Discussion: The Effect of Carbon Pricing on Firm Emissions: Evidence from the Swedish CO2 Tax

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Overview

- Research question: What is the impact of carbon pricing on firm-level emission intensities?
- Manufacturing firm-level data on sales and CO2 emissions: 4,000 manufacturing firms during 1990-2015.
- Outline:
  1. Document: which sectors are heavy CO2 emitters and how emissions are priced (on average and at the margin).
  2. Event studies around major tax changes to evaluate firms' short-run responses to changing marginal tax rates.
  3. Panel regressions to estimate the sensitivity of firm-level CO2 emission intensity to the marginal carbon price over the longer run.
  4. Decompose the change in aggregate CO2 emissions into a "scale", "composition" and "technical" effects.
  5. Use the estimated elasticities to quantify the impact of carbon pricing on aggregate manufacturing CO2 emissions.

Results

1. Carbon emissions in Sweden decreased since 1991 concentrated in narrow number of sectors (75% of aggregate manufacturing CO2 emissions but only 15%-20% of output).

2. Short-run effects: reduction in carbon emissions around changes in marginal tax rates.

3. Long-run effects: a 1% increase in the marginal emissions cost share (to sales) reduces carbon emissions per unit of sales by 2% over a 3-year period.
   - Results are stronger in lower-cost abatement sectors.
   - Less constrained firms display elasticities between two and three (react more) whereas estimates for constrained firms are insignificant and consistently less than one.
   - The difference in elasticities is driven by high abatement cost firms and is stronger during periods of financial crisis.

Results

4. "Scale" (decline in aggregate manufacturing output) and "Composition" (reallocation of output away from CO2 emitting industries to less emitting ones) account for 42% of the total reduction, the bulk is due to changes in technology.

5. Use the reduced from estimates to assess the quantitative importance of the estimated carbon pricing elasticities.
   - Pre-2005 period: without taxation the emission intensity would have been 12-14% higher.
   - Post-2005 period: without taxation emission intensity would have been 30% higher.

General Assessment

- Contribution to the literature estimating the impact of carbon taxes on firm level emissions (previous literature mixed results).
- Careful treatment of the data with a long panel.
- Novel insights on the short- and the long-run effects of carbon pricing
- Results point to the role of technology with great heterogeneity across sectors and firms (financial constraints).

Comments

- Comment I: Specification
- Comment II: Channel
- Comment III: Direct vs Indirect Emissions
- Comment IV: Carbon Leakage
- Comment V: Alternative/Complementary measures

Comment I: Specification Short-Run

- DiD: firms with and without exemptions around changes in marginal tax rates (1991/1993/1997)
- Small sample? Focus on firms from decile 10 sectors and balanced sample.

	Exemption	No exemption	Diff in groups	w Ind. F.E.
	(1)	(2)	(3)	(4)
Panel B: 1991 and 1993 events – Emissions-to-sales				
Period 1: 1990	0.0865	0.0106	0.0759	
			(0.0053)	
Period 2: 1991-1992	0.1027	0.0110	0.0917	
			(0.0032)	
Period 3: 1993-1996	0.1005	0.0162	0.0843	
			(0.0032)	
Difference periods: 2-1	0.0162	0.0004	0.0158	0.0165
	(0.0115)	(0.0015)	(0.0060)	(0.0057)
Difference periods: 3-2	-0.0022	0.0052	-0.0074	-0.0071
	(0.0084)	(0.0015)	(0.0050)	(0.0047)
Panel D: 1997 event – Emissions-to-sales				
Period 1: 1993-1996	0.0706	0.0170	0.0536	
			(0.0036)	
Period 2: 1997-2000	0.0784	0.0151	0.0633	
			(0.0038)	
Difference in periods	0.0078	-0.0019	0.0098	0.0100
	(0.0077)	(0.0014)	(0.0052)	(0.0047)

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- Why not event study approach?
  - Informative about dynamics: how long it takes firms to react
  - Differences in observable characteristics across groups in the pre-treatment? Include fixed effects.
- Are exposed and unexposed firms the same through out periods? If not, staggered treatment: Callaway and Sant'Anna (2021); Sun and Abraham (2021)

Comment I: Specification Long-Run

$$\Delta ln\left(E_{it}/Y_{it}\right) = \alpha + \sum_{s=0}^{q} \beta_s \times \Delta ln\left(1 - C_{it-s}\right) + \mu_i + \delta_t + \epsilon_{it}$$

- Specification in changes (unit root concerns) but why adding firm fixed effects?
- $q = 3$ are effects no longer statistically significant for $q > 3$?
- Important sectoral heterogeneity: include sector-year fixed effects.
- Average elasticity of 2 but the effect is probably not linear. How large the size of the adjustment? Optimal tax

Comment II: Channel

- Decomposition points to the role of **technical change**. Is there firm-level evidence?
- "The Carbon Footprint of Multinational Production" Ezequiel Garcia-Lembergman, Natalia Ramondo, Andres Rodriguez-Clare, and Joseph Shapiro

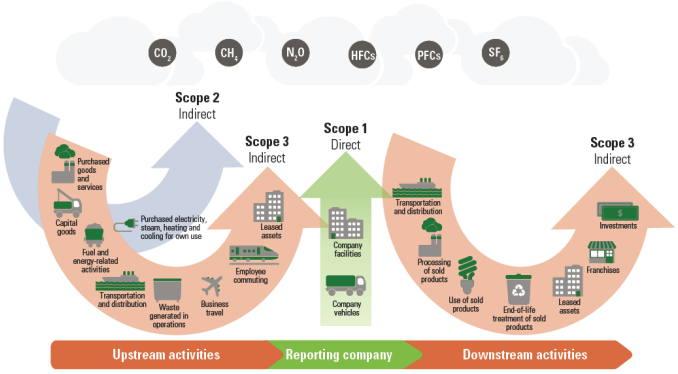
Mini mill - Italy	**Steel plant China**
	

- Other LHS variables? investment in tangible assets or R&D?
- What happens to **production** emissions?

Comment III: Direct vs Indirect Emissions

- **Scope 3**: all indirect emissions that occur in the firm's value chain.
- **Upstream emissions**: purchase and use of goods, services, energy, and capital in the production process.
- **Downstream emissions**: transport, processing, use, and disposal of sold products.

FIGURE 2.1 Emissions Associated with Firms' Activities within Scope 1, 2, and 3



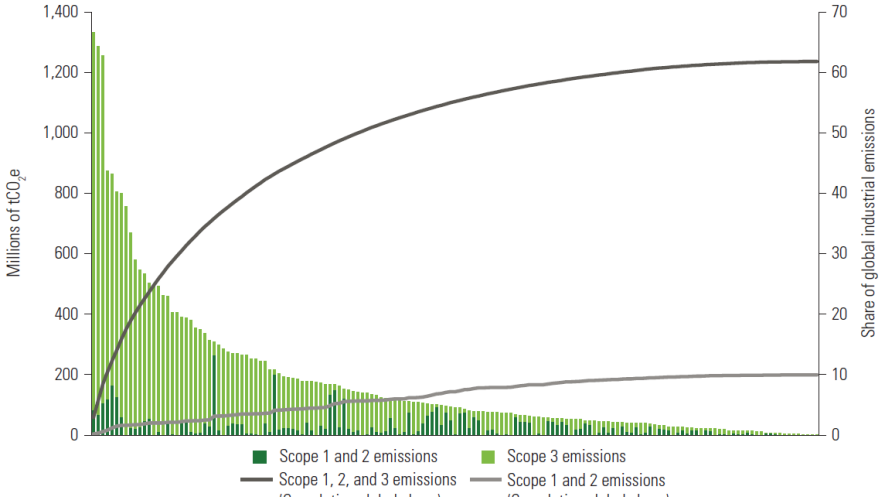
Source: WRI/WBCSD Corporate Value Chain (scope 3) Accounting and Reporting Standard (WRI and WBCSD 2004).

Note: WBCSD = World Business Council for Sustainable Development; WRI = World Resources Institute. CO_2 = Carbon dioxide; CH_4 = Methane; HFCs = Hydrofluorocarbons; N_2O = Nitrous oxide; PFCs = Perfluorocarbons; SF_6 = Sulfur hexafluoride.

Comment III: Direct vs Indirect Emissions

- Total emissions of large MNEs account for 60% of total industrial emissions: own activities account for (only) 10 percentage points while supply chains add 50 percentage points.

FIGURE O.1 Global Industrial Emissions of the Supply Chains of Large MNEs, 2021



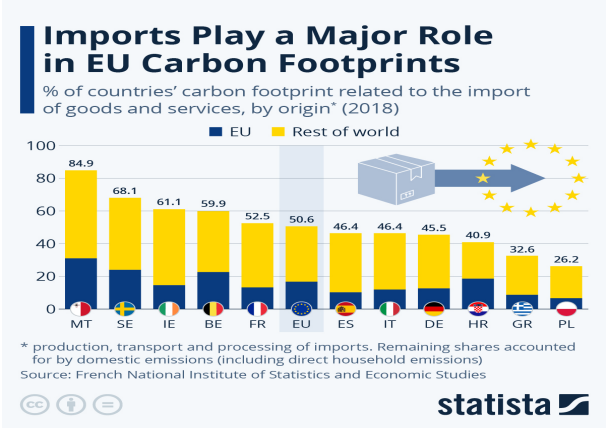
Comment IV: Carbon Leakage

- Carbon leakage discussed in the context of reallocation of activities but what about imports?

- 2021 Swedish court ordered its biggest cement maker to stop mining limestone in its huge Gotland factory to prevent pollution.
- The plant makes 75 per cent of Sweden's cement and is the country's second biggest carbon emitter $\rightarrow$ force to find raw materials elsewhere.
- Cement import from countries that produce more emissions in the overall manufacturing process could have the overall opposite effect.

Comment IV: Carbon Leakage

- INSEE: the carbon footprint subtracts the emissions embodied in exported products but adds those embodied in imported products.
- In 2018, the EU's carbon footprint per capita was 11 tonnes of CO2 equivalent, compared to 21 in the US and 8 in China.
- About one third of the EU's footprint was due to production process located outside the EU.



- Firm data on imports and exports?
- Combine firm-level information with IO tables.

Comment V: Alternative/Complementary measures to carbon pricing

1. **Renewable Energy Transition**: Sweden has made significant investments in renewable energy sources: wind power, solar power, and biomass. Including investment subsidies, to encourage the deployment of renewable energy technologies.
2. **Energy Efficiency Measures**: Sweden has implemented various energy efficiency measures across different sectors: including building codes and regulations that promote energy-efficient construction and retrofitting of buildings, appliance and equipment standards to ensure energy efficiency, and financial incentives for energy-saving measures.
3. **Transportation Policies**: Sweden has taken steps to reduce emissions in the transportation sector. The country has promoted the use of biofuels, electric vehicles (EVs), and public transportation systems. Incentives, such as tax exemptions and subsidies, have been provided to encourage the adoption of low-emission vehicles and the development of charging infrastructure.
4. **Waste Management**: Sweden has adopted a waste-to-energy approach, where waste is used as a fuel for energy production. The country has invested in waste management infrastructure, such as waste incineration plants with energy recovery, to reduce landfilling and utilize waste as a renewable energy source.
5. **Research and Development**: Sweden has prioritized research and development (RD) in clean technologies and sustainable solutions. The government has allocated funding for RD projects focusing on areas like renewable energy, energy storage, and climate-friendly innovations.

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