Trade Effects of Carbon Pricing Policies

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The Definition of Carbon Pricing Policies

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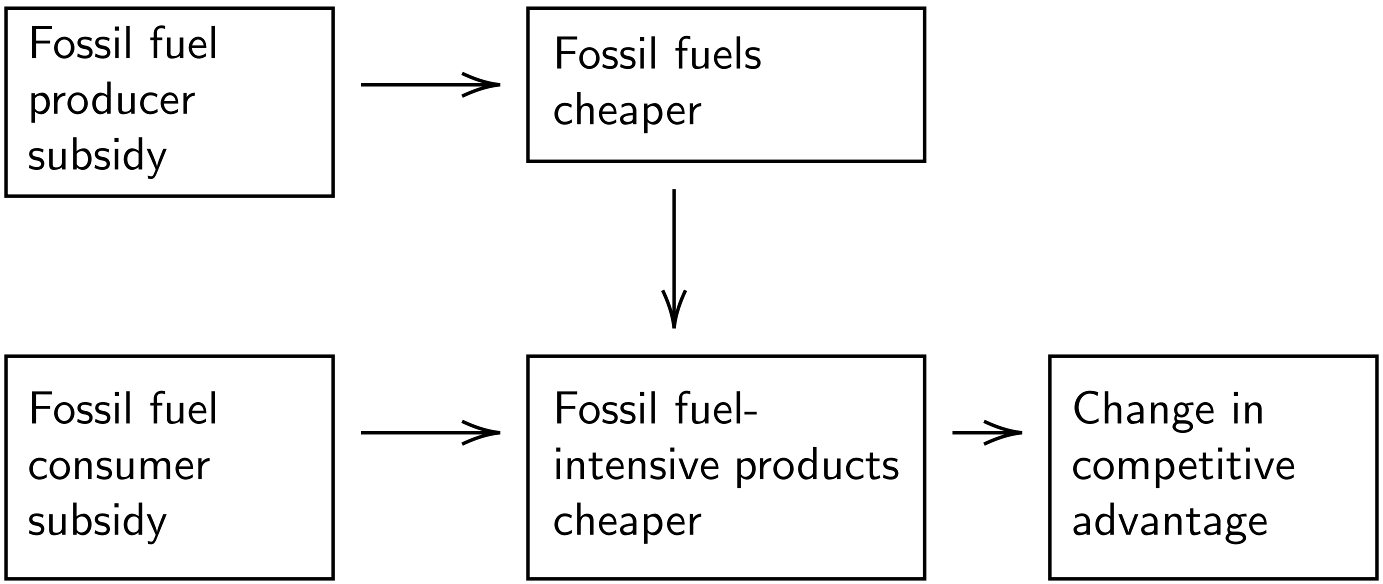
3. Subsidy to fossil fuel consumption through direct budgetary transfers and through tax exemptions
4. Subsidy to fossil fuel production through direct budgetary transfers and through tax exemptions

The (Trade) Distorting effects of Carbon Pricing Policies



Research Question

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Do supply chain linkages alter the policy spillovers?

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3. Econometric analysis at industry level for a large number of countries that complements CGE modelling and country/policy case studies
4. Taking into account possible international spillovers of carbon pricing policy by using input-output linkages

Our Methodology

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Data

- **OECD's Effective Carbon Rates**
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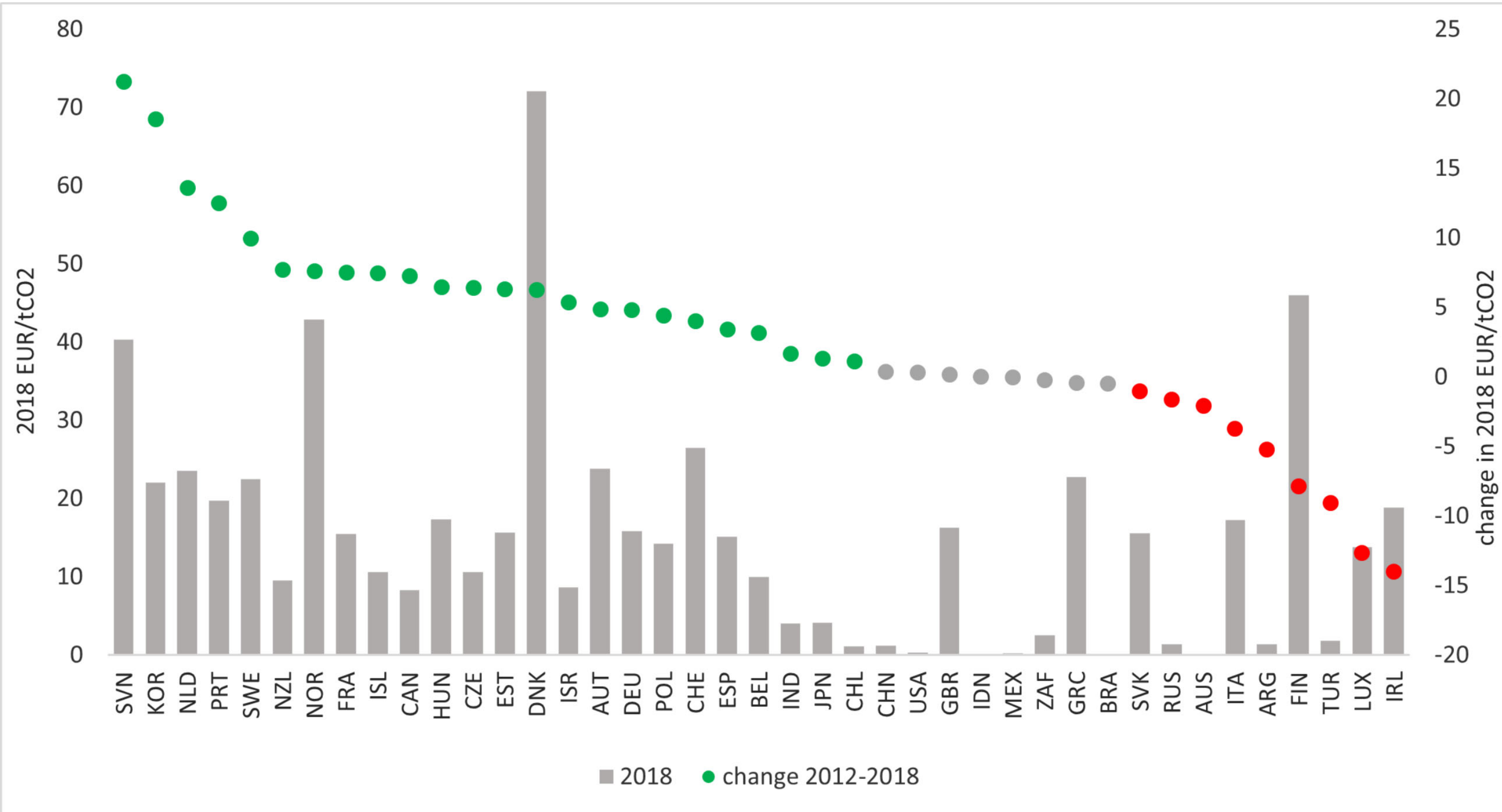
Effective Carbon Rates by Country, the Industrial Sector



Effective carbon rate in 2018 level (%) on the left axis and 2012-2018 change on the right axis.
Colombia, Latvia and Lithuania have missing data for 2012 and therefore are excluded from the chart.

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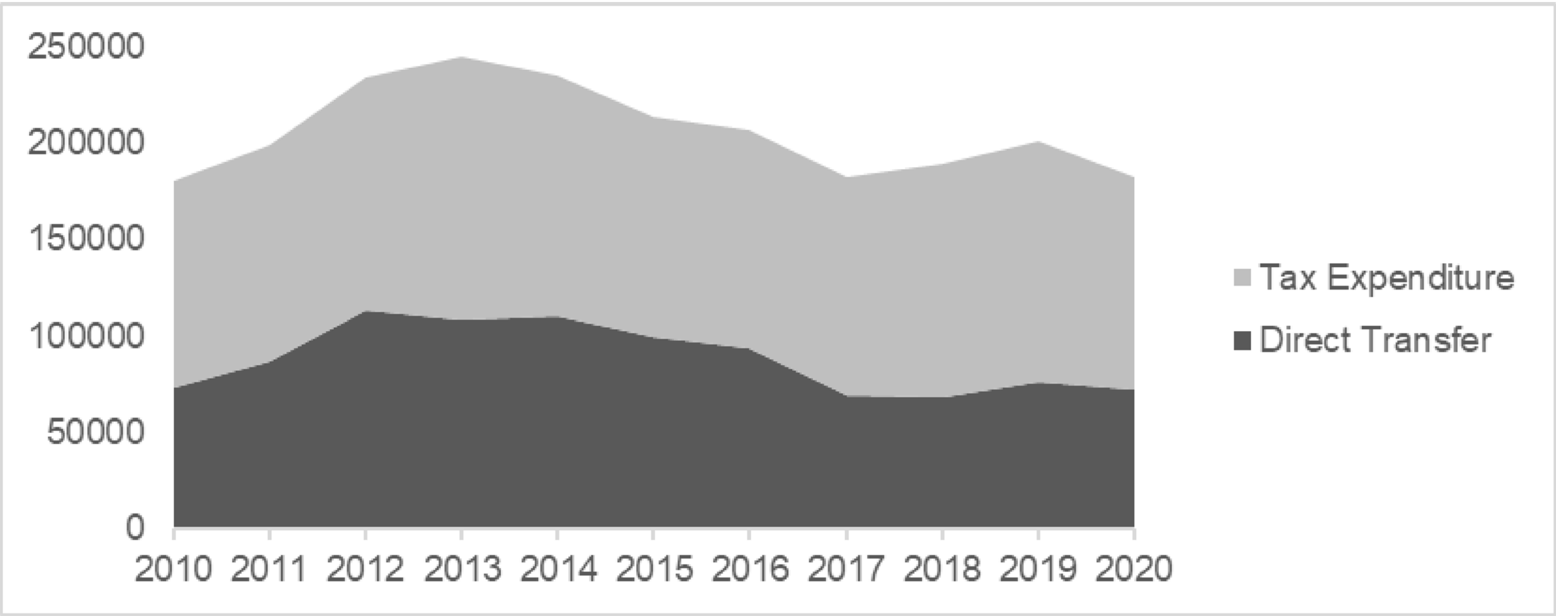
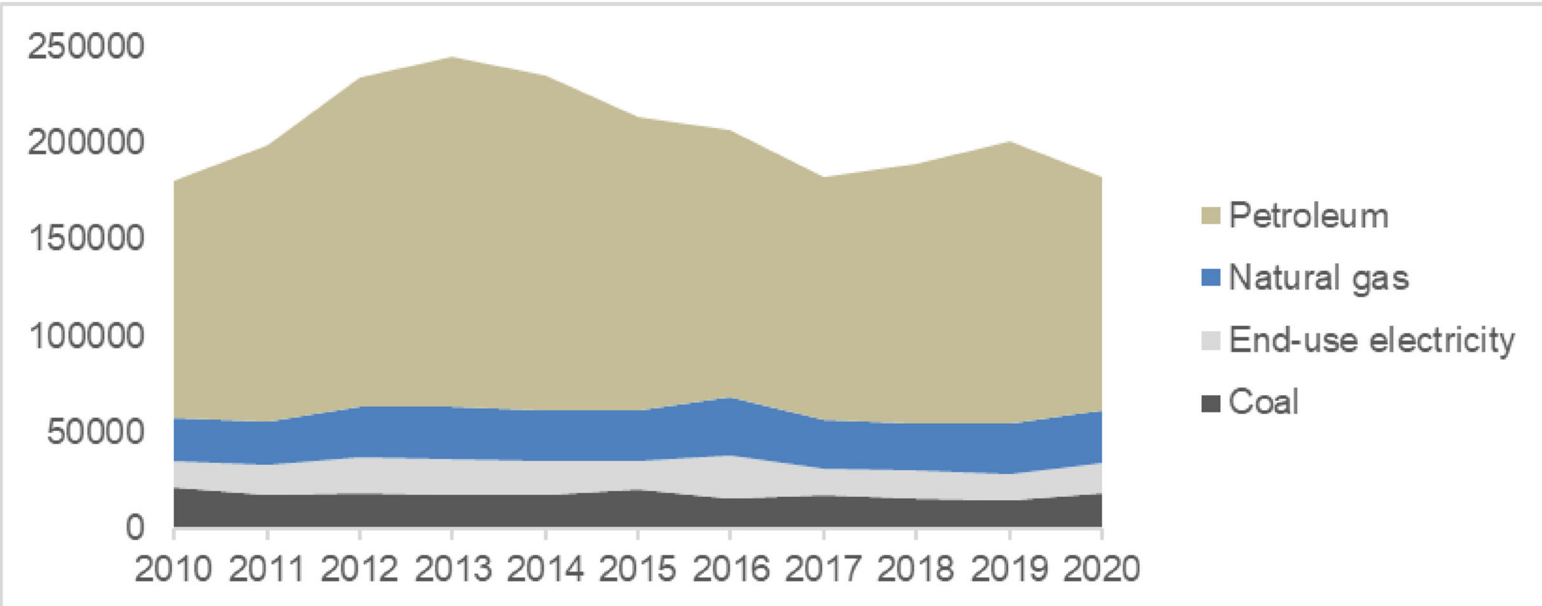
- **OECD's Inventory of Support Measures for Fossil Fuels**
  direct budgetary transfers ~~& tax expenditures~~

Fossil fuel support by mechanism



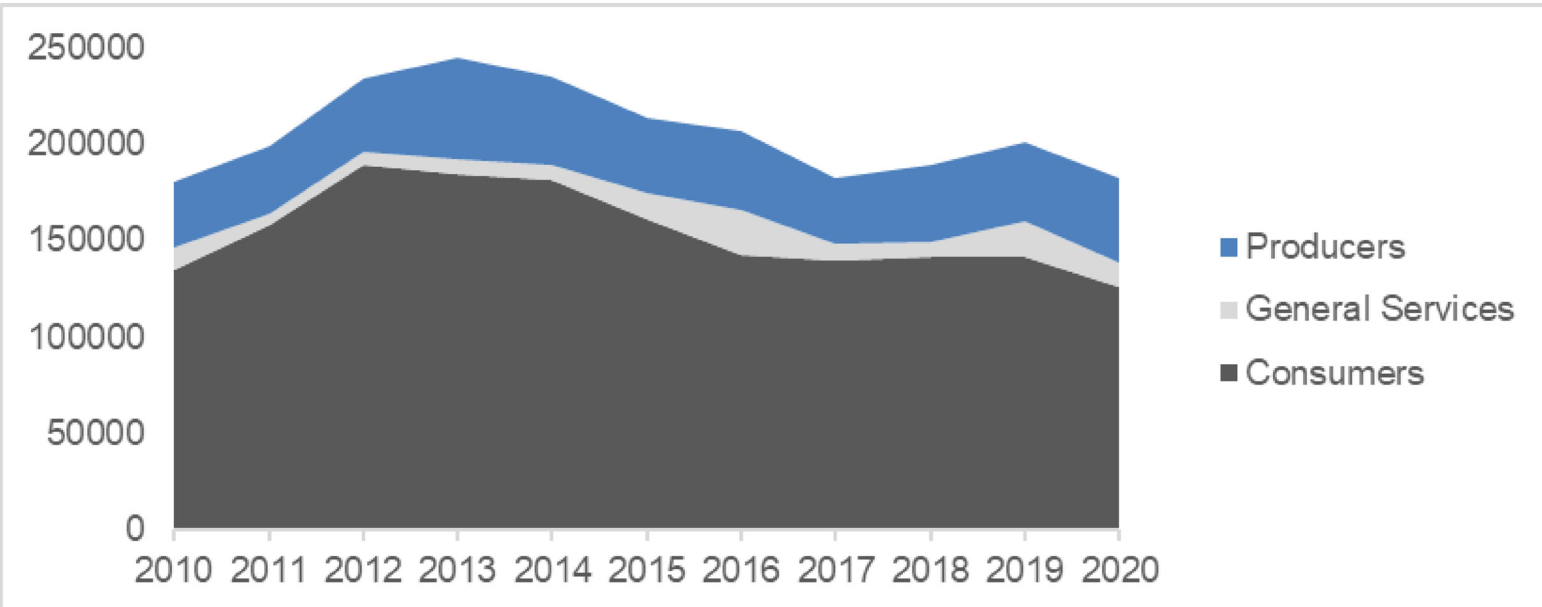
Expressed in millions 2020 US dollars. Sum over all 50 countries covered by the database.

Fossil fuel support by fuel type



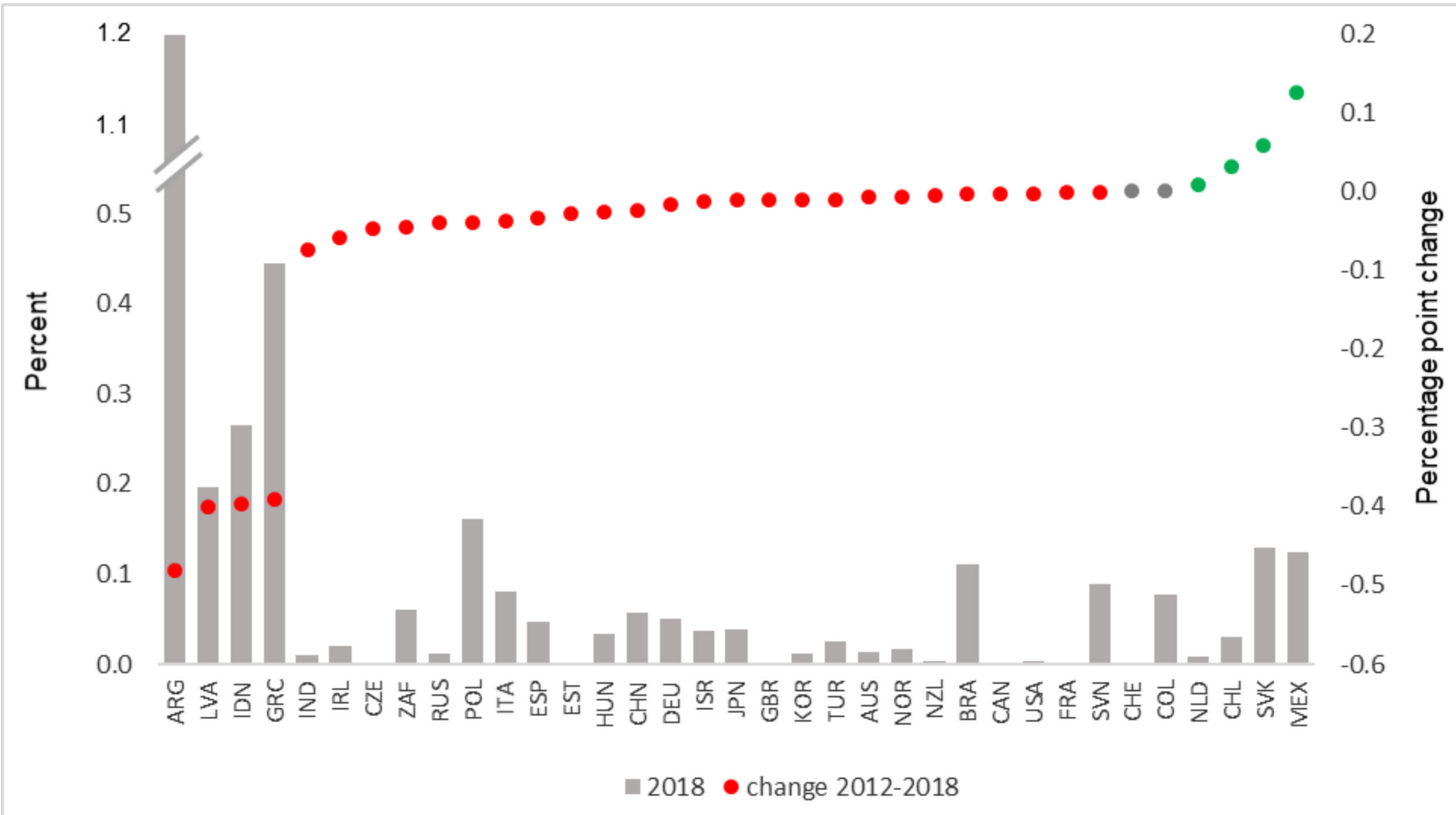
Expressed in millions 2020 US dollars. Sum over all 50 countries covered by the database.

Fossil fuel support by beneficiary



Expressed in millions 2020 US dollars. Sum over all 50 countries covered by the database.

Fossil Fuel Support by Country: Budgetary Transfers in % of GDP



Direct budgetary transfers as percentage of GDP in 2018 on the left axis and 2012-2018 percentage point change on the right axis.
Austria, Belgium, Denmark, Finland, Lithuania, Luxembourg, Portugal and Sweden had zero fossil fuel support through direct transfers in 2012 and 2018, and hence are not included in the chart.

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  direct budgetary transfers ~~& tax expenditures~~
- **Sectoral Carbon Dioxide (CO2) Emissions** from OECD's Trade in Emodied CO2 database as a share of output
- **Sectoral Fossil Fuel Use** from UK Office for National Statistics (2010) as a share of output

Ranking of industries by CO2 intensity

1	Basic metals
2	Other non-metallic mineral products
3	Rubber and plastics products
4	Other manufacturing
5	Chemicals and chemical products
6	Mining and quarrying of non-energy products
7	Pharmaceuticals
8	Paper products and printing
9	Wood and products of wood and cork
10	Food products, beverages and tobacco
11	Textiles, textile products, leather and footwear
12	Fabricated metal products
13	Machinery and equipment, nec
14	Motor vehicles, trailers and semi-trailers
15	Electrical equipment
16	Other transport equipment
17	Computer, electronic and optical equipment

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8	Fabricated metal products
9	Food products, beverages and tobacco
10	Manufacturing nec; repair and installation of machinery and equipment
11	Electrical equipment
12	Machinery and equipment, nec
13	Pharmaceuticals, medicinal chemical and botanical products
14	Motor vehicles, trailers and semi-trailers
15	Other transport equipment
16	Computer, electronic and optical equipment

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- **Industry Fossil Fuel Use** from UK Office for National Statistics (2010) as a share of output
- **OECD's Inter-Country Input-Output (ICIO) Data**
  to obtain international and domestic flows between industries,
  to obtain upstream/downstream exposure (2010) to other sectors (domestic and foreign)
  Baseline estimation sample of 37 countries, 16 industries and 3 years.

Estimation of exporter-industry fixed effects

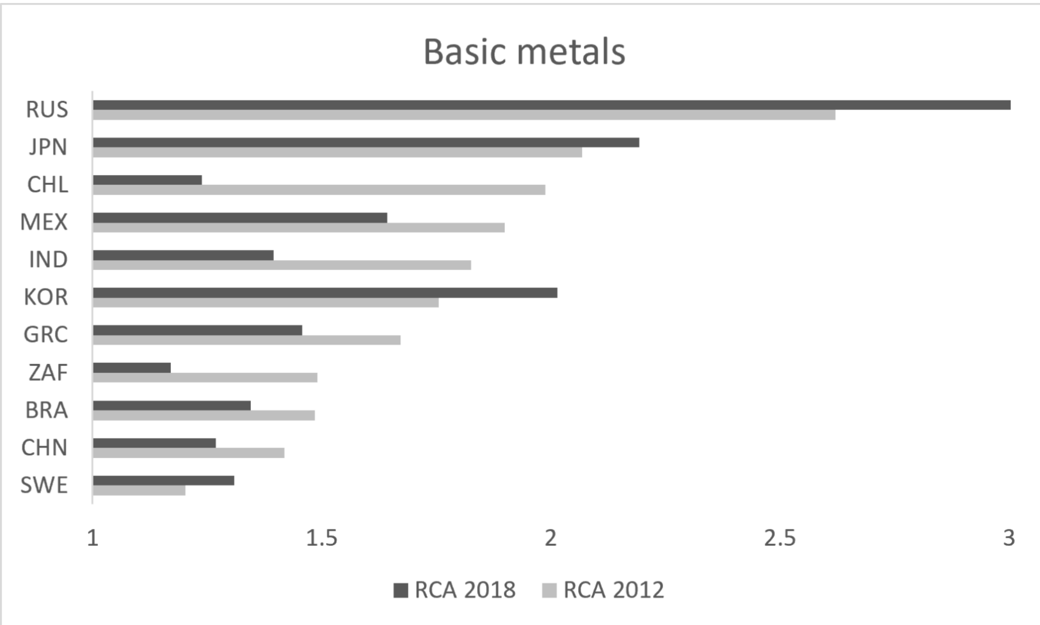
Gravity model as in Egger, Larch, Nigai and Yotov (2021):

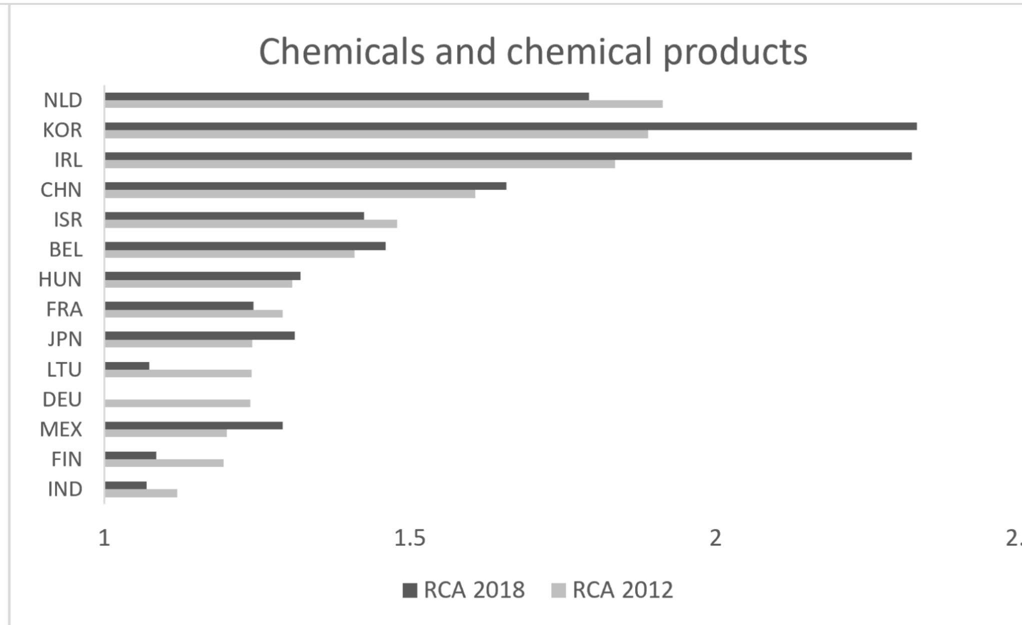
$$\ln\left(\frac{X^{ij}_{od,t}}{X^{ij}_{oo,t}}\right) = \gamma^{i}_{o,t} - \gamma^{i}_{d,t} + \eta^{i}_{od,t} + \varepsilon^{ij}_{od,t}$$

such that $\gamma^{i}_{o,t} = \gamma^{i}_{d,t} \quad \forall o = d$ and $i \neq j$; with:

$X^{ij}_{od,t}$	exports from sector i to j from country o to d
$\gamma^{i}_{o,t}$	exporter-industry-time FE, ln(export capability)
$\eta^{i}_{od,t}$	country-pair-industry FE
$\varepsilon^{ij}_{od,t}$	error term iid. across countries, sectors, & time

Comparative advantage in fossil-fuel intensive industries, top 10 countries





Comparative advantage is the twice normalised estimated exporter capability, here for 2012 and 2018 in the industry "basic metals" and "chemicals and chemical products" which are the industries with high CO2 and fossil-fuel intensity.

2nd Step using the change in estimated export capability

OLS Regression with industry & country clustered standard errors:

$$\Delta\hat{\gamma}_o^i = \alpha_o + \beta^i + \delta_1 I^i \Delta \ln\left(ECR_o\right) + \delta_2 I^i \Delta \ln\left(FFS_o\right) + \lambda\ \Delta_L \hat{\gamma}_o^i + \epsilon_o^i$$

Δ	3-year change from 2012 to 2015 and 2015 to 2018
Δ_L	lagged change in the dependent variable
α_o, β^i	country and sector FE
I^i	CO2/fossil fuel intensity
ECR_o	effective carbon rate
FFS_o	fossil fuel support

Results of second step

	(1)	(2)	(3)	(4)	(5)
	$\Delta\hat{\gamma}_o^i$	$\Delta\hat{\gamma}_o^i$	$\Delta\hat{\gamma}_o^i$	$\Delta\hat{\gamma}_o^i$	$\Delta\hat{\gamma}_o^i$
$I\Delta\ln(ECR)$	-0.346**				
	(0.1537)				
$I\Delta\ln(ECR\ Carbon\ Tax)$		-0.206***		-0.192***	
		(0.0483)		(0.0519)	
$I\Delta\ln(ECR\ Excise\ Tax)$		-0.0136		0.0004	
		(0.1064)		(0.1023)	
$I\Delta\ln(FFS)$			0.041**	0.037**	
			(0.0140)	(0.0151)	
$I\Delta\ln(WCPD)$					-0.128***
					(0.0180)
N	1166	1166	1166	1166	8092
$Within\ R^2$	0.084	0.085	0.087	0.090	0.077

World Carbon Pricing Database (Dolphin & Xiahou, 2022): 2006-2018, 40 countries

Policy exposure along the value chain

Exposure of sector j in country d to changes in carbon pricing policy including in sectors upstream:

$$\Delta \ln\left(ECR_d^{domVC}\right) = \sum_i l_{dd}^{ij} I^i \Delta \ln(ECR_d)$$

Exposure of sector j in country d to changes in carbon pricing policy abroad:

$$x = \sum_{o \neq d} \sum_i l_{od}^{ij} I^i \Delta \ln(ECR_o)$$

l_{od}^{ij} Leontief coefficient in 2010

Results of second step

	(1) $\Delta\hat{\gamma}_o^i$	(2) $\Delta\hat{\gamma}_o^i$	(3) $\Delta\hat{\gamma}_o^i$
$\Delta\ln(\mathit{ECR\ domestic\ VC})$	-0.843***		-0.643***
	(0.1810)		(0.1875)
$\Delta\ln(\mathit{ECR\ foreign\ VC})$	3.397		3.919
	(4.2332)		(3.7548)
$\Delta\ln(\mathit{FFS\ domestic\ VC})$		0.066***	0.056*
		(0.0224)	(0.0262)
$\Delta\ln(\mathit{FFS\ foreign\ VC})$		0.128	-0.025
		(0.3285)	(0.2363)
N	1166	1166	1166
Within R^2	0.0869	0.0847	0.0896

Next steps - quantification

- Counterfactual pattern of comparative advantage if ECR was at the 75th percentile globally and FFS were zero
- Counterfactual changes in the pattern of comparative advantage if (a) carbon pricing policies were kept constant and (b) ECR increased at least to the 75th percentile globally and FFS were reduced to zero
- Have carbon pricing policies skewed global production away from countries with 'natural' comparative advantage in clean energy?

Thank you!

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Robustness Checks done

- vary time intervals
- use non-overlapping intervals
- weigh second step regressions with inverse standard error of first step regression
- use different fossil fuel intensity measures
- use different dependency measures for spillovers
- use all industries
- exclude industries and countries separately to evaluate their individual impact

Related Literature

1. **Positive Effect of Subsidies on Trade Flows**
   OECD (2019), Lane (2021), Girma, Gong, Görg and Yu (2009), Görg, Henry and Strobl (2008)
2. **Influence of Energy Prices on Trade Flows**
   Sato and Dechezleprêtre (2015), Aldy and Pizer (2015)
3. **Influence of EU ETS on Trade Flows**
   Dechezleprêtre, Gennaioli, Martin, Muûls and Stoerk (2022), Naegele and Zaklan (2019), Branger, Quirion and Chevallier (2016)
4. **Influence of other Environmental Policies on Trade Flows**
   Aichele and Felbermayr (2015), Costantini and Mazzanti (2012)
5. **Dynamics of Comparative Advantage**
   - estimation of comparative advantage/exporter fixed effect per industry: Costinot, Donaldson and Komunjer (2012), Egger et al. (2021)
   - exploration of dynamic properties: Hanson, Lind and Muendler (2015)

Effects of Upstream/Downstream Policies: Leontief Inverse

To account for spill-overs via input-output linkages, we calculate the inverse Leontief matrix:

$$x_i = \sum_j a_{ij} x_j + y_i$$

$$x = (I - A)^{-1} y = B\ y$$

$$x_i = \sum_j b_{ij} y_j$$

a_{ij}	coefficients for intermediate inputs i in sector j,	$a_{ij} \in A$
x_i	output of sector i,	$x_i \in x$
y_i	final demand of sector i,	$y_i \in y$
$(I - A)^{-1} = B$	Leontief Inverse,	$b_{ij} \in B$

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To account for spill-overs via input-output linkages, we calculate the inverse Leontief matrix:

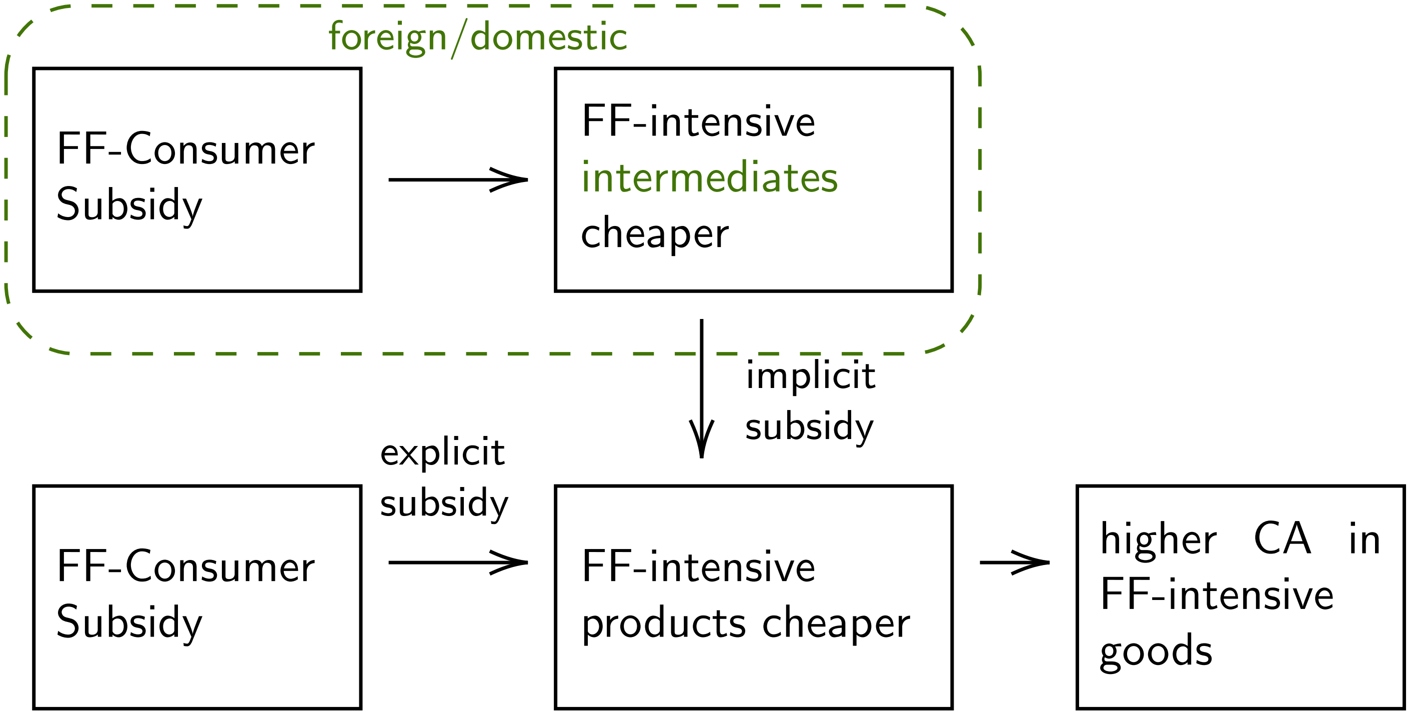
$$x_o^i = \sum_d \sum_j a_{od}^{ij} x_d^j + y_o^i$$

$$x = (I - A)^{-1} y = B\ y$$

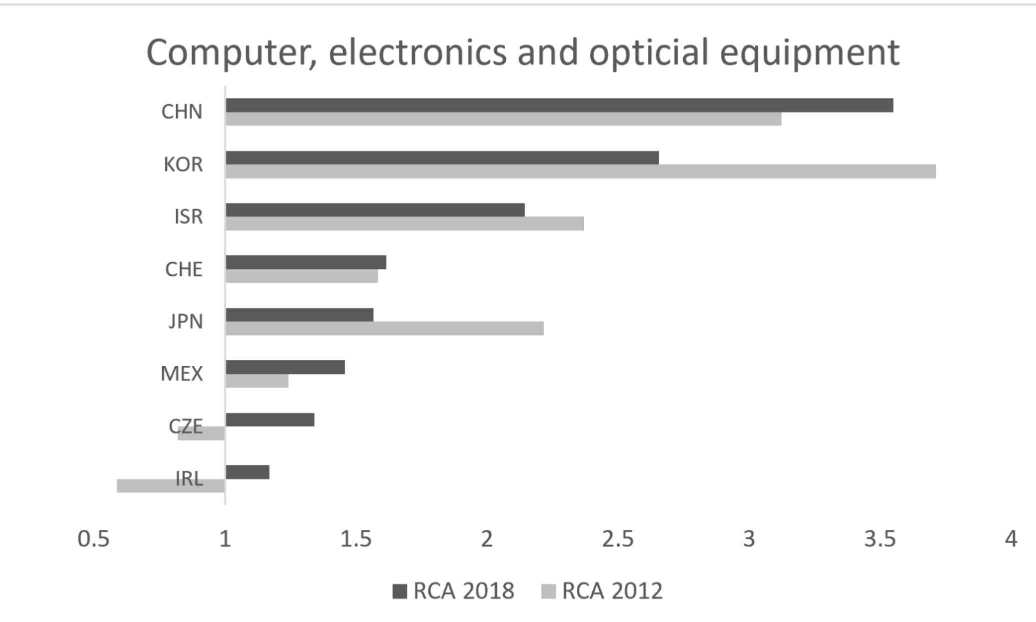
$$x_o^i = \sum_d \sum_j b_{od}^{ij} y_d^j$$

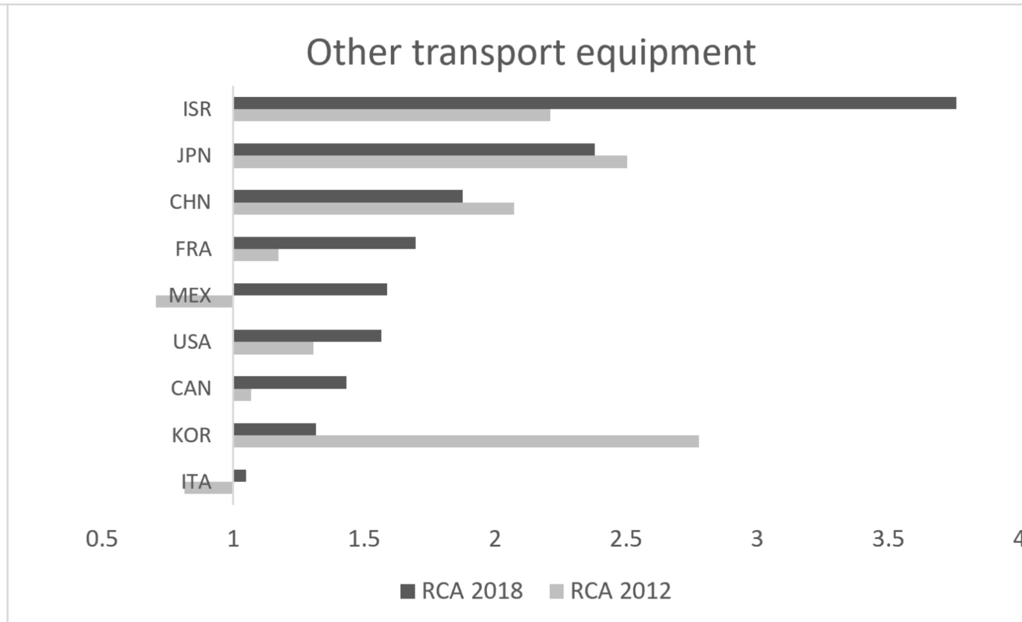
a_{od}^{ij}	coefficients for intermediate inputs i from country o in sector j of country d,	$a_{od}^{ij} \in A$
x_o^i	output of sector i in country o,	$x_o^i \in x$
y_o^i	final demand of sector i in country o,	$y_o^i \in y$
$(I - A)^{-1} = B$	Leontief Inverse,	$b_{od}^{ij} \in B$

How foreign Policies can spill-over along the Supply Chain



Comparative Advantage in "Electronic and optical equipment" and "Other transport equiplment"





Comparative Advantage is the twice normalised estimated exporter capability, here for 2012 and 2018 in the industry "Electronic and optical equipment" which was the industry with the lowest fossil-fuel intensity in 2010 in UK.