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Carbon costs

Towards a system of indicators for the carbon impact of products, enterprises and industries

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International Conference on Statistics for Sustainable Finance
Paris, 15 September 2021

Carbon costs – the vision

- The price system does not fully account for resoure use. We need **granular data on carbon use, direct and indirect.**
- Imagine that for every good and service, **all direct and indirect carbon emissions in the course of production** are known.
- Carbon costs depend on **direct emissions**, the quantity of **inputs** and **their carbon costs**!.
- A secondary price system, indicating the use of carbon on every stage of production.
- Producers, investors, consumers and political authorities would have the information needed for decision making. Competition among producers may induce rapid adjustment!

The paper…

… introduces a consistent system of indicators for the **carbon impact of industries, companies, products and activities**

… works out **3 views**: a cost equation, an IO reduced form and a GHG Protocol representation

… shows how the system of indicators can be **generated in a largely decentralised way.** Carbon cost is like a price tag, can be handed over the stages of the value chain!

… points out the **elements of a working solution. Start with top down estimates, then boot the system bottom up**

… discusses **policy options for central banks**

(1) Cost equation

Consider the *bill of material* (BoM) of product *k*, with r_{ik} being the quantity of good *i* embodied in the production process:

$$\mathbf{r}_k = (r_{k1} \quad r_{k2} \quad \dots \quad r_{kK})'$$

Let d_k be the amount of carbon directly emitted and c_i be the carbon cost of input *i*

Direct emissions Indirect emissions Quantity structure of inputs

Then the carbon cost of good *k* is given as the **sum of direct and indirect emissions**:

$$c_k = d_k + \mathbf{r}_k{}'\mathbf{c} = d_k + \sum_i r_{ki}\, c_i \qquad (1)$$

"Price" structure of inputs

If the c_i is known, we can calculate the carbon cost of product k directly.

(2) IO reduced form

If the c_i are unknown, the equation is recursive. We can solve for the carbon content of all goods simultaneously. Let

$$\mathbf{R} = (\mathbf{r}_1 \quad \mathbf{r}_2 \quad \dots \quad \mathbf{r}_K)$$

be the matrix of the BoMs for all produced goods. With **d** the vector of direct emissions for products 1,…, *K*, we may write:

$$\mathbf{c} = \mathbf{d} + \mathbf{R}'\mathbf{c}$$

and solving for **c** yields

$$\mathbf{c} = (\mathbf{I} - \mathbf{R}')^{-1}\mathbf{d} \qquad (2)$$

We do not need to compute this solution. It is enough to know that it exists and we can let decentralised information processing do the work!

Carbon costs of all goods

Leontief inverse, reflecting interlinkages

Direct emissions for all goods

(3) GHG Protocol representation

Given the widespread use of the Greenhouse Gas (GHG) Protocol emission classes in environmental reporting, it is useful to rephrase the definition of carbon cost.

In the production of good *k*, let $sc1_k$ and $sc2_k$ be Scope 1 and Scope 2 emissions, and $sc3u_k$ be upstream Scope 3 emissions (cradle to gate). Then we have:

$$c_k = sc1_k + sc2_k + sc3u_k. \tag{3}$$

Carbon cost is equal to the sum of Scope 1, Scope 2, and upstream Scope 3 emissions!

This gives us the chance to compute *firm level* carbon costs from emissions data

Company level carbon costs – some descriptives

Level data highly skewed

Company level GHG emission intensities and carbon costs

Trucost environmental data, 2019, world-wide

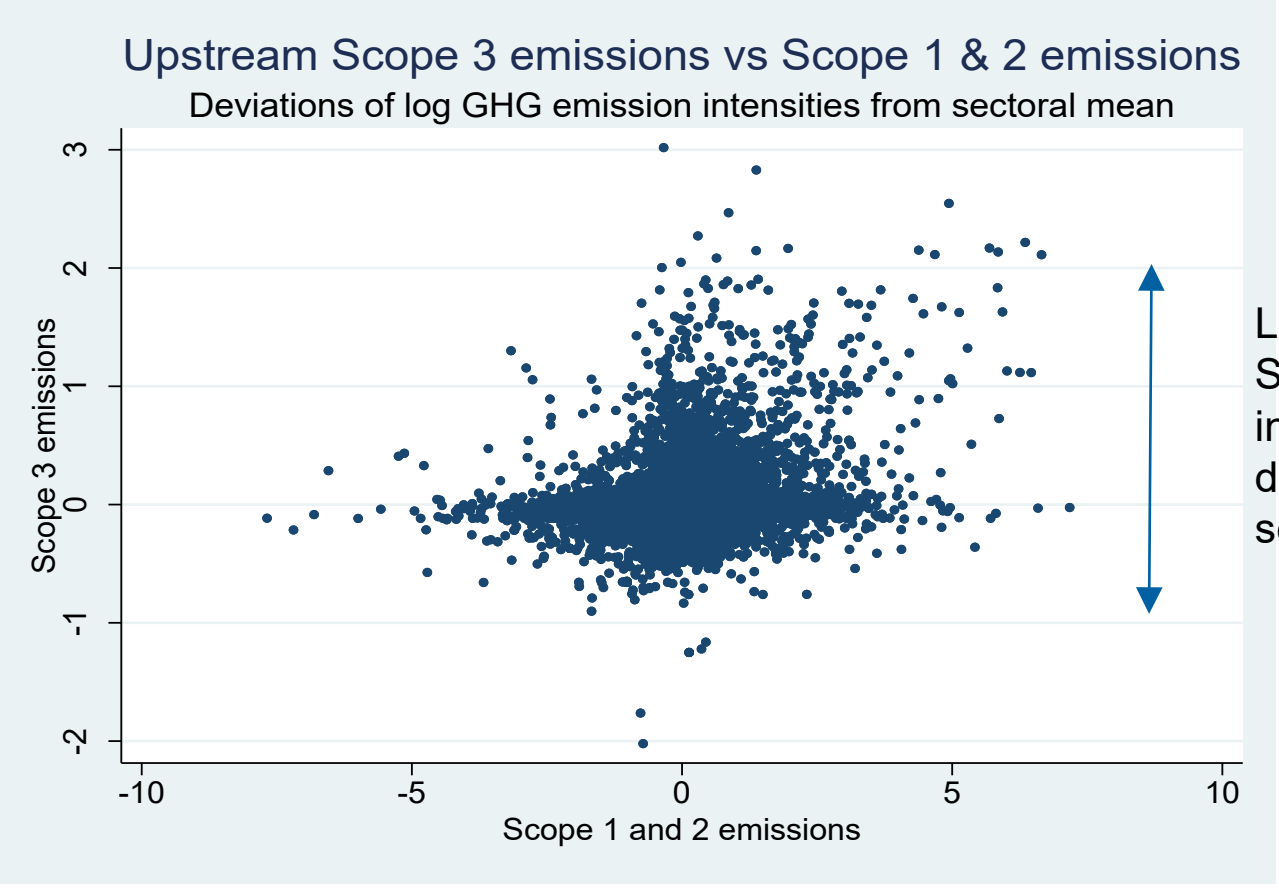
	Mean	Median	Std Dev	# Obs
Intensity levels				
Scope 1 & 2	338.56	39.33	2034.17	19,405
Scope 3 upstream	160.29	97.70	197.07	19,405
Carbon cost	498.84	169.84	2073.89	19,405
Log intensities				
Scope 1 and 2	3.794	3.672	1.790	19,405
Scope 3 upstream	4.577	4.582	0.990	19,405
Carbon cost	5.150	5.135	1.266	19,405

[1] Emission intensities are given as tons of CO2 equivalents, normalised by company revenue in millions of USD. Scope 1 and 2 emissions are direct emissions plus purchased electricity, heat and steam. Scope 3 upstream emissions are indirect emissions that result from intermediate inputs. Carbon cost is defined according to equation (3) as the sum of Scope 1, Scope 2 and upstream Scope 3 emissions. All data are reported unweighted.

Sources: Trucost environmental data, own calculations.

Logs nicely behaved. Scope 3 upstream emissions large contribution!

Company level carbon costs – checking information content



Logs of upstream Scope 3 emission intensities, deviations from sectoral means

Computing carbon costs

To evaluate inputs, we need values for **carbon costs on a product level**.

- Ideal case: Carbon costs for input goods are available from input provider. Carbon costs can be **computed** on the basis of equation (1) and cost accounting allocation models

− **We may approximate input carbon costs** using
  - sectoral data from SEEA and EEIO models
  - granular data from company level data of provider
  - granular carbon costs of reference products

− Disclosed carbon costs and data for proxy valuations can be **disseminated centrally!** It is important that the producer uses her proprietary information!

A detour: Physical flow account of SEEA and EEIO models

- SEEA: "Standard of Environmental Accounting". A UN Standard for aggregate statistics on environmental issues. The physical flow account yields absolute values and intensities for direct and indirect emissions by sector, on the basis of IO models for the whole economy.

- Physical flow account for Germany shows the carbon content of final demand for 49 sectors

- EEIO models: specific IO models for modelling the use of ressources and emissions. The Trucost EEIO model yields carbon intensities for **464 sectors** (US based)

Eq (2) justifies the use of sectoral carbon intensities from SEEA and EEIO models as a first level estimate for carbon costs of inputs!

Top down and bottom up

Producers do not need to know the carbon costs of the whole economy, **only those of their own providers** (or estimates thereof), just as for **cost accounting** we do **not need to know the entire price system, just what our providers charge.**

If all producers give a fair estimate of eq (1) using the information they have, i.e.

- Direct emissions,
- Bill of Material (BoM),
- Carbon costs of input providers if available, estimates if not

and if this information is disclosed and used by all participants alike, in equilibrium the resulting system of carbon costs **will necessarily correspond to the solution given by eq (2)!**

Jumpstart the system with proxies and boot it bottom up!

Is there scope for voluntary disclosure?

It is conceivable to make disclosure compulsory. However, there is a path that leads to **voluntary disclosure by (almost) all firms:**

- Producers with low CC (relative to peer group) will have an **incentive to disclose.** With a low CC, **they can charge higher prices.**
- This generates a **signal value** for the **decision not to disclose**
- Can be **reinforced** by **disseminating disclosed carbon costs on a central data platform**
- Can be **reinforced further** by **calculating sector averages conditional on not disclosing**
- With many companies disclosing, those that do not disclose will **be looking really bad**.

To get this mechanism going, we may need to overcome a **threshold level of disclosures.**

How to get there?

- We need **auditing** to make sure that the carbon costs is a fair estimate, using the information on direct emissions and production interlinkages existing on the company level.

- **Centralised platforms** can make available for everybody the existing information
  - on industry averages (also reduced form from EEIO data)
  - on carbon costs on a product and on the company level, if available

In addition, platforms can compute estimated carbon content for firms of a given industry that do not disclose their CCs**,** from the known industry averages and the known CCs of the firms that do disclose. **This will give a strong incentive for disclosure!**

These measures will make carbon costs informative, an **effective instrument in competition.**

To sum up

- Simple concept: on every stage, the **cumulated carbon content** is computed. This is passed as carbon costs to the next stage.
- Starting with estimates, the **system converges** to the values given by the solution
- Information processing **mostly decentral**. Producers only need to know their technology and the carbon costs of their input. A platform is needed that communicates disclosed carbon cost
- There is a mechanism that makes **disclosure the outcome of economic incentives**
- The system will yield **encompassing and highly granular information.**
- **And central banks and international organisations may have an important role!**

Policy options for CBs and international organisations

1. Co-operate with Eurostat and the NSIs in setting up a **rather disaggregated EEIO-model for the Euro Area**, and also for some of the larger countries if this is warranted by observed heterogeneity.
2. Set up and maintain a **dissemination platform for carbon cost data** on the level of sectors, enterprises and products.
3. Develop and propagate **disclosure standards** and assist in setting them, as a basis for comparability and auditing. Those rules can build on the relevant GHG Protocol standards.
4. Interact with the EU Commission and with the IFRS on **disclosure requirements**, especially regarding the CSRD. Possible disclosure requirements should target large companies, as well as producers of primary goods and importers.

Reserve slide

Carbon costs – the three perspectives

Eq (1) is the definition of carbon costs. Carbon costs result from direct emissions and the carbon costs of other inputs. The system is recursive

$$c_k = d_k + \mathbf{r}_k{}'\mathbf{c} = d_k + \sum_i r_{ki}\, c_i \qquad (1)$$

Eq (2) gives the solution. Under standard regularity conditions, it is unique.

$$\mathbf{c} = (\mathbf{I} - \mathbf{R}')^{-1}\mathbf{d} \qquad (2)$$

Eq (3) shows how carbon costs relate to the standard GHG protocol definitons:

$$c_k = sc1_k + sc2_k + sc3u_k. \qquad (3)$$