Energy for Sustainable Development 31 (2016) 83–90

Contents lists available at ScienceDirect

Energy for Sustainable Development

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

Nurcan Kilinc-Ata

Osmaniye Korkut Ata University, Faculty of Humanities and Social Sciences, Department of Economics, Fakiusagi, 80020, Osmaniye/Turkey

ARTICLE INFO

Article history:
Received 9 October 2014
Revised 30 December 2014
Accepted 24 December 2015
Available online xxxx

Keywords:
Renewable energy
Renewable policy instrument
Panel data models

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

E-mail addresses: nurcanata@osmaniye.edu.tr, nurcankilinc@yahoo.com.

http://dx.doi.org/10.1016/j.esd.2015.12.006
0973-0826/

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 generation. In contrast, Menz and Vachon (2006) analysed the effectiveness of five policy instruments (renewable portfolio standard, fuel generation disclosure requirement, mandatory green power option, public benefit fund, and retail choice) to stimulate wind energy between the years 1998 to 2003 across 39 US states. Employing the ordinary least squares method, they reported a positive relationship between quota policy instruments and development of wind power. Other researchers (Neuhoff et al., 2008; Smith and Urpelainen, 2014; Yin and Powers, 2010) have also found positive and significant relationships between quotas and the capacity of RE deployment.

In this paper, the second 2 will describe the methods and the data used in this study. This includes presenting the model and describing determinants of the variables in detail. The third section will present the empirical findings and discussion, and the fourth section will provide the conclusions and discuss policy implications.

Methods and data

This study uses panel regression tests, resulting in a comprehensive analysis of the links between RE growth and policy trends. I assemble a country-level and state-level panel data set spanning 1990–2008 and employ a country/state fixed-effect model with regression test for robustness and reliability of the results of panel data models. Panel data controls for country heterogeneity using EU and US provide more information than analysing them separately. It is also crucial to consider the reliability of the present work undertaken to confirm appropriate interpretation of the regression test results. To this aim the things that may have an impact on test results will be accounted for (Khandker, 2005). One can use a fixed-effects estimator, since the unobserved heterogeneity is constant over time. A fixed-effect panel specification is used for testing unobserved heterogeneity and all the variables are expressed as deviations from their mean values (Waldfogel, 1997). In other words, panel data are used to examine the hypothesis that renewable electricity capacity is related to observable and unobservable characteristics influencing renewable electricity capacity. As the unobserved sources of renewable heterogeneity are relatively constant over time, this paper can treat these unobserved variables as fixed effects, and use panel data techniques to obtain consistent estimates of the parameter coefficients. This approach provides consistent estimates of the residuals in the regression, for this reason I used the approach to construct a test for correlation between renewable electricity capacity and unobserved heterogeneity (Himmelberg et al. 1999). As Shrimali and Kneifel (2011) note, a country/state fixed effect is vital to control for unobserved heterogeneity, which also affects RE deployment. The estimation regression model is;

$$Y_{\text{it}} = \beta\text{Policy}_{\text{it}} + \delta X_{\text{it}} + \Sigma_{J=1}^{T=1}\tau_j T_j + u_i + \omega_{\text{it}}$$

where Y_{it} is a measure of ratio of renewable electricity capacity in total electricity supply from non-hydro renewable sources in country/state i at year t, $Policy_{\text{it}}$ stands for the RE policy instrument in use (FIT, quota, tender and tax) in country/state i at year t, β is the coefficient of policy variables, X_{it} denotes the vector of explanatory variables, δ is the vector of coefficients of explanatory variables, Tj is a year dummy variable which is equal to one for year j and zero elsewhere, u_i is country/state fixed effect index, and ω_{it} is the random error term that applies to each country/state at each year.

Besides RE policy instruments, this modelling framework allows for the possibilities that other explanatory variables (e.g., GDP, security, and economics) may affect capacity of RE deployment. These variables will be explained in below.

Table 2
Arguments depending upon variables.

Explanatory variable		Positive/negative	Reason/argument
Thermal	Substitute	Negative	Substitute for RE
Nuclear	Variables	Negative	Substitute for RE
GDP growth	Economics	Positive	RE is a normal good
Electricity consumption	Variables	Positive	RE is a normal good
Gas price		Positive	Substitute for RE
Coal price		Positive	Substitute for RE
Energy import	Security Variables	Negative	No need import as RE is sufficient
Electricity import		Negative	No need import as RE is sufficient
Carbon dioxide emission	Environmental Variable	Positive	Pressure to minimize CO_2 emissions and tendency to RE

Data

Annual data for 27 EU countries and 50 US states from 1990 through 2008, for a total sample size of 1463 observations, were derived from a number of sources. The dependent variable in the analysis, Y_{it} — *ratio of renewable electricity capacity*, is the percentage of electricity capacity from RE resources (wind, solar, geothermal, and biomass, combined into a single measure), defined in GWh/year for each country/state in each year. The measurement of RE capacity, Y_{it} excludes – hydropower – in the RE sources. The reason for this exclusion is that hydropower is generally not eligible for subsidies under the policy schemes that are used in this analysis. One cannot determine the effectiveness of the policy if it does not cover the resource (Brunnschweiler, 2010; Zhao et al., 2013). All RE capacity data is obtained from the US Energy Information Administration (EIA) and International Energy Agency (IEA).

Determinants of variables over RE growth

The explanatory variables are those common in the literature, and the research is enhanced by the assumptions/hypothesis related to the explanatory variables. EU countries' and US states' policies have a certain level of homogeneity and commonalities, despite being in different regions of the world. Additionally, existing literature on country and state energy policy adoption informed the choice of independent variables for this analysis: policy, economic, substitute, security and environmental factors (Jenner et al., 2013; Marques et al., 2010). A summary of the variables used in the model, as well as their descriptive statistics and correlation matrix, are found in the appendix. The explanatory variables are presented in Table 2 and detailed below.

The RE policy instruments, $\text{Policy}_{\text{it}}$, are key explanatory variables that include FIT, quota, tender, and tax incentives measured at the country/state-year level. They were collected from a variety of sources such as De Vries et al. (2003), Delmas et al. (2007), Haas et al. (2011), Ragwitz et al. (2012), and EIA. Following Carley (2009), Johnstone et al. (2010), and Zhao et al. (2013), dummy variables were created to indicate FIT, quota, tender, and tax incentives. A country was coded as 1 if it adopted any of the policy instruments (either FIT, quota, tender, or tax incentives) and a zero otherwise. That is, the four policy variables take on a value of 1 after the introduction of any policy instruments, and 0 before. Furthermore, for some countries, more than one policy is adopted, while other countries adopt just one. One drawback of the specification used here is that within policy type heterogeneity is ignored. Policies vary across several dimensions other than type, tax incentives could include reducing the rate of the tax or offering tax credits, as well as technologies acceptable for the tax credit. In addition, in many countries employing tax credits, several different targeted programs exist concurrently, each focusing on specific technologies such as photovoltaics, wind turbine, ocean energy and waste-to-energy (Johnstone et al. 2010). The other explanatory variables to be displayed in Y_{it} are discussed as follows.

Substitute energy sources (*thermal and nuclear*) are included because of the impact of conventional energy sources on renewables (Carley, 2009; Marques and Fuinhas, 2012; Marques et al., 2010). Based on these studies, countries need to consider environmental policies due to high share of fossil fuel consumption. Fossil fuels carry significant environmental problems such as climate change, air pollution and habitat destruction. Hence, this study expects that substitute variables, which are collected from US EIA and IEA, contribute to capacity of RE deployment.

The *income* (*GDP*) *effect* on renewables is commonly tested in the literature (Carley, 2009; Jenner et al., 2013; Marques and Fuinhas, 2011; Marques et al., 2010). Higher income countries are relatively capable of sustaining the costs of RE technologies and stimulate RE deployment through economic incentives (Aguirre and Ibikunle, 2014). It has been argued by Dong (2012), Shrimali and Kneifel (2011), and Yin and Powers (2010) that income (measures such as real GDP or GDP per capita) does not have any effects on the RE capacity. However, Carley (2009) and Chang et al. (2009) asserts that income influences renewables deployment for developed countries. Because developed countries will be included in the analysis, it is anticipated that income will show a positive effect on RE deployment. The present paper includes the growth of GDP as an explanatory variable in the analysis due to non-stationary nature of level of GDP. They are derived from World Bank and EIA.

Prices of natural gas and coal are collected from British Petroleum Statistical Review of World Energy (2009). Traditionally, the price of energy generated from conventional energy sources is lower than the price of energy generated from RE sources. Higher prices of fossil-based energy sources promote the switching from traditional sources to renewable sources. Chang et al. (2009) notes a positive relationship between traditional energy prices and RE growth. Their results suggest that high fossil fuel energy prices stimulate RE supply in high economic growth countries. Another strand of literature indicates that electricity prices are reduced with renewables deployment (Gelabert et al., 2011; Würzburg et al., 2013). Given the relationship captured in literature, this study hypothesizes that prices in fossil based energy sources could be significant determinants of the qualitative improvement of RE capacity.

Dependency of energy security is a crucial policy concern for governments, and research has shown that energy security has an impact on renewables deployment (Aguirre and Ibikunle, 2014; Chien and Hu, 2008; Dong, 2012). The analysis of this study, therefore, considered energy security variables (energy/electricity import) as a probable causal factor for RE deployment, as suggested by Marques et al. (2010), by using energy import variables as a proxy for energy security. While energy would be imported by primary energy sources such as coal, petroleum, and natural gas, electricity imports are electricity transmitted across countries. Popp et al. (2011) found that energy imports are correlated with lower RE use after controlling for both the energy and electricity imported base of a country. Most countries invest in RE not only to reduce dependence on imported oil, but also to increase the supply of secure energy and minimize the price volatility associated with fossil fuel imports (Menyah and Wolde-Rufael, 2010). In fact, the greater energy imports are, the lower the commitment to renewables, and the weaker the response to their development is (Marques et al., 2010). Theoretically, it is critical for a country with high energy/electricity imports to enhance energy security by increasing RE deployment. Gan et al. (2007) suggest that energy diversification and localization, namely RE sources, are essential for the energy security. That is why I use the energy/electricity import dependency of each country/state, anticipating that high energy/electricity imports encourage higher investment in its own RE sources. Energy security is measured by the ratio of net energy imports to total energy/electricity consumption, collected from Eurostat, European Commission, and EIA.

Table 3
Results from panel analysis.[1,2]

Dependent variable: Crenel - Ratio of renewable electricity capacity	Coefficient	Standard error
RE policy instruments		
FIT	.02815***	.00730
Quota	.00295	.00346
Tender	.00759*	.00399
Tax	.00546**	.00272
Substitute variable		
Thermal	−.10772	.06814
Nuclear	−.17068**	.07024
Security variable		
Energy import	−.06780	.07405
Electricity import	.03518	.02241
Economics variable		
GDP growth	.00004	.00002
Electricity Consumption (per capita)	−1.33e−1*	6.955e−1
Coal price	.00012***	.00012
Gas price	.00079	.00079
Environmental variables		
CO_2 emission per capita	.00061	.00061

Notes: Standard errors are corrected for country/state-level serial correlation. The variance inflation factor (VIF) was used to check colinearity between independent variables.
* p value < the significance level of 0.1.
** p value < the significance level of 0.05 and 0.1.
*** p value < the significance level of 0.01, 0.05, 0.1.
[1] For the first differences, I have checked the stationary of a number of variables, which may be non-stationary and used only stationary ones. I removed the most concerning variables (CO_2 growth, GDP growth, and electricity import) and this has had no effect on my results.
[2] Additionally, some robustness checks were done by running the analysis with only policy dummies, by using only the most recent 6 years, and only policy dummies for the last 6 years. According to analysis results with just policy dummies, all RE policy instruments are significant. For the last 6 years analysis results with only policy dummies, feed-in tariff is statistically significant but others are not significant. According to robustness check for the last 6 years results, only feed-in tariff is statistically significant, and others are not significant.

Electricity consumption per capita is the annual average consumption of electricity in each country and states. TOE (Tons of Oil Equivalent) per capita represents the consumption of electricity. They are collected from the EIA and IEA.

Carbon dioxide emissions per capita (CO2PC) is an environmental explanatory variable. Carbon emission effect will be positive for the capacity of RE deployment because higher levels of CO2PC create pressure on the political leaders for environmental issues and sustainability. Given the need to reduce carbon emissions and efforts to fight global warming force countries/states turn to RE sources, since RE does not cause CO2PC into air or generate other waste products. The variable CO2PC is commonly used in literature (Marques and Fuinhas, 2011; Marques et al., 2010).This study hypothesizes that CO2PC has a positive impact on renewables deployment as RE sources have potential global environmental benefits in terms of reduced CO2 emissions. This expectation is in line with the studies of Marques and Fuinhas (2011), Marques et al. (2010), and Sadorsky (2009). CO2PC is collected from European Commission, Eurostat, and EIA. Low carbon energy is likely to remain the priority for energy policy around the world. Therefore, climate change policies, which attempt to reduce CO2 emissions, are likely to sustain RE deployment.

Furthermore, Table A1 provides descriptive statistics of all variables on each measure of RE capacity. The correlation matrix is provided in

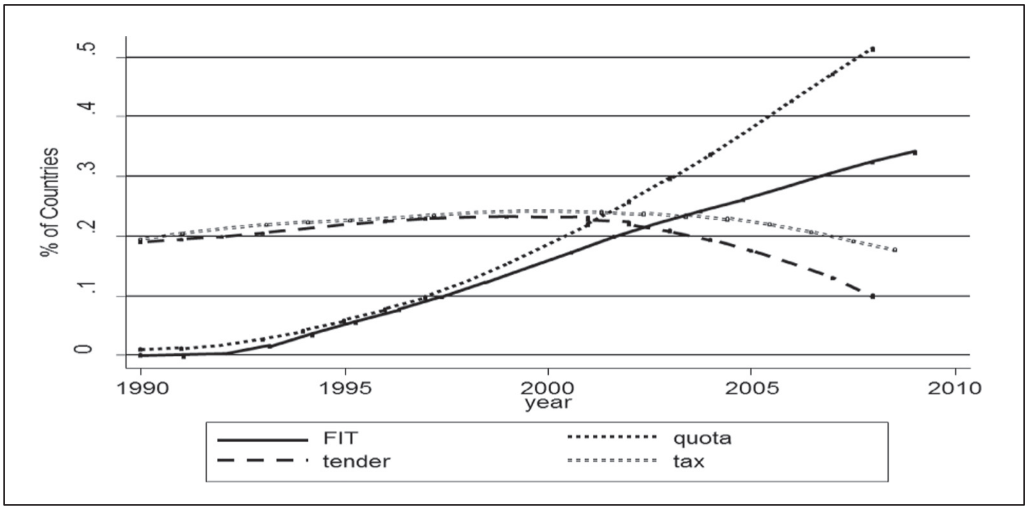

Fig. 1. Comparison of use of RE policy instruments from 1990 to 2008.

Table A2, and correlation coefficients suggest the strong of multicollinearity between the explanatory variables.

Results and discussion

Table 3 presents the results from several estimations of fixed-effect model given in the equation.

Table 3 shows the results from panel data regression. The analysis revealed several explanatory variables that are significant determinants of RE deployment capacity. All traditional/substitution energy sources which include thermal (coal/natural gas/petroleum) do not have effect on RE capacity, while nuclear participation in the total energy generation has negative relationships with RE deployment. In other words, thermal energy has no affect on RE participation whereas nuclear energy is statistically significant yet affects to RE deployment negatively. An argument may be that the consumption of nuclear energy increases steadily over the whole period. The results thus suggest that countries/states with increasing population growth, energy use, and energy demand tended to follow more traditional energy solutions instead of renewables. Another argument may be that the consumption of nuclear energy increases steadily over the whole period. The results thus suggest that countries/states with increasing population growth, energy use, and energy demand tended to follow more traditional energy solutions instead of renewables. This is because nuclear energy is considered to provide major solutions to the problems of energy security and environmental degradation since they are seen as virtually carbon free energy sources and relatively cheap technology comparing to RE sources (Apergis et al., 2010). In this regard, nuclear power may be viewed as a competitor to RE sources.

Traditional energy sources (coal/natural gas/petroleum) are not statistically significant in RE deployment. Theoretically, these relationships between renewables and traditional energy sources are an expected finding. This may be an indicator that lobbying activities of traditional energy sources are restraining the deployment of RE (Marques and Fuinhas, 2011). Traditional energy lobby activities in many countries are very effective because fossil based energy sources are chosen due to economic reasons. Thus, renewable promotion policies are being enacted due to powerful lobbying activities in traditional industries (Aguirre and Ibikunle, 2014). Additionally, the fossil based energy industry has been funding political campaigns in the world because politicians are mainly related with the current levels of wealth and quality of life. Fossil-based fuels have also been used as a strong geo-strategic force in the military industry, employment, capital markets and economy in general (Sovacool, 2009).

Similar to nuclear power, electricity consumption has a negative effect on the deployment of RE capacity. One explanation might be that non-RE sources decrease gross electricity price, theoretically making RE more costly and suppressing its development (Jenner et al., 2013). These results suggest that future electricity needs discourage investment in RE sources as well as traditional ones. Furthermore, energy security variables do not have a significant effect on RE sources. This claim is in line with the studies of Aguirre and Ibikunle (2014) and Popp et al. (2011). This result suggests that energy security is not a principal driver in RE deployment. This may be an indicator that new technologies have continued to open up new frontiers for accessing fossil fuel deposits that were previously thought to be inaccessible; therefore, energy security is becoming less of concern to policy makers (Aguirre and Ibikunle, 2014). However, previous research has shown that security variables are significant to RE encouragement deployment. For instance, Marques and Fuinhas (2011) suggest that renewables may lead to increase in fossil-based fuel imports and the need for continuous supplies. Further, Zhao et al. (2013) show that an increase in energy/electricity dependence, enhancement in financial market equality and accretion of human capital could promote RE deployment.

The results for the effects of traditional energy prices on the RE capacity are mixed. For the time span and the countries and states considered, the results show that the effect of the price of coal on RE is significant and consistent with the work of Chang et al. (2009). In the case of natural gas prices, the model reveals that it is not a significant factor for promotion of RE use. This is in line with the studies of Aguirre and Ibikunle (2014), and Marques et al. (2010) and their results for the analysis of EU countries. The relationship between prices of fossil energy sources and renewable deployment might be unclear due to other factors. For instance, Gelabert et al. (2011), and Würzburg et al. (2013) suggest that expansion of RE sources could lead to a reduction in electricity prices, when electricity prices are on the rise. Furthermore, the theoretical support of the fossil fuel price effect on renewables could be more sophisticated than the simple direct mechanism of high price of fossil energy sources making renewables more attractive. These higher prices should be incentive for the deployment of RE capacity, since higher fossil-based fuel prices make investment in renewables more desirable (Marques et al., 2010). In brief, natural gas prices are statistically insignificant for RE deployment in the countries and states under consideration. At the same time, coal prices are statistically significant and coal prices have a positive effect on RE deployment.

Similar to gas prices, income does not have an effect on renewables. The results indicate that income is not significant in the deployment of RE capacity for the time span and for the set of countries/states under review. One explanation might be that economic growth gives rise to more demand. That demand is matched with more production, requiring needs more energy consumption (Marques and Fuinhas, 2011). The literature is mixed on whether measures of wealth indicate encouragement (Carley, 2009; Shrimali and Jenner, 2013) or discouragement (Aguirre and Ibikunle, 2014; Marques and Fuinhas, 2011) of RE deployment.

The results here suggest that different countries/states have environmental concerns for capacity of RE deployment, and these concerns are important drivers to stimulate renewables. However, there is no relationship between CO2 emissions and renewables found in the model. Environmental concerns do not seem to be encouraging the use RE sources. This result suggests that social pressure with regard to environmental quality and climate change developments were not consequent in the decision process of switching to renewable sources (Marques et al. 2010). This is in line with the work of Marques and Fuinhas (2011), who found that greater CO2 emissions do not effect to promote RE deployment. In contrast, Aguirre and Ibikunle (2014), and Smith and Urpelainen (2014) found that CO2 emissions do help stimulate the RE deployment.

Policy variables

RE technologies are relatively expensive and cannot compete with traditional energy technologies without supporting policies (Aguirre and Ibikunle, 2014). Therefore, RE policy instruments play crucial role in the deployment of renewable capacity (Johnstone et al. 2010). Fig. 1 shows the use of RE policy instruments which include FIT, quota, tender and tax reduction between 1990 and 2008, a period of 19 years.

Fig. 1 indicates that the use of FIT and quota policy instruments at the beginning of the study period were virtually nil, increasing steadily through 2008 to become the most commonly implemented RE policy instruments. In contrast, at the start of the study period tax and tender were virtually the only policies employed, with their use slightly increasing through 2000, before falling gradually through 2008 to become the least favoured RE policy instruments. In other words, tax and tender RE policy instruments followed a similar pattern over the period. They remained fairly stable between 1990 and 2000, then, they gradually decreased trend from 2000 to 2008.

The estimates of policy effectiveness presented here suggest that FIT, tender and tax are positively linked to capacity of RE deployment. However, quota-based RE policies do not seem to have significant effect on renewables whilst having the increased reliance. A quota policy is revealed to have an insignificant relationship with RE capacity, in other words, countries/states with quota based policies do not have statistically higher rates of capacity of RE deployment than countries/states without quota based policies. Results show that countries/states may not meet their quota targets satisfactorily. Subtle factors may be obscuring effectiveness of quota based RE policies.[3] For example, Marques et al. (2010) argue that RE policies are often implemented simultaneously with other energy policies, and given a high level of energy consumption, increasing energy efficiency can reduce reliance on fossil energy sources, thus diminishing demand for RE and weakening the effect of quota-based policies. Shrimali et al. (2012) note that the quota stringency by itself is inadequate representation of the richness of a quota based policies, and quota based policy characteristics (e.g. automatic compliance payment or regional trading) may cause quota structures to be more or less effective. Furthermore, Carley (2009) suggests a lack of effectiveness for quota (RPS) policies is linked to poor policy enforcement such as weak or inadequately structured policy design requirements and a lack of applicable penalties for non-compliance. Likewise, the empirical support found here for FIT policies deserves some qualification. For instance, Popp et al. (2011) use the FIT for each RE technology and also apply ROC -quota- for the percentage of electricity for renewables. When doing so, both policy instruments are not statistically significant in their analysis. For more detailed analysis of these political, economic and substitute factors that influence RE growth see Huang et al. (2007), Jenner et al. (2013), and Lyon and Yin (2010). Furthermore, RE policy instruments have different policy outcomes (Johnstone et al. 2010) and a lot of RE policies have overlapping aims and interact with each other to some degree (Elizondo Azuela and Barroso, 2012; Fischer and Preonas, 2010; Zhao et al. 2013). It can be expected that RE policy effect grows faster with policy complementarities or decreases with policy conflicts. This issue is elaborated in the literature by De Jonghe et al. (2009), Grace et al. (2011), and Philibert (2011).

[3] *My quota result should be interpreted with caution, as it is possible that a delay in implementation of the policy would potentially bias my estimate downward and thus make the estimate statistically insignificant.*

Conclusion and policy implications

This study investigated the effectiveness of four renewable policies in promoting RE capacity for the EU and US by employing a much larger data set than in previous studies. That is, this empirical study analyses the determinants of country/state-level renewables participation. More specifically, it evaluates the effectiveness of RE policy indicators on the deployment of RE capacity for a set of 27 EU countries and 50 US states, from the year 1990 to 2008 with some explanatory variables such as RE policy instruments, income, energy/electricity consumption, electricity/energy import, gas/coal price and CO_2 emission. To substantiate this argument, this paper employs a fixed-effects regression model and use inherently panel dataset with policy instruments and other variables within country/state level.

The findings show different effects of the policies. FITs, tender and tax have a positive and statistically significant effect on the capacity of RE deployment in Europe and US. The study also found that the variable for quota provided no significant results. This policy type is the most frequently expanded instrument in the case of US states. The lack of an effect suggests that quota does not generate the anticipated result. Another argument may be that quota could be considered to have lenient policy characteristics which allow utilities to be flexible to employ out of countries/states resources to meet renewable requirements for quota (Shrimali et al., 2012). This could cause difficulty for quota based policies to significantly make a difference. In essence, price based policies found to be more effective than quantity based policies. In particular, FIT is essential for green energy sources because of influencing the relationship between growth and RE innovation. Hence FIT looks effective for encouraging capacity of RE, while quota does not have any effect on RE capacity. The findings suggest that tender and tax incentives do seem to have a positive effect on RE deployment. The results of this analysis confirm the general conclusion in the literature that FIT, tender and tax have driven RE capacity deployment in EU and US. The panel driven fixed-effects approach verifies that FIT, tender and tax have contributed sizeable impact.

A striking result indicates that nuclear, electricity consumption, and coal price are significant indicators of RE deployment, while income, security variables, gas price and carbon emission are not. The lack of predictive power for these explanatory variables was unexpected. This suggests that nuclear, electricity consumption, and coal price are more pertinent than income, security variables, gas price and carbon emission for countries and states. Furthermore, electricity consumption is negatively linked to RE capacity because under high pressure to provide the energy supply, countries/states prefer to use less RE and more traditional energy sources due to their cost advantage.

Overall, the capacity of renewable use in the previous period has a positive and highly significant effect on the current period. However, in the period under analysis, this paper does not find evidence for social awareness to reduce emission of greenhouse gases. Furthermore, income and gas prices were not deceive for the development of renewable over the analysed period. Therefore, it was not the market that stimulated renewables due to cartelism. The prices of gas may be constrained by the falling prices of renewable sources, which is a result of progress in technology. This is an issue that deserves attention for further research.

This empirical investigation has strong policy implications. Government/states should make special efforts to assess the compatibility among renewable policies and other regulatory policies due to further improve the effectiveness of renewable policies. Furthermore, considering the fact that some policy instruments are effective only for specific renewable sources, it is crucial for governments to incorporate specific targets of RE capacity outcomes. In addition, while three of policy instruments in this study are significant for renewable energy participation, quota has negative relationship with dependent variable. There is critical insight to be gained here for policy makers since quota is the most commonly deployed instrument in my sample of 50 states.

Some caution should be used while interpreting these findings. It was not the intention of this study to include all possible explanatory variables in the analysis. For example, surface and grid transmission variables were not included, and in a more comprehensive analysis they could prove to be a significant factor in the influence of RE deployment. Furthermore, there is a potential bias resulting from relevant omitted variables (e.g., grid transmission/development, Kyoto Protocol) that could be linked simultaneously with both dependent variables and the policy variables. For instance, RE projects depending on grid development could have moved together with economic growth and policies over time. The current paper attributes the growth in renewables to RE policies while some of the policies are enacted via grid development. Although combining EU countries with all US states offers a comprehensive picture of the general effectiveness of RE policies, which was the goal of this study, application of these findings to a particular locale is problematic. Individual countries or states, each with different political, economic, social, and environmental factors, which could not be completely controlled for here, suggests any specific RE policy implementation for a particular locale would vary in effectiveness based on these factors. The stringency of the policy, if it had been included, could have also affected the results of this study. However, deriving a reliable measure of intensity is troublesome given the long time frame studied and the tendency, over this time period, for policies to change in intensity. Similarly, there are possible limitations of the dependent variable chosen. In this analysis the percentage of electricity capacity from RE resources (wind, solar, geothermal, and biomass) is combined into a single measure. Individual countries and states have different kinds of renewable sources. For instance, while one country or state is only using wind energy, another one is operating solar energy. These differences cannot be completely controlled due to large differences across countries and states. Finally, the effect of polices varied by technology and regulation type, a distinction subsumed by the use of dummy variables in this study. With the use of dummy variables, one drawback of the specification used here is that policy type heterogeneity is ignored. In other words, the limitations of the policy dummies are used due to the fact that no account is taken of the level of FIT or intensity of the quota. A more careful examination of this distinction, as well as factors related to grid, transmission, overlapping policies and policy intensity, are all potentially fruitful pursuits for further investigation.

Acknowledgement

I appreciate the detailed comments of the anonymous reviewers and the kind help of the Editor. I am indebted to the Turkish Ministry of Higher Education for the grant to carry out this study, Dr. Ian Lange and Prof. Frans De Vries for his immense contributions and the participants of University of Stirling Economics Division's Workshop, for their positive feedbacks.

Appendix A. Appendix

Table A1: Variable definition and summary statistics

Variables	Observation	Mean	Standard Deviation	Min	Max
Dependent variable					
Crenel (Ratio of renewable electricity capacity)	1463	.032	.054	0	.618
Independent variables					
Renewable Policy Variables					
FIT (Dummy)	1463	.125	.330	0	1
Quota (Dummy)	1463	.186	.389	0	1
Tender (Dummy)	1463	.205	.404	0	1
Tax (Dummy)	1463	.226	.418	0	1
Substitute variables					
Thermal	1463	.652	.266	.000	1.000
Nuclear	1463	.194	.212	−.007	.878
Security variables					
Energy import	1463	.244	.300	−.528	1.138
Electricity import	1463	.026	.143	−.881	1.015
Economics variables					
GDP growth	1463	3.204	18.642	−527.6	119.938
Electricity consumption	1463	4.17e	5.54e	158.336	3.49e
Coal price	1463	28.797	23.928	0	149.78
Gas price	1463	5.646	3.254	1.42	36.73
Environmental variables					
CO2PC emission growth	1463	−.018	.795	−6.594	5.529

Table A2: Variable correlations

	Crenel	fit	quota	tender	tax	thermal
crenel	1.000					
Fit	0.268	1.000				
quota	0.032	−0.172	1.000			
tender	−0.057	−0.126	−0.253	1.000		
tax	−0.049	−0.157	−0.217	0.279	1.000	
thermal	−0.147	−0.116	0.028	0.079	−0.026	1.000
nuclear	−0.081	0.038	0.046	0.077	0.021	−0.642
energy import	0.141	0.481	−0.148	0.231	−0.187	−0.111
electricity import	0.106	0.015	0.024	0.022	0.020	−0.012
Gdp growth	0.129	0.218	0.000	0.071	−0.046	−0.022
elect consumption	−0.152	0.293	0.228	0.020	0.068	0.105
CO2pc growth	0.006	0.007	−0.025	0.019	−0.029	0.008
coal price	0.354	0.549	−0.024	0.209	−0.126	−0.113
gas price	0.089	0.004	0.398	0.015	0.061	0.044

	nuclear	energy import	electricity import	gdp growth	electricity consumption	CO2pc growth
nuclear	1.000					
energy import	0.030	1.000				
electricity import	−0.170	0.225	1.000			
gdp	0.040	0.193	−0.027	1.000		
elect consumption	0.056	−0.434	−0.087	−0.157	1.000	
CO2pc growth	−0.016	−0.024	−0.051	0.010	0.013	1.000
coal price	0.043	0.593	0.040	0.220	−0.390	−0.055
gas price	0.019	−0.233	−0.005	−0.070	0.178	−0.038

	coal price	gas price
coal price	1.000	
gas price	0.143	1.000

Notes: The table indicates the correlation coefficients for all variables reviewed in this paper. The variables are as defined in Table A1.

References

Aguirre M, Ibikunle G. Determinants of renewable energy growth: A global sample analysis. Energy Policy 2014;69:374–84.

Apergis N, Payne JE, Menyah K, Wolde-Rufael Y. On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. Ecol Econ 2010;69(11):2255–60.

Bläsi A, Requate T. Feed-in tariffs for electricity from renewable energy resources to move down the learning curve? Public Financ Manag 2010;10(2):213–50.

Brunnschweiler CN. Finance for renewable energy: an empirical analysis of developing and transition economies. Environ Dev Econ 2010;15:241–74.

Buckman G. The effectiveness of renewable portfolio standard banding and carve-outs in supporting high-cost types of renewable electricity. Energy Policy 2011;39(7):4105–14.

Carley S. The era of state energy policy innovation: A review of policy instruments. Rev Policy Res 2011;28(05):265–94.

Carley S. State Renewable Energy Electricity Policies: An Empirical Evaluation of Effectiveness. Energy Policy 2009;37:3071–81.

Carley S, Miller CJ. Regulatory stringency and policy drivers: A reassessment of renewable portfolio standards. Policy Stud J 2012;40(4):730–56.

Chang TH, Huang CM, Lee MC. Threshold effect of the economic growth rate on the renewable energy development from a change in energy price: evidence from OECD countries. Energy Policy 2009;37:5796–802.

Chien T, Hu JL. Renewable energy: An efficient mechanism to improve GDP. Energy Policy 2008;36(8):3045–52.

Couture T, Gagnon Y. An analysis of feed-in tariff remuneration Models: implications for renewable energy investment. Energy Policy 2010;38:955–65.

Cozzi P. Assessing reserve auctions as a policy tool for renewable energy deployment. The Center for International Environment & Resource Polict, 007; 2012.

De Jonghe C, Delarue E, Belmans R, Dhaeseleer W. Interactions between measures for the support of electricity from renewable energy sources and CO2 mitigation. Energy Policy 2009;37:4743–52.

De Vries HJ, Roos CJ, Beurskens LWM, Kooijman-van Dijk AL, Uyterlinde MA. Renewable electricity policies in Europe. Country fact sheets; 2003.

Delmas M, Montes-Sancho M. U.S. state policies for renewable energy: Context and effectiveness. Energy Policy 2011;39(5):2273–88.

Delmas M, Russo M, Montes-Sancho M. Deregulation and environmental differentiation in the electric utility industry. Strateg Manag J 2007;28(2):189–209.

Dong CG. Feed-in tariff vs. renewable portfolio standard: An empirical test of their relative effectiveness in promoting wind capacity development. Energy Policy 2012;42:476–85.

EIA. Electric power monthly with data for January 2014. U.S. Energy Information Administration; 2014. http://www.eia.gov/electricity/monthly/pdf/epm.pdf, [14.06.2014].

Elizondo Azuela G, Barroso LA. Design and Performance of Policy Instruments to Promote the Development of Renewable Energy: Emerging Experience in Selected Developing Countries; 2012. https://openknowledge.worldbank.org/handle/10986/9379, [01.05 2014].

Fischer C, Preonas L. Combining policies for renewable energy: is the whole less than the sum of its parts? Int J Environ Resour Econ 2010;4:51–92.

Frondel M, Ritter N, Schmidt CM, Vance C. Economic impacts from the promotion of renewable energy technologies: The German experience. Energy Policy 2010;38:4048–56.

Gagnon T, Coutere Y. An analysis of feed-in tariff remuneration models: Implications for renewable energy investment. Energy Policy 2010;38(2):955–65.

Gan L, Eskeland GS, Kolshus HH. Green electricity market development: Lessons from Europe and the US. Energy Policy 2007;35(1):144–55.

Gelabert L, Labandeira X, Linares P. Anex-post analysis of the effect of renewables and cogeneration on Spanish electricity prices. Energy Econ 2011;33(1):S59–65.

Grace RC, Donovan DA, Melnick LL. When renewable energy policy objectives conflict: A guide for policymakers. National Regulatory Research Institute Working Paper 2011;11–17.

Green R, Yatchew A. Support schemes for renewable energy: An economic analysis. Econ Energy Environ Policy 2012;1.

Haas R, Panzer C, Resch G, Ragwitz M, Reece G, Held A. A historical review of promotion strategies for electricity from renewable energy sources in EU countries. Renew Sust Energ Rev 2011;15:1003–34.

Held A, Ragwitz M, Haas R. On the success of policy strategies for the promotion of electricity from renewable energy sources in the EU. Energy Environ 2006;17(6):849–68.

Himmelberg CP, Hubbard RG, Palia D. Understanding the determinants of managerial ownership and the link between ownership and performance. J Financ Econ 1999;53(3):353–84.

Huang MY, Alavalapati JR, Carter DR, Langholtz MH. Is the choice of renewable portfolio standards random? Energy Policy 2007;35(11):5571–5.

Hughes S. Feed-in tariffs are disappointing for local renewable energy. The Guardian; 2010. http://www.theguardian.com/environment/cif-green/2010/feb/02/feed-in-tariff-renewable-energy, [14.05.2014].

Jacobs D, Marzolf N, Parades JR, Rickerson W, Flynn H, Becker-Birck C, Solano-Peralta M. Analysis of renewable energy incentives in the Latin America and Caribbean region: The feed-in tariff case. Energy Policy 2013;60:601–10.

Jacobsson S, Bergek A, Finon D, Lauber V, Mitchell C, Toke D, Verbruggen A. EU renewable energy support policy: faith or facts? Energy Policy 2009;37:2143–6.

Jenner S, Groba F, Indvik J. Assessing the strength and effectiveness of renewable electricity feed-in tariffs in European Union countries. Energy Policy 2013;52:385–401.

Johnstone N, Hascic I, Popp D. Renewable energy policies and technological innovation: Evidence based on patent counts. Environ Resour Econ 2010;45:133–55.

Kanes DA, Wohlgemuth N. Evaluation of renewable energy policies in an integrated economic energy environment model. For Policy Econ 2008;10:128–39.

Khandker SR. Microfinance and poverty: Evidence using panel data from Bangladesh. World Bank Econ Rev 2005;19(2):263–86.

Klessmann C, Lamers P, Ragwitz M, Resch G. Design options for cooperation mechanisms under the new European renewable energy directive. Energy Policy 2010;38:4679–91.

Krieger EM. State of Renewables: US and state-level renewable energy adoption rates: 2008-2013; 2014. http://www.psehealthyenergy.org/data/RenewablesRates.pdf, [01.04.2014].

Kwant KW. Renewable energy in The Netherlands: policy and instruments. Biomass Bioenergy 2003;24(4-5):265–7.

Lipp J. Lessons for effective renewable electricity policy from Denmark Germany and the United Kingdom. Energy Policy 2007;35:5481–95.

Lyon TP, Yin H. Why do states adopt renewable portfolio standards?: An empirical investigation. Energy J 2010;31(3):133–57.

Marques CA, Fuinhas JA. Do energy efficiency measures promote the use of renewable sources? Environ Sci Pol 2011;14:471–81.

Marques CA, Fuinhas JA. Is renewable energy effective in promoting growth? Energy Policy 2012;46:434–42.

Marques CA, Fuinhas JA, Manso JRP. Motivations driving Renewable energy in European countries: A panel data approach. Energy Policy 2010;38:6877–85.

Menegaki AN. Growth and renewable energy in Europe: Benchmarking with data envelopment analysis. Renew Energy 2013;60:363–9.

Menyah K, Wolde-Rufael Y. CO2 emissions, nuclear energy, renewable energy and economic growth in the US. Energy Policy 2010;38(6):2911–5.

Menz FC, Vachon S. The effectiveness of different policy regimes for promoting wind power: experiences from the states. Energy Policy 2006;34:1786–96.

Nagy K, Körmendi K. Use of renewable energy sources in light of the "New energy strategy for Europe 2011–2020. Appl Energy 2012;96:393–9.

Neuhoff K, Johnston A, Fouquet D, Ragwitz M, Resch G. The proposed new EU renewables directive: An interpretation. Discussion Paper; 2008.

Panzer C. Renewable energy sources - Lessons learned and potential future pathways? International Summer School Sustainable Energy Systems, September 23rd – 28th; 2013. Dresden, Germany.

Philibert C. Interactions of Policies for Renewable Energy and Climate. IEA Working Paper; 2011.

Popp D, Hascic I, Medhi N. Technology and the diffusion of renewable energy. Energy Econ 2011;33(4):648–62.

Rabe BG. States on steroids: the intergovernmental odyssey of American climate policy. Rev Policy Res 2008;25(2):105–28.

Ragwitz M, Winkler J, Klessmann C, Gephart M, Resch G. Recent developments of feed-in systems in the EU. A research paper for the international feed-In cooperation. Berlin: BundesministeriumfürUmwelt, NaturschutzundReaktorsicherheit; 2012.

Rickerson W, Gifford J, Grace R, Cory K. Analysis of international experience and FIT design to support geothermal development in the US. National Renewable Energy Laboratory; 2012.

Sadorsky P. Renewable energy consumption and income in emerging economies. Energy Policy 2009;37:4021–8.

Sardianou E, Genoudi P. Which factors affect the willingness of consumers to adopt renewable energies? Renew Energy 2013;57:1–4.

Sawin JL. Policy lessons for the advancement & diffusion of renewable energy technologies around the world, *Thematic Background Paper*. Bonn: Secretariat of the International Conference for Renewable Energies; 2004.

Schmalensee R. Evaluating Policies to Increase Electricity Generation from Renewable Energy. Rev Environ Econ Policy 2012;6(1):45–64.

Shaw D, Hung MF, Lin YH. Using Net Energy Output as the Base to Develop Renewable Energy. Energy Policy 2010;38:7504–7.

Shrimali G, Jenner S. The impact of state policy on deployment and cost of solar photovoltaic technology in the U.S.: A sector-specific empirical analysis. Renew Energy 2013;60:679–90.

Shrimali G, Jenner G, Groba F, Chan G, Indvik J. Have state renewable portfolio standards really worked? Synthesizing past policy assessments to build an integrated econometric analysis of RPS effectiveness in the US, *Discussion Papers*, 1258; 2012.

Shrimali G, Kneifel J. Are government policies effective in promoting deployment of renewable electricity resources? Energy Policy 2011;39(9):4726–41.

Sirin SM, Ege A. Overcoming problems in Turkey's renewable energy policy: How can EU contribute?". Renew Sust Energ Rev 2012;16:4917–26.

Smith MG, Urpelainen J. The effect of feed-in tariffs on renewable electricity generation: an instrumental variables approach. Environ Resour Econ 2014;57(3):1–26.

Sovacool BK. Rejecting renewables: The socio-technical impediments to renewable electricity in the United States. Energy Policy 2009;37:4500–13.

Stokes CL. The politics of renewable energy policies: The case of feed-in tariffs in Ontario Canada. Energy Policy 2013;56:490–500.

UNEP (United Nations Environment Programme). The renewables 2013 Global Status Report. http://www.unep.org/pdf/GSR2013.pdf, [21.12.2013], .

Waldfogel J. The effect of children on women's wages. Am Sociol Rev 1997;209–217.

Woo CK, Horowitz I, Moore J, Pacheco A. The impact of wind generation on electricity spot-market price level and variance: the Texas experience. Energy Policy 2011;39(7):3939–44.

Würzburg K, Labandeira X, Linares P. Renewable generation and electricity prices: taking stock and new evidence for Germany and Austria. Energy Econ 2013;40(1):S159–71.

Yin H, Powers N. Do state renewable portfolio standards promote in-state renewable generation? Energy Policy 2010;38(2):1140–9.

Zhao Y, Tang T, Wang L. Do renewable electricity policies promote renewable electricity generation? Evidence from panel data. Energy Policy 2013;62:887–97.