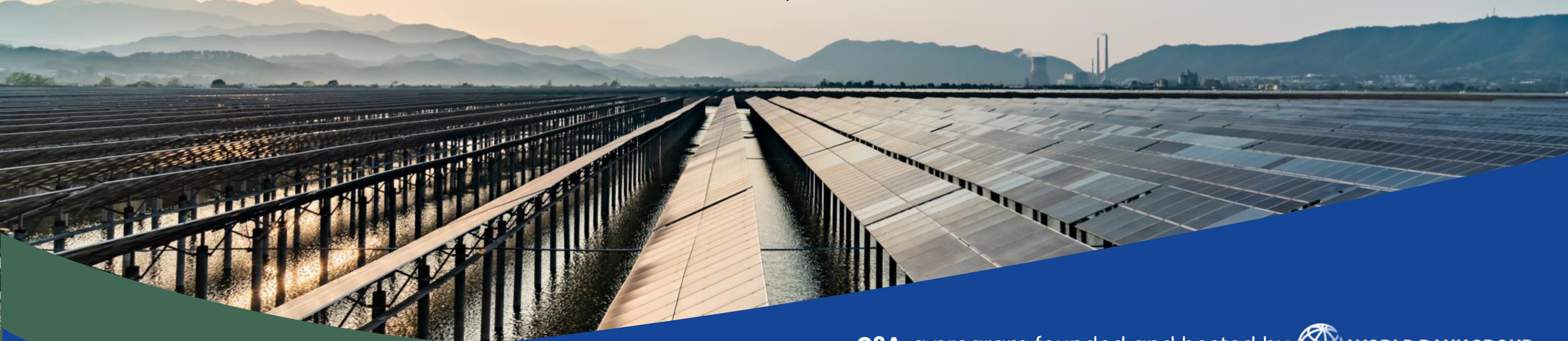
C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Research Segment

Session 6: International Trade and Related Risks

Diana Jimenez Miranda & Hugo Lapeyronie

December 6th, 2024 - Paris



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Logo partner

Planetary boundaries footprints – an empirical assessment on trade

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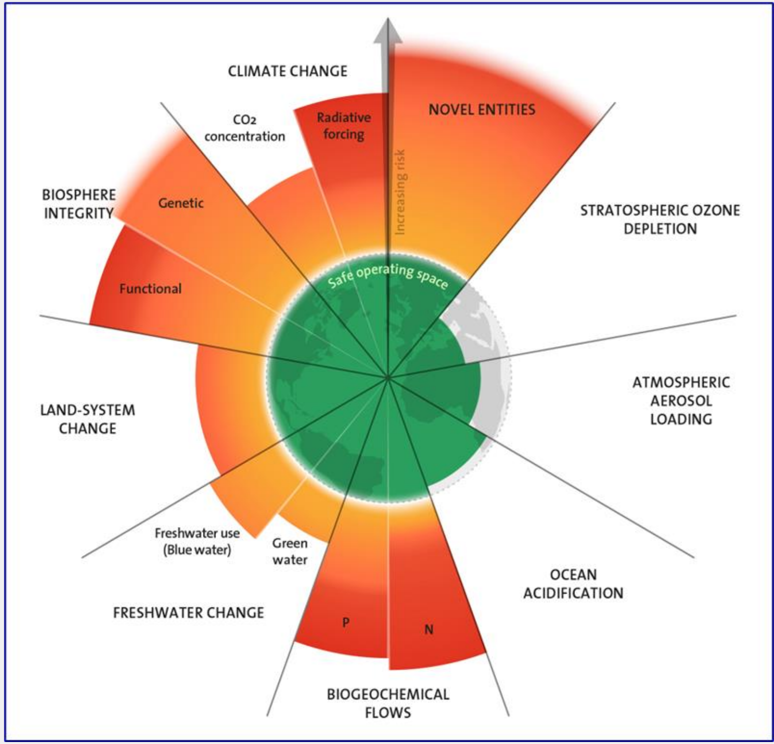
The Planetary Boundaries (PB)

- Planetary Boundaries and tipping points: PB consider processes that are critical for maintaining the stability and resilience of the Earth system as a whole
- Use but do not exclusively rely on tipping points
- Should not be interpreted as representing tipping points (ex. Biodiversity)
- Six of the nine boundaries are transgressed
- Pressures are geographically located
- Some countries are "resource suppliers" and other "resource consumers"
- When different boundaries are observed, countries switch positions along a multidimensional spectrum
- Ex: One country could be an exporter of "water" and an importer of "land" at the same time*



Richardson *et al.* (2023)

Objectives and Methodology

Objective: Understand the pressure exerted by global trade over the planetary boundaries

- Find which countries and economic activities (economic sectors) lead the pressure over each Planetary Boundary
- Previous research on global trade pressure over individual Earth System's processes (Lenzen et al., 2012; Wiedmann & Lenzen, 2018)
- Fall short on addressing the multidimensional spectrum of different countries and economic sectors

Methodology: Pressure is measured through a modified form of consumption-based footprint accounting

- Pressure is driven by import consumption pressure from importing countries
- Ecological and Economic flow variables are selected from GLORIA for the year of 2021

Proxies for pressure on PB

Earth system process	Variables employed in planetary boundaries' latest assessment[1]	Variables employed in this study
Biogeochemical flows: P and N cycles	❖ Phosphate global: P flow from freshwater systems into the ocean ❖ Phosphate regional: P flow from fertilisers to erodible soils (Tg of P year-1) ❖ Nitrogen global: industrial and intentional fixation of N (Tg of N year-1)	❖ Fertiliser minerals directly and indirectly embodied in agriculture production (tonnes)
Climate change	❖ Atmospheric CO2 concentration (ppm CO2) ❖ Total anthropogenic radiative forcing at top-of- atmosphere (W m-2)	❖ Total GHG emissions provided by EDGAR (kilotonnes CO2 equivalent)
Change in biosphere integrity	❖ Genetic diversity: E/MSY ❖ Functional integrity: measured as energy available to ecosystems (NPP) (% HANPP)	❖ Potentially Disappeared Fraction (PDF)
Freshwater change	❖ Blue water: human induced disturbance of blue water flow ❖ Green water: human induced disturbance of water available to plants (% land area with deviations from preindustrial variability)	❖ Agriculture and non-agriculture blue water consumption (million m3 H2Oeq) ❖ Agriculture and non-agriculture water stress (million m3 H2Oeq)
Land system change	❖ Global: area of forested land as the percentage of original forest cover ❖ Biome: area of forested land as the percentage of potential forest (% area remaining)	❖ Total area used by the economic activity (1000 ha)
Novel entities	❖ Percentage of synthetic chemicals released to the environment without adequate safety testing	❖ Non-energy material footprint embodied in chemical production (tonnes)

Share of PB pressure exerted by intercountry traded goods

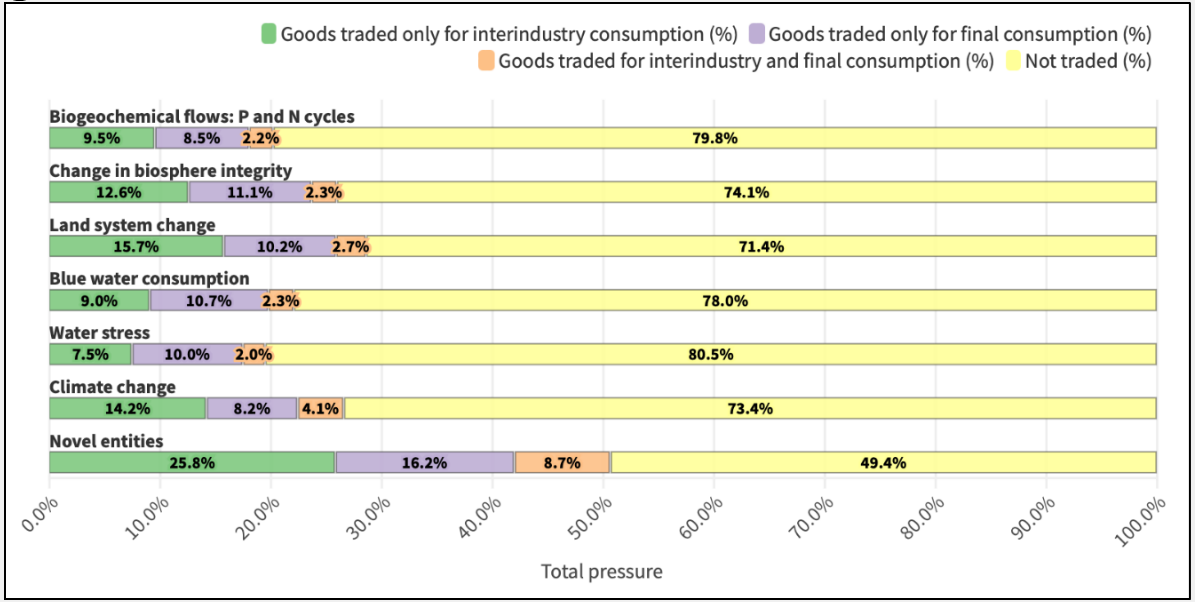


Figure 1: Share of pressure exerted by intercountry traded goods. Source: GLORIA environmental extended multi-regional input-output database. Note: *Not traded goods* are goods whose productive chain and final consumption take place inside only one country. *Goods traded for interindustry and final consumption* are goods whose productive chain involves cross-border trade and final consumption takes the form of an import. *Goods traded only for final consumption* are goods whose productive chain takes place in only one country and final demand takes the form of an import. *Goods traded only for interindustry consumption* are goods whose productive chain involves cross-border trade and final demand consists of a domestic purchase.

Share of PB pressure exerted by different income groups

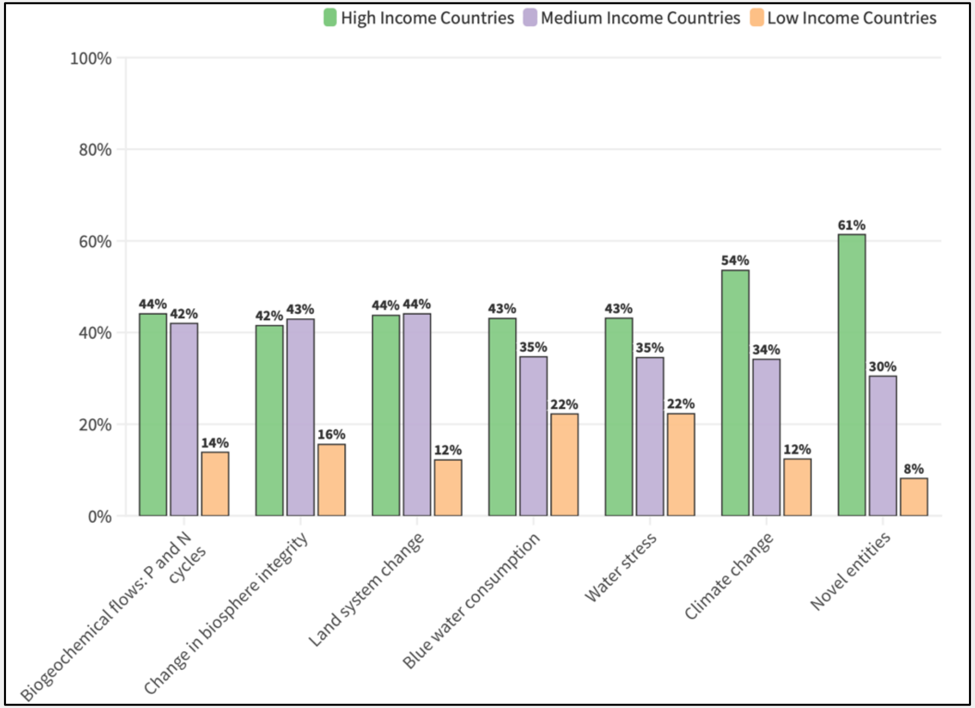


Figure 2: Trade pressure on the planetary boundaries exerted by different income groups of countries. Source: GLORIA environmental extended multi-regional input-output database

PB pressures between regions (biochemical flows PB)

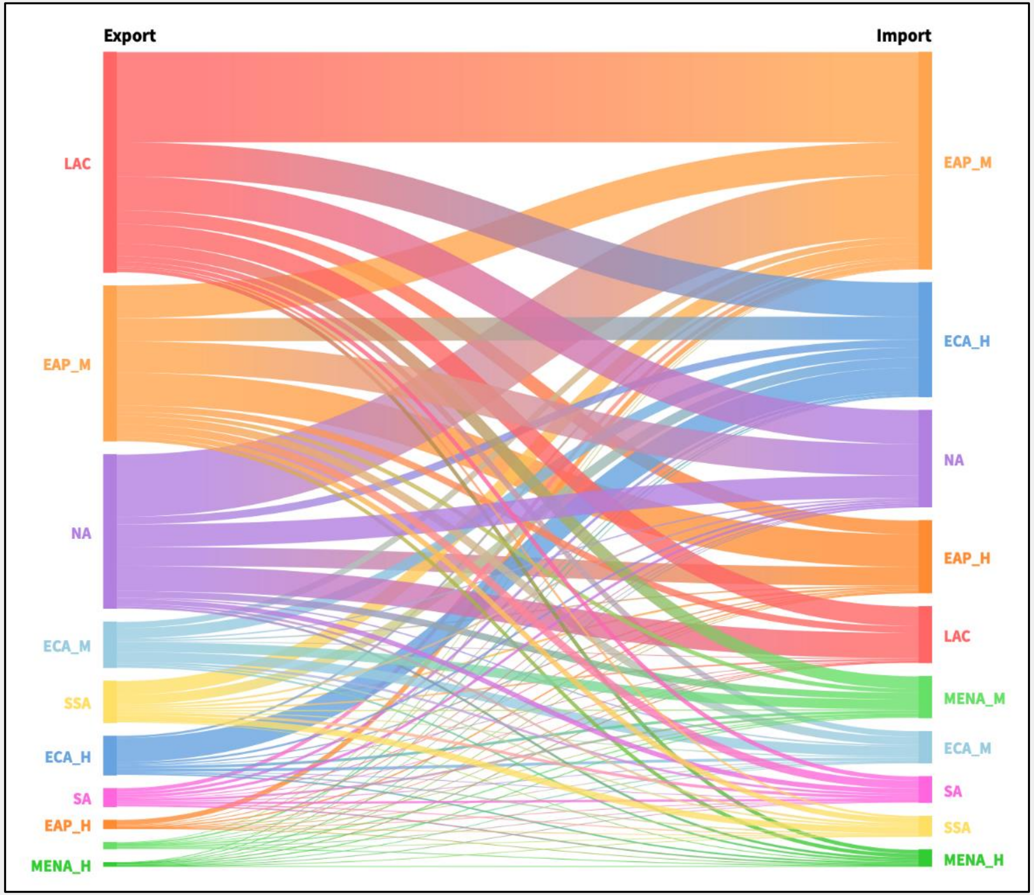


Figure 3: Sankey diagram of global trade's pressure over the Biogeochemical flows boundary.

Note: EAP_H: High-income East Asia and Pacific, EAP_M: Middle- and low-income East Asia and Pacific, ECA_H: High-income Europe and Central Asia, ECA_M: Middle- and low-income Europe and Central Asia, SA: South Asia, SSA: Sub-Saharan Africa, MENA_H: High-income Middle East and North Africa, MENA_M: Middle- and low-income Middle East and North Africa, NA: North America, LAC: Latin America and the Caribbean. **Source:** GLORIA environmental extended multi-regional input-output database.

Biosphere integrity

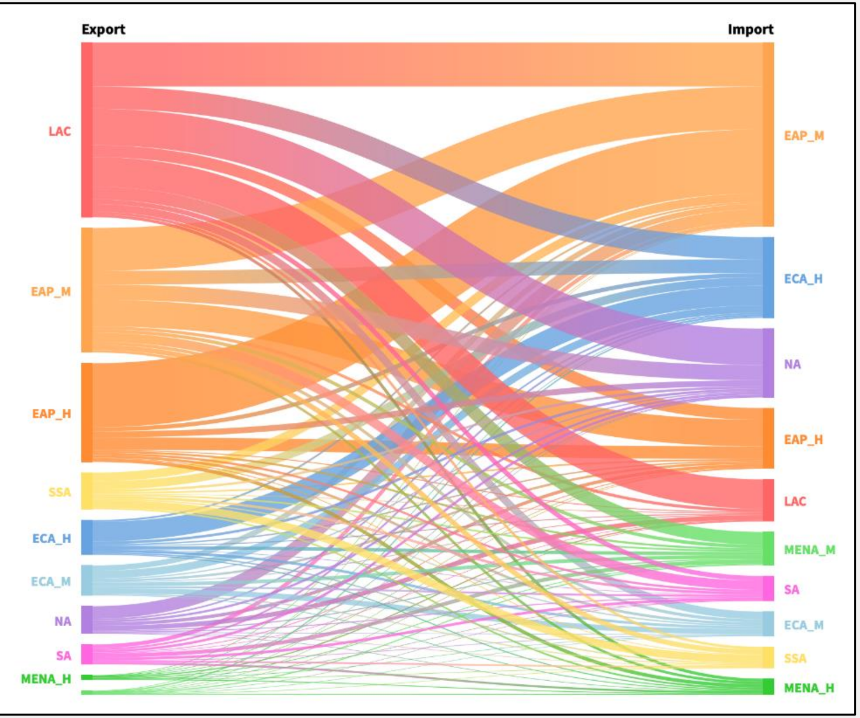


Figure 4: Sankey diagram of global trade's pressure over the Biosphere integrity boundary.

Land use change

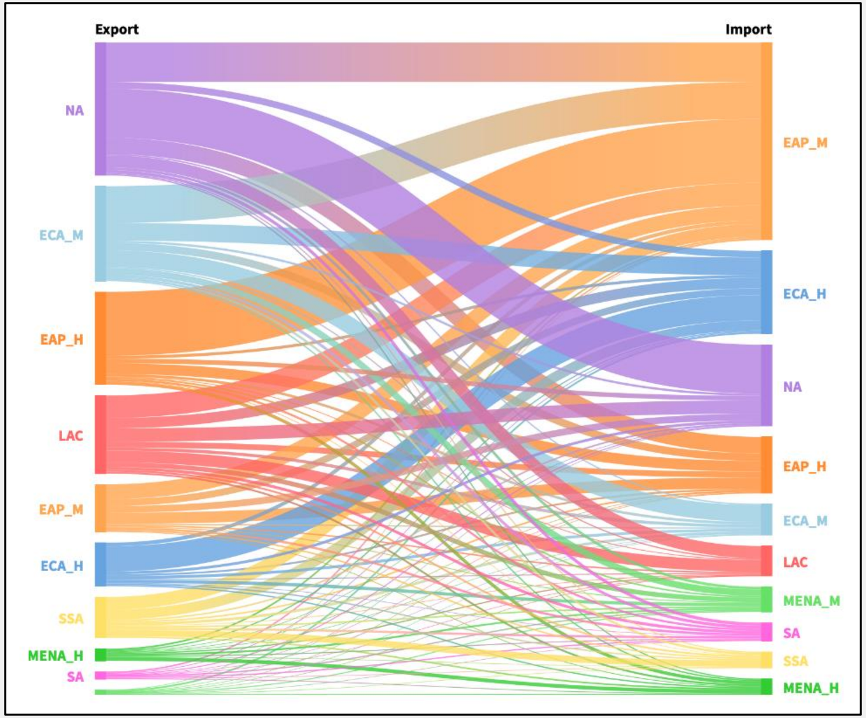


Figure 5: Sankey diagram of global trade's pressure over the Land use boundary.

Freshwater change (blue water consumption)

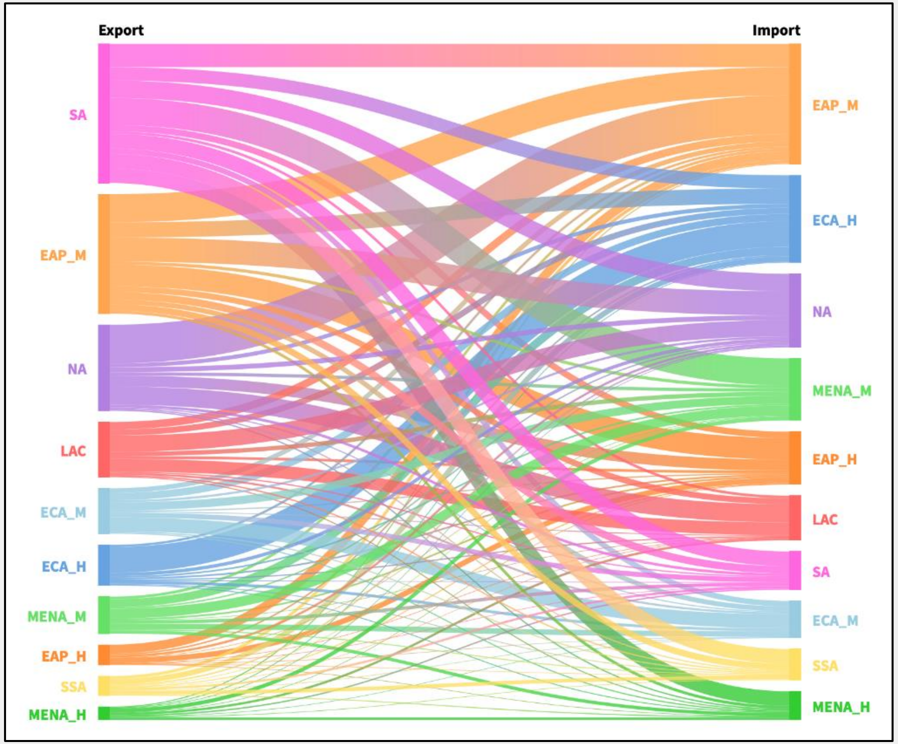


Figure 6: Sankey diagram of global trade's pressure over the Freshwater change boundary.

Climate change

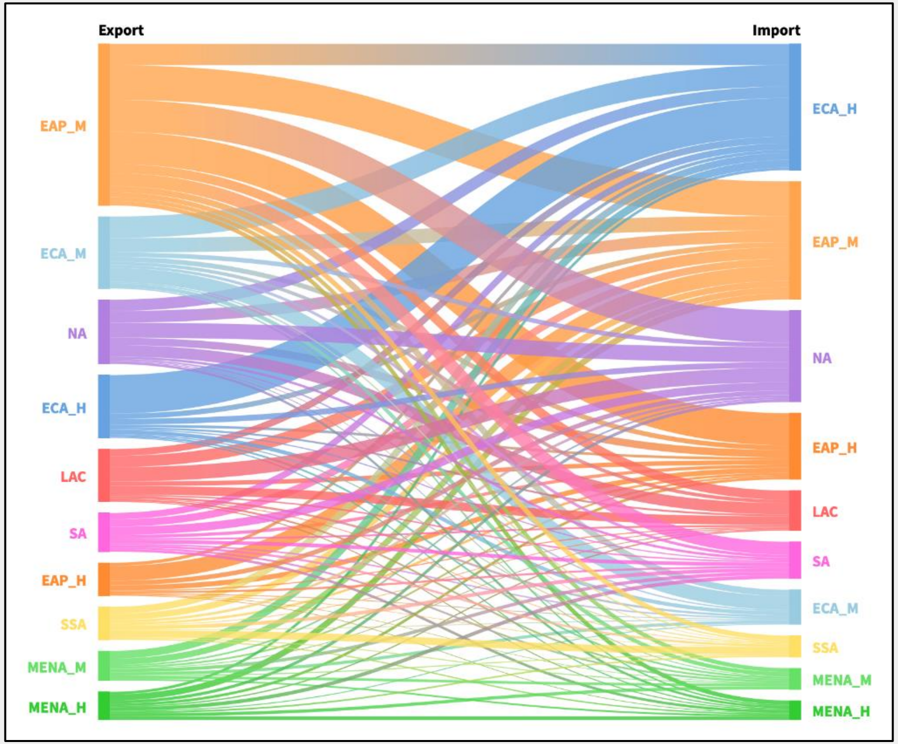


Figure 7: Sankey diagram of global trade's pressure over the Climate change boundary.

Novel entities

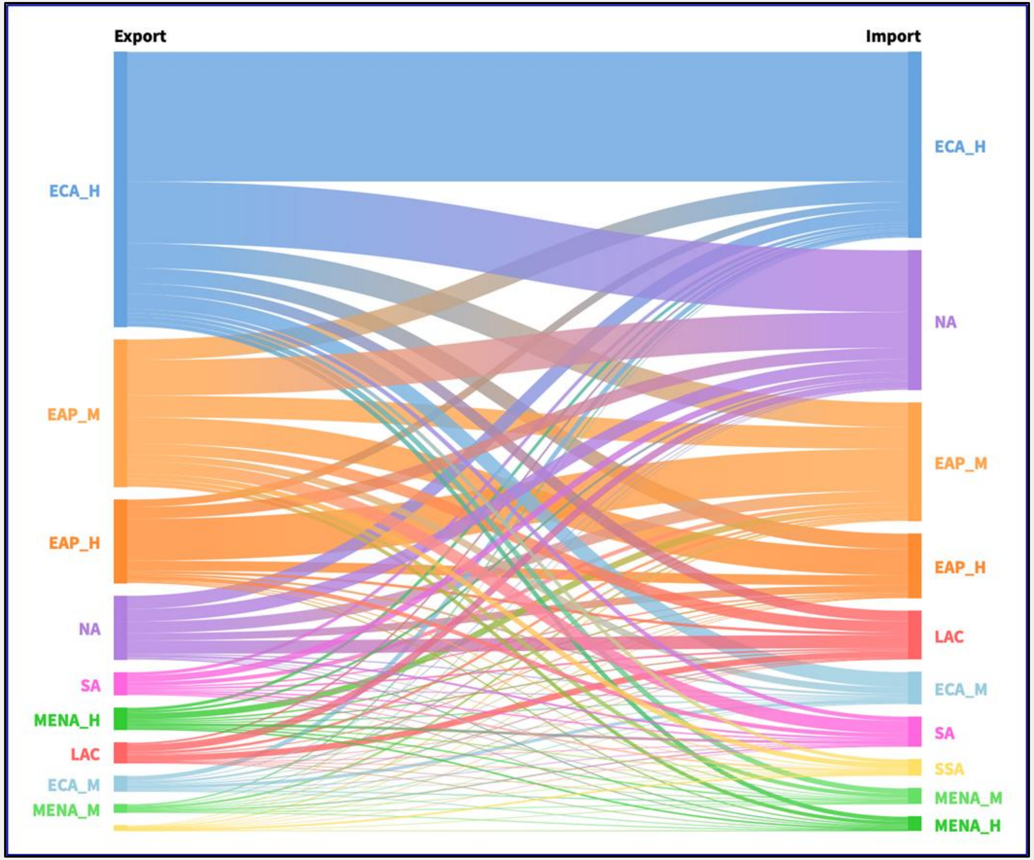
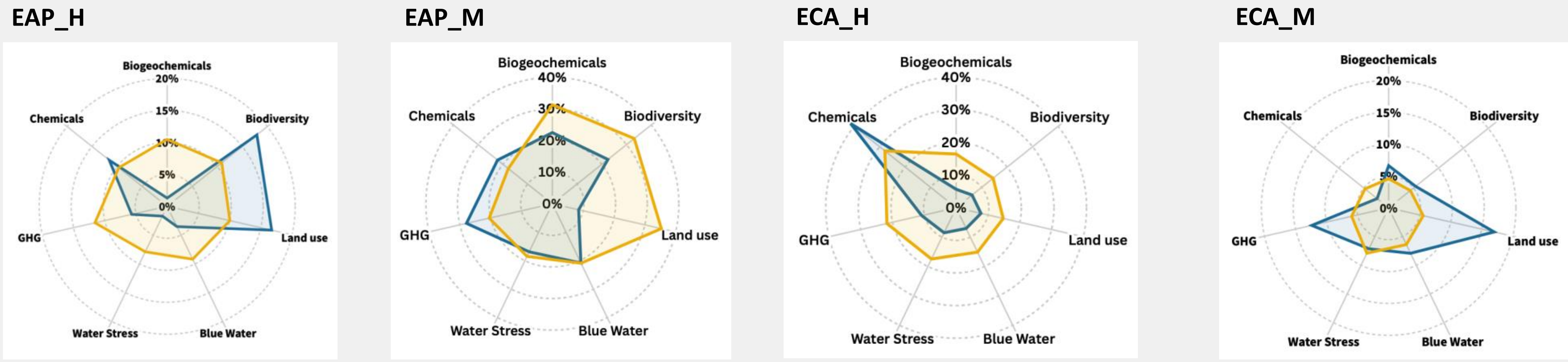


Figure 8: Sankey diagram of global trade's pressure over the Novel entities boundary.

Note: EAP_H: High-income East Asia and Pacific, EAP_M: Middle- and low-income East Asia and Pacific, ECA_H: High-income Europe and Central Asia, ECA_M: Middle- and low-income Europe and Central Asia, SA: South Asia, SSA: Sub-Saharan Africa, MENA_H: High-income Middle East and North Africa, MENA_M: Middle- and low-income Middle East and North Africa, NA: North America, LAC: Latin America and the Caribbean. **Source:** GLORIA environmental extended multi-regional input-output database.

Consumption/production pressures across PBs by region



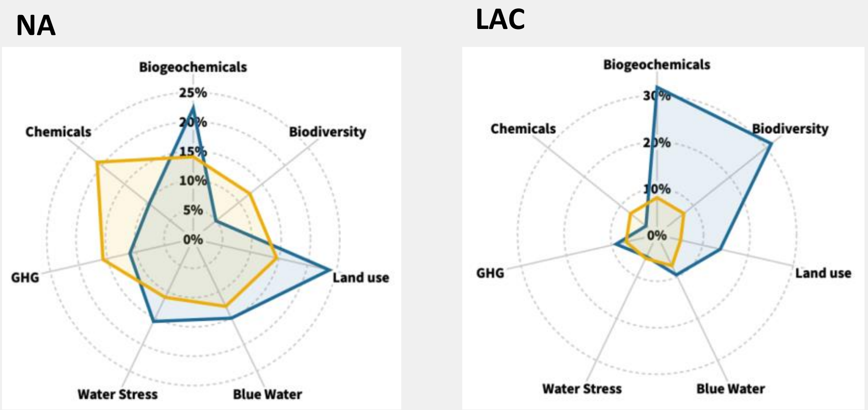
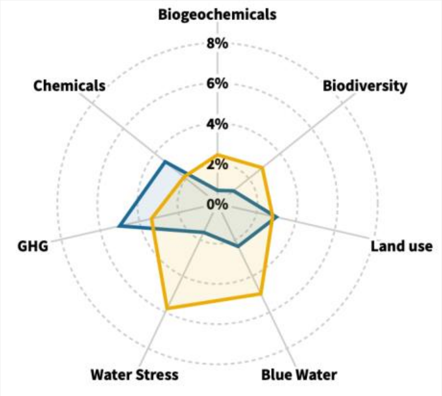


Figure 9: Share of pressure from import (consumption) and export (production) perspectives for selected regions.

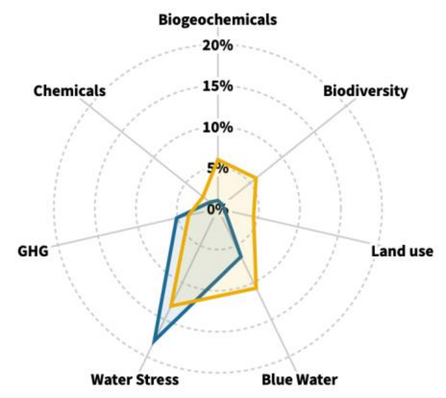
Note: Scales are different for each radar chart. EAP_H: High-income East Asia and Pacific, EAP_M: Middle- and low-income East Asia and Pacific, ECA_H: High-income Europe and Central Asia, ECA_M: Middle- and low-income Europe and Central Asia, SA: South Asia, SSA: Sub-Saharan Africa, MENA_H: High-income Middle East and North Africa, MENA_M: Middle- and low-income Middle East and North Africa, NA: North America, LAC: Latin America and the Caribbean.
Source: GLORIA environmental extended multi-regional input-output database.

Consumption/production pressures across PBs by region

MENA_H

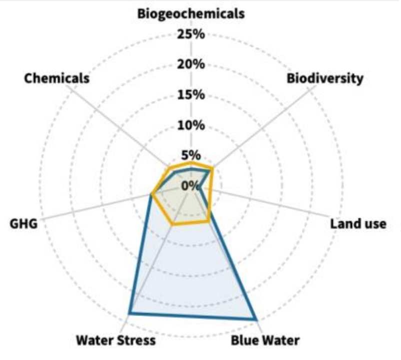


MENA_M

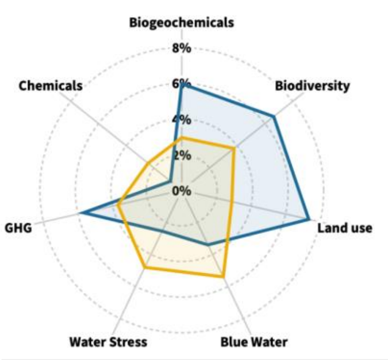


Exports Imports

SA



SSA



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Source: GLORIA environmental extended multi-regional input-output database.


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CALCULATING TRADE PRESSURE

- MRIO Model using GLORIA: 164 countries and 120 sectors (Lenzen et al., 2017; Lenzen et al., 2021)
- Total global footprint for 2021:

$$\mathbf{e}^{\mathbf{F}} = \hat{\mathbf{e}}(\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{F}$$

- Traditional consumption-based trade accounting (Lenzen et al., 2012; Kanemoto et al., 2012):

$$\mathbf{e}^{\mathbf{MF}} = \hat{\mathbf{e}}(\mathbf{I} - \mathbf{A})^{-\mathbf{1}}(\mathbf{F} \oslash \mathbf{IF})$$

- <u>Limitation:</u> captures goods that were only imported in the "final demand step"
- What about the final goods that are purchased domestically but were traded during their productive processes?

IF -> a matrix with the same dimension of $\mathbf{F}$ with zero for domestic relations and one for trade across countries

CALCULATING TRADE PRESSURE

ID -> a matrix with the same dimension of $\mathbf{A}$ with zero for domestic relations and one for trade across countries

- 4 kinds of goods:

Interindustry matrix	Final demand	Was it traded?	Equation
Domestic	Domestic	No	-
Domestic	Imported	Yes	$\mathbf{e}^{\mathbf{MF}} = \hat{\mathbf{e}}(\mathbf{I}-\mathbf{A})^{-1}(\mathbf{F} \oslash \mathbf{IF})$
Imported	Domestic	Yes	$\mathbf{e}^{\mathbf{ML}} = \hat{\mathbf{e}}\left[(\mathbf{I}-\mathbf{A})^{-1} \oslash \mathbf{ID}\right]\mathbf{F}$
Imported	Imported	Yes	$\mathbf{e}^{\mathbf{DM}} = \hat{\mathbf{e}}[(\mathbf{I}-\mathbf{A})^{-1} \oslash \mathbf{ID}](\mathbf{F} \oslash \mathbf{IF})$

- Problem: if we sum all equations -> <u>double counting</u>
- Solution: rewrite $\mathbf{e}^{\mathbf{MF}}$ and $\mathbf{e}^{\mathbf{ML}}$ subtracting $\mathbf{e}^{\mathbf{DM}}$

CALCULATING TRADE PRESSURE

- Final equations:

Interindustry matrix	Final demand	Was it traded?	Equation
Domestic	Domestic	No	$\mathbf{e} = \mathbf{e}^{\mathbf{MF}} - \mathbf{e}^{\mathbf{ML}} - \mathbf{e}^{\mathbf{DM}}$
Domestic	Imported	Yes	$\mathbf{e}^{\mathbf{MF}} = \hat{\mathbf{e}}(\mathbf{I} - \mathbf{A})^{-1}(\mathbf{F} \oslash \mathbf{IF}) - \mathbf{e}^{\mathbf{DM}}$
Imported	Domestic	Yes	$\mathbf{e}^{\mathbf{ML}} = \hat{\mathbf{e}}\left[(\mathbf{I} - \mathbf{A})^{-1} \oslash \mathbf{ID}\right]\mathbf{F} - \mathbf{e}^{\mathbf{DM}}$
Imported	Imported	Yes	$\mathbf{e}^{\mathbf{DM}} = \hat{\mathbf{e}}[(\mathbf{I} - \mathbf{A})^{-1} \oslash \mathbf{ID}](\mathbf{F} \oslash \mathbf{IF})$

Total footprints related to trade	$\mathbf{e}^{\mathbf{tr}} = \mathbf{e}^{\mathbf{MF}} + \mathbf{e}^{\mathbf{ML}} + \mathbf{e}^{\mathbf{DM}}$

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WIFO ÖSTERREICHISCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG

ASCII Supply Chain Intelligence Institute Austria

Quantifying external trade risks

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Motivation and Scope

- Countries and sectors are **highly vulnerable** to value chain (input) shocks.
- We **quantify** the **expected output** loss due to supplier (input) outages, and **rank the suppliers** based on their **quantitative importance and risk**.
- The method can be applied to regions, countries, sectors, or products.
- It delivers the initial direct effect (shock) of an outage scenario, *currently* without considering indirect effects or price adjustment.
- The overarching aim is to combine the **production technology**, **inventory strategy and supplier diversification** to assess supply chain risks.

Method

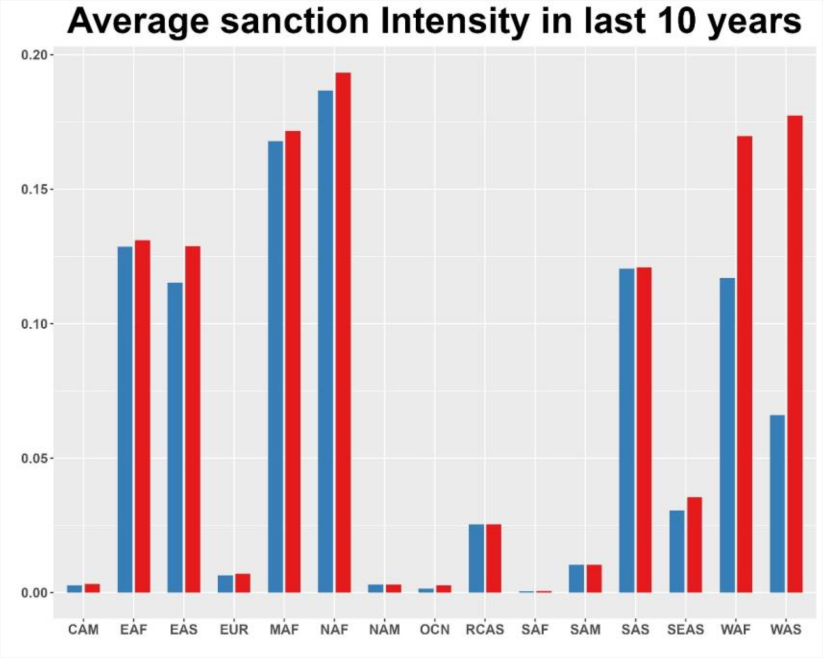
- We **model stochastic output loss** to foreign supply shocks by combining:

  - **IO data** (GLORIA MRIO 2022) that provides the structure of production and bilateral trade relationship aggregated to 19 (ISIC) sectors and 15 regions.

  - Data on **international sanctions** (GSDB v3) as a proxy for risk.

- Risk profiles (CDF of output loss) show the probability that a supply shock (outage of intermediate inputs) will cause output to **decline below a critical level**.
- This **critical level** reflects the maximum (economically or politically) acceptable level of output loss that could depend on inventories.
- Stochastic scenarios span all combinations of outages that originate from 15 regions, starting from the stoppage of all trade (domestic supply only) to full supply (status quo).
- The output loss can be **structural**, or **risk-weighted**, with or without herding.

Sanctions and trade linkages



Adjusted Correlation Matrix

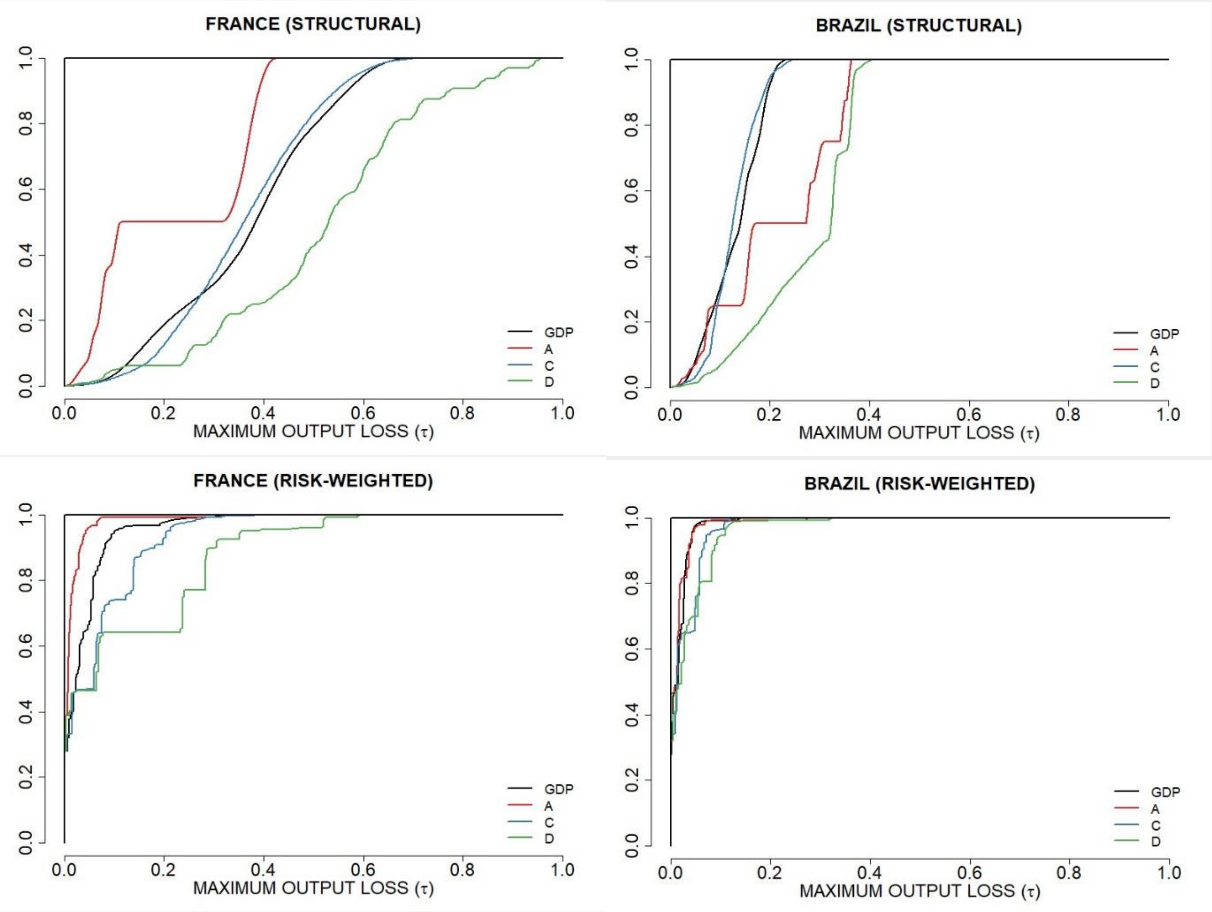
	CAM	EAF	EAS	EUR	MAF	NAF	NAM	OCN	RCAS	SAF	SAM	SAS	SEAS	WAF	WAS
CAM	1	0.44	0.2	0.45	0.54	0.24	0.03	0.5	0.36	0	0.4	0.67	0.69	0.12	0.45
EAF	0.44	1	0.2	0.32	0.36	0.03	0	0.66	0.39	0.16	0.19	0.42	0.19	0.59	0.4
EAS	0.2	0.2	1	0	0.36	0.36	0.23	0.24	0.18	0	0.01	0.27	0.27	0.01	0.17
EUR	0.45	0.32	0	1	0.5	0	0	0.66	0	0.09	0.08	0.55	0.44	0.02	0.25
MAF	0.54	0.36	0.36	0.5	1	0.15	0.08	0.61	0	0	0.23	0.74	0.3	0.08	0.34
NAF	0.24	0.03	0.36	0	0.15	1	0.29	0	0.35	0.03	0.22	0.42	0.42	0.49	0.07
NAM	0.03	0	0.23	0	0.08	0.29	1	0.18	0.25	0.25	0.02	0.3	0.35	0.25	0.32
OCN	0.5	0.66	0.24	0.66	0.61	0	0.18	1	0.25	0.04	0.34	0.52	0.39	0.34	0.62
RCAS	0.36	0.39	0.18	0	0	0.35	0.25	0.25	1	0.58	0.64	0.35	0.37	0.27	0.15
SAF	0	0.16	0	0.09	0	0.03	0.25	0.04	0.58	1	0.34	0.33	0.12	0.1	0
SAM	0.4	0.19	0.01	0.08	0.23	0.22	0.02	0.34	0.64	0.34	1	0.31	0.17	0	0.03
SAS	0.67	0.42	0.27	0.55	0.74	0.42	0.3	0.52	0.35	0.33	0.31	1	0.51	0.2	0.35
SEAS	0.69	0.19	0.27	0.44	0.3	0.42	0.35	0.39	0.37	0.12	0.17	0.51	1	0.24	0.42
WAF	0.12	0.59	0.01	0.02	0.08	0.49	0.25	0.34	0.27	0.1	0	0.2	0.24	1	0.38
WAS	0.45	0.4	0.17	0.25	0.34	0.07	0.32	0.62	0.15	0	0.03	0.35	0.42	0.38	1

We proxy the risk based on the frequency of all sanctions and trade sanctions.

The hoarding effects are based on correlations derived from the trading volumes.

Structural and risk-weighted profiles

- Structural profile derives from the input structure without assumptions about risk distribution.
- Risk profile extends the structural profile to include a distribution of multiple input outages.
- Y-axis shows the probability that the maximum output loss will not exceed a certain percentage (CDF).

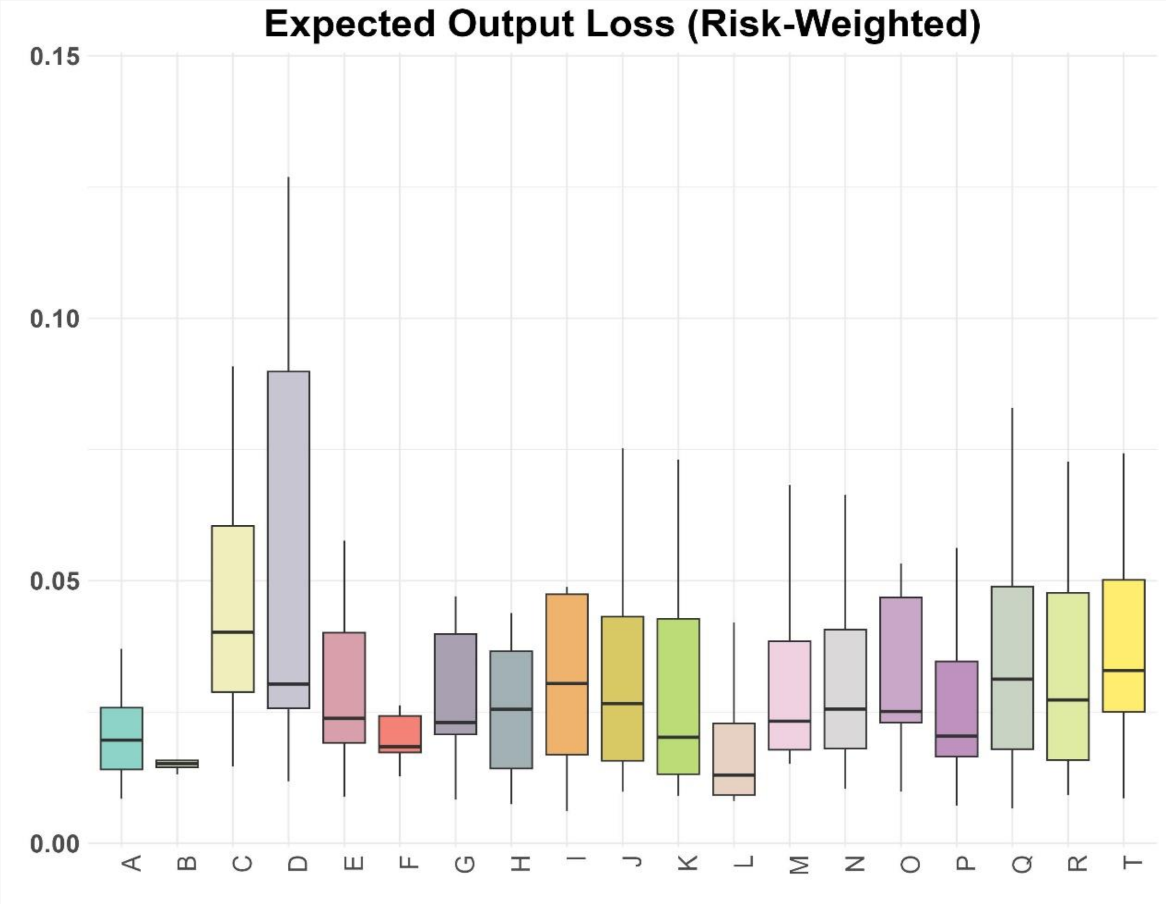


ISIC sectors
A = Agriculture, forestry and fishing
C = Manufacturing,
D = Electricity, gas, steam and air conditioning supply

Risk-weighted expected output loss (top 10 economies)

Sectors differ in structural and risk-weighted expected output losses.

The manufacturing (**C**) and energy sectors (**D**) are more heterogeneous with respect to expected loss.



Next steps

- Obtain probability intervals, e.g. using trade sanctions vs all sanctions, as **low** vs **high** risk.
- Use a trade matrix to calibrate **positive correlation** between regional outages due to global trade links.
- Use IO analysis to model the **propagation** of the input shock, with the aim of computing the aggregate effect of an outage scenario on the domestic economy beyond the initial shock.

Potential future developments

- Incorporate the probability of **other causes** of supply disruptions: natural disasters, accidents, unrest.
- Apply the methodology to **specific products**, taking into account domestic **inventories**.

Limitations

- The complexity of obtaining a multivariate outage distribution limits the number of suppliers.
- The results apply in the initial output shock, without offset by other supply sources or price adjustments.

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AGENCE FRANÇAISE DE DÉVELOPPEMENT

Financial exposure to trade-induced extinction risk footprints

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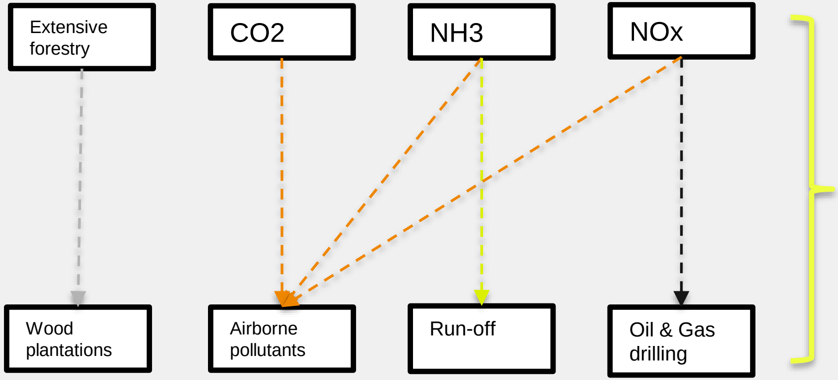
SPECIES EXTINCTION RISK

A link between nature, economy and finance

Environmental pressures from economic activities



IUCN Red List threat classification scheme

Extinction risk category (W_i):

4: Critically Endangered
3: Endangered
2: Vulnerable
1: Near Threatened

Threat Impact Score (TS_t):

- **Severity (timing)**
- **Scope**

$$STAR_{it} = W_i * TS_t$$

Aggregated into a vector by country and sector

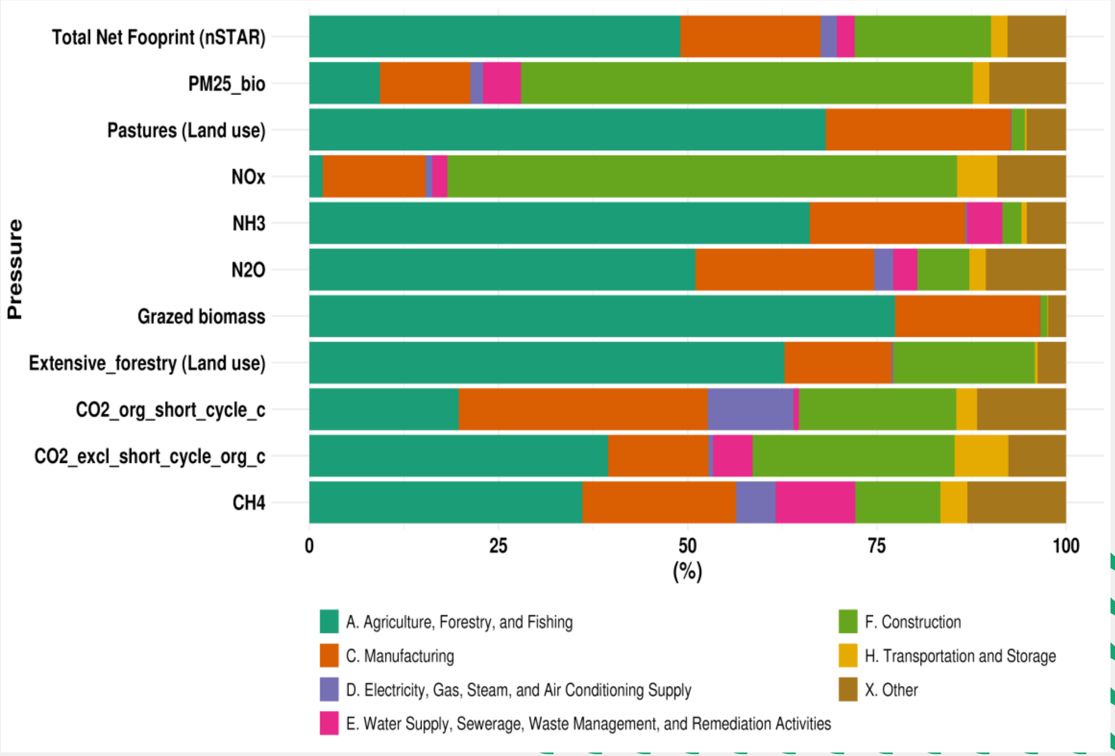
Gloria Input-Output model

Accounting for consumption-based footprint globally

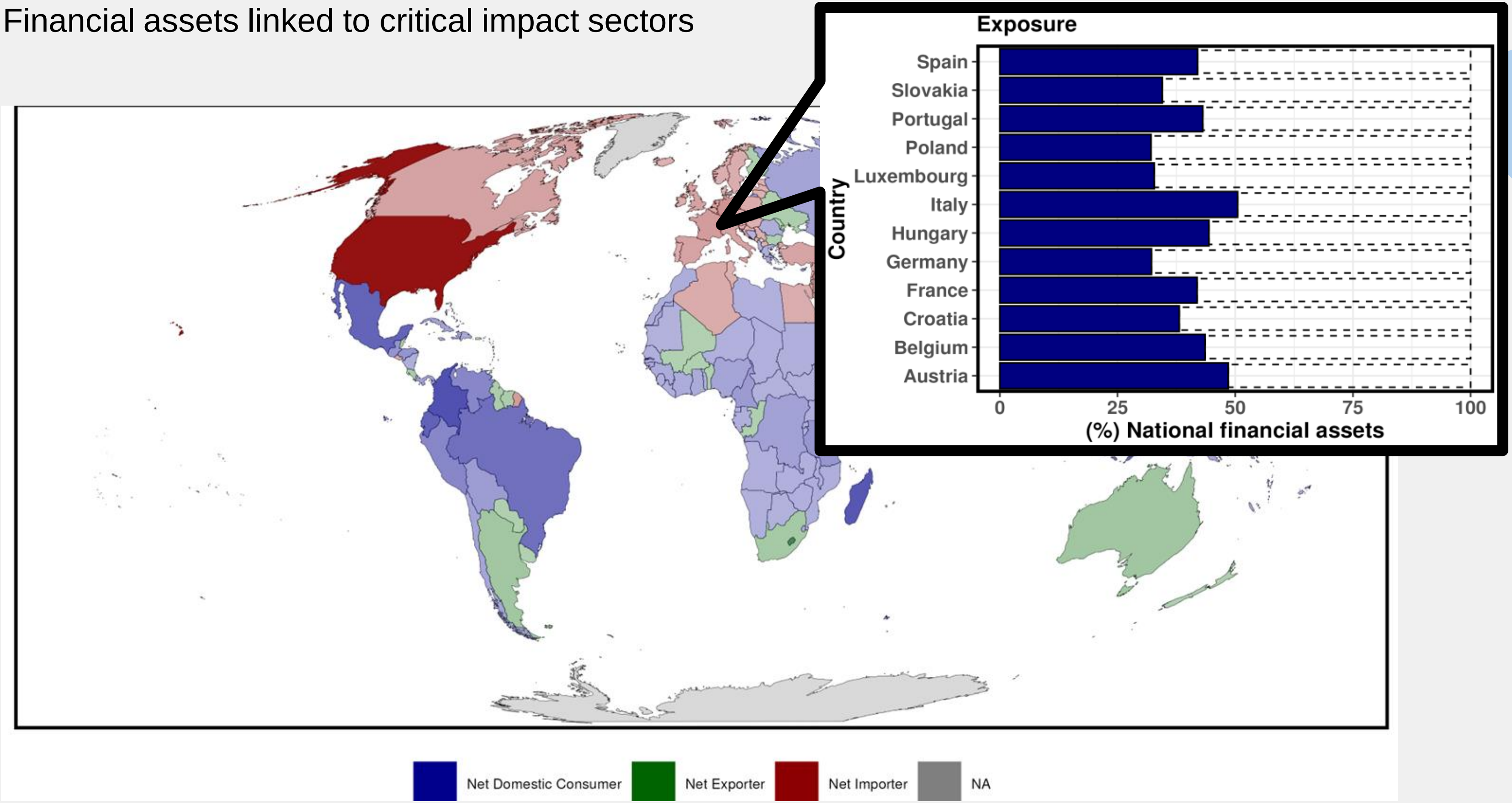
CRITICAL SECTORS OF EXTINCTION RISK FOOTPRINT

Footprint through multiple pressures

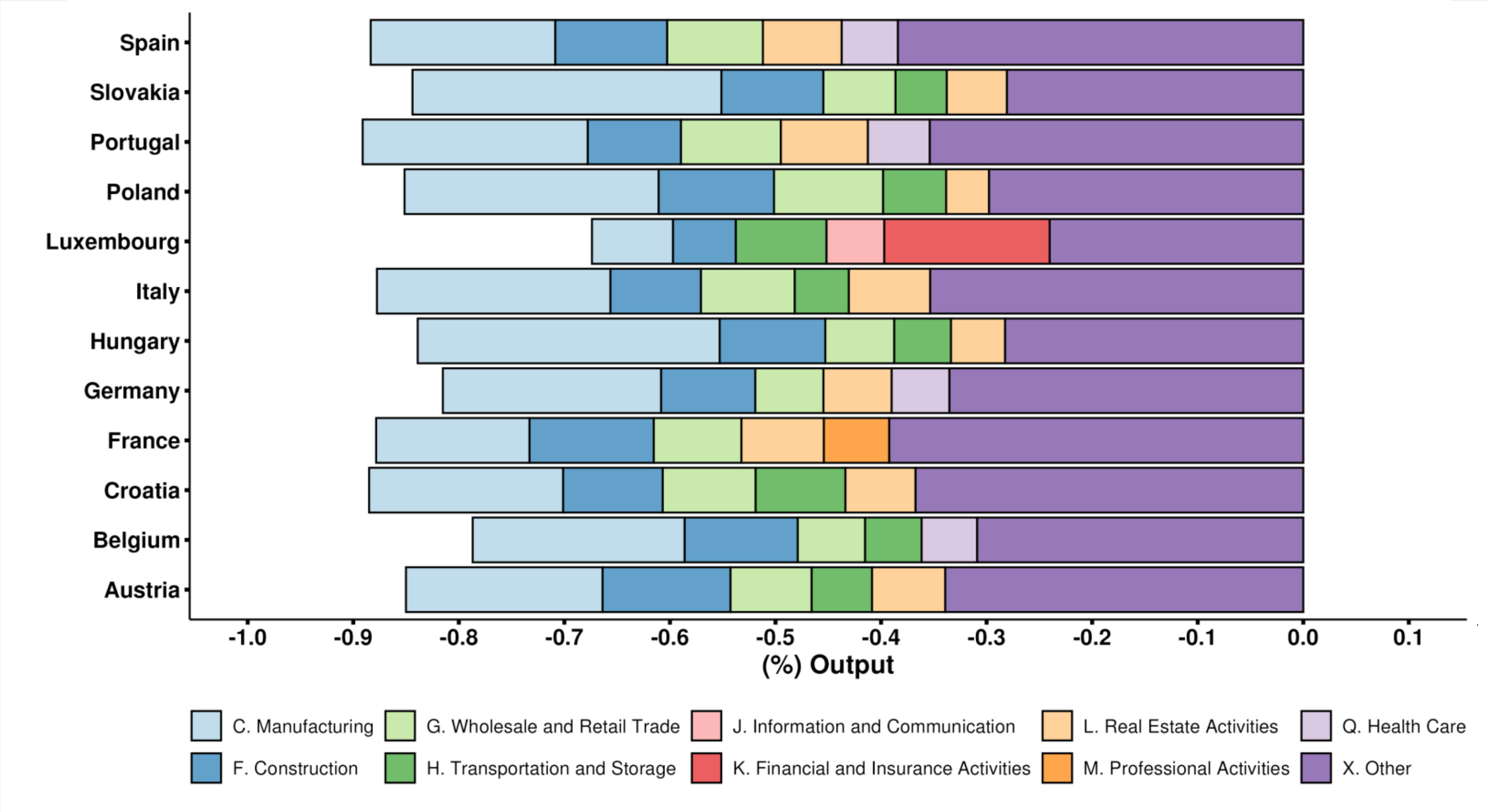
- Agriculture
  - Extensive and intensive monoculture
  - Habitat destruction
- Manufacturing
  - Direct + diverse upstream impacts
  - Examples: material sourcing, transport, processing
- Construction
  - Sourcing of raw materials (sand, gravel, timber, etc.)
  - Processing and production of concrete
  - Transportation



EUROPEAN EXPOSURE TO TRANSITION RISKS
Financial assets linked to critical impact sectors



REQUIRED EU OUTPUT REDUCTION FOR 1% BIODIVERSITY IMPACT DECREASE



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Countries' unequal exposure to climate change impacts through international trade

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Extreme weather events already disrupt international supply chains…

2021

2024

… and it might get worse with future climate change

Context

- **Supply chain risk** have risen to **the top of the policy agenda**

→ Academics (Baldwin et al. 2022, 2023) and public institutions (OECD 2022) have been increasingly interested in measuring countries' exposure to supply chain shocks.
→ But risk is defined as depending too much on foreign countries.

- However, in the future, **relying on high-risk climate countries** may pose a **greater challenge** than relying on low-risk ones.

- **Trade ripple effects of extreme events** are studied in the climate change impact literature

→ But studies focus on a limited number of extreme event (heat-stress, river floods, etc.) (Wenz and Levermann 2016, Kuhla et al. 2021, Sun et al. 2024),
→ or on a limited number of economic sectors (Nakano 2017, Nakano 2020).

Research question

Research gap:
A simple method is still needed for a systematic quantitative assessment of climate exposure through trade

Research question:
How do countries compare in their exposure to climate change through trade?

Methods

Data

Trade data = Multi-Regional Input-Output Tables (MRIOT)

- Imports/exports
- Intermediate and final consumption
- Direct and indirect exposure to foreign countries (Leontief matrix)

Climate risk country indices

- Country score (/10 or /100)
- Publicly available and used by development practitioners
- Risk = hazard + exposure + vulnerability
- Hazard = future climate change projections

We use 2 MRIOT data : ICIO and EORA26.

- ICIO OECD (45 sectors and 66 countries)
  - Used by Baldwin et al. (2023) ; OECD (2022).
- EORA26 (26 sectors and 189 countries)
  - More countries with high climate risk are covered.

We use 2 climate risk country indices

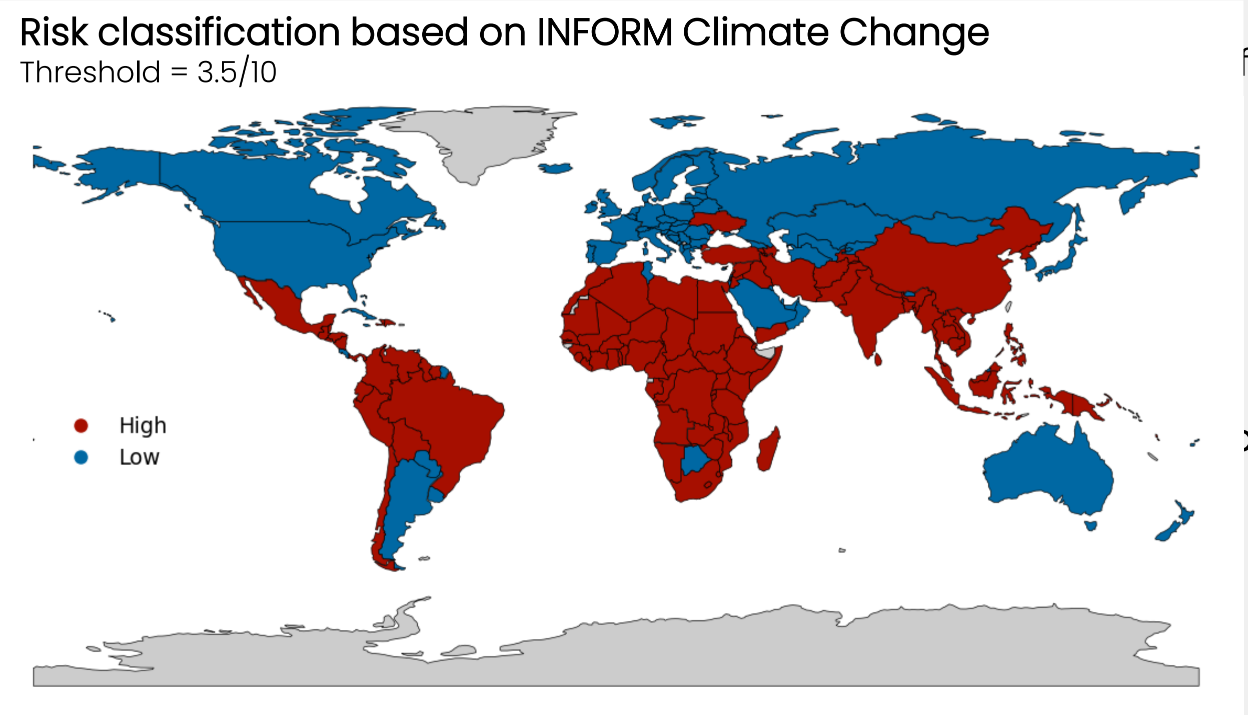
- ND-Gain
  - 191 countries
  - Score /100
- INFORM Climate Change
  - 189 countries.
  - Score /10

ND-GAIN Notre Dame Global Adaptation Initiative

INFORM CLIMATE CHANGE

Combining trade and climate risk data

- **Countries are divided into two categories** : low and high climate risk.
- An exampl for **imports** of **intermedia**
- Exposure c sure indices.
- "Exposure" rtners"



Limits

Exposure and not cost

- Only a measure of exposure but no “cost of climate change impacts” : no substitution, or production function.
- Sufficient to do cross-country / cross-sector broad comparison.

Coarse geography

- Climate risk measured at a national scale, not at a sub-national or city level.
- However, climate risk is mainly regional, especially vulnerability (Birkmann et al. 2021).

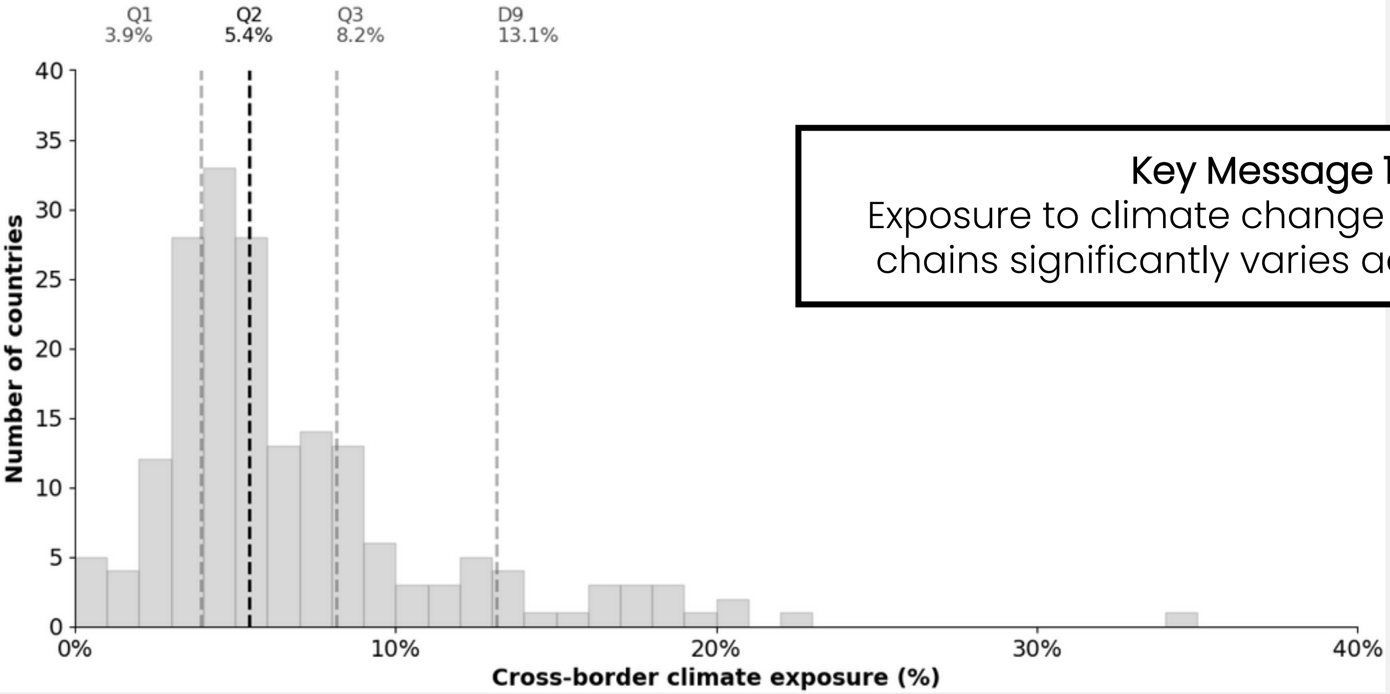
Coarse sector analysis

- A country at risk might not be at risk for every sector (agriculture vs manufacturing).
- Limited by publicly available climate risk indices.

Results

Exposure across countries

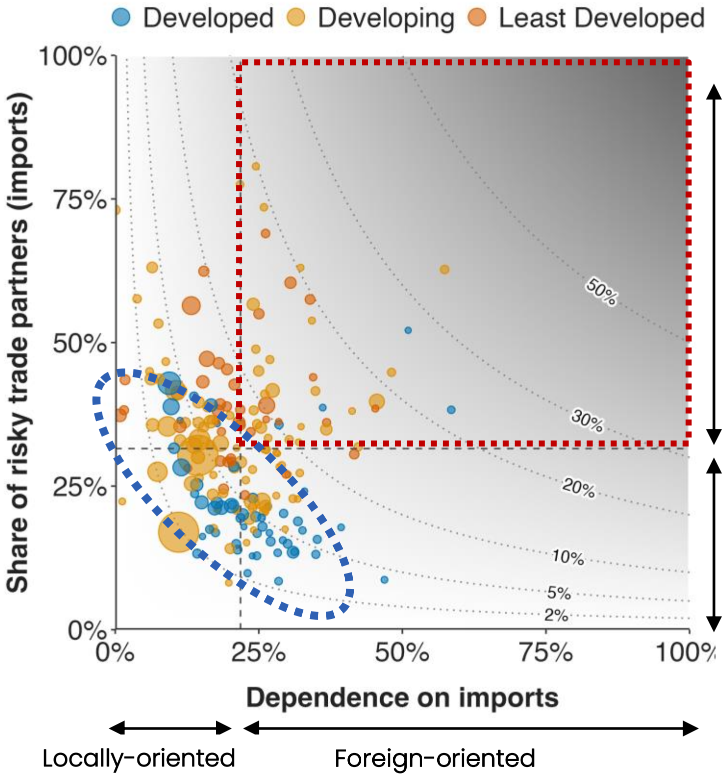
Cross-border exposure for imports of intermediate consumption
EORA26 – INFORM Climate Change



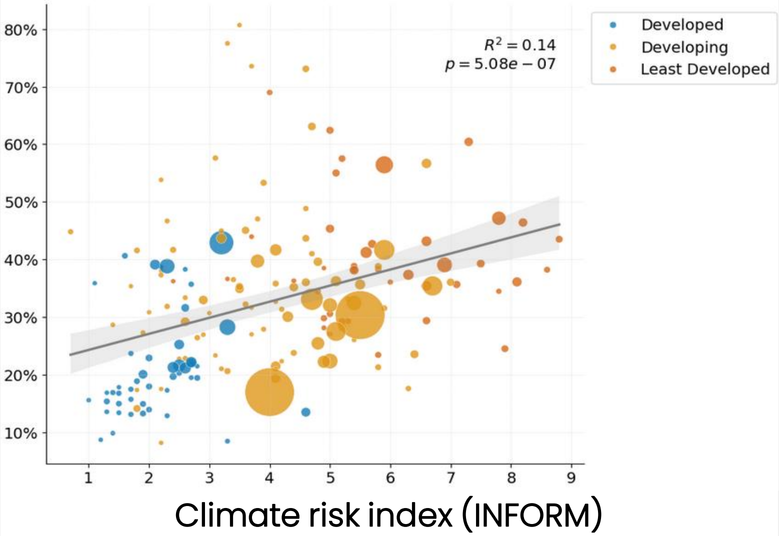
Key Message 1 :
Exposure to climate change through supply chains significantly varies across countries

Countries with highest and lowest exposure?

Exposure for imports of intermediate consumption

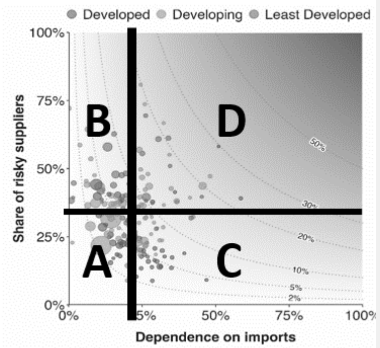


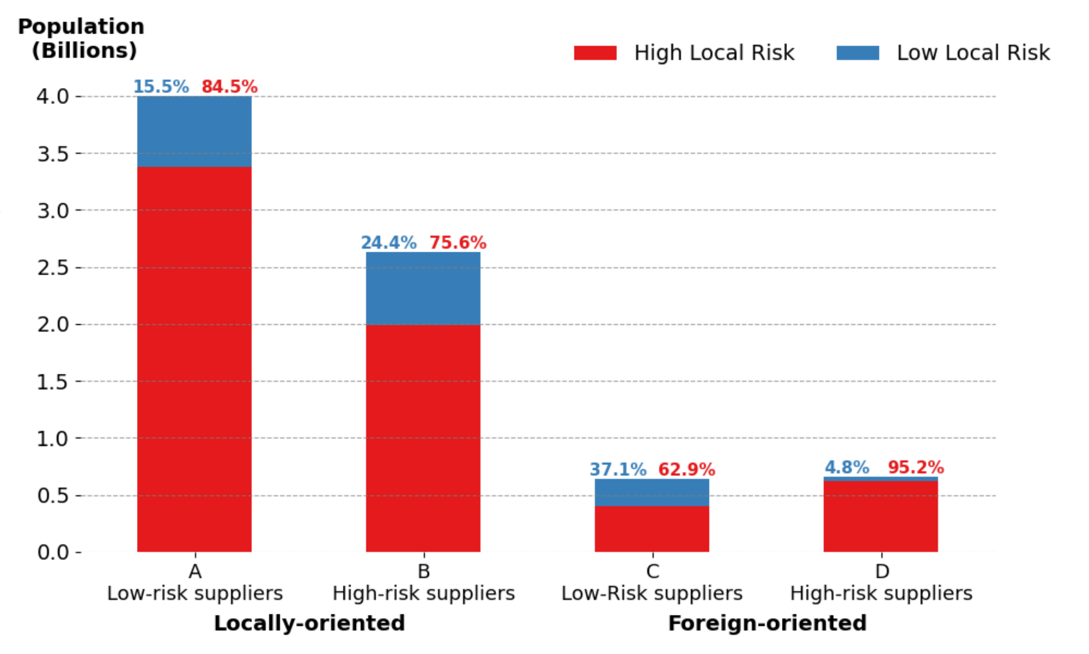
Share of risky suppliers (%)



Key Message 2
Having risky suppliers correlated with local risk → trade is regional and climate risk is concentrated

People facing double exposure





People facing high supply chain risks are also significantly exposed to direct risks

Low Exposure Intermediate Exposure High Exposure

Final consumption ? Exports ? Robustness ?

Results are qualitatively similar for imports of final consumption.

Results are different for exports

- Developed countries are typically more export-oriented, as a share of gross output, than developing/least-developed countries.
- A higher degree of economic openness offsets the lower proportion of trade with risky partners.

Robustness analysis

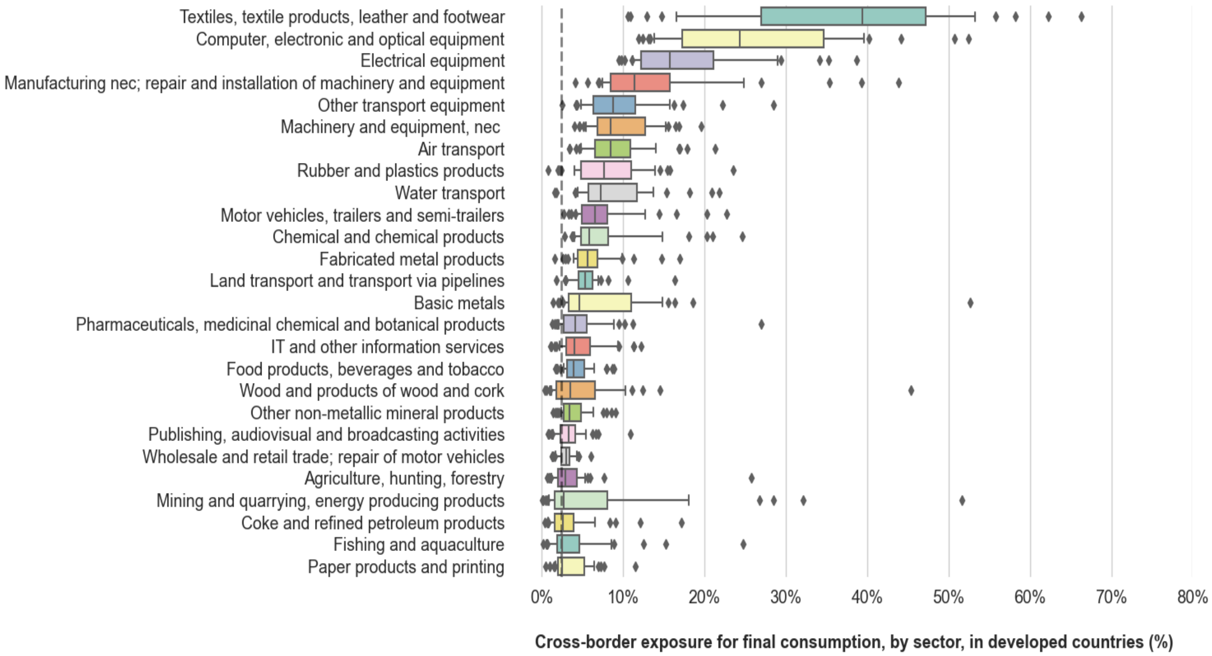
- IO tables (ICIO and EORA26)
- Climate risk index (ND-GAIN, INFORM Climate Change)
- Threshold between low/high climate risk (3.5 $\pm$ 0.75/10 and 50$\pm$10/100)
- Removing one country at a time from the high-risk list

Strong dependence on certain types of goods

Key Message 3 : Even when absolute exposure is low, some sectors are highly exposed.

In developing countries, manufacturing (textile, electronics, machinery, vehicles, metals, plastics).

Cross-border exposure for final consumption, by sector, in developed countries (%) EORA26 – INFORM Climate Change



Conclusion

Key takeaways

Research question : How do countries compare in their exposure to climate change through trade?

Exposure to climate change **through international supply chains significantly varies across countries.**

- For imports of intermediate consumption : median = 5.8%, 90th percentile 14.1%.

Double burden = the more a country is directly exposed to climate impacts, the more its suppliers/buyers are also risky

- For developed countries (among the least climate-risky countries), share of high climate risk suppliers (20%) lower than developing/least developed countries (37%).

Even with low aggregate exposure, **strong dependence on high risk countries for some goods.**

- 3.4% aggregate exposure for developed countries but 39.5% in textile or 24.3% in electronic products.

Policy recommendations

- From a developed country perspective, **financing climate adaptation in the Global South can be justified from a national resilience perspective**.

- **"Hidden" exposure through supply chains** must be accounted for in national climate risk assessments.

- For countries with high cross-border exposure, **diversifying future trade outside regional scope could be a solution**, even though it might be costly.

  → Lower exposure must be balanced against lower gains from trade.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FERDi

Navigating international taxation: the effects of a carbon levy on shipping

Audrey-Anne de Ubeda (Ferdi), with Vianney Dequiedt (Ferdi, Cerdi-UCA) and Edouard Mien (Ferdi)

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Table of contents

Introduction and motivation

- International taxation of maritime transport is a longstanding issue
- International Maritime Organization 2023 revised strategy
- Ongoing negotiations and confluence of climate / development agendas

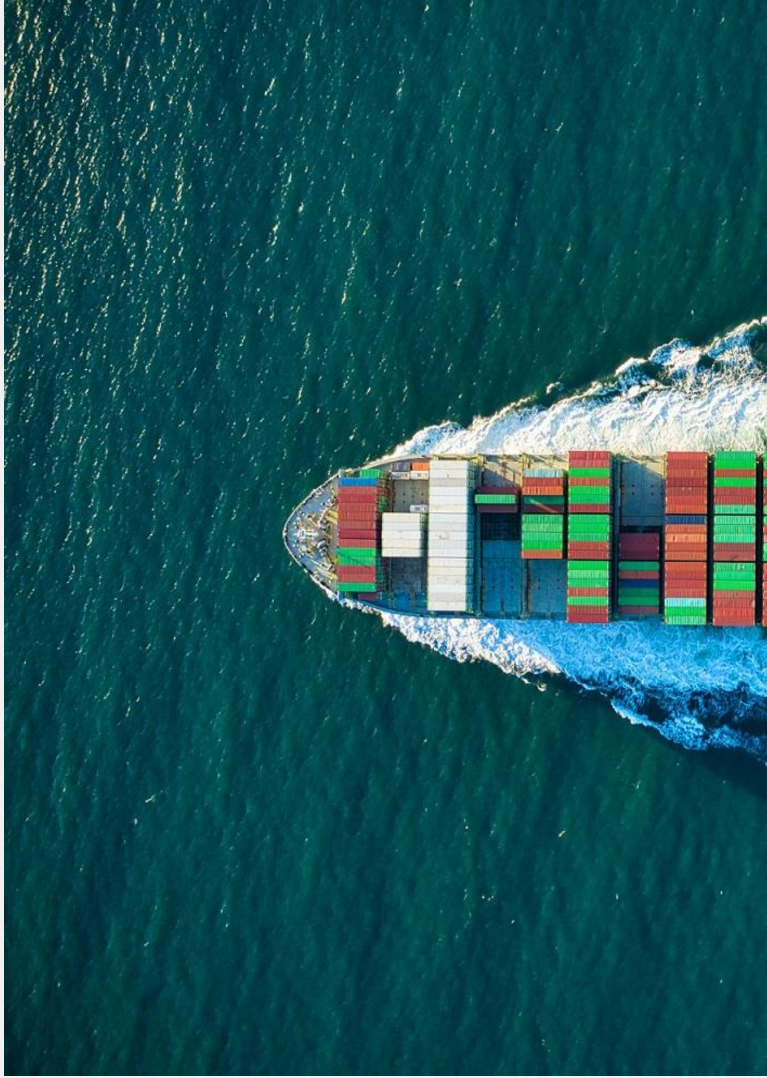
Research question : What would be the effects of the implementation of a global carbon tax on international shipping ?

- What countries would be the most impacted by the tax ?
- What would be the effects of the tax on carbon emissions ?
- What would be the tax proceeds and the corresponding economic costs?

Seaborne trade stylized facts

- In 2022, 11 billion tons of merchandise were transported internationally by sea
- For the EU, seaborne trade represents approx. 45% of external trade in value, 75% in volume
- Shipping is the main mode of transportation for a wide range of products
- International trade generates > 10% of global CO_2 emissions, shipping represents 3% of GHG emissions worldwide (IMO)

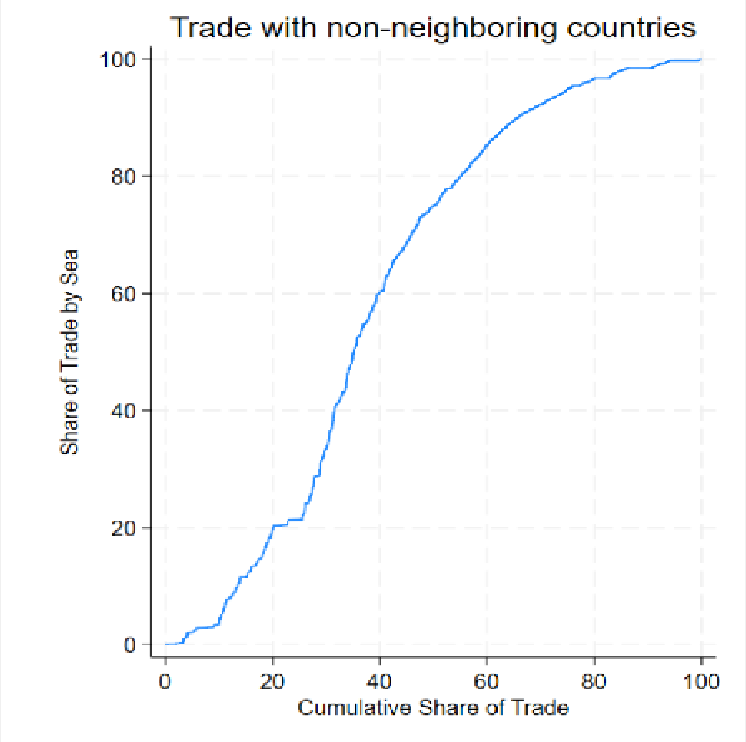
There is no existing publicly available dataset on disaggregated and bilateral maritime trade flows with worldwide coverage



Analytical framework

- We simulate a \$40/tCO_2 global carbon tax implemented worldwide on maritime transport
- Our analysis is based on trade data covering 192 countries over the period 2012-2019, disaggregated at the HS2-level
- We apply a multi-sector structural gravity model; marine fuel costs being a component of iceberg trade costs ➔ we propose a parsimonious approach to isolate maritime trade and estimate the elasticities per HS2-level sector
- Counterfactual analysis: *what effects of a carbon levy if it were implemented in 2019?*

Shares of U.S. + UE seaborne trade (average 2012-2019)



Main results (1/2)

Richer countries would be relatively less impacted by the tax than poorer countries ➔ (OECD countries = average -0.24% welfare loss, -0.77% for LDCs, -1.15% for SIDS)

Modest reduction in CO_2 emissions from international shipping [-1.91% ; -1.44%], and even lower for total international trade [-1.14% ; -0.04%]

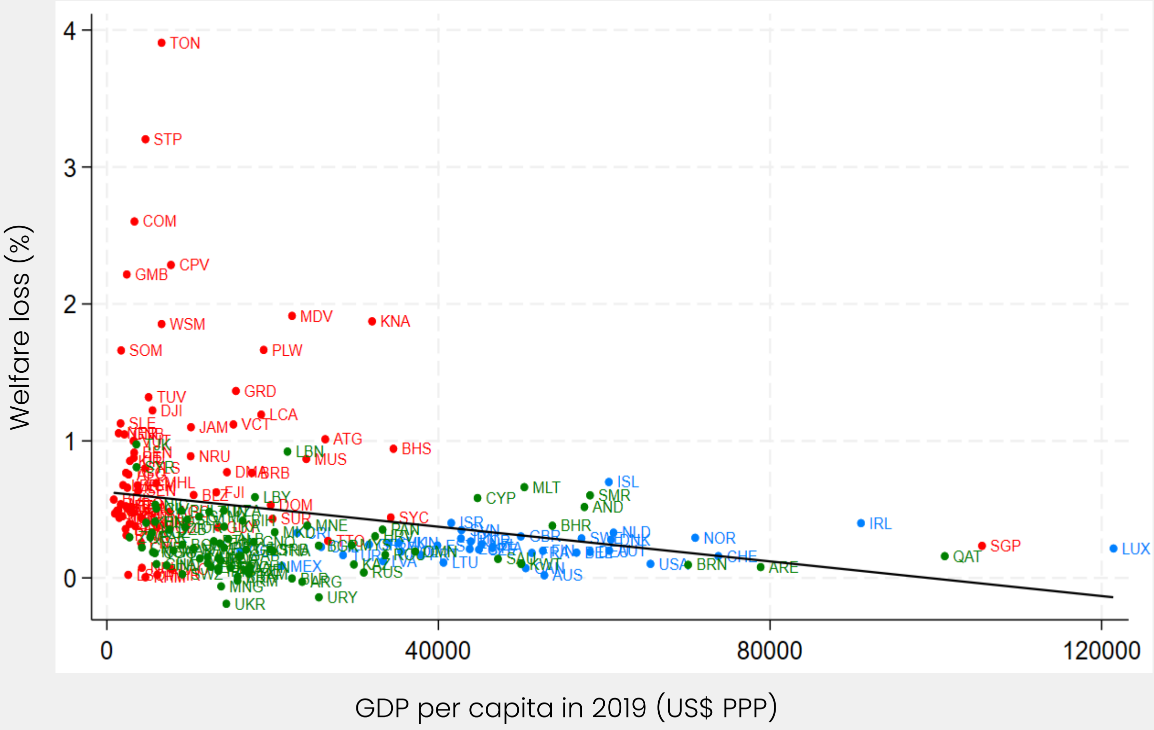
The proceeds from the tax are estimated to range from $20bn to $70bn, for a total economic cost of $115bn

Main results (2/2)

10 most impacted countries (welfare loss)

Country	Loss
Tonga	- 3.91%
Sao Tome & Pr.	- 3.20%
Comoros	- 2.60%
Cabo verde	- 2.29%
Gambia	- 2.22%
Yemen	- 2.06%
Cook Islands	- 2.05%
Maldives	- 1.91%
St Kitts & Nevis	- 1.87%
Samoa Islands	- 1.85%

Impact of carbon tax on welfare per country as a function of GDP per capita



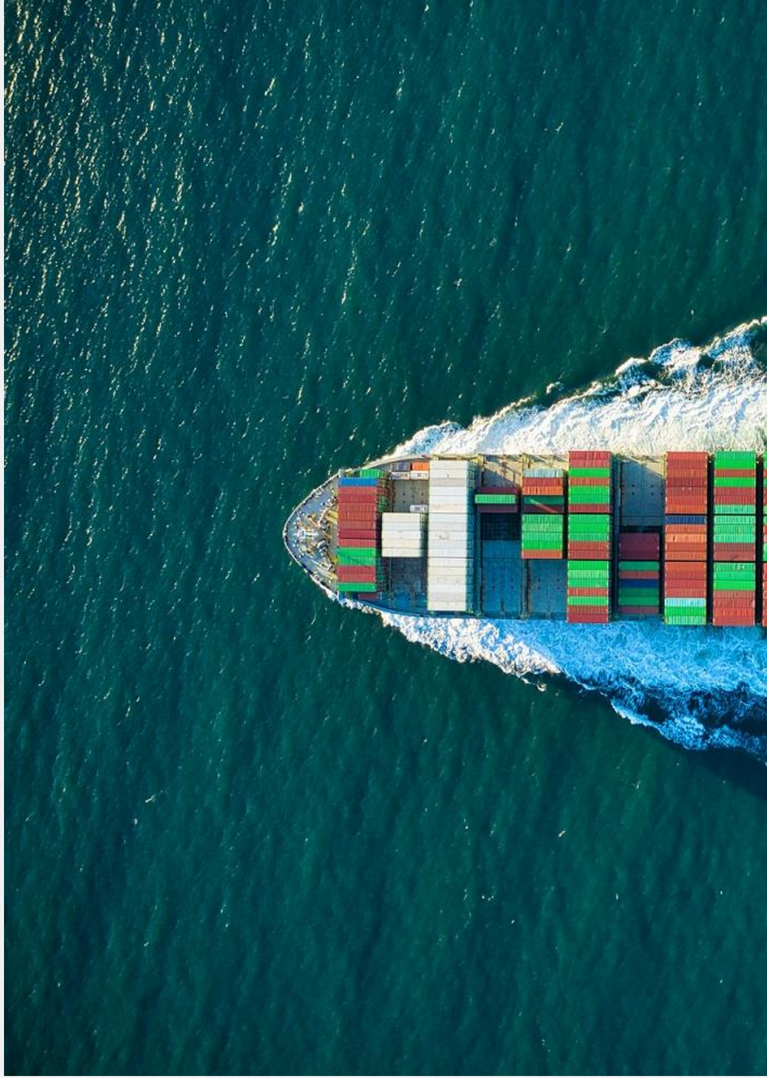
Red: LDCs and SIDS; blue: OECD countries; green: other countries.

Conclusion
& key messages

- A \$40 per ton of CO_2 tax on marine fuel would disproportionately impact poor countries
- It would induce modest reduction in trade emissions, due to redirection of trade flows
- Tax proceeds could be used to finance global public goods and compensate countries, but at a relatively high cost

Policy implications of the study

- Negotiations on global maritime carbon taxation should not neglect emissions from other modes of international transportation
- Other fiscal instruments should be considered and compared
- Further studies are required to investigate the long-run potential effects of such a taxation scheme



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