Capacity choice, technology mix and market power

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Liberalization

Historically

1. Chaotic development of systems ;
2. regulation because of
   - the need for coordination of transport and generation ;
   - and increasing returns in transport and generation (nuclear, coal hydro).
3. 'deregulation' for several reasons :
   - political ;
   - conceptual (peak-load pricing, natural monopoly...) ;
   - technological.

Liberalization

Technological changes :

- Combined cycle gas turbine (CCGT) :

  small, flexible, standardized ;

- CCGTs are perceived as the main vehicle for competition.

  new technology using CCGTs makes entry at modest scales simple and quick : construction times are short, and the technology is readily available and is competitive with existing larger thermal stations.

  David M. Newbery (1992)

- But 'renaissance' of nuclear and coal that are 'specific' technologies ;
- Limited access to hydro resources ;

$\longrightarrow$ firms are heterogeneous.

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$\longrightarrow$ firms are **heterogeneous**.

Investment

From over to under investment ?

- Regulated regime was criticized for overinvestment ;
- with liberalized regime there are concerns about underinvestment (or suboptimal one) ;
- initial concerns about peaking units because of reliability issues,
- extend to baseload (and capital intensive) one !

$\longrightarrow$ Three (main) explanations :

  - missing money ;
  - risk ;
  - market power.

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Investments

Ingredients :

- Heterogeneous firms ;
- strategic in the long term ;
- several technologies ;
- variable load.

Dish :

- a highly tractable mode ;
- comparative statics on the number of firms ;
- positive and normative results.
- Welfare consequences of development of competition via a unique technology ?

Literature

Capacity choice with variable demand :

Short term - quantity competition :

- Gabsewicz and Poddar (1997) ;
- Zoetl (2008)(chap 1) ;

Existence and uniqueness of equilibrium ; variation $\longrightarrow$ capacity $\nearrow$.

Short term - price competition

- von der Fehr and Harbord (1997) ;
- Reynolds and Wilson (2000) ;
- Fabra and al. (2008).

No symmetric equilibrium ! Design of auctions.

Literature

Technological mix :

- With Cournot competition there is a strategic incentive to invest in baseload capacity (Murphy and Smeers, 2005) and Zoetl, 2008, chap 4).
- With 'competitive' spot market there is an incentive to underinvest in aggregate capacity and in baseload capacity (von der fehr and harbord, 1997, Arellano and Serra).

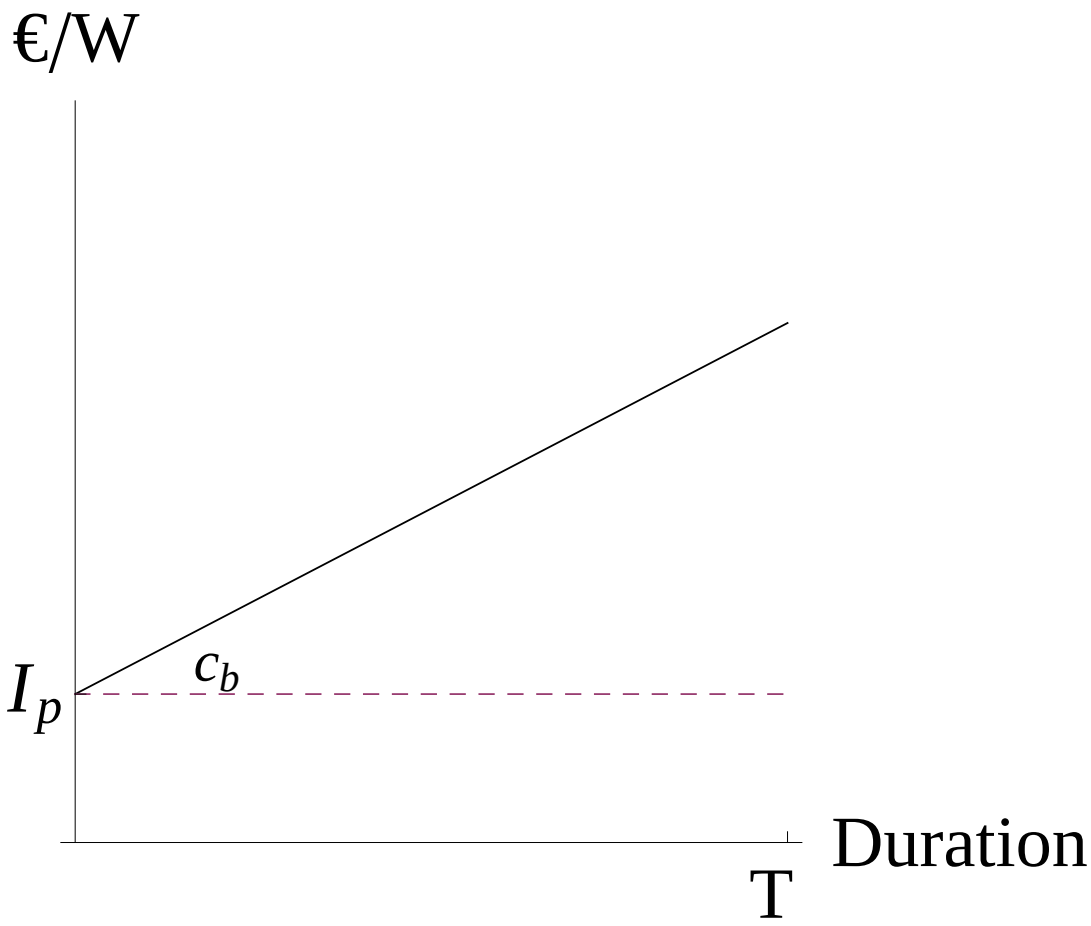
Literature

Heterogeneity :

- All papers mentioned consider identical firms except Murphy and Smeers (2005) ;
- and no comparative static is done on the number of firms (analytical difficulty ?) ;
- with homogeneous firms welfare increases with the number of firms.

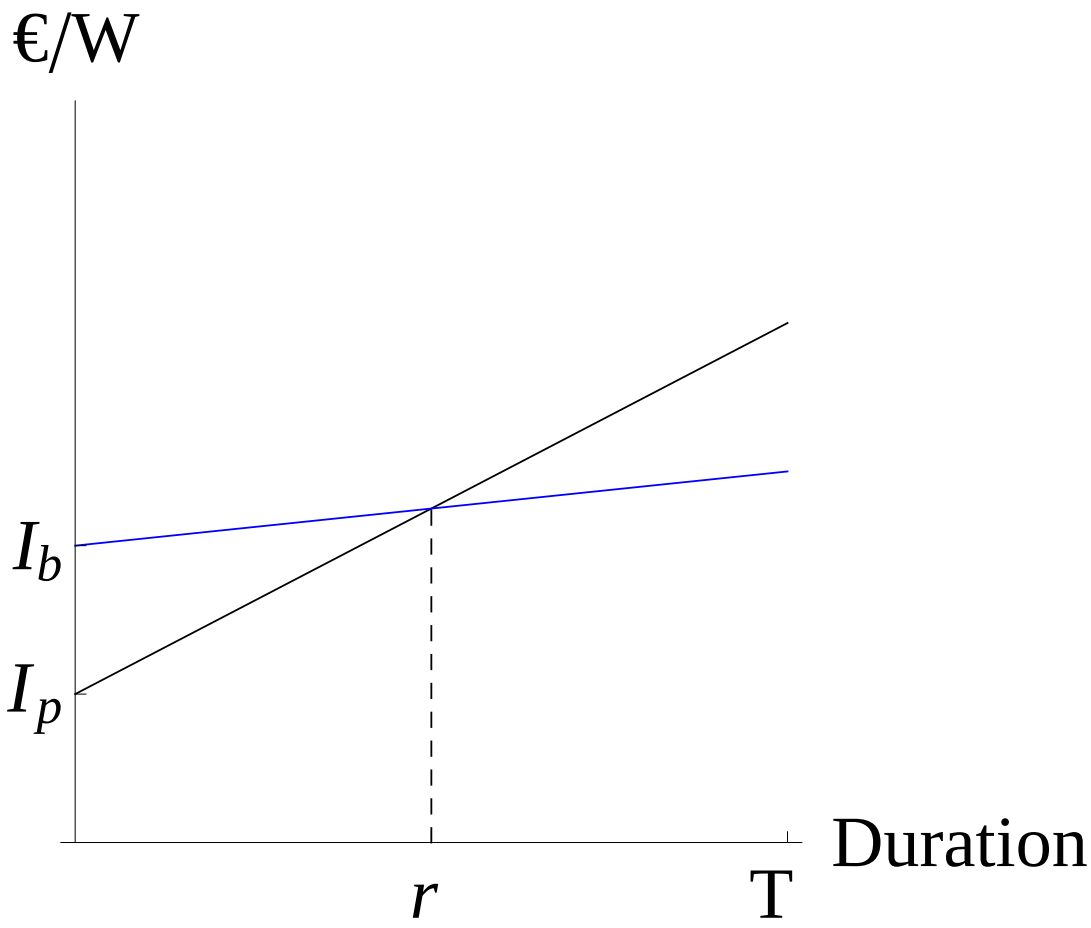
Model

Production costs : peak (p)



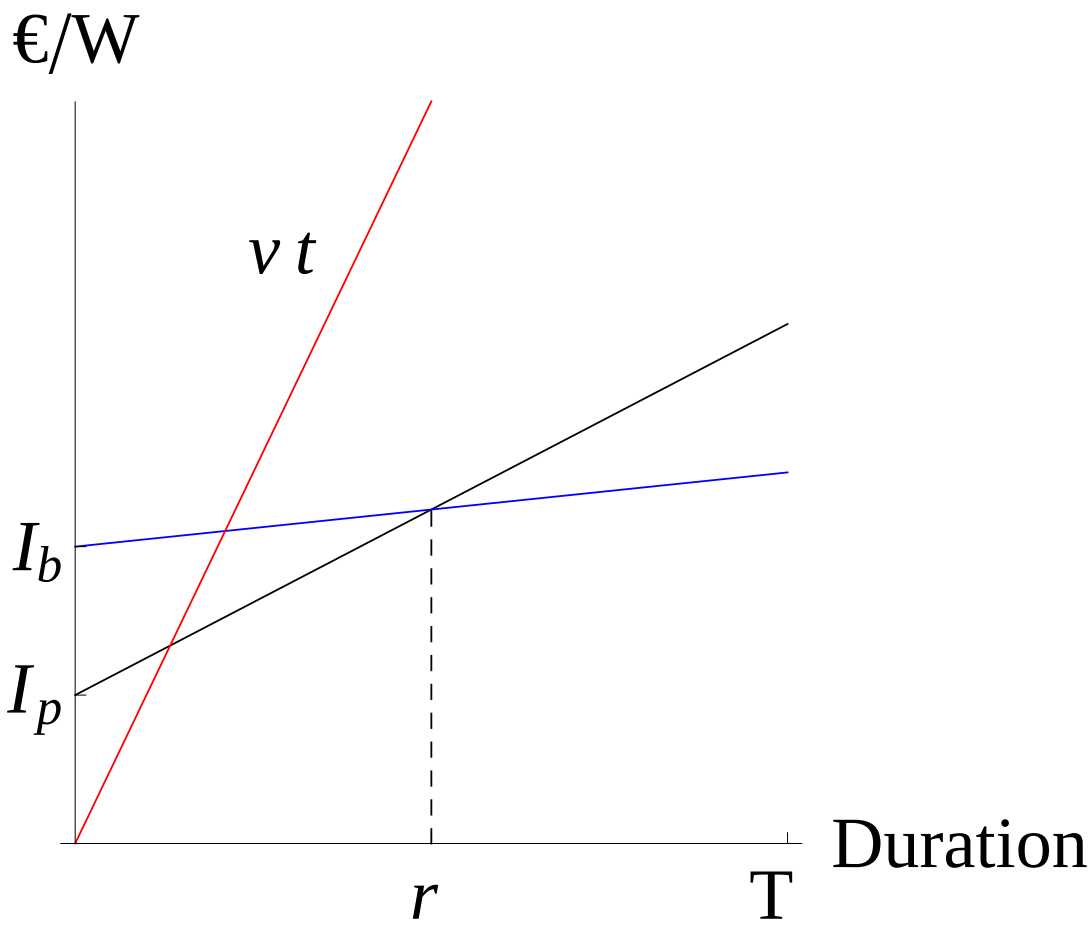
Model

Production costs : baseload(b)



Model

Production costs : surplus



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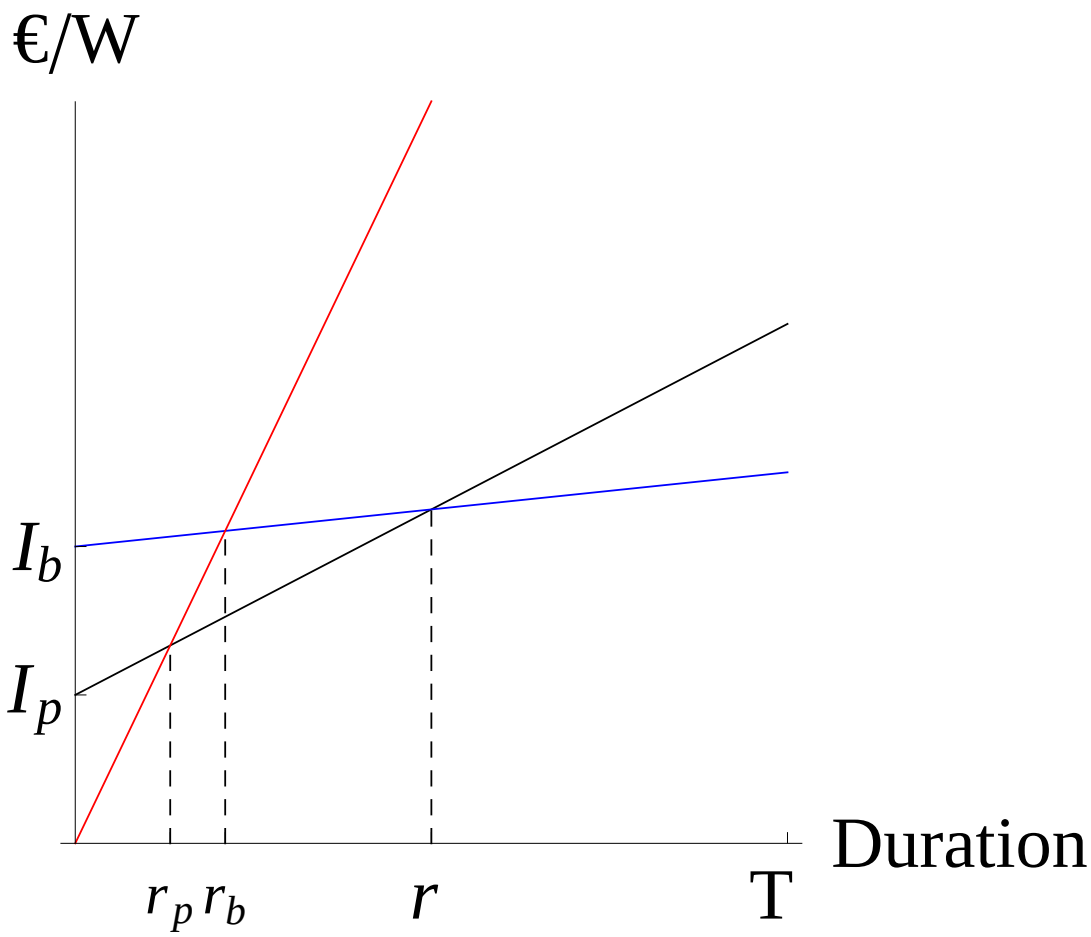
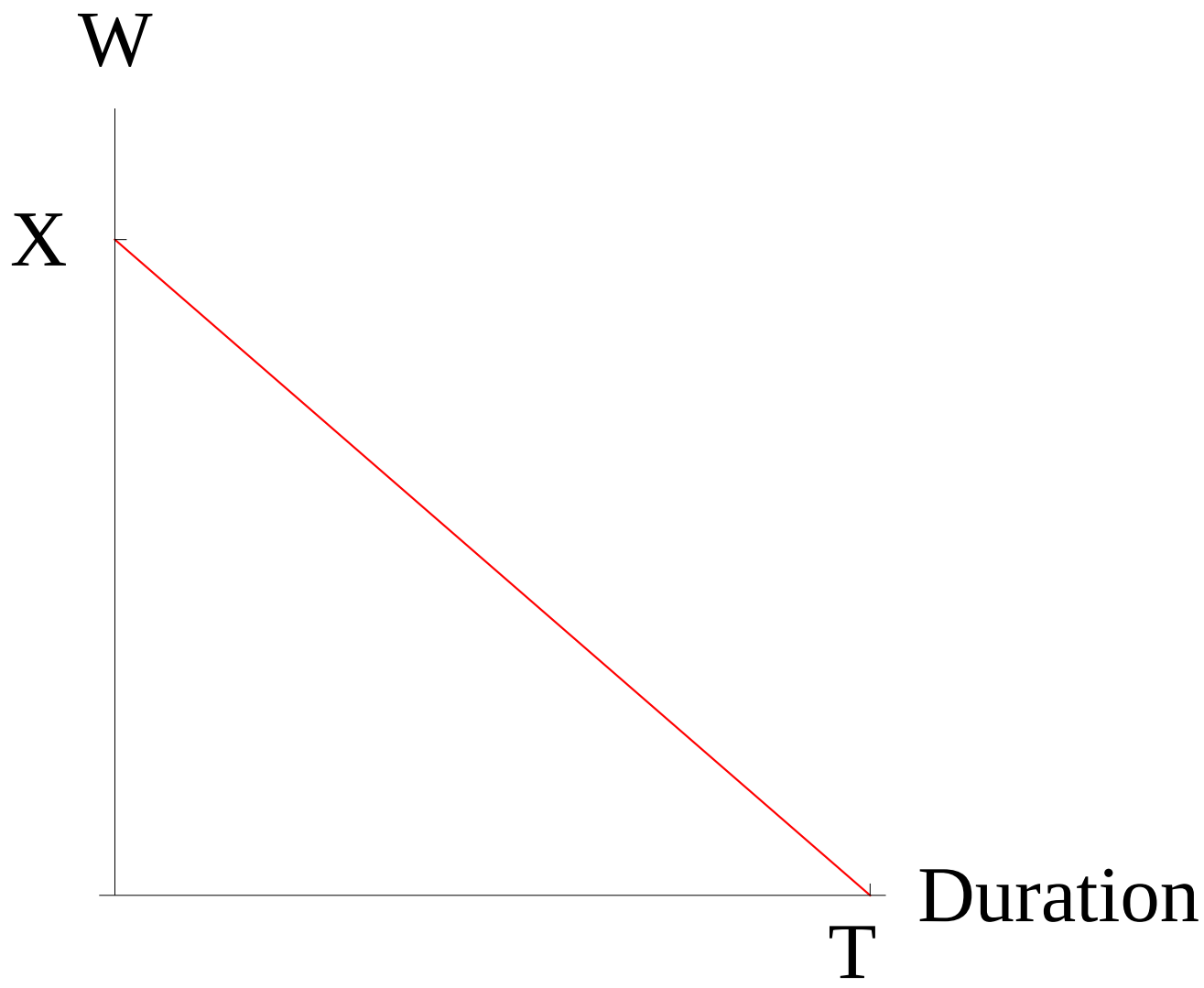


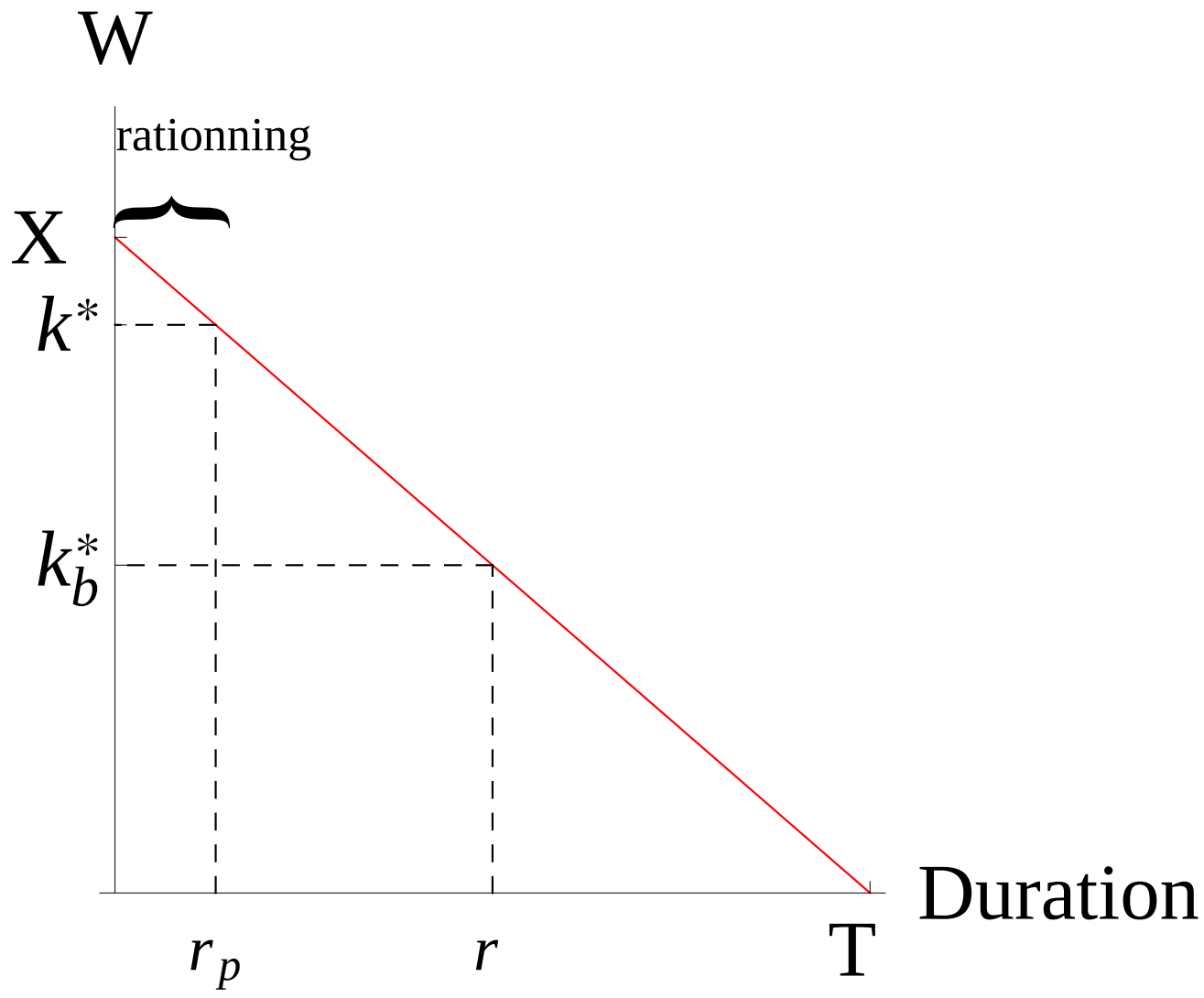
Optimum

Load duration curve :



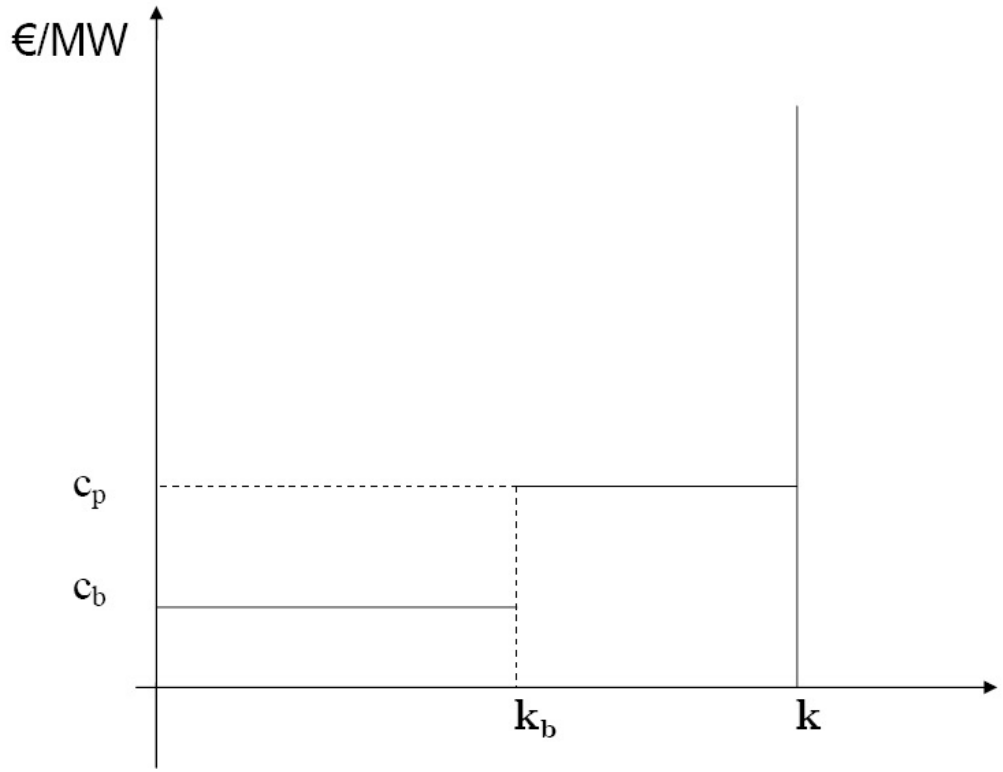
Optimum

Optimal technology mix : k^*, k_b^*



Short term

The short term is assumed ‘competitive’ : the price is fixed at the variable cost of the marginal unit or at the VOLL in case of rationing.



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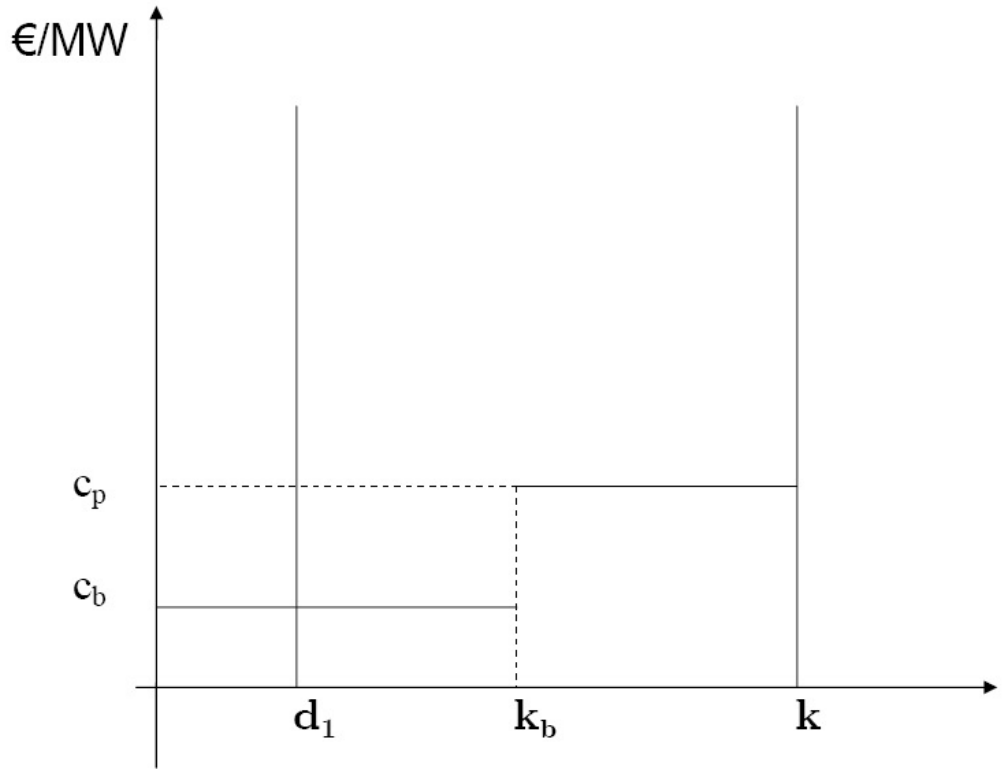

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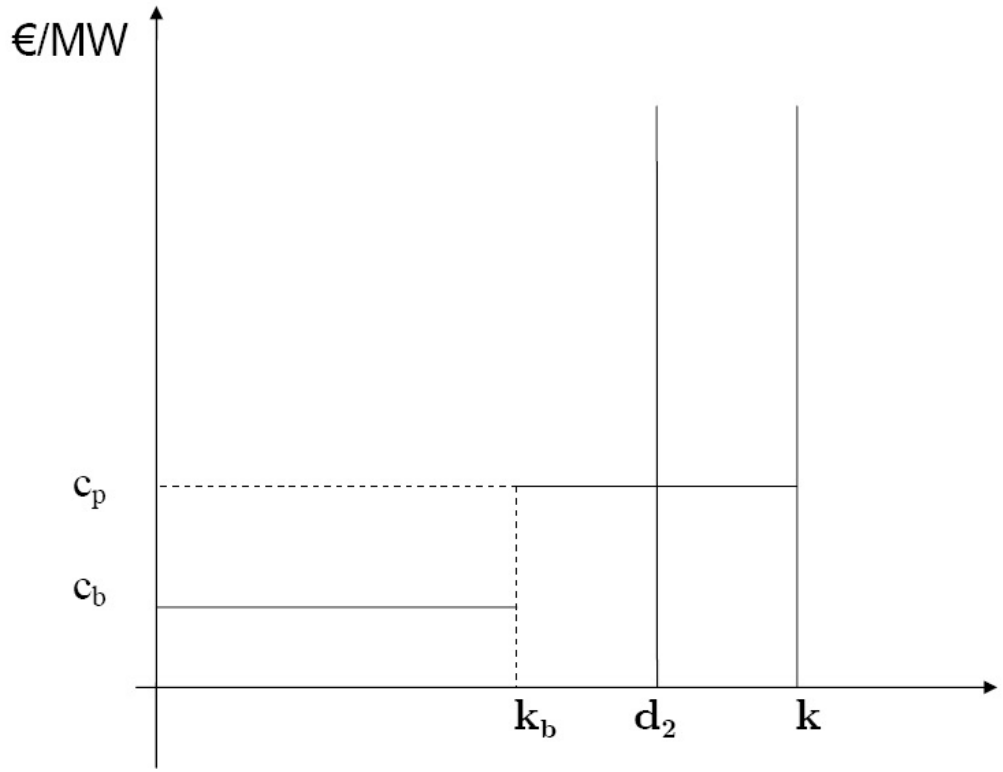

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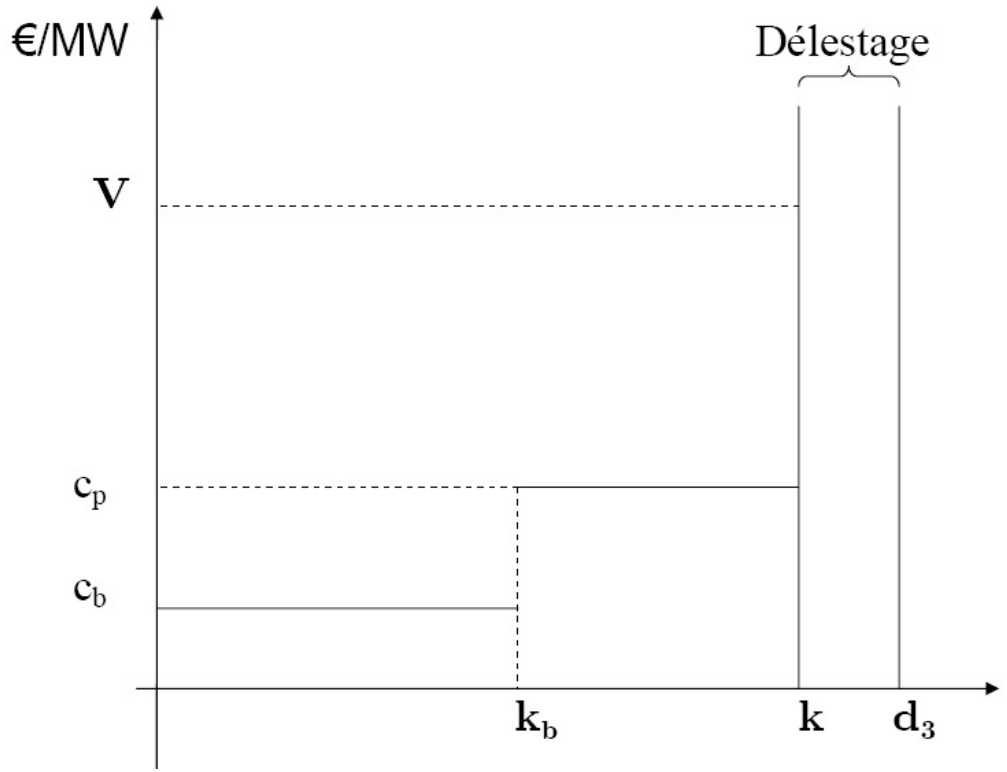

Firms

Heterogeneous firms :

- s_t for $t = b, p$ specialized firms that can only invest in technology t ;
- g generalist firms that can invest in both ;
- $n = s_b + s_p + g$

Firms

- Firm i profit is :

$$\begin{aligned}\pi =& \frac{1}{X}\int_{k_b}^{k_b+k_p}(c_p - c_b)\,k_b dx \\ &+ \frac{1}{X}\int_{k_b+k_p}^{X}\left[(v-c_p)k_p + (v-c_b)k_b\right]dx \\ &- I_b k_b - I_p k_p\end{aligned}$$

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- Alternative writing that stresses the role of the technology mix :

$$\begin{aligned}\pi =& \frac{1}{X}\int_{k_b}^{X}(c_p - c_b)\, k_b dx \\ &+ \frac{1}{X}\int_{k}^{X}(v-c_p)k dx \\ &- I_p k - (I_b - I_p)\, k_b\end{aligned}$$

Equilibrium

Proposition

There a unique equilibrium of the capacity game with individual capacities :

$$k_b^S, k_p^S, k_b^G, k_p^G$$

- p-firms limit investment to keep price at v ;
- b-firms have an additional revenue when the price is c_p ;
- the aggregate capacity of a g-firm is equal to a p-firm capacity if they invest in peakers ;
- a g-firm distorts its mix to increase the duration of price at c_p ;
- a g-firm invest in less baseload plants than a b-firm.

Equilibrium

Specialization :

Proposition

Generalist firms do not invest in baseload plants iff $s_b > (n+1)\frac{1-r}{1-r_b}$;
Generalist firms do not invest in peaking units iff $s_p > (n+1)\frac{r-r_b}{1-r_b}$.

- In these case there is 'overinvestment' in one technology :
- Any situation can occur.
- G-firms specialized when there is overinvestment in a technology ;

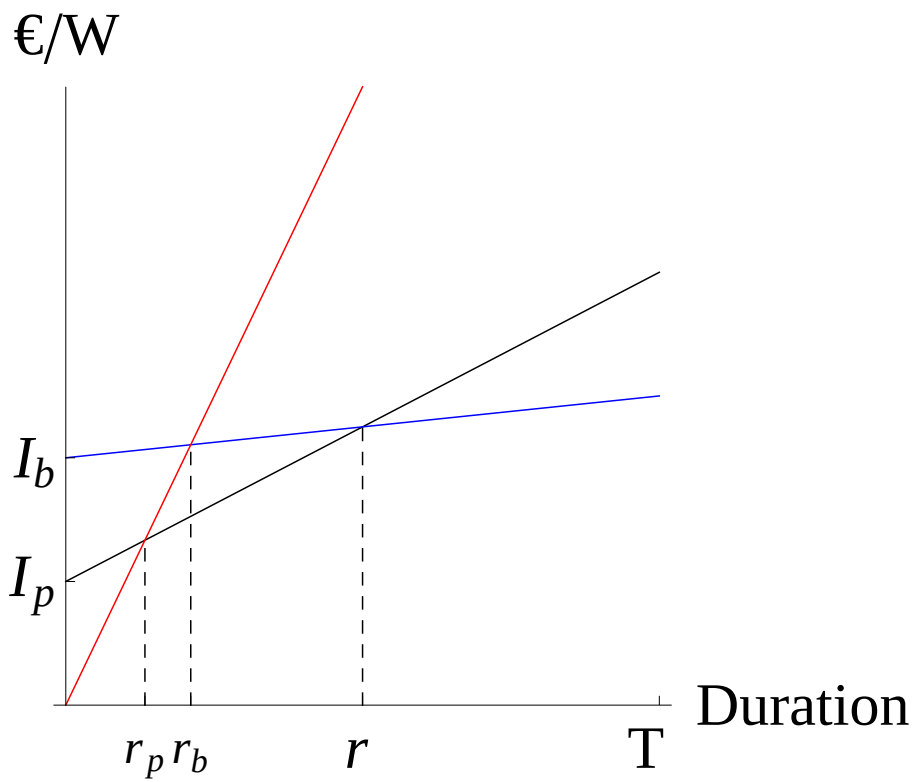
$\rightarrow$ In that case there are less firms than expected that invest in this technology.

Equilibrium

Specialization :

Specialization in peakers iff

$$\frac{s_b}{n+1} > \frac{1-r}{1-r_b}$$



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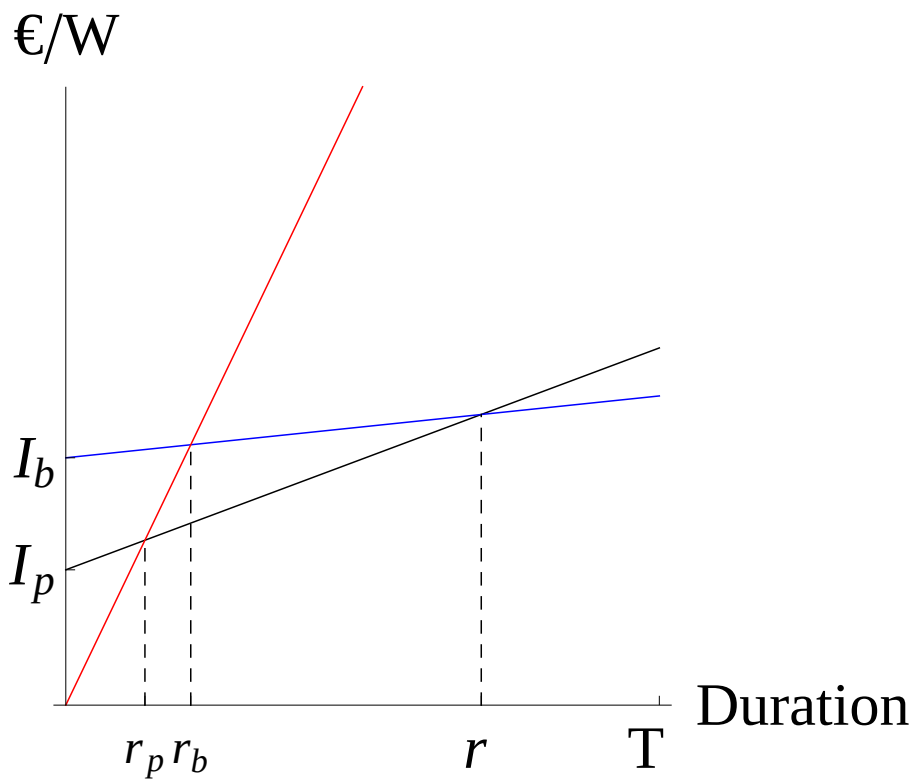
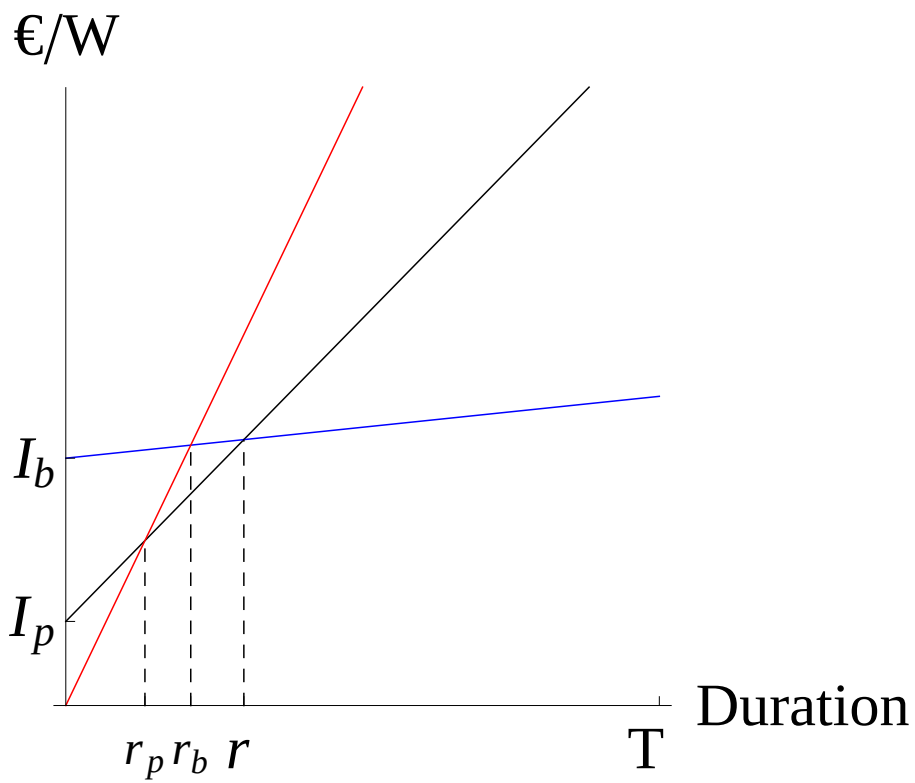


Equilibrium

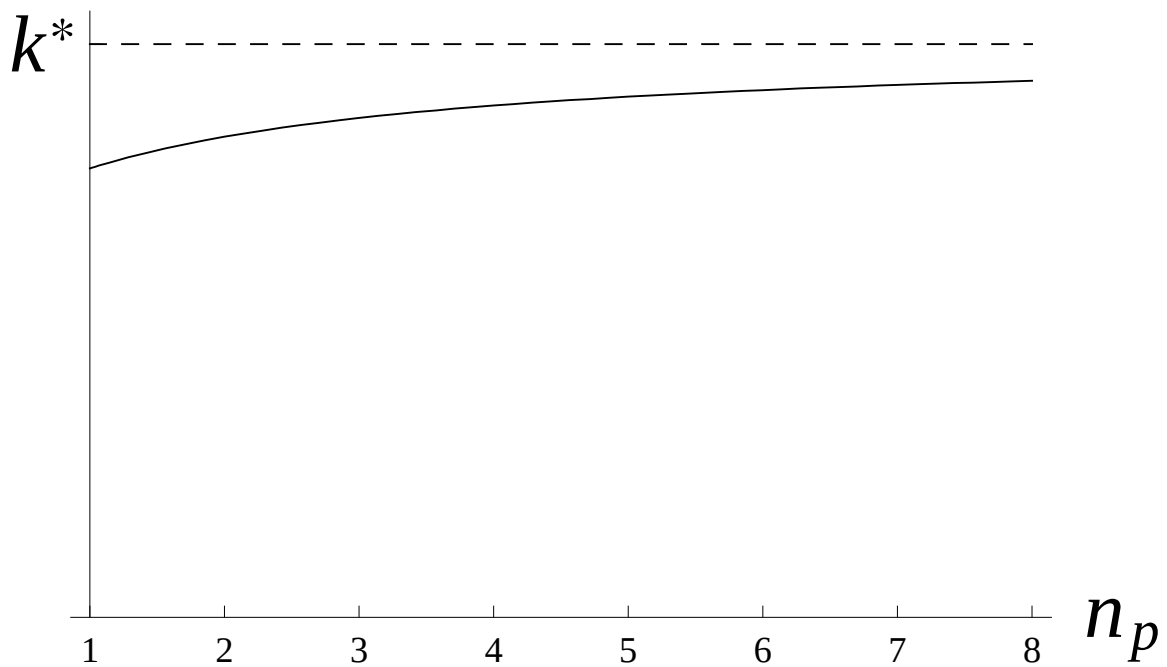
Specialization :
Specialization in baseload iff

$$\frac{s_p}{n+1} > \frac{r - r_b}{1 - r_b}$$



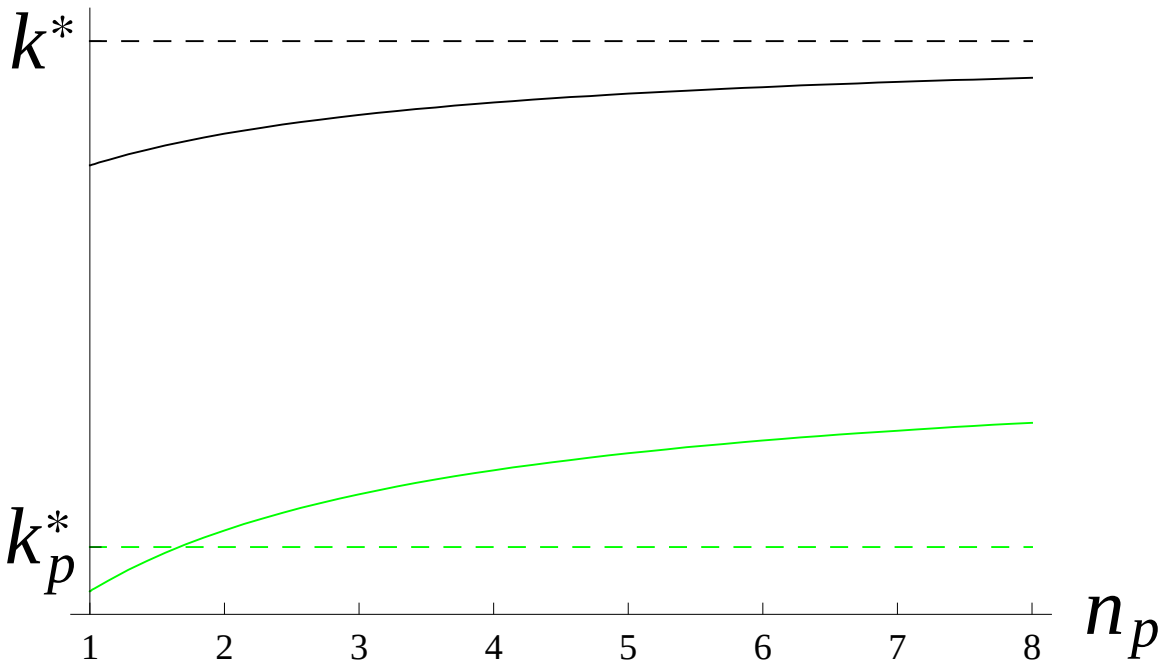
Comparative statics

An increase of the number of peaking firms :
Increases aggregate capacity,



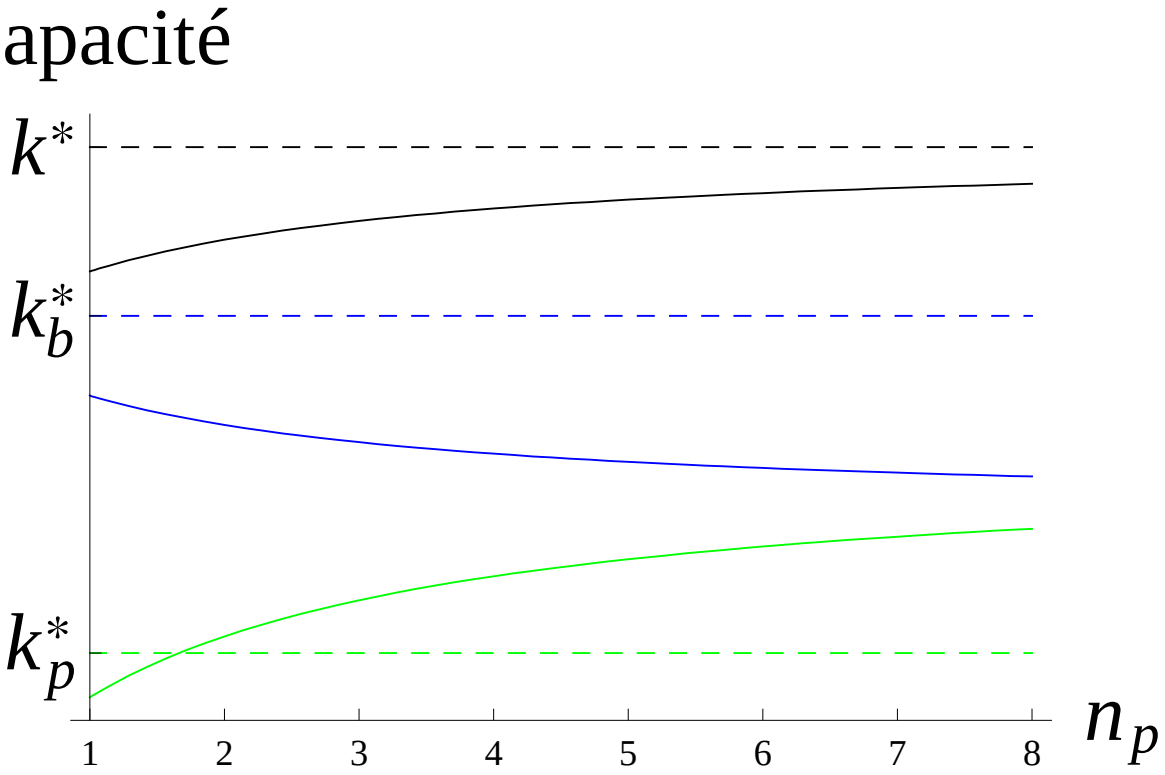
Comparative statics

An increase of the number of peaking firms :
but modify the mix :



Comparative statics

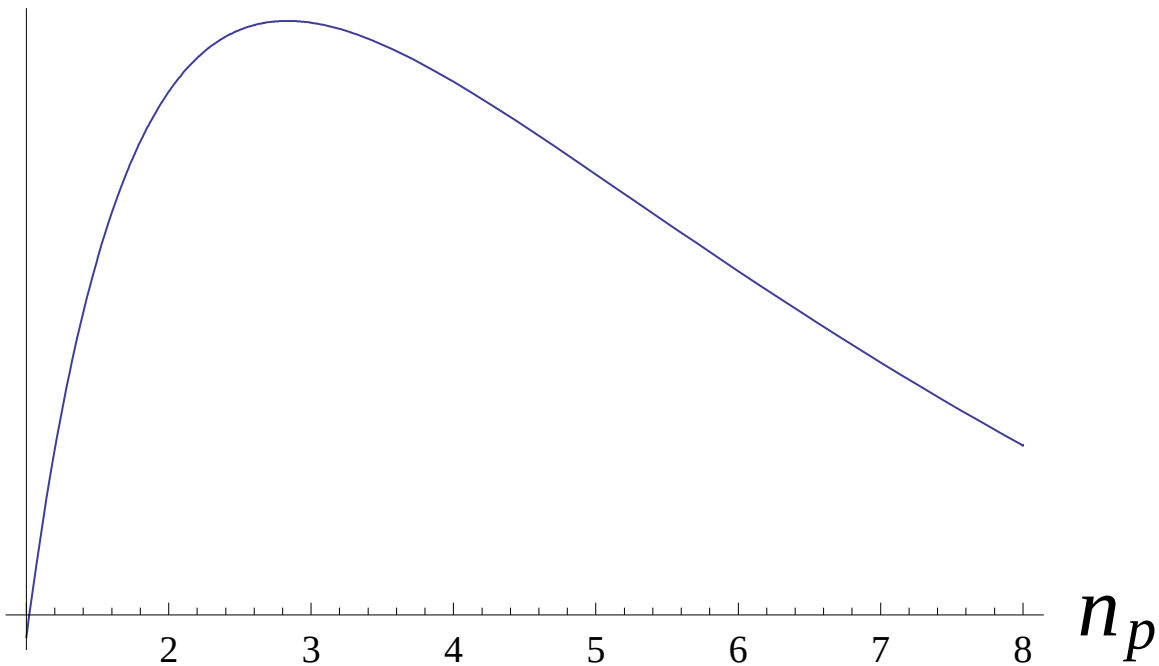
An increase of the number of peaking firms :
with a decrease of baseload :



Comparative statics

An increase of the number of peaking firms :
Welfare is quasi concave :

Welfare



Comparative statics

Proposition

Welfare is quasi concave with respect to s_b, it is increasing iff

$$(s_b + 1)k_p^S > s_b k_b^S$$

Consumers net surplus is increasing with respect to s_p.

the condition can be written :

$$\frac{k_p^S}{K} > \frac{1}{n}.$$

Comparative Statics

Proposition

Welfare is quasi concave with respect to s_b, it is increasing iff :

$$(v - c_b)(s_b + 1)k_b^S > (v - c_p)s_b k_p^S$$

Consumers surplus is increasing with respect to s_b

In both cases the welfare loss is supported by firms.
$\longrightarrow$ literature on welfare loss in Cournot games (Cörchon 2008).
$\longrightarrow$ Here both technologies are 'efficient'.

Policy implications

- To limit the number of competitors ?
- to regulate investment in 'specific' technologies :
  - command and control (France ?),
  - to subsidize investment,
  - to reduce entry barriers.
- In the US and UK, government try to reduce nuclear regulatory costs.

Conclusion

- An efficient spot market is not sufficient to ensure long term efficiency ;
- firms heterogeneity matters ;
- the developemnt of competition through only one technology can be inefficient ;
- technologies should be ‘standardized’ - accessible ;
- or investment regulated (capacity paiements).

Perspectives

- Endogenize the number of active firms ;
- Capacity markets - capacity paiements ;
- Vertical integration.