The production network impacts of carbon pricing: innovation, productivity and greenhouse gas emissions

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Carbon markets are growing in number and scope around the globe as a response to the need to decarbonise economies and avoid dangerous climate change. In the EU, for instance, carbon pricing has so far focused on electricity generation as well greenhouse gas (GHG)-intensive industries. Typically, only a subset of firms is regulated. However, one might expect that the carbon price that regulated firms face affects not only their own operations and investments, but also those of other firms in their production network even when suppliers or clients are not directly subject to a carbon price themselves. This could be directly through a price effect, but also through changes in the production process or market structure. This project uses a unique dataset for Belgium to explore how the EU's carbon price affects low-carbon innovation, productivity and GHG emissions intensity across the entire production network in the industrial sector.

While this paper is still at an extended-abstract stage, the data collation and matching are in their final stages, thus ensuring that the paper will be ready in time for the research conference. We draw on years of experience with Belgian firm-level data at the National Bank of Belgium (see, e.g. Dhyne et al 2021, Baqaee et al. 2022, Bernard et al. 2022, Dhyne et al. 2022).

We will here present a brief overview of the literature, followed by a description of the data and finally the research design.

Literature

A growing literature has been analysing the impact of carbon markets on firms' emissions, innovation, and operations (e.g., Colmer et al 2021, Calel and Dechezleprêtre 2016). In addition, the literature has started to explore how market structure interacts with the effects of a carbon price (Fabra and Reguant 2014, Hintermann et al. 2020, Barrows et al. 2022). This has also been explored in the context of other environmental policies, with a particular focus on intra-firm reallocations (Gibson 2019, Chen et al. 2021). From a theoretical perspective, the position of a firm in a network has also inspired the definition of optimal carbon pricing as considering the entire production network matters for the costs, benefits, and speed of the policy's effect (King et al. 2019).

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The economics literature has also examined the interaction between industrial policies and production networks (e.g., Liu 2019). Research linking microeconomic dynamics and macroeconomic shocks has increasingly shown the sizable economic importance of production networks[4]. To date, however, there is no work on studying how production networks affect the firm-level effects of climate policy to inform decarbonisation efforts. It is at the intersection of these different research frontiers that we aim to situate this project. We are in the fortunate position to having access to precisely the microdata needed to undertake this work.

Data

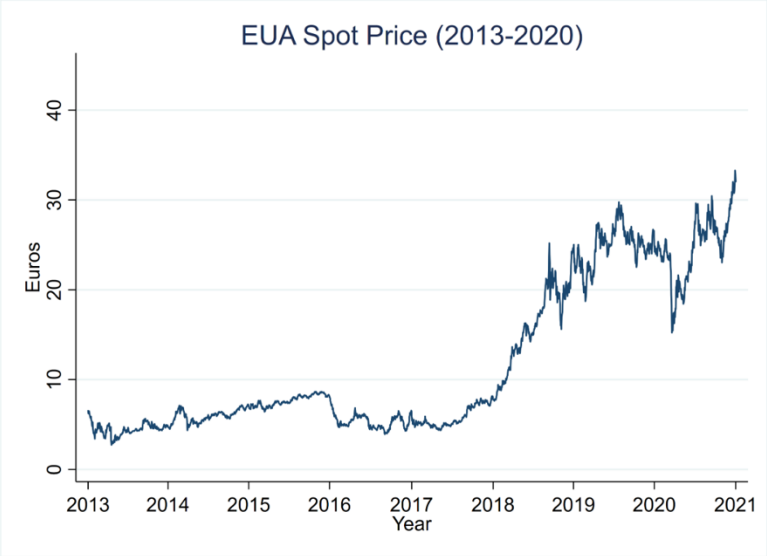
We use (mostly-)confidential microdata on the universe of Belgian firms covering a variety of dimensions from 2005 to 2020.

a. *Financial data*: Firms' annual accounts allow for measurement of employment, capital, investment, etc
b. *VAT business to business transactions data*: For each year, the value of total sales or purchases is reported for all B2B transactions of each firm, based on their tax VAT returns. This means that the entire production network within Belgian boundaries can be identified.
c. *Trade data*: the trade transactions data observes annual trade flows by product and country of destination/origin. Whilst it is at a different aggregation level to the B2B data, it allows some measurement of the cross-boundary production network.
d. *PRODCOM*: provides production values and quantities by product by firm for a large subsample of our firms. This provides the opportunity to be more precise in identifying dimensions of the production network. Building on earlier work in Forlani et al. (2022), this also allows us to differentiate between mark-ups, demand and quantity TFP.
e. *GHG emissions data*: combining the above data with firm-level data from the EU ETS carbon market (emissions and permit allocations) and private data providers of Scope 1 and Scope 2 emissions that we have purchased access to (Refinitiv, Carbon4Finance and Trucost), we will measure or – where needed - impute firm-level emissions across the entire manufacturing sector and its suppliers.
f. *Patent data:* PATSTAT data on patents as a measure innovation, with the potential to differentiate between low-carbon and non-low carbon patents.

Research approach and contribution.

While the price of a ton of carbon on the EU ETS market – or the price of an Emissions Allowance Unit, remained relatively low in the early phases of the EU's carbon market, it has increased due to a combination of factors from below 10€ in 2018 to 30€ in 2020 (and up to 80 Euros since), as shown in the graph below.

[4]See Carvalho and Tahbaz-Salehi 2019 for an overview paper; McNerney et al. 2022 for an illustration on how production networks amplify economic growth; and Baqaee 2022 for a frontier contribution linking micro and macro dynamics via production network data.



Notes: This figure plots the time series of daily EUA spot settlement prices in euros during the EU Emissions Trading System Phase 3 (2013-2020).

One can assume that the price increase is not endogenous to Belgian firms' operations given their relative size in the market. We therefore aim to exploit this price change and measure how it affected directly regulated firms in our sample, but also firms throughout their network. Using typical shock propagation approaches, we aim to consider several outcome variables: emissions, emissions intensity, productivity, market power, and innovation. We will also add other shocks to the Belgian economy to leverage combined effects.

Such an understanding will not only inform the economic dynamics of decarbonisation, it will also be important evidence in the design of policies to cute hard-to-abate emissions in industrial sectors such as cement, limestone or steel who still produce substantial quantities of combustion and process emissions, and whose ability to mitigate these might depend on the firms upstream and downstream. With carbon markets being considered as the key policy tool in many countries, leveraging insights from production networks is key for designing future climate policy on the way towards climate neutrality.

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