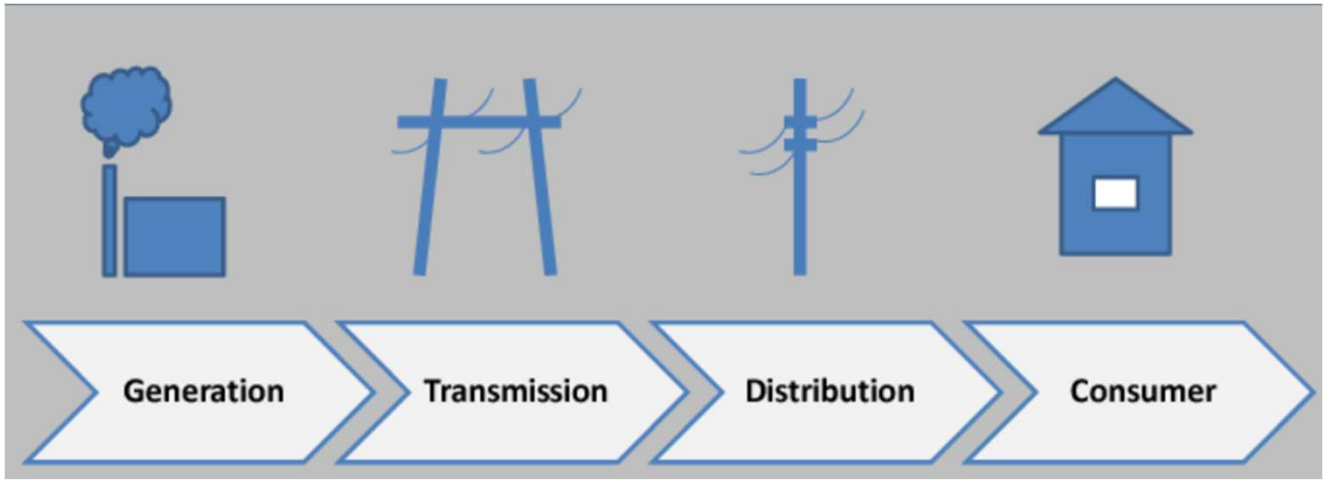
ECON3133
Microeconomic Theory II

Tutorial #11: Imperfect Competition – the case of electricity supply

Today's tutorial:

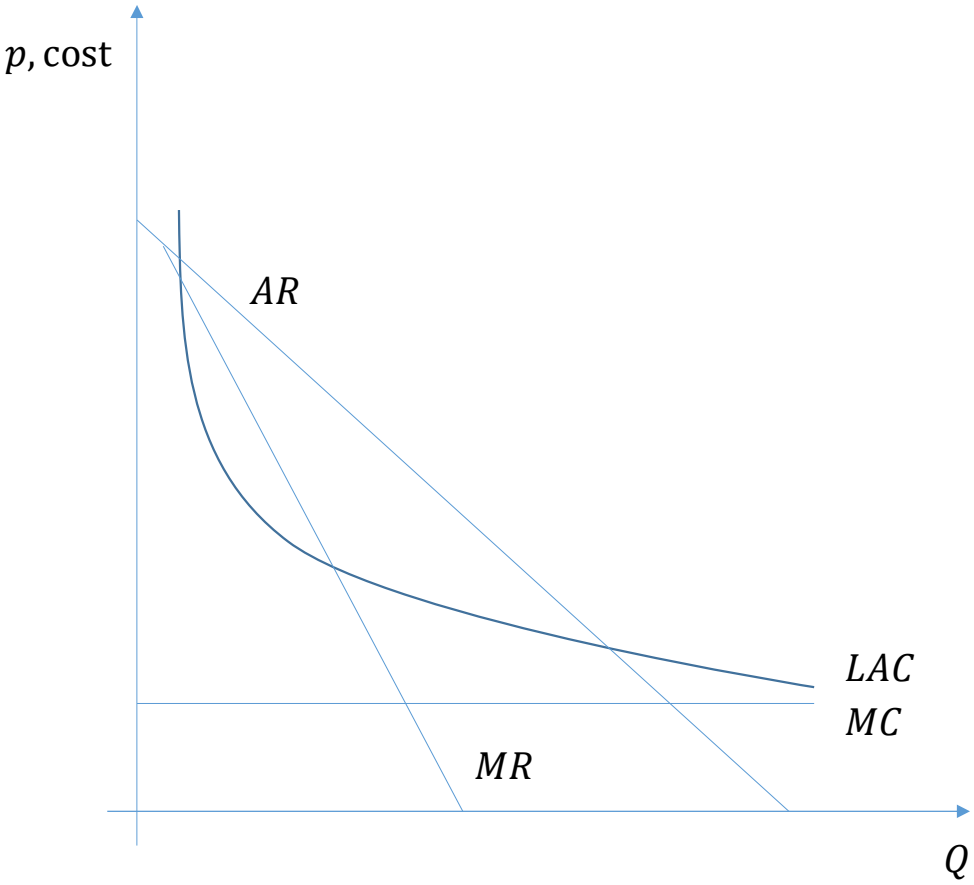
- Imperfect competition and the case of electricity supply
  - The supply of electricity is a homogenous product
  - Can be analysed in terms of the models of imperfect competition that we have looked at
  - The analysis is inspired by the case of the UK, where electricity distribution was privatised in 1990
- Questions to answer:
  - What happens to electricity output, its price, suppliers' profits and consumer surplus in the case of:
    - A monopoly provider
    - A privatised market

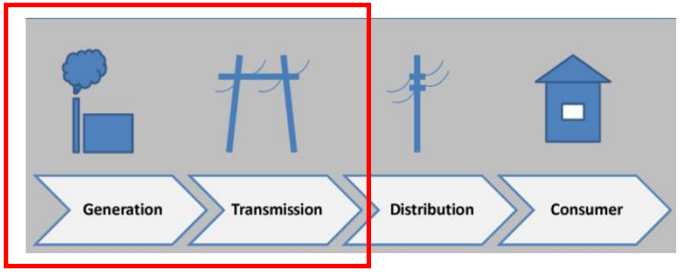
Structure of the electricity industry:



- The electricity industry consists of 3 activities
  - Generation: making the electricity from eg coal/oil/nuclear/wind/renewables
  - Transmission: making the electricity available to a national network
  - Distribution: selling the electricity to the consumer (households, firms etc.)

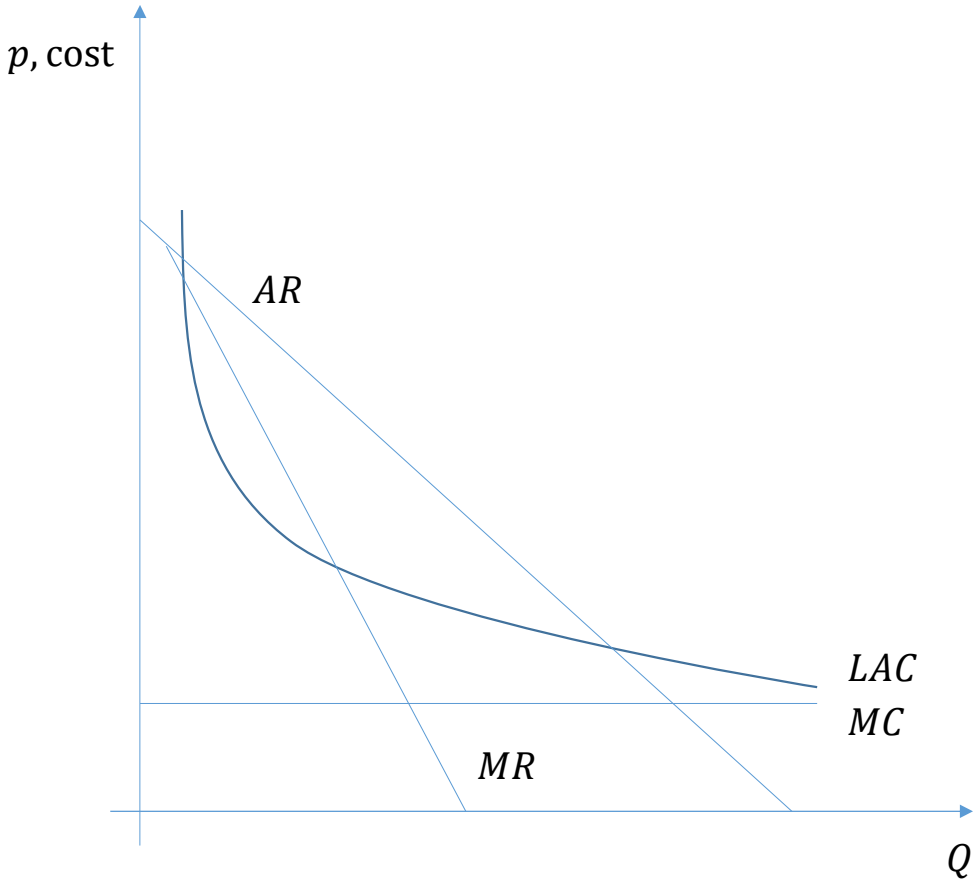
The electricity market: generation and transmission





- Electricity <u>generation and transmission</u> may be considered a <u>natural monopoly</u>
  - Very high fixed costs (eg building a power generation plant)
  - Declining long run average costs over a wide range of output levels
  - Very high technical barriers to entry

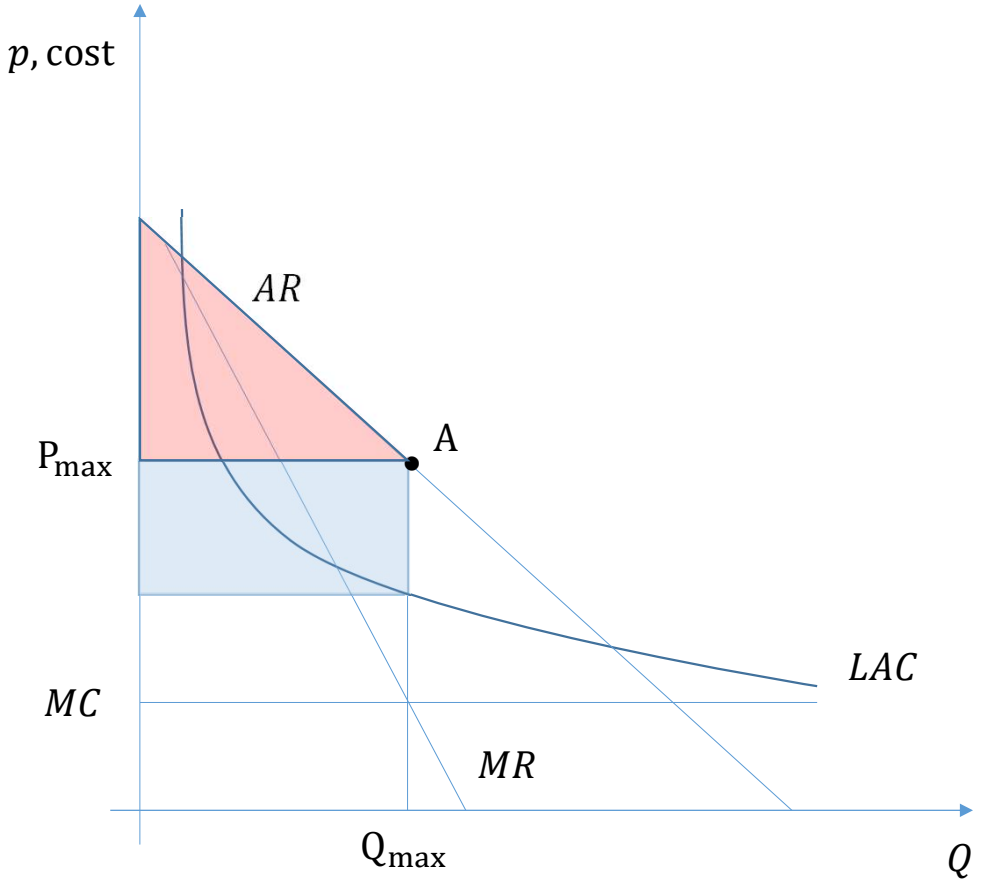
The starting point: a monopoly electricity company



- Assume that a single firm is responsible for electricity generation, transmission and distribution
- Suppose that the firm has total costs
  - $TC = 10000 + 4Q$
- Then $LAC = \frac{10000}{Q} + 4$ and $MC = 4$
- Also suppose that the market demand curve is given by

  $Q^D = 500 - \frac{1}{2}p$
- Assume that the firm maximises profits
- What is the equilibrium output, Q, price, p, profits, Π and consumer surplus in this case?

The starting point: a monopoly electricity company



- The firm's optimisation problem:

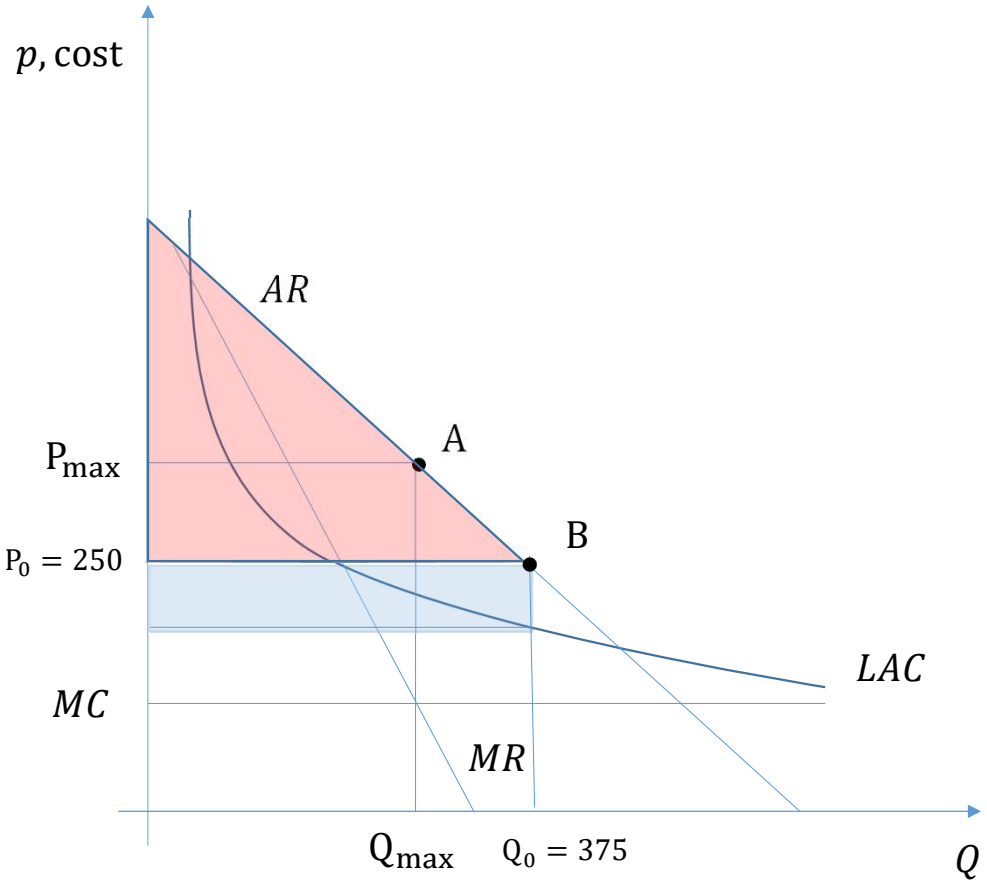
$$\max_Q \Pi = pQ - TC$$
$$= 1000Q - 2Q^2 - 10000 - 4Q$$
$$= 996Q - 2Q^2 - 10000$$

- FOC: $\frac{d\Pi}{dQ} = 996 - 4Q = 0$

$$Q_{max} = 249$$
$$P_{max} = 1000 - 2 \times Q_{max}$$
$$= 502$$
$$\Pi_{max} = 249 \times 502 - 10000 - 4 \times 249$$
$$= 114{,}002$$

$$CS_{max} = \frac{1}{2}(1000 - 502) \times 249$$
$$= 62{,}001$$

The starting point: a monopoly electricity company



- Now suppose that the government decides that 502 is too high a price to pay for electricity, and fixes the price at 250
- What are output, profits and consumer surplus in this case?
- The firm now produces $Q_0 = 500 - \frac{1}{2}p_0 = 375$ (from 249 previously)
- Note that the firm maximises profits in this case by producing on the demand curve ($MR = p_0 > \text{MC}$ for $Q \leq Q_0$)
- Profits are now $\Pi = 250 \times 375 - 10000 - 4 \times 375 = 82{,}250$ (from 114,002 previously)
- CS is now $\frac{1}{2}(1000 - 250) \times 375 = 140{,}625$ (from 62,001 previously)

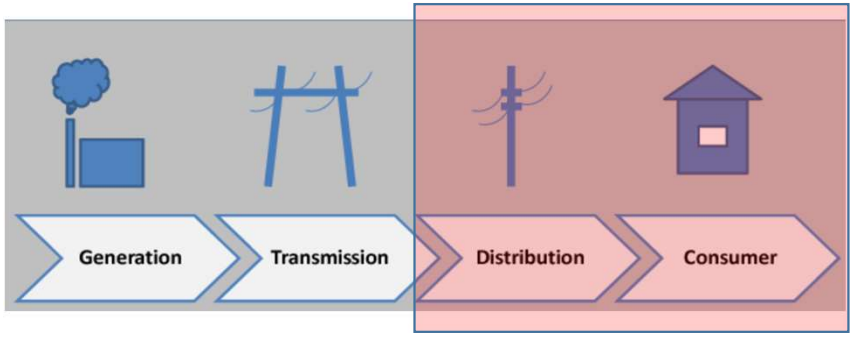
The starting point: a monopoly electricity company

- Summary: A single monopoly firm

	Without price control	With price control
Q	249	375
P	502	250
Π	114,002	82,250
CS	62,001	140,625

- Consumers are much better off with the price control
- Notice that with the price control, profits only fall by 29% (31,752)

Extending the analysis: privatizing electricity distribution



Government policy:

- Create 10 new distribution companies
- The companies each buy electricity from the generator
- Their (total) marginal costs are 200
- The generating company still makes a profit because its costs have fallen (no distribution cost)

- Now suppose that the government thinks that the price of electricity is so high because distribution is very inefficient
- The government believes that introducing competition into distribution would lower prices for consumers, whilst making profits for newly created distribution companies
- At the same time, generation and transmission would remain a monopoly, but the firm responsible could benefit from economies of scale to keep costs low

Extending the analysis: privatizing electricity distribution

Who's this?

- In 1988, the Minister for Energy (Cecil Parkinson) said to the House of Commons:

"The new structure will be just the start. It will create a framework in which a modern, competitive industry will develop. It will create a customer-led industry, with the 15 distribution companies free to find the cheapest sources of power for their 22 million customers.

The fact that there is only one shop in the village does not mean that there has to be only one supplier to that shop. We do not need a monopoly in the power stations just because there is only one set of wires to the customer"

Extending the analysis: the new energy distribution market

- The new market is characterised by:
  - Homogeneous product
  - Market demand curve $Q = 500 - \frac{1}{2}p$
  - 15 distribution firms
  - Marginal cost equal to 200 for all firms
- Firms buy a quantity of electricity from the generating company, and allow price to be determined by the market
  - ie price determined by the inverse demand function $p = 1000 - 2Q$
- This is a Cournot problem, with $n = 15$

Extending the analysis: the Cournot problem for $n = 15$

- Each of the 15 firms solves the optimisation problem:

$$\max_{q_i} \pi_i(q_i, Q_{-i}) = q_i(1000 - 2q_i - 2Q_{-i} - 200)$$

$$= 800q_i - 2q_i^2 - 2q_iQ_{-i}$$

$$\frac{\partial \pi_i}{\partial q_i} = 800 - 4q_i - 2\,Q_{-i} = 0$$

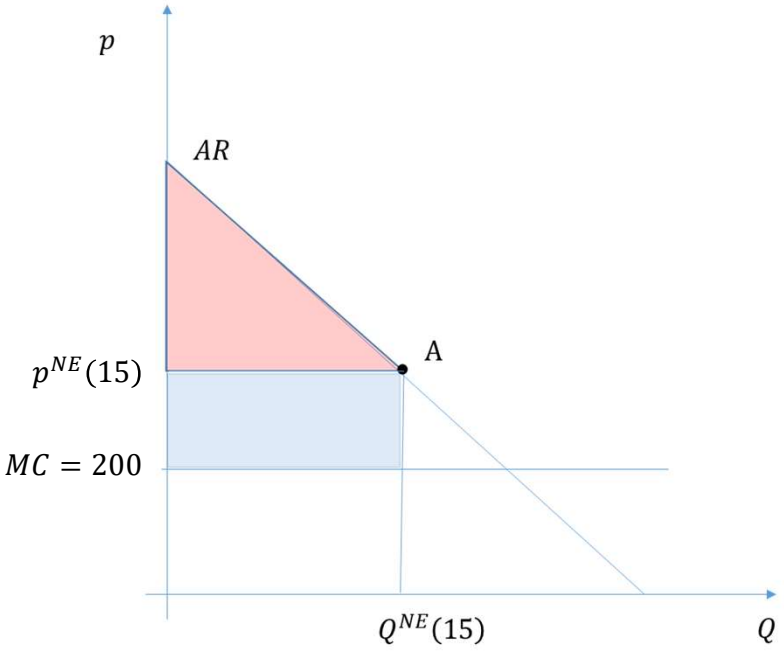
$$q_i^{NE} = BR_i(Q_{-i}) = 200 - \frac{1}{2}\,Q_{-i}$$

- Because the problem is symmetric, we have $q_1^{NE} = q_1^{NE} = \cdots = q_{15}^{NE}$
- We then have:
  - $q_{NE} = 200 - \frac{1}{2}\sum_{i \neq j}^{15} q_{NE}$

Extending the analysis: the Cournot problem for $n = 15$

- Then:
  - $q_{NE} = 200 - \frac{1}{2} \times 14 \times q_{NE}$
  - $q_{NE} = \frac{200}{8} = 25$
- Note that for $c = 200$ and any n:
  - $q_{NE} = 200 - \frac{1}{2} \times (n-1) \times q_{NE}$
- So that:
  - $q_{NE} = \frac{400}{n+1}$
- With a monopoly distribution company ($n = 1$): $q_{NE} = \frac{400}{2} = 200$
- An $n \to \infty, q_{NE} \to 0$

Extending the analysis: the Cournot problem for $n = 15$



- With $n = 15$:
  - Market quantity $Q^{NE}(n) = 15 \times q_{NE} = 375$
  - Market price $= p^{NE}(\mathrm{n}) = 1000 - 2 \times Q^{NE}(n) = 250$
  - Firm i's profits $= p^{NE}(\mathrm{n}) \times q_{NE} - 200 \times q_{NE}$

    $= 250 \times 25 - 200 \times 25$

    $= 1250$
  - Market profits $= 15 \times 1250$

    $= 18{,}750$
  - Consumer surplus $= \frac{1}{2}(1000 - 250) \times 375$

    $= 140{,}625$

Summary: A single monopoly firm and the situation immediately after privatisation

	Before privatisation: monopoly		Privatisation
	Without price control	With price control	15 firms
q_i	-	-	25
Q	249	375	375
P	502	250	250
π_i	-	-	1250
Π	114,002	82,250	18,750
CS	62,001	140,625	140,625

- Note: in the case of the single monopoly firm, the cost function is different to the cost function after privatisation; therefore, profit figures are not completely comparable
- Nevertheless, it looks like the monopoly generator is making profits whilst the new companies are barely profitable
- Consumer surplus numbers are comparable, however

The next phase: distribution companies want to increase profits

- The distribution companies start to complain to the government that their profits are too low
  - Their shareholders require a higher rate of return
  - They need more profit to pay for capital investment
    - Either from retained profits or else by borrowing in bond markets
- The companies say that they need profits of 10,000 each to be viable in the long run
- How could the profits of the distribution companies be increased?

  1)

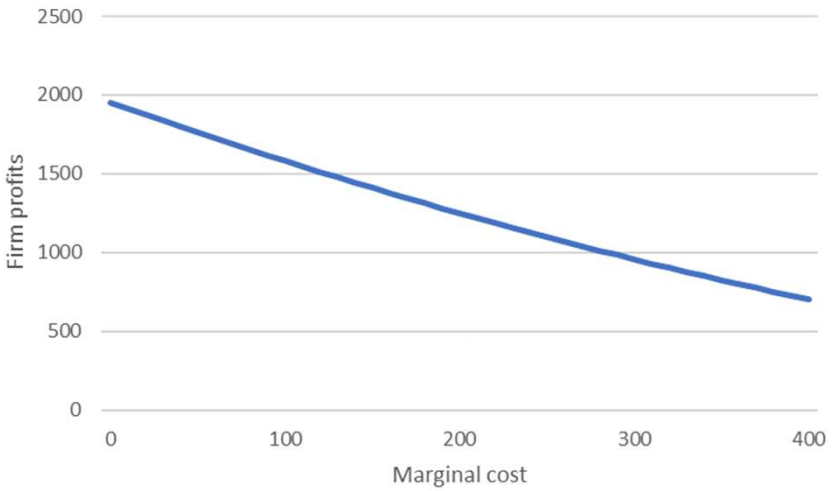
  2)

  3)

  4)

Increasing distribution company profits 1: reduce marginal costs

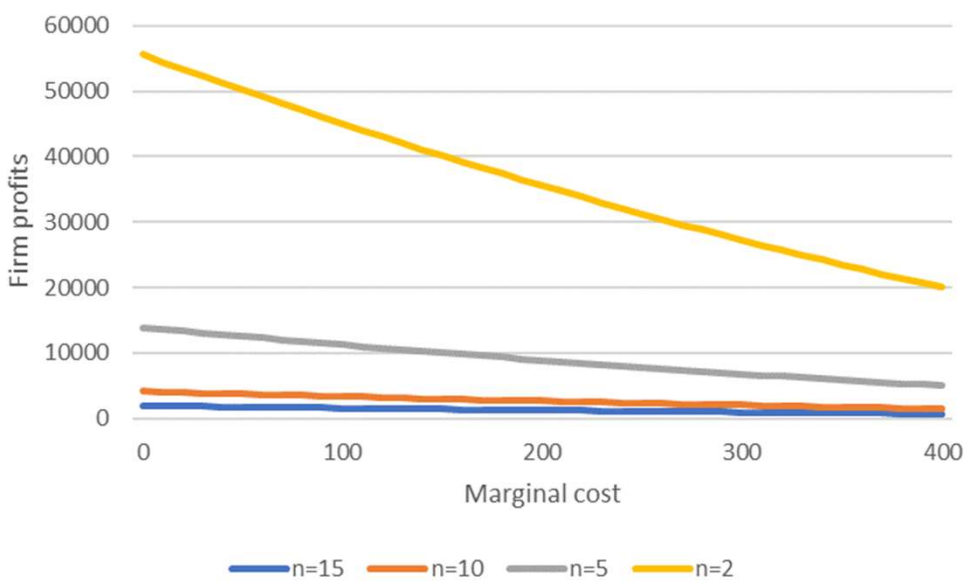
Firm profits vs marginal costs ($n = 15$)



- For n, c given, we have:
  - $q_{NE}(\mathrm{n}, \mathrm{c}) = \frac{2}{n+1}\left[250 - \frac{c}{4}\right]$
  - $Q^{NE}(n, c) = n \times q_{NE}$
  - $p^{NE}(\mathrm{n}, c) = 1000 - 2 \times Q^{NE}(n)$
  - $\pi_i(n, c) = p^{NE}(\mathrm{n}, c) \times q_{NE}(n, c) - \mathrm{c} \times q_{NE}(n, c)$
  - $\Pi(n, c) = n \times \pi_i(n, c)$
- By how much would marginal costs have to fall to give firm profits of 10,000?
- Note that this means that price controls on the generator wouldn't work either

Increasing distribution company profits 2: allow mergers to increase firm profits

Firm profits vs marginal costs



- What else could work?
  - Mergers to reduce the number of firms
- Suppose that the government allows firms to merge as long as each new firm can achieve synergies and cut marginal cost to 150
- Also, suppose that firms start a 'merger frenzy' and that soon there are only 5 firms left


FINANCIAL TIMES

Mergers & Acquisitions + Add to myFT

Merger mania whips up $120bn of tie-ups in just one day

Monday's flurry of dealmaking takes value of 2018's global transactions to $1.7tn

Increasing distribution company profits 2: allow mergers to increase firm profits

- We have:
  - $q_{NE}(\mathrm{n}, \mathrm{c}) = \frac{2}{n+1}\left[250 - \frac{c}{4}\right]$
  - $Q^{NE}(n, c) = n \times q_{NE}$
  - $p^{NE}(\mathrm{n}, c) = 1000 - 2 \times Q^{NE}(n)$
  - $\pi_i(n, c) = p^{NE}(\mathrm{n}, c) \times q_{NE}(n, c) - \mathrm{c} \times q_{NE}(n, c)$
  - $\Pi(n, c) = n \times \pi_i(n, c)$
  - $n = 5$
  - $c = 150$
  - $q_{NE}(\mathrm{n}, \mathrm{c}) = \frac{2}{6}\left[250 - \frac{150}{4}\right] = 70.8$
  - $Q^{NE}(n, c) = 5 \times q_{NE} = 354$
  - $p^{NE}(\mathrm{n}, c) = 1000 - 2 \times Q^{NE}(n) = 292$
  - $\pi_i(n, c) = p^{NE}(\mathrm{n}, c) \times q_{NE}(n, c) - \mathrm{c} \times q_{NE}(n, c)$
    $= (292 - 150) \times 70.8 = 10{,}054$
  - $\Pi(n, c) = 5 \times \pi_i(n, c) = 50{,}270$
  - $CS = \frac{1}{2}(1000 - 292) \times 354 = 125{,}316$

Summary: the situation after reducing the number of firms and cutting MC

	Before privatisation: monopoly		Privatisation	
	Without price control	With price control	15 firms, $MC = 200$	5 firms, $MC = 150$
q_i	-	-	25	70.8
Q	249	375	375	354
P	502	250	250	292
π_i	-	-	1250	10,054
Π	114,002	82,250	18,750	50,270
CS	62,001	140,625	140,625	125,316

- Reducing the number of firms increases firm and market profits, but consumer surplus falls compared to the original privatisation case
- Firms have achieved their desired profit level, so could now become attractive investments

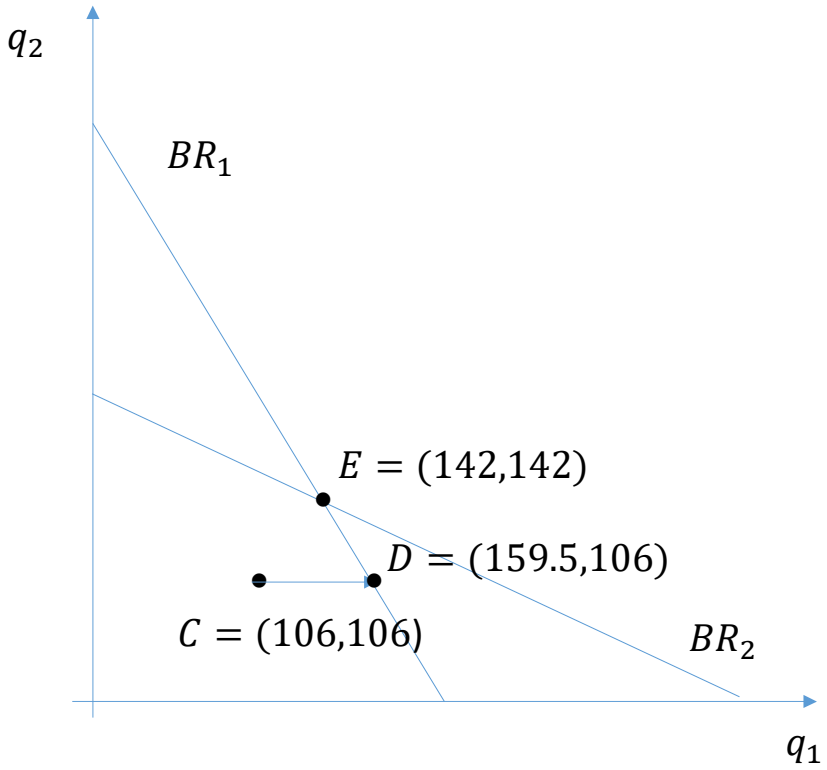
The final case: a duopoly and tacit collusion between them

- Now assume that the merger frenzy continues until there are only 2 firms left
- They still set quantity and allow the market to determine price
- Do the firms have an incentive to collude?
- Step 1): Consider the monopoly result
  - $\max_Q \Pi = pQ - cQ = (1000 - 2Q)Q - 150Q$
  - $Q^{MON} = 212.5$
  - $q^{MON} = 106.25$
  - $P^{MON} = 1000 - 2 \times Q_{MON} = 575$
  - $\Pi^{MON} = (575 - 150) \times 212.5 = 90{,}312.5$
  - Assume that profits are shared in collusion:
    - $\pi_i^{MON} = \frac{90{,}312.5}{2} \approx 45{,}156$

The final case: a duopoly and tacit collusion between them

- Step 2): Consider the NE result
  - $q_{NE}(\mathrm{n}, \mathrm{c}) = \frac{2}{n+1}\left[250 - \frac{c}{4}\right]$
  - $Q^{NE}(n, c) = n \times q_{NE}$
  - $p^{NE}(\mathrm{n}, c) = 1000 - 2 \times Q^{NE}(n)$
  - $\pi_i(n, c) = p^{NE}(\mathrm{n}, c) \times q_{NE}(n, c) - \mathrm{c} \times q_{NE}(n, c)$
  - $\Pi(n, c) = n \times \pi_i(n, c)$
  - $n = 2$
  - $c = 150$
  - $q_{NE}(\mathrm{n}, \mathrm{c}) = \frac{2}{3}\left[250 - \frac{150}{4}\right] = 141.7$
  - $Q^{NE}(n, c) = 5 \times q_{NE} = 283.4$
  - $p^{NE}(\mathrm{n}, c) = 1000 - 2 \times Q^{NE}(n) = 433$
  - $\pi_i(n, c) = p^{NE}(\mathrm{n}, c) \times q_{NE}(n, c) - \mathrm{c} \times q_{NE}(n, c)$
    $= (433 - 150) \times 141.7 = 40{,}101$
  - $\Pi(n, c) = 5 \times \pi_i(n, c) = 80{,}202$
  - $CS = \frac{1}{2}(1000 - 433) \times 283.4 = 80{,}344$
  - Note:
    - $Q^{NE} = 283.4 > 212.5 = Q^{MON}$
    - $\pi_i^{NE} = 40{,}101 > 45{,}156 = \Pi_i^{MON}$

The final case: a duopoly and tacit collusion between them



- NE at E
- Collusion outcome at C
- What is Firm 1's best deviation response?
- Firm 1 maximises profits given that firm 2 is at the collusion equilibrium
- So firm one produces $q_1^{BR}(q_2 = q_2^C)$:

$$\pi_1 = (1000 - 2q_1 - 2q_2^C - 150)q_1$$
$$= (1000 - 2q_1 - 212.5 - 150)\, q_1$$
$$= 637.5q_1 - 2q_1^2$$

- $q_1^{DEV} = \frac{637.5}{4} = 159.4$
- $p^{DEV} = 1000 - 2 \times (q_1^{DEV} + q_2^C) = 468.75$
- $\pi_1^{DEV} = (468.75 - 150) \times 159.4 = 50{,}809$

The final case: a duopoly and tacit collusion between them

- We may calculate δ_{min} in this case:
  - $\delta_{min} = \frac{\Pi^{DEV} - \Pi^{C}}{\Pi^{DEV} - \Pi^{NE}}$

    $\approx \frac{50{,}809 - \quad ,15}{50{,}809 - \quad ,101}$

    ≈ 0.53
- So there is scope for collusion

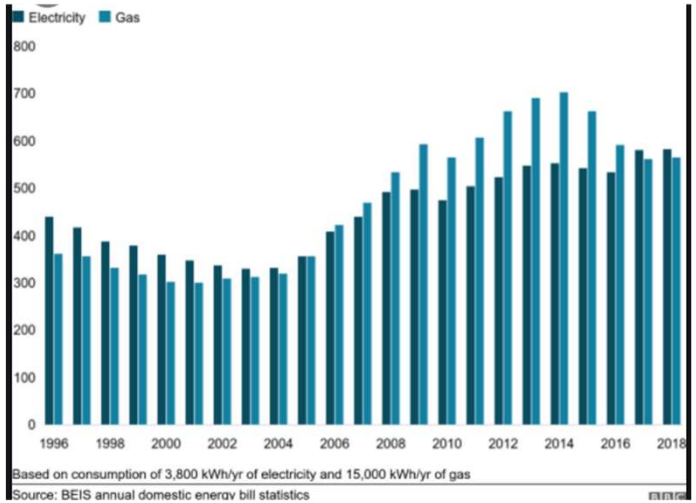
Summary: all the cases

	Before privatisation: monopoly		Privatisation			
	Without price control	With price control	15 firms, $MC = 200$	5 firms, $MC = 150$	2 firms, $MC = 150$, NE	2 firms, $MC = 150$, collusion
q_i	-	-	25	70.8	141.7	159.4 (deviant)
Q	249	375	375	354	283.4	265.7
P	502	250	250	292	433	468.75
π_i	-	-	1250	10,054	40,101	50,809 (deviant)
Π	114,002	82,250	18,750	50,270	80,202	84,676 (total)
CS	62,001	140,625	140,625	125,316	80,344	70,563

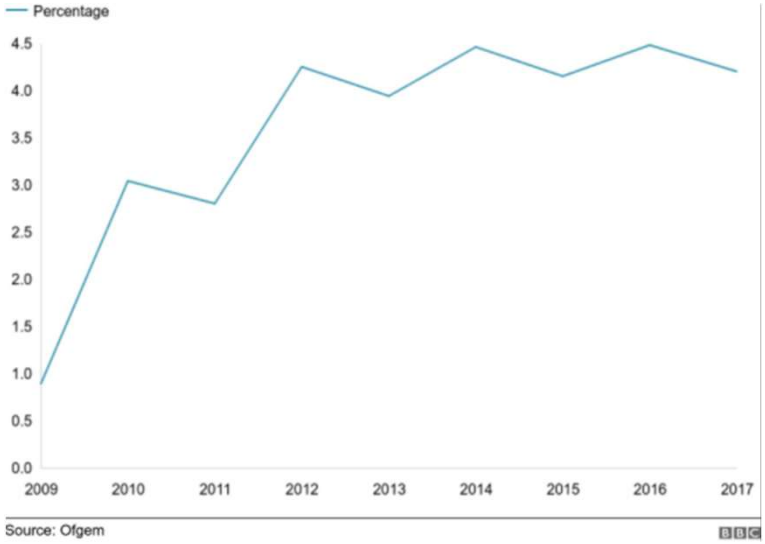
- Reducing the number of firms significantly increases their profitability (eg the difference in profits between 15 and 5 firms)
- This happens at the expense of lower output, higher prices and lower consumer surplus

What happened in the UK as a result of privatisation?

Average annual household energy bills



Profit margins of the main energy suppliers



- The UK experience suggests that privatisation can benefit shareholders at the expense of consumers
  - Regulatory and political 'capture' by the firms at the expense of consumers
- In the UK, the underlying question of how best to manage a natural monopoly, ie the electricity generator, has not been adequately addressed