Climate policies and induced technological change: Impacts and timing of technology subsidies

by

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1. Motivation

- Carbon policies and the rate of technological change in energy technologies are connected:
  - R&D or Learning by doing (LBD)

- How does this affect climate policies (taxes, subsidies)?
  - Optimal policy mix, timing

We ask the following questions:

- How should a technology subsidy evolve over time?
- What are the costs of simpler rules or delays in policy implementation?
- A suboptimal policy can lead to lock-in of the wrong technology. Should we avoid using subsidies as a policy instrument?

2. The model

- Consider a stylised learning-by-doing (LBD) model with 3 energy supply technologies based on Manne and Baretto (2002):
  - **Defender (def):** Representative of energy tehnologies in the year 2000, mainly fossil fuels. No LBD.
  - **Challenger (chl):** Representative of carbon free technologies available in 2000. High-cost but LBD.
  - **Advanced (adv):** A carbon free technology that becomes available in 2050. Low-cost and LBD.

2. The model (cont.)

$$\max_{C,E} U(E,C) = \sum_{2000}^{2200} \Delta^t u(E_t, C_t)$$

subject to constraints:

1. Energy demand equals energy supply from the three technologies.
2. Intertemporal budget constraint.
3. The unit cost of energy from technology *j* (j ≠ def) declines with experience (LBD).
4. Production in year *t* increases experience in year *t+1.*
5. Technologies are subject to expansion and decline constraints.
6. Carbon constraint on cumulative emissions (no depreciation).

Figure 1: Baseline Energy Supply
(% of base year adjusted for economic growth)

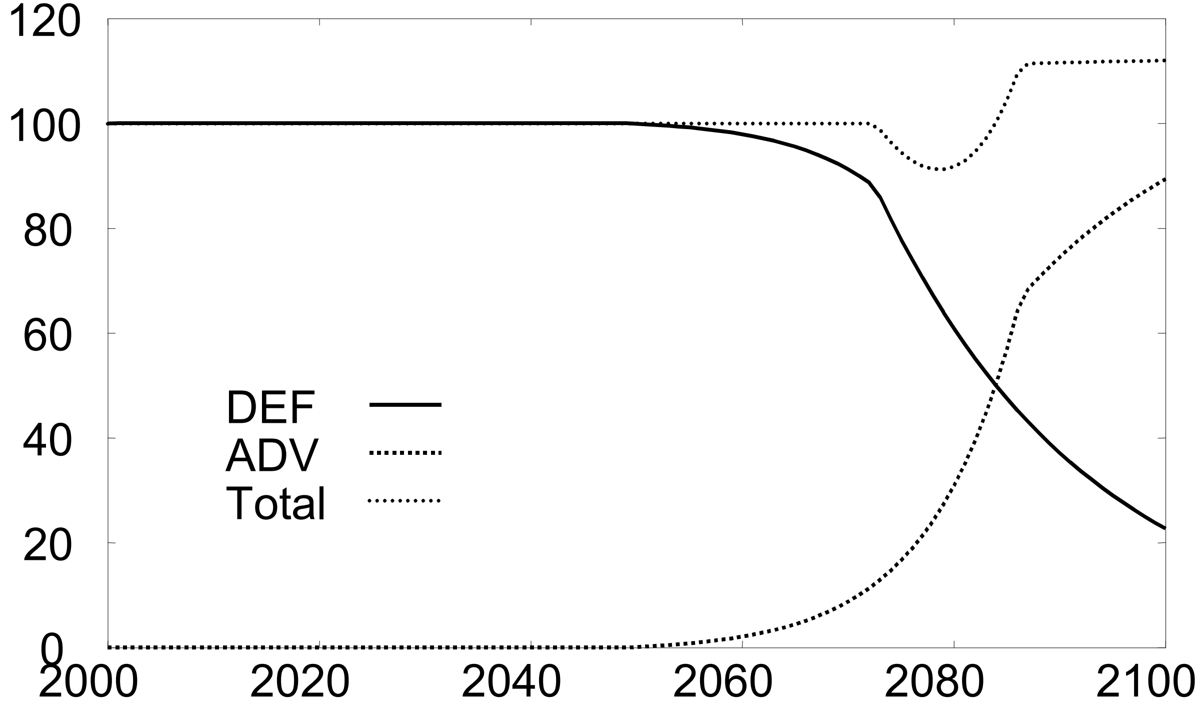

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Figure 3: Energy Supply with Optimal Abatement (% of base year adjusted for economic growth)

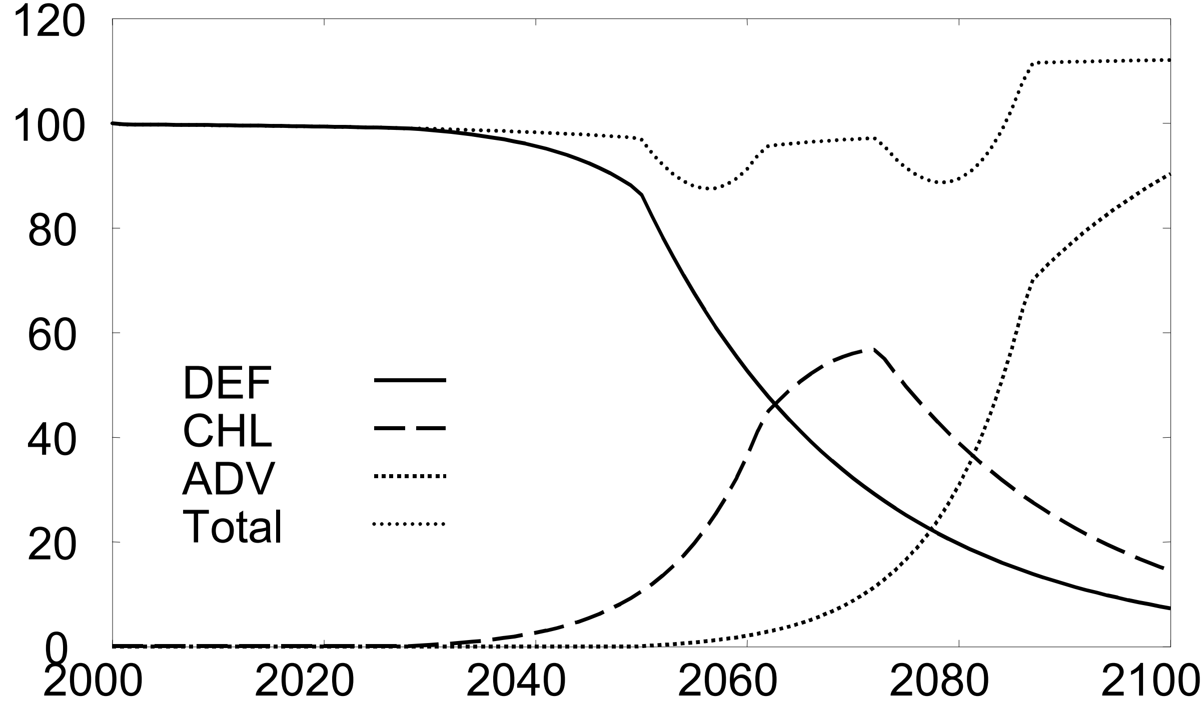

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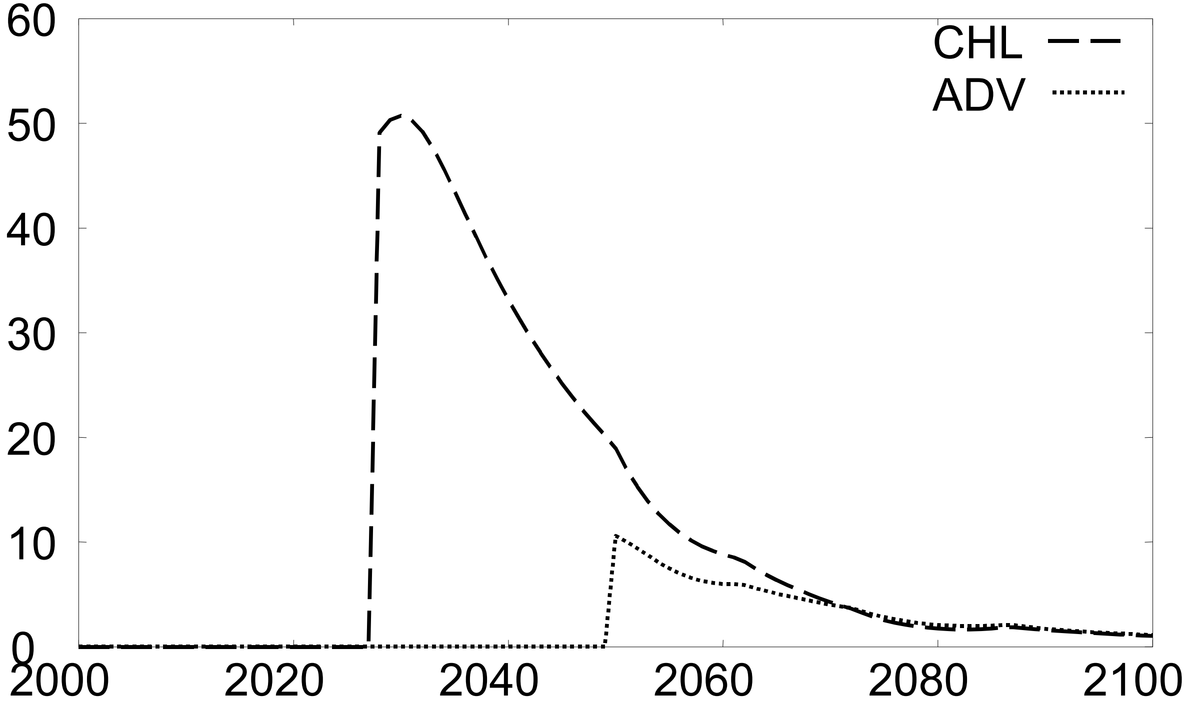
Figure 4: Learning Premia (% of value of supply)



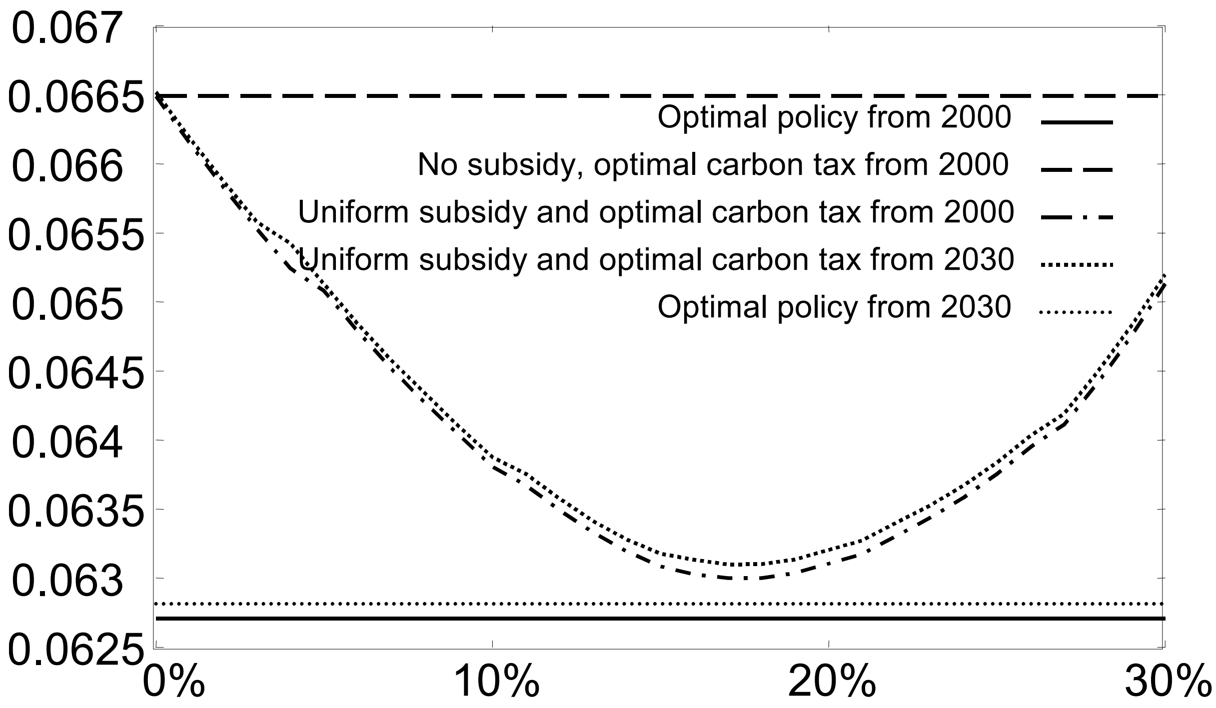
3. Knowledge as a public good

- Experience may not generate any return to the firm generating it: *Subsidise production*

- Optimal subsidies requires a lot of information, what are the cost of simpler rules?
  - 2000-2060: Subsidy to **chl** at a constant rate (0-30%).
  - Carbon taxes begins either immediately or are delayed for 30 years.
  - Optimal subsidy to **adv**.

- What are the costs of delayed action, i.e., no policy before 2030?

Figure 9: Economic Cost of Alternative Programs (welfare effects, % change)



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4. Technology lock-in: Picking the right winner

- There are no-lock in effects with our main assumptions. However, for other assumptons, our simulations confirms the possibility of lock-in effects and welfare losses with technology subsidises:
  - Higher costs of ADV may give lock in of CHL. Costs of not subsidising ADV, but aslo of not subsidising CHL.
  - If we are less optimistic about CHL and more optimistic about ADV, e.g., timing, the importance of lock-in increases. No subsidy may be better than subsidies only to the existing technology.

5. Conclusions

Aswers to the three questions:

- The greatest return to learning and, therefore, the highest optimal subsidy occurs when a technology is first being introduced.
- There are efficiency cost of uniform subsidies over time, but low when the uniform subsidy is close to the average subsidy level over time in the optimal policy scenario. The timing of the technology subsidy is more important than the timing of the carbon taxes.
- It is difficult to give a general advise regarding technology subsidies and lock-in. However, it is important to aquire as much information as possible about not only costs, but also learning potentials of technologies and realistic prospects of new, advanced technologies.