DO AUCTIONS PROMOTE INNOVATION IN RENEWABLE TECHNOLOGIES? AN ECONOMETRIC STUDY OF SOLAR PV

[Pablo del Río, Spanish National Research Council, +34916022560, Pablo.delrio@csic.es]
[Leticia García-Martínez, Universidad Carlos III, +34916022560, leticia.g.martinez@uc3m.es]

Overview

Innovation in renewable electricity technologies (RETs) is a main component of the clean energy transition (IEA 2021). Innovation contributes to the improvement and cost reductions of these technologies and makes it easier (or less costly) to achieve renewable energy targets.
There is a widespread agreement that two types of policy measures are complementary and, thus, needed to spur innovation: supply-push and demand pull. The former refers to public support for R&D investments. Demand-pull instruments, such as auctions, quotas with renewable energy certificates (RECs), administratively-set feed-in tariffs or premia (FITs, FIPs) have an impact on diffusion and, thus, according to the chain-linked model of innovation (Kline and Rosenberg 1986), also on invention and innovation.
The focus of this paper is on one type of demand-pull policies (auction) and its role in inducing innovation compared to the other demand-pull instruments. Auctions have experienced an impressive increase in their implementation worldwide. 116 countries had adopted auctions by 2020, compared to only 6 countries in 2005 and FITs/FIPs were implemented in 83 countries in 2020 (REN21 2021).
There is a presumption in the literature that auctions lead to technological innovation. This is the case in the auction-general literature, in the literature on renewable energy auctions and in policy documents. However, such presumption is not based on empirical findings. Indeed, the very scarce empirical evidence suggests that auctions may not encourage innovation or do so to a lesser extent than other demand-pull instruments (del Río and Kiefer, forthcoming). Thus, the aim of this paper is to identify and discuss the comparative innovation effects of renewable energy support instruments, focusing on renewable energy auctions, with the help of an econometric analysis. This article covers a gap in the literature since, to the best of our knowledge, there isn't an in-depth quantitative analysis of this topic. Therefore, two hypotheses are put forward:

Hypothesis 1: The incentive to innovate in RETs provided by auctions is weak.
Hypothesis 2: The incentive to innovate in RETs is lower than with alternative deployment support instruments and, particularly, administratively-set feed-in tariffs and premiums.

Methods

This paper relies on an unbalanced panel of data, built by the authors on the basis of several sources of data, including the IEA, the AURES II Database and OECD Statistics. Patent data are based on the PATSTAT database and the Cooperative Patent Classification Y02E10/50 for Solar PV (family size = 2 or greater, avoiding irrelevant inventions; technology selection: OECD ENV-TECH definitions). Data for 20 OECD countries are included.

The dependent variable (PAT) refers to patent counts. Two sets of explanatory variables have been included: policy variables and additional (control) variables. The former include: FIT (FITs adopted, dummy), REC (REC adopted, dummy), AUC (auctions adopted, dummy) and RDEXP/RDSTOCK (public RD&D budget, annual data and accumulated stock, respectively). The additional variables include: CO2 (CO2 emissions in metric tons per capita), EGEN (Gross electricity production (GWh) from renewables), GDPPC (per capita GDP) and OILPRICE (Spot Crude Oil Price: West Texas Intermediate, 2020 Dollars per Barrel). All variables are technology specific except CO2 and OILPRICE. Except for the dependent variable and the dummy variables, all variables are log-transformed. Therefore, the models are specified as follows:

$$PATENTS_{i,t} = \beta_0 + \beta_1(FIT_{i,t}) + \beta_2(REC_{i,t}) + \beta_3(AUC_{i,t}) + \beta_4(RDEXP_{i,t-x}) + \beta_5(EGEN_{i,t}) + \beta_6(\mathrm{CO2}_{i,t}) + \beta_7(\mathrm{GDPPC}_{i,t}) + \beta_8(\mathrm{OILPRICE}_{i,t}) + \alpha_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$PATENTS_{i,t} = \beta_0 + \beta_1(FIT_{i,t}) + \beta_2(REC_{i,t}) + \beta_3(AUC_{i,t}) + \beta_4(RDEXP_{i,t-x}) + \beta_5(EGEN_{i,t}) + \beta_6(\mathrm{CO2}_{i,t}) + \beta_7(\mathrm{GDPPC}_{i,t}) + \beta_8(\mathrm{OILPRICE}_{i,t}) + \beta_9(\mathrm{EXPFIT}_{i,t}) + \beta_{10}(\mathrm{EXPREC}_{i,t}) + \beta_{11}(\mathrm{EXPAUC}_{i,t}) + \alpha_{i,t} + \varepsilon_{i,t} \quad (2)$$

Model 2 is the same as Model 1 + interaction variables (supply-push variables [RDEXP] with demand-pull variables [FIT / REC / AUC]). In addition, we have specified and estimated two models (3 and 4), which are Models 1 and 2 changing RDEXP by RDSTOCK and removing EGEN (in order to avoid multicollinearity).

Since our dependent variable is a count variable, Poisson is the adequate distribution for count data. However, the likelihood ratio test of alpha = 0 shows that the overdispersion parameter is different from 0 for all model specifications. To address this overdispersion, we use a negative binomial distribution (NB2) instead of Poisson.

Results

The results of the econometric estimations (Table #) show that auctions have a negative but not statistically significant effect on innovation in solar PV technologies. Feed-in Tariffs show a positive and significant effect in the models without policy interactions. RECs show a positive and significant effect in the models with policy interactions and in both models with public R&D expenditure as the supply-push variable.

Table #: Estimation results of the negative binomial models with country fixed effects for solar PV energy

VARIABLES	(1)	(2)	(3)	(4)
Public Policy Variables				
Feed-in Tariffs (FIT)	0.265**	0.271	0.312***	0.134
	(0.121)	(0.259)	(0.118)	(0.143)
Renewable Energy Certificates (REC)	0.273**	0.662***	0.207	0.619***
	(0.134)	(0.264)	(0.133)	(0.167)
Auctions (AUC)	-0.0554	-1.072	-0.00906	-0.535
	(0.149)	(0.724)	(0.143)	(0.752)
R&D Expenditure (RDEXP)	-0.0475	0.0328		
	(0.0411)	(0.102)		
R&D Stock (RDSTOCK)			-0.0275	-0.0334
			(0.132)	(0.142)
Control variables				
CO2 Emissions (CO2)	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
Electricity generated from RES (EGEN)	[illegible]	[illegible]		
	[illegible]	[illegible]		
GDP per capita (GDPPC)	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
Oil price WTI (OILPRICE)	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

A surprising, unexpected result is that public R&D support does not have a significant effect on technological innovation in any of the model specifications. The rest of control variables show the expected results.

The only significant (and negative) interaction is that of R&D expenditure and REC. Given that R&D not significant overall, we could not expect interactions to be significant overall.

Conclusions

Innovation in RETs will be a critical component of a clean energy transition. Auctions are the main instrument to support renewable electricity deployment, both in the EU and worldwide. Deployment policies such as auctions may have an indirect contribution to the energy transition (supporting technological innovation in RETs) in addition to the direct one (supporting their deployment). However, the analysis of the innovation effects of auctions has not received attention in the literature. This paper covers this gap in the literature. It tries to answer the research questions: Do auctions promote innovation in RETs? Do auctions promote innovation more than other deployment-support instruments? Although there is an abundant research on the impact of FIT/FIPs on technological innovation, the literature on the innovation impacts of auctions is tiny. This issue has both an academic and policy relevance. First, innovation is a critical element of the energy transition. Second, the innovation literatura stresses the relevance of both supply-push and demand-pull for innovation in RETs. Third, auctions are the deployment instrument of choice everywhere. Therefore, the demand-pull effects of renewable energy auctions on RET innovation are worth analyzing.

The results of the econometric analysis suggest that the hypothesis that “the incentive to innovate in RETs provided by auctions is weak” cannot be rejected. In addition, the hypothesis that “the incentive provided for innovation by auction is lower than with alternative deployment support instruments and, particularly, administratively-set feed-in tariffs and premiums” can also not be rejected.

The policy implications of these results are not trivial. It is obvious that auctions should not primarily be judged for their capacity to encourage innovation, but effective and cost-efficient deployment of renewable energy technologies. However, if, as suggested by the innovation economics literature, policy-induced innovation requires a combination of supply-push and demand-pull instruments and the demand-pull influence is not present with the most widespread deployment instrument (auctions), then innovation processes may suffer, i.e., they may be slower or incomplete.