THE PASS-THROUGH OF CO2 COSTS TO ELECTRICITY PRICES:

economic theory and empirical analysis

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Why is the impact of EU ETS on electricity pricing so relevant?

- The performance of the trading scheme largely depends on the effectiveness in inducing the power industry to reduce CO2 emissions significantly both in the short and long runs
- On the other hand, it would imply higher power prices for all consumers, including households and energy-intensive industries; if the latter are hardly able to pass through the higher costs into their outlet prices, they could face less profits, less production and less employment and a possible shift in investment and production opportunities outside the EU ETS (so called “carbon leakage”)
- Hence researchers, operators and regulators are so interested in the interaction between carbon and power prices

Economic literature review

- Current literature is quite controversial from both the **theoretical** and the **empirical** points of view
- As for the **theoretical side,** there is an open issue on how the CO2 cost pass-through is correlated with different market structures. In particular, while there is a general consensus with reference to pure competitive frameworks, opinions diverge under imperfect competition. The fact is that each study is based on specific hypotheses on the strategic behaviour of firms, the technological mix and the regulation of both power and allowances markets
- The **empirical side** provides controversial results as well, which are partly due to the use of different methodological approaches

Results cannot be generalized

Method of allocation of allowances

- The options for the allocation of emission allowances in a trading scheme are:
  1. **Grandfathering (*)** – in which allowances are provided for free to each installation on the basis of either historical or expected future requirements
  2. **Benchmarking** – in which allowances are provided for free to the installation on the basis of specific benchmarks
  3. **Auctioning** – in which allowances are provided to the installation on the basis of prices that the installation is willing to pay in an auction

(*) The term originally referred only to the free allocation of a fixed amount of allowances to installations based on historic emissions but is now often used in a much wider meaning, referring to all kinds of free allocation, including benchmarking.

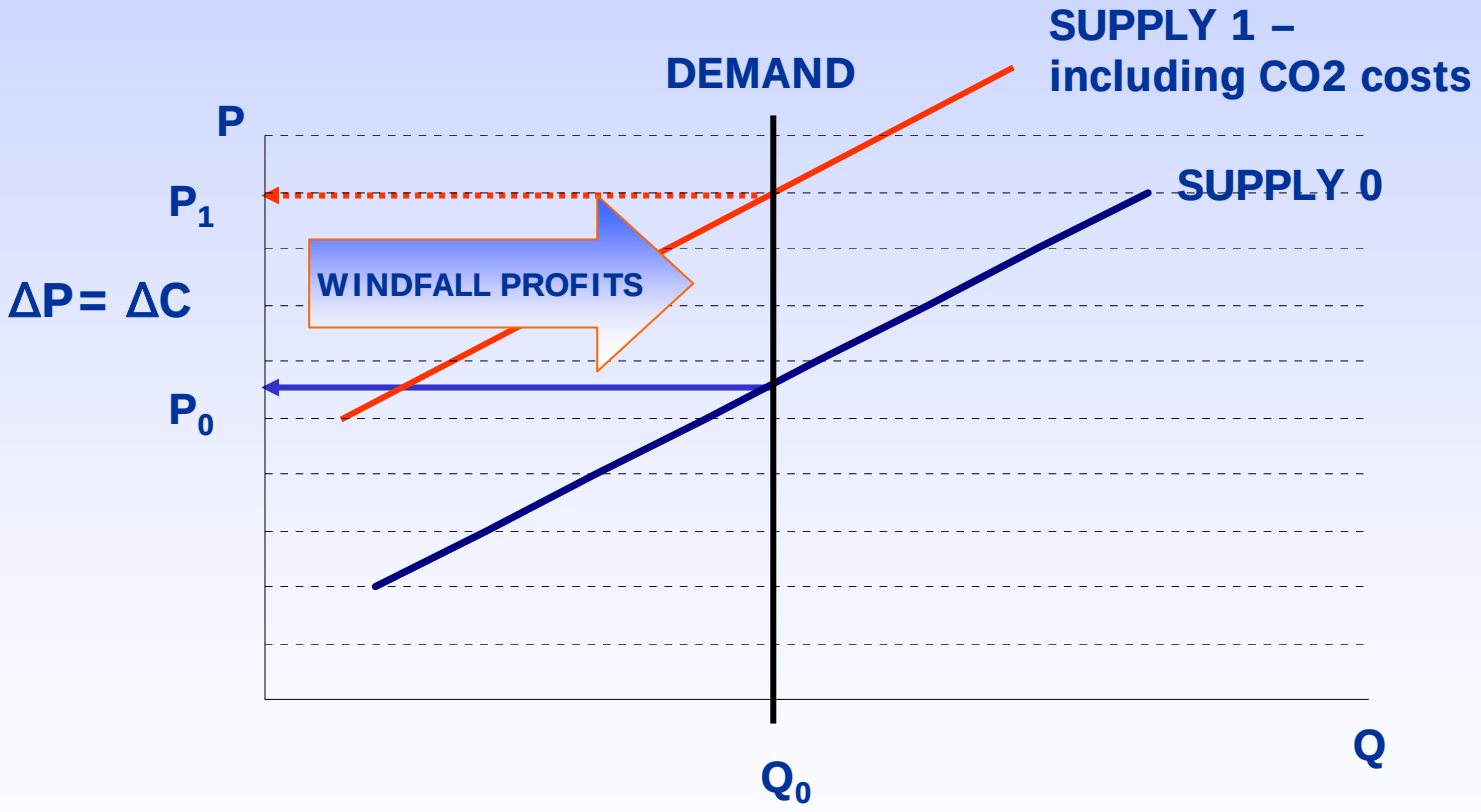
Economic theory - 1

- Since under the current EU ETS free allocation is the general rule, each generator has 3 main options:
  1. To invest into low-carbon technologies and sell the unused CO2 allowances (in the short run this means switching from coal-fired plants to CCGT plants)
  2. To generate less and sell the unused CO2 allowances
  3. To generate more and buy the necessary CO2 allowances

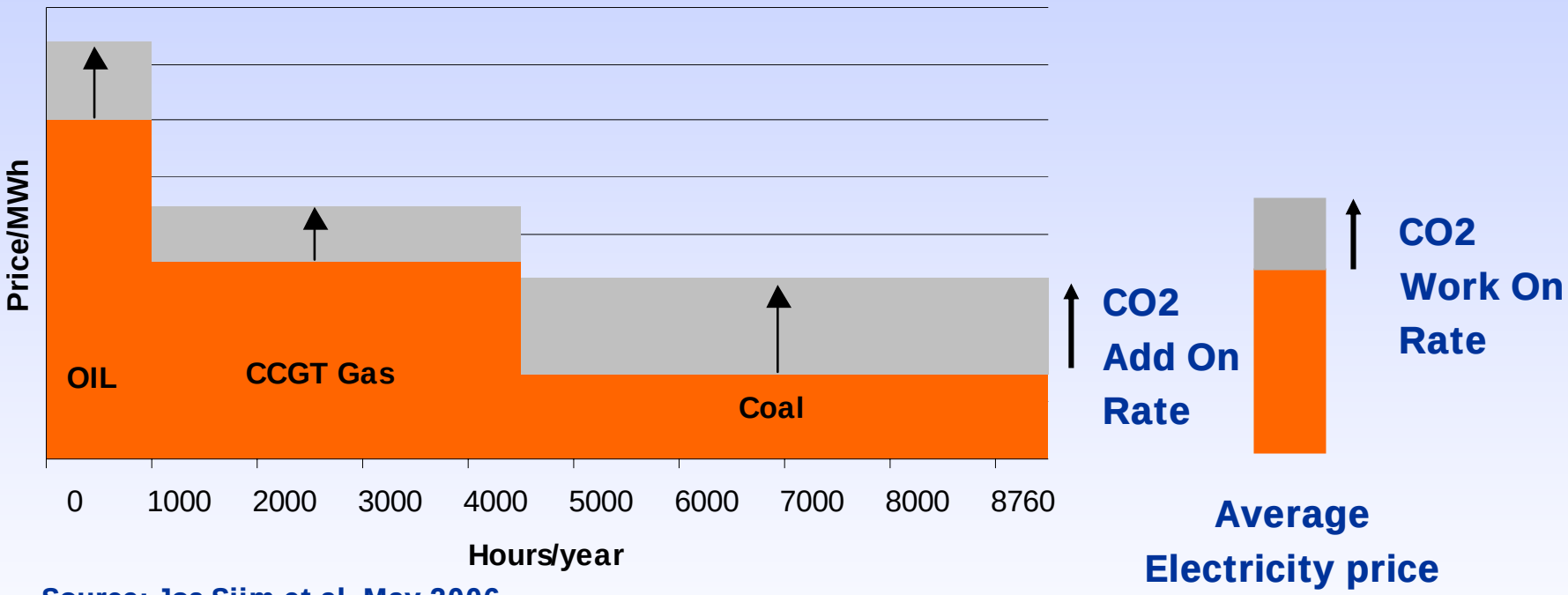
- The CO2 price becomes an **opportunity cost** for the generator that it must take into account in deciding to generate
- It will only generate electricity therefore if the revenue from selling electricity exceeds the revenue that it could earn from selling its fuel and CO2 permits in the respective spot markets, **regardless whether the allowances are allocated for free or purchased at an auction market**

Economic theory - 2

PERFECT COMPETITION AND FREE ALLOCATION



Economic theory - 3



Source: Jos Sijm et al, May 2006

- The increase of the bid of the marginal unit ("add-on") will then determine how much of the CO2 prices are "worked-on" the electricity price
- The work-on rate may be lower than the add-on rate for a number of reasons

Economic theory - 3 a

- The level of passing through carbon costs with free allocation will depend on:

• Market structure	**The greater the degree of market concentration, the *smaller/higher* the proportion of CO2 costs will be passed on ???**
• Outside competition	**Fossil fuel plants could not be able to pass through their carbon costs in case of competition from non-fossil installations**
• A change in the merit order	**The add-on rate for marginal production technology can be 100% but the work-on rate will be lower**
• Carbon-saving innovations	**Induced in the long run by changes in the costs of emission trading**
• Demand response	**If the power demand is elastic the change in power price is smaller than the change in marginal costs due to emission trading**

Economic theory - 3 b

- The level of passing through carbon costs with free allocation will depend on:

• Price regulation	**Reduction of production and of the work-on rate because of reduction of other marginal production costs but no restriction of the add-on rate and hence of windfall profits**
• Decline of mark-ups	**Newcomers may be encouraged to invest in new production capacity and to enter the market resulting in more competition in the long run**
• Free allocation as a subsidy of fixed costs	**Subsidisation could reduce the average fixed costs of power production if both incumbents and newcomers receive their allowances for free, thus partially offsetting power price increases due to pass-through of carbon costs**
• Market imperfections time lags, etc.	**Because of uncertainties, lack of information, other objectives besides profit maximization CO2 costs may not always be fully or immediately passed on to power prices**

Economic theory – the impact of market structure - 1

- Studies aimed at examining the CO2 pass-through under imperfect competition:
  - Sijm et al. (2005) – based on a game theoretical simulation model => finds that the electricity price in a competitive scenario increases more than under market power
  - Reinaud (2003); Newbery (2005) – state that electricity prices are likely to increase more under market power
  - Gullì et al. (2007) – shows that under imperfect competition (dominant firm-competitive fringe model) the extent to which the carbon cost is passed through into power prices depends on:
    - The degree of market concentration
    - The technology mix
    - The available capacity
    - The allowances prices

Economic theory – the impact of market structure - 2

- Gullì et al. (2007) main model results:

Marginal pass-through under market power	CO2 Price vs switching price	Capacity	Market concentration	Plants mix
A1) Base less than 100% and in peak lower than in offpeak	n.r.	No excess	Low	n.r.
A2) Nil	n.r.	No excess	Medium-high	n.r.
B1) Base more than 100% and in peak higher than in offpeak	Low	Excess	n.r.	Low share of most polluting plants
B2) Base = 100% and in peak higher than in offpeak	Low	Excess	n.r.	Medium share of most polluting plants
B3) Base less than 100%	Low	Excess	High	High share of most polluting plants

More complex patterns with excess capacity and high allowances prices

Empirical analyses - 1

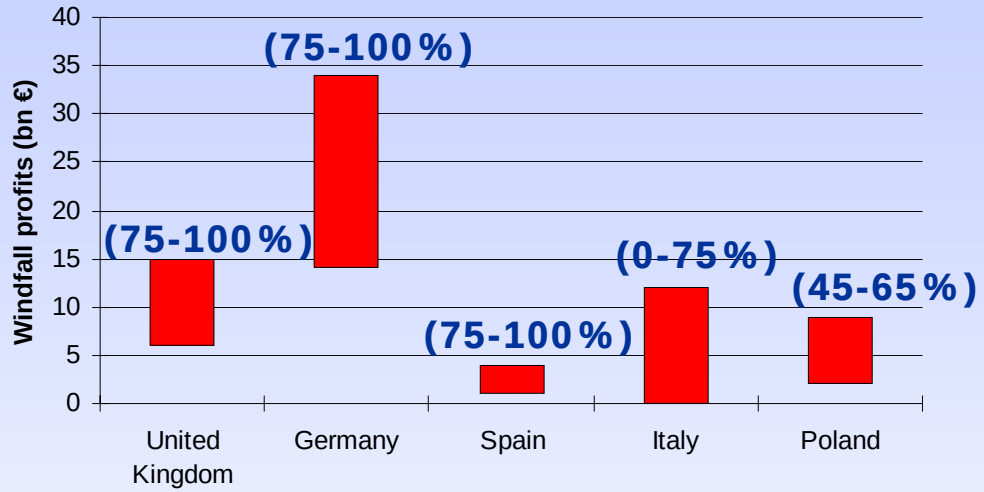
- Main methodological approaches:
  - Econometric studies of time series of either forward or spot prices (for both power and carbon): they estimate the impact of ETS on the average electricity prices eventually distinguishing between peak and offpeak hours; main drivers used are fuel costs and temperature; generally these models don't consider the marginal technology hour by hour, but a standard technology (with fixed generic fuel efficiency) which is supposed to set the price in the observation period
  - Load duration curve approach based on examining the change on the price and/or spread duration curve (by ordering power prices, fuel costs and CO2 costs by decreasing level of demand) – Actual observations can be eventually compared to the predicted results of an analytical model

Empirical analyses - 2

Country *(Study)*	Methodology	Power Price	Period	Pass-through rate % Peak	Pass-through rate % Offpeak
Germany *(Sijm et al.)*	Econometric OLS	Forward	Jan-Jul 2005	69-72	42
Netherlands *(Sijm et al.)*	Econometric OLS	Forward	Jan-Jul 2005	40-44	47-53
Finnland *(Honkatukia)*	Econometric VECM ARIMA Model AR-GARCH	Spot	2005-2006	43-47	102-111
Italy – North Italy – South Italy – Whole *(Gullì et al.)*	Load Duration Curve	Spot	2006	150 – 210 0 - 50 110 - 150	90 – 110 90 – 110 90 – 110
UK *(Bunn-Fuzzi)*	Econometric VAR	Spot	2005-2006	42	
Scandinavia *(Fell)*	Econometric VECM	Spot	2005-2008	71-103	83-141

OLS = Ordinary Least Squares; VECM = Vector Error-Correction; ARIMA = Autoregressive Integrated Moving Average; GARCH = Generalized Autoregressive; VAR = Vector Autoregressive

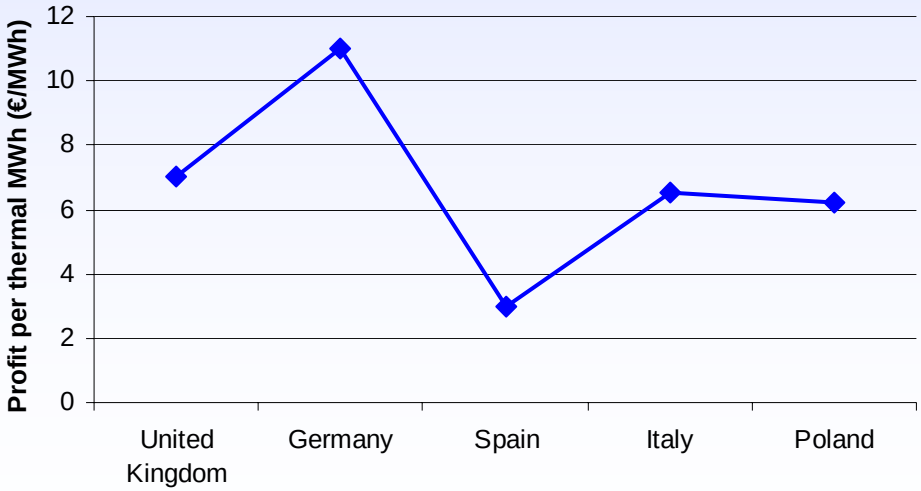
Empirical analysis – windfall profits in Trading Phase 2



Range of expected windfall profits over 2008-12 (bn €)

(assumed pass-through rates)

WINDFALL PROFITS IF REVENUES FROM THE PASS-THROUGH OF CO_2 OPPORTUNITY COSTS > INCURRED COMPLIANCE COSTS



Windfall profit per thermal MWh generation over 2008-12 (€/MWh)

Source: PointCarbon, March 2008

Looking ahead to Phase 3: auctioning

- Main advantages of auctioning versus free allocation:
  - More efficient distribution of allowances
  - Both incumbents and new entrants are treated in the same equal and fair way
  - No windfall profits or wealth transfer from consumers to producers
  - Best reflection of the polluter-pays principle and, hence, best incentive for technological innovations and cost-effective adjustments in existing production and consumption patterns
  - Auction revenues to be recycled

- Main disadvantages of auctioning versus free allocation:
  - It raises the costs of participating industries to the trading scheme => competitiveness problems
  - It is not easy to decide how the auction revenues can be recycled in the most optimal way
  - The auction revenues distribution may partly cancel out the main advantage of full auctioning with regard to efficiency

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