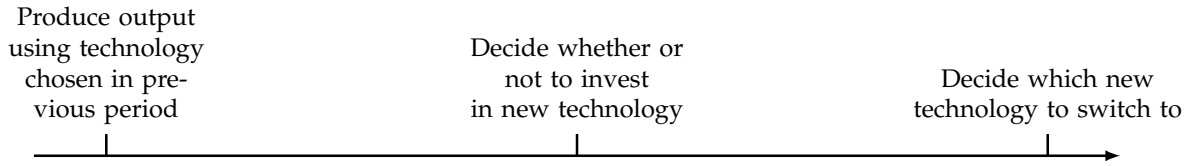


Introduction

This document presents a methodology for forecasting industrial decarbonization incentivized by a carbon price. The agents in our model are firms operating in various industrial sectors, including but not limited to producers of Iron and Steel, Cement, Plastics, and Chemicals. Importantly, while these are examples, the methodology is sector-agnostic and can be applied to other similar problems. Central to the model is the decision-making of firms. Given a set carbon price and considering the age of their current facilities within a sector as well as the prevailing technological landscape, firms will decide whether or not to invest in green technology. It's worth noting that within each sector, we make the simplifying assumption that firms produce a singular, homogeneous good. For instance, despite the existence of myriad steel varieties—many of which are not substitutes for one another—we assume that all steel producers generate the same kind of steel.

1 Model set-up

The firm will make decision



1.1 Technology turnover

In the simplest version of the model, the decision whether to invest in a new technology is made once every L periods. Where L is the lifetime of the asset in the sector. Assets are assumed to be homogeneous within a sector with respect to their lifetime. We will need to keep track of when technology switching occurs and the distribution of the age of the assets within a sector. To this end, let us define a matrix \mathbf{A}^t where $\mathbf{A}_{\theta,l}^t$ is the percentage of facilities in the sector using technology θ that are l years old at time t . If when we are able to define a stochastic matrix \mathbf{P}^t where $\mathbf{P}_{\theta,\theta'}^t$ is the probability that a firm using technology θ in period t , will switch to technology θ' in the next period, we can update \mathbf{A}^t as follows:

$$\mathbf{A}^{t+1} = \left[\mathbf{P}^t \mathbf{A}^t[L], \mathbf{A}^t[1], \dots, \mathbf{A}^t[L-1] \right] \quad (1)$$

1.2 Technology choice

For any given sector, firms have a range of production technologies available, indexed by θ which spans from 1 to Θ . Each of these production technologies comes with its own fixed cost, $F_{\theta,t}$, which is incurred only once during the asset's lifetime. Additionally, there's a variable cost, $c_{\theta,t}$, and a carbon intensity, $e_{\theta,t}$. Therefore, when switching to a new technology, the production cost is represented by:

$$C_{\theta,t} = F_{\theta,t} + \sum_{\tau=t}^L \beta^{t-\tau} (c_{\theta,\tau} + e_{\theta,\tau} \cdot p_{\tau} + \epsilon^i) \cdot D^i \quad (2)$$

In the above equation, p_t denotes the prevailing carbon price at time t , while D_i refers to the demand allocated to the i th firm. Consequently, the primary objective for any firm is to select a technology, θ^* , that minimizes the cost. This decision can be mathematically represented as:

$$\theta_t^* = \arg \min_{\theta \in \Theta} C_{\theta,t} \quad (3)$$

Sketch of a solution (this will have to be worked out in detail, however, I'm quite sure that given some distributional assumption a solution similar to the one below can be obtained).

Assuming $\epsilon^i \sim \text{Gumbel}(-\gamma\nu, \nu)$. It can be shown that:

$$\mathbf{P}[\theta' = \theta^*] = \frac{\exp(-C_{\theta',t})^{1/\nu}}{\sum_{\theta \in \Theta} \exp(-C_{\theta,t})^{1/\nu}} \quad (4)$$

Assuming a continuum of firms will get that shares of firms choosing a given θ' will approach the probabilities above.

1.3 Competition and demand reduction

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2 Calibration and estimation of parameters

2.1 Modelling the variable cost of production

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