Carbon Policy Simulator — Model Parameters

This document summarises the estimated parameters from the paper, which underlie the interactive simulator: (i) firms' production cost, (ii) demand and import supply, and (iii) abatement investment cost.

1 Production cost and parameters

Static Cournot environment (per market-period)

In the model, firms compete à la Cournot under capacity constraints. For firm i with output q_i and annual capacity s_i, production cost follows a "hockey-stick" form with constant marginal cost up to a utilisation threshold, and a cost escalation once this threshold is crossed to reflect foregone maintenance. Mathemtically, this reads as:

$$C(q_i; \delta, \eta_i, \tau) = \delta_1 q_i + \mathbf{1}[q_i > \delta_2 s_i] \, \delta_3 \left(\frac{q_i}{s_i} - \delta_2 \right)^2 + \phi(q_i, \eta_i, \tau), \tag{1}$$

where η_i is emission intensity and τ the carbon price (policy). Under a carbon tax:

$$\phi(q_i, \eta_i, \tau) = \tau \, q_i \, \eta_i. \tag{2}$$

In the paper, I estimate the following:

Parameter	Value	Units
Constant marginal production cost δ_1	72.35	EUR/ton
Utilisation threshold δ_2	0.75	Utilisation threshold
Utilisation cost curvature δ_3	0.67	EUR

2 Demand and import elasticity

Aggregate demand (isoelastic)

In each market m and period t, aggregate demand is isoelastic:

$$\ln Q_{m,t}(P_{m,t}) = \alpha_{0,m,t} + \alpha_1 \ln P_{m,t}. \tag{3}$$

The elasticity is set to $\alpha_1 = -2$, and market-year intercepts $\alpha_{0,m,t}$ are fitted based on the observed market-year price-quantity pairs.

Import supply (isoelastic)

Import supply into market m at time t is:

$$\ln I_{m,t}(P_{m,t}) = \rho_{0,m,t} + \rho_1 \ln P_{m,t}, \tag{4}$$

with import supply elasticity $\rho_1 = 0.5$. Market-year intercepts $\rho_{0,m,t}$ are computed as for the demand.

Domestic strategic firms face residual demand after subtracting imports (and the competitive fringe, if included), so changes in τ affect equilibrium both through marginal cost and the import margin.

3 Investment cost and comparison to techno-economic estimates

Firms choose an abatement level $\theta_i \in [0, 100]$, interpreted as a percentage reduction in emission intensity relative to baseline intensity $\bar{\eta}$. Baseline intensity is set to $\bar{\eta} = 0.63$ tCO$_2$e per ton of cement, implying the mapping:

$$\eta_i = \left(\frac{100 - \theta_i}{100} \right) \bar{\eta}. \tag{5}$$

Investment cost function (level)

Investment costs are proportional to capacity and increasing in abatement, with an idiosyncratic cost shock affecting marginal costs:

$$\text{InvCost}_i(\theta_i \mid \lambda, \varepsilon_i) = s_i \, \theta_i \, (\lambda_1 + \lambda_2 \theta_i + \lambda_3 \varepsilon_i), \qquad \varepsilon_i \sim \mathcal{N}(0, 1). \tag{6}$$

If a firm moves from θ_i to $\theta_i' > \theta_i$, it pays the incremental (step) cost:

$$\text{InvCost}_i(\theta_i' \mid \theta_i) = \text{InvCost}_i(\theta_i' \mid \lambda, \varepsilon_i) - \text{InvCost}_i(\theta_i \mid \lambda, \varepsilon_i). \tag{7}$$

This structure reflects scalable, combinable abatement options and incremental upgrading. The discount factor is set at 0.975.

In the paper, I estimate the following:

Parameter	Estimate
λ_1	0.62
λ_2	0.12
λ_3	4.07

These parameters are estimated by matching (i) mean investment and (ii) within-market dispersion (standard deviation) of investment across firms over investment periods.

Comparison to techno-economic benchmarks

As a reference point reported in the paper, the estimated cost curve implies an expected cost of about EUR 6.3bn to reduce the emission intensity of the entire French cement industry by 50%, while a techno-economic assessment reports about EUR 3.3bn for the same reduction (ADEME, 2021). The interpretation is that the structural estimates embed additional opportunity costs (overhead, downtime, financing, implementation frictions) beyond engineering CAPEX.