PITFALLS OF INSURING RENEWABLE ENERGY PRODUCTION: A CASE STUDY ON SOME WIND POWER AUCTIONS IN FRANCE

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Overview

Subsidies to electricity production from renewable energy sources (RES), through mechanisms such as feed-in-tariffs (FiT) or feed-in-premium (FiP), are widespread as a public policy mechanism to support the development of mature RES technologies such as wind and solar. However, the design of these mechanisms varies according to many aspects across countries, periods or technologies supported. Nowadays these subsidies most often take the form of subsidy contracts awarded by governments to developers through auctions, in order to select the best projects and minimize the cost of support. One important aspect of these mechanisms is the payment rule which specifies how firms will be subsidized depending on their electricity production. Variations in the design of subsidy mechanisms may induce differences regarding efficiency (e.g. ensuring that the best projects will be selected through auctions and that proper incentives will be given to the winning firms at the development stage), and the public cost of support to renewable electricity producers.

One of the main issues in the design of these mechanisms is to limit the risk borne by electricity producing firms, in order to limit their risk premium that would be passed on to the government through their bid for subsidies. This paper focuses on a feature of the mechanism used by the French government to support off-shore wind projects on specific sites selected by the government, awarded in 2011 and 2013. This mechanism's payment rule departs from typically used linear[1] feed-in-tariffs, insofar as producers are insured against yearly production variations within a range of +/-10% around the expected yearly production (see fig. 1). This feature was most likely intended to lower the risk borne by the firm regarding production variation due to meteorological conditions. It could lower the risk premium the firms would include in their bids. However, a flaw of such a design arises from firms being asked to estimate themselves the expected yearly production of their windfarm, allowing them to bias their estimation. This paper analyses the consequences of such strategic behaviour.

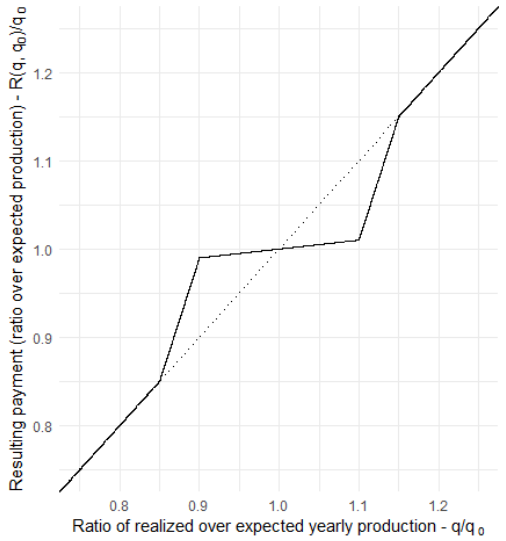

Figure 1: French payment rule for offshore wind FiT (in the case of unit price: p=1)*

Methods

We consider an auction mechanism under which each bid is composed of two values: the price (p^*) and the expected yearly production (q_0^*), and where the yearly subsidy received by the winner takes the form of $p^*.R(q_t, q_0^*)$, where q_t is the realized production for a given year t (fig. 1 depicts the function R in French offshore wind procurement). We consider bidding firms to be symmetric regarding their payoff function including initial investment costs (C_0), risk aversion (captured through utility function $u(.)$), probability distribution of q_t, and discount rate (r). We solve the auction game under four paradigms:

1. *Firms bid truthfully*: they report their true expected production, and then minimize their price bid p in order to win the auction, subject to a constraint of positive expected utility of revenue;
2. *Firms bid strategically*: they then report a couple (p^*, q_0^*) solving the optimization problem below;

$$p^* = \min p \quad \text{s.t. } \mathbb{E}[u(\sum_{t=1}^{T} \frac{1}{(1+r)^t} pR(q_t, q_0^*(p)))] \geq u(C_0) \quad \text{with } q_0^*(p) = \arg\max_{q_0>0} \mathbb{E}[u(\sum_{t=1}^{T} \frac{1}{(1+r)^t} pR(q_t, q_0))]$$

3. *Only one firm is strategic*: the strategic firm reports a price just below the non-strategic firms' equilibrium price (i.e. equilibrium p^* from the previous case), while q_0^* is chosen in order to maximize its expected utility;

[1] Meaning the amount of subsidies perceived depends linearly on production, the slope of this relationship being the auction-determined FiT.

4. *Each firm is strategic with a given probability*: each firm is strategic with probability α, and considers other firms competing in the auction to be strategic with the same probability. In equilibrium, non-strategic firms are bidding as in paradigm 1 while strategic firms use a mixed strategy on p.

Equipped with our equilibrium analysis, we simulate the best response of firms under these four paradigms, while considering a wide range of risk aversion. The distribution of yearly production is obtained from a model developed by Staffell and Pfenninger (2016), which allows for the simulation of 19 years of electricity production for specific locations based on historic wind data and wind turbines characteristics. This historical data is used to generate a proxy of production probability distribution through bootstrapping. Several wind farms in different locations are simulated, allowing for an investigation of firms' behaviours under different meteorological conditions.

Furthermore, variations of the French payment rule are explored in order to see if other rules of similar shapes might perform better. This includes varying parameters, such as the width of the interval inside which revenue varies little or the amount by which it varies within this interval, or adding new features such as punishments for abnormally low production (which might discourage firms from overestimating q_0).

Results

First, we show analytically that, under certain weakly restrictive conditions, such production-insuring payment rules always provide an incentive for firms to overestimate their expected production, all the more that firms are less risk averse. As long as firms either all bid truthfully or all bid strategically, and are risk neutral, the expected subsidy paid remains the same as in the linear payment rule benchmark, which matches the levelized cost of electricity (LCOE). A pitfall of production-insuring payment rules compared to linear FiT arises when firms are asymmetric (as in paradigms 3 and 4), as they capture a rent which increases public cost. However, when considering firms' risk aversion, the impact on public cost is no more tractable and is thus an empirical issue.

Through simulations, we show that the French payment rule diminishes the risk premium embedded in the firms' bid by 85-95% compared to the linear payment rule case, provided that they bid truthfully. On the other hand, if all firms bid strategically they overestimate their expected production allowing them to artificially lower their price bid. The impact on average actual payment to the firm will be null, except for their risk premium which will be way above truthfully bidding firms' risk premium and actually even higher than with a standard linear payment rule (by 25-50%). However, the impact on public cost is rather small as risk premiums in this framework represent a small part of the total public cost of support (below 0.1%), compared to the impact of asymmetric behaviour among bidders.

We estimate a strategic firm knowing other firms bid truthfully might be selected instead of a non-strategic firm by bidding a slightly lower face price, but still receiving an average revenue about 5% higher than what a non-strategic firm would have received (i.e. 5% higher than the LCOE). In a more realistic framework where each firm has a given ex ante probability to adopt a srategic behaviour, then the rent captured by a winning strategic firm at equilibrium is about 1 to 3% (over the LCOE).

Finally, we test variations of this payment rule and show that, in the presence of strategic bidding, a linear payment rule appears to be preferable to any of the explored variations.

Conclusions

The auction determined FiT mechanism adopted by France for offshore wind farms is very likely not to reach its objective, that is lowering public cost of support by insuring electricity producers, as it induces strategic behaviours translating into rents being captured by winning firms and increased risk premiums. In the end, with this specific mechanism, the government is likely to subsidize renewable electricity production from offshore windfarms in excess (by 1-5%) compared to its actual LCOE. In addition, any variation within the same kind of mechanism appears to perform worse than a linear payment rule. Therefore, the latter should be preferred by the government over a production-insuring payment rule.

A specificity of the French mechanism is that it fully allows firms to state their expected production themselves, leaving no barrier against strategic behaviour. However, other countries did implement production-insuring subsidy mechanisms for renewable electricity, but most often involving a third party providing the estimation of expected electricity production and/or later updating the estimation according to past production (as for instance in Brazil). Even though this might limit a firm's ability to bias its expected production estimation, it does not fully guarantee the firm could not influence this estimation at all, therefore raising issues similar to the one highlighted in this paper.

References

Staffell, Iain and Pfenninger, Stefan (2016). Using Bias-Corrected Reanalysis to Simulate Current and Future Wind Power Output. Energy 114, pp. 1224-1239. doi: 10.1016/j.energy.2016.08.068