OPTIMAL INVESTMENT STRATEGY IN RENEWABLE POWER UNDER DEMAND UNCERTAINTY

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Overview

Public policy in the domain of energy transition, relies on models to construct projections of the future electricity system, electricity demand and the cost of different technologies to predict the cost of the future electricity production mix. These models, published by organisations such as Transmission System Operators, think-tanks, research institutes, etc., have an impact on the decision to support specific types of energy by the regulator. However, these projections are very often based on deterministic scenarios. This assumption of determinism clearly fails to account for the impact of uncertainty and risk aversion on long-term investments. In particular, demand uncertainty increases with the time horizon, and is also likely to increase with the advent of the climate change.

In this paper, we evaluate the impact of demand uncertainty on the optimal renewable energy investment path using dynamic stochastic optimization.

Methods

In our model, a central planner has to decide on an optimal investment path in the future electricity generation capacity, making a choice between controllable conventional (gas) and renewable (wind) generation capacity. He has perfect information about future investment costs of technologies and future environmental policies (green subsidies and carbon tax).

We find the optimal solution by solving the Bellman equation with a stylised cost function for a given demand and electricity mix, based on the merit order. We then compare two types of problems: a problem where demand is modelled as a stochastic process, and revealed to the planner at each period, and problem where the demand is a coherent deterministic scenario known by the planner.

We provide a simulation exercise based on German data obtained via the ENTSO-E website (production, prices, imports, installed base), Renewable Ninja (wind simulation), and Enerdata, using several econometrics technics detailed in the paper.

Results

In line with the literature, our first results show a “delay” in the energy transition to a greener technology under demand uncertainty. The planner prefers to wait to observe the future demand trajectory, even if it means missing the optimal investment timing. This delay is nevertheless compensated for by a higher overall investment compared to the deterministic scenario. The production cost is usually lower in the stochastic version, mostly because the planner is afraid of underestimating the needed capacities and to face failure costs. Since the planner overinvests, he has more available renewable capacities, which allow to lower the production cost (cheaper marginal and fixed costs).. However, this benefit is offset by a higher investment cost so that the stochastic solution becomes more expensive than the deterministic scenario solution.

Conclusions

The lack of consideration of demand uncertainty alone appears to be sufficient to significantly underestimate the final cost of the generation mix. These results encourage caution in the interpretation of models comparing mix costs between controllable (and therefore certain) technologies and intermittent technologies.

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