Modelling the short-run impact of 'carbon trading' on the electricity sector with endogenous market power

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The topic

- EU-ETS covers several industry sectors of which power generation is the largest one
  - its performance depends on power industry behaviour
  - the EU-ETS might have a significant impact on power prices and emissions and consequently on social welfare
- On these issues, there is a controversial debate, especially with regard to their relationship with market structures
  - perfectly competitive markets
  - Imperfectly competitive markets (endogenous market power)

Three questions and related literature

- **How can the ETS impact on the degree of market power in electricity markets?**
  Literature:
  - most contributions adopt exogenous market power and one-shot models (Requate, 2005)
- **How does the ETS impact on power pricing?**
  Literature:
  - some authors state that the electricity price in a competitive scenario increases more than under market power (Sijm et al., 2005)
  - other authors state that electricity prices are likely to increase more under imperfect competition (Reinaud, 2003; Lise, 2005; Honkatukia et al., 2008)
- **How can the ETS affect aggregate emissions in the short run?**
  Literature
  - environmental policy can contribute to increase pollution under certain conditions in terms of demand if there is imperfect competition and firms are sufficiently asymmetric (Requate, 2005)

Model setting: basic assumptions

- **Power demand**. Totally inelastic (except for when we deal with the impact on emissions) and represented by a typical load duration curve
- **Power supply**. Two groups of plants, a and b and two technological scenarios

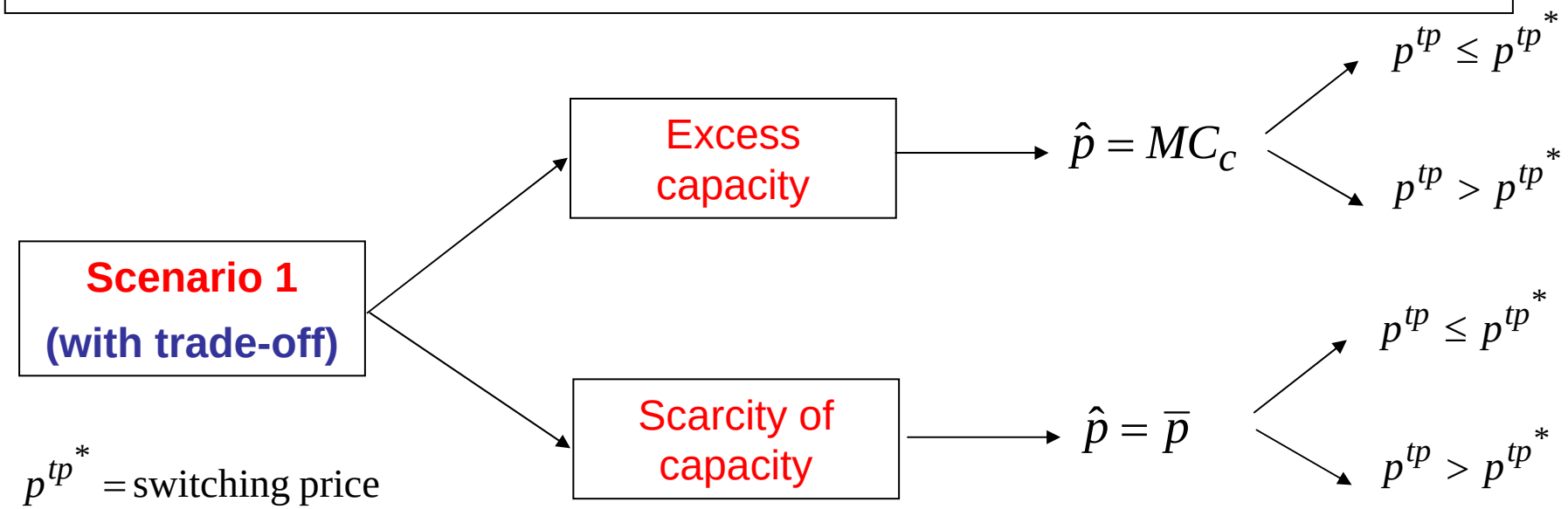
  - coal versus CCGT plants (Trade-off) $v_b > v_a ; e_b < e_a$

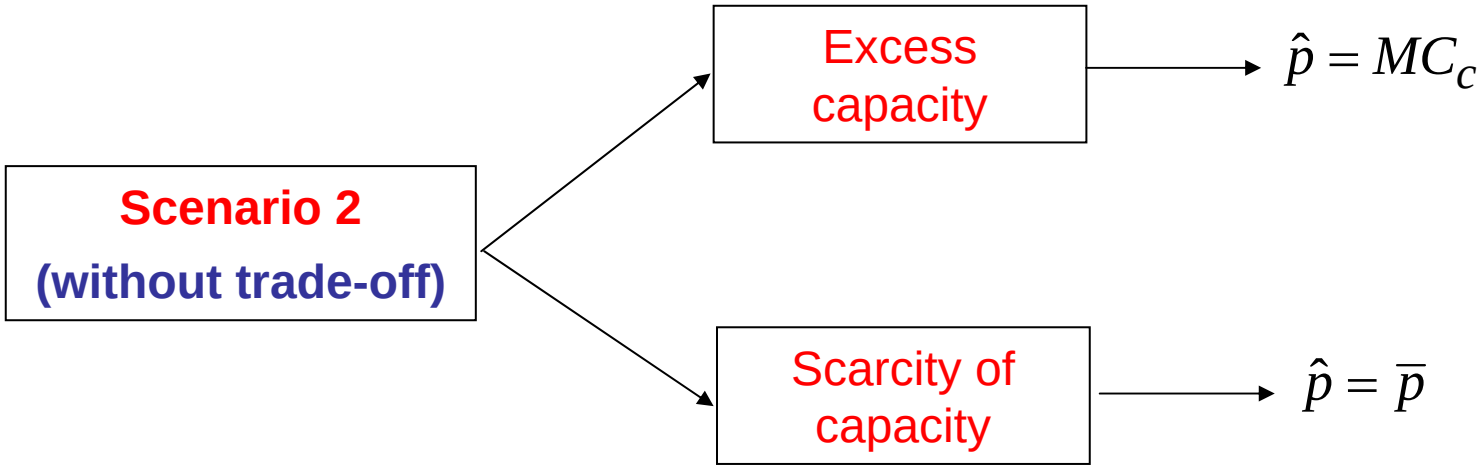
  - steam cycle gas-fired versus CCGT plants (no Trade-off) $v_b > v_a ; e_b > e_a$
- **Power market**. Spot market, uniform first price auction, price cap (insensitive to carbon price)
- **Allowance market**. Abatement is impossible (short run analysis); allowance price given exogenously; free allocation
- **Market structure and competition model.** Dominant firm facing competitive fringe model
- **Capacity conditions**. Two cases:

  - with excess capacity (price threshold = marginal cost of a peaking technology with $e > e_b$)

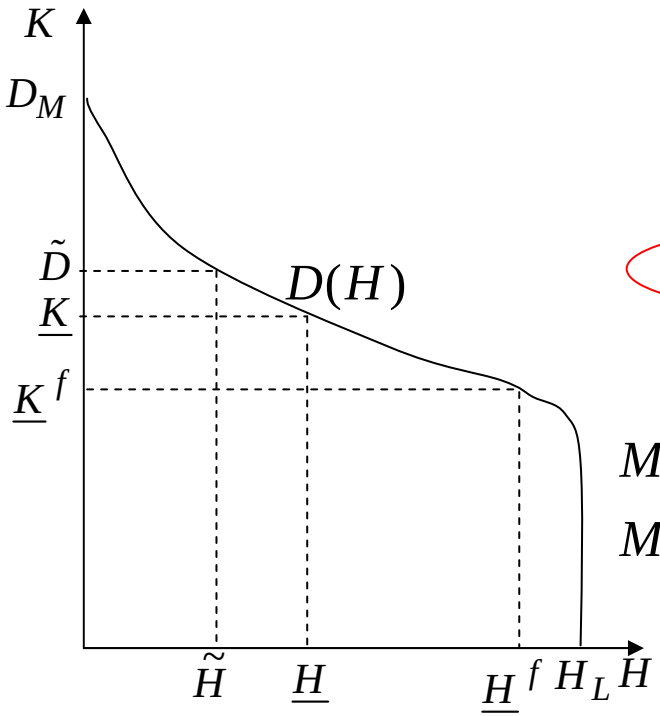
  - scarcity of capacity (price threshold = price cap)

Model setting: Supply configurations





Model output: scheme



$MC_j = v_j + e_j p^{tp}$

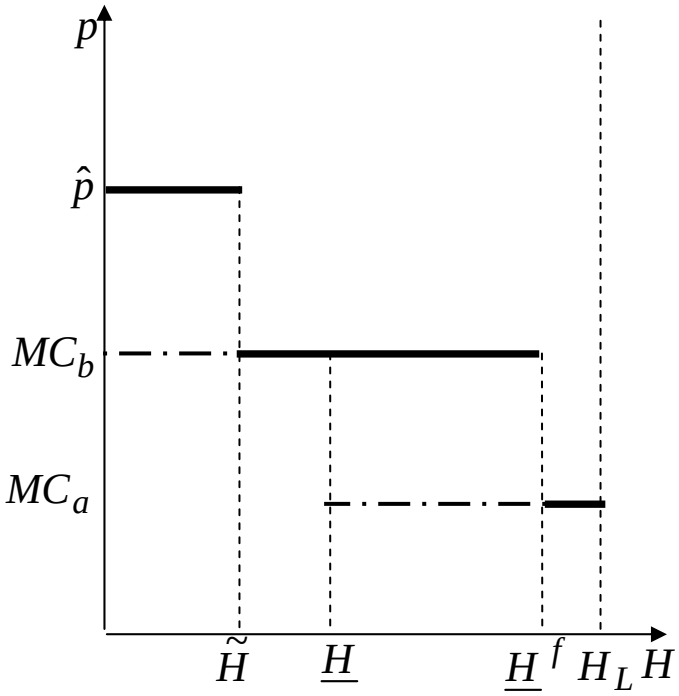
v_j = variable cost

p^{tp} = allowance price

e_j = emission rate

MC_b = marginal cost of the least efficient plants (CCGT)

MC_a = marginal cost of the most efficient plant (coal plants)



$\tilde{D}$ (or $\tilde{\tilde{D}}$) $= g(\delta, \mu_a^d, \mu_a^f, p^{tp})$

δ = market concentration

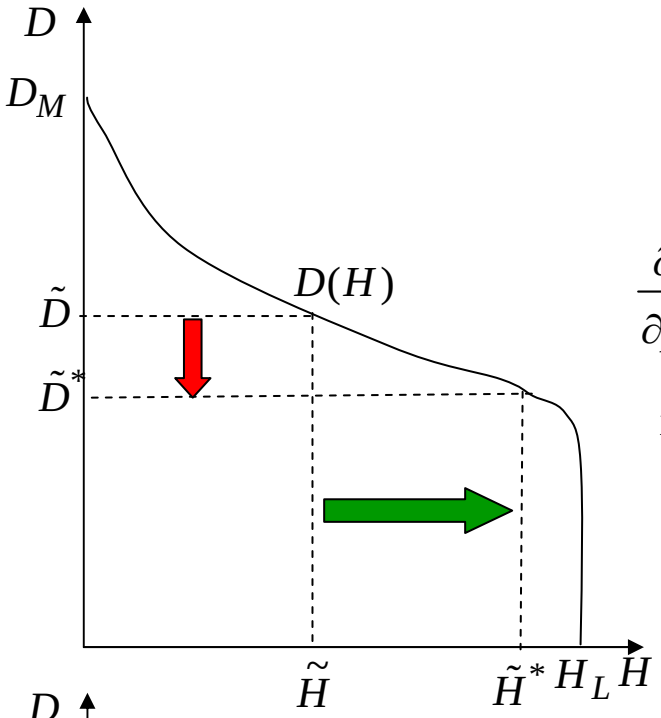
μ_a^d = leader's share of the most efficient plants

μ_a^f = fringe's share of the most efficient plants

$\hat{p} = MC_c = v_c + e_c p^{tp}$ if there is excess capacity

$\hat{p} = \overline{p}$ if there is scarcity of generation capacity

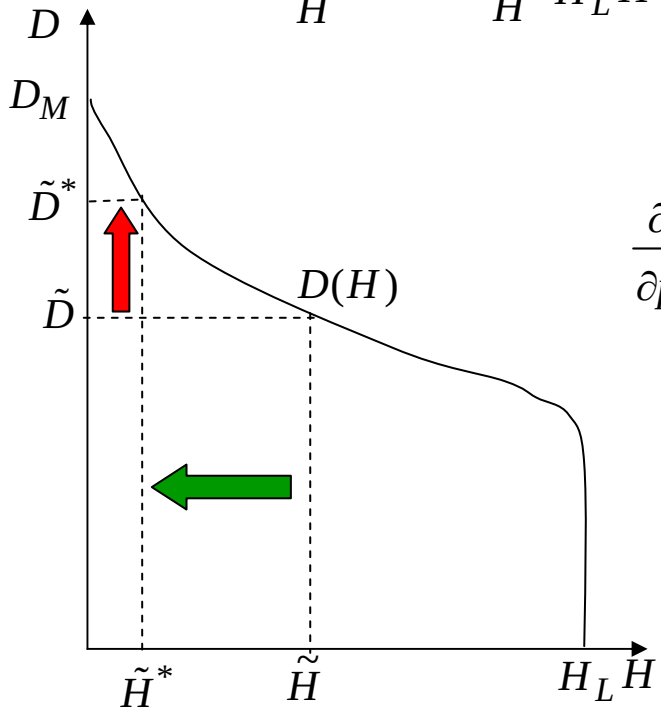
Question1 : Impact on market power



$$\frac{\partial \tilde{D}}{\partial p^{tp}} < 0, \text{ increasing market power}$$

$$\text{if } (e_b - e_a)(\hat{v} - v_a) < (\hat{e} - e_a)(v_b - v_a)$$

Surely satisfied → Under trade-off, excess capacity and low allowance prices



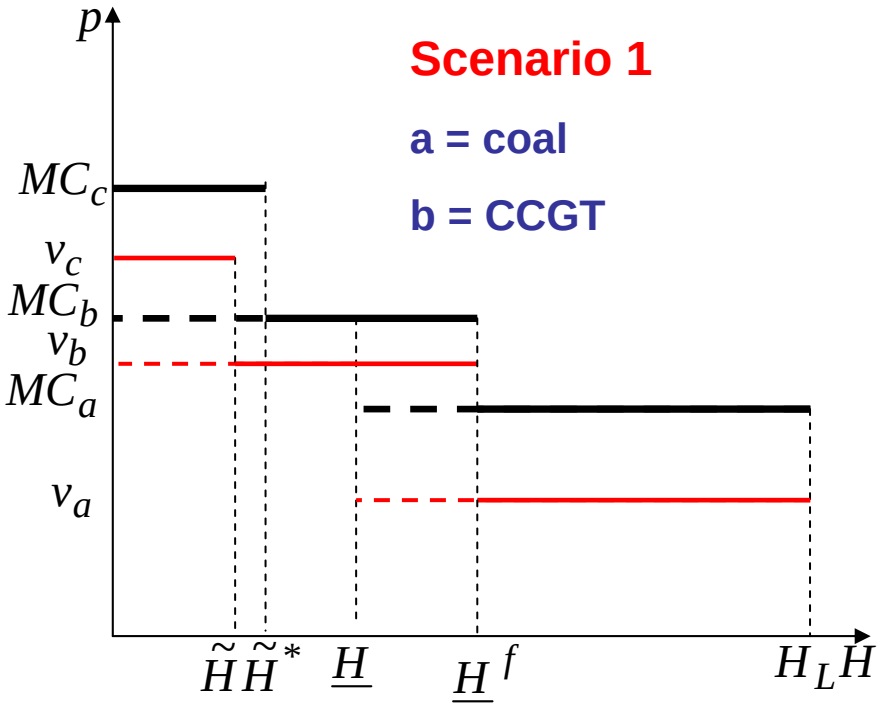
$$\frac{\partial \tilde{D}}{\partial p^{tp}} > 0, \text{ decreasing market power}$$

$$\text{if } (e_b - e_a)(\hat{v} - v_a) > (\hat{e} - e_a)(v_b - v_a)$$

Surely satisfied → Under trade-off, excess capacity and high allowance prices

Surely satisfied → No trade-.off and scacity of capacity

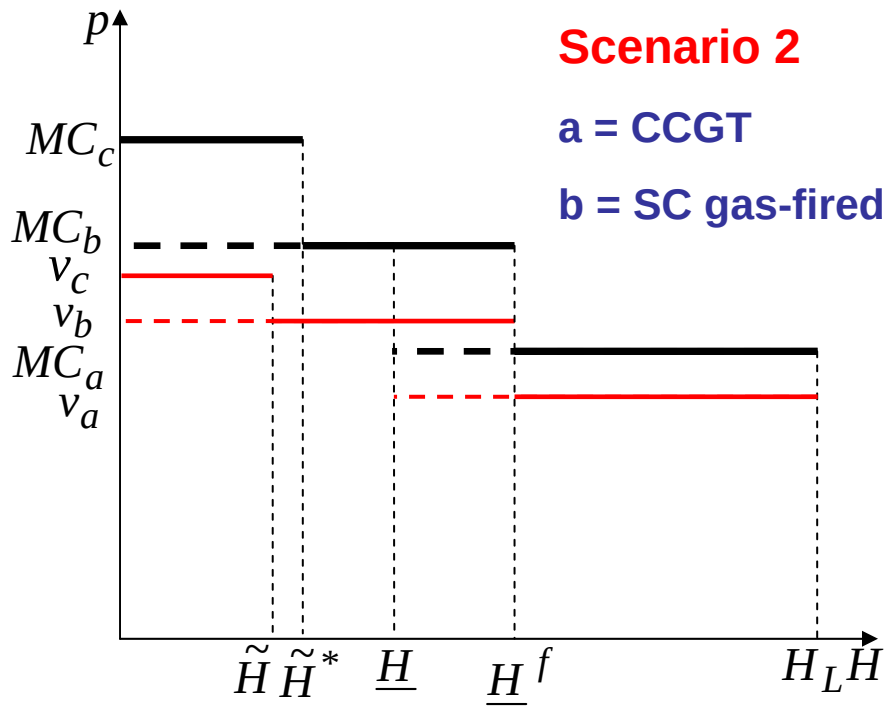
Question 2: Marginal pass-through rate: with excess capacity



Scenario 1

a = coal

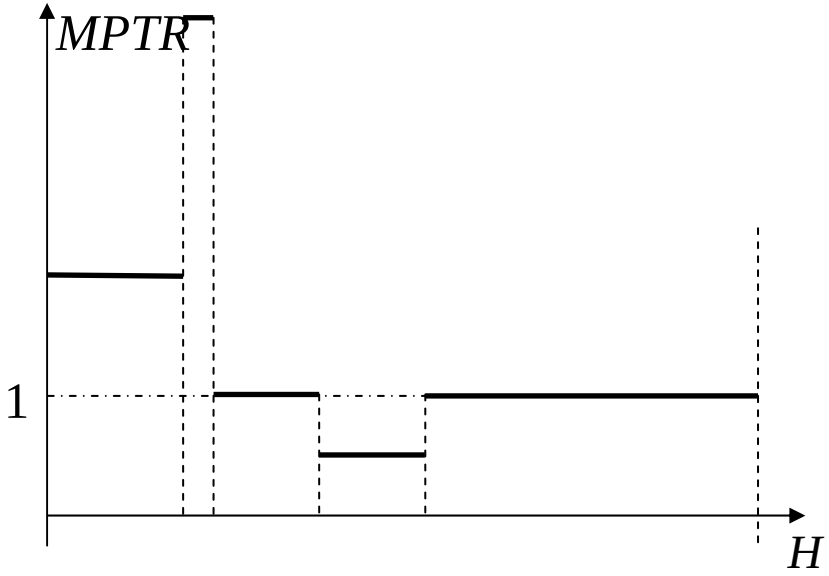
b = CCGT

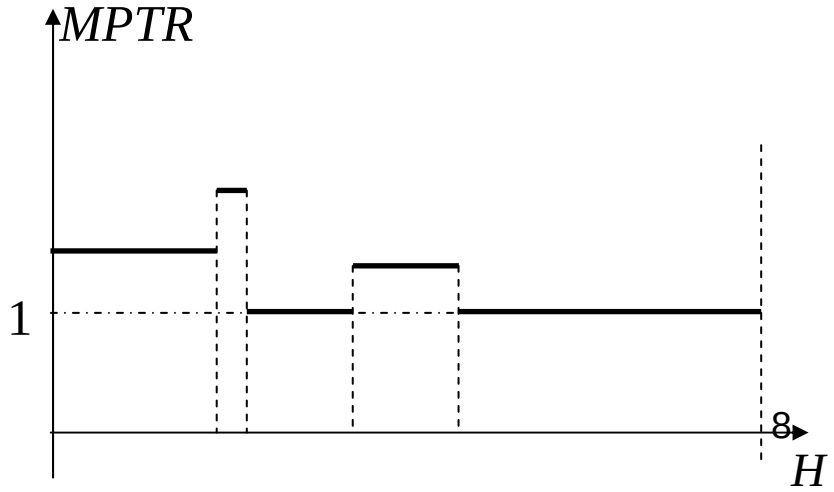


Scenario 2

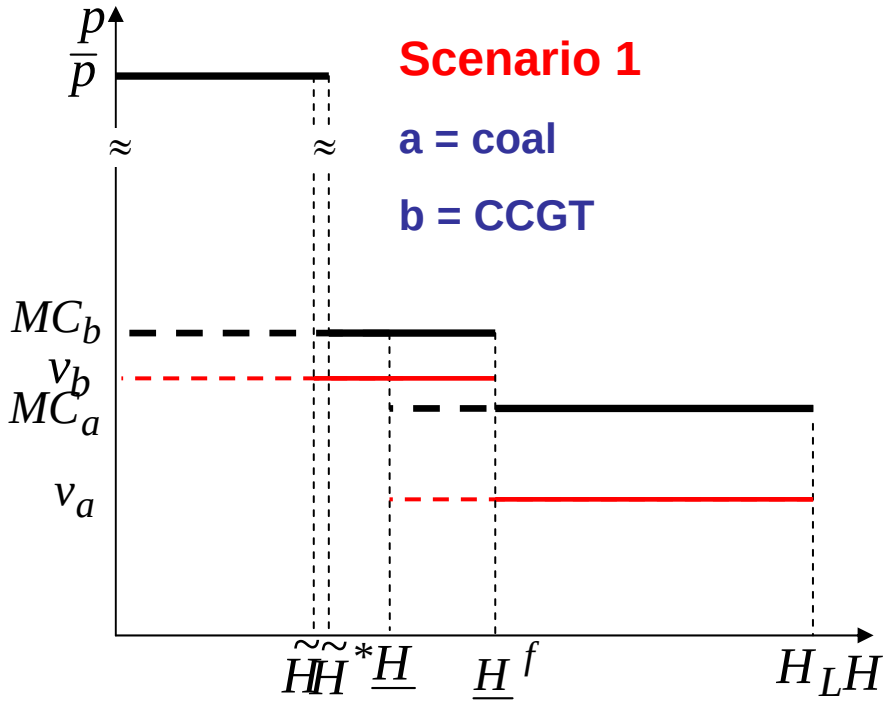
a = CCGT

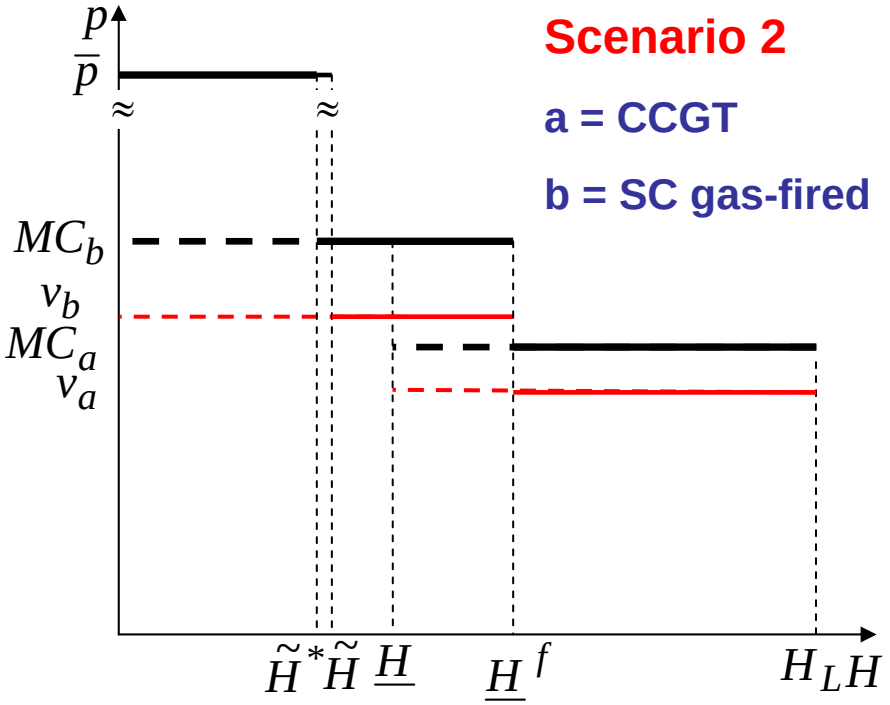
b = SC gas-fired

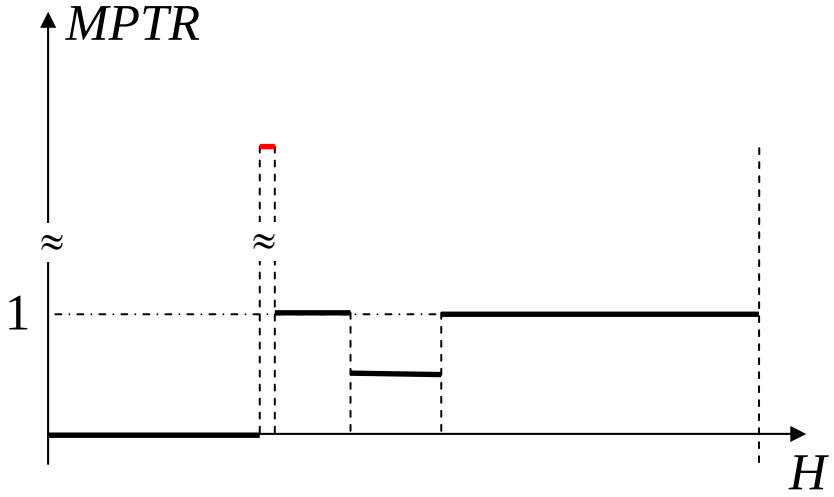


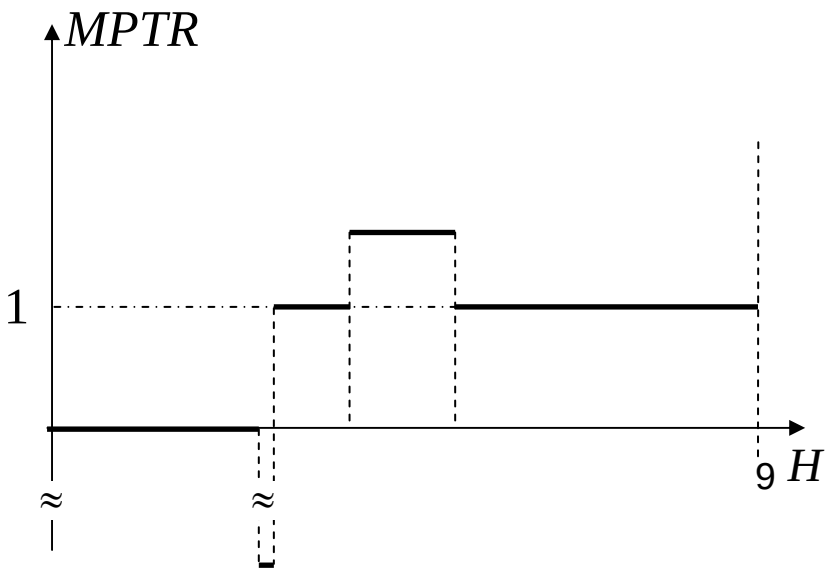


Question 2: Marginal pass-through rate: with scarcity of capacity



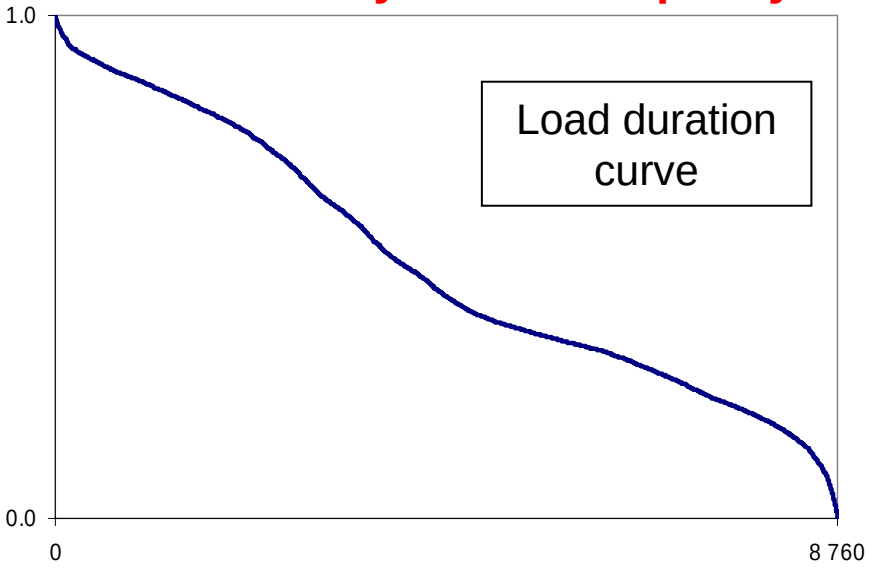


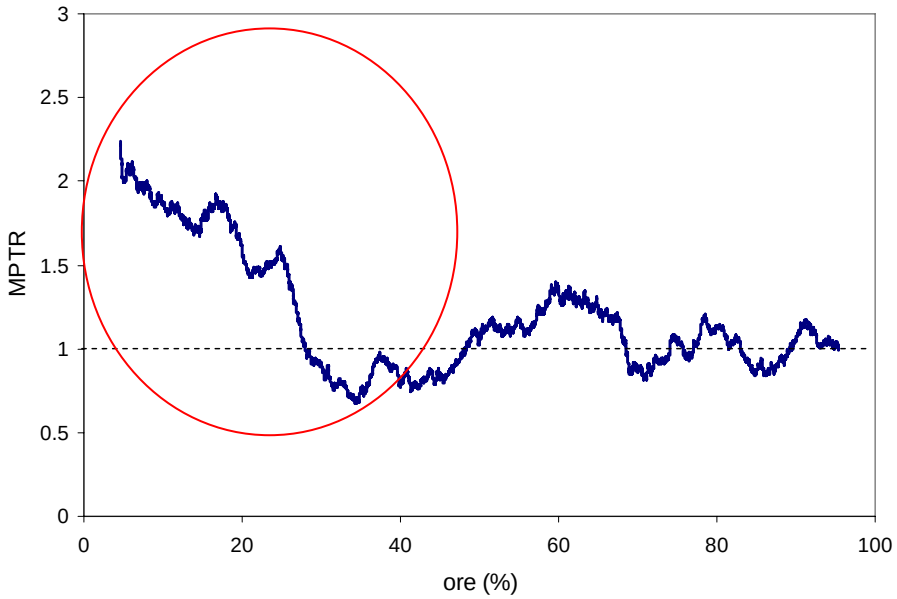




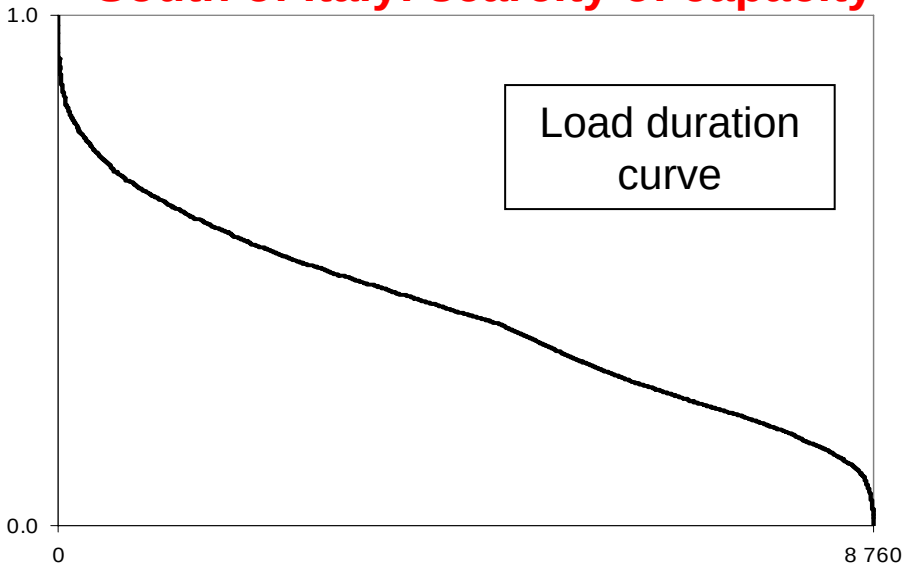
Question 2: Empirical evidence (1): the case of Italy (2006)

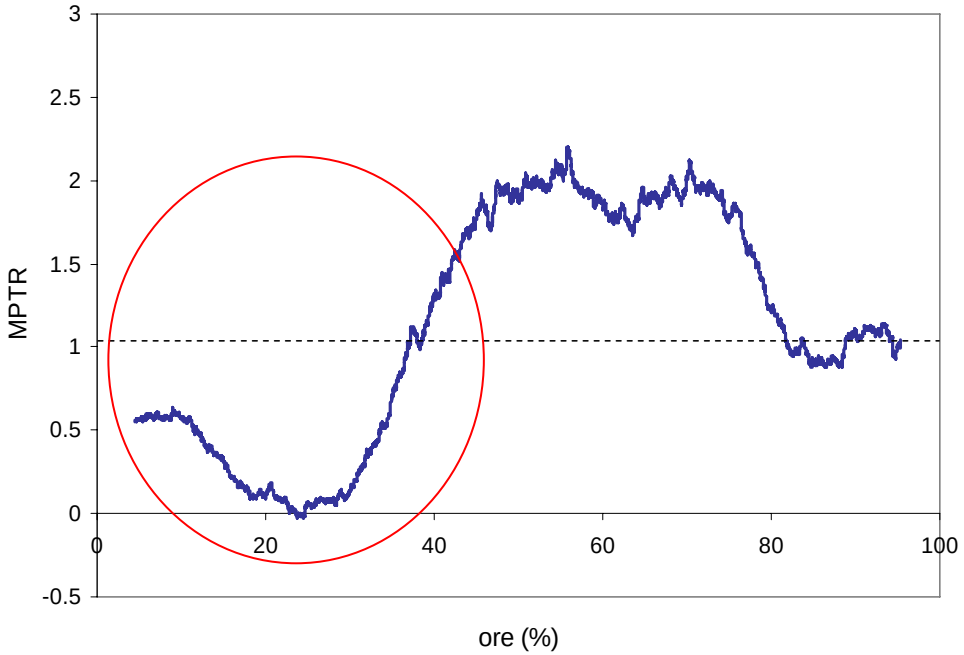
North of Italy: excess capacity





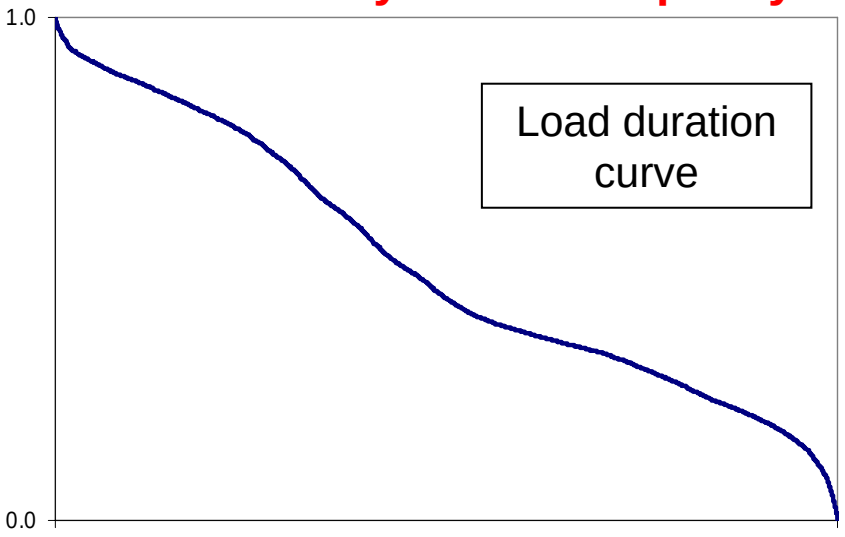
South of Italy: scarcity of capacity

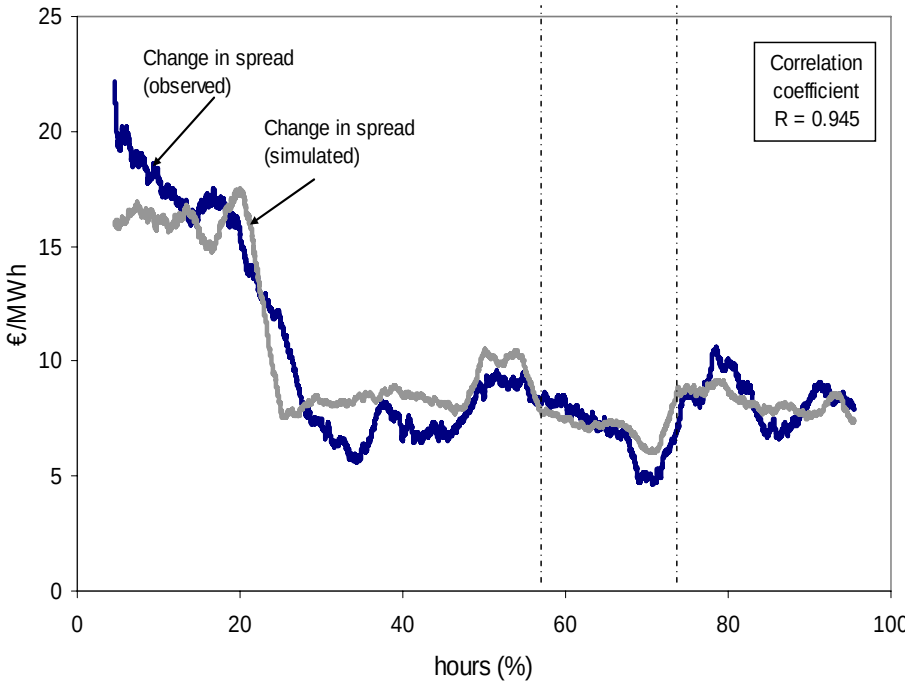




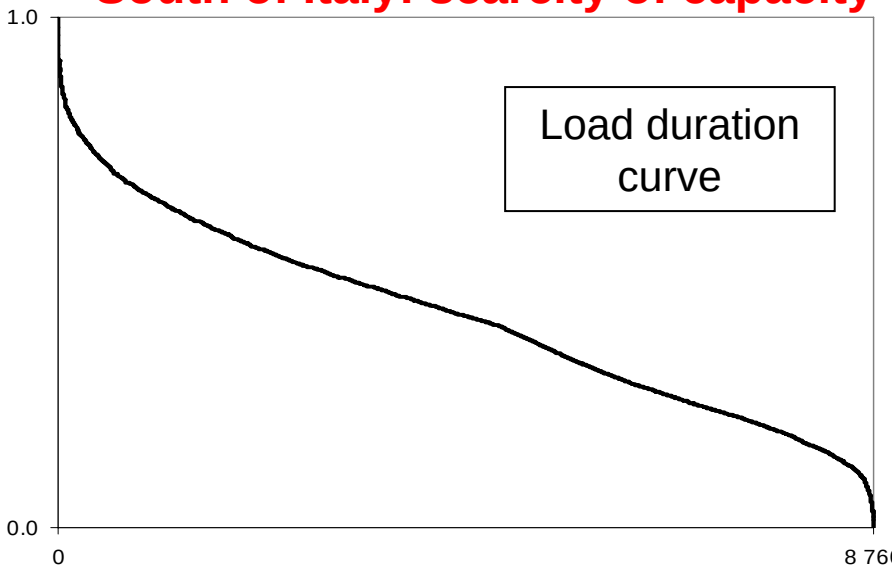
Question 2: Empirical evidence (2): the case of Italy (2006)

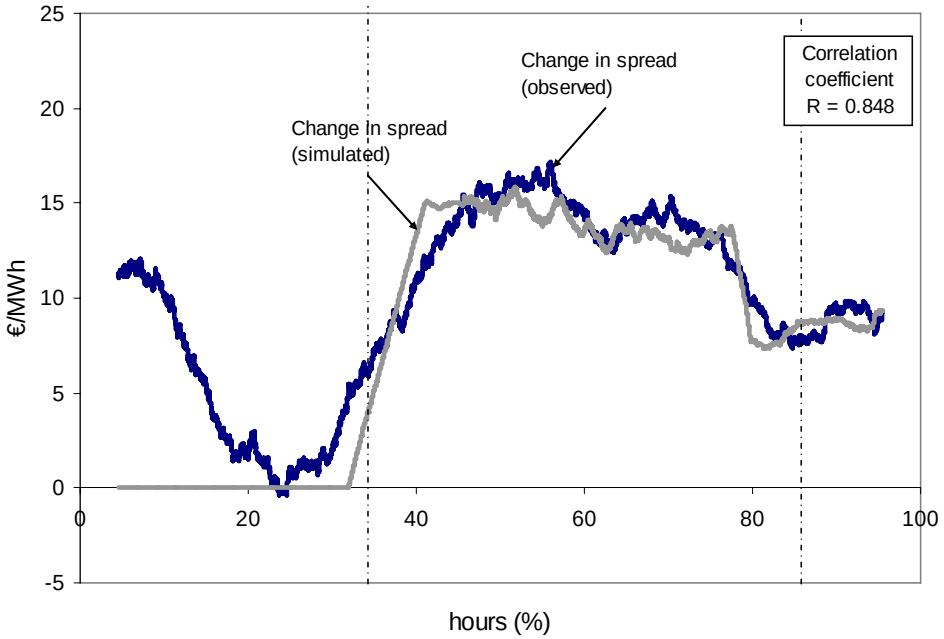
North of Italy: excess capacity



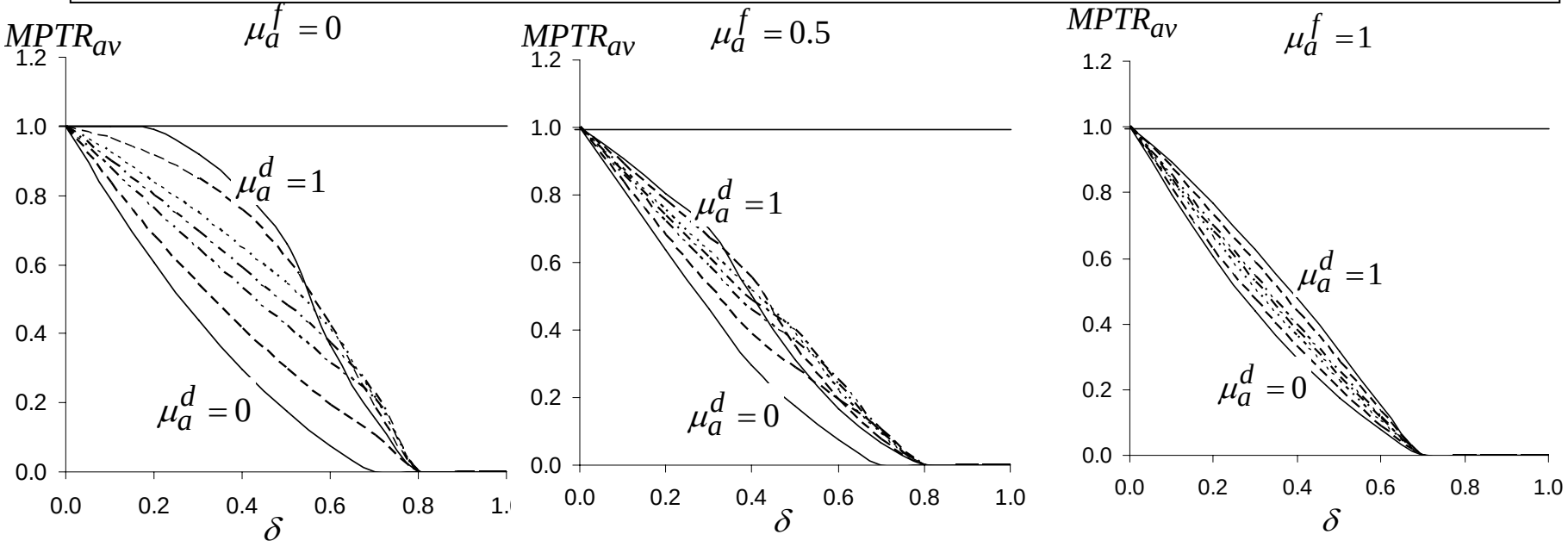


South of Italy: scarcity of capacity

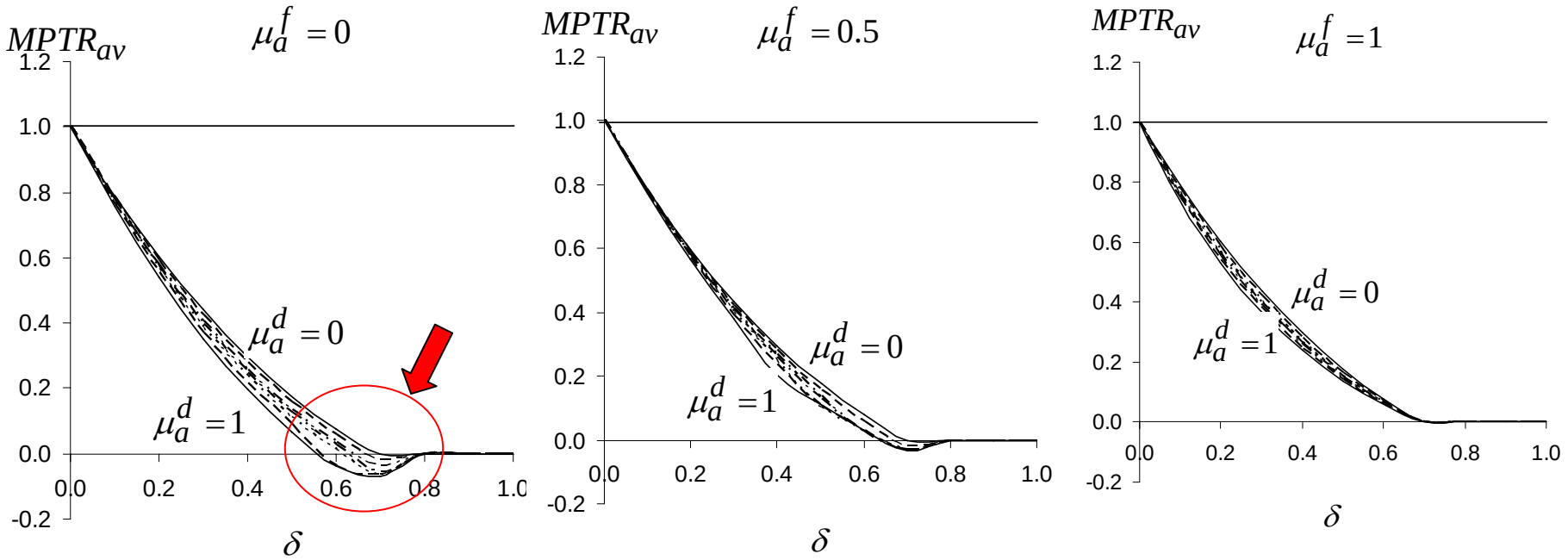




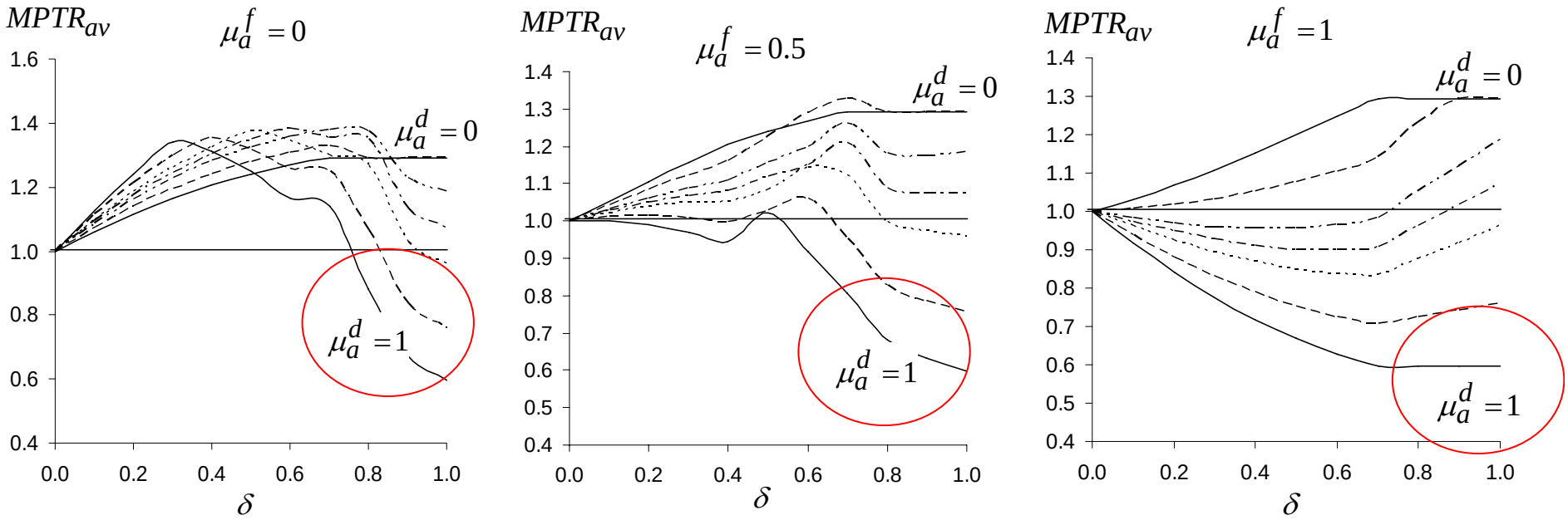
Question 2: Average marginal pass-through rate: **Scenario 1** with **scarcity** of capacity



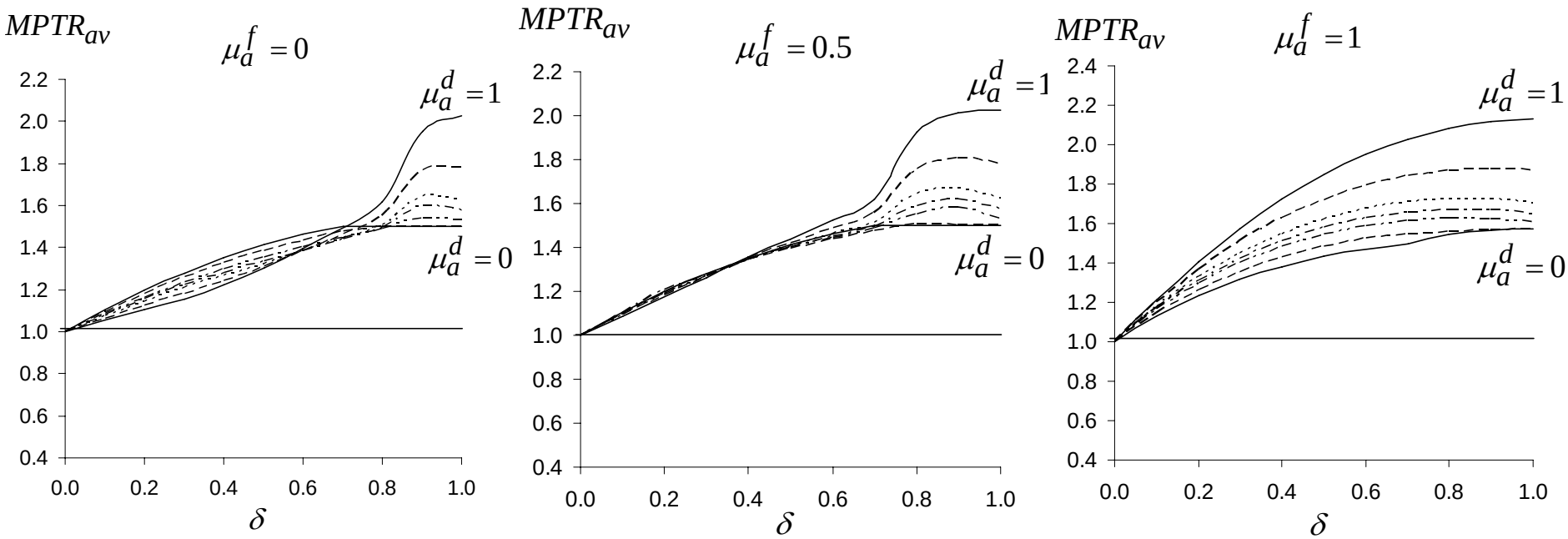
Question 2: Average marginal pass-through rate: **Scenario 2** with **scarcity** of capacity



Question 2: Average marginal pass-through rate: **Scenario 1** with **excess** capacity



Question 2: Average marginal pass-through rate: **Scenario 2** with **excess** capacity



Question 3: The impact on aggregate emissions (effects)

- **The ETS affects aggregate emissions in the short-run by means of three effect:**

  - **The effect due to the change in power prices and consequently in power demand (and production)**
  - **The effect due to the possible switch in the merit order of the generating plants**
  - **The effect due to the change in the degree of market power**

Question 3: The impact on aggregate emissions (results)

- **Proposition. Under imperfect competition, the ETS can increase pollution only under the following simultaneous conditions:**

  - **without trade-off in the plant mix**
  - **Price threshold sufficiently increases in the allowance price (case of excess capacity)**
  - **Price elasticity is sufficiently low and**
  - **The share of least polluting plants operated by the dominant firm is sufficiently high**

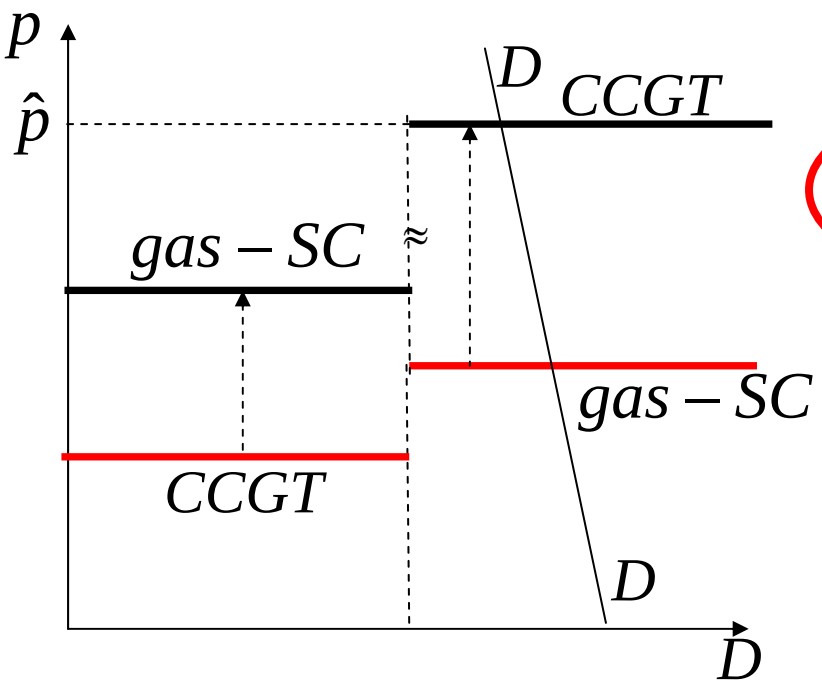
  } ⇒ **Increasing market power**

- **Otherwise the ETS always decreases emissions, but this decrease may be higher or lower than that under perfect competition depending on the combination of the demand and market power effects, i.e. again depending on the structural factors of power markets**

Question 3: The effect due to the change in market power: no trade-off

$$\Delta E^* > 0$$

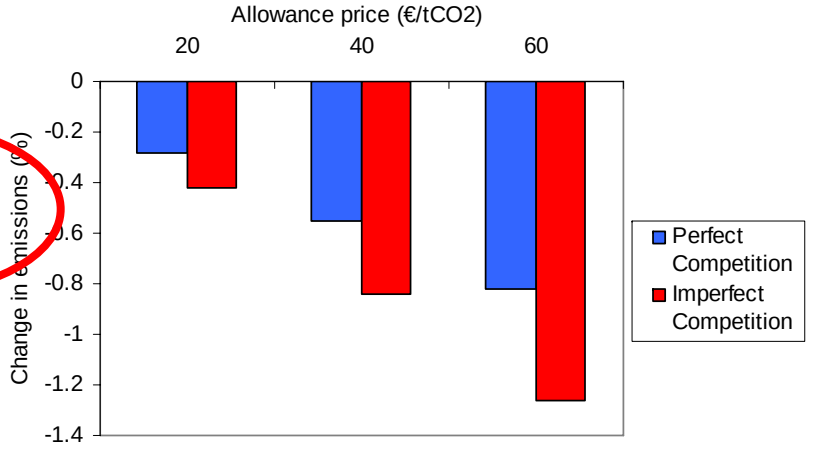
$$e_b > e_a; \Delta \hat{D} < 0$$



$$\delta = 0.7; \beta = 0.5$$

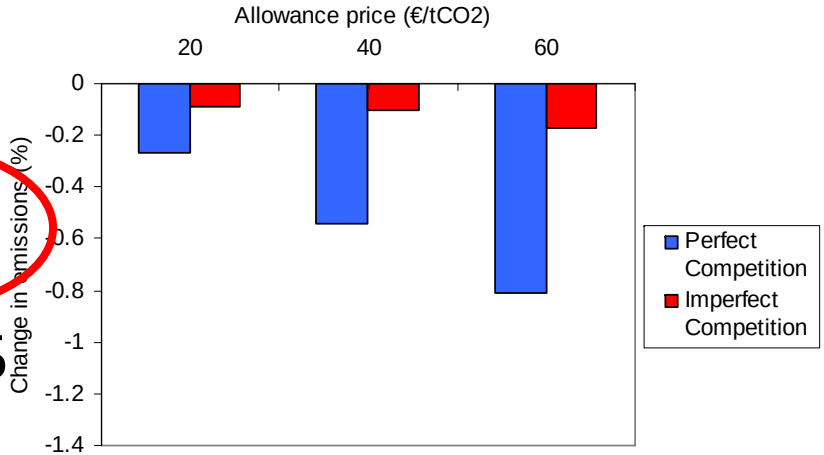
$$\mu_a^d = 0$$

$$\mu_a^f = 1$$



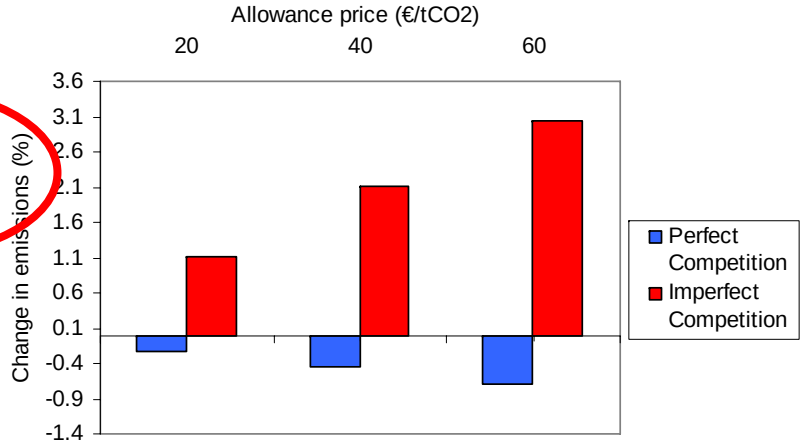
$$\mu_a^d = 0.5$$

$$\mu_a^f = 0.5$$



$$\mu_a^d = 1$$

$$\mu_a^f = 0$$



Conclusions

- **With regard to the impact on market power and the impact on power pricing the results are ambiguous. Depending on several structural factors**
  - **the ETS can either increase or decrease market power**
  - **the pass-through can be either more or less than 1**
- **The message:**
  - **Market power would determine a significant deviation from the "full pass-through" rule but we can not know the sign of this deviation, a priori, i.e. without before taking carefully into account the structural features of the power market.**
- **With regard to the impact on emissions**

- **Imperfect competition may lessen the emissions reduction compared to perfect competition**
- **If certain conditions are satisfied, under imperfect competition the ETS might increase pollution (in the short run)**
- **Thus under certain conditions imperfect competition make it more difficult to achieve the environmental targets**