Technology-specific or technology-neutral? Designing support schemes for renewables cost-effectively

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OUTLINE

- Introduction
- Benefits of technology-specific support
- Conclusion
TECHNOLOGY-SPECIFIC RES SUPPORT IS UBIQUITOUS

Feed-in tariffs for electricity generation from renewable energy sources (RES) in Germany in 2014

<table>
<thead>
<tr>
<th>Source</th>
<th>Feed-in Tariffs (Ct/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>4.95 – 15.40 Ct/kWh</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>9.23 – 13.15 Ct/kWh</td>
</tr>
<tr>
<td>Biomass</td>
<td>5.85 – 15.26 Ct/kWh</td>
</tr>
<tr>
<td>Geothermal</td>
<td>25.20 Ct/kWh</td>
</tr>
<tr>
<td>Water</td>
<td>3.50 – 12.52 Ct/kWh</td>
</tr>
<tr>
<td>Landfill, mine gas</td>
<td>3.80 – 8.42 Ct/kWh</td>
</tr>
</tbody>
</table>

Source: BMWi 2014
CRITIQUE: TECHNOLOGY-SPECIFIC RES SUPPORT IMPAIRS COST-EFFECTIVENESS

Marginal costs of generation of RES 1

Excess cost of technology-specific support

Marginal costs of generation of RES 2

RES target
RESEARCH QUESTIONS

Under which conditions can technology-specific support improve cost-effectiveness?

- Technology market failures?
- Uncertainty and capital market failures?
- Path Dependencies?
- Negative externalities of RES deployment?
Existing studies: Technology-specific support brings down consumer costs by reaping producer rents (e.g. Bergek/Jacobsson 2010, Held et al. 2014, Resch et al. 2014)

This study: Can technology-specific support bring down producer costs?
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MODEL ASSUMPTIONS

- Partial-equilibrium model of the power sector with two periods, discounting at a rate $\delta$ between period
- Two types $i$ of RES power: wind $w$ and photovoltaics $p$
- Power generation in both periods: $x_t^i$
- Generation costs in period 1: $c_1^i(x_1^i)$
- Generation costs in period 2: $c_2^i(x_2^i, x_1^i)$
  - with $\partial c_2^i / \partial x_1^i < 0$ (= technology learning)
OPTIMIZATION PROBLEMS

- Social planner aims to attain a certain renewables target $\bar{Z}$ in period 2 at least total cost $C$:

$$\min C = \sum_i c_1^i(x_1^i) + \delta \sum_i c_2^i(x_2^i, x_1^i)$$
subject to $\bar{Z} = \sum_i x_2^i$

- Representative firm in renewable sector aims to maximize its profit $\pi$ given a subsidy to RES generation in both periods, $s_t^w$ and $s_t^p$:

$$\max \pi = \sum_i s_1^i x_1^i - \sum_i c_1^i(x_1^i) + \delta \left[ \sum_i s_2^i x_2^i - c_2 \sum_i (x_2^i, x_1^i) \right]$$
ISSUE 1: TECHNOLOGY MARKET FAILURE

- Knowledge created by learning may spill over to other firms; technology-specific spillover rate $\rho^i$

- Optimal RES subsidy in period 1: $s^i_1 = -\delta (1 - \rho^i) \frac{\partial c^i_2}{\partial x^i_1}$

- Technology-specific design in period 1 optimal if:
  1. Learning varies with technologies: $\frac{\partial c^w_2}{\partial x^w_1} \neq \frac{\partial c^p_2}{\partial x^p_1}$
  2. Spillovers vary with technologies: $\rho^w \neq \rho^p$
ISSUE 2: UNCERTAINTY AND CAPITAL MARKET FAILURES

- Future net income from RES investment uncertain
- Firms risk-averse due to capital market failures:
  (1) Firms’ discounting > social discounting: $\delta^f < \delta^s$
  (2) Firms’ discounting varies with technologies: $\delta^f_w \neq \delta^f_p$

- Optimal RES subsidy in period 1: $s^i_1 = \left( \delta^f_i - \delta^s \right) \frac{\partial c^i_2}{\partial x^i_1}$

- Technology-specific design in period 1 optimal if:
  (1) Learning varies with technologies: $\partial c^w_2 / \partial x^w_1 \neq \partial c^p_2 / \partial x^p_1$
  (2) Risks vary with technologies: $\delta^f_w \neq \delta^f_p$

Only second-best solution!
ISSUE 3: PATH DEPENDENCIES

- RES investments produce techno-institutional path dependencies and lock-in effects
- Switching costs: $c_2^p(x_2^p, x_1^p, x_1^w)$ with $\frac{\partial c_2^p}{\partial x_1^w} > 0$ and v.v.

- Optimal RES subsidy in period 1: $s_1^w = -\delta \frac{\partial c_2^p}{\partial x_1^w}$, $s_1^p = -\delta \frac{\partial c_2^w}{\partial x_1^p}$

- Technology-specific design in period 1 optimal if:
  (1) Switching costs vary with technologies: $\frac{\partial c_2^p}{\partial x_1^w} \neq \frac{\partial c_2^w}{\partial x_1^p}$ (holds true if switching costs are progressive and one technology dominates RES deployment period 1)
ISSUE 4: NEGATIVE EXTERNALITIES

- RES deployment also produces negative externalities: environmental and system integration costs: \( e_t^i(x_t^i) \)

- Optimal RES subsidy in period 1: \( s_1 = -\frac{\partial e_1^i}{\partial x_1^i} \)

- Optimal RES subsidy in period 2: \( s_2 = \frac{1}{\delta} \left( \lambda - \frac{\partial e_2^i}{\partial x_2^i} \right) \)

- Technology-specific design in both periods optimal if:
  1. Externalities vary with technologies:
     \( \frac{\partial e_t^w}{\partial x_t^w} \neq \frac{\partial e_t^w}{\partial x_t^p} \)
Market failures may drive a wedge $\Delta^i$ (positive or negative) between private and social costs.
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CAVEATS TO DESIGNING TECHNOLOGY-SPECIFIC RES SUPPORT

- Asymmetric information: How specific in detail?
- Political economy: Premium to simplicity?
- Picking winners or „being picky on your picks“?
CONCLUSION

- Technology-specific RES support may increase cost-effectiveness, also in second-best settings.

- Technology-specific RES support is not by definition welfare-increasing!

- But neither is technology-neutral RES support!
Thank you for your attention!

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