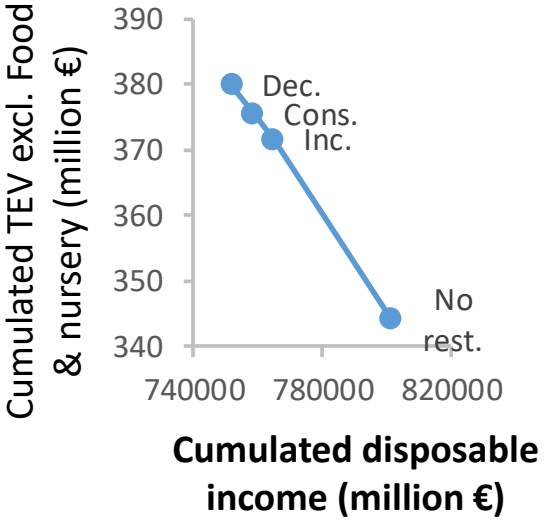
- Graphs display **cumulated values** summed over the 2012-2032 period.
- They show **trade-offs** between economic indicators and ecological indicators

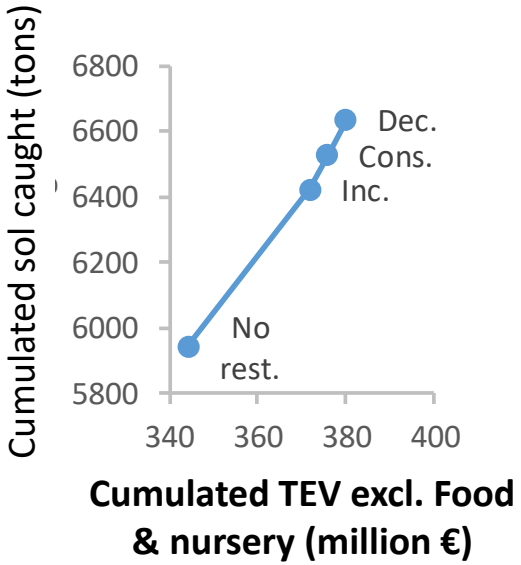






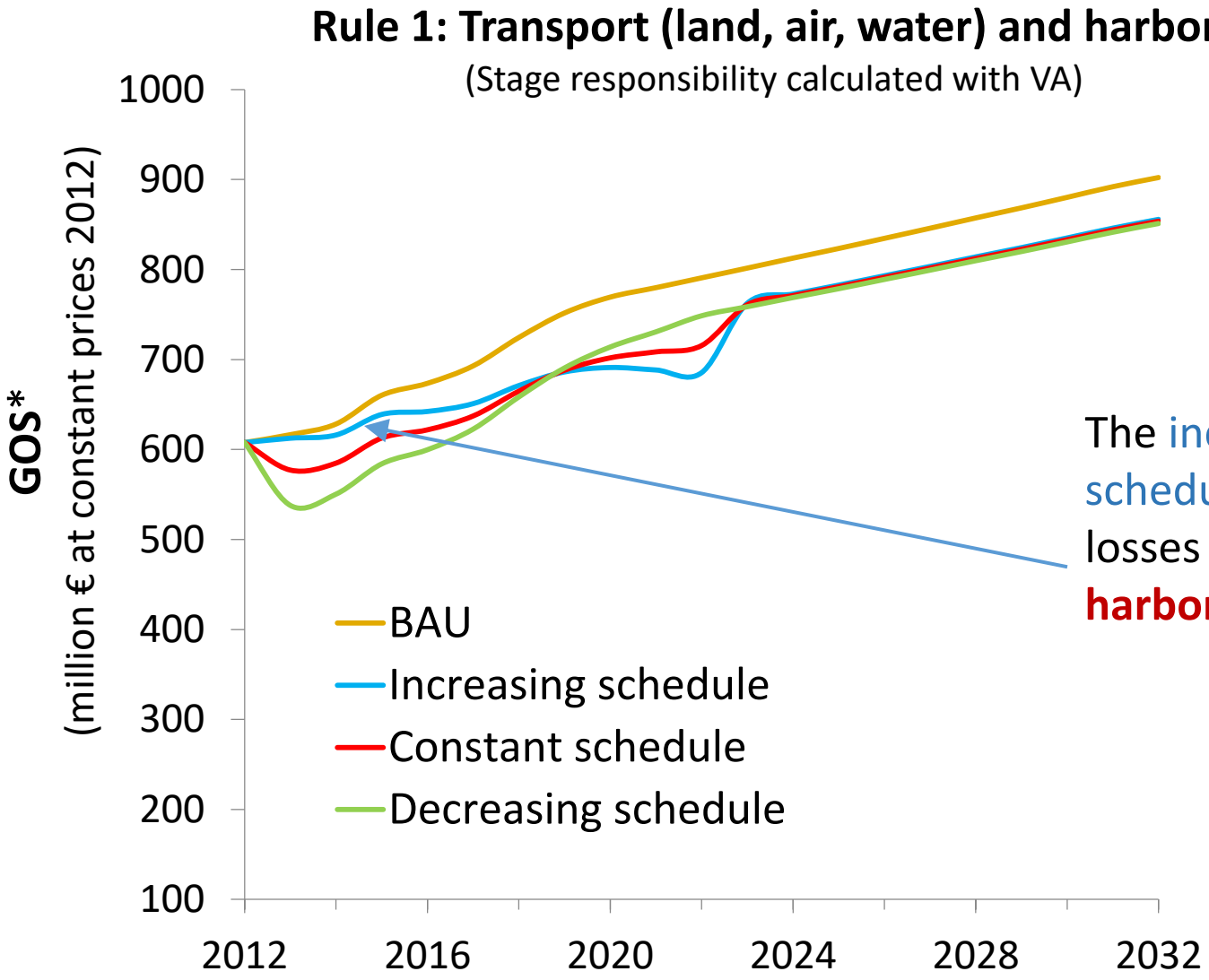






M

Sectorial impacts of restoration schedules



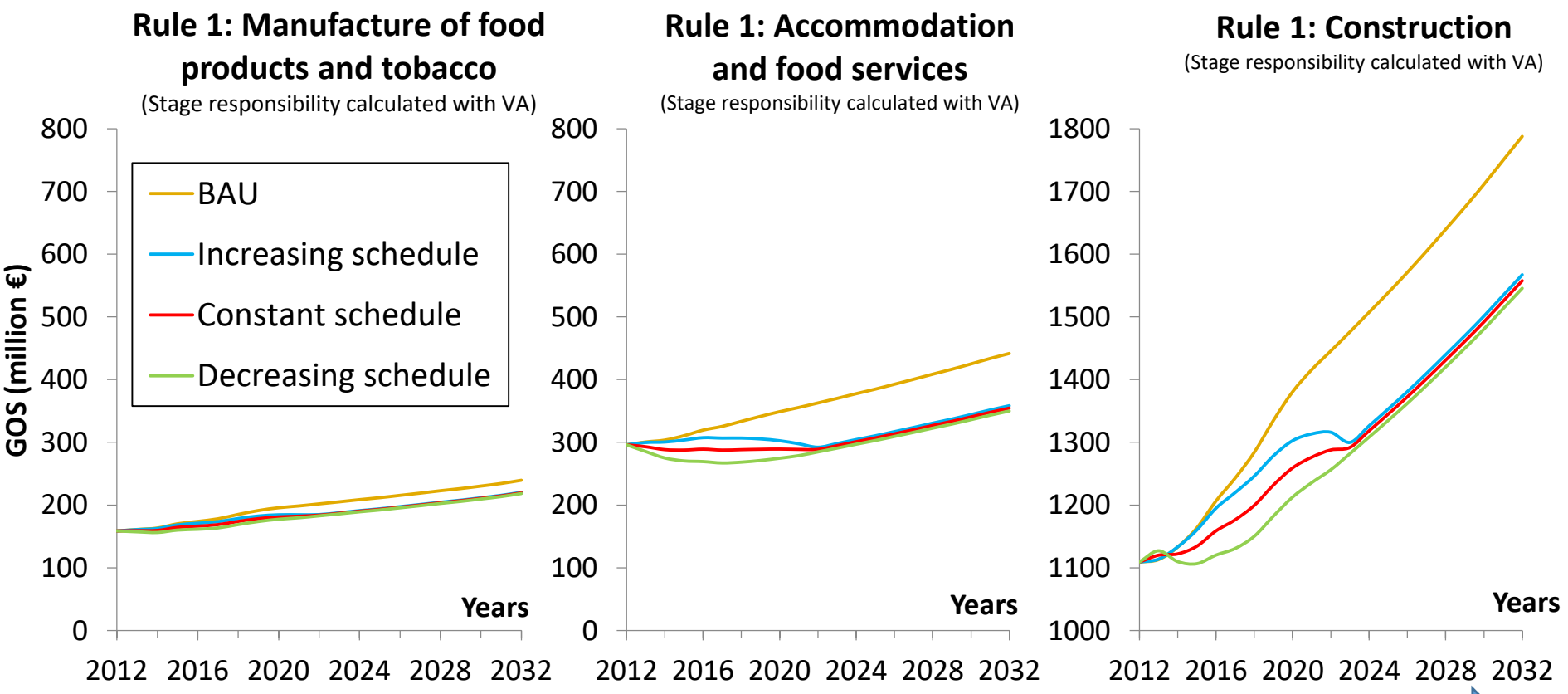
The increasing restoration schedule minimizes profit losses **for the transport & harbors sector**

* GOS (gross operating surplus) is a measure of profit

M

Sectorial impacts of restoration schedules

- The increasing restoration schedule minimizes profit losses **for other sectors**

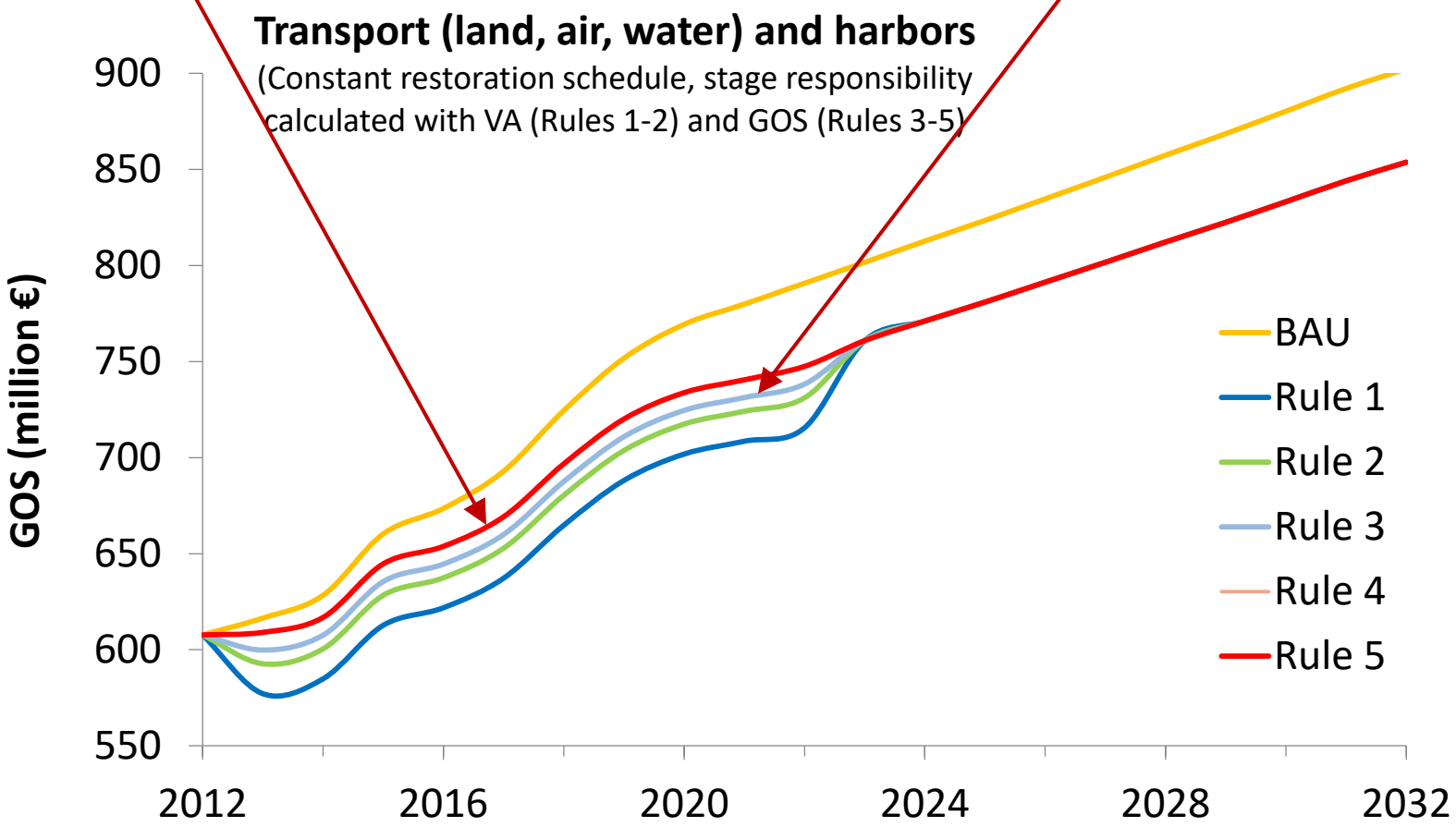


Sectors with higher income elasticity suffer greater profit losses due to income slow down

M

Sectorial impact of cost allocation rules

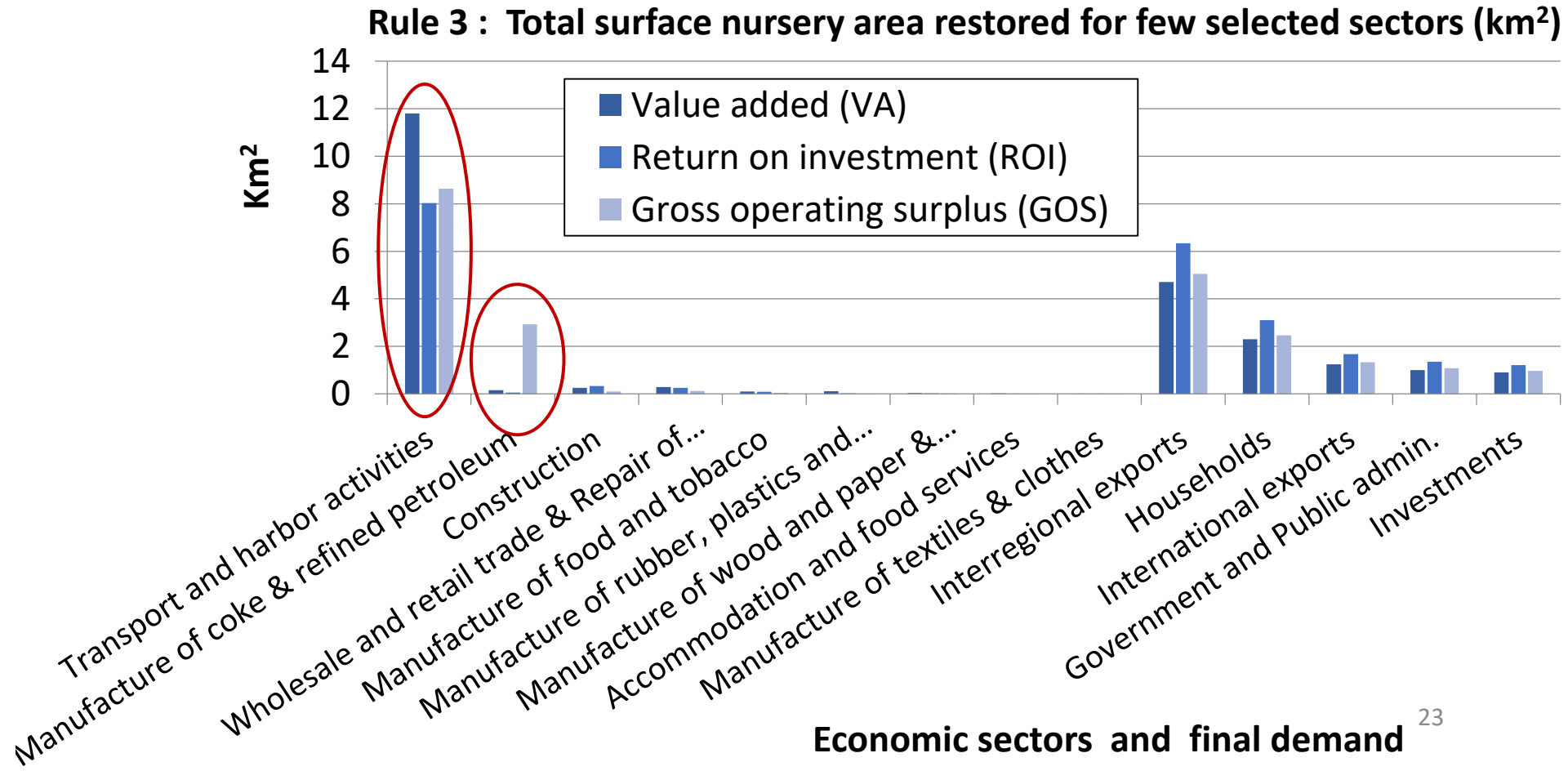
- **Rules 4 and 5** (they overlap) minimize profit losses **for the transport & harbors sector** thanks to cooperation and grandfathering mechanisms.
- Would economic sectors disagree on such mechanisms, **rule 3** provides a second best option for profit loss minimization.



M

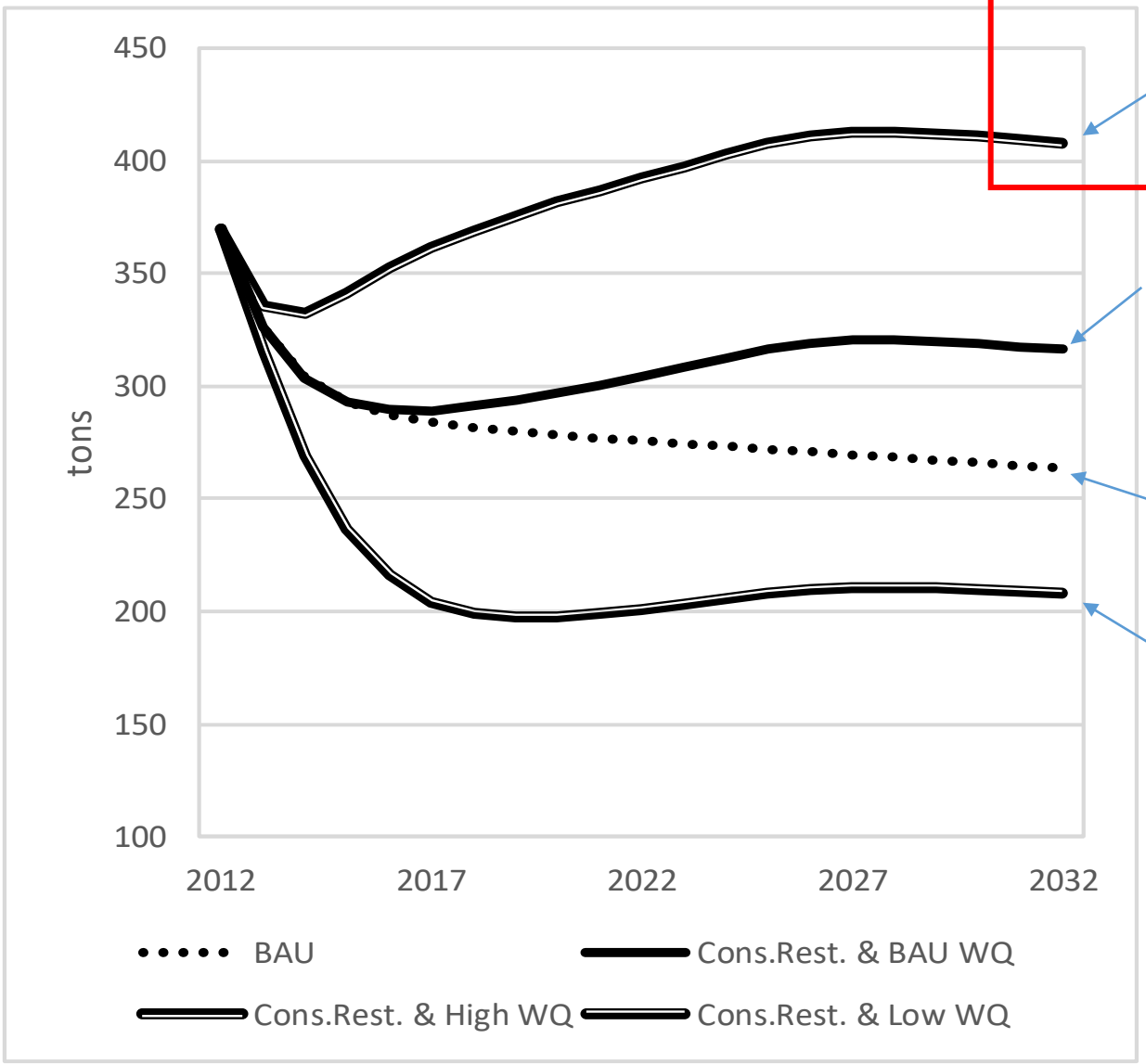
Sectorial impacts of stage responsibility calculations

- The **GOS ratio** helps to improve the social legitimacy of the shared environmental responsibility principle as it includes a sector bearing an important second stage responsibility : manufacture of coke and refined petroleum.



T

Impact of water quality & restoration on Soles caught*



High water quality [1.00] with constant restoration

Current water quality [0.77] with constant restration

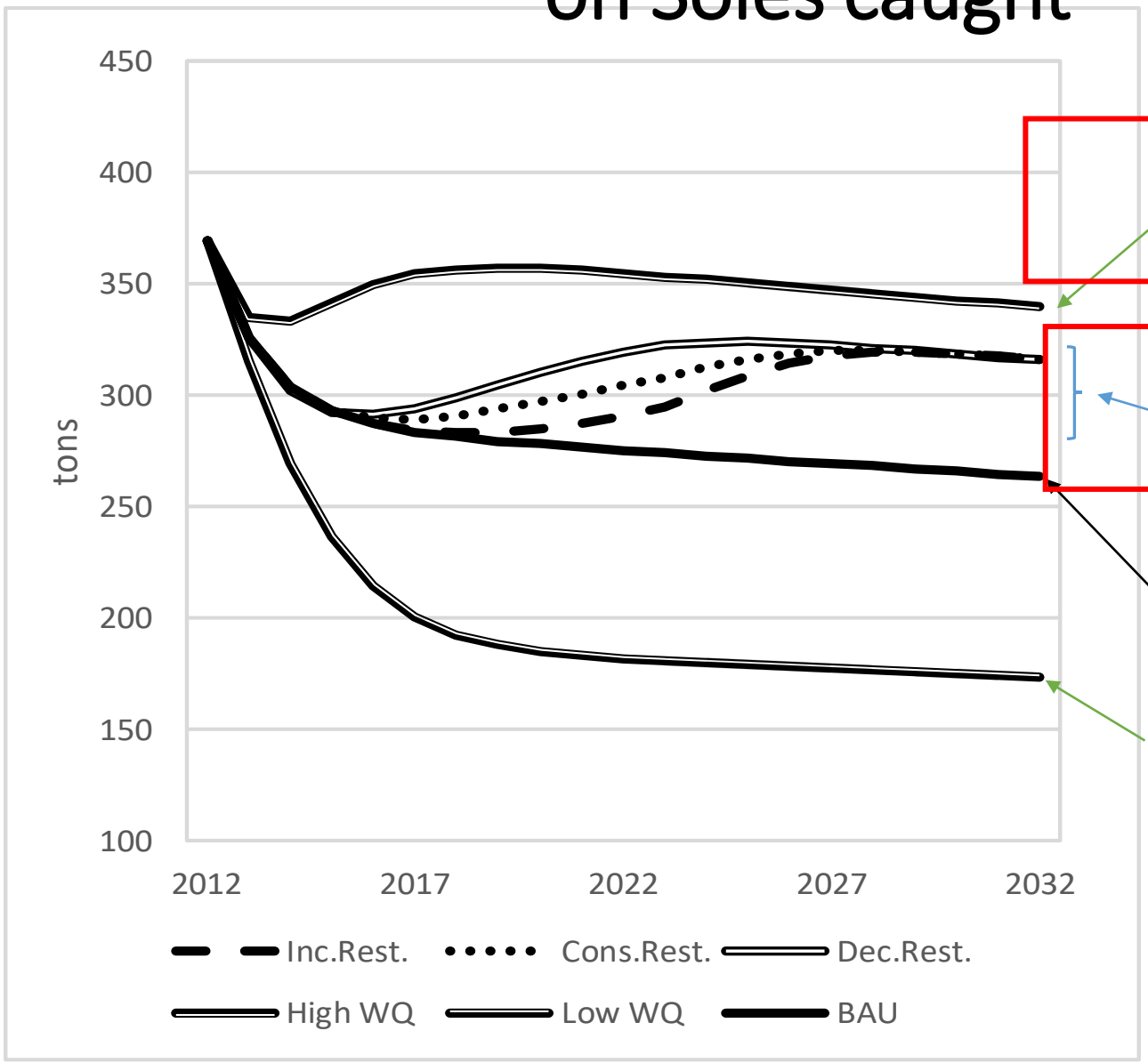
Current water quality (0.77) without restoration

Low water quality [0.50] with constant restoration

* Soles caught refers to catch of soles originating from the internal part of the Seine estuary

T

Impact of water quality vs. restoration on Soles caught*



High water quality [1.00] without restoration

Current water quality (0.77) with various restorations

Current water quality (0.77) without restoration

Low water quality [0.50] without restoration

T

Conclusions

T

Limitations and future research

- Longer term trade-offs could change our conclusions.
- Reflecting ecological thresholds could change our conclusions.
- It is important to further delve into the impact of water quality due to contaminants such as endocrine disruptors*:*

- **Alkylphenols:** used in detergents in textile industry, plastics, pesticides, paper production, water paintings.
- **Organotin:** compounds of biocide paintings such as TBT on ships but production is forbidden nowadays. However, historical contamination remains in sediments.
- **Phthalates (DBP, DiBP, DEP, DEHP, MEHP):** used in plastics, cosmetics, textiles, and insecticides.
- **PolyBromoDiphénylEthers (PBDE):** used as flame retardant additive in textiles, furniture made of textile components, etc. Suspected to be an endocrine disruptor.
- **PCB (PolyChloroBiphényles):** not used anymore, have been forbidden a long time ago but historical contamination remains in sediments.
- **PAHs (Polycyclic aromatic hydrocarbons):** result from incomplete combustion of organic matter (wood-burning and combustion of other biofuels, industrial processes and the extraction and use of fossil fuels, wildfires, tobacco smoking, etc.)

→ involves sectoral and spatial (i.e., within and outside the region) responsibilities.

T

For more details, read us :-)

ELSEVIER

Ecological Economics 140 (2017) 46–57

journal homepage: www.elsevier.com/locate/ecolecon

Methodological and Ideological Options

An Input-output Economic Model Integrated Within a System Dynamics Ecological Model: Feedback Loop Methodology Applied to Fish Nursery Restoration

Mateo Cordier [a,b,*], Takuro Uehara [c], Jeffrey Weih [e], Bertrand Hamaide [d]

sustainability **2018**, 10, 1765

MDPI

Article

Fully Dynamic Input-Output/System Dynamics Modeling for Ecological-Economic System Analysis

Takuro Uehara [1,*], Mateo Cordier [2,3] and Bertrand Hamaide [4]

Economic Systems Research

Journal of the International Input-Output Association

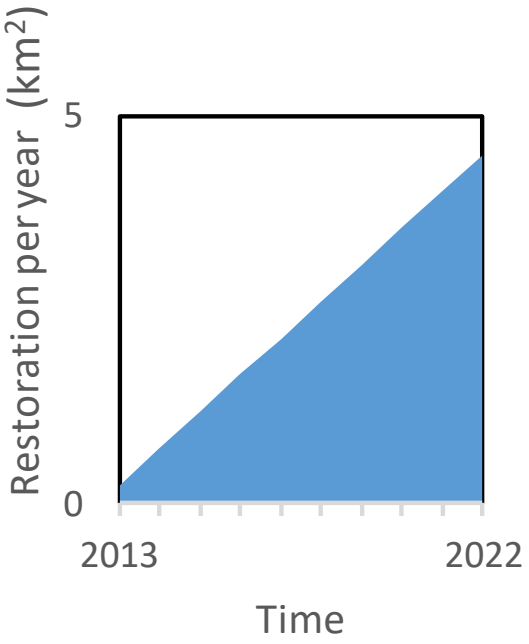
The shared environmental responsibility principle: new developments applied to the case of marine ecosystems

Mateo Cordier, Thomas Poitelon, Walter Hecq (2018, under press)

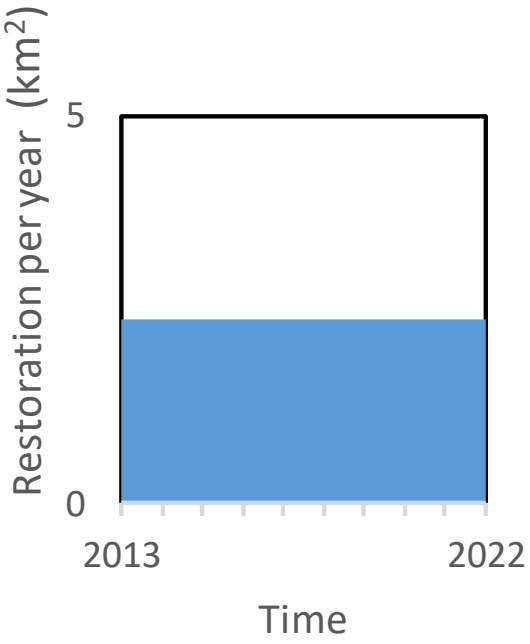
Appendix

Restoration schedule

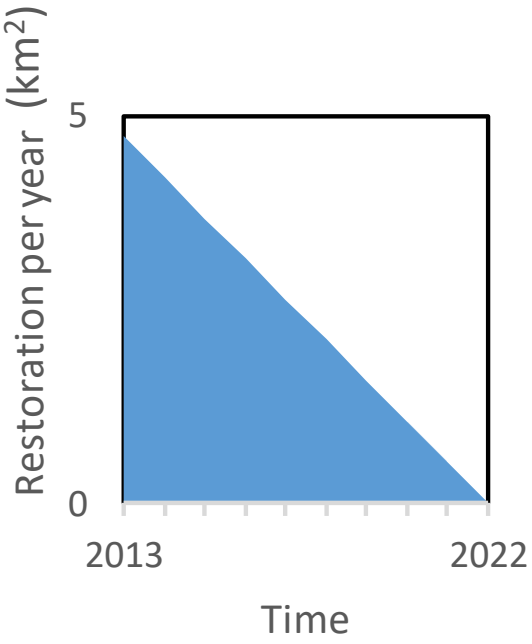
- 3 schedules distributing annual restoration of nursery areas through time have been simulated:



(a) Increasing



(b) Constant



(c) Decreasing

Water quality

- Juvenile density in the Seine estuary is **23%** lower today compared to 1850 because of water quality degradation (Rochette et al., 2010).
- We assume that water quality improvement can recover the juvenile abundance by **23%** maximum as follows:

$$Abundance\ Multiplier_i = Water\ Quality\ Index * Abundance\ Multiplier_i^{max}$$

- With that equation, we carry out a sensitivity analysis in which we assume juvenile abundance to be proportional to water quality.
- The current Water Quality Index (**BAU scenario**) = 0.77 (= 100%–23%).
- In policy sensitivity analysis, Water Quality Index varies between [0.50, 1.00].
- The Water Quality Index is exogenously given as this variable is determined out of the system boundary.