EFFECTS OF GOVERNMENT INCENTIVES ON WIND INNOVATION IN THE UNITED STATES

Nathaniel Horner, Carnegie Mellon University, 919-961-6033, nhorner@andrew.cmu.edu

Overview

In the United States, as elsewhere, state and federal governments have considered or implemented a range of policies to create more sustainable energy generation systems in response to concerns over climate change, security of fuel supply, and environmental impacts, as well as the desire to promote local employment. These policies include both regulatory instruments such as renewable portfolio standards (RPSs) and market incentives such as tax credits. While these policies are primarily geared towards increasing renewable generation capacity, they indirectly affect innovation in associated technologies through a "demand-pull" dynamic. Other policies, such as public research and development (R&D) funding, directly incentivize innovation through "technology-push" means.

This paper attempts to identify the correlations of these policies to innovation in the United States wind energy industry. Results will show which policies have tended to be associated with increasing innovation in wind turbine technology. This paper differs from other wind innovation studies in the literature (Nemet 2009; Johnstone, Haščič, and Popp 2010) in that it includes more recent policy and patent data and focuses exclusively on the United States.

Methodology

Taking cues from existing innovation literature, I construct a set of econometric models relating a set of U.S. federal and state policies to patenting activity in wind technologies over the period 1974-2009. Patent counts have been shown to be highly correlated with private R&D investment and can function as a measure of innovation (Griliches 1998). The principal model is a negative binomial regression of U.S. wind-related patent counts on various policy variables:

$$\mathrm{E}[windpats_t | policies_t, controls_t] = \exp\{\beta_1(policies_t) + \beta_2(controls_t) + \varepsilon_t\}$$

where $policies_t$ is a vector of policy variables and $controls_t$ is a vector of variables controlling for non-policy factors. The data elements of each vector are described below.

Patent data are obtained using a hybrid class- and keyword-based patent search on the United States Patent and Trademark Office (USPTO) database. Policy data include the federal wind R&D funding (Energy Efficiency and Renewable Energy, U.S. Department of Energy 2012; Ruegg and Thomas 2009), investment tax credits at the federal and state levels (Musgrove 2010), the federal production tax credit (PTC) (Ruegg and Thomas 2009), and state-level renewable portfolio standards (RPSs) (Lawrence Berkeley National Laboratory 2012; North Carolina Solar Center 2012). Policy variables are represented by continuous measures of relevant attribute values, such as the percent return of a tax credit or the mandated generation associated with an RPS, where possible. Different model specifications control for various economic indicators such as electricity price and consumption and GDP (EIA 2012) and overall patenting (USPTO 2012). I conduct a sensitivity analysis on policy leads and lags and test several functional forms of the model for robustness.

Results

Results consist of regression estimates of the coefficients on the policy and control variables. The estimated coefficients for the ``main'' model specification, with patent counts as a negative binomial response are shown in the table below:

Variable	DOE Wind R&D	PTC Horizon	ITC-Federal	ITC-California	Aggregate RPS+2	All Patents	Elec. Price	Elec. Consump.
	$millions	*months*	*%-pts*	*%-pts*	*annual TWh*	*thousands*	*cents/kWh*	*annual TWh*
Coefficient	**0.00315*****	0.000212	0.0177	0.00957	**0.0295*****	**0.0130*****	−0.0256	**−0.00103*****
Std. Error	(0.000921)	(0.00219)	(0.0116)	(0.00633)	(0.00201)	(0.00239)	(0.0800)	(0.000221)

Due to uncertainty in the model, however, I emphasize the signs and relative magnitudes of these estimates rather than their precise values. Federal R&D has a significant, positive sign, as expected, but a relatively small value. The investment tax credits and the PTC coefficients are not significant, while the RPS coefficients are generally highly significant. Additionally, the overall level of patenting activity is positive and significant except when foreign-originated patents are excluded.

Conclusions

Though the model has some important limitations, which I discuss, I find that RPS policies have had significant positive effects on wind innovation, whereas tax-based incentives have not been particularly effective. RPSs function as "technology-forcing" regulations because they require producers to meet their obligations within the existing market environment (Komor 2004). I also find evidence that the effects of RPS incentives differ among states. Additinally, public R&D funding can be a significant driver of wind innovation, though its impact in the U.S. has been surprisingly modest. R&D does not significantly lead patenting, which is in accord with the findings of (Griliches 1998). Finally, the growth in patenting in the U.S. is coming largely from abroad, indicating that an expanding U.S. wind market is incentivizing foreign inventors to patent their innovations here at increasing rates. I caution that these conclusions relate to policy effects on *innovation* only; they do not attempt to describe policy effectiveness on wind *deployment*.

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