Is industrial decarbonization at odds with competitiveness?

An assessment of competition dynamics in two EU industries

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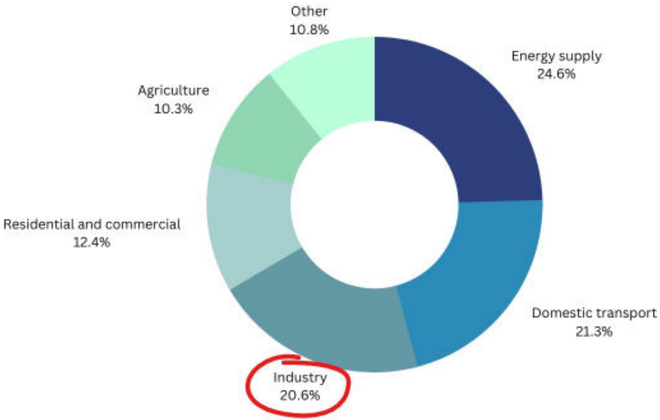
Industrial emissions

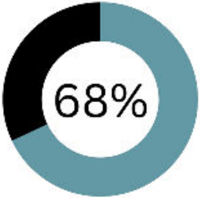
1/5th of EU emissions



Source: European Environmental Agency

The EU ETS

Main instrument for industrial decarbonization



Industrial emissions covered

Excluding power sector

10,000 installations

3 types of GHGs

Energy-intensive sectors

Climate policies vs competitiveness?

> *If international partners do not share a comparable ambition to the EU, there is a risk of carbon leakage.*
>
> – European Commission, 2021

EU ETS

→ Oldest and most stringent system in the world

→ Stringency set to increase

Climate policies vs competitiveness?

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Leakage mitigation measures

→ Free allocations + Indirect cost compensation

→ Soon: CBAM

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Leakage mitigation measures

→ Free allocations + Indirect cost compensation

→ Soon: CBAM

⇒ Are these policies effective at inducing carbon abatement AND protecting competitiveness?

Measuring carbon leakage risk

Economic literature

In the literature:

Strand of literature	Seminal papers / Literature reviews	Method of measurement	Leakage risk assessment	Limitations
Theoretical	Hoel (1991), Markusen et al. (1993)	Game theory	High	No empirical validation
Ex-ante	Branger and Quirion (2014), Carbone and Rivers (2017)	CGE models	Very dependent on elasticities	Highly aggregated
Ex-post	Verde (2020), Joltreau and Sommerfeld (2019)	Empirical estimation	Low	No stringent policies tested

→ Is the difference between empirical estimates and ex-ante studies only caused by low prices? Method of allocation? Could market structure play a role?

Measuring carbon leakage risk

European Commission methodology

Based on simple indicators:

→ trade intensity

→ emission intensity

→ qualitative assessment for some threshold cases

▷ Third phase ▷ Fourth phase

Literature finds EU measure **overstates** carbon leakage risk (Fischer & Fox, 2018; Fowlie & Reguant, 2018; Martin et al., 2014; Sato et al., 2015) ▷ References

What about market structure?

Evidence of **cost pass-through** (Cludius et al., 2020) and **weaker incentives** for carbon abatement because of free allocations (De Vivo & Marin, 2018).

Paper contributions:

→ Proposes new empirical method to determine the **relevant market** in sectors at risk of carbon leakage

→ Estimates highly disaggregated **substitution elasticities**

→ **Country-level** assessment of leakage risk

Methodology

Application of **hypothetical monopolist test** for market delineation (SSNIP) (Werden, 2003)

Inputs:

- → Calculation of own- and cross-price elasticities based on monopolistic competition model
- → Gravity model for estimation of substitution elasticities (Yotov et al., 2016)

⇒ Consistent monopolistic competition micro framework

Scope

→ **Time**: 2008-2018

→ **Products**: Hydraulic cement, clinker, flat and long steel products

→ **Geography**: World

Main results

- → Cement products are more substitutable between countries than steel products
- → Sub-products do not vary substantially in terms of their substitutability
- → Hypothetical monopolist test results:
  - » Steel → mostly national markets
  - » Cement → mostly regional / somtimes global markets

Model assumptions

- → N countries in the world
- → Two agents: upstream producer and downstream producer
- → Armington structure of international trade (country = upstream producer = variety of a good)
- → Common monopolistic competition micro foundation

Hypothetical monopolist test

Micro-founded market delineation method (Werden, 2003)

Intuition:
Relevant market = where a monopolist could exert market power and make a profit.

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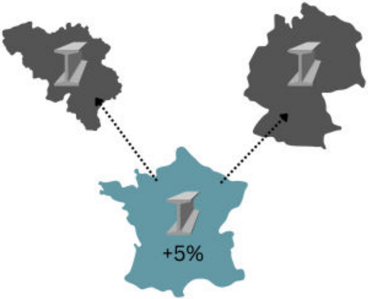

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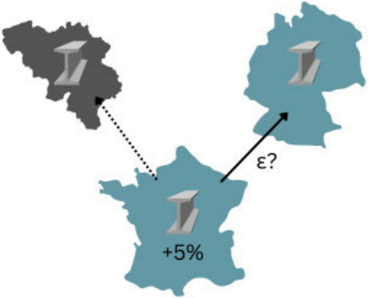

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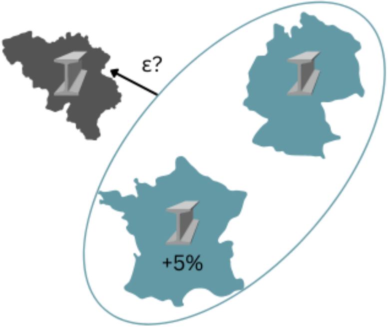

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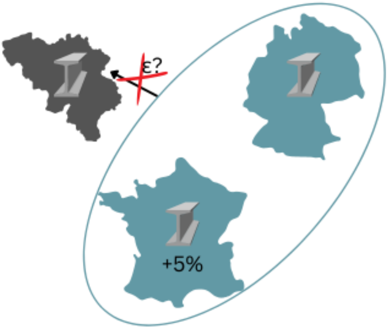

Hypothetical monopolist test

Profit after 5% price increase > Profit before 5% price increase

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$\iff$ Starting country h's own-price elasticity < critical elasticity

Hypothetical monopolist test

Profit after 5% price increase > Profit before 5% price increase

$\iff$ Starting country h's own-price elasticity < critical elasticity

$$\iff -\varepsilon_{hh} < \frac{1}{\mu_h + x} + \sum_{n \neq h} \frac{\mu_n}{\mu_h + x} \frac{\nu_n}{\nu_h} \varepsilon_{nh}$$

ε_{hh}: Starting country h's own-price elasticity
ε_{hn}: Cross-price elasticity between starting country's good h and substitutes $n \in \{1, ..., N'\}$
μ: Margin rate
ν: Turnover
x: small but significant non-transitory price increase

Data needs

Variable		Source	Details
Own- & cross-price elasticities	ε	Estimated from modified gravity model	▷
Margin rate	μ	Eurostat data	
Turnover	ν	Production data * estimated price data	▷
Price increase	x	Conventionally set at 5%	

Data sources

Type of data	Source	Time scope	Geo scope
International trade flows	CEPII's BACI database	2007 - 2020	World
Steel production	World Steel Association	2006 - 2017	World
Cement production	USGS Mineral Yearbook	2004 - 2017	World
Clinker production	Constructed from GCCA	2012 - 2018	World regions
Margin rates	Eurostat	2008 - 2020	Europe
Input-output table	WIOD	2016	World
Price data	Constructed from BACI	2007 - 2020	World

Gravity model results

Table: PPML estimation

	Dependent variable:			
	Trade flow (value)			
	(1)	(2)	(3)	(4)
	Hydraulic cement	Clinker	Flat steel	Long steel
Log distance	-4.005***	-4.252***	-2.004***	-2.694***
	(0.278)	(0.628)	(0.082)	(0.117)
Observations	2424	1150	2166	3024
AIC	57499635	41881771	381428235	197387610
BIC	57465968	41865445	381389852	197337925
Likelihood	-28749128	-20940248	-190713738	-98693325

Note: *p<0.1; **p<0.05; ***p<0.01

▷ Gravity controls

Elasticities of substitution

Product	Elasticity
Hydraulic cement	4.33*** (0.278)
Clinker	4.72*** (0.628)
Flat steel products	3.018*** (0.082)
Long steel products	3.585*** (0.117)

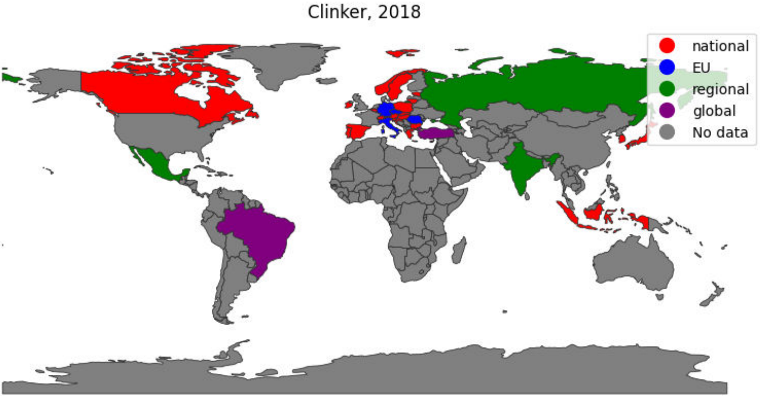
Own-price elasticities

Hypothetical monopolist test results

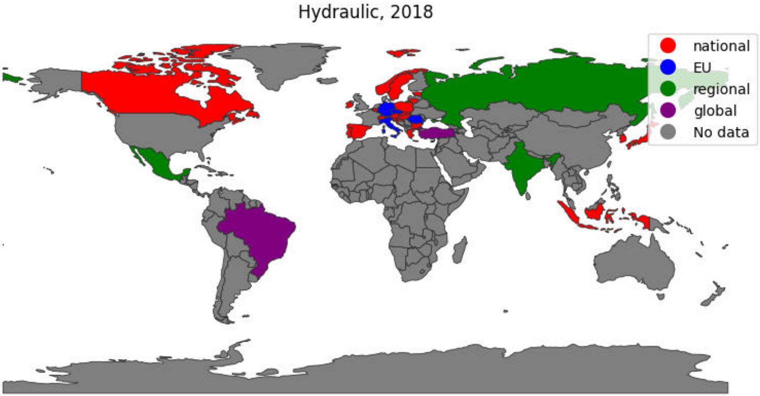
Taking Germany as base country

	Clinker	Hydraulic cement	Long steel	Flat steel
2008	[DEU, LUX]	[DEU, FRA, NLD]	[DEU]	[DEU]
2009	[DEU]	[DEU, FRA, NLD]	[DEU]	[DEU]
2010	[DEU]	[DEU, FRA, NLD]	[DEU]	[DEU]
2011	[DEU]	[DEU, FRA]	[DEU]	[DEU]
2012	[DEU, DNK, ESP]	[DEU, FRA]	[DEU]	[DEU]
2013	[DEU, ESP]	[DEU, FRA]	[DEU]	[DEU]
2014	[DEU]	[DEU, FRA]	[DEU]	[DEU]
2015	[DEU, CHE]	[DEU, FRA]	[DEU]	[DEU]
2016	[DEU]	[DEU, FRA]	[DEU]	[DEU]
2017	[DEU]	[DEU, FRA, POL]	[DEU]	[DEU]
2018	[DEU, TUN]	[DEU, FRA]	NaN	NaN

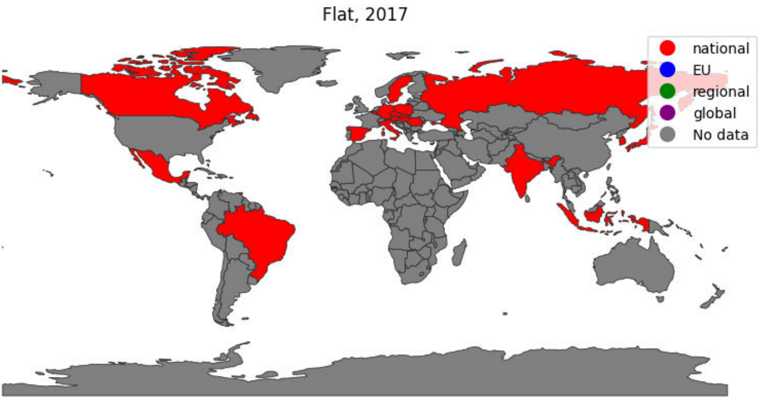
Hypothetical monopolist world results - clinker



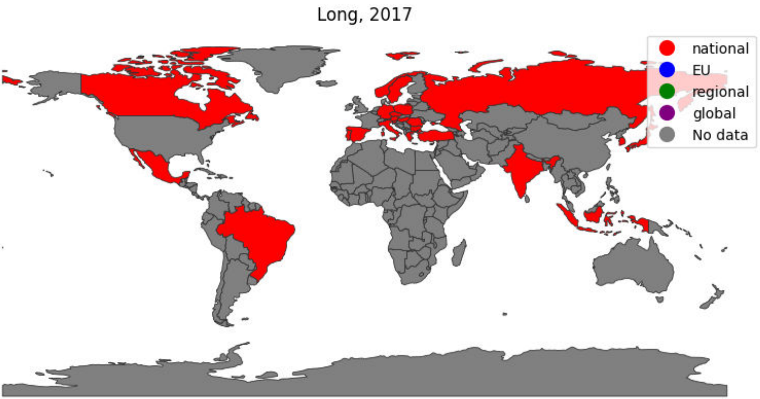
Hypothetical monopolist results - hydraulic



Hypothetical monopolist results - flat steel



Hypothetical monopolist results - long steel



Secondary results

- → Earliest year available ▷
- → Random order of countries for iteration ▷
- → Monte Carlo simulation of margin rates ▷

Hypothetical monopolist intuitions

→ Why does the test (almost) always show the relevant market is national for long and flat steel products?

→ Margin rates are low so critical elasticity is high

$$\text{critical elasticity} = \frac{1}{\mu_h + x} + \sum_{n \neq h} \frac{\mu_n}{\mu_h + x} \frac{\nu_n}{\nu_h} \varepsilon_{nh}$$

→ Opposite of cellophane fallacy

→ For hydraulic cement, relevant market is delineated intra-EU

→ For clinker, relevant market is delineated with extra-EU countries

Conclusion

→ Need to take market power into account

→ Cement products are more substitutable between countries than steel products

→ Sub-products do not vary substantially in terms of their substitutability

→ Hypothetical monopolist test results (in current market conditions!):

- » Steel → mostly national markets
- » Cement → mostly regional / somtimes global markets

→ Could be an indication of specialization of products, or of existing market power

Thank you for your attention!

Questions/comments?

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Third phase methodology

- $\rightarrow$ direct and indirect costs from implementation increase production costs by $> 5\%$ **AND** trade intensity with non-EU countries $> 10\%$
  OR
- $\rightarrow$ direct and indirect costs $> 30\%$
  OR
- $\rightarrow$ trade intensity with non-EU countries $> 30\%$

▷ Back

Fourth phase methodology

First level of assessment:

→ trade intensity * emissions intensity > 0.2

Second level of assessment:

→ if $0.15 <$ trade intensity * emission intensity $< 0.2 \rightarrow$ qualitative assessment

→ emission intensity > 1.5

→ free allocation calculated on basis of refineries benchmark

→ listed in EU ETS phase 3 carbon leakage list at 6-digit or 8-digit level

▷ Back

Price elasticities

Step 1: Gravity model (1)

Modified version of the standard gravity model (Yotov et al., 2016):

→ Maximizing agent is downstream producer

→ Armington structure of trade

→ Nested production function, with σ the CES elasticity of substitution:

$$Y_j = L_j^{\alpha} M_j^{1-\alpha} \tag{1}$$

$$M_j \equiv \left(\sum_{i=1}^{N} m_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

→ Demand for each variety

$$m_{ij}^{*} = p_{ij}^{-\sigma} M_j^{*} \left(\sum_{i=1}^{N} p_{ij}^{1-\sigma} \right)^{\frac{\sigma}{1-\sigma}} \tag{3}$$

Price elasticities

Step 1: Gravity model (2)

→ Iceberg transport costs are defined as:

$$t_{ij} = \delta_j \, dist_{ij} \exp(\theta_j D_{ij}) \tag{4}$$

With δ_j j's distance elasticity, $dist_{ij}$ the geographical distance between i and j and D_{ij} a vector of cultural distance variables

→ Gravity model used for estimation:

$$\begin{aligned} \log X_{ij,t} = & - \log O_t + (1-\sigma) \log dist_{ij,t} + \theta_j (1-\sigma) D_{ij} \\ & + \pi_{i,t} + \chi_{j,t} + \epsilon_{ij,t} \end{aligned} \tag{5}$$

With $X_{ij,t}$ trade flows from i to j, O_t gross world production, and $\pi_{i,t}$ and $\chi_{j,t}$ exporter-year and importer-year fixed effects, respectively.

These elasticities are derived from a monopolistic competition model (Yotov et al., 2016).

$$\varepsilon_{jj} = \frac{\partial m_{jj}}{\partial p_{jj}} \frac{p_{jj}}{m_{jj}} \quad \text{and} \quad \varepsilon_{ij} = \frac{\partial m_{ij}}{\partial p_{jj}} \frac{p_{jj}}{m_{ij}}$$

$$\varepsilon_{jj} = (-\sigma) + (\sigma - \alpha) \frac{p_{jj}^{1-\sigma}}{\sum_{i=1}^{N} p_{ij}^{1-\sigma}} \tag{6}$$

$$\varepsilon_{ij} = (\sigma - \alpha) \frac{p_{jj}^{1-\sigma}}{\sum_{i=1}^{N} p_{ij}^{1-\sigma}} \tag{7}$$

▷ Back

Gravity model results

Sensitivity to standard gravity model control variables

Table: PPML gravity model

	Dependent variable:			
	Trade flow (value)			
	(1)	(2)	(3)	(4)
	Hydraulic cement	Clinker	Flat steel	Long steel
Log distance	-3.333***	-3.715***	-2.018***	-2.585***
	(0.130)	(0.069)	(0.073)	(0.112)
Contiguity	-0.802***	-0.798	-0.383*	-0.236
	(0.247)	(0.656)	(0.217)	(0.239)
Common language	-1.606***	-1.843*	-1.139**	-1.774***
	(0.459)	(1.014)	(0.470)	(0.511)
Colonial ties	0.511	2.497	1.599***	0.680
	(0.603)	(1.518)	(0.191)	(0.511)
Regional trade agreement	-1.807***	-3.732***	-0.492***	-0.398
	(0.217)	(0.481)	(0.168)	(0.243)
Observations	2424	1150	2166	3024
AIC	30700578	9748059	302949737	176139867
BIC	30666934	9731753	302911377	176090207
Likelihood	-15349595	-4873387	-151474485	-88069450
Note:	*p<0.1; **p<0.05; ***p<0.01			

▷ Back

Literature evaluating measures of carbon leakage

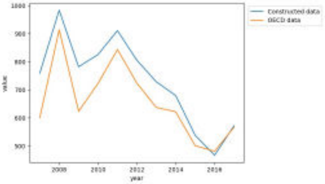
⇒ Overall, tends to show EU's measure of carbon leakage overstates risk of carbon leakage

- → **Fischer and Fox (2018)**: Econometric estimates of parameters related to trade sensitivity. Highlight aggregation bias.
- → **Fowlie and Reguant (2018)**: Simplified model to show challenges of measuring carbon leakage. Note the need for better modeling of foreign responses to carbon pricing.
- → **Martin et al. (2014) and Sato et al. (2015)**: Interviews with industry representatives + micro data. Find most firms were overcompensated for carbon leakage risk.

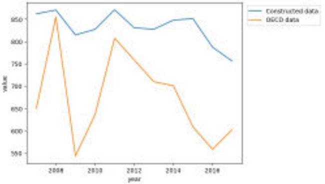
▷ Back

Price data

Domestic price = weighted average of export prices



Japan - flat steel product unit prices (EUR/t)



USA - long steel product unit prices(EUR/t)

	plat	long
CHN	0.834219	0.438151
EU	0.906324	0.924162
JPN	0.943256	0.888726
USA	0.803326	0.653474
SEA	/	0.170657
IND	0.876998	/
RUS	0.724492	0.929019

Correlation coefficients with OECD data

Clinker production

clinker production = cement production * clinker ratio - clinker imports + clinker exports

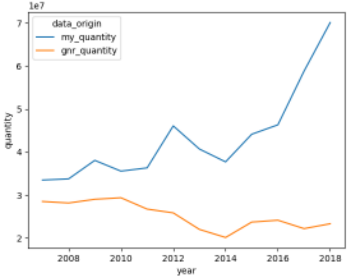


Figure: Egypt

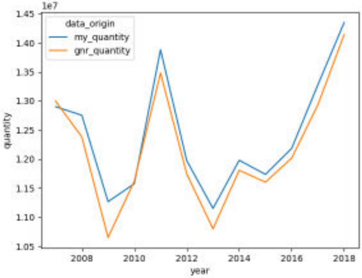


Figure: Poland

▷ Back

Own-price elasticities (1/2)

country	clinker	flat	hydraulic	long
AUS	-7.72398	-3.84155	-0.46518	-9.39003
AUT	-8.10898	-6.28505	-5.04302	-4.37974
BEL	-5.23284	-2.81728	-5.01203	
BGR	-14.2618	-1.49351	-6.0801	-4.45267
BRA	-0.00095	-3.45466	-4.10429	-9.40446
CAN	-11.0213	-1.91681	-8.76299	-9.39594
CHE	-0.79607		-11.3005	
CHN	-2.76708		-1.45569	-9.57233
CYP	-2.54045		-3.26306	
CZE	-1.88145	-3.58095	-8.71323	-9.42988
DEU	-8.30985	-6.27714	-10.8579	-9.41489
DNK	-5.66204		-4.22345	
ESP	-12.7406	-6.27565	-2.38873	-9.41313
EST	-6.73307		-15.0383	
FIN	-0.12403	-6.26373	-0.67424	-1.48296
FRA	-9.64694	-6.24765	-0.97347	-9.38004
GBR	-1.03414	-2.49108	-0.38593	-3.54677
GRC	-14.5681		-12.862	-9.39038
HRV	-12.1379		-1.67239	-9.39294
HUN	-4.23902	-3.876	-2.82989	-3.81304

Own-price elasticities (2/2)

country	clinker	flat	hydraulic	long
IDN	-7.81413	-2.0199	-15.1549	-9.40027
IND	-3.58964		-6.14408	-9.53301
IRL	-7.12912		-6.0571	
ITA	-8.51074	-6.27572	-14.8059	-6.17689
JPN	-5.56202		-15.1585	-9.47811
KOR	-15.8306		-4.73681	-9.52975
LTU	-1.39687		-8.32308	
LUX	-5.67954		-10.8813	-9.37749
LVA	-16.4184		-6.49826	-9.38171
MEX	-16.3552	-0.91131	-15.0636	-9.41381
NLD	-0.68172	-3.30304	-1.44837	
NOR	-1.8E-06		-11.0788	-5.99497
POL	-2.5143	-3.61162	-0.43233	-4.293
PRT	-16.417		-14.092	-6.38249
ROU	-1.48768	-6.2869	-2.28163	-9.42644
RUS	-7.28328	-3.47566	-4.41773	-9.47617
SVK	-9.19558	-6.2731	-8.43001	
SVN	-2.73549	-0.90588	-7.53897	-2.60286
SWE	-16.3953	-6.26606	-8.45702	-9.40179
TUR	-0.84192		-14.7238	-9.42881
USA	-2.64375		-4.19979	-9.38363

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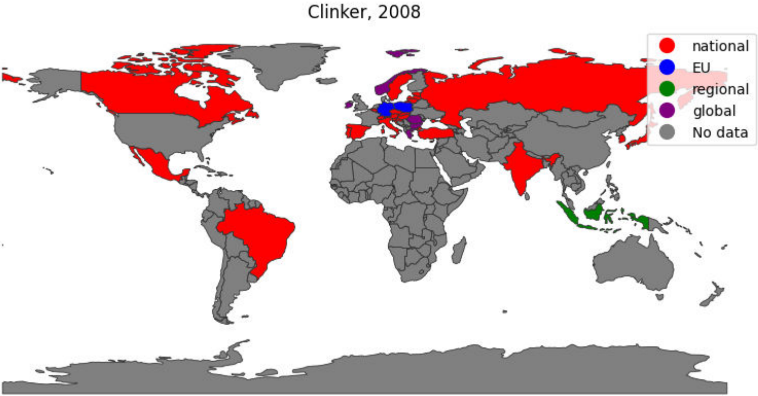
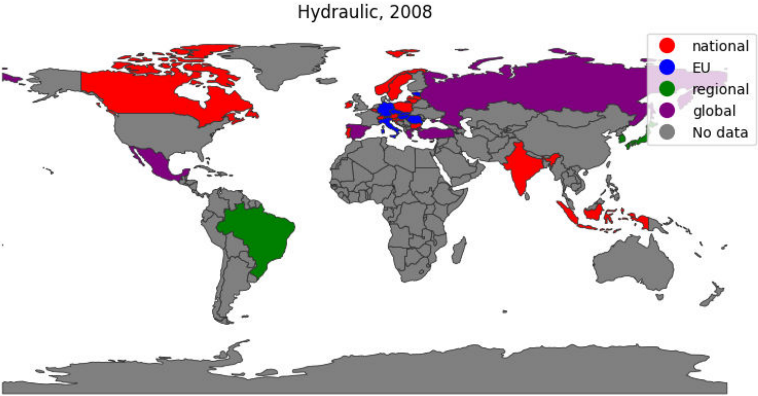
Results - earliest year (1/4)

Clinker



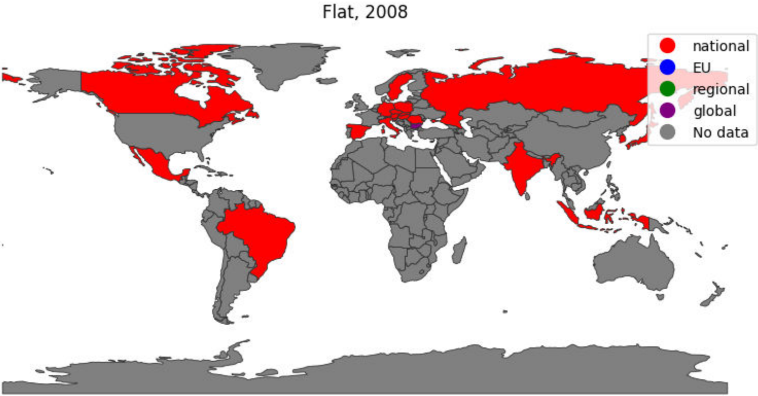
Results - earliest year (2/4)

Hydraulic cement



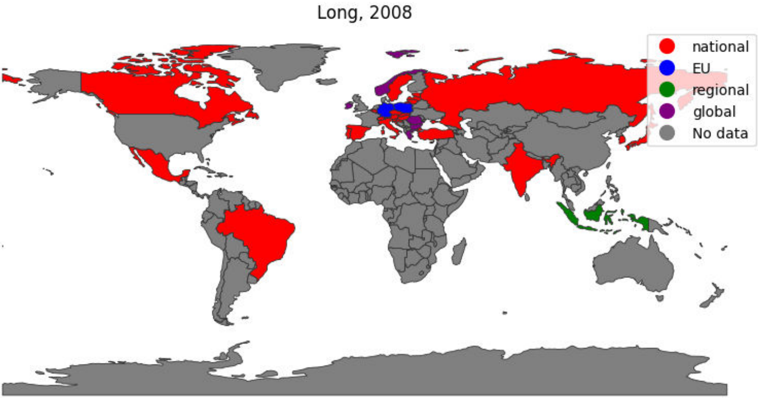
Results - earliest year (3/4)

Flat steel



Results - earliest year (4/4)

Long steel



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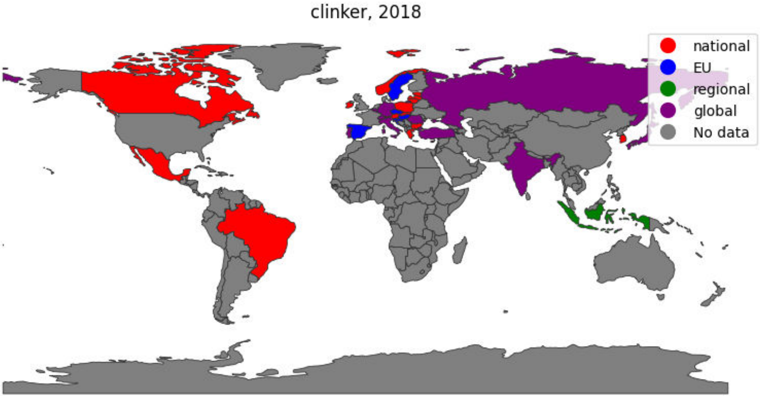
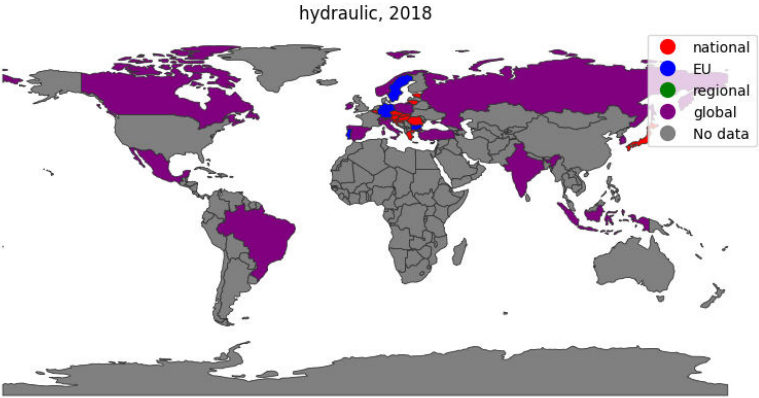
Random order of iteration (1/4)

Clinker



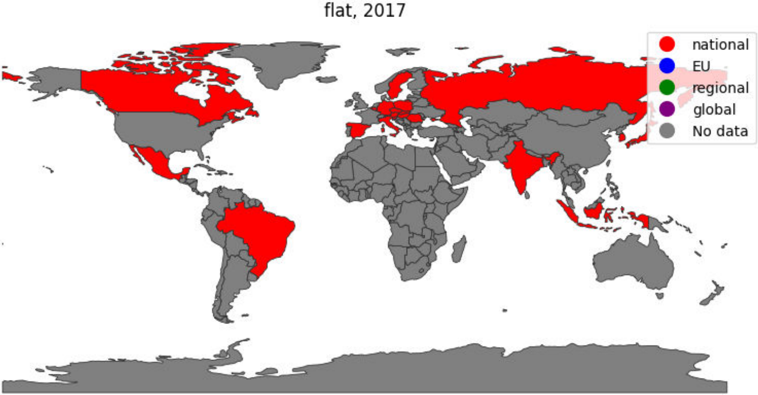
Random order of iteration (2/4)

Hydraulic cement



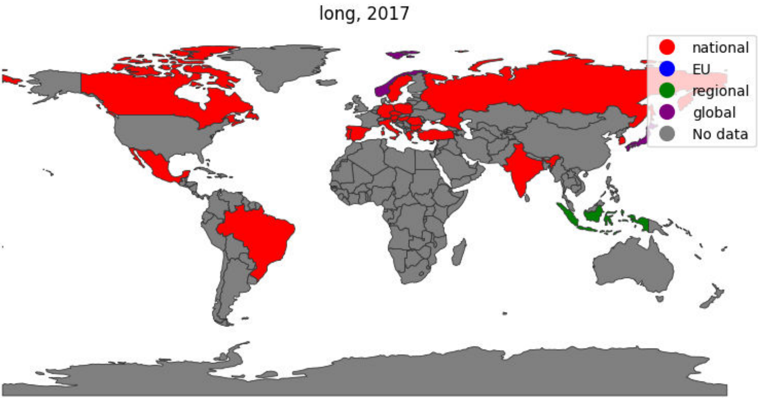
Random order of iteration (3/4)

Flat steel



Random order of iteration (4/4)

Long steel



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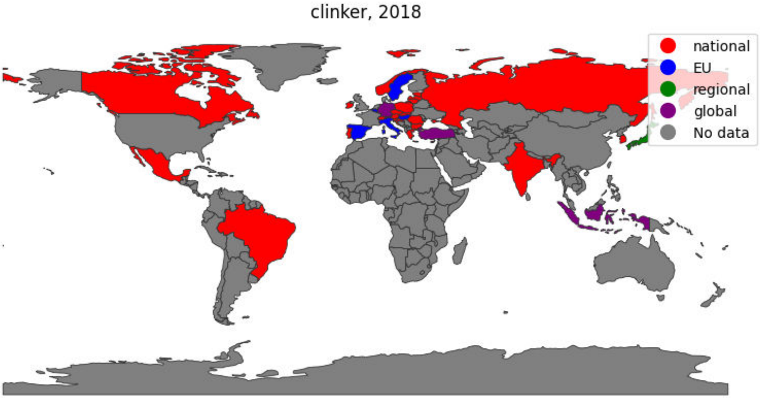
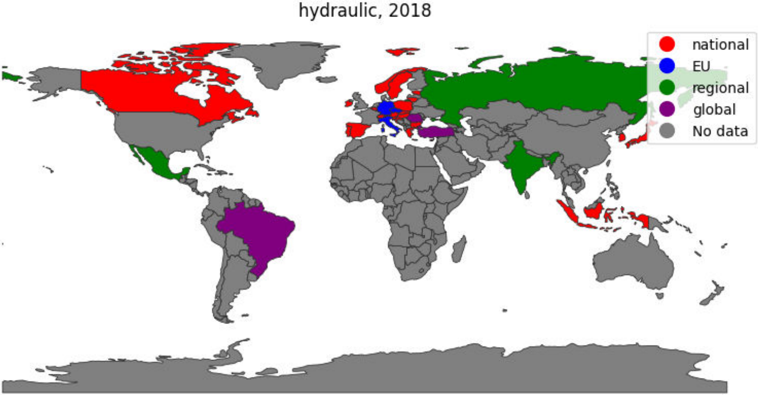
Monte Carlo simulation for margin rates (1/4)
Clinker



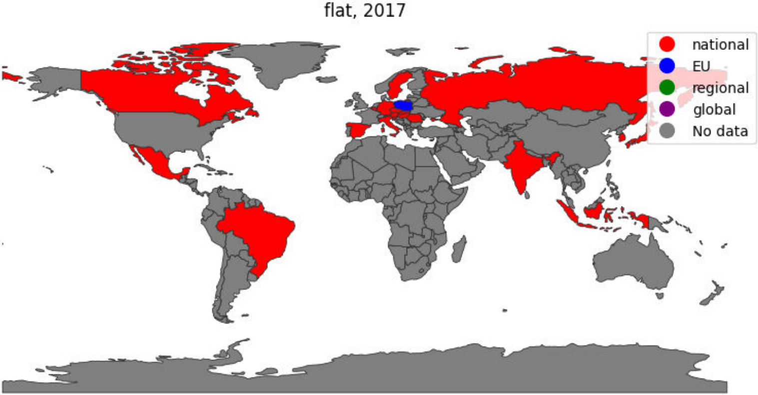
Monte Carlo simulation for margin rates (2/4)

Hydraulic cement



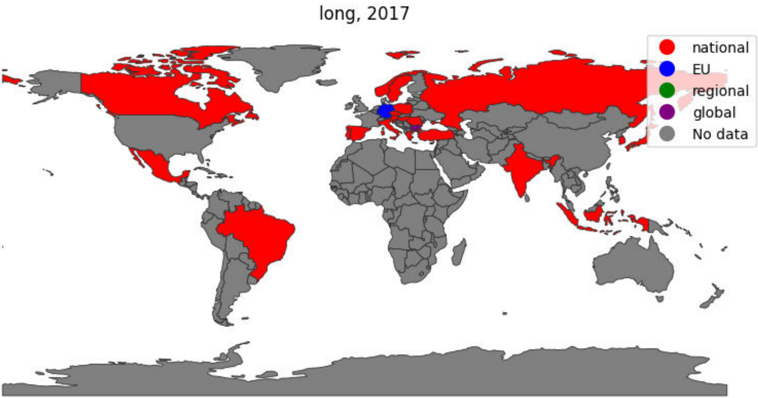
Monte Carlo simulation for margin rates (3/4)

Flat steel



Monte Carlo simulation for margin rates (4/4)

Long steel



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