Nuclear Market Power: Taxation or Liberalization?

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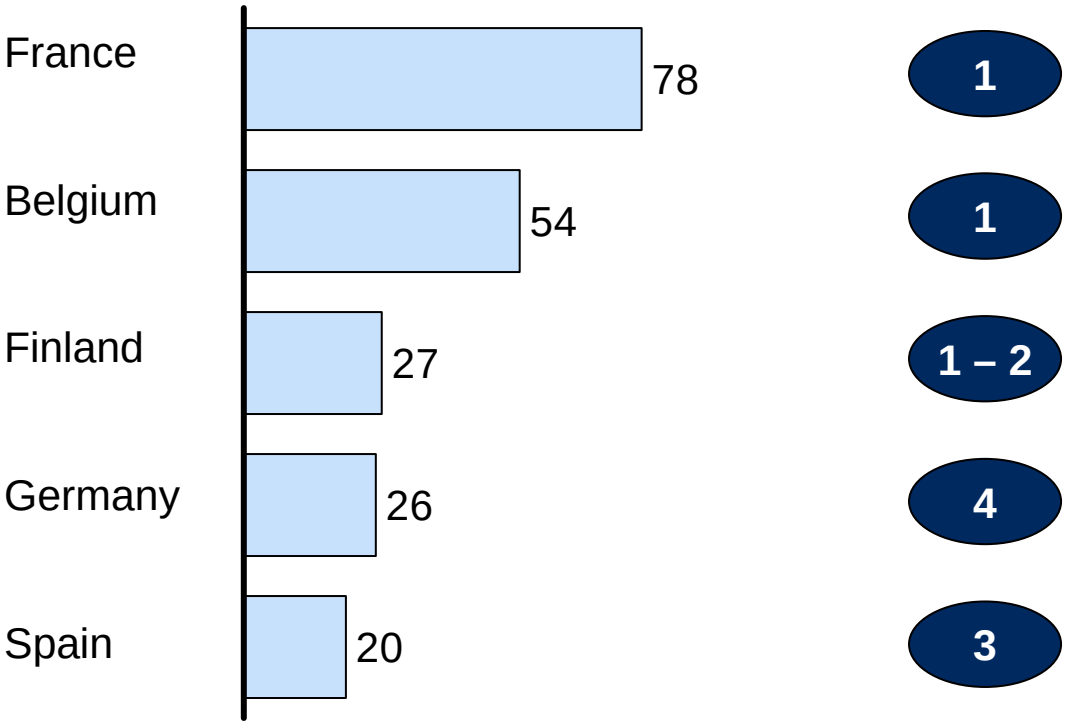
* The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the Chicago Booth School of Business or the European Commission, respectively

In several European countries, nuclear has a significant share in the energy mix, often in the hands of few companies

Share of nuclear power in electricity production mix
Percent

Number of distinct decision centers in plant ownership



- **Nuclear may represent a large share of the power market in the hands of few companies**
- **The situation may provide market power – and hence potential rents – to nuclear companies**

Our paper investigates how national governments can tackle the market power

Source: Eurostat, IAEA

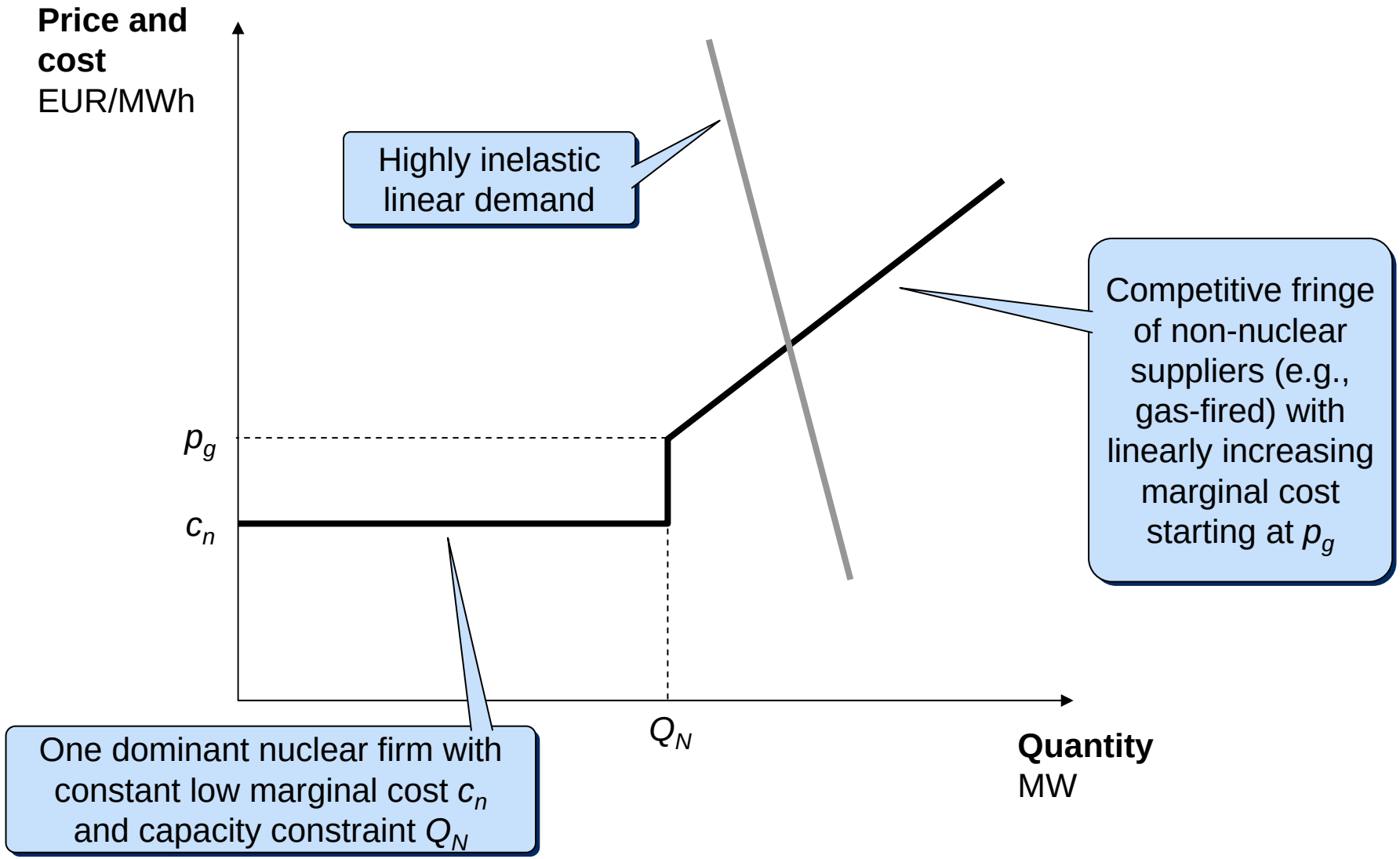
Agenda

- **Introduction to the model**
- Analysis of policy measures
- Numerical results and conclusions

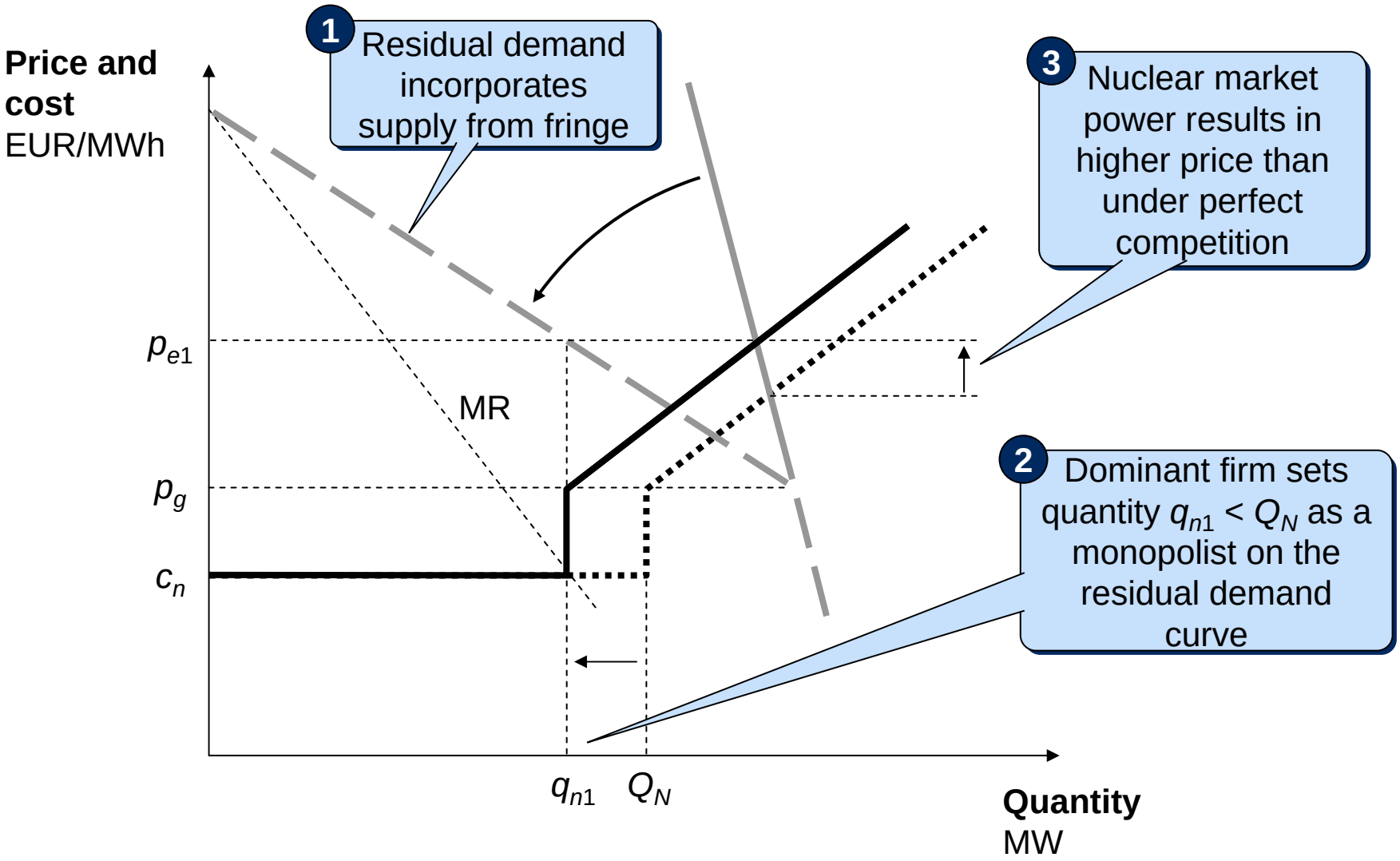
The paper considers one nuclear firm and a competitive fringe, under highly inelastic demand

Industry marginal cost curve and demand curve

COST CURVE ON THIS SLIDE DRAWN UNDER ASSUMPTION OF PERFECT COMPETITION



We assume a 'dominant firm – competitive fringe' equilibrium, in which the dominant firm maximizes profits along the residual demand curve*



* The model may have a second equilibrium, in which the nuclear firm pushes the fringe completely out of the market. Since fossil-fuel power plants are anyhow needed for peak supply, we do not consider this alternative equilibrium

Three policy options for national governments are investigated

A **Proportional* taxes on nuclear production**

B **Liberalization through asset divestiture**

C **Liberalization through increased cross-border transmission capacity**

* Lump sum taxes (which, theoretically, would not cause market disturbances) are excluded from the analysis because they are difficult to justify legally

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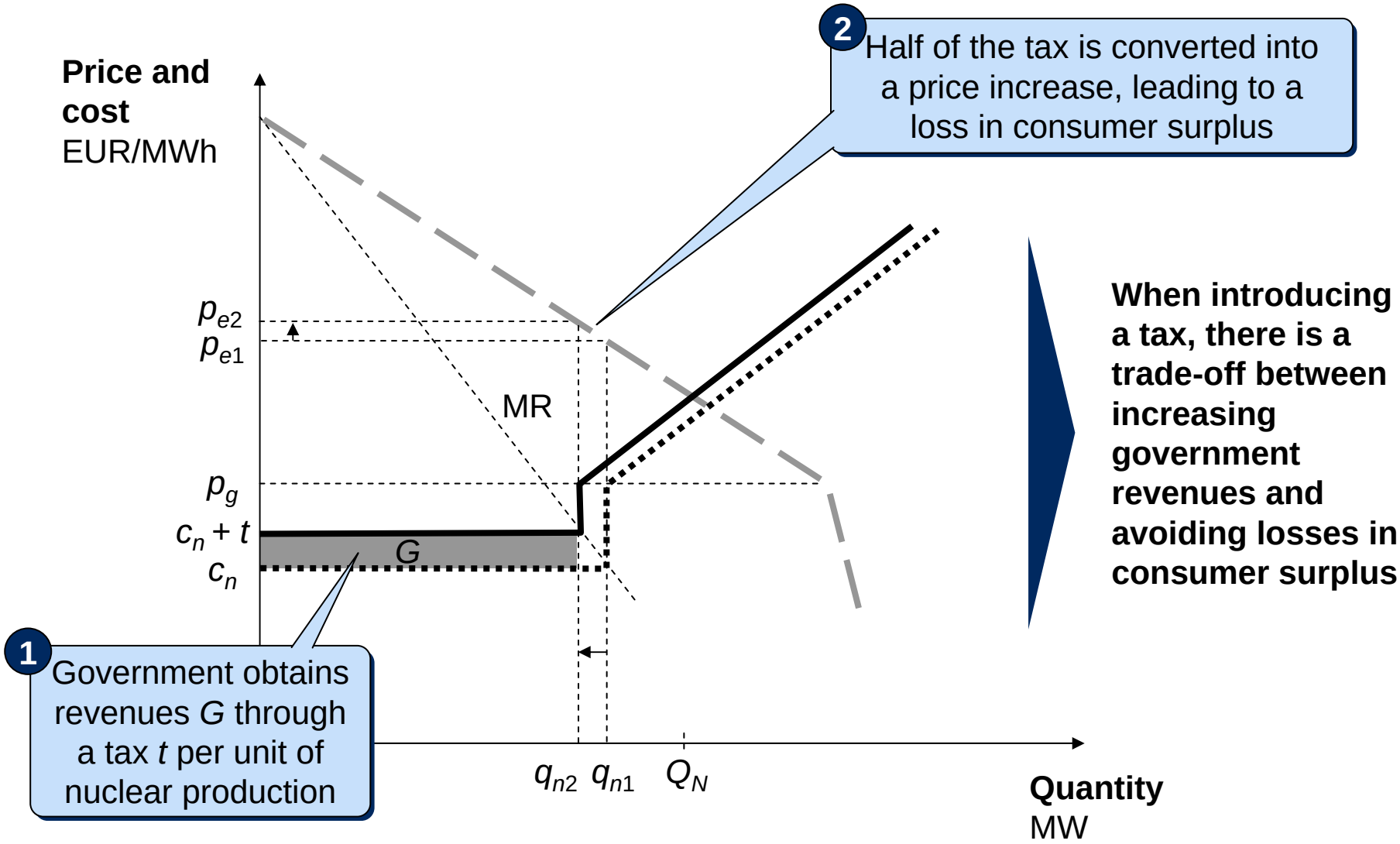
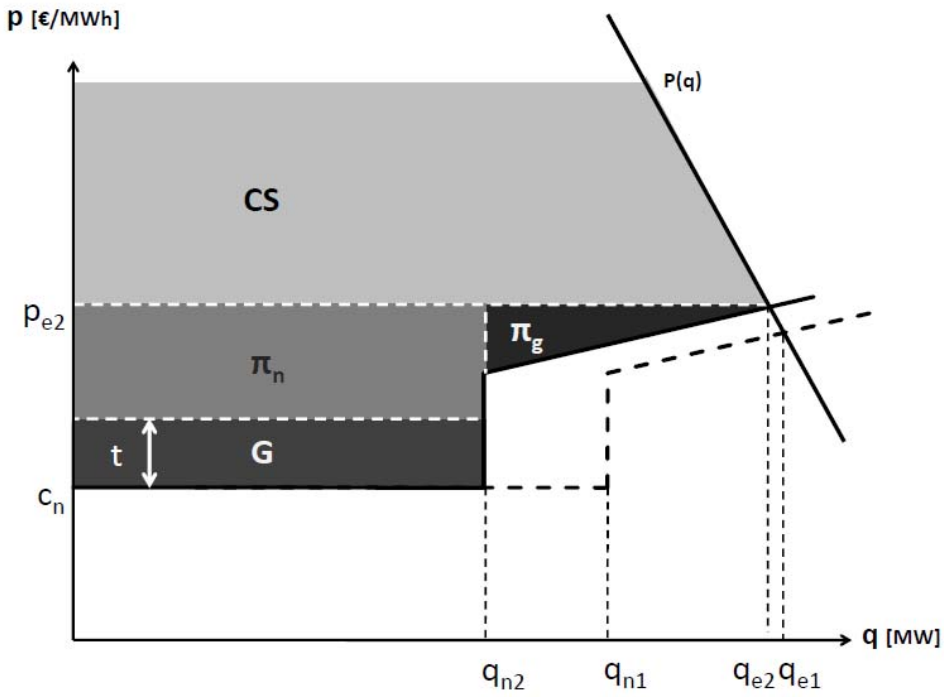
A Proportional taxes on nuclear production capture part of the nuclear rents, but reduce consumer surplus



A Taking into account that some citizens are nuclear shareholders, the government can set an optimal short-run nuclear tax rate



Assumption of government objective function

National welfare = $G + CS + s_l \pi_n$

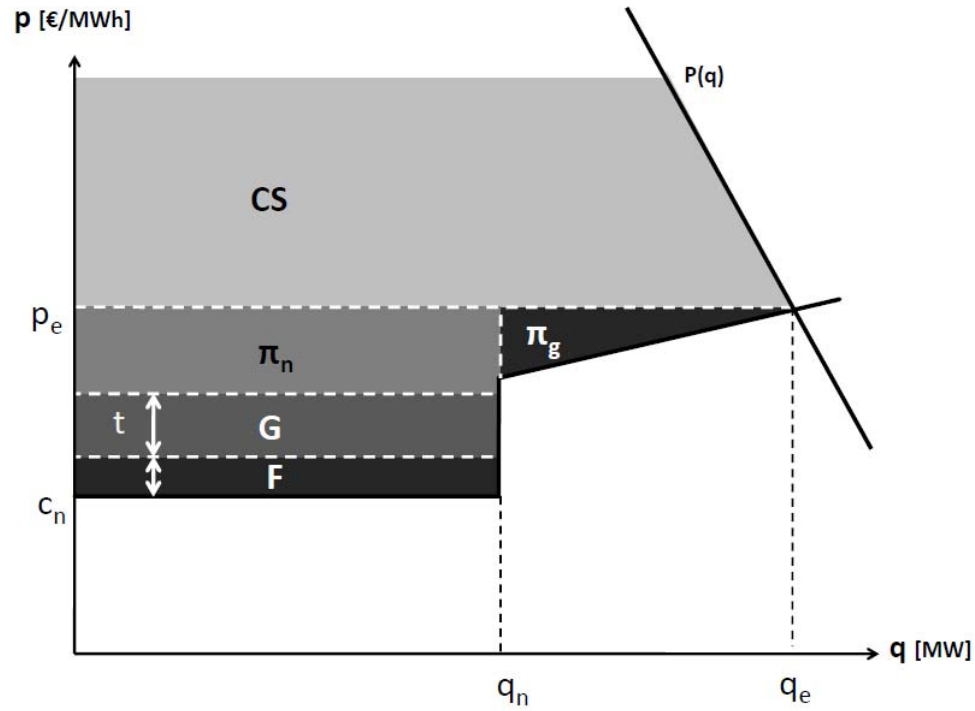
Share of nuclear firm in the hands of the country's citizens

- **Optimal tax under completely inelastic demand*:** $\frac{(1-s_l)(p_g - c_n) - s_l bc}{2 - s_l}$
- **If no citizens are shareholders, then the optimal tax is halfway between the marginal cost of nuclear and the cheapest competitive fringe supplier**

* *b* is the inelastic demand level. *c* is the slope of the marginal cost curve of the competitive fringe

A The long-run problem is different, because capacity investments need to be included

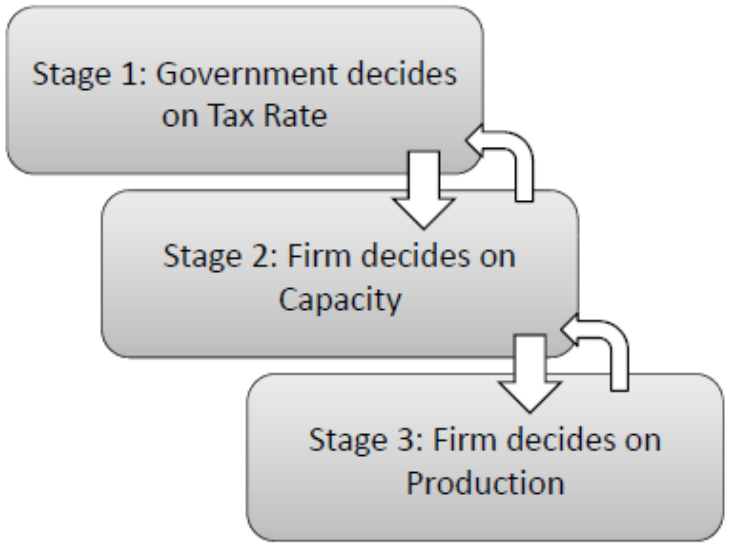
- In the **long run**, the nuclear firm needs to decide on its **capacity level** Q_N (capacity investment becomes endogenous)
- Therefore, in the long run, the nuclear firm considers not only the marginal cost c_n , but **also the fixed investment cost** (*F*)
- As a result, the firm's long-run response to a tax rate *t* is different (less favorable) than its short-run response: in the long run, **taxes decrease investment incentives**
- Note that the **long-run capacity decision** Q_N turns out to be **always a binding constraint** for subsequent short-run production decisions



A The paper considers two tax scenarios: with and without credible government commitment

A1 The government can credibly commit to a tax rate

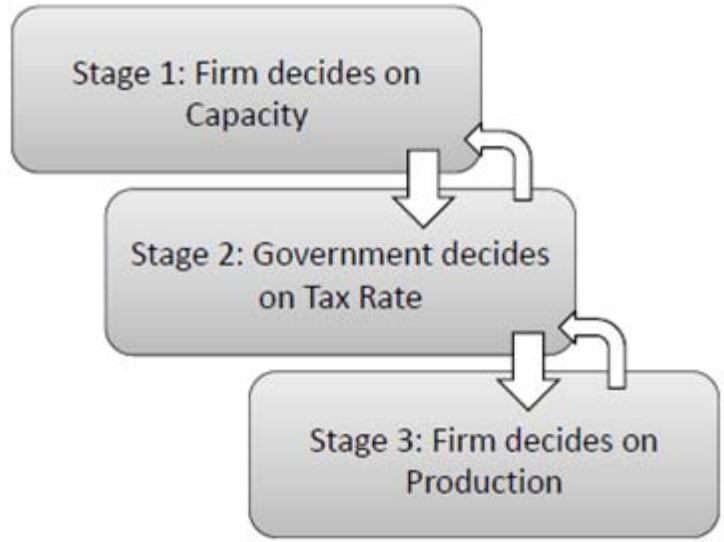
Game structure



Results

- Tax rate is set as in short-run case, but replacing c_n by average total cost (*AC*)
- Nuclear quantity will be lower than in short run

A2 The government cannot credibly commit to a tax rate



- Tax rate is set exactly as in short-run case
- Since the nuclear firm anticipates this, capacity investment will be even lower than in scenario A1

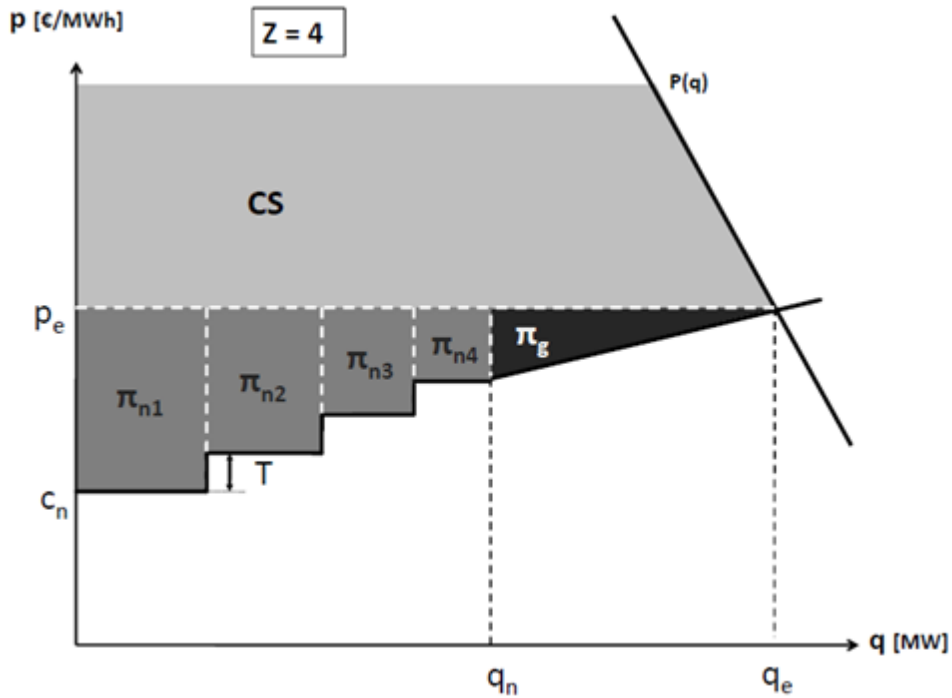
B Liberalization through asset divestitures – i.e. splitting the nuclear firm into competitors – leads to a Cournot-style solution

- Liberalization through asset divestitures means **splitting the nuclear firm** into multiple (say *z*) individual competing firms
- In our model, firms will **compete à la Cournot**, with joint Stackelberg leadership over the competitive fringe
- The well-known result is that **electricity price decreases with the number of firms *z***:

$$p_e^{split} = \frac{zAC}{1+z} + \frac{p_g + bc}{(1+z)(1-ac)}$$

C Liberalization through increased cross-border transmission capacity is another – albeit less favorable – way of introducing competition

- We assume that the number of nuclear players increases through a **gradual increase of cross-border transmission capacity**
- Additional players are assumed to be located further and further away, leading to **higher transmission costs per additional player** (see figure)
- The resulting **electricity price** can be expressed analytically **as a function of the number of players *z*:**



$$p_e^{trans} = \frac{zAC}{1+z} + \frac{z(z-1)T}{2(z+1)} + \frac{p_g + bc}{(1+z)(1-ac)}$$

This positive term is the only difference with policy B

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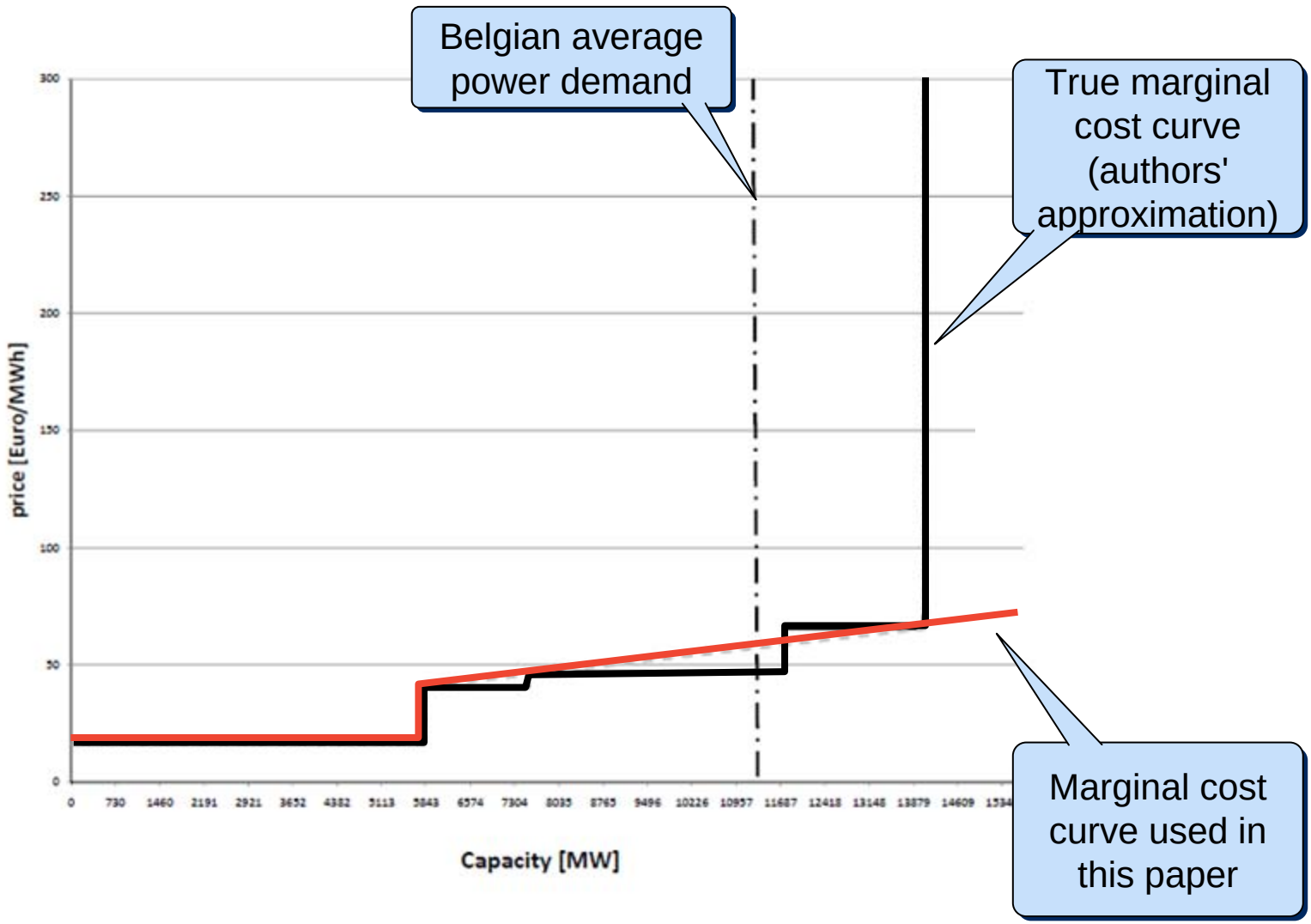
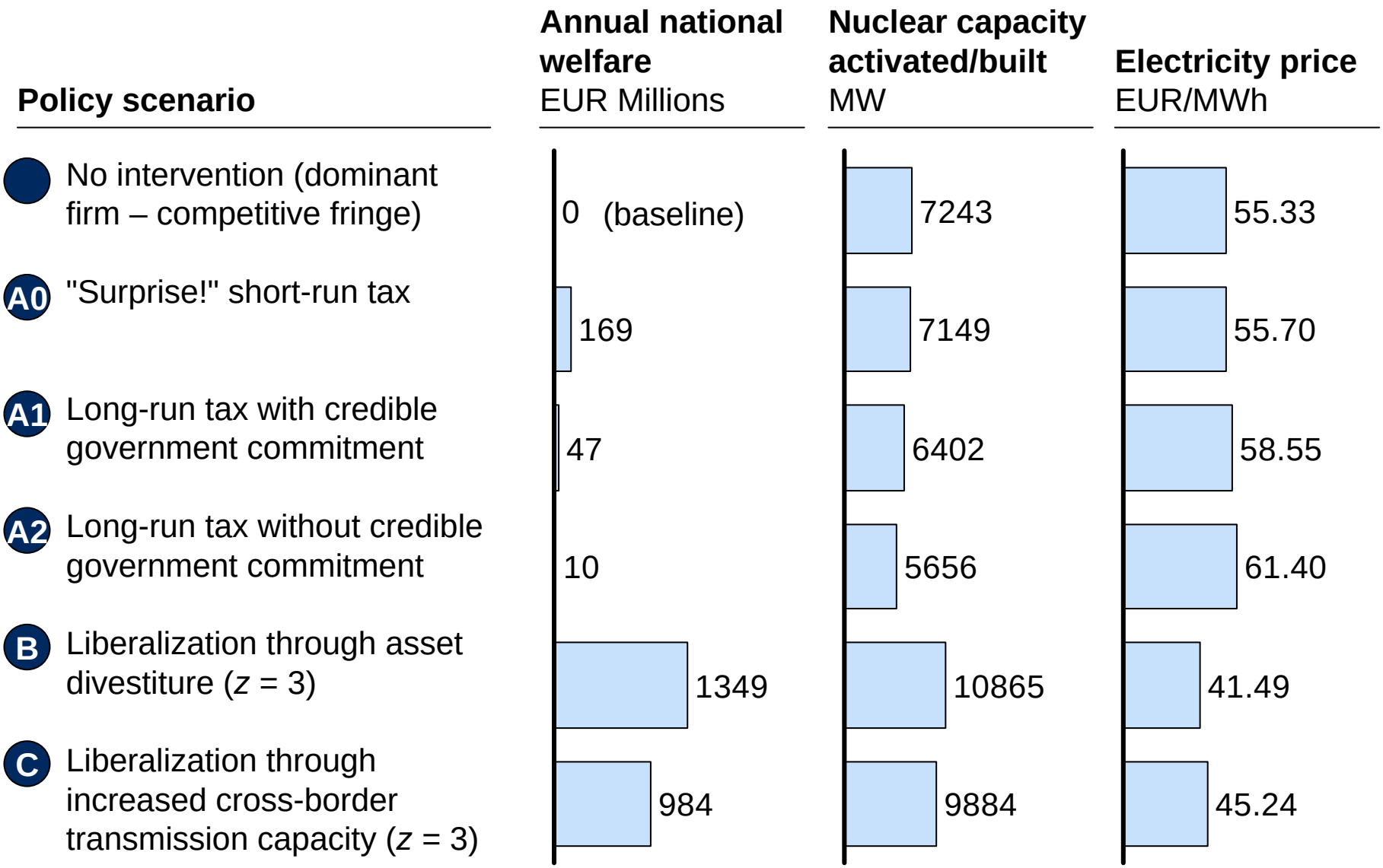
The model is calibrated on the Belgian situation



Source: ELIA

The numerical simulations show the advantages of liberalization compared to taxation, especially in the long run



Conclusions

- Liberalizing the nuclear segment by **splitting up the country's nuclear capacity is the most efficient instrument** to maximize national welfare
- **Increasing cross-border transmission capacity** is a close second, but **slightly less attractive** because of transmission costs
- **Welfare gains obtained by imposing proportional taxes** are **much smaller** than those obtained by liberalization
- Welfare effects of taxes are found to be **even less favorable when one considers the negative long-run effects on investments**, especially if governments cannot credibly commit to a tax rate

Model limitations and ideas for further research

- **Time values**. This model did not take the time value of profits and costs into account for the sake of conciseness. Future research may incorporate the time value of these flows.

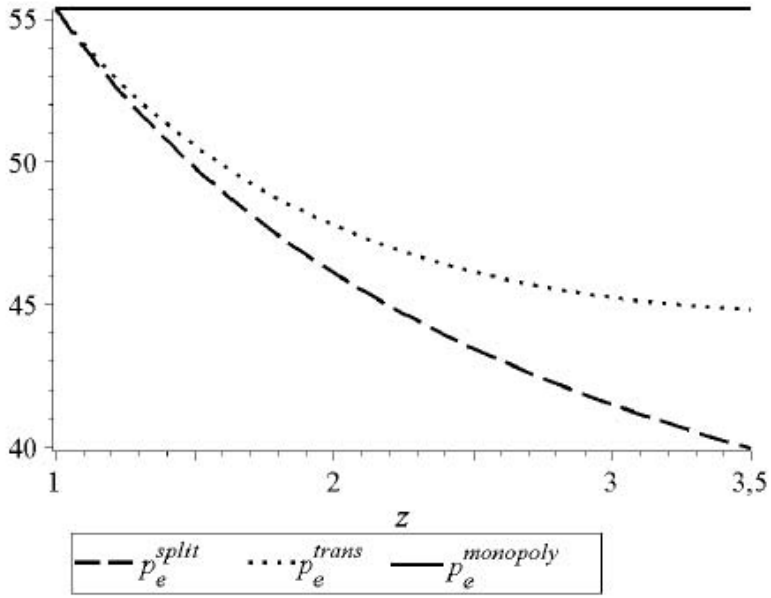
- **Investments and government policies**. If policies towards nuclear energy are too restrictive, investments in nuclear capacity will be deflect away from the local market. Future research could include this option explicitly into the model.

- **Capacity strategy**. Having capacity in a certain country is a way to be able to produce in that country, because it offers greater production flexibility to respond to variations on the demand side, stabilizes the market and it can be used as an entry deterrent. Future research may include these strategic considerations into the model.

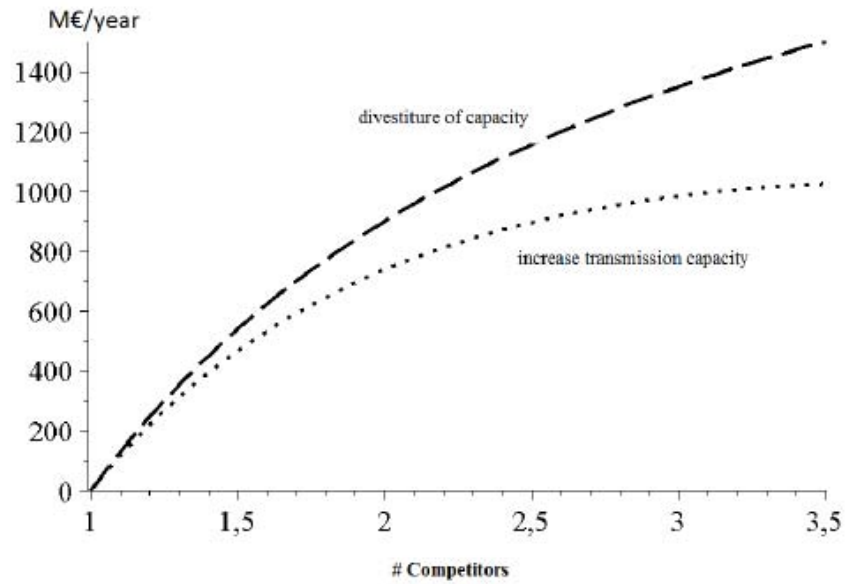
- **Withholding**. On the one hand, there are political and legal arguments to say it is very unlikely that generators withhold capacity. On the other hand, in the long term there are arguments to say that generators can withhold capacity. It is possible to direct the long term investments in order to manipulate the short term production. In the short term the generator will use its full capacity so they cannot be accused of abusing market power. Nevertheless, there are also some strategic arguments against the abuse of market power. According to Wolfram (1999) firms with market power will not fully use their power in a liberalized electricity market. This phenomenon is explained by regulatory constraints and a threat of entry. Financial contracts between suppliers and their customers may also explain the observed difference between the prices predicted by market power models and the real electricity prices. Prices can be strategically set just below the long term costs of new entrants. Wolfram (1999) estimates that the actual use of market power is only 20% of the potential monopoly margin. The effects of this strategic withholding and the autoregulation could be investigated in future research.

Appendix

Sensitivity on the number of firms resulting from liberalization



A: price in function of the number of competitors



B: ΔCS in function of the number of competitors

Figure 13: Effects of a liberalization of the Belgian nuclear generation capacity on the electricity price and the consumer surplus. (^{split} is the case of a divestiture (split-up) of the nuclear capacity while ^{trans} is the case with the increased interconnection capacity)

The optimal tax as a function of the national shareholdership: there may sometimes be a case for nuclear subsidies

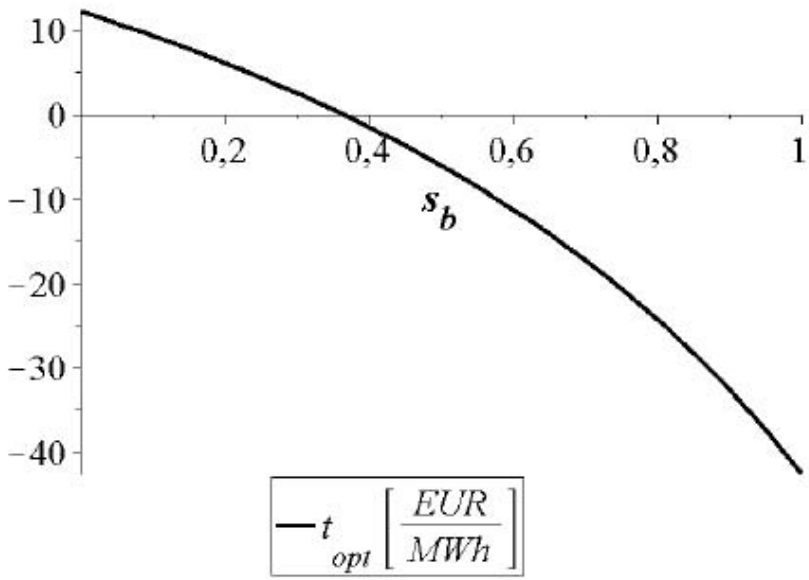


Figure 9: Basic short run scenario: evolution of the optimal tax with varying ownership shares. As s_l increased, the optimal tax decreases and becomes negative.