Incentives for environmental R&D

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Climate Agreements and Climate Policy
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Motivation (climate policy)

- A price on carbon emissions is the most important policy instrument to reduce carbon emissions
- Do we need other instruments in addition to a carbon tax (or quotas)?
- Yes if other market failures
- Markets for knowledge creation are imperfect
- But is there a difference between environmental R&D and other R&D?

Relationship with previous literature

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Present paper:

- private sector R&D
- compares environmental R&D with marked goods R&D
- assumes environmental policy is set optimally but without commitment

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- competitive downstream sector
  - output is a regular market good
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  - output is a regular market good
  - output is abatement
- an upstream monopolistic R&D sector
- emission tax or quotas as the policy instrument
- no commitment

The analysis

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2. calculate the innovator's future equilibrium revenue from this innovation
3. higher revenue implies larger incentives for R&D
4. compare the revenue for two cases:
   - an ordinary market good
   - abatement

Notation

x	output/abatement
p	output price/emission tax or quota price
ℓ	price of new technology per "something"
$v(x,\ell)$	revenue to innovator
$B'(x)$	inverse demand/marginal benefit of abatement
$C(x,0)$	aggregate social cost function if technology were free
$C(x,\ell)$	actual aggregate social cost function
$C(x,\ell)+v(x,\ell)$	actual aggregate private cost function

A regular good

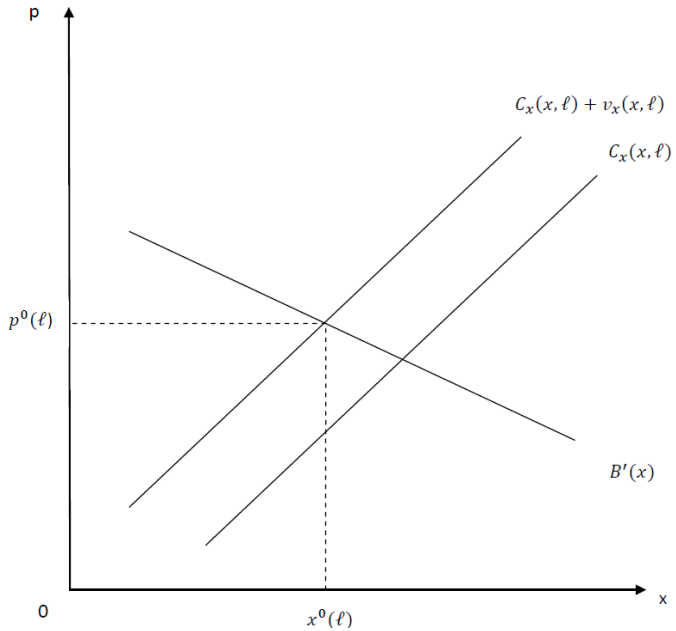


Figure 2

A regular good

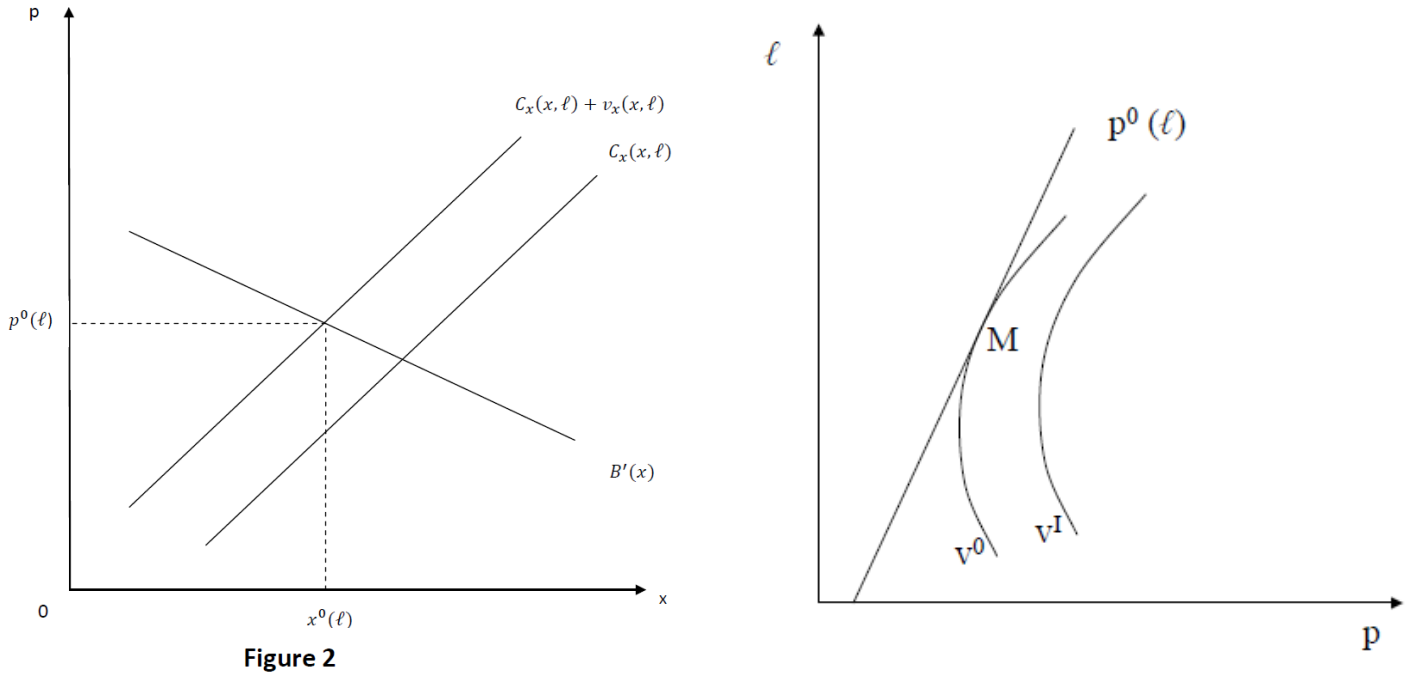


Figure 2

The innovator chooses its price ℓ to maximize $v(x^0(\ell), \ell)$, giving the point M

Abatement

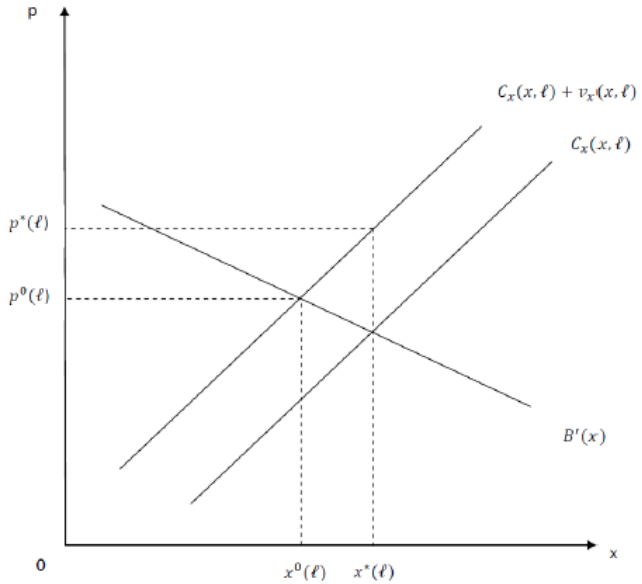
Four possible decision sequences

1. p or x – R&D – ℓ – technology choice and abatement
2. R&D – p or x – ℓ – technology choice and abatement
3. R&D – ℓ – p or x – technology choice and abatement
4. R&D – ℓ & p or x – technology choice and abatement

Present analysis considers 2, 3 and 4

The tax is set after the licence fee

Regulator's response function is defined by the solution to $\max_x [B(x) - C(x, \ell)]$
giving $x^*(\ell)$ and $p^*(\ell)$ defined by $B'(x) = C_x(x, \ell)$



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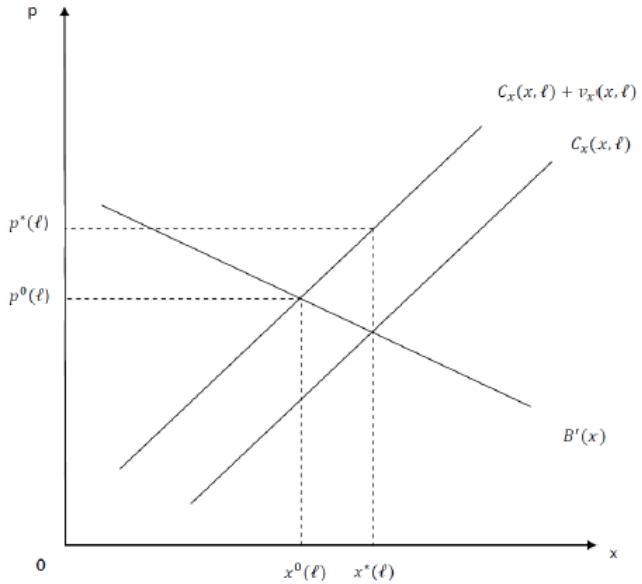

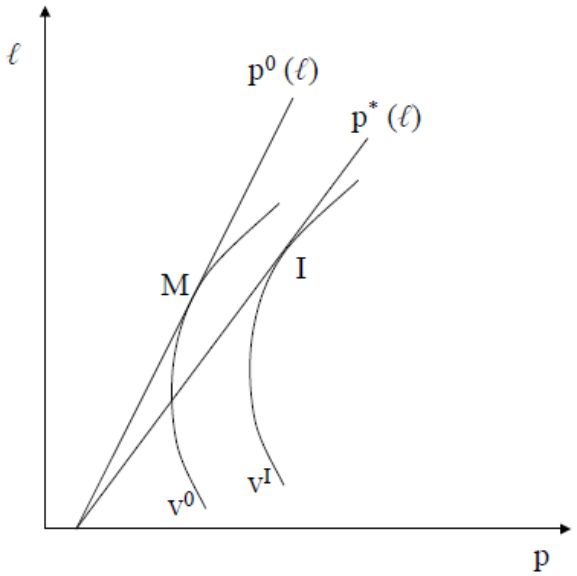

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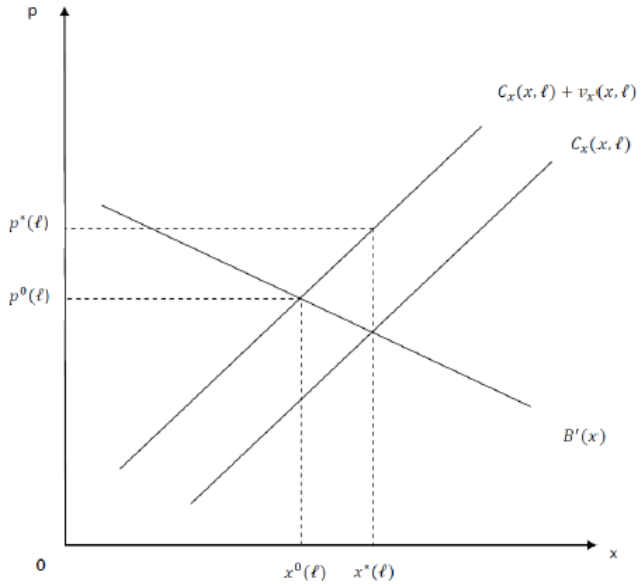

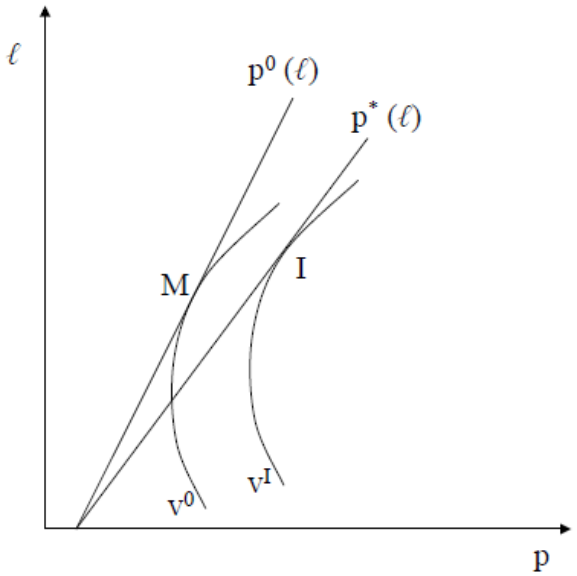

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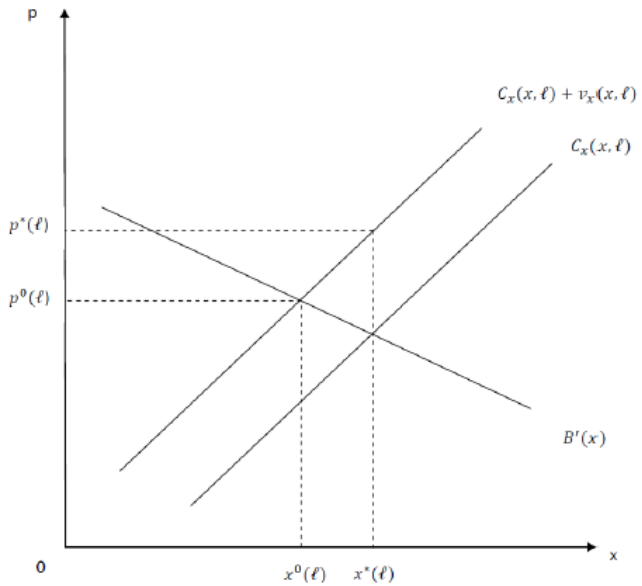
Proposition 1: *If environmental policy (tax or quota) is set after the innovator sets the licence fee, incentives are higher for environmental R&D than for market goods R&D.*

The tax is set simultaneously with the licence fee

Innovator's response function $\ell(p)$ is defined by the solution to $\max_\ell [v(x(p,\ell),\ell)]$, giving the curve $\ell(p)$



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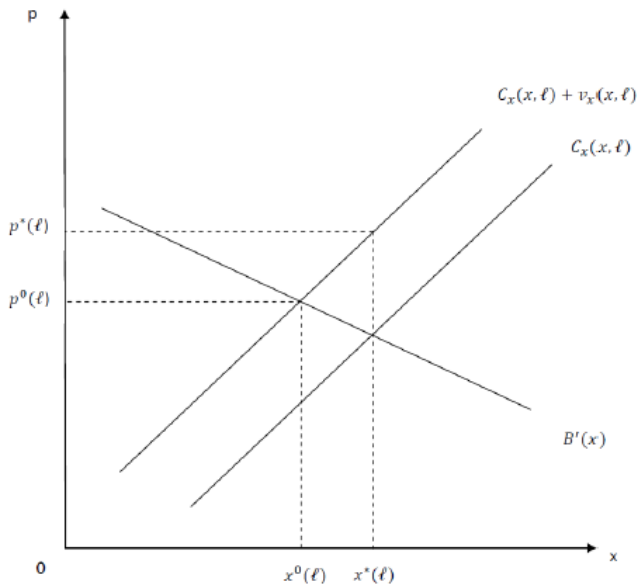

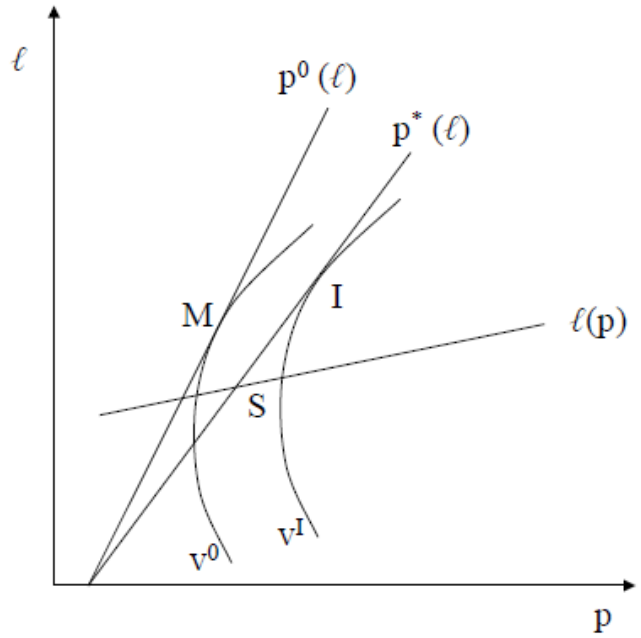

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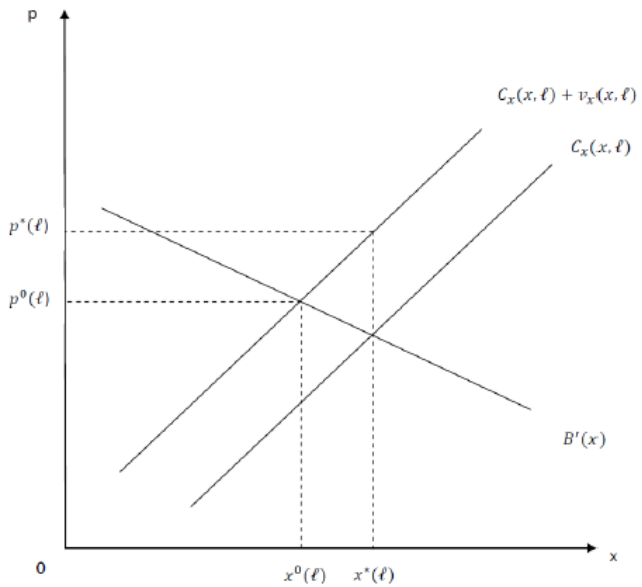
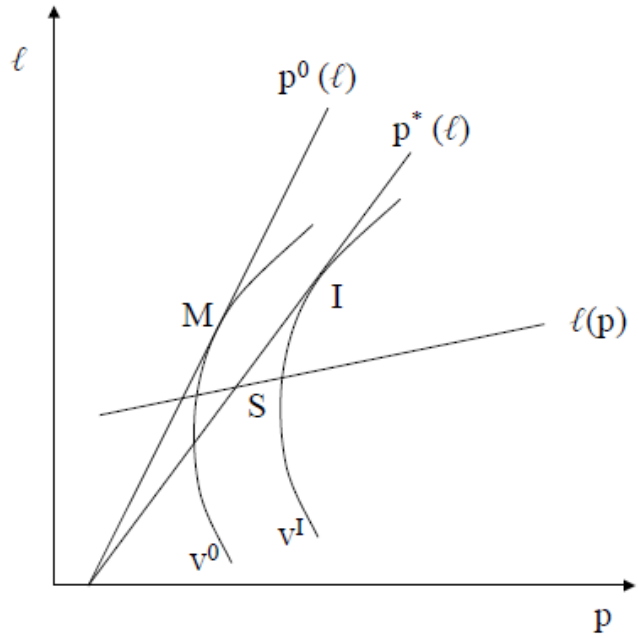
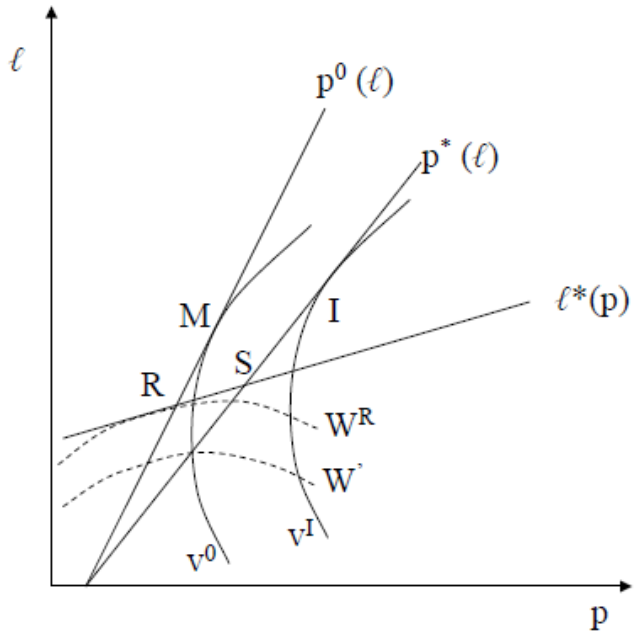




Proposition 2: *If the emission tax is set simultaneously with the innovator setting the licence fee, incentives are higher for environmental R&D than for R&D for market goods if B'' is sufficiently small.*

The tax is set prior to the licence fee



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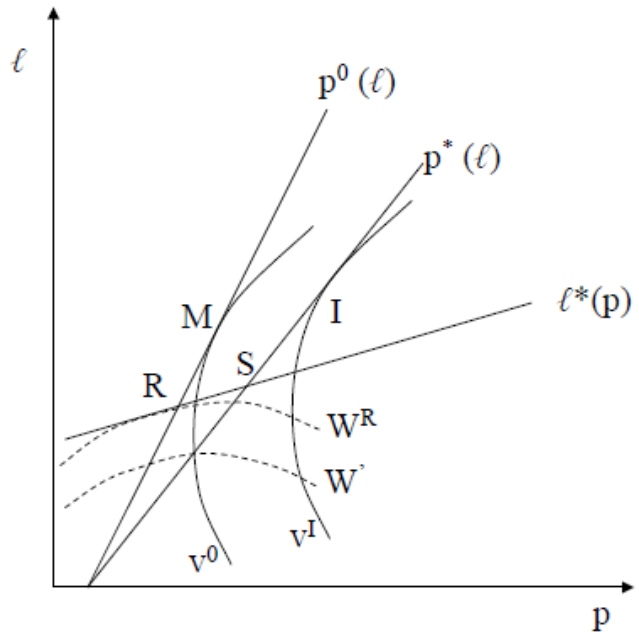

Using an example we show that

Proposition 3: *If the emission tax is set before the innovator sets the licence fee, the sign of* $v^R - v^0$ *is ambiguous. For the case of* $B'' = 0$*, the sign of* $v^R - v^0$ *is equal to the sign of* $p - B'$*.*

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- If environmental policy is set simultaneously with or prior to the licence fee, the regulator's payoff $B(x) - C(x, \ell)$ is always at least as high with an optimal tax as with an optimal quota.
- If quotas nevertheless are used, we find the same ambiguity as with taxes.

All of the benefits from R&D captured by the innovator

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- Fixed number of firms
- Each firm benefits from the new technology but to a different degree
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$V = \left\{\max_x [px - C(x,0) - \ell x] - \pi^{old}(p)\right\} + \ell x = V(p,x)$

Properties of the innovator's revenue function

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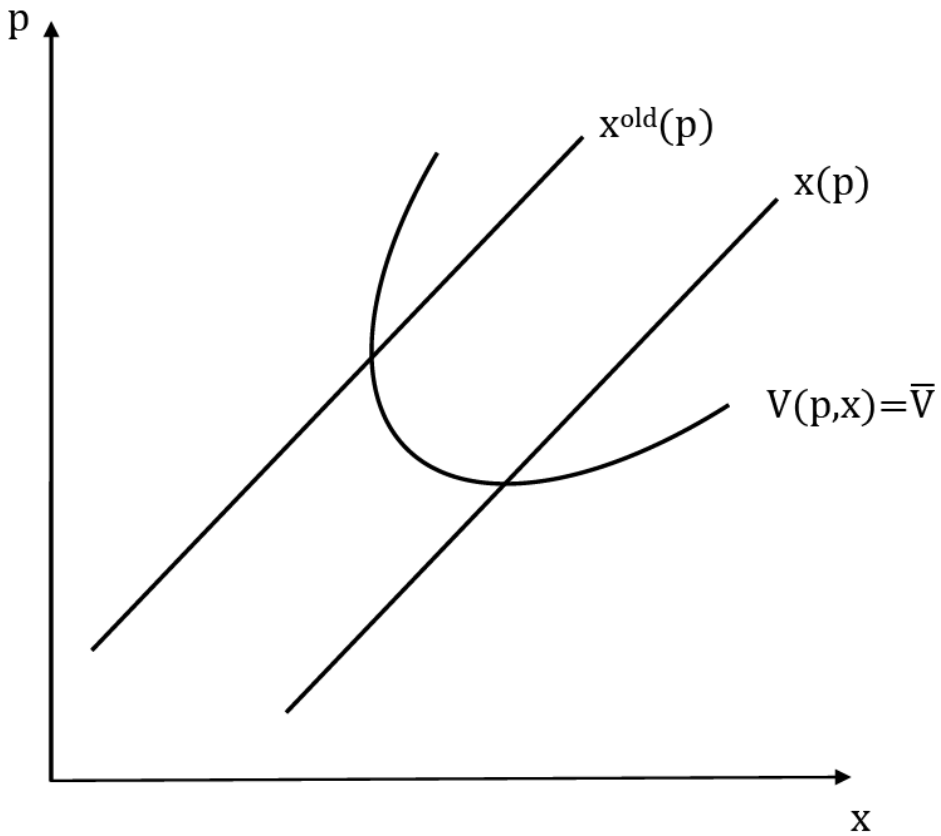
$V(p,x) = [px - C(x,0)] - \pi^{old}(p)$
$V_x(p,x) = p - C_x = 0$ defines horizontal iso-V
$V_p(p,x) = x - x^{old}(p) = 0$ defines vertical iso-V

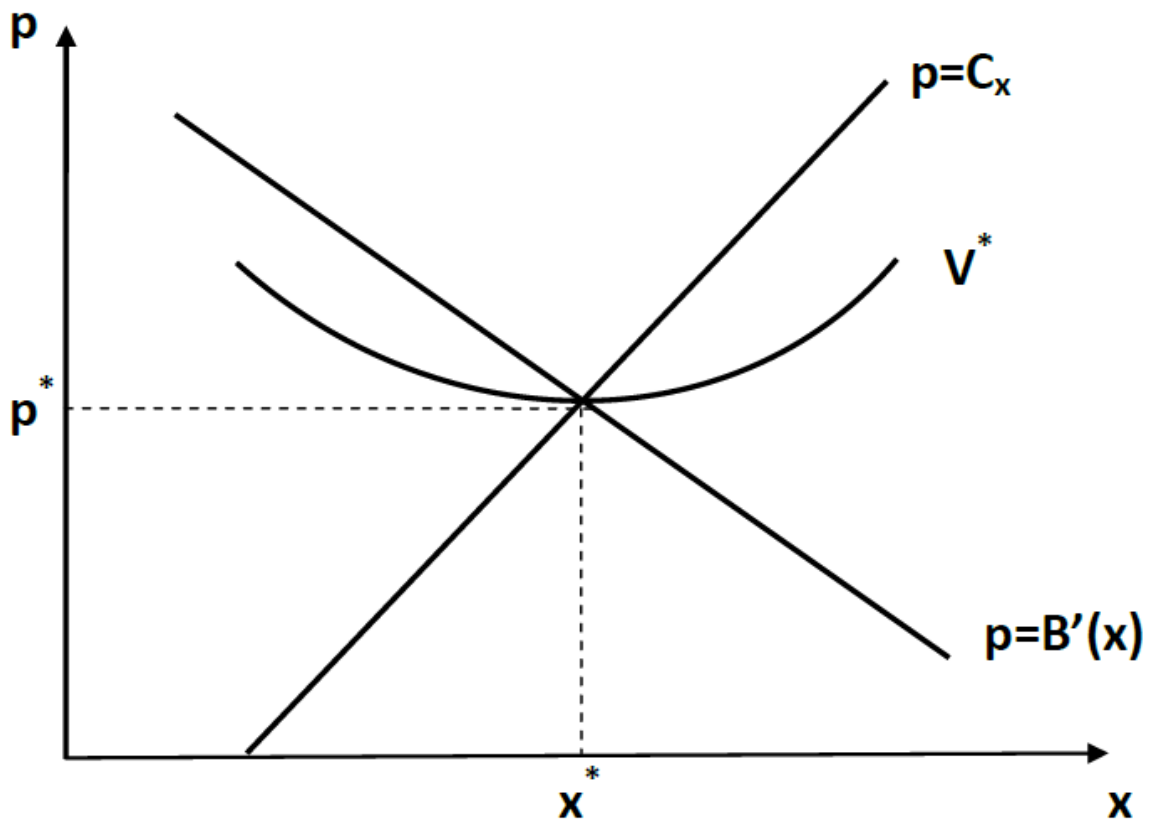


Optimal policy

Regulator always wants $B'(x) = C_x(x, 0)$, defining x^*

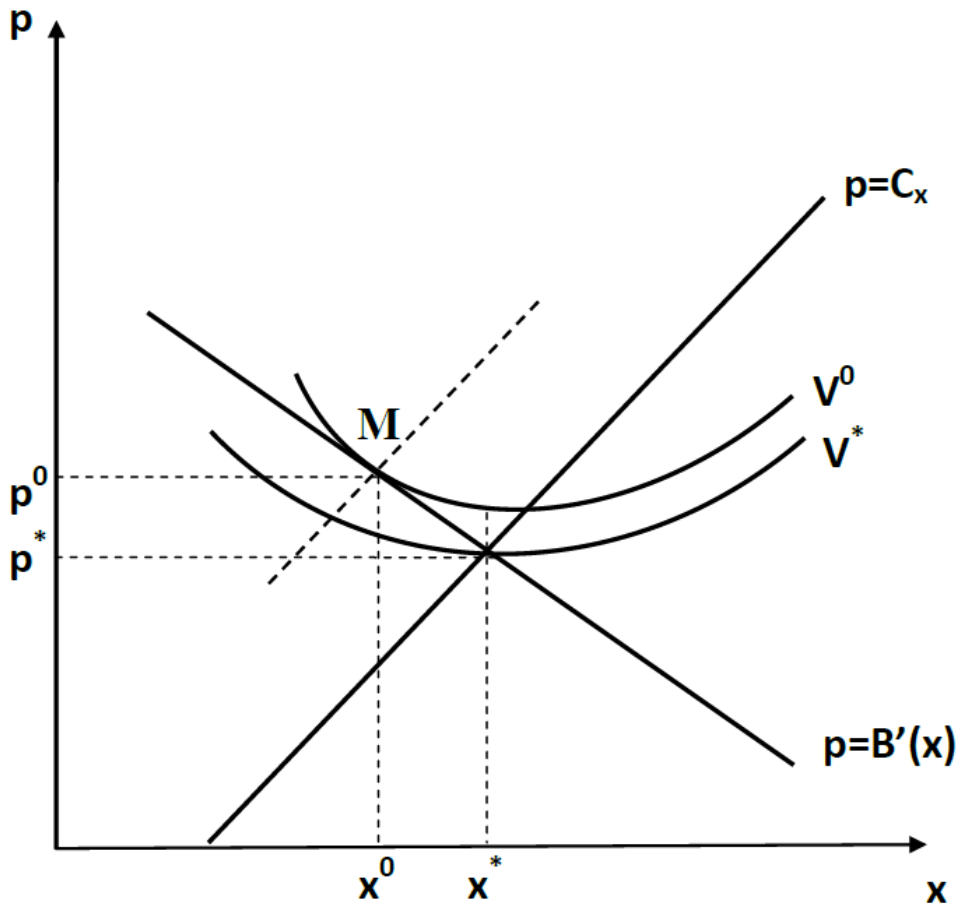
Tax first or simultaneously:

Optimal tax is p^*, innovator obtains V^*



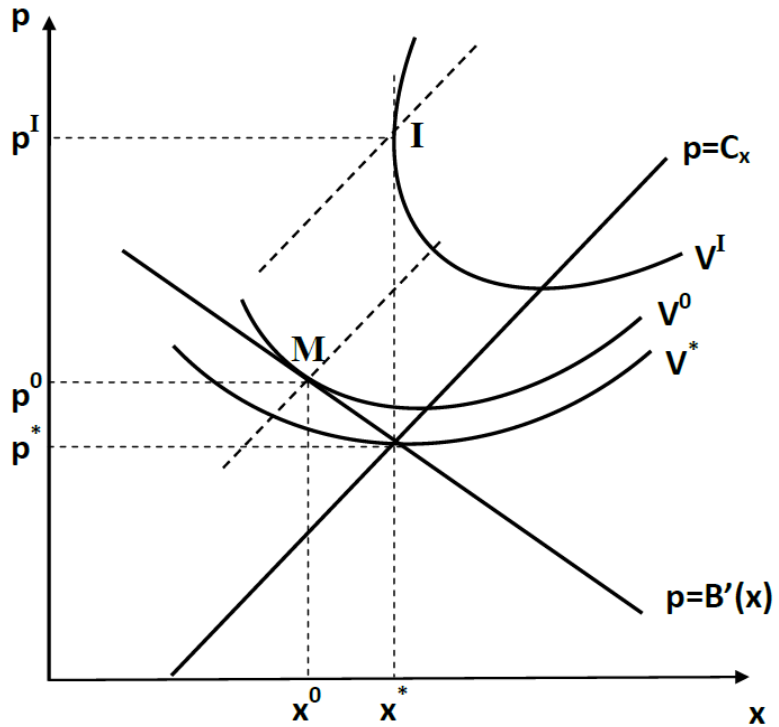
Market:

Innovator set its price parameters so x^0 is achieved, giving $V^0 > V^*$



Innovator's pricing first:

Innovator knows $x = x^*$ whatever it does, so it sets its price parameters so the equilibrium tax is p^I , giving $V^I > V^0 > V^*$



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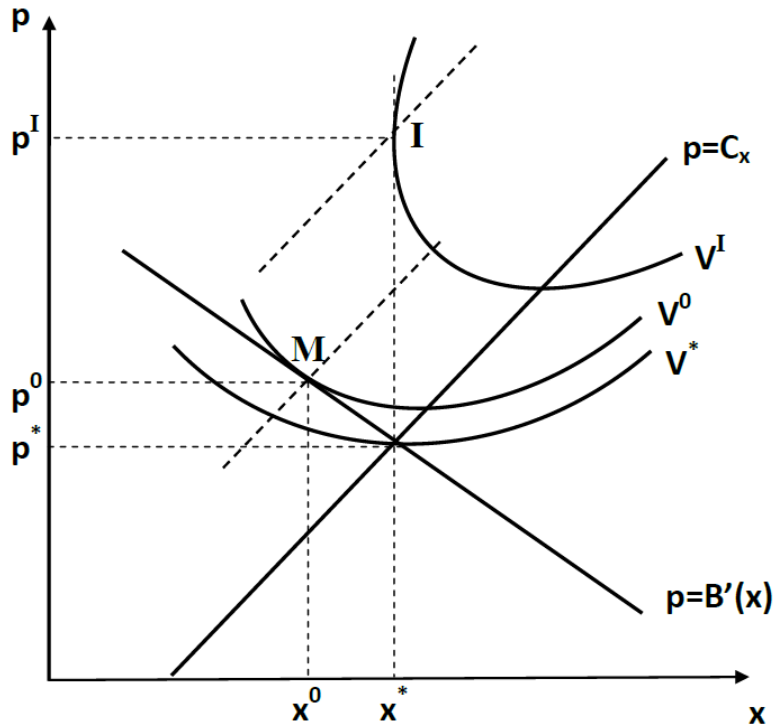

Quotas:

Same as above, since innovator knows $x = x^*$ whatever it does

Conclusions

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  - timing of environmental policy and pricing of the technology
  - whether the innovator through its price scheme is able to capture all the benefits of its innovation
  - whether taxes or quotas are used as the policy instrument
- if the environmental policy is set after the pricing of the technology, R&D incentives for environmental R&D are stronger than they are for other R&D