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The evaluation of renewable energy policies across EU countries and US states: An econometric approach

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ABSTRACT

Renewable energy policies are implemented to promote the diffusion of renewable energy sources within the market. However, their effectiveness on renewable electricity capacity remains subject to uncertainty. This paper addresses what renewable policy instruments are effective ways to increase capacity of renewable energy sources. This study employs a 1990–2008 panel dataset to conduct an econometric analysis of policy instruments, namely, feed-in tariffs, quotas, tenders and tax incentives, in promoting renewable energy deployment in 27 EU countries and 50 US states. The results suggest that renewable energy policy instruments play a significant role in encouraging renewable energy sources, but their effectiveness differs by the type of renewable energy policy instruments. Findings reveal that feed-in tariffs, tenders and tax incentives are effective mechanisms for stimulating deployment capacity of renewable energy sources for electricity, while the other commonly used policy instrument – quota – is not.

Introduction

Are renewable energy (RE) policies effective in fostering RE deployment? Obtaining an accurate answer to this question has become increasingly more important as governments cope with energy challenges such as demand growth, national security risk with fossil fuel dependence, climate change, and pollution (Jacobs et al., 2013; Marques and Fuinhas, 2012; Stokes, 2013; Woo et al., 2011). In response to these challenges, use of RE has expanded in recent years, particularly in EU countries and US states. The electricity generation from RE sources in Europe and the United States was 4.21% and 2.65% of total electricity generation between 1990 and 2008, respectively. Adding further pressure on the need for accurate assessment of RE policy initiatives, aggressive targets for RE growth have been proposed. For example, the EU has set a target of 20% of electricity generation from RE sources by 2020 (Menegaki, 2013; EIA, 2014). In the US states, Oregon's target is 25% of electricity from RE sources by 2025 (Delmas and Montes-Sancho 2011), California's target is 33% of electricity from RE by 2020, and New York's aim is 29% of RE consumption by 2015 (Krieger, 2014). However, meeting these goals will be difficult without a thoughtful examination of existing RE policy instruments and their impact on RE deployment.

The present study aims to contribute to the existing research in several ways. First, this paper applies an econometric framework to assess the effectiveness of four policy instruments (feed-in tariffs – FITs – quotas, tenders and tax incentives), in 27 EU countries and 50 US states over a longer span of time than previously considered. In addition to RE policy instruments, this paper also uses substitution (thermal/nuclear), economic (real GDP, coal/gas price, electricity consumption), security (energy/electricity import), and environmental (CO_2 emission per capita) variables to examine their impact on RE capacity.

Second, this study has an EU and US focus, unlike the studies of Carley (2009; 2011), Delmas and Montes-Sancho (2011), Marques et al. (2010) and Jenner et al. (2013), who focused on more specific locales. This EU and US focus allows me to analyse the effects of a wider variety of policy instruments, including FITs, quotas, tenders and tax incentives, on the capacity of RE deployment. Furthermore, the time interval is longer and more recent than those of Marques and Fuinhas (2011) and Smith and Urpelainen (2014).

Finally, in the econometric analysis, this study employs the standard panel data techniques to assess RE policy instruments and explanatory variables that affect the RE capacity. Panel models are used because of time-invariant regional characteristics (fixed effects) such as geographical factors (country/state level), which may be correlated with the explanatory variables. For example, this study finds policy instruments that are price based have been more effective than quantity based policies. This effectiveness could be because price based policies guarantee electricity generation to be purchased by the electric utility services for a long term whereas quantity based policies require suppliers to

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meet a certain capacity goal of RE generation. It is expected to gain meaningful insight for broader perspectives on the effectiveness of renewable policy instruments.

RE policy instruments

My model includes four different RE policy instruments. *FIT* policies offer guaranteed prices for fixed periods of time for electricity produced from RE sources (Couture and Gagnon, 2010; Schmalensee, 2012). It is the most commonly implemented policy instrument worldwide for at least 65 countries across the world and 27 US states (Bläsi and Requate, 2010; UNEP, 2013). It is also the most popular RE support scheme in EU countries; more specifically, 87% of the world's PV (photovoltaics) and 64% of the world's wind capacity was estimated to have been installed under FITs by the end of 2010 (Rickerson et al., 2012).

Quotas are quantity-based policy instruments, and they usually require electricity retailers to supply a minimum percentage of electricity demand from RE sources (Buckman, 2011). Other common names for the same concept include Renewable Portfolio Standard (RPS), Renewable Electricity Standard (RES) and Renewables Obligation/Certificates (RO/ROC) (Schmalensee, 2012). This policy is widely used across US states. For instance, Carley and Miller (2012) discuss the different forms of RPS adopted by state level policymakers and Lyon and Yin (2010) point to the local renewable potential in the framing of policy choices. An RPS is an appealing state policy instrument for a number of reasons, for instance, RPS policies express great political feasibility, they are presented as cost-effective opinions to support RE sector grow and help new renewable technologies become cost-competitive with conventional sources of fossil fuel energy (Rabe, 2008).

Tax incentives are structured as investment based policy instruments and a fiscal policy instrument (Kwant, 2003). Opinions vary on the effectiveness of this policy instrument. Kanes and Wohlgemuth (2008) suggest that a fossil energy tax reduction is more efficient and useful than subsidy and tax reduction for RE, which might be required to encourage efficient investment decisions. Sardianou and Genoudi (2013) suggest tax deduction is the most effective financial policy instrument to promote consumers' acceptance of RE. In contrast, Delmas et al. (2007) argue that tax incentives do not have an effect on deployment of RE sources.

Another renewable policy instrument is known as a *tender* or reverse auction, which is generally described as a means by governmental organizations to encourage lower electricity generation cost from RE sources (Cozzi, 2012). In the tendering processes, the providers with the lowest costs contract to produce power. The tendering process has advantages for encouraging competition between RE technologies without governments having to speculate which providers will be the most cost effective. Tendering for capacity systems are a quantity-driven mechanisms. A fixed amount of capacity to be installed is auctioned and contracts are agreed to ensure the capacity is built (Held et al., 2006).

Table 1
General policy options supporting RE.
Source: Panzer, 2013; Jenner et al. 2013; Haas et al. 2011.

	Price driven	Quantity driven
Investment	Investment incentives Tax credits Low interest/soft loans	Tendering for investment grant
Generation	FIT	Tendering for capacity system for long term contracts
	Fixed premium system	Tradable green certificate system (Quota)

RE support policies are classified as shown in Table 1. A fundamental distinction can be made between investment and generation policy instruments. Generation based policies are green electricity tariffs, with and without labelling, while the most important investment based policies are shareholder programs, donation projects and ethical input. These categories can be further divided based on policy instruments that address price or quantity. Price and quantity driven policies provide investment incentives (tax and tender) or generation incentives (FIT and quota) for capacity expansion. That is to say, FIT and quota-based policies are generation incentives policies, however while FIT is a price-based policy, quota is a quantity-based policy. Likewise, tax and tender-based policies are investment incentives; the former is a price-based policy and the latter is a quantity-based policy. In line with these policies, the price is determined by requiring utility operators to generate a certain percentage of electricity from RE sources. In other words, these policies aim at demand creation for REs in the marketplace through internalizing negative externalities or reducing market barriers.

Previous RE policy evaluations

The majority of studies investigating the effectiveness of RE policies have relied on exploratory analyses and case studies at the individual state or country level. Although some studies suggest positive relationships between RE policy instruments and deployment, others have found no relationship or a negative one. This is most likely due to individual studies having a narrow geographic focus, using methods appropriate for a focused approach, and examining a wide variety of variables.

The performance of specific RE policy instruments in individual countries, or in several countries, has been evaluated by Green and Yatchew (2012), Jacobsson et al. (2009), Haas et al. (2011), Klessmann et al. (2010), Ragwitz et al. (2012), and Smith and Urpelainen (2014). In Europe, Dong (2012) compared three FIT based countries (Denmark, Germany, and Spain) with three quota based countries (United Kingdom, Ireland and France) using annual data on total and cumulative wind capacity installed. Dong (2012) demonstrated that FIT countries increased total wind energy production capacity over the renewable portfolio standards of the quota countries. Sawin (2004) examined Italy and Spain with respect to FIT success and found positive outcomes for Spain, but not for Italy. In the case of Italy, a number of problems interfered with FIT success, including a lack of confidence in continuation of the policy, financial setbacks, and technological problems accessing the electrical grid. Likewise, Hughes (2010) reported that FITs were unsuccessful in Britain by discouraging local promotion of RE capacity. For the most part, other studies (Frondel et al., 2010; Gagnon and Coutere, 2010; Jenner at al., 2013; Lipp, 2007; Shaw et al., 2010; Smith and Urpelainen, 2014) have found a positive relationship between FIT policy and RE deployment. However, many of the previously detailed studies (e.g., Nagy and Körmendi, 2012; Sirin and Ege, 2012) lack empirical analysis and instead focus on overview of RE policy. This study takes a broader, more inclusive approach.

Several econometric studies evaluated the effectiveness of RE policies at the US state level. Carley (2009) prepared a model using fixed effects vector decomposition (FEVD) across 48 US states between 1998 and 2006. She examined the influence of policy, socioeconomic, and political variables on RE electricity production. A key result indicated that quota implementation is not a significant predictor of the percentage of RE electricity generation. Shrimali et al. (2012) investigated the impact of RPS on individual renewable technologies by using a panel data analysis for renewable deployment in the 50 US states over 1990–2010. They ran multiple time series cross-sectional regressions with fixed effects. Their results suggest that RPS has no effect, and that income causes a negative impact on RE deployment. Delmas et al. (2007) also concluded that the quota (RPS) system does not have an impact on RE