Let the Sun Shine: Optimal Deployment of Photovoltaics in Germany

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What the paper does

- *Methodological contribution*:
  - A simple discrete choice investment model taking account of feed-in-tariffs (FITs) is developed,
  - and is then embedded in an optimal control setting to study the dynamic path of FITs minimizing total subsidy costs for a *given* target of installed capacity;
- *Empirical contribution*:
  - The model is calibrated to investigate the diffusion of photovoltaics in Germany and simulate future developments.
  - Main findings:
    - The model adequately describes the evolution of the German PV market
    - Three phases are identified: a high growth phase followed by a stable market phase, and then a phase with a return to growth and the end of FITs
    - Simulations show that FITs should fall to zero in 2017

Why this is an interesting paper

- The paper deals with a hot topic of substantial current interest to policymakers (and researchers)
- It sheds light on the potential distorsions of public policies regarding PV (with respect to the cost-minimizing policy) and offers new insights on the evolution of PV markets when FITs are used.
    - Interestingly, one source of suboptimality in the German case is that actual FITs were *too low* during the first phase of deployment given the pre-defined target (the opposite of what many other commentators have argued...).
- The framework developed in the paper can be applied to other countries and/or other targets, and could be extended in several interesting directions.

Comments

- It would be useful to study *theoretically* the installed capacity dynamics before moving to calibration:

$$x_{t+1} - x_t = f\left(FIT_t, r_t, x_t\right)$$

- This would allow the reader to see how flexible your model is and get a sense of the *a priori* structure you're imposing (which needs to be justified or, at least, discussed)
- For instance, one can show that your modeling choices imply the following two properties:
  1. The marginal effect of FITs on installed capacity is increasing in their level, i.e. $\frac{\partial^2 f}{\partial FIT_t^2} > 0$
  2. There exists a threshold $\tilde{x}$ such that $\frac{\partial^2 f}{\partial FIT_t \partial x_t} < 0$ if $x_t < \tilde{x}$ and $\frac{\partial^2 f}{\partial FIT_t \partial x_t} > 0$ if $x_t > \tilde{x}$

Comments

- Property 2 hinges on the particular shape of the learning curve $p_t = p_0 \left(\frac{x_t}{x_0}\right)^{-b}$
  - It can be shown that the learning curve needs to be convex enough (its derivative needs to decrease faster than $1/x_t$) for Property 2 to hold.
  - Is there any empirical evidence that the learning curve is indeed "very convex"?
- To what extent are your findings about:
  - the actual FITs being too low in the first phase of deployment,
  - and the existence of three phases in the evolution of the PV market

  related to Properties 1 and 2?

Comments

The investment tax credit r_t is considered exogenous (for tractability reasons).

- It would be nice to have some (even very preliminary) insights regarding what would happen if r_t were endogeneized.
- In particular, the substituability between r_t and the FIT could be discussed.
  - In which phase(s) of the market evolution is the investment tax credit most useful?
  - How would an exogenous shock on the investment tax credit affect the optimal path (F_t)?
- Complementary exercise: set the FITs to their actual level and use r_t as the only control variable...

Extensions

- It would be nice to generalize the present framework to account for one or many intermediate targets in addition to the final target.
- Targets are sometimes multi-dimensional: for instance they can specify a given installed capacity + an absolute or relative level of prices (as in Germany)
  - In the current paper, there is a one-to-one relation between prices and installed capacities, so the dimensionality of the problem can be reduced from 2 to 1.
  - This may not be the case in a more general setting (especially with more than one control variable)
    $\Longrightarrow$ a multi-dimensional counterpart of the present framework could be very useful.