Promoting renewable energy without hurting the poor when production costs are uncertain

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Research question

From a **fiscal** point of view,
which kind of policy instrument should a regulator pick
when wanting to both **reduce pollution**
from electricity production
and **protect poor consumers**
while **uncertain** about the production costs
of **renewable** energy?

The paper in one slide

- *Framework:* partial equilibrium model of the perfectly competitive retail electricity market,
- *Policy tools:* two alternative incentive schemes for RES-E:
  1. price-based feed-in tariffs,
  2. quantity-based mandatory share.
- *Assumption:* uncertainty on the production costs of renewable energy.
- *Conclusion:* an **identical** estimation error leads to **opposite** effects depending on the policy tool used in terms of:
  1. equilibrium P and Q,
  2. equilibrium level of pollution,
  3. cost of subsidizing the poor.

Literature

The literature on impact analysis of policy aimed at fostering RES-E has mainly focused on

1. **efficiency and effectiveness**,
   - analysis of RES-E incentive schemes,
     Haas et al. [2011], Labandeira et al. [2005, 2009], Menanteau et al. [2003]
   - prices vs. quantities in climate change policy,

     Weitzman [1974], Pizer [1997], Montero [2002]
2. but not that much on **equity**, so far.
   - distributional consequences of policy:
   - in general, starting from tax incidence
     Feldstein [1972], Fullerton [2001, 2008, 2011]
   - in particular: impacts of environmental and energy policy.
     Fullerton and Heutel [2007, 2010, 2011], Metcalf [2010, 2011]

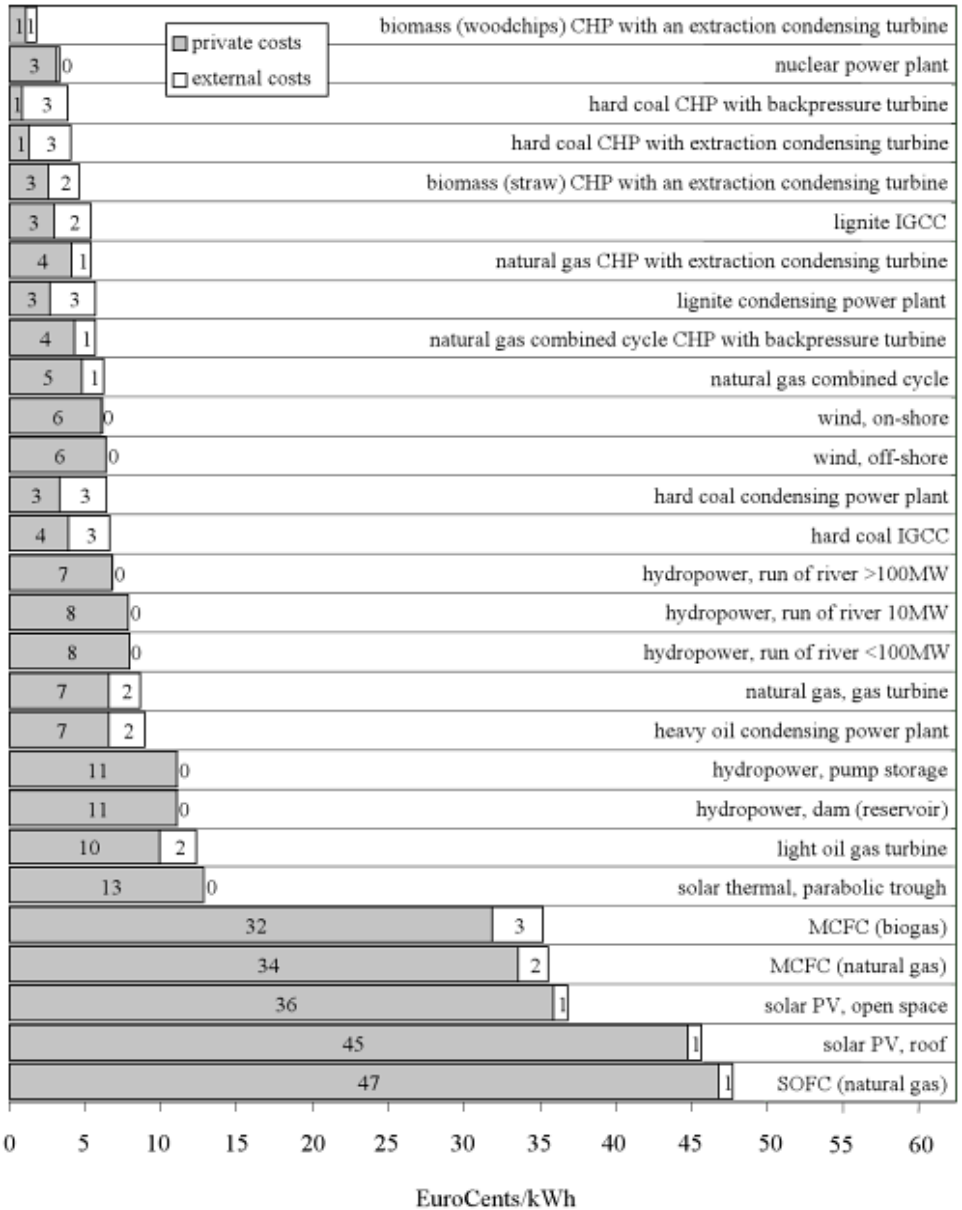
→ very little on the **fiscal costs associated to the policies aimed at neutralizing distributional concerns that arise when implementing RES-E incentive schemes.**

The model: roadmap

- **Setting**: retail electricity market.
- **Setup** of the model:
  - supply side ▸,
  - demand side ▸,
  - government objectives and tools ▸.
- **Scenarios**.

Notation

- x^* = **optimal** level of x (in perfect information)
- $\hat{x}$ = **expected** equilibrium level of x (in imperfect information)
- x = **realized** equilibrium level of x.



- Private and external costs of electricity generation in EU **in 2005-2010**.
- Costs are expressed in EuroCents / kWh.
- Source: "The Social Cost of Electricity. Scenarios and Policy Implications" edited by A. Markandya, A. Bigano and R. Porchia. Fondazione Eni Enrico Mattei, 2010.

Supply side: Technologies ▸ roadmap

- Electricity can be produced through fossil and renewable energy:

$$Q = q_f + q_r$$

- Production costs of renewable energy q_r are assumed to be
  a) structurally higher than those of q_f. ▸
  b) subject to uncertainty.

Supply side: Structure of retail market prices

Under a **Q-based mandatory share** s:

$$P = \frac{q_f P_f + q_r P_r}{Q}$$
$$\Leftrightarrow P = 1 + \hat{c} s^2 Q$$

- **certain** share of RES-E,
- **uncertain** equilibrium price.

Under a **P-based FIT** $h = \hat{c}\hat{q}_r$:

$$P = 1 + \hat{c}\hat{q}_r$$
$$\Leftrightarrow P = 1 + \hat{c}\hat{s}\frac{K - \gamma}{1 + \gamma\hat{c}\hat{s}^2}$$

- **uncertain** share of RES-E,
- **certain** equilibrium price.

- $\hat{c}$ = uncertain additional cost per unit of q_r
- s (resp. $\hat{s}$) = mandated (resp. expected) share of q_r out of total electricity produced.

Demand side

roadmap

- q_r and q_f are perfect substitutes to consumers.
- Aggregate demand:

$$Q = K - \gamma P$$

- Aggregate demand can be disentangled into:
  - q_p, perfectly inelastic demand from poor consumers,
  - q_w, demand from other consumers (to simplify: the wealthy), strictly decreasing in price.

Government objectives

roadmap

The government pursues two objectives:

1. Keep pollution below the critical level at the lowest possible cost:

$$\psi \leq \psi^*(q_f^*)$$

   - feed-in tariff h,
   - mandatory share of RES-E s.

2. Keep constant the electricity price for poor consumers using transfers.

$$T = P - P_f$$

   - Poor consumers only pay $P_p = 1$,
   - Market price $P_w = P$ only concerns non-poor consumers.

The model: roadmap

- **Scenarios**: compare Q-based vs. P-based policy tools when production costs of renewable energy are...
  1. **certain**: Q-based and P-based tools yield the same outcomes. ✔
  2. **uncertain**:
     a) introduce a Q-based mandatory share of renewables out of total electricity produced ▸,
     b) introduce P-based feed-in tariffs ▸.

  ▸ timeline

Timeline of the problem

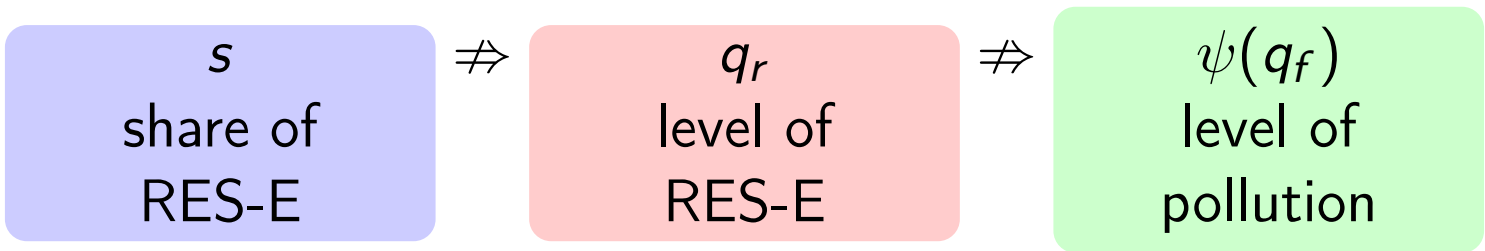
$t = 1$: uncertain production cost of renewables $\hat{c} \neq c$

- government chooses ▸ FIT vs. ▸ mandatory share ,
- $\hat{P}_r = 1 + \hat{c} q_r$.

$t = 2$: production cost of renewables c is observed

- electricity producers take their production decision.

Q-based instruments: **shares** vs. **levels**

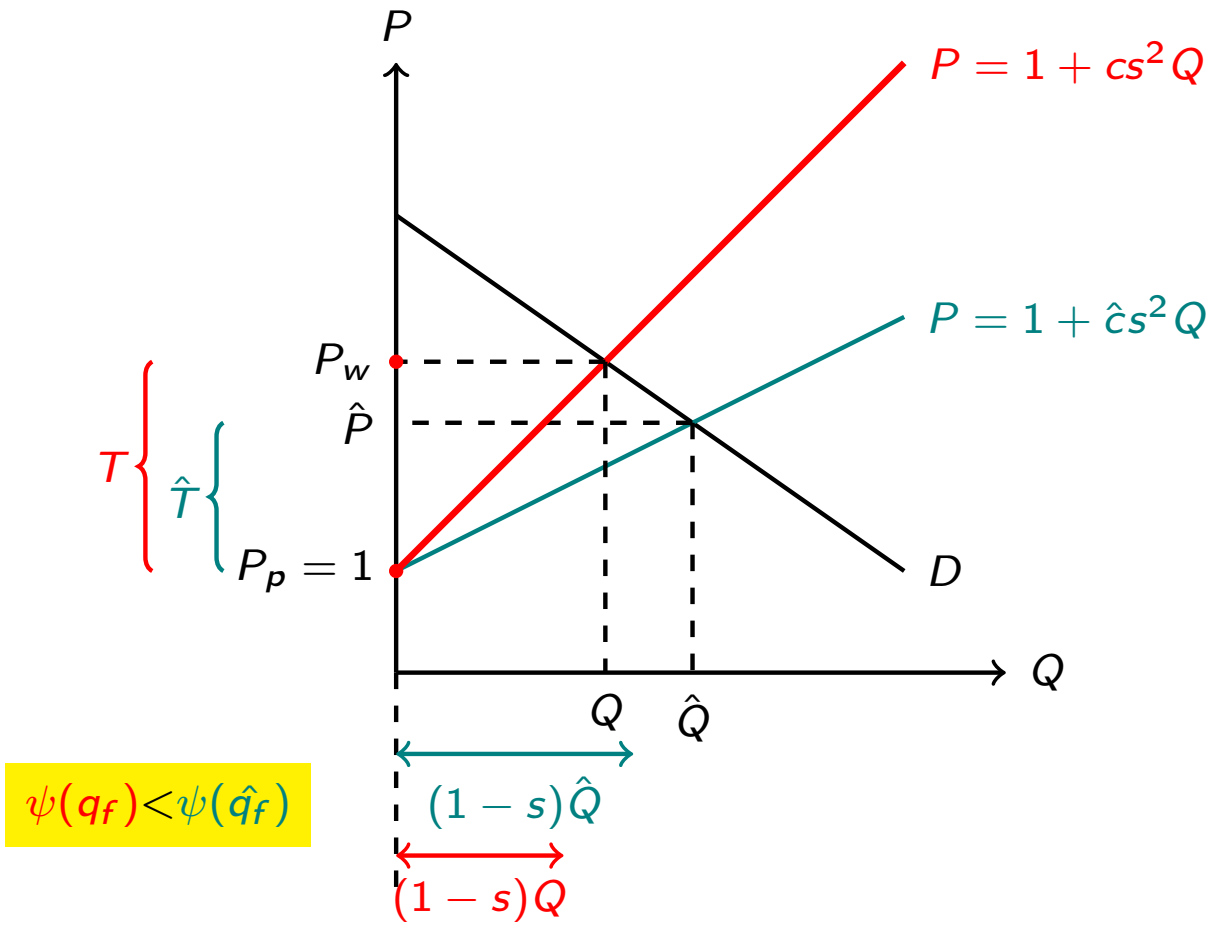


Q-based instruments: a mandatory share

- Government fixes a mandatory share of RES-E s given $\hat{c}$, expected production cost of renewables :
  - expected fossil-based electricity production: $\hat{q_f}$.
  - expected pollution is $\psi(\hat{q_f})$.

Retail electricity market: a mandatory share s

The case of cost underestimation $c > \hat{c}$



$\psi(q_f) < \psi(\hat{q}_f)$

P-based instruments: a feed-in tariff

- Government yields to producers a per-unit subsidy h per each unit of q_r produced:

$$h = \hat{c}\hat{q}_r$$
$$\Leftrightarrow h = \hat{c}\hat{s}\frac{K-\gamma}{1+\gamma\hat{c}\hat{s}^2}$$

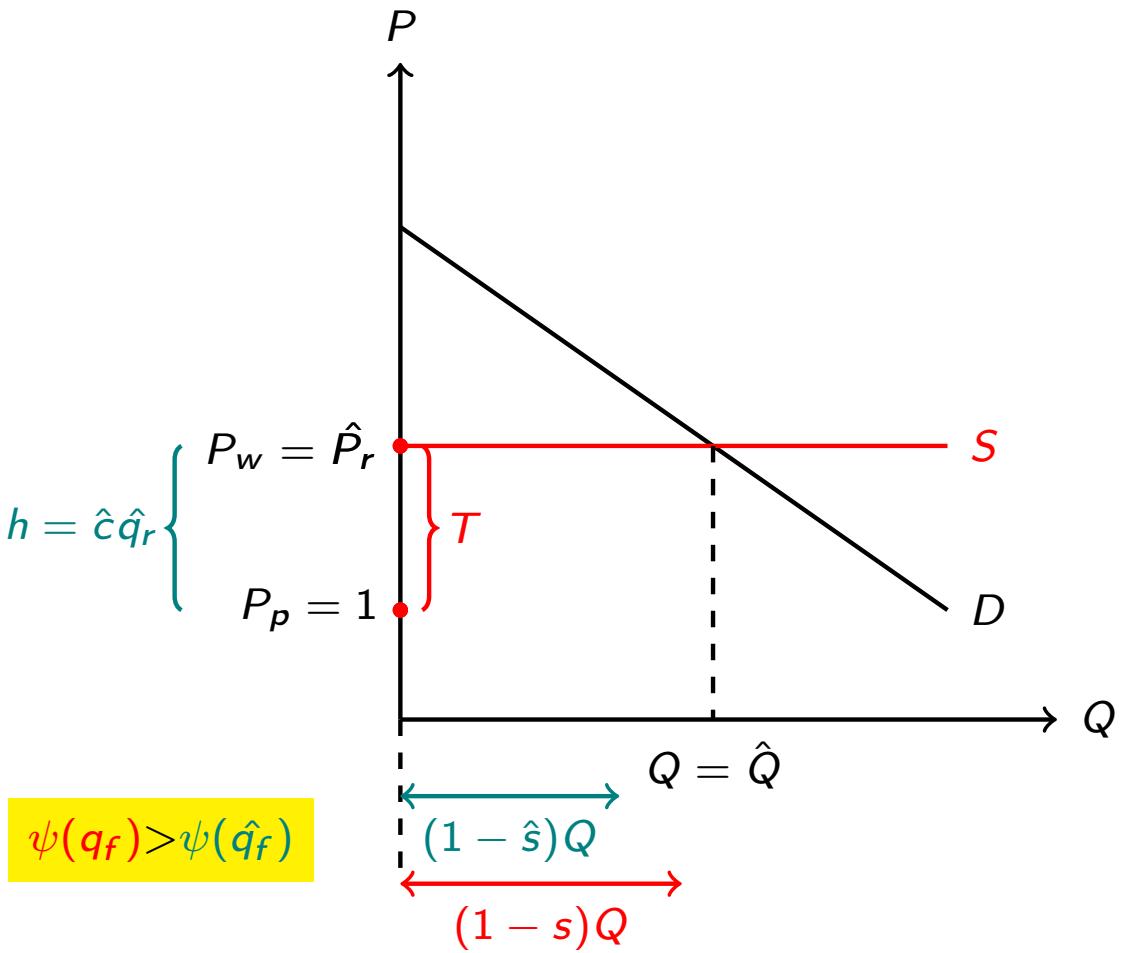
- The producer picks q_r according to the rule

$$P_f = P_r$$
$$\Leftrightarrow 1 = 1 + cq_r - h$$
$$\Leftrightarrow q_r = \frac{\hat{c}}{c}\left(\hat{s}\frac{K-\gamma}{1+\gamma\hat{c}\hat{s}^2}\right)$$

- The subsidy is financed through a tax per each unit of electricity purchased by wealthy consumers.

Retail electricity market: a FIT h

The case of cost underestimation $c > \hat{c}$



The risks of **underestimating** the cost of renewables

Benchmark: **perfect information setting**

Criteria	**Q-based mandatory share** s	**P-based feed-in tariff** h
Share of RES-E attained	unaffected	lower
Retail market price	higher	lower
Pollution	lower	higher
Cost of transfers to firms	unaffected	higher
Cost of transfers to the Poor	higher	lower

To wrap up...

If the regulator tends to underestimate production costs of renewables...

- **Quantity-based tool**: lower pollution; higher fiscal costs for distributional reasons.
- **Price-based tool**: higher pollution; double distortion (taxing the wealthy, transfers to the poor).

If the regulator tends to overestimate production costs of renewables, results are exactly symmetric.

Conclusions

	cost underestimation $c > \hat{c}$	**cost overestimation** $c < \hat{c}$
Pollution obj.	Q > P	P > Q
Social + Fiscal obj.	P > Q	Q > P

- We **quantify** + identify the **sources** of trade-offs associated with alternative policy schemes aimed at curbing pollution from electricity production.
- **Policy conclusion:** a fiscally-constrained government who cares about distributional issues (and local re-election) could tend to pick more cautious incentive schemes for RES-E and end up with a relatively more polluting electricity sector.

Thank you for your time!

Comments are welcome:

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