CZECH TECHNICAL UNIVERSITY IN PRAGUE

Katedra ekonomiky, manažerství a humanitních věd

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Young Economists' Meeting in Brno 2015

Analysis of Electricity Industry Liberalization in Great Britain: How Did the Bidding Behavior of Producers Change?

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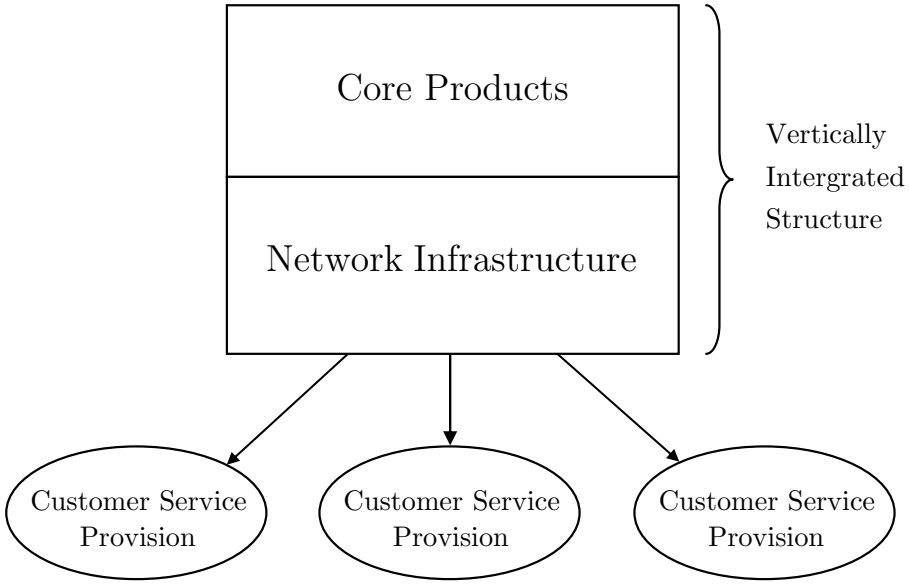
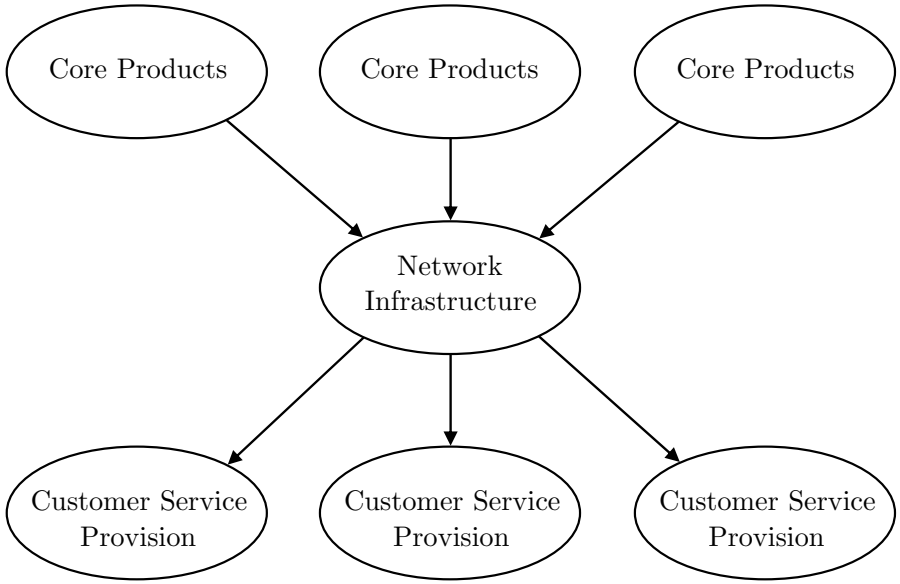
Fig. 1: *Structure of a Network Industry* **before** *and* **after** *Liberalization*

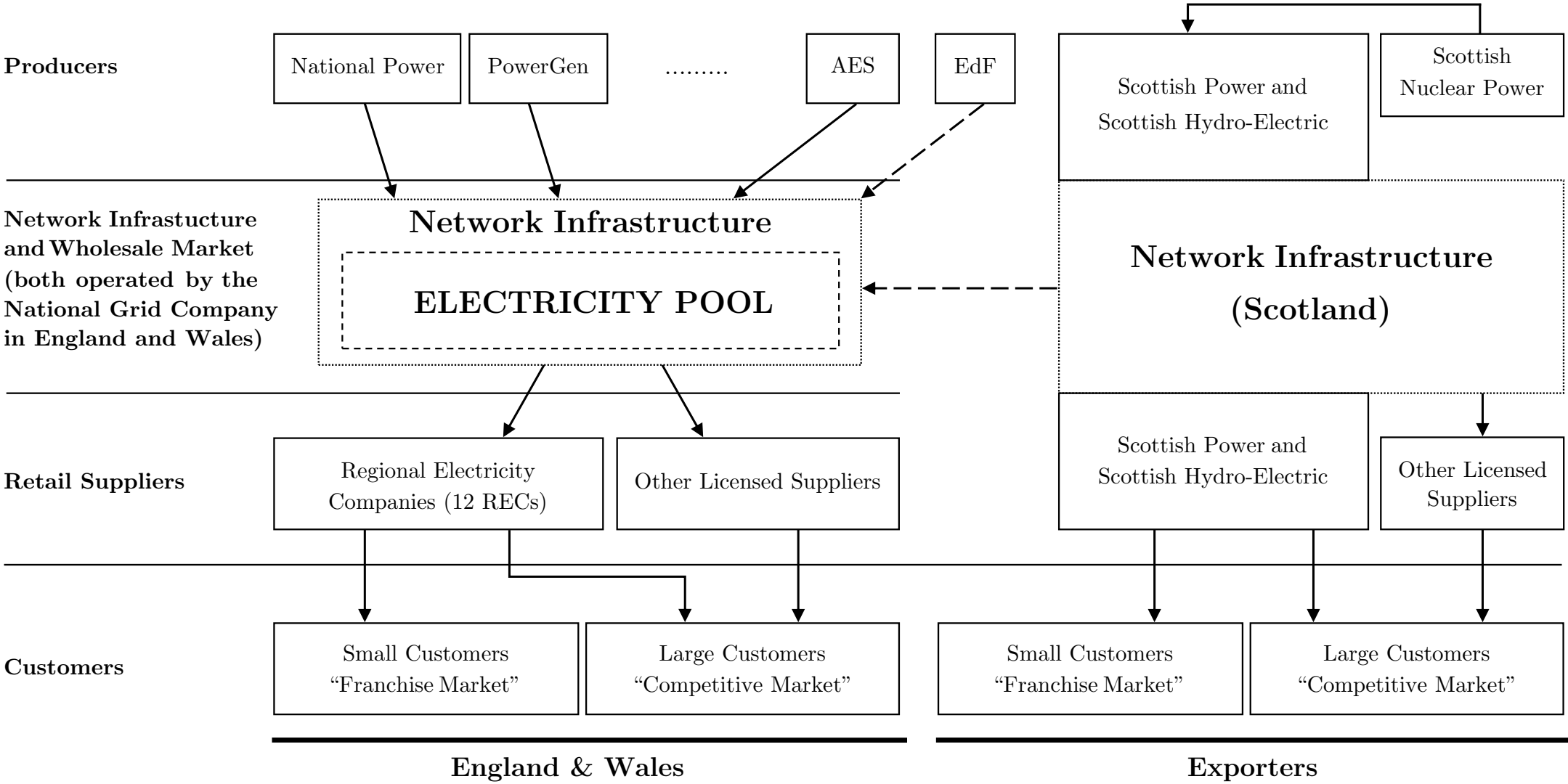


(a) Vertically Integrated Case



(b) Vertically Separated Case

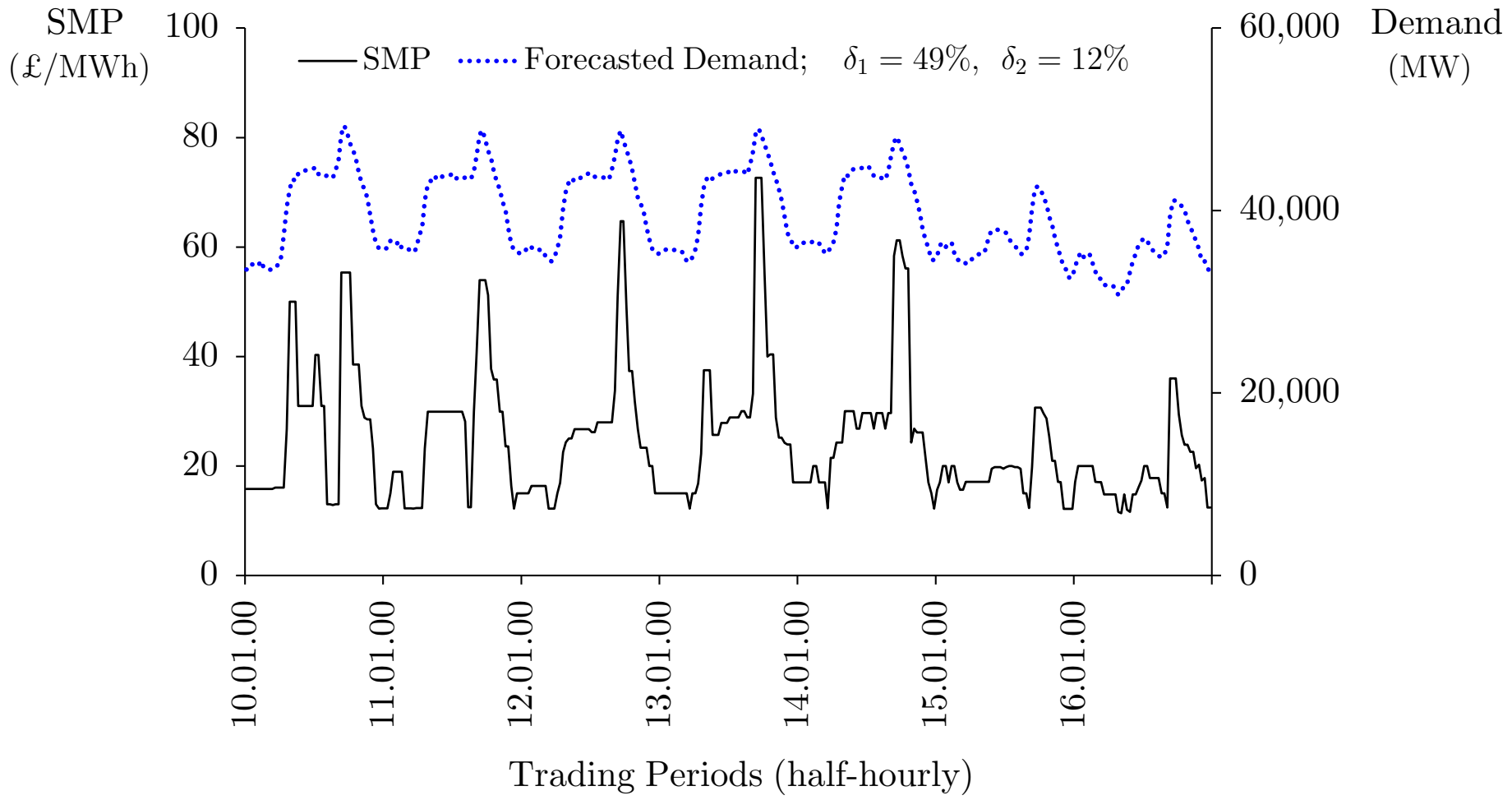
Fig. 2: *Description of the Electricity Industry in Great Britain*



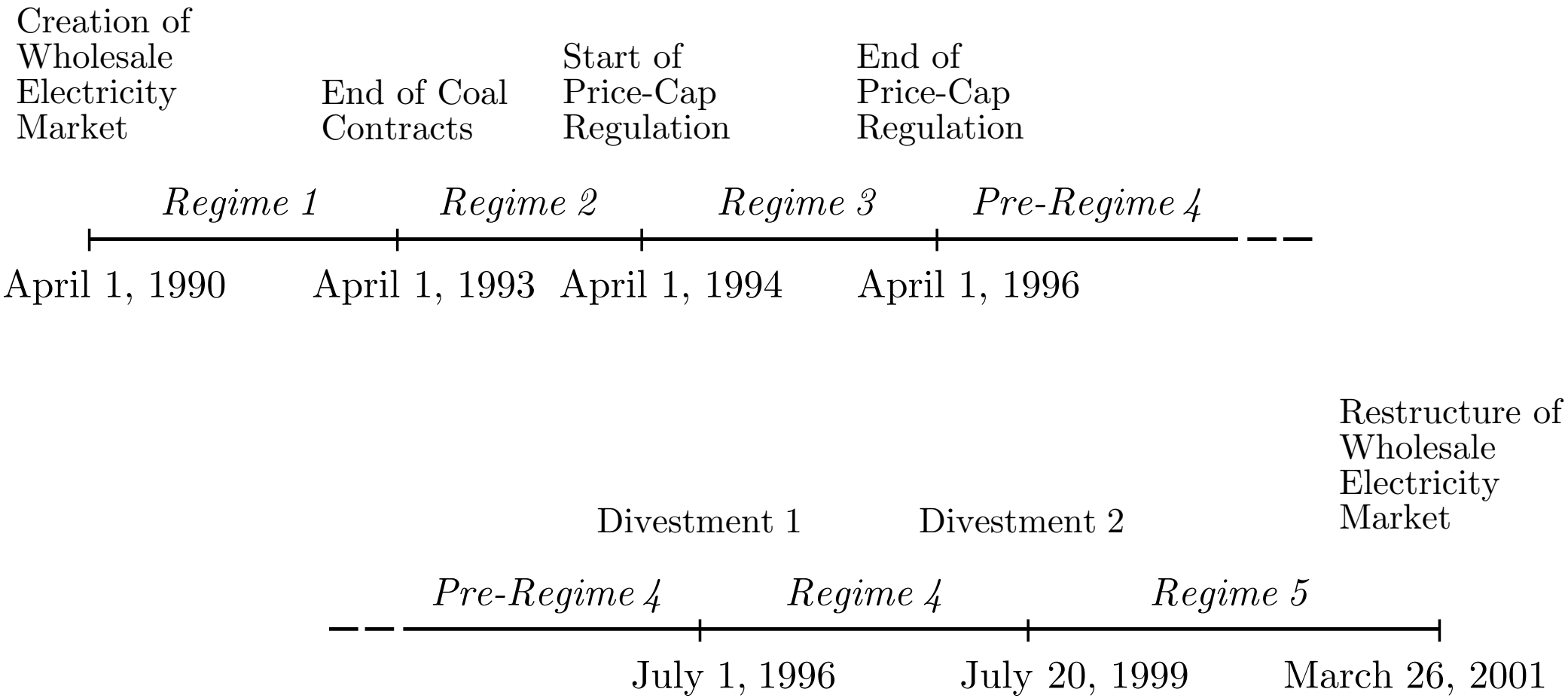
- The Key Question to Analyze Liberalization
  - Does liberalization lower prices?
- Case Study
  - Wholesale electricity market in England and Wales

- Motivation

Fig. 3: *SMP and Demand for Electricity (10.01.2000–16.01.2000)*



Institutional Changes and Regulatory Reforms



Analysis of Electricity Industry Liberalization in Great Britain:

How Did the Bidding Behavior of Producers Change?

Paper How Did the Bidding Behavior of Producers Change?

- Motivation

Policy Importance

- Market power:
  - inefficient allocation of production resources
  - higher electricity prices for consumers

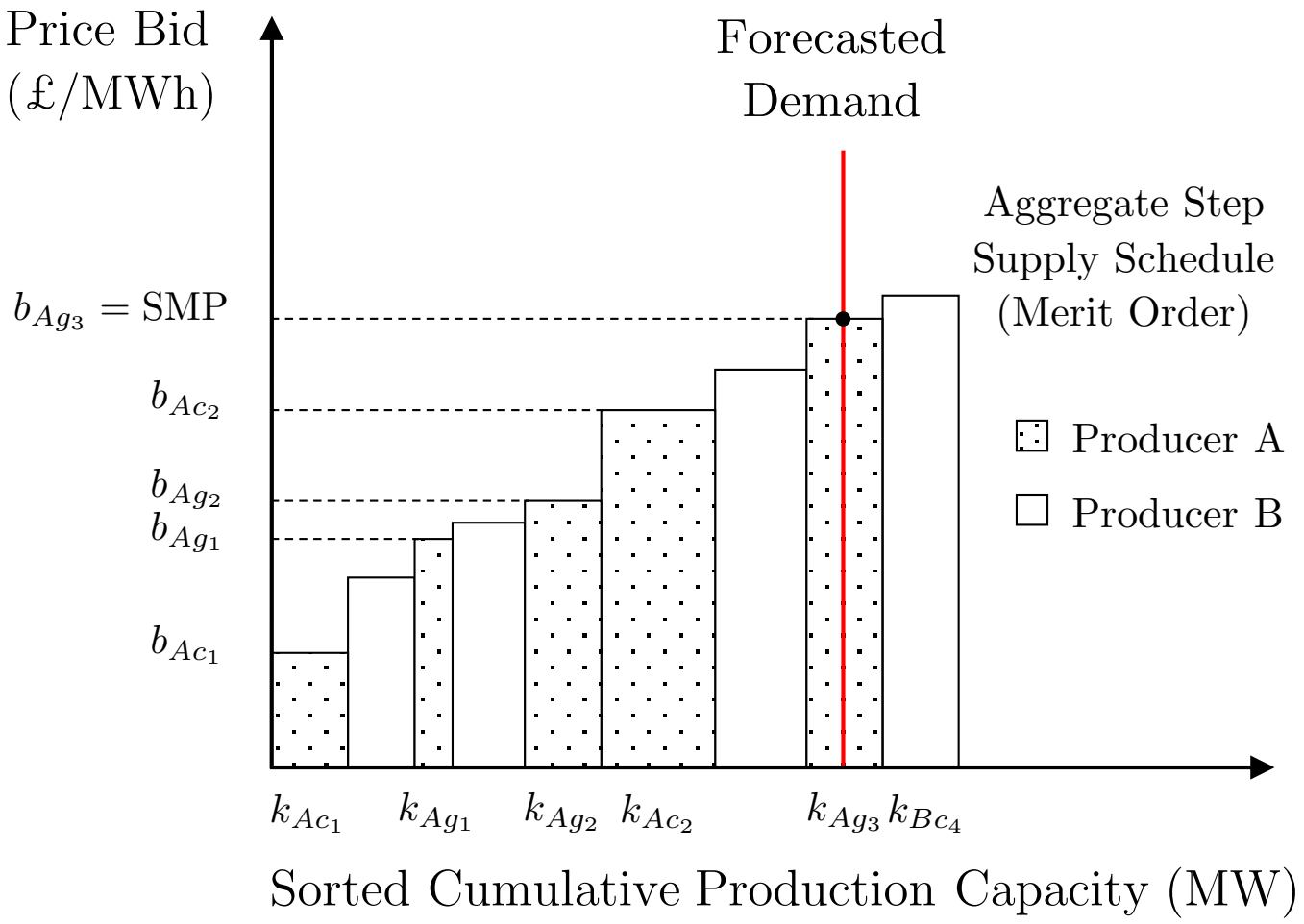
Research Question

- Were regulatory reforms successful at mitigating the exercise of market power during the liberalization process?

Research Approach

- duopoly case
- regression model

Fig. 4: *Half-Hourly One-Sided Uniform Price Auction (Hypothetical)*



Paper How Did the Bidding Behavior of Producers Change?

- Literature Review

  - **Green and Newbery (1992)**
    Seminal empirical research using the SFE approach.

  - **Wolfram (1998)**
    What creates an incentive/disincentive to submit price bids reflecting a higher bid markup?

  - **Crawford *et al.* (2007)**
    Are there asymmetries in bidding behavior?

  - **Sweeting (2007)**
    Market concentration *vs* market power in the late 1990s.

Paper How Did the Bidding Behavior of Producers Change?

- Assumptions, Model, and Theoretical Predictions

1. No uncertainty in the demand for electricity.
2. Marginal costs can be approximated.

Thermal efficiency rate of production unit X using input Y reflects the % of useful work done and is defined in the following way:

$$\kappa(X,Y) = \frac{\big(1 \text{ MWh of electricity}\big) \cdot \text{factor } E}{\text{input } Y \cdot \text{factor } Y} = \frac{\textit{What we get}}{\textit{What we pay for}}$$

Approximated marginal costs of production unit X using input Y:

$$MC(X,Y) = \big(\text{price of input } Y\big) \cdot \text{input } Y =$$

$$\big(\text{price of input } Y\big) \cdot \frac{\big(1 \text{ MWh of electricity}\big) \cdot \text{factor } E}{\kappa(X,Y) \cdot \text{factor } Y}$$

Paper How Did the Bidding Behavior of Producers Change?

- Assumptions, Model, and Theoretical Predictions

- Empirical Specification of a Regression Model

$$\begin{aligned} \log\left(Markup_{ijt}\right) &= \beta_0 + \beta_{1i} \cdot \log\left(Production\ Capacity\ below\ Bid\ b_{ijt}\right) + \\ &+ \beta_{2ij} \cdot \log\left(Production\ Capacity\ at\ Bid\ b_{ijt}\right) + \varepsilon_{ijt}\,, \end{aligned}$$

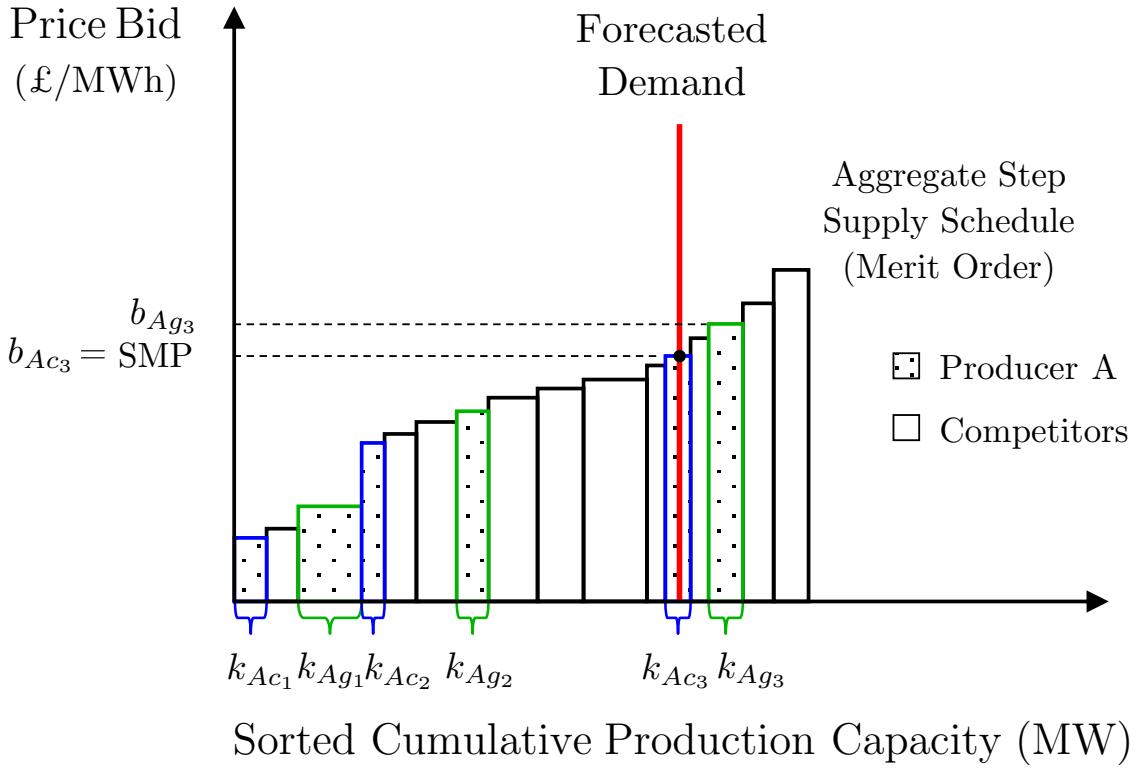
where i stands for electricity producer and j stands for input type.

- Two Hypotheses

$\mathbf{H_0}$: $\beta_{1i}^{\text{before}} = \beta_{1i}^{\text{after}}$

$\mathbf{H_0}$: $\beta_{2ij}^{\text{before}} = \beta_{2ij}^{\text{after}}$

- Assumptions, Model, and Theoretical Predictions



Production Capacity below Bid b_{Ag_3} : $k_{Ac_1} + k_{Ag_1} + k_{Ac_2} + k_{Ag_2} + k_{Ac_3}$

Production Capacity at Bid b_{Ag_3} : k_{Ag_3}

$Markup_{Ag_3}$: $b_{Ag_3} - c_{Ag_3}$

Paper How Did the Bidding Behavior of Producers Change?

- Assumptions, Model, and Theoretical Predictions

- ***Theoretical prediction 1***

  A large total capacity of production units below a price bid creates an incentive to submit a high price bid in excess of marginal cost

- ***Theoretical prediction 2***

  The incentive to submit a high price bid in excess of marginal cost is restrained by the presence of a threat that the production unit at stake may not be scheduled to produce electricity

Table 1: Descriptive statistics for inframarginal capacity (MWh) during peak-demand trading periods for NP and PG

	Regime 3 (Jan 95–Mar 96) Price-cap		Pre-regime 4 (Apr 96–Jul 96)		Regime 4 (Jul 96–Jul 99) Divestment 1		Regime 5 (Jul 99–Sept 00) Divestment 2	
	NP	PG	NP	PG	NP	PG	NP	PG
Mean	6921.5	4983.3	5184.0	4025.4	4438.5	3911.0	2457.4	2774.0
% Scale for Mean	100	100	75	81	64	78	36	56
Min	3153.7	2287.0	3376.5	2354.5	1347.5	1466.8	890.0	979.5
Max	9574.5	7325.5	7049.0	5323.0	7036.0	6213.5	4522.5	4420.0
St Dev	1437.2	1105.2	917.6	756.3	943.6	803.8	725.2	581.2
Coef of Var (%)	20.8%	22.2%	17.7%	18.8%	21.3%	20.6%	29.5%	21.0%
Obs	401	401	91	91	1111	1111	439	439

Table 2: Capacity-weighted average of nominal and real markups (£/MWh) of marginal and extra-marginal production units of NP during peak-demand trading periods

Capacity Type	Regime 3 (Jan 95–Mar 96) Price-cap		Pre-regime 4 (Apr 96–Jul 96)		Regime 4 (Jul 96–Jul 99) Divestment 1		Regime 5 (Jul 99–Sept 00) Divestment 2	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
Large Coal	9.1	9.0	10.6	10.1	15.5	14.2	15.5	13.8
Medium Coal	6.2	6.1	11.3	10.8	17.7	16.2	46.8	41.6
Small Coal	33.9	33.8	10.2	9.7	21.6	19.8		
Oil	25.0	24.7	46.1	44.1	37.8	34.7	40.3	35.6
OCGT	83.5	82.9	39.5	37.7	47.9	43.9	44.9	39.8
All Types	27.5	27.2	27.1	25.9	27.8	25.5	35.4	31.4

Table 3: Capacity-weighted average of nominal and real markups (£/MWh) of marginal and extra-marginal production units of PG during peak-demand trading periods

Capacity Type	Regime 3 (Jan 95–Mar 96) Price-cap		Pre-regime 4 (Apr 96–Jul 96)		Regime 4 (Jul 96–Jul 99) Divestment 1		Regime 5 (Jul 99–Sept 00) Divestment 2	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
Large Coal	10.6	10.5	4.9	4.7	15.1	13.9	14.6	12.9
Medium Coal	10.7	10.6	22.2	21.3				
Oil	29.1	28.7	52.0	49.7	39.5	36.3	41.2	36.5
OCGT	80.6	79.8	34.9	33.3	48.5	44.5	29.4	26.1
All Types	25.0	24.7	33.6	32.1	29.5	27.1	30.8	27.3

Table 4: Descriptive statistics for SMP (£/MWh) during peak-demand trading periods

	Regime 3 (Jan 95–Mar 96) Price-cap	Pre-regime 4 (Apr 96–Jul 96)	Regime 4 (Jul 96–Jul 99) Divestment 1	Regime 5 (Jul 99–Sept 00) Divestment 2
Mean	36.6	35.3	42.0	36.3
% Scale for Mean	100	96	115	99
Min	7.9	17.2	14.5	15.5
Max	211.2	76.7	105.1	77.9
St Dev	19.2	11.4	19.3	12.1
Coef of Var (%)	52.5	32.3	45.9	33.5
Obs	456	91	1114	439

Paper How Did the Bidding Behavior of Producers Change?

- Results for $\hat{\beta}_{1i}$

  - Estimates of $\hat{\beta}_{1i}$ generally conform to the first theoretical prediction and is, therefore, consistent with earlier research by Green and Newbery (1992) and Wolfram (1998).

  - There is statistical evidence that during later regime periods the incentive to exercise market power has increased for NP, PG, and AES. This is partly in line with the findings in Sweeting (2007), where the author using the methodology of competitive benchmark prices shows that the extent of exercising market power has generally increased during the late 1990s.

  - For the other electricity producers the incentive to exercise market power during later regime periods has either decreased or been relatively low.

Paper How Did the Bidding Behavior of Producers Change?

- Results for $\hat{\beta}_{2ij}$

  - $\hat{\beta}_{2ij}$ measures the percentage change in the markup, when the capacity of a production unit at stake is larger by 1%. The second theoretical prediction suggests that $\hat{\beta}_{2ij}$ should be negative.

  - However, in some instances, especially during the price-cap regulation period, the estimates of $\hat{\beta}_{2ij}$ are positive, but statistically insignificant.

  - After the divestment series were introduced, the estimates for $\hat{\beta}_{2ij}$ conformed to the second theoretical prediction.

Paper How Did the Bidding Behavior of Producers Change?

- Conclusions

  - Estimation results provide statistical evidence that the divestment series were more successful than price-cap regulation at fostering bidding behavior consistent with the second theoretical prediction. However, this took place at the expense of an increased incentive to exercise market power by the incumbent producers.

  - This, therefore, suggests that the structural remedies were generally more successful than behavioral remedies at fostering bidding behavior consistent with the second theoretical prediction, but not necessarily at decreasing the extent of exercising market power.

  - Nevertheless, since in a less concentrated market structure it is easier to promote competitive bidding, structural remedies could be superior.

Thank You

- Motivation

Fig. 6: *SMP and Demand for Electricity (9.01.1995–15.01.1995)*

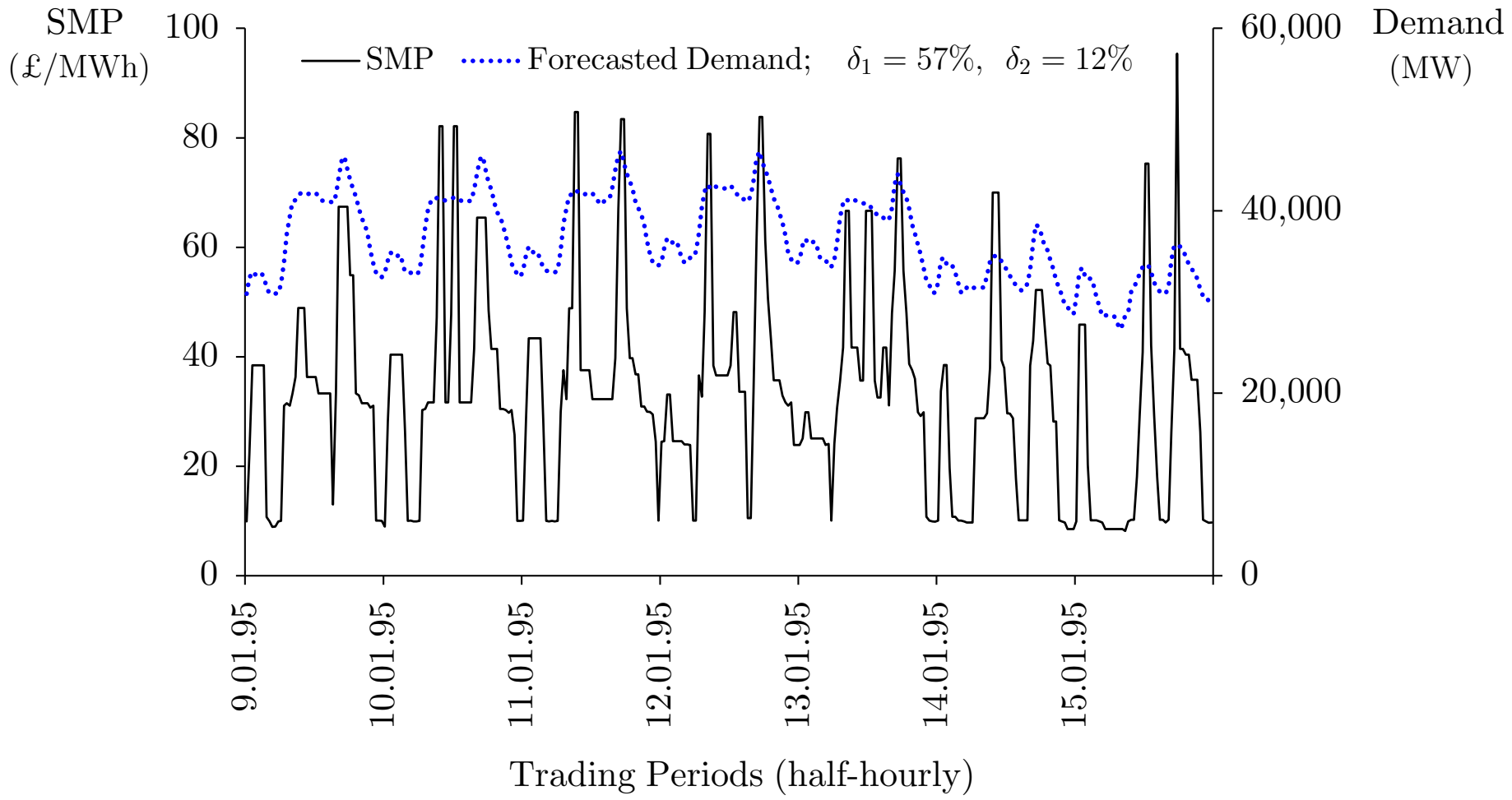


Fig. 7: *Half-Hourly One-Sided Uniform Price Auction (Real)*