Carbon leakage and Capacity-Based Allocations. Is the EU right?

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ETS and carbon intensive internationally traded industries

- Leakage and competitiveness issues have led to free allocations in various forms (Hood 2010).
  - Output based in New-zealand, Australia, California;
  - Capacity based in the EU.
- Previous literature only partially addressed the issue.
  - Quirion (2009), Fisher and Fox (2011);
  - Ellerman (2008), Neuhoff (2006), Zhao et al. (2010);
- This paper
  - Introduces a model of capacity decisions under uncertainty;
  - Characterizes the optimal allocation scheme;
  - Applies the analysis to the EU-ETS for cement.
The model (Simplified specification)

- An homogenous good with a variable price function:

\[ p(q, \theta) = a + \theta - bq; \]

- Home production:
  - Old plants: \( c_h \cdot q_o + \gamma h q_o^2 \)
  - New plants: \( c_h \cdot q_n + c_k \cdot k \)

\[
C_h(q, k) = \begin{cases} 
  c_h q & \text{if } q < k \\
  c_h q + 0.5 \gamma h (q - k)^2 & \text{otherwise}
\end{cases}
\]

- Imports:

\[ C_f(q_f) = c_f + \gamma f q_f^2. \]
The Model

Figure: Supply curve and demand without regulation.
The Model

- Environmental damage ($\sigma$ exogenous):
  \[
  \sigma E = \sigma [u_h q_h + u_f q_f]
  \]

- Welfare:
  \[
  W = \int_{\theta} [S(q(\theta), \theta) - C_h(q_h, k) - C_f(q_f) - \sigma E] d\theta - c_k k
  \]

- Policy:
  - Home emissions are taxed $\sigma$ but imports are not regulated.
  - Production and capacity are subsidized, $s_h$ and $s_k$.

- Timing:
  1. The regulator fixes $s_h$ and $s_k$ subsidy on production and capacity;
  2. Firms invest in $k$;
  3. $\theta$ is known and firms produce and import.
Direct technology effect

Figure: Without regulation
Direct technology effect

Figure: Uniform carbon price (BTA)
Direct technology effect

Figure: Unilateral carbon price (auctioning)
Direct technology effect

Figure: The subsidy scheme \((s_h, s_k)\)
The optimal Scheme

- Intuition for the results:
  - the first-best would be to tax domestic and foreign emissions (BTA);
  - without uncertainty the second best would be to subsidize home production (OBA);
  - with uncertainty, the regulator would like to set a different subsidy in each demand state;
  - if he cannot do so there is a welfare loss in low demand states;
  - the subsidy on capacity allows to discriminate among demand states.
The optimal Scheme

Corollary

With the linear specification, the optimal couple of subsidies satisfies:

\[
    s_h = \sigma u_f \frac{b}{b + \gamma_f} \frac{1 - F(\theta^+)}{1 - F(\theta^+) + A} \\
    s_k = s_h \frac{\gamma_h}{b} F(\theta^-),
\]

in which

\[
    A = \left[ \gamma_h + \gamma_f \frac{b}{b + \gamma_f} \right] \left[ \frac{F(\theta^-)}{b} + \frac{F(\theta^+) - F(\theta^-)}{b + \gamma_h} \right].
\]
The optimal Scheme

\[ s_h = \sigma_u f \frac{b}{b + \gamma_f} \frac{1 - F(\theta)}{1 - F(\theta^+) + A} \]  \hspace{1cm} (4)

\[ s_k = s_h \frac{\gamma_h}{b} F(\theta^-) \]  \hspace{1cm} (5)

- The subsidy on production is the product of three factors:
  - the marginal environmental damage of foreign production;
  - the sensitivity of imports to home production;
  - the ratio between the expected effect of the subsidy on production in high demand states (with imports) and the expected effect in all states.

- The subsidy on capacity is null if capacity is fully used in all states.
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\[ s_k = s_h \frac{\gamma h}{b} F(\theta^-), \quad (5) \]
The optimal Scheme

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- The subsidy on capacity is null if capacity is fully used in all states.
Application to the EU-ETS for the cement industry

- Some characteristics of cement
  - A carbon intensive internationally traded industry
  - Previous analysis of leakage and competitiveness
  - Demand fluctuations and imports
  - Calibration of the Model (2007 high demand, 2009 low demand)
Comparison of the optimal scheme with the actual scheme

- The optimal (2nd best) scheme is an OBA scheme with a rate of output-based allocations:

\[ s_k = 0 \text{ and } \frac{s_h}{\sigma} = u_f \frac{b}{b + \gamma_f} = 0.284t \text{ CO}_2/t. \]

- The EU-ETS policy correspond to:

\[ \frac{s_k}{\sigma} = 0.766t \text{ CO}_2/t \text{ and } s_h = 0 \]

and grandfathering (based on production in years 2005–2008).
## Calibration

### Part 1: Data used for calibration of the No Policy scenario

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand curve slope (1/b)</td>
<td>2 Mt/(€/t)</td>
<td>Own estimation</td>
</tr>
<tr>
<td>Clinker price (high demand - h.d.)</td>
<td>80 €/t</td>
<td>UN Comtrade (2007)</td>
</tr>
<tr>
<td>Clinker price (low demand - l.d.)</td>
<td>60 €/t</td>
<td>UN Comtrade (2009)</td>
</tr>
<tr>
<td>Production from existing plants (h.d.)</td>
<td>220 Mt/yr</td>
<td>Cembureau (2007)</td>
</tr>
<tr>
<td>Production from existing plants (l.d.)</td>
<td>140 Mt/yr</td>
<td>Cembureau (2009)</td>
</tr>
<tr>
<td>Production from new plants</td>
<td>20 Mt/yr</td>
<td>Own estimation</td>
</tr>
<tr>
<td>Imports (h.d.)</td>
<td>30 Mt/yr.</td>
<td>UN Comtrade (2007)</td>
</tr>
<tr>
<td>Imports (l.d.)</td>
<td>10 Mt/yr.</td>
<td>UN Comtrade (2009)</td>
</tr>
</tbody>
</table>
## Part 2: Parameters calibrated

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected demand curve intercept</td>
<td>360 Mt/yr</td>
</tr>
<tr>
<td>Standard deviation of $\theta$</td>
<td>70 Mt/yr</td>
</tr>
<tr>
<td>Annualized fixed cost of capacity ($c_k$)</td>
<td>45 €/t</td>
</tr>
<tr>
<td>Operational cost of new plants and of the least costly existing plant ($c_h$)</td>
<td>25 €/t</td>
</tr>
<tr>
<td>Price of cheapest import ($c_f$)</td>
<td>50 €/t</td>
</tr>
<tr>
<td>Slope of existing plants supply curve ($1/\gamma_h$)</td>
<td>4Mt/(€/t)</td>
</tr>
<tr>
<td>Slope of imports supply curve ($1/\gamma_f$)</td>
<td>1Mt/(€/t)</td>
</tr>
</tbody>
</table>

## Part 3: Additional parameters used for the other scenarios

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>CO$_2$ price ($\sigma$)</td>
<td>20 €/t</td>
<td>Grubb and Cooper (2011)</td>
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<tr>
<td>Benchmark for free allocation in the ETS</td>
<td>766kg CO$_2$/t</td>
<td>E.C. (2010)</td>
</tr>
<tr>
<td>Specific emissions, EU27 ($u_h$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- for $\sigma = 0$</td>
<td>858 kg CO$_2$/t</td>
<td>E.C. (2010)</td>
</tr>
<tr>
<td>- for $\sigma = 20€/t$</td>
<td>758 kg CO$_2$/t</td>
<td></td>
</tr>
<tr>
<td>Specific emissions, rest of the world ($u_f$)</td>
<td>852 kg CO$_2$/t</td>
<td>WBCSD + E. C. (2010)</td>
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<tr>
<td>MAC curve slope</td>
<td>0.2 €/ kg CO$_2$</td>
<td>Own estimation</td>
</tr>
</tbody>
</table>
Scenarios

Five scenarios are compared to the No-Policy reference:

- Auctionning;
- NER: capacity-based allocation;
- EU-ETS: capacity-based allocation + grandfathering;
- OBA: output-based allocation;
- BTA: border tax adjustment.
# Investment and Production

<table>
<thead>
<tr>
<th></th>
<th>No-Policy</th>
<th>Auction</th>
<th>OBA</th>
<th>EU-ETS &amp; NER</th>
<th>BTA*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>OBA*</td>
<td></td>
<td></td>
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<tr>
<td>Investment</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>79</td>
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<tr>
<td>Low demand</td>
<td></td>
<td></td>
<td>OBA^0</td>
<td></td>
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<tr>
<td>new plants</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>79</td>
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<tr>
<td>old plants</td>
<td>140</td>
<td>124</td>
<td>133</td>
<td>140</td>
<td>79</td>
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<tr>
<td>Imports</td>
<td>10</td>
<td>22</td>
<td>19</td>
<td>11</td>
<td>11</td>
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<tr>
<td>Total</td>
<td>170</td>
<td>146</td>
<td>152</td>
<td>168</td>
<td>168</td>
</tr>
<tr>
<td>High demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>new plants</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>79</td>
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<tr>
<td>old plants</td>
<td>220</td>
<td>204</td>
<td>213</td>
<td>220</td>
<td>159</td>
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<tr>
<td>Imports</td>
<td>30</td>
<td>42</td>
<td>39</td>
<td>31</td>
<td>31</td>
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<tr>
<td>Total</td>
<td>270</td>
<td>246</td>
<td>252</td>
<td>oo</td>
<td>268</td>
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</table>

JP Ponssard ()

Capacity-Based Allocations

2012 15 / 20
## Price and profits

### Low demand

<table>
<thead>
<tr>
<th></th>
<th>No Policy</th>
<th>Auction</th>
<th>OBA</th>
<th>NER</th>
<th>EU-ETS</th>
<th>BTA*</th>
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</thead>
<tbody>
<tr>
<td>Price (€/t)</td>
<td>60</td>
<td>72</td>
<td>69</td>
<td>61</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>Profit (M€)</td>
<td>2300</td>
<td>2156</td>
<td>2405</td>
<td>2340</td>
<td>46</td>
<td>2497</td>
</tr>
<tr>
<td>Public revenue</td>
<td>0</td>
<td>1876</td>
<td>1258</td>
<td>0</td>
<td>1183</td>
<td>-1252</td>
</tr>
<tr>
<td>Free allocation</td>
<td>0</td>
<td>0</td>
<td>758</td>
<td>2380</td>
<td>1207</td>
<td>3642</td>
</tr>
</tbody>
</table>

### High demand

<p>| | | | | | | |</p>
<table>
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<tr>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Price (€/t)</td>
<td>80</td>
<td>92</td>
<td>89</td>
<td>81</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>Profit (M€)</td>
<td>6700</td>
<td>6073</td>
<td>6450</td>
<td>6700</td>
<td>4412</td>
<td>6863</td>
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<tr>
<td>Public revenue (M€)</td>
<td>0</td>
<td>3088</td>
<td>2009</td>
<td>0</td>
<td>2394</td>
<td>-42</td>
</tr>
<tr>
<td>Free allocation (M€)</td>
<td>0</td>
<td>0</td>
<td>1212</td>
<td>3335</td>
<td>1207</td>
<td>3658</td>
</tr>
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</table>

### Average

<p>| | | | | | | |</p>
<table>
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</thead>
<tbody>
<tr>
<td>Profits dom. (M€)</td>
<td>4250</td>
<td>3551</td>
<td>3961</td>
<td>4250</td>
<td>1962</td>
<td>4413</td>
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<tr>
<td>vs No Policy (%)</td>
<td>-16%</td>
<td>-7%</td>
<td>0%</td>
<td>-54%</td>
<td>4%</td>
<td>-7%</td>
</tr>
<tr>
<td>Public revenue (M€)</td>
<td>0</td>
<td>2481</td>
<td>1634</td>
<td>0</td>
<td>1788</td>
<td>-647</td>
</tr>
<tr>
<td>Free allocations (M€)</td>
<td>0</td>
<td>0</td>
<td>985</td>
<td>2987</td>
<td>1207</td>
<td>3642</td>
</tr>
</tbody>
</table>

# Leakage and Emissions

<table>
<thead>
<tr>
<th>Emissions</th>
<th>No-Policy</th>
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<th>BTA*</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>OBA*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>from domestic production</td>
<td>172</td>
<td>124</td>
<td>131</td>
<td>149</td>
<td>150</td>
</tr>
<tr>
<td>from imports</td>
<td>17</td>
<td>27</td>
<td>25</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>189</td>
<td>151</td>
<td>156</td>
<td>167</td>
<td>167</td>
</tr>
<tr>
<td>Leakage ratio (%)</td>
<td>-</td>
<td>22</td>
<td>19</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

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Capacity-Based Allocations 2012 17 / 20
Welfare

Capacity-Based Allocations

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The paper provides the optimal second best scheme as a mixture of OBA and CBA which depends on
  - the market uncertainty;
  - the level of international competition

NB This contradicts traditional OBA analysis based on leakage ratio.

It is relevant for EU-ETS 2013–2020, Australia, California; New-Zealand...

its application to EU cement sector shows:
  - current scheme triggers excessive investment (Mt);
  - induces excessive transfers (2,3M€);
  - and is associated with a welfare loss of 5%.
Thank You!