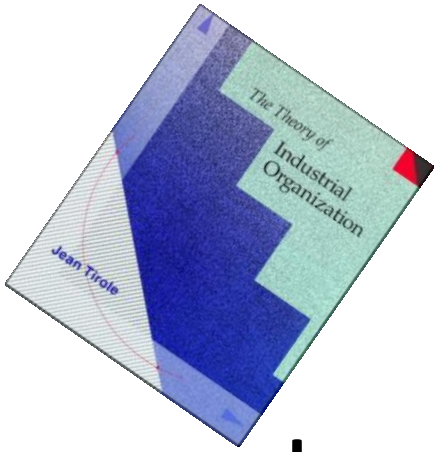


horizontal subcontracting and intermittent power generation

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Authority for Consumers & Markets (ACM)
The Hague, The Netherlands
12:30-17:00

intermittent energy sources

- *increase* the need for flexible back-up capacity



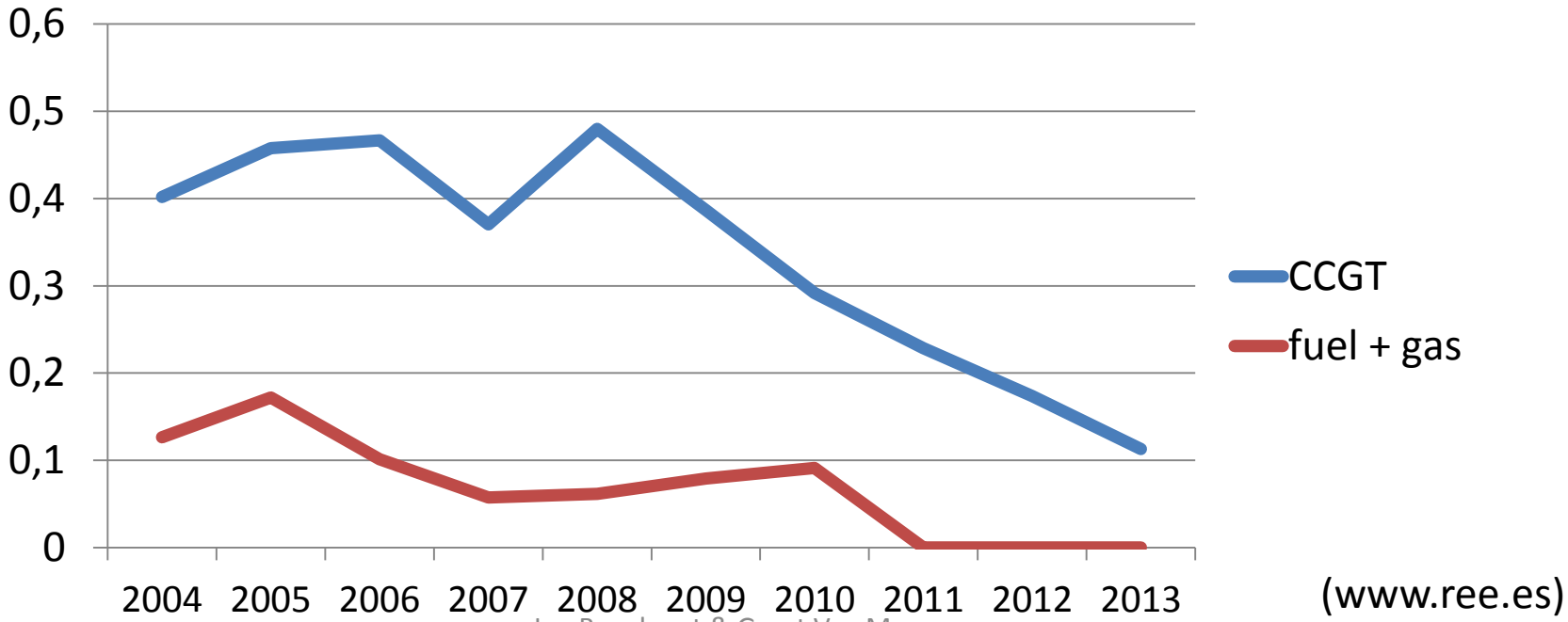
- *reduce* the #hours of operation of conventional capacity
- *decrease* their plant profitability

examples

- 1 MW of wind power removes only 0.2-0.3 MW of reliable energy sources (US)

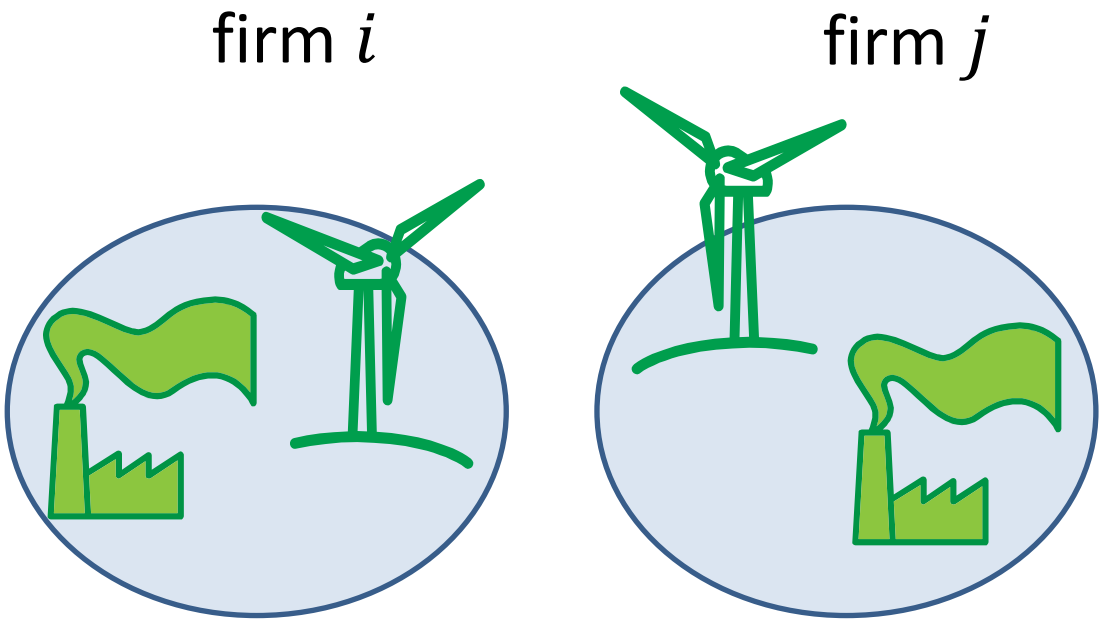
examples

- 1 MW of wind power removes only 0.2-0.3 MW of reliable energy sources (US)
- capacity factors (Spain)

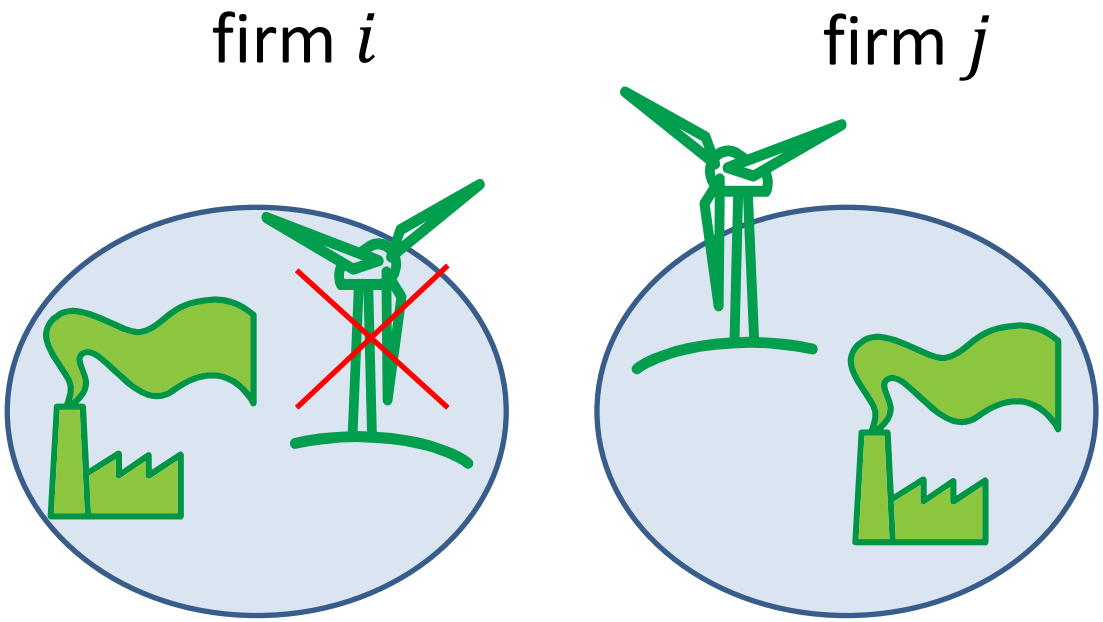


(www.ree.es)

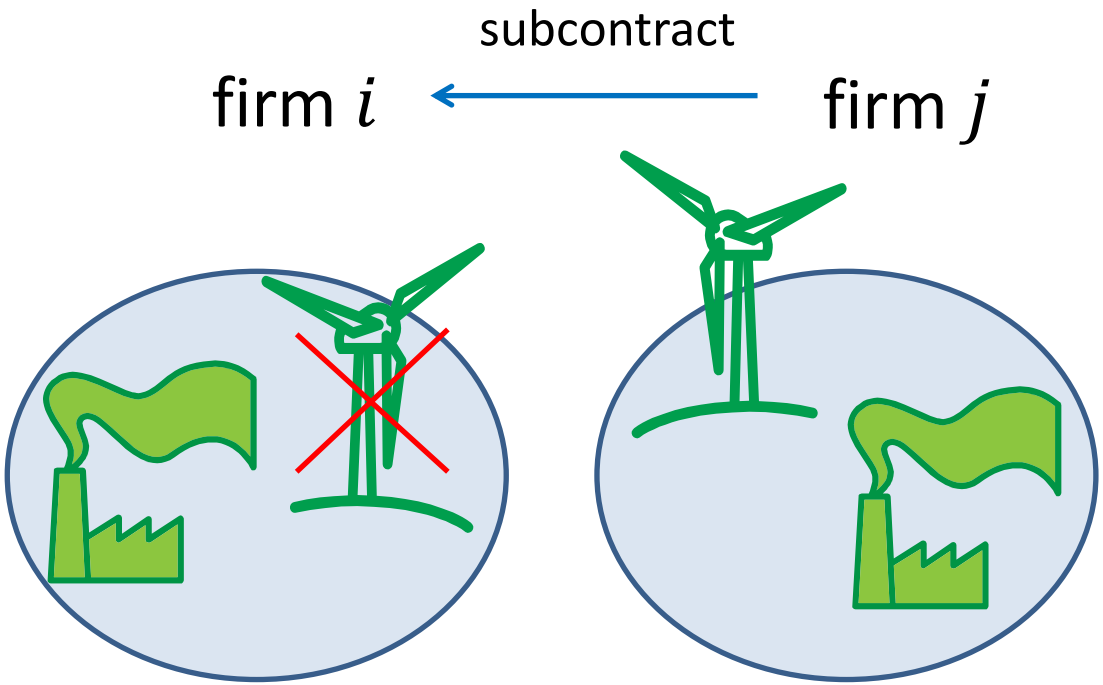
reliable and intermittent sources



reliable and intermittent sources



horizontal subcontracts!



firms gain from outsourcing conventional generation to the wind-abundant rival

what's new?

- literature : Kamien et al. (1989), Spiegel (1993)
  - gains from subcontracting
  - the subcontracting terms alter equilibrium behavior

subcontracting literature:

- state-contingent option contracts
- consumer welfare: Cournot can outperform Bertrand

power markets literature:

- plant profitability underestimates firms' willingness to invest: conventional plants *need* not be used to maximize profits

plan of the talk

- general set-up
  - conventional plants and plant profitability
- analysis
  - equilibrium
  - welfare
- the option contract
  - competition
  - collusion
- discussion & robustness
- conclusions

the model

- symmetric duopoly
- two production technologies
  - intermittent, zero marginal cost
  - expensive back-up: $TC = 0.5\beta q^2$
- two-stage game
  - stage 1: competition for customers
    market demand $Q = 1 - p$
  - stage 2: subcontracting

stage 2: nature reveals state

		firm j: w	firm j: $\bar{w}$
firm i	w	$0.5(-1+2\alpha+\rho)$	$0.5(1-\rho)$
	$\bar{w}$	$0.5(1-\rho)$	$0.5(1-2\alpha+\rho)$

- $\alpha =$ prob. wind-abundant $\Rightarrow$ f**irm-intermittency**
- $\rho =$ prob. both firms have identical generation conditions $\Rightarrow$ **system intermittency**

stage 2: gains from subcontracting

Firm i \ Firm j	w	$\bar{w}$
w	0	$TC(q_j)$
$\bar{w}$	$TC(q_i)$	$TC(q_i)+TC(q_j)$ $-2TC\left(0.5(q_i+q_j)\right)$

- efficient subcontracts
- seller appropriates share $0 \leq \sigma \leq 1$ of the gains from subcontracting

back-up cost parameter β

- determines generation costs if $(\overline{w}, \overline{w})$
- determines gains from subcontracting

=> installing back-up

- limits the price paid for subcontracting
- is profitable, even if never used

Link with ***Tirole***'s work

- *Maskin-**Tirole*** (1988, *Econometrica*): unused capacity as a retaliatory weapon

  "[firms] accumulate capacities above the level necessary to supply half the market at the monopoly price, and yet charge the monopoly price forever. That is, the firms *accumulate capacities that they never use* simply to make undercutting less attractive for their rivals."

We add: idle capacity limits the "hold-up" problem.

Link with ***Tirole***'s work

- *Laffont-Rey-**Tirole*** (1998, *RAND*): "bill-and-keep" vs. usage charge

  "[A] "bill-and-keep" system in which networks do not pay each other access charges is not equivalent since a network's incentive to raise price is affected by the existence of a positive access charge."

We uncover: same logic applies in power market.

Bertrand: *i*'s profit function

- if *i* sets the *lowest* price
  - customer revenues - costs no subcontracting

$$(1-p_i)\,p_i-(1-\alpha)TC(Q(p_i))$$

$$+$$

  - appropriated gains from subcontracting

$$(1-\sigma)\underbrace{\left(\frac{1-\rho}{2}TC(Q(p_i))+\frac{1-2\alpha+\rho}{2}0.5TC(Q(p_i))\right)}_{\text{expected gains from subcontracting}}$$

Bertrand: i's profit function

- If rival j sets the *lowest* price
  - customer revenues - costs no subcontracting

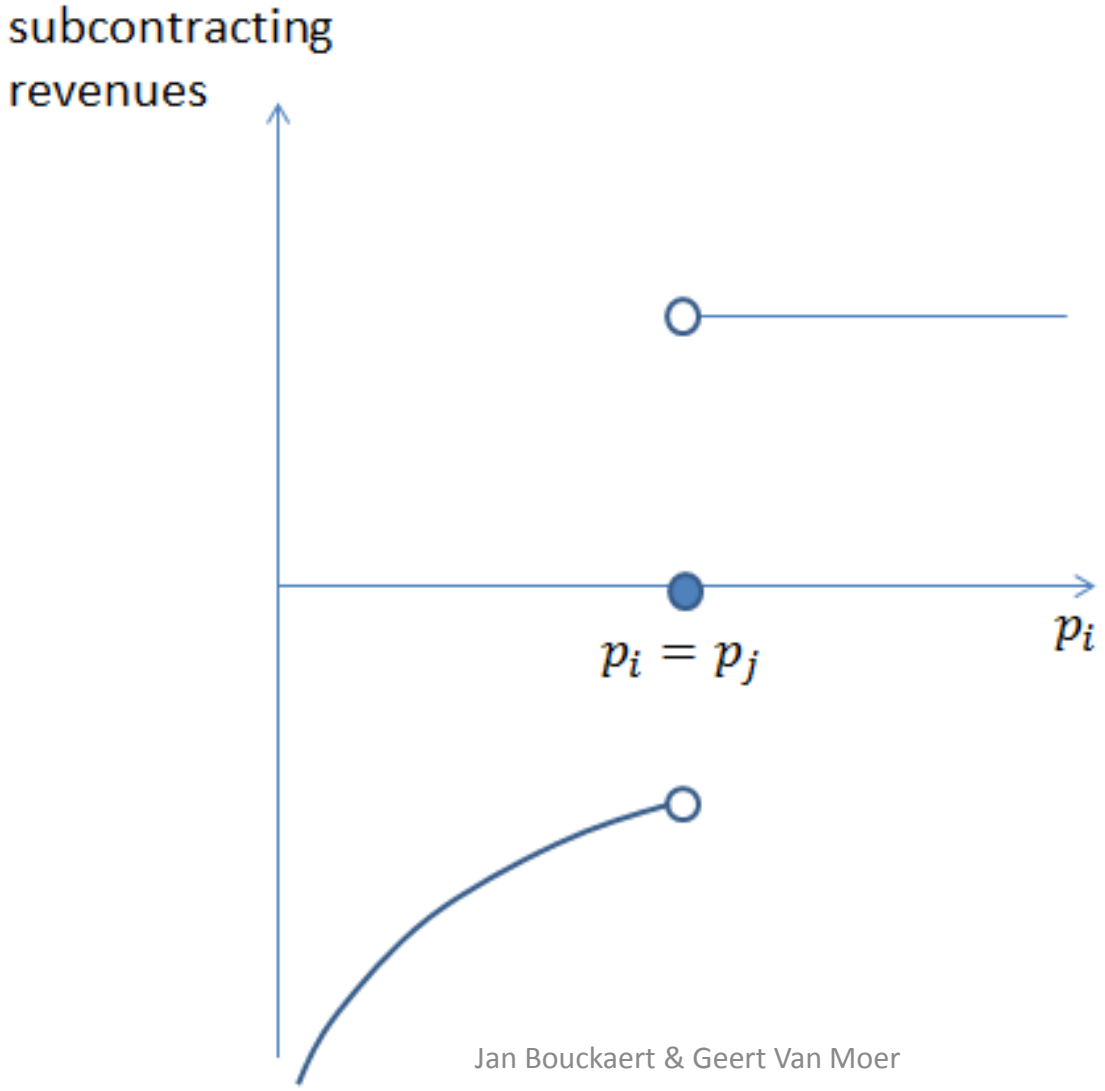
$$0$$

$$+$$

  - appropriated gains from subcontracting

$$\sigma\left(\frac{1-\rho}{2}TC\left(Q(p_j)\right)+\frac{1-2\alpha+\rho}{2}0.5TC\left(Q(p_j)\right)\right)$$

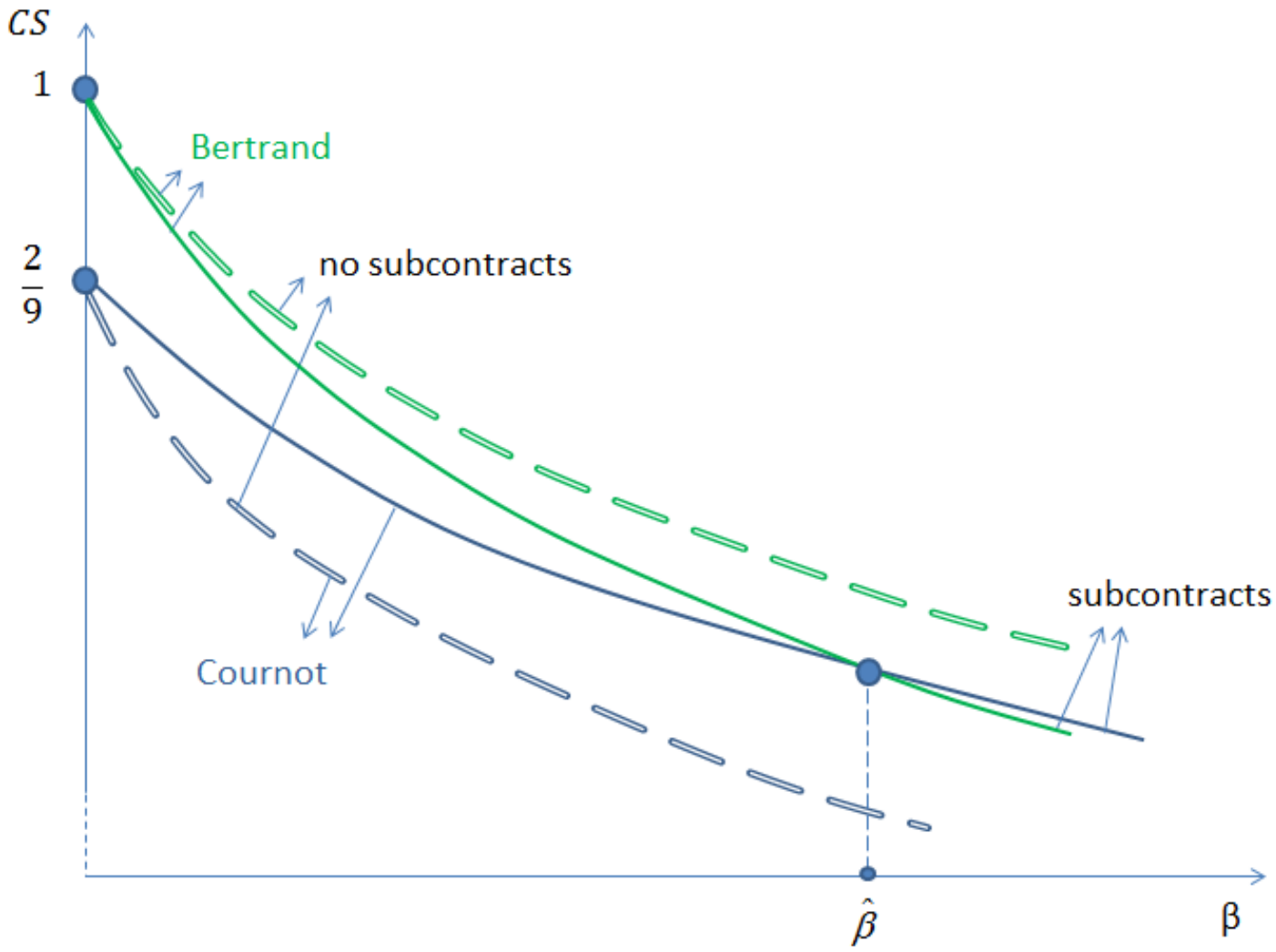
subcontracting revenues



Bertrand-equilibrium price p^*

- increases in σ
  - subcontracting costs go up
  - high-price firm boosts subcontracting revenues
- can result in less competition compared to Cournot outcome

consumer surplus



profit-maximizing subcontracting terms

- are set in a binding “ex ante option contract”, after which firms compete
- are a device to increase profits

profit-maximizing subcontracting terms

firms

- non-cooperatively set identical $\boldsymbol{\sigma} = \sigma_a$
- maximize profits s.t. $\sigma_a \leq 1$
  (option contract must outperform in-house production)
- set $\sigma_a^* = 1$ if back-up is cheap
- charge $\sigma_a^* < 1$ if back-up is expensive:
- can non-cooperatively implement monopoly profits

colluding subcontracting terms

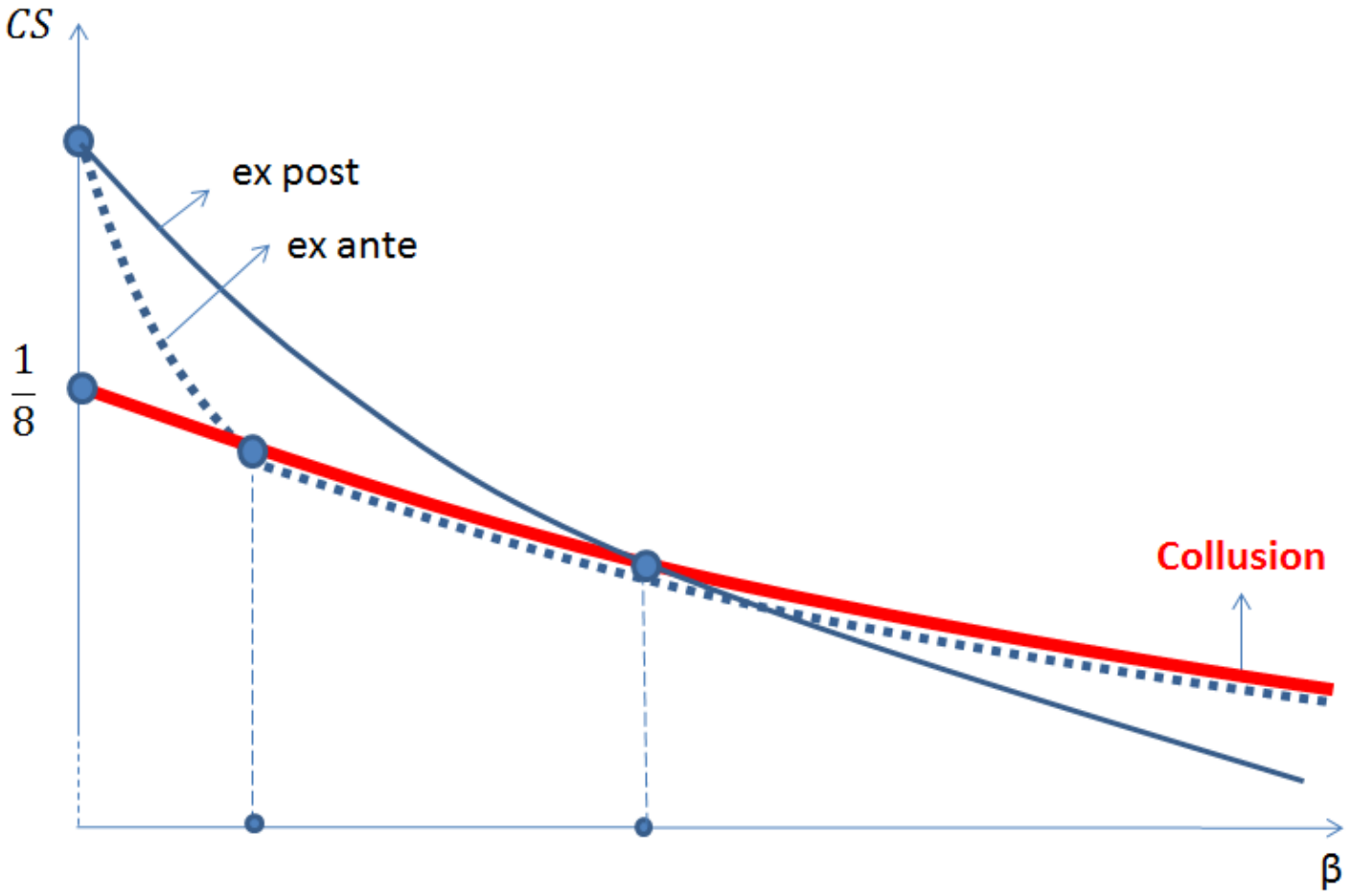
- are set in a binding option contract, after which firms collude
- are a device to minimize critical discount factor

colluding subcontracting terms

colluding firms set $0 \leq \sigma_a^c \leq 1$ to minimize deviation profits:

- $\sigma_a^{c*} = 1$ if back-up is cheap
  intuition: increase subcontracting payments
- $\sigma_a^{c*} < 1$ if back-up is expensive
  intuition: deviation/competing coincides with colluding

profit-maximizing subcontracts need not deteriorate consumer surplus



discussion and robustness

- supply function competition
- limited wind
- oligopoly
- linear tariffs
- arbitrage
- subsidies and taxes

insights

- conventional plants *need* not be used to maximize profits
- consumer welfare: Cournot can outperform Bertrand
- subcontracting terms
  - maximize each firm's profits non-cooperatively
  - need not deteriorate consumer surplus

THANK YOU!