On the relativity of environmental bounds

Nothing gets eaten as hot as it gets cooked

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Elastic demand in optimisation models

» Where bottom-up and top down methodologies meet

» Interpretation – what does it represent
» How to quantify
» How elastic demand reacts on (environmental) limitations
Quantifying energy service elasticities

\[ EDE = - \sigma (1 - \delta) + \delta \text{ESE} \]  
\( \text{Vanregemorter} \)

\( \delta \): budget share of energy in ES

\( \sigma \): elasticity of substitution > 0

Conclusions:

- \( EDE < \text{ESE} < 0 \) if \( \sigma \) big
- \( \text{ESE} < EDE < 0 \) if \( \sigma \) small
- \( \text{ESE} \uparrow \) then \( \text{EDE} \uparrow \)

Guidelines for ESE quantification

» Assume \( EDE \) is known

» Determine \( \delta \) and \( \sigma \) (3 model runs)
  » Price increase and \( \text{ESE} = 0 \) ➔ \( EDE1 \)
  » Arbitrary \( \text{ESE2} \) ➔ \( ED2 \)
  » \( \delta = (E\text{D1-ED2})/\text{ES2} \), \( \sigma = E\text{D1}/(\delta - 1) \)
  » \( \text{ESE}=(E\text{DE}+\sigma(1-\delta))/\delta \)
Simple model

Reference scenario: Demand 100 – No carbon constraint - inelastic demand

Carbon intensive technology A: Cost € 5/GJ CO2: 100 kg / GJ
Carbon free technology B: Cost € 10 /GJ

Solution: Activity A: 100 - B: 0, Cost 500, Shadow price 5 € /GJ, CO2_ref 10000 kg

Policy scenario: Demand elasticity ε, CO2_p < CO2_ref

Solution: see next picture

Graphical representation

Conclusions:
• Shift in shadow price causes considerable demand loss, even for a very small policy objective.
• Technology A makes a profit.
Realistic?

» Yes for markets with real marginal pricing - all customers pay the same price
» Other markets for energy services - housing, transport?

Relative bounds

» Per unit of activity limitation : kg CO2/ GJ delivered
» Reference scenario \( CO2_{ref} \) : 100 kg /GJ
  Policy scenario \( CO2_{pol} < CO2_{ref} \)
  Policy scenario \( CO2_{pol} < CO2_{Ref} \)

Solution: always requires mix of technology A and technology B
Shares of A and B determined by relative constraint
Dual value of commodity determined by shares of A & B
Effect on commodity prices of absolute and relative bounds

![Graph showing the effect on commodity prices of absolute and relative bounds. The x-axis represents CO2 reduction, and the y-axis represents commodity price. Two lines are depicted: one for the absolute bound and another for the relative bound.](image)