Trade Effects of Carbon Pricing Policies

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The Definition of Carbon Pricing Policies

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1. Carbon tax, carbon emissions permit price
2. Excise tax on the consumption of fossil fuels

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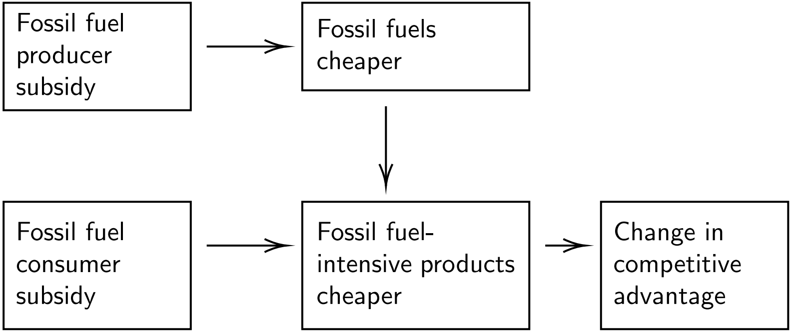
3. Subsidy to fossil fuel consumption through direct budgetary transfers and through tax exemptions
4. Subsidy to fossil fuel production through direct budgetary transfers and through tax exemptions

The (Trade) Distorting effects of Carbon Pricing Policies



Research Question

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Do foreign policies spillover along the supply chain?

$\rightarrow$ *No.*

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2. A comprehensive measure of the stringency of carbon pricing that accounts for direct and indirect carbon taxes, and direct subsidies of fossil fuels
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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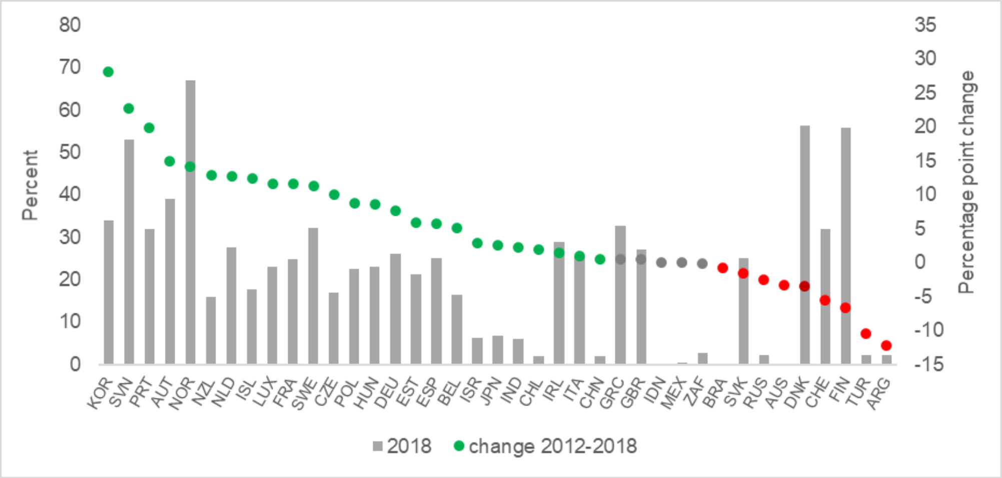
3. **Back-of-the-envelope calculations** of the contribution of changes in carbon pricing policy to changes in comparative advantage

Data for 42 countries, 15 groups of manufacturing industries, 2012-2018

- **OECD's Carbon Pricing Score** (Effective Carbon Rates),
  share of emissions priced at EUR 60 [2012, 2018]
  includes emissions permit price, carbon tax, and fuel excise taxes

Carbon Pricing Score by Country, the Industrial Sector



Carbon pricing score at EUR 60 benchmark expressed in 2018 level (%) on the left axis and 2012-2018 percentage point change on the right axis. Canada, Colombia, Lithuania, Latvia and the US have missing data for 2012 and therefore are excluded from the chart.

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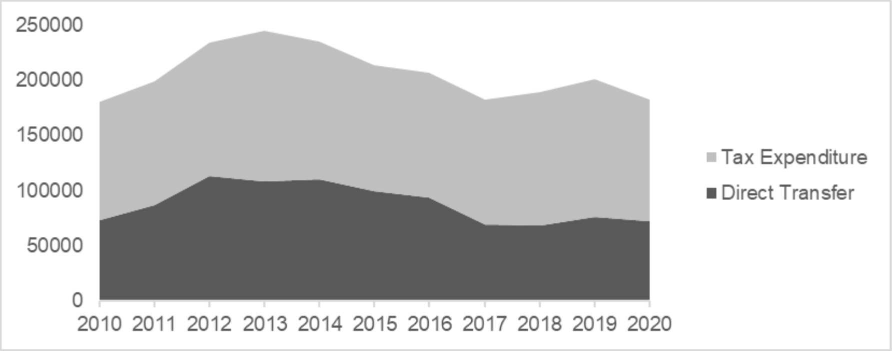
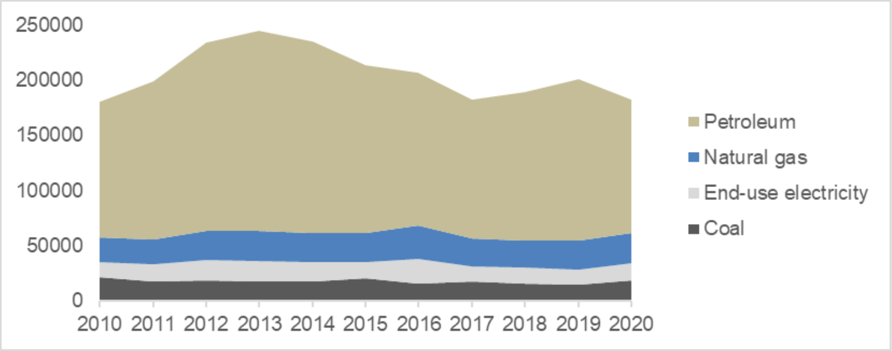
- **OECD's Inventory of Support Measures for Fossil Fuels**
  direct budgetary transfers ~~& tax expenditures~~

Fossil fuel support by mechanism



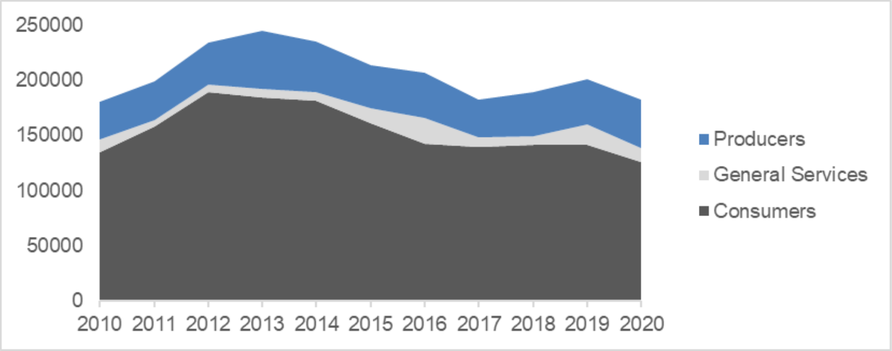
Expressed in millions 2020 US dollars. Sum over all 50 countries covered by the database.

Fossil fuel support by fuel type



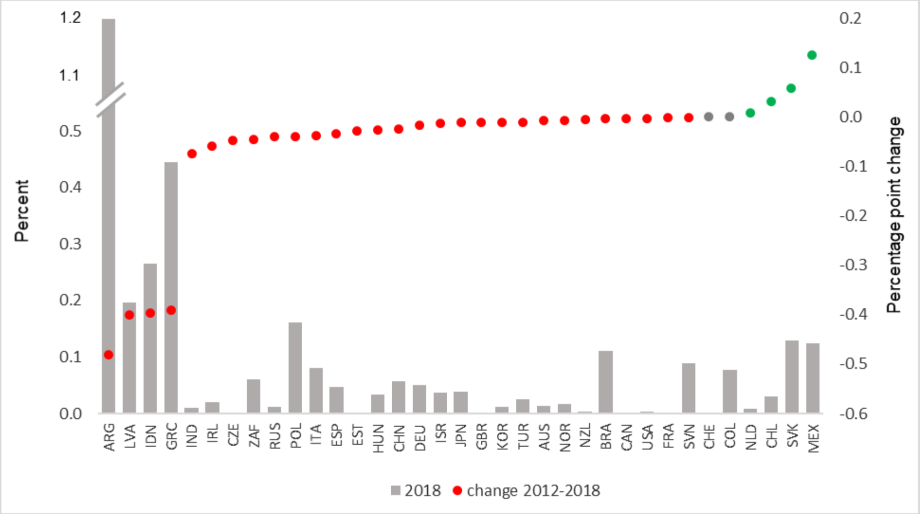
Expressed in millions 2020 US dollars. Sum over all 50 countries covered by the database.

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 Fossil Fuel Use** from UK Office for National Statistics (2010) as a share of output

Ranking of industry fossil fuel intensity

1	Basic metals
2	Chemicals and chemical products
3	Other non-metallic mineral products
4	Paper products and printing
5	Textiles, textile products, leather and footwear
6	Wood and products of wood and cork
7	Fabricated metal products
8	Food products, beverages and tobacco
9	Manufacturing nec; repair and installation of machinery and equipment
10	Electrical equipment
11	Machinery and equipment, nec
12	Pharmaceuticals, medicinal chemical and botanical products
13	Motor vehicles, trailers and semi-trailers
14	Other transport equipment
15	Computer, electronic and optical equipment

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  direct budgetary transfers ~~& tax expenditures~~
- **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)
- **Countries' Shares in Global Reserves** of Oil, Natural Gas, and Coal
  as controls, from BP Statistical Review of World Energy

Estimation of exporter-industry fixed effects

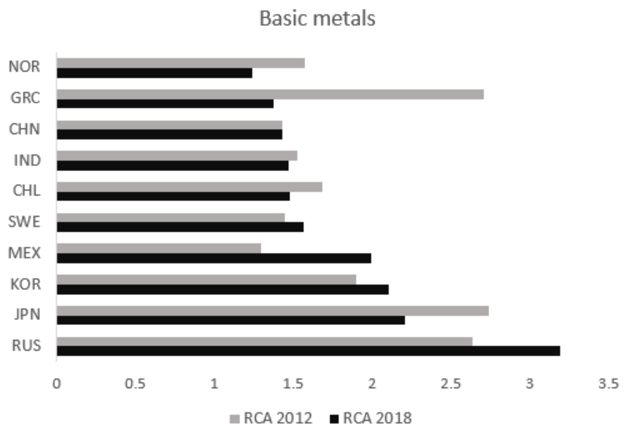
Gravity model as in Egger, Larch, Nigai and Yotov (2021):

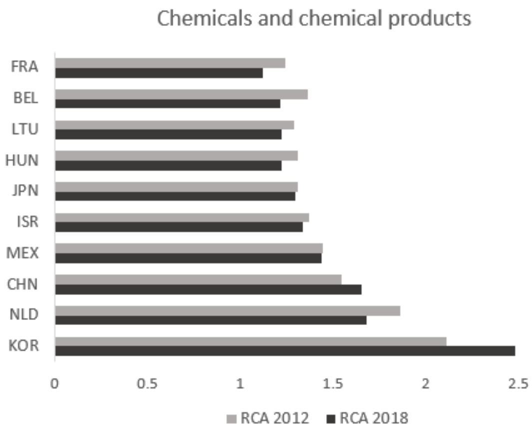
$$\ln\left(\frac{X^{ij}_{od,t}}{X^{ij}_{oo,t}}\right) = \gamma^{i}_{o,t} - \gamma^{i}_{d,t} + \eta^{i}_{od,t} + \varepsilon^{ij}_{od,t}$$

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 were the industries with the highest fossil-fuel intensity in 2010 in UK.

2nd Step using the estimated export capability

OLS regression with sector & country clustered SE, for t=2018:

$$\hat{\gamma}_o^i = \alpha_o + \beta^i + \delta_1 I^i \ln(C_o) + \delta_2 I^i \ln(F_o) + \kappa \; I^i R_o + \epsilon_o^i$$

α_o, β^i	country and sector FE
I^i	fossil fuel intensity
C_o	carbon pricing score
F_o	fossil fuel support via budgetary transfers
R_o	shares of global reserves of oil, gas, & coal

2nd Step using the change in estimated export capability

OLS Regression with sector & country clustered SE:

$$\Delta \hat{\gamma}_o^i = \alpha_o + \beta^i + \delta_1 I^i \Delta \ln(C_o) + \delta_2 I^i \Delta \ln(F_o) + \lambda \, \Delta_H \hat{\gamma}_o^i + \epsilon_o^i$$

Δ	change from 2012-2018
Δ_H	change from 2004-2010 (historic trend)
α_o, β^i	country and sector FE
I^i	fossil fuel intensity
C_o	carbon pricing score
F_o	fossil fuel support via budgetary transfers
R_o	shares of global reserves of oil, gas, & coal

Policy exposure along the value chain

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

$$\Delta \ln\left(C_d^{dom\_US}\right) = \sum_i l_{dd}^{ij} I^i \Delta \ln(C_d)$$

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

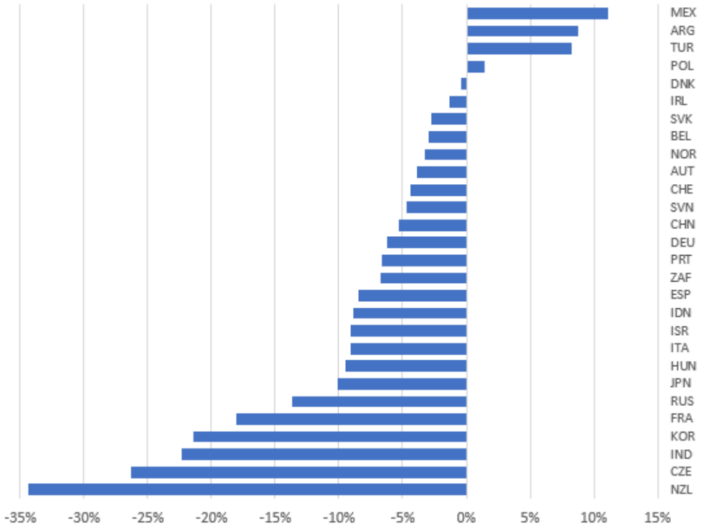
$$\Delta \ln\left(C_d^{for\_US}\right) = \sum_{o \neq d} \sum_i l_{od}^{ij} I^i \Delta \ln(C_o)$$

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

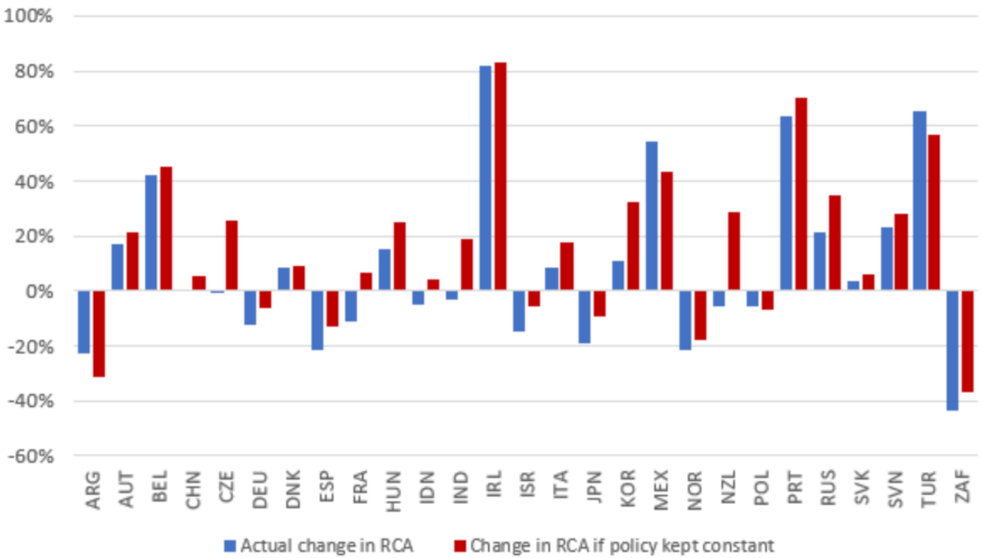
Results of second step

	(1)	(2)	(3)	(4)
	$\hat{\gamma}^i_o$	$\Delta\hat{\gamma}^i_o$	$\Delta\hat{\gamma}^i_o$	$\Delta\hat{\gamma}^i_o$
	$I^i \ln(P_o)$	$I^i \Delta \ln(P_o)$	$I^i \Delta \ln\left(P_o^{dom\_US}\right)$	$I^i \Delta \ln\left(P_o^{for\_US}\right)$
P: Domestic ECR	-0.070**	-0.021***	-0.039**	-0.032**
	(0.0240)	(0.0060)	(0.0132)	(0.0117)
P: Domestic FFS	0.0035	0.028***	0.046***	0.054***
	(0.0087)	(0.0085)	(0.0141)	(0.0101)
P: Foreign ECR				-0.584
				(0.8305)
P: Foreign FFS				0.291*
				(0.1575)
N	629	420	420	420
Adjusted R^2	0.643	0.343	0.344	0.345

Back-of-the-envelope: policy effect



Back-of-the-envelope: counterfactuals



Next steps

- Robustness using trade data with more detailed industry disaggregation (the direct effect)
- IMF Dataset on Fossil Fuel Subsidies (price-gap approach)
- Identification of the direct effect?
- 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
- use different fossil fuel intensity measures
- use different dependency measures for spillovers
- use all industries
- weigh second step regressions with inverse standard error of first step regression
- exclude industries and countries separately to evaluate their individual impact
- use interest rates as instrument for FFS

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)

Data Selection

- consolidate countries, BEL+LUX, CHN+HKG, and economically small economies in ROW (ISL, BRN, CYP, MLT, LAO, MMR, KHM, SAU)
- exclude support to transportation and residential sectors in fossil fuel support

back to Data

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

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,	$y_o^i \in y$
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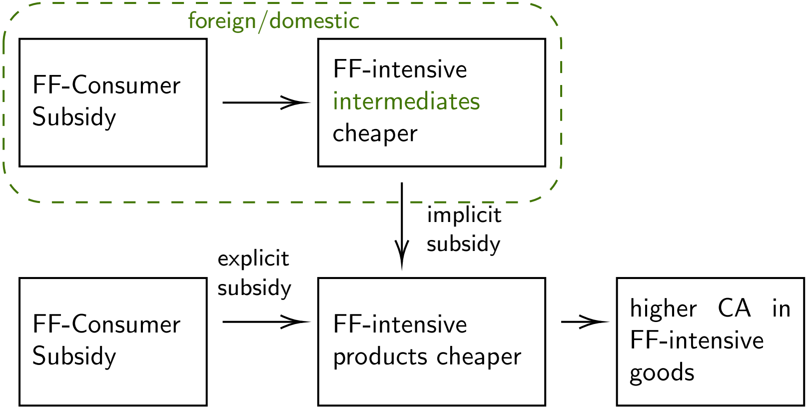
If a country increases its carbon pricing score by **10%**,
then it's export capability

- in Basic Metals changes by **-0.7 %** *(= 1.61 x 10 x (-0.041))*
- in Electronic and optical equipment changes by **+0.2 %** *(= -0.52 x 10 x (-0.041))*

How foreign Policies can spill-over along the Supply Chain



2nd Step: Downstream Value Chain Policy Exposure (ds)

OLS Regression with sector & country clustered SE:

$$\Delta\hat{\gamma}_o^i = \alpha_o + \beta^i + \delta_1 \underbrace{cds^i_{oFF}(p)}_{\text{domestic VC}} + \delta_2 \underbrace{dds^i_{oFF}(p)}_{\text{VC 1 border}} + \delta_3 \underbrace{eds^i_{oFF}(p)}_{\text{VC} \geq 2 \text{ borders}} + \epsilon_o^i$$

for $p = \{\Delta \ln (C), \Delta \ln (F)\}$

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for $p = \{\Delta \ln(C), \Delta \ln(F)\}$

We use an exogenous value chain structure from the ICIO 2010. more on policy exposure

2nd Step: Upstream Value Chain Policy Exposure (*us*)

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We use an exogenous value chain structure from the ICIO 2010. more on policy exposure

Effects of Upstream/Downstream Policies: Decomposition of VC

Decomposition of value chain (VC) streams, similar to Wang, Wei, Yu and Zhu (2017):

$$x = \underbrace{L}_{C}\ y + \underbrace{LA^F L}_{D}\ y + \underbrace{LA^F(B-L)}_{E}\ y,$$

$$x_o^i = \sum_d \sum_j \underbrace{(c_{od}^{ij} + d_{od}^{ij} + e_{od}^{ij})}_{=b_{od}^{ij}} y_d^j,$$

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with $B = C + D + E$ and:

C	domestic production chains only
D	production chains with one border
E	production chains with at least two borders
$A - A^D = A^F$	direct dependency on non-domestic intermediates
$(I - A)^{-1} = B$	Leontief Inverse
$(I - A^D)^{-1} = L$	Local Leontief Inverse

Effects of Upstream/Downstream Policies: Exposure (1/2)

Exposure of sector i in country o to Downstream Policies (p):

$$ds_o^i(p) = \sum_d \frac{\sum_j (c_{od}^{ij} + d_{od}^{ij} + e_{od}^{ij}) y_d^j}{x_o^i} p_d$$

Exposure of sector j in country d to Upstream Policies (p):

$$us_d^j(p) = \sum_o \sum_i (c_{od}^{ij} + d_{od}^{ij} + e_{od}^{ij}) p_o$$

Effects of Upstream/Downstream Policies: Exposure (2/2)

Exposure of sector i in country o to Downstream Policies (p) via Fossil Fuel intensities:

$$ds^{i}_{o\,FF}(p) = \sum_{d} \frac{\sum_j I^j (c^{ij}_{od} + d^{ij}_{od} + e^{ij}_{od}) y^j_d}{x^i_o} p_d$$

Exposure of sector j in country d to Upstream Policies (p) via Fossil Fuel intensities:

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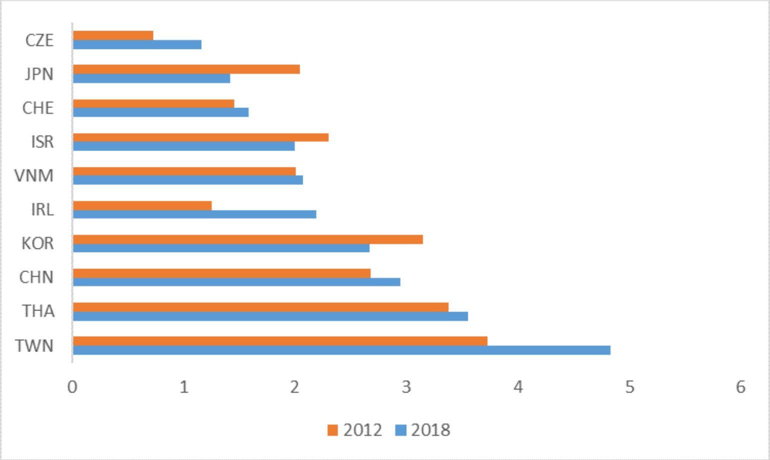
back to Spillover Analysis

Comparative Advantage in "Electronic and optical equipment" for 2018's top 10 Countries



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.