Feed-In-Tariffs and Government Corruption: Another Look at the Diffusion of Renewable Energy Technologies

Vergis V. Emmanouil [1]
Genius Margarita [2],
February 2013

Abstract

The literature on diffusion theory argues that government's intervention could act as a lever for the successful deployment of RETs. However, institutional factors and particularly government corruption can distort the incentives provided by the policy maker. This paper provides a systematic analysis of the factors that contribute to the diffusion process of solar photovoltaic and wind systems as proposed by diffusion theory literature but its main objective is to shed light on how policy variables, such as the level of Feed-in Tariffs (FITs) and other support policies, and variables related to the perceptions of a country's level of corruption affect the propagation of Renewable Energy technologies (RETs). A panel dataset for twenty one EU countries covering the period 1999 - 2010 is analyzed using instrumental variables methods to confront the endogeneity problem of Feed-in-Tariffs. The results show that FITs were successful in boosting investments towards solar photovoltaic and wind systems. However the strength of the effect diminishes as the perceived levels of corruption are lower which means that more policy intensity is required when corruption perceptions improve. Furthermore, we find that an overgenerous applied level of Feed-in-tariff might involve the danger of attracting investors trying to exploit public funds, especially in countries were institutions and bureaucrats acts lack transparency.

Keywords: Renewable Energy, Panel Data IV, Feed-In-Tariffs, Corruption Perceptions
JEL: Q42, Q48, C26

[1] PhD student at the University of Crete, Greece, Department of Economics, Gallos Campus, 74100, Rethymno, Tel.:+30 2810 322733, Fax: +30 28310 77404, E-mail: mvergis@econ.soc.uoc.gr.

[2] Assistant Professor of economics at the University of Crete, Greece, Department of Economics, Gallos Campus, 74100 Rethymno, Tel.: +30 28310 77414, Fax: +30 28310 77404, E-mail: genius@uoc.gr.

1. Introduction

The frail economic situation experienced at present by most European economies seems to have diminished the importance of global warming concerns in the political agenda. The spearhead of the struggle to preserve the environment, is the substitution of conventional energy production technologies with renewable energy technologies (RET). The levels of Green House Gas (GHG) emissions as well as the temperature of the planet were balanced for thousands of years until the beginning of the past century. Human activity together with burning of fossil fuels raised the concentration of GHG emissions by more than one third over the past several decades causing the global warming effect. The world energy demand increased by 39% from 1990 to 2008 (IEA), which in turn boosted the produced CO2 emissions. In response to this situation world leaders started taking combined action which led to the adoption of the Kyoto Protocol on 11 December 1997. At the time the protocol was firstly adopted it only encouraged the signatory countries to reduce GHG emissions, however, on February 16 2005 the protocol became mandatory for the 37 industrialized countries while the European community ratified it. Thus, the parties that ratified the Kyoto Protocol were obliged to reduce GHG emissions by an average of five per cent below their 1990 levels over the five-year period 2008-2012.

The EU took action to promote RET diffusion towards the fight against global warming even earlier than the adoption of the Kyoto protocol. Although Europe initiated a strategic approach for its energy future with the publication of the White Paper on November 26 1997, the member targets were not compulsory. Even when the EU set Directive 2001/77/EC on September 27 2001 in order to promote renewable energy use in electricity generation, the established ambitious national targets - 12% of the EU energy consumption ought to be derived from RES by the year 2010 - were left to the environmental consciousness of each member state. In the light of the unsatisfactory progress made by the European community, the EU decided to move towards a mandatory and comprehensive Energy European Policy on October 27 2005 and proceeded to establish Directive 2009/28/EC with binding targets henceforth. The share of energy produced from RES and the share of RES used in the transport sector should increase to 20% and 10% respectively by the year 2020.

In the technology diffusion literature, environmental regulation constitutes the main driver for the adoption of technologies with low and zero carbon emissions (Gray and Shadbegian, 1998; Kerr and Newell, 2003). All of the aforementioned studies argue that in order for investors to allocate their funds to environmentally favourable technologies, environmental regulation must be both stringent and coherent. The lack of stringency, which is partly due to the lack of conviction among policy makers on the ability of new technologies to supersede the old ones, eventually constitutes an obstruction to the implementation of policy mechanisms (Nilsson et. al 2004). On the other hand, the fact that the energy industry is highly capital intensive makes it more difficult for RET technologies to replace conventional ones in the immediate future in the absence of environmental regulation especially in the cases where projects involving other sources such as oil, gas and nuclear power have not yet paid back their investments. Due to the urgency to confront the global warming problem, governments could just eradicate the use of technologies using conventional sources in the energy sector. However, a policy maker that abruptly harms investment funds will hardly be trusted by investors in the future. Thus, the diffusion of RET should follow a dynamic process where policy schemes are designed so as to provide security for investors (Jaccobson and Bergek, 2004).

Beyond the discouragement of energy production from conventional sources, policy instruments can also be directed to the encouragement of RET (Popp et. al, 2011) by providing valuable incentives to new RET investments in the energy sector. The traditional energy producing technologies are far more cost competitive than RETs, thus the provision of incentives inspiring stability and coherency is a prerequisite for RETs to diffuse (Ringel 2006; Angoluchi 2008). However, government intervention must not be rigid and must be adjusted according to the energy technology needs. The effectiveness of a policy scheme is depicted through the long term achieved targets and is obviously affected by the outcome on the diffusion process. The literature on diffusion theory suggests that both innovation and diffusion processes should be considered as endogenous in the sense that they simultaneously cause cost reductions to new technologies entering a market (Jaffe and Stavins, 1995; Söderholm and Klaassen, 2007). Moreover, policy supports such as Feed-in Tariffs could also be endogenous since they are revised according to changes in investment costs as the need for policy supports is lower as investment costs fall.

In addition to policy instruments applied by each country, other factors can influence the diffusion process of RETs. Institutional factors and particularly government corruption can negatively affect investment activities (Everhart et. al., 2009; Mauro, 1995) and distort incentives provided by the policy maker (Fredriksson, List and Millimet, 2003; Fredriksson, Vollebergh and Dijkgraaf, 2004). On the other hand, government corruption, if highly organized, could have a positive effect on investments as shown by Campos et. al. (1999) in the case of Asian countries since potential investors might find investments rather attractive in a corrupt environment. It could for instance lead to a reduction in red tape or bureaucracy and speed up certain procedures. From another standpoint, Fredriksson, Vollebergh and Dijkgraaf (2004), confirmed that coordination between lobby groups may result in policy schemes effectiveness. It is therefore not clear at the outset whether corruption could speed up or slow down the diffusion of RETs.

The aim of the present paper is to scrutinize the determinants of RE generation proliferation and in particular Solar Photovoltaic and Wind generators (SP&W hereafter) in 21 countries of the Europe area. In doing so, the main determinants proposed in the literature related to technology diffusion theory of RE systems will be considered with special emphasis on policy schemes enhancing RE and corruption perceptions. Our contribution to the literature of RET diffusion is that we i) empirically scrutinizing factors proposed from the literature of diffusion theory, ii) investigate the interplay between the effectiveness of policy instruments as a mechanism to enhance investments on SP&W and the prevailing perceptions about government corruption, and iii) handle Feed-in-tariffs which is a price mechanism for RES producers compensation, as endogenous following the intuition proposed from the diffusion literature. Overall, the present paper offers a thorough analysis of the determinants of SP&W proliferation mainly based on the literature dealing with technology diffusion and empirically analyzes the importance of these determinants using a balanced panel data for 21 countries during the period 1999-2010.

The remainder of the paper is organized as follows: section 2 provides a background review concerning the role of policy schemes in the diffusion theory RETs and examines the existing empirical research dealing with the factors affecting the diffusion of RETs, while section 3 provides some motivation for the use of corruption perceptions as a determinant. Section 4 describes the main variables, while section 5 presents the econometric model and the basic results. Section 6 offers a discussion of the results and lastly, Section 7 presents the main conclusions and limitations of our methodology and data.

2. Literature on the Diffusion of Environmental Technologies

Diffusion of new technologies is regarded as the process by which old technologies are gradually substituted by new more cost-effective and efficient ones. The duration needed for one new technology to reach a critical mass and to be established in the market, is an issue closely related to the technology characteristics and the market for which it is intended. For instance, in the case of the electricity industry where conventional source technologies are generally used, the process of RETs diffusion has taken more than two decades and its progress has been slower than expected. The reason behind this lies in the fact that investors act in a highly capital intensive market and have not yet been presented with the right incentives (Pizer and Popp, 2008; Angolucci, 2008). Rational investors' behavior is driven by investment returns' maximization and not by social welfare considerations such as reducing CO_2 emissions. In this sense, without policy intervention, investors do not have any incentives to allocate their funds towards RETs (Jaccobson and Bergek 2004). Government intervention through policy mechanisms results in a reduction of RETs costs which is the determining factor that influences investors' decisions to adopt RETs (Söderholm and Klaassen, 2007).

The literature on diffusion of environmental friendly technologies argues that there are three main government support schemes to enhance the competitiveness of new technologies. The first is through innovation, where new technological advances result in cost reductions of new technologies (Söderholm and Klaassen, 2007; Pizer and Popp, 2008; Popp et. al, 2011; etc). Söderholm and Klaassen (2007) develop a rational choice model in which profit maximizing firms choose to invest in windmills in Europe and learning by doing effects are introduced in their model, in the form of cumulative R&D expenses in the wind industry. The authors empirically test their model using pooled time series and conclude that investments in R&D translated into technological cost reductions and thus assisted in the diffusion process of windmills in Europe. This effect is confirmed by Popp et. al, (2011), in a panel data analysis of 26 OECD countries. Using patent data, the authors created knowledge stocks which were found to have a small effect on RETs investments. Further analysis on the effects of technological change can be found in the review provided by Pizer and Popp (2008).

The second type of schemes includes the regulation imposed by governments to reduce GHG emissions produced from the existing technologies by simply raising their production cost (Jaffe and Stavins, 1995; Kemp, 1998; Gray and Shadbegian, 1998; Xepapadeas and Zeeuw, 1999; Kerr and Newell, 2003), making them thus less competitive. Examples of such environmental regulation are carbon tax emissions and technology standards among others. For instance, Jaffe and Stavins (1995) develop a theoretical model explaining the adoption of new technologies in the presence of different policy schemes and apply it to empirically analyze the effect of building codes and energy taxes on the adoption of thermal insulation by US households, however, they find no evidence that building codes had a significant effect on insulation adoption. In the same direction are the results of Snyder et. al (2003) who find that regulatory factors had no effects on adoption of new technologies in their particular example of membrane-cell technology. The main disadvantage of imposing policy mechanisms to reduce the competiveness of existing more polluting technologies is the downsizing of the profitability of the industry which may have adverse effects and scare new investment funds (Xepapadeas and Zeeuw, 1999). On the other hand, Gray and Shadbegian (1998) and Kerr and Newell (2003) find evidence that stringent environmental regulation could raise the profitability of new less polluting technologies with respect to the existing ones and thus enhance their diffusion process.

Finally, governments can promote the diffusion of new technologies by providing incentives for their deployment. A number of policy schemes enhancing the diffusion of

SP&W systems have been implemented in the European Union during the last two decades. EU countries have devised economic instruments aiming at either the prompt increase of electricity production from renewable energy sources (RES) or at the long term viability of RES investments. The main policy mechanisms implemented in EU countries are Feed-in Tariffs(FITs) where RES electricity producers are paid an additional premium on top of the electricity market price, Quotas/Tradable Green Certificates (TGC) upon which a parallel market of renewable energy certificates is established with producers benefiting from the sale of certificates and Investment incentives where a proportion of the overall investment cost of RES electricity production projects is financially supported. Fiscal and tax reduction incentives along with tenders, a predefined bidding process for fix amounts of power installations which offers winners propitious price or investment conditions, are usually applied by EU countries as complementary instruments. Excluding Finland, whose predominant policy instrument is investment incentives, the rest of EU countries rely on either Feed-in Tariffs or TGCs policy mechanisms. However, the success of the implementation of such policy instruments in the EU is not yet clear (OPTRES 2007).

The main policy schemes, FITs and TGCs have generated a great deal of discussion among scholars concerning their effectiveness, or lack of it, in enhancing RETs. Ringel (2006) argues that policy schemes must be constructed in compliance with both economic effectiveness and ecological efficiency raising doubts on how FITs can be compatible with a common European electricity market. Nevertheless, the author acknowledges that FITs constitute the proper mechanism for a country seeking to rapidly adopt RETs, but they do not make it possible for policy makers to accurately forecast the amount of the energy produced from RES in a given period. Moreover, Mulder (2008), studied policies implemented to promote wind energy in EU countries and argued that although relatively low Feed-in-Tariffs has been an effective policy scheme for Germany, Denmark and Spain, its effectiveness relied on the early and consistent way in which they were implemented. Falconett and Nagasaka (2010) argue that FITs is the best instrument to support less mature RETs while TGCs are more suitable for more mature technologies. In the same line, Wang (2006) argues that the TGCs supporting mechanism does not provide stimulation for high capital cost technologies such as SP&W systems. EU countries using predominantly Feed-in-Tariffs instead of TGCs showed a substantial increase of electricity produced from SP&W (Maza et. al, 2010).

The positive effect of FITs on the expansion of wind capacity in four European countries has also been uncovered by Söderholm and Klaassen (2007). Although these authors find that ceteris paribus FITs increase investments in capacity, they show, on the other hand, that high Feed-in-Tariffs can discourage investments on innovation activities due to the fact that there is no need to further reduce the costs of a new technology. Popp et. al. (2011) find that both FITs and other policies such as TGCs, investment incentives etc, have an insignificant effect on RE investments. In the same direction, the results of Johnstone et. al. (2010) show that the FITs effect is insignificant on the proliferation of RETs patents. Jensen et al. (2013), on the other hand, find significant positive effect of FITs when included in an index denoted as the return of the investment on either wind or Solar Photovoltaic technologies. Given the contradictory results in the literature, the present paper tries to shed some light about the effects of policies targeting SP&W sources, mainly Feed-in Tariffs and other supporting instruments such as Investment Subsidies, Quotas, Tenders, Tax and fiscal incentives while at the same time it investigates whether policies are endogenous to the deployment of SP&W as suggested in the literature of technology diffusion and policy making (Söderholm and Klaassen, 2007, Jaffe and Stavins, 1995; Mazaa and Winden, 2004). From an econometrics point of view the endogeneity of policies, when these are used as determinants of SP&W can lead to erroneous conclusions if this is not taken properly into account.

From a rational investor point of view, the decision to invest in RETs will be solely based on profit maximization considerations. While the price received by the RETs generator plays an important role for profit maximization it is the case that the price of alternative electricity generation sources will also affect his choice. For instance, Söderholm and Klaassen (2007) include the price of coal in the profit function of their rational simultaneous choice model, which for the countries examined was considered the main competitor of windmills. The idea behind the inclusion of coal prices lies in the fact that increasing coal prices result in increasing costs of electricity production from coal-fired technologies, thus creating a more attractive environment for the option of wind generators. In the same direction are the models developed by Kemp (1998), Gray and Shadbegian (1998) and Kerr and Newell (2003). The effect of prices of conventional sources was also examined by Van Ruijven and Van Vuuren (2009) using the energy model TIMER where they argue that higher prices of traditional sources could favour the deployment of alternative energy sources including RES. On the other hand, a number of econometric studies examining the proliferation of RETs fail to confirm any relation with the prices of conventional sources (Marques et al. 2011; Shrimali and Kniefel, 2011).

3. The Role of Government Corruption

Although the European Union has a strong commitment to reducing CO2 emissions through the deployment of RE sources as well as achieving price reductions for consumers, government corruption could cause deficiencies in the behaviour and strategies of investors in the electricity sector (i.e. Henisz and Zelner, 2001; Jamasb 2006). Generally speaking, government corruption is defined as the abuse of authority by public servants in order to satisfy personal gains or special interest groups' agenda and constitutes one of the most severe hazards to economic growth (see Blackburn and Forgues-Puccio, 2010). It has not been until recently that the literature has examined corruption as a threat to different economic sectors. However, because bureaucrats' and public servants' corruption cannot be easily documented, in the sense that actions concerning corruption remain secret, several impacts of these actions continue to be unexplored.

Investment activities can be negatively affected by the existence of corruption since it creates an environment where returns to investment are harder to predict (Everhart et al., 2009). In his seminal paper, Mauro (1995) finds evidence that corruption lowers private investment for a sample of 67 countries that includes several of the countries considered in our study. Yet, some authors claim that corruption could be investment enhancing since red-tape can be bypassed in heavily bureaucratic societies as explained by Mauro (1995). When corruption is predictable or is organized then it could have a positive effect on investment as shown by Campos et al. (1999) in the case of Asian countries. Blackburn and Forgues-Puccio (2009) make the claim that countries with organized corruption networks are likely to display higher rates of growth than countries with disorganized corruption arrangements.

On the other hand, the political and policy design literature identifies that government policies result from the cooperation of different agents which commonly are bribed or influenced by the existence of lobbying parties in the market (Fredriksson, List and Millimet 2003; Damania et al. 2003; Fredriksson, Vollebergh and Dijkgraaf, 2004; Mazaa and Winden, 2008;). The effect of corruption on environmental regulation has been examined by Damania et al. (2003), where the authors find that less efficient environmental policies will be produced when higher corruption exists. In this direction, Fredriksson, Vollebergh and Dijkgraaf, (2004), provide a simple model of bribery and empirically find that government corruption has a negative effect on the stringency of energy policies implemented in 11 industry sectors. However, some authors claim that the negative effect of corruption on the stringency of environmental policies diminishes as political competition increases (Fredriksson and Svensson 2003). According to the authors, such a situation makes lobbies to become reluctant to bribe and influence the formation of an environmental policy because of the risk that it will remain inapplicable.

The literature related to the effect of corruption on environmental regulation, described above, refers to corruption as bribes paid by firms and lobbies in order to influence environmental laws. Wilson and Damania's study, (2005), goes one step further and recognizes that corruption could also take the form of firms giving bribes in order to be excluded from the enforcement of the environmental policy. The authors, using a model of bribery where both types of corruption are included, argue that when weak institutions are present, political insecurity urges firms to allocate their bribery funds towards wriggling out of emission taxation instead of influencing the actual level of the environmental tax.

Although there exists an abundant literature on the effects of corruption on investment and growth (Mauro, 1995; Campos et. al., 1999; Everhart et al., 2009; Evrensel, 2010 among others), and on environmental policy (Fredriksson, List and Millimet 2003; Fredriksson, Vollebergh and Dijkgraaf, 2004; Leitão, 2010; Damania et al. 2003, etc), its relationship to the diffusion of RETs, to the best of our knowledge, has only been analyzed by Gennaioli and Tavoni (2011). The aforementioned authors provide a simple model of bribery and criminal activity, and empirically find that criminality is positively related to the growth of wind installations in regions of Italy, especially when weak institutions give rise to the probability of higher economic gains from exploiting public incentives. Their analysis consists of a bureaucratic environment where firms that are willing to invest in producing electricity from wind are able to bribe in order to obtain a permit more easily.

Consequently, following the literature analyzed earlier, the present paper will try to shed some light about the possible directions in which corruption can affect the deployment of RETs. To begin with, corruption might exist in higher levels of governance and through bribe paying can influence policy making. In this direction, the level of corruption could negatively affect the effectiveness of policies that enhance electricity production from RES because potential investors might not find RES investments as attractive, in a corrupt environment where policy makers are influenced or are thought to be bribed by lobbies supporting conventional sources. However, corrupted policy makers which act under greater lobbying groups coordination may produce more effective policies. In any case, the influence that corruption can have on renewable energy policy mechanisms favouring RET deployment is subject to the existence and the size of coalitions opposing or supporting RES electricity production (Angolucci, 2008). On the other hand, when weak institutions exist, corruption might possibly spread to different levels of country governance institutions, where lower level bureaucrats receive payments under the table so as to discriminate the distribution of public funds. To this extent, investors might be willing to undertake investments in an environment of weak institutions if the necessary policy incentives are offered.

4. Data and Main Variables

Our analysis of the main factors related to the diffusion of RETs focuses on the installed capacity of Solar Photovoltaic and Wind systems only mainly due to their higher growth rate in the past decade (see Table 1). We excluded Biomass, wave and tidal and cogeneration because of their most recent appearance and the lack of data before 2005.

Furthermore, most of the EU members appear to have a clear-cut policy scheme supporting SP&W systems, in contrast to the aforementioned technologies', making SP&W more attractive for Europe's RE future. Although the EU policy schemes and measures concerning the stimulation of investments on Renewables date back to the 1990s, limitations on finding available policy data along with the delayed adoption of SP&W from several European members, led us to apply a balanced panel data analysis from 1999 to 2010 to a set of 21 European region countries.

Table 1: Capacity production in Mw - Percentage change in the EU area

period/year	Wind Systems	Solar Photovoltaics	Hydro Electric	Geothermal
1990-1995	2.746	2,8	0,119	-0.038
1995-2000	15.358	1,85	0,874	0.225
2000-2005	2.698	8,89	-0,003	0.172
2005-2010	0,996	14,86	0,04	0,097

Source: Eurostat Energy Statistics - Infrastructure - electricity - annual data (nrg_113a)

4.1. Main Variables

Dependent variable

As dependent variable, the growth rate of SP&W installed capacity is used. The dependent variable is set to be the growth rate of capacity installations or in other words, the first difference of the natural logarithm of the cumulative capacity (***DLSPW***). At the outset, we selected capacity installations rather than electricity production due to the fact that potential investors on SP&W technologies decide mainly about the capacity to be installed and not so much on the final amount of electricity produced. This is because electricity production is subject to multiple factors that cannot be controlled or foreseen by investors, namely, weather conditions, technology efficiency and possible damage to equipment among others. Consequently, the main questions of the present research is whether and to what extent policy instruments such as FITs, other policy instruments and perceptions on government corruption could increase the level of new investments on SP&W technologies. Data on the installed capacity of SP&W installations were taken from Eurostat, and are expressed in MW nominal power. The graphical representation of the dependent variable is depicted in Figure A.1. in the Appendix. Panel unit root tests were applied to ***DLSPW*** and the results are reported in Table A2 in the Appendix. All of the tests reject the null hypothesis of a unit root, namely the Levin et al. (2002) test, the Im et al. (2003) test and the Fisher type tests using ADF and PP tests proposed by Maddala and Wu (1999) and Choi (2001).

Explanatory variables

Following our discussion about the main factors that can affect the deployment of RETs in section 2, we use the following explanatory variables ***FITS***, ***OTHPOL***, ***LCOALPPC***, ***LOILPPCR***, ***LGASPPCR***, ***CORPI***, ***LEPC***, ***LCO2PC***, ***COALS***, and ***EU01***, which are presented in Table 2 below, while Table A1 in the Appendix shows their descriptive statistics. The first explanatory variable, ***FITS***, represents the source (Wind or Solar Photovoltaic) weighted average of Feed-in-Tariffs promoting SP&W systems for each of the countries in our dataset. The data about legislation and feed-in-tariffs levels were taken from both the IEA database and the European Renewable Energy Council (EREC). However several European countries have designed complex tariff schemes whereas the level of the tariff depends to the levels of installed capacity, thus higher nominal capacity installations end up receiving smaller tariffs due to economies of scale. Due to the fact that we do not have data on the number and the size of installation by country and year we proceeded in with calculating the tariffs of each source using the un-weighted average. Furthermore, the published data of FITS correspond to the price producers of SP&W systems receive at the year where they began producing, without taking into account any possible future digression imposed to producer's fees for any year later. For instance, Germany's Feed-in-Tariff mechanism which was officially introduced in 1991 for wind and in 1998 for solar photovoltaic installations, determine a 5% annual tariff reduction. In addition, Italy imposed a tariff reduction of 2% for existing solar photovoltaic systems since 2007.

It is important to mention at this point that the data obtained from the IEA/IRENA database related to policy mechanisms other than FITS, consisted mainly of information about their existence and not on their policy level. Thus we formed the variable ***OTHPOL***, which denotes the number of other policies namely TGCs, tax and fiscal reductions, tenders and investment subsidies in order to control for the coherency or in other words the fluctuation of the policy instruments applied in each of the counties under study. We would normally expect that countries implementing an additional policy towards the promotion of SP&W, might have an adverse effect on their growth, due to the fact that a risk of confusing investment funds is involved (Ringel, 2006; Angoluchi, 2008). Other than that, this would suggest that instead of committing to the efficiency of the already implemented instruments a policy maker in order to meet the targets set for RES electricity production, proceeds in by differentiating the whole structure of the scheme.

In addition to the policy variables described earlier, the natural logarithm of the real prices of conventional sources (***LCOALPPCR***, ***LOILPPCR*** and ***LGASPPCR*** for Coal, Oil and Gas respectively) are introduced in order to illustrate the effect of how increased prices of the most competitive alternatives of SP&W systems influence the choice of investors. The nominal prices data were taken from BP statistical review (2011), and were adjusted to real values using a CPI index from the IMF (2011). We should expect that higher prices would contribute to the growth of solar PV and wind systems confirming diffusion theory. However, we should bear in mind that the EU and the rest of the world have gradually diminished traditional energy sources such as oil and coal in favor of less polluting alternatives such as gas. In that sense, for energy security reasons, countries may support both RETs and less polluting technologies using gas.

Table 2: Variables Definition, units and source

	Definition	Description	Source
DLSPW	First difference of the natural logarithm of the cumulative capacity	Dependent variable	Eurostat - Infrastructure electricity annual data (nrg_113a)
COALPPCR	Coal Prices per country in real terms in US dollars	real terms using CPI IMF	BP Statistical Review of World Energy 2011
GASPPCR	Gas Prices per country in real terms in US dollars	real terms using CPI IMF	BP Statistical Review of World Energy 2011
OILPPCR	Oil Prices per country in real terms (US dollars)	real terms using CPI IMF	BP Statistical Review of World Energy 2011
FITS	Level of applied Feed-in-Tariffs weighted by the percentage of each source	€cents	IEA, EREC
OTHPOL	Number of policies supporting each source,		IEA EREC
CORPI	Country corruption perception index (index 0-10)	larger: better performance	Transparency International
EPC	Energy consumption per Capita (kg/Capita)		Eurostat - Primary energy consumption - annual data (nrg_ind_335a)
CO2PC	CO2 emissions per Capita	(kg/Capita)	Eurostat – Air pollution (env_air_emis)
COALS	Share of Coal in the total electricity production		Eurostat - Supply, transformation, consumption - solid fuels - annual data (nrg_101a)
EU01	Directive 2001, Dummy variable (0 for time before 2001, 1 otherwise)	(country invariant)	

Furthermore, market demand conditions are controlled for using the natural logarithm of energy consumption per capita (***LEPC***) which is measured in KToe per capita and were taken from Eurostat. Given that policies have managed to provide a competitive advantage for SP&W investments, an increase in ***LEPC*** could lead to new investments in RES thus enhancing the diffusion of SP&W. In this direction the results of Marques et al. (2011) show that increasing energy needs have been covered by renewable energy sources. Moreover, in order to account for the level of a country's pollution we use the natural logarithm of the Carbon Dioxide emissions per capita (***LCO2PC***) and the share of coal in the total electricity production (***COALS***). Data on the levels of CO_2 emissions and share of electricity produced using coal sources were both taken from Eurostat. The coal share is selected over other polluting conventional sources, since it is regarded as one of the most polluting ones and additionally possesses the highest rank in terms of contribution to electricity production in the 21 European countries under study. In addition, we introduce a dummy for Directive 2001/77/EC (***EU01***) of September 27 2001, in order to depict the influence of collective action taken from EU members, on the growth rate of the SP&W capacity installations.

Finally, in an attempt to control for the institutional factor of corruption we use the natural logarithm of the *corruption perceptions index*[3] (***LCORPI***), taken from Transparency International (http://cpi.transparency.org) which ranks countries according to the perceptions of corruption in the public sector. According to the CORPI index, newer members of the European region display greater variances in their beliefs while corruption perceptions improve over time showing a decreasing level of distrust. In addition, the index shows that the European south is more susceptible to government corruption with leader countries being Greece and Italy. On the other hand, Denmark and Finland experience the higher rank in terms of CORPI and in general highly ranked countries experience fewer variations on their perceptions of government corruption. Finally, the country that noted the highest decrease on the perceived level of government corruption in the time span examined is Belgium. Although these type of indices have been empirically used by scholars in the literature on political theory, investments and growth (see Fredriksson, Vollebergh and Dijkgraaf , 2004; Ederveen et al, 2006; Evrensel 2010), they have only recently been introduced in the diffusion of RET literature (see Gennaioli and Tavoni, 2011). Although, we expect that low corruption perceptions (high values of the CORPI index) will be linked to higher investment funds allocated to RE, the opposite might occur if investors' funds are attracted whenever institutions are weak and corrupt bureaucrats are present in higher and lower levels of governance.

5. Econometric Model and Results

In order to uncover which of the above discussed factors affect the diffusion of SP&W technologies we use the panel data specification given by eq(1) below,

[3] The Corruption Perceptions Index (CORPI) is an aggregate indicator that combines different sources of information about government corruption, making it possible to compare countries. It captures information about the administrative and political aspects of corruption. Broadly speaking, the surveys and assessments used to compile the index include questions relating to bribery of public officials, kickbacks in public procurement, embezzlement of public funds, and questions that probe the strength and effectiveness of public sector anti-corruption efforts (Transparency International).

$$\mathrm{DLSPW_{it}} = \beta_1 \mathrm{LCOALPPCR_{it}} + \beta_2 \mathrm{LOILPPCR_{it}} + \beta_3 \mathrm{LGASPPCR_{it}} + \beta_4 \mathrm{FITS_{it}} + \beta_5 LCORPI_{\mathrm{it}} + \beta_6 LCORPI_{it}^2 + \beta_7 \mathrm{FITS_{it}} \times \mathrm{LCORPI_{it}} + \beta_8 \mathrm{OTHPOL_{it}} + \beta_9 L\mathrm{EPC_{it}} + \beta_{10} LCO2PC_{\mathrm{it}} + \beta_{11} COALS_{\mathrm{it}} + \beta_{12} \mathrm{EU01}_i + a_i + \varepsilon_{\mathrm{it}} \quad \text{eq 1}$$

where $\boldsymbol{DLSPW_{it}}$ is the first difference of the natural logarithm of the cumulative SP&W capacity installed in country *i* at time t, α_i represents unobserved individual (country) heterogeneity and ε_{it} is the usual idiosyncratic error. The unobserved effect is assumed to be fixed over time and captures factors that influence the diffusion of SP&W that are country specific such as geographic or weather conditions and institutional factors. Although, we specifically control for corruption perceptions, it is quite possible that other institutional factors affecting bureaucracy might affect investment decisions on SP&W technologies.

Note that as previously discussed, in order to test whether government corruption perceptions affect the effectiveness of Feed-in Tariffs as a policy instrument, an interaction term between the corruption index and the Feed-in-Tariff value is introduced in the model. In addition, since corruption can affect investments made towards RET systems in multiple and complex ways, we introduce the square term of $\boldsymbol{LCORPI_{it}^2}$ in order to capture any nonlinear effect perceptions on government corruption may have on the growth rate of SP&W capacity.

In order to check for possible autocorrelation of the error term in (1) we follow Wooldridge (2002, p. 282) and estimate the first difference (FD) transformation. The estimated first order correlation coefficient of the FD residuals is $\rho = -0.45$ with a standard error of 0.059 and therefore the Wald test accepts the null hypothesis that the corresponding population parameter is equal to -0.5 with the p-value being 0.40. Moreover, the Hausman (1978) specification test leads to the rejection of the null hypothesis of uncorrelated unobserved heterogeneity with the repressors of eq(1) with a p-value of 0.01, favouring thus a fixed effects specification for our model. The results of the fixed effects estimation are shown in the table 3 below (FE/Model 1).

Another issue that is of great importance for the validity of the estimation results is whether there are some issues of endogeneity in our model. According to the diffusion literature discussed in section 2, government intervention through policy mechanisms should be treated as endogenous (Söderholm and Klaassen, 2007, Jaffe and Stavins, 1995). To this extent, both simultaneity and omitted variables problem can arise. For instance, support mechanisms such as ***FITS*** could be adjusted downward as the SP&W installed capacity increases because investment costs are lower or adjusted upward whenever the capacity targets are not being met. Towards this direction, we test for the endogeneity of ***FITS***, using the Hausman (1978) specification test for endogeneity. The results of the testing procedure indicate that the level of FITs is endogenous at the 10% level and so is its interaction term.

Table 3. Estimation results for DLSPW

Independent Variables	FE / Model I Estimate	FE / Model I Std. Error	FE 2SLS / Model II Estimate	FE 2SLS / Model II Std. Error
$Constant\ Term$	-19.342	8.8212**	-23.827	9.1059***
$LCOALPR$	-0.2825	0.2291	-0.2823	0.2278
$LOILPR$	0.7802	0.4901	0.9073	0.5283*
$LGASPR$	-0.8701	0.4781*	-0.9531	0.5062*
$FITS$	0.1419	0.0547***	0.2369	0.1012**
$FITS * LCORPI$	-0.0316	0.0133***	-0.0517	0.0252**
$LCORPI$	10.4796	5.0370**	12.823	5.3007**
$LCORPI^2$	-1.2159	0.6093**	-1.4881	0.6402**
$OTHPOL$	-0.0047	0.0249	-0.0168	0.0273
$LEPC$	-1.7730	1.1350	-1.8642	1.1369*
$LCO2PC$	1.2025	0.8432	1.2149	0.8529
$COALS$	0.2595	0.5959	0.2872	0.6172
$EU01$	0.2093	0.1188*	0.2338	0.1260*
Cross Sections	*21*		*21*	
Time periods	*12*		*12*	
OIR			*1.08*	
(p-value OIR)			*(0.80)*	

*/**/*** Significant at the 10%/5%/1% levels

In order to confront this endogeneity problem we estimated eq. (1) by Fixed Effects 2SLS methods using strictly exogenous instruments for both endogenous variables. For FITs we use a dummy variable that indicates whether a Feed-in-tariff scheme is in place for other RETs different from SP&W (***OTHFIT***), as well as years of implementation of Solar Photovoltaics (***SPmat***) and a dummy variable related to the most important date of the European legislation, Directive 2009/28/EC (***EU09***) where mandatory targets for renewable energy consumption were set. A question that may arise is whether ***OTHFIT*** and ***SPmat*** are valid instruments. One can argue that ***OTHFIT*** is exogenous since it is intended to support alternative RETs to SP&W and therefore its existence will more likely depend on the achieved deployment levels of the alternative RETs. In addition, this instrument was selected since it is the case that countries supporting different energy strategies rely, mostly but not all of the times, in the same policy instruments. For instance a policy maker that decides to promote Small Hydro along with SP&W systems will more likely use the same instrument unless the targets set for the technology define otherwise.

Continuing with ***SPmat***, which is translated as the maturity of the Solar Photovoltaic technology, its link to the level of feed-in-tariffs is clear in the sense that a policy maker defines different levels of FITs for each technology according to the technology maturity level. As far as the interaction term ***(FITS*LCORPI)*** is concerned, we use the ***OTHFIT*** instrument and the real gross domestic product of each country (***GDPR***), expecting that more funds will be directed to policy schemes promoting SP&W when a country's real GDP is higher, multiplied with ***LCORPI***. The regression of $\boldsymbol{FITS_{it}}$ as dependent variable on all strictly exogenous variables of eq. (1) and on all of the exogenous instruments[4] shows that all of them are highly significant. Finally, we fail to reject the null hypothesis that the instruments are not correlated with the idiosyncratic error term since the Sargan test statistic which is distributed as a chi-square with 3 degrees of freedom is 1.08 with a p-value of 0.80. As depicted on Table 3, above, the differences between the robust standard errors of the two estimated models are reasonable although, as expected, they are bigger in the case of IV estimation. Additionally, note that the standard errors in Table 3 are the White diagonal robust standard errors which are robust to any kind of heteroscedasticity of the error term[5].

Turning now to the parameter estimates, we note that correcting for endogeneity has mostly affected the parameter estimates for the FITs variable and its interaction effect which is almost double in magnitude. If we focus on the FE 2SLS results we find that prices of the traditional energy sources of oil and gas have a significant effect on the growth of SP&W installations. We find that an increase of oil prices does have a significant and positive impact, at the 10% level, on the diffusion rates for the technologies under study. In contrast, an increase in the price level of gas significantly and negatively affects the percentage change of SP&W installations. Furthermore, we find ***FITS*** to have a positive and significant effect on the growth of SP&W capacity at the 5% significance level, but this effect although always positive is smaller for higher levels of corruption perceptions (lower perceived levels of corruption). Moreover, we fail to confirm any effect of the other policy instruments applied to promote SP&W systems since ***OTHPOL*** variable turns out to be insignificant.

Turning now to the perceptions on government corruption, ***LCORPI*** has a significant effect at the 10% level and positively affects the deployment of SP&W systems, while $\boldsymbol{LCORPI^2}$, turns out to be significant (at the 5% level) and negative. Therefore the results show that the log of perceptions on government corruption and the growth SP&W systems have an inverted U relation and that the effects of the former variable on the latter diminish as countries apply greater incentives through increasing feed-in-tariffs levels. Continuing with the results for Model II energy consumption per capita has a significant (at the 10% level for

---

[4] Descriptive statistics on all exogenous instruments are provided in the Appendix in the table A.3.

[5] The white diagonal heteroskedasticity-robust standard errors are asymptotically valid in the presence of any kind of heteroskedasticity including homoscedasticity. In addition, the ordinary standard errors are smaller than the white diagonal heteroscedasticity robust standard errors.

Model II) negative effect on ***DLSPW*** indicating that increasing energy needs are covered from the use of other conventional or renewable sources and not from SP&W. As far as the pollution factors that we have introduced in our analysis, namely ***LCO2PC*** and ***COALS***, we find that that the growth of SP&W systems is not responsive to each country's pollution level. Finally, collective action under the form of Directive 2001/77/EC, although its targets were not mandatory, positively and significantly (at the 10% level) influences the diffusion of SP&W technologies.

6. Discussion

The literature dealing with the diffusion of environmental friendly technologies argues that government intervention through policy schemes can create incentives to the process of technological substitution. On the other hand, corruption may have a complex effect on the investor's decision strategy. In the present study we capture the positive effect of a widespread applied policy scheme namely Feed-in-Tariffs and try to unravel the complex dynamics that government corruption has on the diffusion of RETs.

Introducing the variable ***FITS***, which represents the level of €cent per Kilowatt that producers receive, we find that an increase in the level of ***FITS*** indeed spurs investments towards SP&W installations for the 21 countries under study. However the magnitude of this effect decreases with the level of the corruption index or in other words, is less strong when corruption is perceived as being low. At a first sight this result might seem counterintuitive but it could just portray a situation where in countries which are prone to corruption, potential investors hold beliefs that corruption will also "leak" to the SP&W market and that they can secure certain returns through parallel channels to Feed-in Tariffs. A parallelism exists here with the topic of agricultural subsidies whereas increasing subsidies could lead to an increase of farming activity which is especially strong in countries where producers misreport the level of their production and authorities fail to combat fraud.

In order to further support this view we refer to White (2010) who gives the example of Spanish solar panel operators being paid "for producing solar energy during the night". Thus, when entrepreneurs believe corruption levels are high in their country and that they can easily conduct fraudulent activities then any small increase in the levels of Feed-in-Tariffs will be more effective than in less corrupted environments in attracting investment funds towards SP&W. This result comes in contradiction with the literature studying government corruption, since corruption negatively influences the efficiency of policies such as environmental taxation (Fredriksson, List and Millimet 2003; Fredriksson, Vollebergh and Dijkgraaf, 2004). This is the case because government corruption can be negatively linked with emissions taxation policy due to the fact that firms and lobbies are prone to bribe in order to reduce their loss by influencing the level of the tax or avoiding being taxed. On the other hand, when a direct policy incentive such as FITs is concerned the opposite is true. In any case, we confirm the findings of Söderholm and Klaassen, (2007) that Feed-in-Tariffs do have a significant positive effect on renewable energy technologies diffusion. Furthermore this effect remains positive for all levels of CORPI.

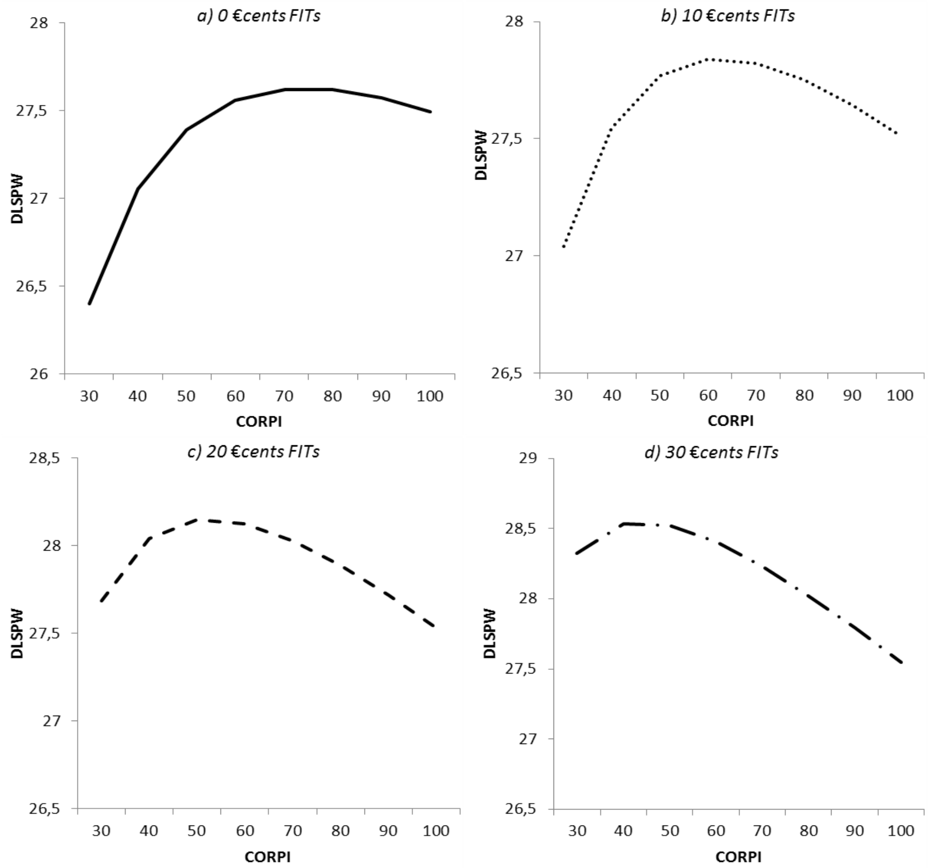

Figure 1: *Dependent variable values (**DLSPW**) for different levels of CORPI index and for different levels of FITS (a-d).*

Analyzing the effect of the perceptions on government corruption we find that an increase in the level of the CORPI index will positively affect SP&W deployment up until a point where the effect will become negative. This turning point depends on the level of Feed-in-Tariffs as can be seen in Figure 1 above. Figure 1, which depicts the estimated relationship between our dependent variable (***DLSPW***) and the corruption perception index where the other variables are omitted as if there are held up constant, shows that when countries apply higher Feed-in-Tariff schemes (Figure 1.a to 1.d) the maximum point of the curve moves to the left. Therefore, the effect of an improvement in the perceptions of government corruption (CORPI index) on the growth of SP&W installations is relative to the level of a country's CORPI score and to the applied level of FITS, as represented by the changing in slopes in the four diagrams in Figure1. Under the extreme case of zero level of Feed-in-Tariffs (Figure 1.a), an increase on the perceived level of government corruption (lower CORPI) will have a negative effect on investments directed to SP&W systems for almost the whole range. Under no incentives given to promote investments on RETs, an investor might not be willing to allocate her funds to a more corrupted environmsent. While, under the other extreme, whereas FITs are 30 €cents (Figure 1.d), higher government corruption leads to higher growth rate of SP&W capacity installations. The latter is in agreement with Gennaioli and Tavoni, (2011), who find that more projects of wind installations were carried out in provinces of Italy that operate under the same supporting scheme but with weaker institutions. Altogether, government corruption can constitute both an incentive but also a constrained on the growth of SP&W capacity installations.

An issue that arises from our results is the economic efficiency of FITs. An incentive can be considered inefficient when the funds financing it are not optimally allocated. This is the case where under a higher cost basis, the implementation of the incentive has the same result as if another is used. In our case, we have shown that under excessive levels of FITs higher CORPI index results to greater diffusion of SP&W systems. Under weak institutions this will result to higher amount of bribes paid by investors in order to profit from exploiting less stringent conditions against fraud. Thus a significant part of the funds financing FITs will turn out to be lost. On the other hand, a country can focus on improving the perceived levels about government corruption and implement Feed-in-tariff levels to be just enough, in terms of economic efficiency, so as to achieve the requisite targets over ecological efficiency by always taking into account both technology and cost characteristics. Overall, Feed-In-Tariff instrument is a successful policy mechanism for the promotion of RETs. However, in terms of economic efficiency, an excessive applied level might involve the danger of attracting investment funds trying to exploit public funds, especially in countries were institutions applying and officials deciding over the scheme act without transparency.

Continuing our discussion over the determinants of SP&W technologies diffusion, our results indicate that implementing an additional policy mechanism will have no effect on the proliferation of SP&W technologies. This outcome could stem from the fact that the intensity of a policy instruments and not the implementation itself is the cause of attracting investment funds towards SP&W. Thus, countries should focus on the efficiency of the already applied policy mechanisms rather than just introduce new instruments for the sake of political (Angoluchi, 2008) or lobby level gains.

As diffusion theory suggests, apart from the incentives government intervention produces, the decision of investors to install SP&W technologies is subject to the profitability of other alternatives. We would expect that higher prices of conventional sources would result in higher levels of the capacity installations of solar PV and wind systems confirming diffusion theory. In this direction our estimation results about the price of oil justify diffusion theory (see Kemp, 1998; Gray and Shadbegian, 1998; Kerr and Newell, 2003; Van Ruijven and Van Vuuren 2009). However we should bear in mind that this is more likely to occur for high hydrocarbon fuels such as oil and coal and not for the less polluting natural gas. Thus we find that a percentage increase in the real prices of gas in the 21 EU countries result in reductions of the growth rate of SP&W capacity installations. This result could be easily justified by considering that natural gas along with renewables are foreseen as the main contributors of the EU energy supply strategy which actually makes the two sources to act as competing clean energy sources. Hence, an increase in the price of Gas, increases the cost of producing power electricity from Gas, thus it will result in drawing funds designated to RETs funding. Nevertheless, according to our findings the prices of coal appear to have no impact on the investors' choice towards SP&W systems. In this direction are the findings of Söderholm and Klaassen, (2007), that find coal price to be insignificant to the diffusion process of windmills in the EU.

Nevertheless, according to our findings the prices of coal appear to have no impact on the investors' choice towards SP&W systems. In this direction are the findings of Söderholm and Klaassen, (2007), that find coal price to be insignificant to the diffusion process of windmills in the EU. Furthermore, controlling for the energy market demand conditions we find a small negative effect on the capacity installations from SP&W systems. Popp et. al, 2011, found that electricity demand growth has a negative but insignificant effect on investments made in RETS. On the other hand, Marques et al. (2011), finds that for the EU region, RETs catches up with the increasing energy needs. In our case, the EU countries with high levels of energy consumption could be facing either high costs or production limitations in producing electricity from SP&W and as a result turn to other renewable or conventional sources. One policy implication of this result is that limiting energy consumption per capita might be crucial when devising energy policies. Finally, our estimation results indicate that although Directive 2001/77/EC did not have mandatory targets on the proliferation of RETs, it positively and significantly affects investments towards this direction. Thus, the EU must continue to enforce legislative acts towards the promotion of RETs.

6. Conclusions and Limitations

Diffusion theory, argues that government intervention could act as a lever to the successful deployment of RETs by eliminating technology lock-out barriers. Therefore, the study of the factors that affect the diffusion of new environmental friendly technologies, could provide a better understanding to policy makers and aid them in devising successful policy strategies. To this extent, the present research results provide some useful guidelines to policy makers.

Our results show that for the 21 European countries under study increases in the Feed-in-tariff levels have a positive effect on the growth rate of SP&W installed capacity. On the other hand, FITs seem to be more effective in economies in which investors believe corruption is high and we have linked this effect to the higher opportunities for fraud existing in corrupted environments. Furthermore, we find that improvements on the perceived level of government corruption can have both negative and positive effect in the diffusion of SP&W systems. This effect is directly related to the applied levels of FITs and to the degree of transparency existing in a country. Overall, we find that the investors' undertaken risk to allocate her funds towards RETs in a highly corrupted country, is reduced when opportunities to exploit public funds through excessive and inefficient FITs levels are present.

In addition, it is shown that the deployment of SP&W cannot catch up with a growing energy consumption and energy policies should also focus on the consumption side in addition to the production side. Moreover, as it is suggested from diffusion theory, we find that increases in the price of oil enhance the proliferation of SP&W technologies but on the other hand, increases in the prices of gas adversely affect its growth rate. The latter is contradictory to diffusion theory but it is justified due to the fact that gas has a primary role in the EU energy future planning. Finally, Directive 2001/77/EC, has proven to be a decisive facilitator of investments towards SP&W due to the fact that it provided security to investors that turned to RETs, hence further similar joint international actions must continue to take place.

A limitation of the present research is stemming from not including technological change and environmental regulation as mechanisms to proliferate RETs. However the inclusion is delayed for future work. Furthermore, we have only examined the efficiency of the Feed-in-Tariff mechanism, excluding other important supporting mechanisms such as TGCs and Investment Subsidies because level data was not available.

Appendix - Figure A.1.

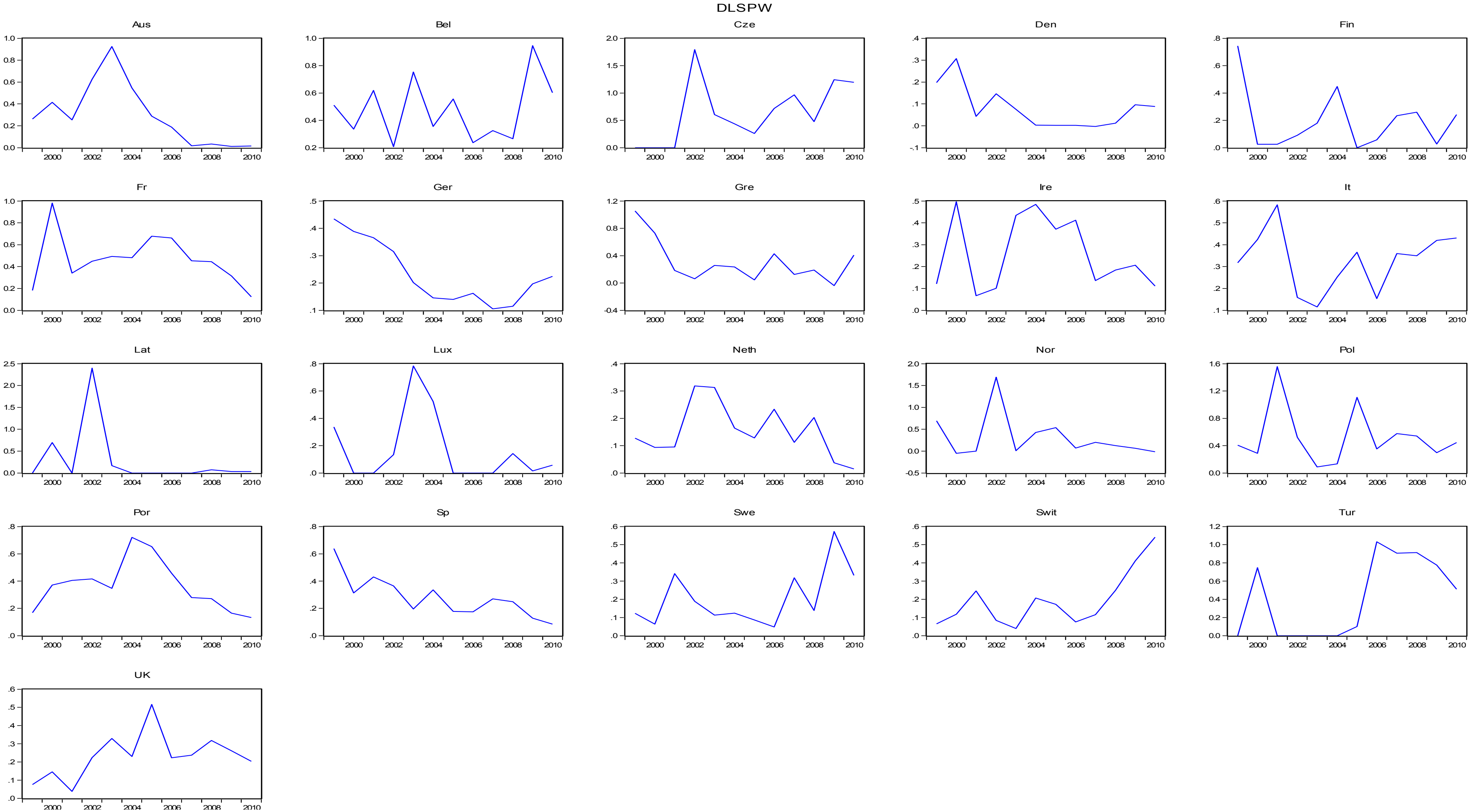

Table A1: Descriptive statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	N	Desc
DLSPW	0.3055	0.2243	2.3979	-0.0513	0.3255	252	-
OILPPCR	23.9209	22.0896	48.7413	8.6686	11.1580	252	Real prices
COALPPCR	31.3320	30.2696	74.0089	13.8881	14.6531	252	Real prices
GASPPCR	2.8179	2.4297	5.7941	0.9062	1.2666	252	Real prices
FITS	6.4516	5.8000	43.167	0.0000	7.3421	252	€cents
OTHPOL	2.4008	2.0000	6.0000	0.0000	1.6801	252	Number
CORPI	70.325	75.000	100.00	31.000	19.850	252	Index 0-100
EPC	3913.293	3711.378	10383.11	994.1295	1748.690	252	Ktoe pc
CO2PC	11181.72	11021.70	28077.10	4096.172	4321.374	252	Kg pc
COALS	0.2556	0.2344	0.9381	0.0000	0.2433	252	Percentage
EU01	0.8333	1.0000	1.0000	0.0000	0.3734	252	Dummy 0-1

Table A2: Panel Unit Root test on Lsnwtt

Method	Statistic	Prob.**	N
Levin, Lin & Chu t*	-4.857	0,000	249
Im, Pesaran and Shin W-stat	-5.280	0,000	248
ADF - Fisher Chi-square	87.360	0,000	249
ADF – Choi Z statistic	-4.118	0,000	249
PP - Fisher Chi-square	95.129	0,000	249
PP – Choi Z statistic	-4.734	0,000	249

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution.
All other tests assume asymptotic normality.
Individual intercept in the Im, Pesaran and Shin test.
Automatic lag length selection (Schwarz Information Criteria) used.
The null hypothesis for the first test is a unit root (assumes common unit root process).
For the other five tests, the null hypothesis is a unit root (assumes individual unit root process).

Table A3: Descriptive statistics of the exogenous instruments

	Mean	Median	Maximum	Minimum	Std. Dev.	N	Desc
OTHDFIT	0.6230	1.0000	1.0000	0.0000	0.4856	252	Dummy
SPmat	8.9405	10.000	21.000	0.0000	6.8052	252	Years
GDPR	5.4953	0.2581.	24.0490	0.0715	6.6236	252	Real prices/Milion €
EU09	0.1667	0.0000	1.0000	0.0000	0.3734	252	Dummy

References

Agnolucci, Paolo, 2008. Factors influencing the likelihood of regulatory changes in renewable electricity policies. Renewable and Sustainable Energy Reviews 12 pp 141–161.

Breitung, J., 2000. "The Local Power of Some Unit Root Tests for Panel Data", Advances in Econometrics, 15, Nonstationary Panels, Panel Cointegration, and Dynamic Panels, Amsterdam: JAI Press, p. 161–178.

Blackburn K.,Gonzalo F., Forgues-Puccio, 2009. Why is corruption less harmful in some countries than in others? Journal of Economic Behavior & Organization 72 797–810.
Blackburn K., Gonzalo F. Forgues-Puccio, 2010. Financial liberalization, bureaucratic corruption and economic development, Journal of International Money and Finance, Volume 29, Issue 7, November 2010, Pages 1321-1339, ISSN 0261-5606, 10.1016/j.jimonfin.2010.05.002.
BP, Statistical review of world energy; 2011.
Campos J. Edgardo, Donald Lien and Sanjay Pradhan, 1999. The Impact of Corruption on Investment: Predictability Matters. World Development Vol. 27, No. 6, pp. 1059 - 1067, 1999.
Choi, I., 2001. "Unit Root Tests for Panel Data", *Journal of International Money and Finance*, 20, p. 249–272.
Everhart, S., Martinez- Vazquez J., & Robert M. McNab (2009): Corruption, governance, investment and growth in emerging markets, Applied Economics, 41:13, 1579-1594
Evrensel, Ayse Y. 2010. Corruption, growth, and growth volatility. International Review of Economics and Finance 19 501–514.
Eurostat: Energy Statistics, Primary energy consumption. Code: nrg_ind_335a, http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database.
Eurostat: Energy Statistics, Infrastructure electricity annual data. Code: nrg_113a, http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database.
Eurostat: Energy Statistics, Supply, transformation, consumption. Code: nrg_101a, http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database.
Eurostat: Environment Statistics, Air pollution. Code: env_air_emis, http://epp.eurostat.ec.europa.eu/portal/page/portal/environment/data/database.
EU (2009) Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
Richard Damania, Per G. Fredriksson, John A. List, 2003 Trade liberalization, corruption, and environmental policy formation: theory and evidence, Journal of Environmental Economics and Management, Volume 46, Issue 3, Pages 490-512.
Fredriksson, Per G., John A. List, Daniel L. Millimet, 2003. Bureaucratic corruption, environmental policy and inbound US FDI: theory and evidence, Journal of Public Economics, Volume 87, Issues 7–8, August, Pages 1407-1430.
Fredriksson, Per G, Jakob Svensson, 2003 Political instability, corruption and policy formation: the case of environmental policy, Journal of Public Economics, Volume 87, Issues 7–8.
Fredriksson, Per G., Vollebergh, Herman R.J. and Dijkgraaf, Elbert, 2004. Corruption and Energy Efficiency in OECD Countries: Theory and Evidence. Journal of Environmental Economics and Management, Vol. 47, pp. 207-231.
Falconett Irina, Ken Nagasaka, 2010 Comparative analysis of support mechanisms for renewable energy technologies using probability distributions, Renewable Energy, Volume 35, Issue 6, June, Pages 1135-1144, ISSN 0960-1481, 10.
Gray, W.B., Shadbegian, R.J., 1998. Environmental regulation, investment timing, and technology choice. Journal of Industrial Economics 46 (2), 235–256.
Caterina Gennaioli, Massimo Tavoni, 2011. Clean or "Dirty" Energy: Evidence on a Renewable Energy Resource Curse. Note di lavoro Working Paper.
Hausman, J. A. (1978), ''Specification Tests in Econometrics,'' Econometrica 46, 1251–1271.
Henisz, W.J., Zelner, B.A., 2001. The Political Economy of Private Electricity Provision in Southeast Asia, Reginald H. Jones Center Working Paper WP 2001-02, The Wharton School, University of Pennsylvania.
Im, K.S., M.H. Pesaran and Y. Shin, 2003. Testing for unit roots in heterogeneous panels. J. Econometrics, 115: 53-74.
International EnergyAgency,2011a. Policies and Measures Database, IRENA .OECD/IEA, Paris.

International Monetary Fund (IMF) 2011, World Economic Outlook Database.
Jaffe, A. B. and R. N.Stavins, 1995. 'Dynamic Incentives of Environmental Regulations: The Effects of Alternative Policy Instruments on Technology Diffusion', Journal of Environmental Economics and Management 29, S43–S63.
Jacobsson, S. and A. Bergek, 2004. 'Transforming the energy sector: the evolution of technological systems in renewable energy technology', Industrial and Coorporate change, Volume 13, Number 5, pp 815-549.
Jamasb, Tooraj 2006. " Between the state and market: Electricity sector reform in developing countries," Utilities Policy 14, 14–30.
Johnstone N, Hašcic I, Popp, D., 2010. Renewable energy policies and technological innovation: evidence based on patent counts. Environ Resource Econ 45:133–155.
Steffen Jenner, Felix Groba, Joe Indvik, 2013. Assessing the strength and effectiveness of renewable electricity feed-in tariffs in European Union countries, Energy Policy, Volume 52, Pages 385-401,
Kemp, René, 1998, The diffusion of biological waste-water treatment plants in the Dutch food and beverage industry, Environmental and Resource Economics 12: 113–136, 1998.
Kerr, S., Newell, R.G., 2003. Policy-induced technology adoption: evidence from the U.S. lead phase down. Journal of Industrial Economics 51 (3), 317–343.
Levin, A., and C. Lin, 1993. "Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties," Mimeo, University of California, San Diego.
Levin, A., C. Lin, and J. Chu, 2002. "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," *Journal of Econometrics*, 108, 1–24.
Alexandra Leitão, 2010. Corruption and the environmental Kuznets Curve: Empirical evidence for sulfur, Ecological Economics, Volume 69, Issue 11, 15 September, Pages 2191-2201
Mauro, Paolo, 1995. Corruption and growth. Quarterly Journal of Economics 109, 681-712.
Maddala, G. S., and Wu, S., 1999. A Comparative Study of Unit Root Tests with Panel Data and New Simple Test", *Oxford Bulletin of Economics and Statistics*, 61, 631-652.
Maza Adolfo, María Hierro, José Villaverde, 2010. Renewable electricity consumption in the EU-27: Are cross-country differences diminishing?, Renewable Energy, Volume 35, Issue 9, September, Pages 2094-2101, ISSN 0960-1481, 10.
Marques António C., Fuinhas José A., Manso José P., 2011a. A Quantile Approach to Identify Factors Promoting Renewable Energy in European Countries. Environ Resource Econ 49:351–366.
Mulder Arjen, 2008. Do economic instruments matter? Wind turbine investments in the EU(15), Energy Economics, Volume 30, Issue 6, November, Pages 2980-2991, ISSN 0140-9883, 10.
Nilsson L, Johansson B., Åstrand K., Ericsson K., Svennsingsson P., Börjesson P., and Neij L., 2004. Seeing the wood for the trees: 25 years of renewable energy policy in Sweden, *Energy for Sustainable Development*, Vol. 8(1), pp 67-81.
OPTRES 2007. Assessment and optimisation of renewable energy support schemes in the European electricity market. Recommendations for implementing effective & efficient renewable electricity policies. Report of the IEE project OPTRES.
David Popp, Ivan Hascic, Neelakshi Medhi, 2011. Technology and the diffusion of renewable energy, Energy Economics, Volume 33, Issue 4, July, Pages 648-662, ISSN 0140-9883, 10.
Ringel Marc, 2006. Fostering the use of renewable energies in the European Union: the race between feed-in tariffs and green certificates. Renewable Energy 31 p. 1–17.
Snyder, Lori, Nolan Miller, and Robert N. Stavins. 2003. "The Effects of Environmental Regulation on Technology Diffusion: The Case of Chlorine Manufacturing." The American Economic Review, Vol. 93, No. 2, pp. 431-435.
Söderholm, Patrik, Klaassen, Ger, 2007. Wind power in Europe: a simultaneous innovation–diffusionmodel. Environmental and Resource Economics 36, 163–190.
Gireesh Shrimali, Joshua Kniefel, 2011. Are government policies effective in promoting deployment of renewable electricity resources?, Energy Policy, Volume 39, Issue 9.

Transparency International, 1997 – 2009. http:// www.transparency.org/cpi.
Van Ruijven B, Van Vuuren D, 2009. Oil and natural gas prices and greenhouse gas emission mitigation. Energy Policy 37:4797–4808.
Wooldridge, J.M. (2002), Econometric Analysis of Cross Section and. Panel Data, MIT Press
Wang Y., 2006. Renewable electricity in Sweden: an analysis of policy and regulatiosns. Energy Policy 34:1209–1220.
White T, 2010. "Spanish Solar-Panel Trade Group Calls for Fraud Investigation," Bloomberg Businessweek, April 12.
John K. Wilson, Richard Damania,2005. Corruption, political competition and environmental policy, Journal of Environmental Economics and Management, Volume 49, Issue 3.
Pizer A. William & Popp David, 2008. "Endogenizing technological change: Matching empirical evidence to modeling needs," Energy Economics, Elsevier, vol. 30(6), pages 2754-2770.
Xepapadeas, Anastasios and De Zeeuw, Aart J. 1998, Environmental Policy and Competitiveness: The Porter Hypothesis and the Composition of Capital. Tilburg University, Center for Economic Research Discussion Series No. 1998-38.