The Effect of the Feed-in-System Policy on Renewable Energy Investments: Evidence from the EU Countries

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Abstract

We study the effect of the Feed-in-System (FIS) policy on wind and solar photovoltaic energy investments in the European Union (EU), over the time period between 1992 and 2015, considering the heterogeneity of the policies and market conditions across the EU countries. We develop a FIS subsidy performance indicator that distinguishes feed-in-tariff (FIT) from feed-in-premium (FIP) and considers other important aspects of each of these contracts, such as the duration, tariff price, energy spot price and production costs, as well as the market conditions. We conclude that the mere existence of the FIS policy does not necessarily enhance renewable energy investments, it depends on the type of the FIS contract and its features, and may vary across the different sources of renewable energy. Some of our findings are new to the literature and can have important implications in the development of new public investment incentives to promote renewable energy.

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1. Introduction

In the European Union (EU) over the last decades, different types of subsidies have been adopted to enhance renewable energy investments.[1] The motivation underlying these subsidies is the prevention of further climate changes for which we need a significant reduction in the use of fossil fuel and wiser use of natural resources and technological development (Carley 2009; Lyon and Yin 2010). Akadiri et al. (2019) study the energy consumption in the EU-28 countries and highlights the importance of renewable energy given that there is a positive long-term relationship among environmental sustainability, renewable energy consumption and economic growth.

The Feed-in-System (FIS) is a popular subsidy policy and encompasses two types of contracts, a Feed-in-Tariff (FIT) and Feed-in-Premium (FIP), whose specificities, such as the tariff price or price premium, duration and digression rate, vary significantly across the EU countries and the renewable energy sources. The FIT guarantees a price tariff per MW of energy produced, whereas the FIP provides a tariff premium on top of the energy market price. These renewable energy subsidy systems are also popular in the world, for instance, Shallenberg-Rodrigues (2017) report that the FIS might be progressing to become the most popular renewable energy subsidy system.

The specificities of these contracts and the market conditions determine the profitability of renewable energy investments and, therefore, the effectiveness of the FIS policy. There are countries where the FIS policy is based on a high tariff over a short period of time and countries where it is based on a low tariff over a long period of time. There are also cases where the energy price tariff for the FIT, or the price premium for the FIP, changes over the time period of the contract. Despite its great popularity in the EU, the FIS policy effect on wind and solar photovoltaic (PV) energy investments vary significantly across countries. Pyrgou et al. (2016) investigate the regulatory and policy framework of the FIT scheme in the European renewable energy market and conclude that these contracts should be set by each country considering their own specificities.

[1] For further details on the adopted policies, see Tables A.2 and A.3 in the Appendix.

Most of the literature which examines the impact of the FIS policy and socio-economic, ecological and macroeconomic factors on wind and solar PV investments rely on a dichotomous (dummy) variable, which takes the value of "1" if the subsidy policy exists and "0" otherwise (Menz and Vachon 2006; Del Río and Gual 2007; Marques et al. 2011). However, the use of a dummy variable ignores the existence of two types of FIS contracts and the role of their specificities, such as the time period, the price tariff or the price premium, and the digression rate, on the investment decision (Jenner et al., 2012).

This paper studies the impact of the FIS policy on wind and solar PV investments for the EU countries considering the two types of FIS contracts (FIT and FIP) and their specificities, as well as the market conditions. We develop a subsidy performance indicator, the "present value of the subsidy per megawatt-hour (MWh) of energy produced" (PvRev), which is considered in our fixed effects panel regression models. For each country and year, if the FIS policy is available, we estimate the PvRev considering the tariff price or the tariff premium, otherwise, we use the energy market price. Jenner et al. (2013) and Bolkesjø et al. (2014) also study the effect of the subsidy on renewable energy investments but neglect the role of the above variables.

Yin and Powers (2010) study the effect of subsidies on renewable energy investments. They also use a subsidy performance indicator and consider the specificities of the subsidy policy. Nevertheless, while we focus on the EU and our subsidy performance indicator measures the present value of the subsidy, they focus on some states of the U.S.A. and the subsidy performance indicator measures the stringency of the subsidy policy on the renewal policy standards (RPS). Their results reveal that the RPS has a positive effect on investments but this effect disappears when the specificities of the subsidy policy are not considered.

Jenner et al. (2013) also develop a subsidy performance indicator, the "return on investment" (ROI), considering the specificities of the FIS policy, but it does not distinguish the FIT policy from the FIP policy. More recently, they investigate the effect of the power purchasing agreements, capital grants and tax incentives on wind and solar PV investments in the EU, and conclude that the FIT plays an important role in the wind and solar PV energy investments.

Bolkesjø et al. (2014) study the effect of FIT on renewable energy investments for the five largest energy demand countries in the EU. Following Jenner et al. (2013), they consider the effect of the ROI of the FIT policy on investments, taking into account the specificities of the FIT contract and the market conditions. They neglect however the type of FIS contract. Interestingly, perhaps because of the differences between their data samples, Jenner et al. (2013) and Bolkesjø et al. (2014) results are contradictory. While Jenner et al. (2013) find that there is not a statistically significant effect of the FIT subsidy on investments, Bolkesjø et al. (2014) show that the FIT subsidy has a positive and statistically significant effect on wind energy investments. Pablo-Romero et al. (2017) study the measures adopted in the EU-28 to enhance biogas investments, making a connection between these and the targets each country has set in their national renewable energy action plans and, following Pyrgou et al. (2016), also conclude that the FIT or the FIP used by each country should fit with the peculiarities of their energy market.

Our PvRev considers the FIT and FIP policies and the distinct features of these contracts over time and across the 27 EU countries. We conclude that the FIS policy has a positive and statistically significant effect on wind energy investments and no effect on solar PV investments. For both the FIT and the FIP policy, our PvRev subsidy performance indicator is positively associated with wind and solar PV energy investments. However, if the FIS policy is not available, the relationship between the PvRev and the wind energy investment is positive and statistically significant, and the relationship between the PvRev and solar PV investment is not statistically significant.

The remainder of this paper is organized as follows. Section 2 introduces our subsidy indicator. Section 3 presents the data sample and the regression methodology. Section 4 shows our main results. Section 5 concludes.

2. The Feed-in-System Policy

2.1 The Feed-in-Tariff and Feed-in-Premium

The Feed-in-System (FIS) policy varies across the EU countries in terms of the type of contract, Feed-in-Tariff (FIT) or Feed-in-Premium (FIP), and its specificities, such as the tariff price or the tariff premium, the time period and the scheduled tariff changes over time. On the other hand, the market conditions, such as the gross domestic product (GDP), energy price, production cost, and interest rate, can also affect the performance of the FIS policy (Jenner et al., 2013; Bolkesjø et al., 2014). Therefore, studies on the effectiveness of the FIS policy in promoting renewable energy investments should take all these factors into account.

2.2 The PvRev Subsidy Performance Indicator

We develop a subsidy performance indicator (PvRev) to be used in our regression analysis. It measures the present value of the subsidy per MWh of energy produced. For each country, year and (wind and solar PV) renewable energy, we examine whether the FIS policy is available and, when it is available, whether it is a FIT or a FIP policy.[2]

We start by estimating for year t, with $t \in \{0; n\}\ and\ n = 23$, renewable energy i, with $i \in \{wind, solar\ PV\}$, and country j, $with\ j \in \{EU\ countries\}$, the net revenue from the subsidy ($NREV_{ijt}$) under a FIS policy:[3]

$$NREV_{ijt} = P_{ijt}^{FIS}.S_{ijt}^{FIS}.CT_{ijt} + P_{ijt}^{mkt}.S_{ijt}(TL_{ijt} - CT_{ijt}) - TOC_{ijt} \quad (1)$$

where P_{ijt}^{FIS} is the energy price under a FIS contract, S_{ijt}^{FIS} is the energy production under the FIS contract, P_{ijt}^{mkt} is the energy market price, S_{ijt} is the energy production after the end of the FIS contract, TL_{ijt} is the lifetime of the adopted renewable energy technology i, CT_{ijt} is the time period of the FIS contract, and TOC_{ijt} is the operating cost associated with the adopted technology i.[4]

The operating costs are given by Equation (2):

$$TOC_{ijt} = ACEP_{ijt}.S_{ijt} \quad (2)$$

[2] We use market data for both the operating costs and the lifetime of the renewable energy technologies.

[3] For the estimation of the $PvRev_{ijt}$, if the FIP policy is in place, we use the market price of energy plus the tariff premium, if the FIT is in place, we use the tariff price and, when the FIT and the FIP policies encompasses changes in the tariff price and the tariff premium over time, this aspect is also considered.

[4] If the FIS contract covers the entire life of the technology, $CT_{ij} = TL_{ij}$, therefore, $NREV_{ijt} = P_{ijt}^{FIS}.S_{ijt}^{FIS}.CT_{ij}$. If the FIS policy does not exist in country j in a given year t, $CT_{ijt} = 0$, and the revenue from a renewable energy investment comes from selling the energy in the market at the market price, P_{ijt}^{mkt}.

where $ACEP_{ijt}$ is the per MWh production costs.

Assuming full utilization of the energy production capacity, we estimate the present value of the revenues from investing in the renewable energy *i* in country *j* at time *t*, $PvRev_{ijt}$:

$$PvRev_{ijt} = \sum_{t=0}^{t=n} \frac{P_{ijt}^{FIS} S_{ijt}^{FIS} - TOC_{ijt}}{(1+r)^t} + \sum_{t=n}^{t=m} \frac{P_{ijt}^{mkt} S_{ijt} - TOC_{ijt}}{(1+r)^t} \quad (3)$$

The first summation represents the present value of the revenue from investing in renewable energy *i* under a FIS contract, whereas the second represents the present value of the revenue from investing in the renewable energy *i* for the time period after the end of the FIS contract; *r* is the discounting rate for country *j*; *n* is the number of years of the FIS contract; and *m* is the lifetime of adopted renewable energy technology *i*.[5]

Equations (4) converts the $PvRev_{ijt}$ into $PvRev_{ijt}MWh$:

$$PvRev_{ijt}MWh = \frac{NPV\_Rev_{ijt}}{S_{ijt} \cdot TL_{ij}} \quad (4)$$

where $PvRev_{ijt}MWh$ represents the present value of the revenue per MWh from investing in the renewable energy *i*, and NPV_Rev_{ijt} is the net present value of the revenue from investing in the renewable technology *i*.

In our regression analysis, we use $PvRev_{ijt}MWh\_1$, $PvRev_{ijt}MWh\_2$, $PvRev_{ijt}MWh\_3$ and $PvRev_{ijt}MWh\_4$, which represent, respectively, the existence of the FIS policy (FIT or FIP), the FIT policy, the FIP policy, and the absence of a FIS policy.

Notice that, it is difficult to predict the energy prices in the long-term (Karakatsani and Bunn 2008; Torró 2009; Liu and Shi 2013). For instance, Felder (2011) advocates that with the rapid development of renewable energy technologies, the energy prices will decrease significantly, but Reuter

[5] We use the country borrowing rate with a premium of 10 percent on top. We put a premium of 10% due to the highly expensive nature of borrowing for capital intensive projects such as RES-E projects. For robustness check, we used different rates of return and noticed that no significant changes were observed.

et al. (2012) argue that it is hard to estimate the energy prices in the future because they depend on a very high number of factors. Therefore, in our subsidy performance indicator (PvRev), we assume that the energy market price is the same all over the lifetime of the investment.

3. Data Sample and Methodology

3.1. Data Sample

We use hand-collected data from 27 EU countries to form a national policy database for each country, for the time period between 1992 and 2015. We conclude that 25 of the 27 EU countries adopted, at some point in time, the FIS policy. The data source for our FIS policy dataset is the International Energy Agency (IEA) Policies and the Measures Database, supplemented, whenever necessary, with information from Huber et al. (2004) and Haas et al. (2011). The data on the wind and solar energy capacity as well as on the wholesale energy prices were gathered from the European Union Statistics Database (Eurostat).

For the EU, there is not yet available reliable information on the production costs of renewable energy technologies (Bolkesjø et al. 2014). Therefore, we follow Jenner et al. (2013) who use the levelized cost of production data provided by Schilling and Esmundo (2009). However, this data is only available for the time period between 1980 and 2005. Hence, for the time period between 2006 and 2015, we get the data from the GreenX final report. We also use data on the production costs from the IEA database, when it is not available in the data sources stated above.

In our regression analysis, we control for the country risk, using the long-term borrowing rate as the discounting rate. However, the countries' long-term borrowing rate reflects the sovereign risk, not renewable energy investment risk. Therefore, we add a 10% premium on top of the country's long-term borrowing rate. The data on the long-term borrowing rate is retrieved from the DataStream.

3.2. Methodology

We test the impact of FIS policy on the capacity development of wind and solar PV energy in the EU. We use the following panel OLS regression model with country and year fixed effects specification:

$$Ln(AC_{ijt}) = \beta_0 + \beta_1 PvRev_{ijt-1} MWh + \beta_k H_{ijt-1} + \beta_g U_{ijt-1} + k_j + \phi_t + \epsilon_{ijt} \quad (5)$$

where the subscripts i, j and t stand, respectively, for the renewable energy source, $i \in \{wind, solar\ PV\}$, the EU country, and the year; $Ln(AC_{ijt})$ is the natural log of the added renewable energy *i* capacity for country *j* in year *t*; $PvRev_{ijt-1}MWh$ is the present value of the revenue per MWh from investing in renewable energy *i* at time *t-1*; H_{ijt-1} represents a set of dummy variables which take into account the existence of other renewable energy policies (quota system, tax benefits, tender, and caps). U_{ijt-1} is the natural log of a set of market variables (GDP, electricity consumption, coal share, natural gas share, nuclear share, oil share, renewable share, population growth, CO2, oil price, natural gas price, coal price, and energy import). To control for any unobserved, time-invariant country-specific factors that may influence the country's added renewable energy capacity, we include country fixed effects in the model, indicated with k_j. ϕ_t denotes year fixed effects to control for any systematic variation in added renewable energy capacity in any given year across all EU countries. All explanatory variables and controls are lagged by one year. $\in_{ijt}$ is the error term.

$$Ln(AC_{ijt}) = \beta_0 + \beta_1 PvRev\_1_{ijt-1}MWh + \beta_k H_{ijt-1} + \beta_g U_{ijt-1} + k_j + \phi_t + \in_{ijt} \quad (6)$$

$$Ln(AC_{ijt}) = \beta_0 + \beta_1 PvRev\_2_{ijt-1}MWh + \beta_k H_{ijt-1} + \beta_g U_{ijt-1} + k_j + \phi_t + \in_{ijt} \quad (7)$$

$$Ln(AC_{ijt}) = \beta_0 + \beta_1 PvRev\_3_{ijt-1}MWh + \beta_k H_{ijt-1} + \beta_g U_{ijt-1} + k_j + \phi_t + \in_{ijt} \quad (8)$$

$$Ln(AC_{ijt}) = \beta_0 + \beta_1 PvRev\_4_{ijt-1}MWh + \beta_k H_{ijt-1} + \beta_g U_{ijt-1} + k_j + \phi_t + \in_{ijt} \quad (9)$$

where $PvRev\_1_{ijt-1}$, $PvRev\_2_{ijt-1}$, $PvRev\_3_{ijt-1}$ and $PvRev\_4_{ijt-1}$ represent the present value of the revenue from investing in the renewable energy *i* considering, respectively, that it is adopted a FIS policy (FIT or FIP), a FIT policy only, a FIP policy only, and the FIS policy is absent. Table A.1 in the Appendix, provides the definition of all our regression variables.

Our estimation enables us to control for the time-invariant country-specific effects, such as wind and solar potential, the differences in planning regimes, commitment to renewable energy, and existing wind and solar PV capacity before our sample time period. It also enables us to control for the time-variant factors, such as the market uncertainties and the learning effects. The use of a one-year lag captures the effect of the time it takes to add capacity after the adoption of a policy and also mitigates the endogeneity concern regarding the renewable share variable.

We choose the fixed effects model over the random effects following both the previous literature (Carley, 2009; Marques et al., 2011; Aguirre and Ibikunle, 2014), and our results from the Hausman test reported in Table 1. The use of a fixed-effects model also suits better with the nature of our data due to the heterogeneity among the EU countries and its estimations also controls for unobserved country heterogeneity, eliminating therefore the coefficients bias when these effects are correlated with capacity development and with the policy adoption.

We start our analysis by using the Jarque and Bera (1980) test, in order to examine the normality of our data, which we report in Table 1. Our findings reveal that it deviates from normality. Therefore, it should be transformed to avoid a biased analysis, specification in errors and inconsistencies in the estimates. Both the skewness and kurtosis test independently and jointly were significant at the 1% confidence level. Following Carley (2009) and Aguirre and Ibikunle (2014), we transform the data by taking the natural log of each variable. We re-run the Bera and Jarque's test that reveals that the kurtosis is significant but the significance was reduced to a 10% confidence level, which is close to normality. The skewness is statistically insignificant. The significance of the joint test was also reduced to 10% confidence level, which we can assume to be close to normality.

-Table 1-

3.3. Regression Variables

3.3.1. Dependent Variable

In our regression analysis, we use added capacity (*AC*) as the measure for the wind and solar PV capacity development, although, in the literature, other measures are also used, such as actual production, cumulative capacity and percentage of renewable energy capacity on the installed energy production capacity (Carley, 2009; Lyon and Yin, 2010; Yin and Powers, 2010; Marques et al., 2011; Bolkesjø et al. 2014). There are advantages in using the *AC* as a dependent variable in our regression analysis, namely because it enables us to estimate the present value of the FIS subsidy and distinguishing the effect of the subsidy policy among the different sources of renewable energy.

3.3.2. Independent Variables

3.3.2.1. PvRev Subsidy Performance Indicator

The FIS policy varies significantly among the EU countries, namely in terms of the type and the duration of the contract, tariff price, tariff premium, and digression rate. On the other hand, the market conditions, such as energy prices, production costs, and interest rates, also vary significantly across the EU countries. Therefore, the existence of very heterogenous conditions among the EU countries may justify differences in their responses to the FIS policy (Jenner et al. 2012; Jenner et al. 2013; Bolkesjø et al. 2014).

The use of our subsidy performance indicator (PvRev) enables us to consider the specificities of the FIS policy and the impact of these factors on the renewable energy capacity development. In our regression models, $PvRev_{ijt}MWh\_1$, $PvRev_{ijt}MWh\_2$, and $PvRev_{ijt}MWh\_3$ represent the existence of the FIS policy (FIT or FIP), FIT policy, and FIP policy, respectively, whereas $PvRev_{ijt}MWh\_4$ represents the case where the FIS policy is absent.

We also examine the effect of the contribution of FIT and FIP on capacity development by segregating the stated relative monetary value of the policies and examine its impact on capacity development. This enables us to analyse the effect of the monetary tariff price announced by governments on the capacity development of wind and solar PV. These variables are represented by FIT_ABS and FIP_ABS respectively. We expect a positive relationship between these variables and capacity development.

As an illustrative example, we report in Figure 1 a comparison between Germany and France regarding the yearly PvRev per MWh and the annual added capacities. It shows the degree to which the FIS subsidy performance indicator (PvRev) drives the added capacity of wind and solar PV energy. This relation is expected to be positive. We notice that, regarding France, Figure 1 shows that there are years in which the PvRev is negative and yet investment is made in solar PV.

-Figure 1-

3.3.2.2. Control Variables

Our regression analysis includes two groups of controls variables. The first group includes controls that capture the use of other policy enactments, renewable energy subsidies and incentives, by each country in our sample, such as, tax exemptions, investment grants, and soft loans. To this end we use the following dummy variables: Tax, Tender, Quota and Cap, when these are in place. We also test for the impact of the relative tariff amount on capacity development.[6]

Second type of controls include socio, economic, environmental, and political factors which are found to be important determinants of capacity development of renewable and solar energy. Following the existing literature (see e.g., Carley, 2009; Jenner et al., 2012; and Bolkesjø et al., 2014), we include electricity consumption, GDP, Oil Price, Gas Price, Coal Prices, Oil Share, Coal Share, Natural Gas Share, Renewable Share, population growth and Energy Import Dependence.[7]

4. Results

In Table 2, we present the descriptive statistics of our regression models variables. It shows the minimum and the maximum for the PvRev (€/MWh) for wind and solar energy are €140.32 and €159.38, and -€358.324 and -€15.169, respectively. It also shows negative values for the added capacity, population growth, and energy import dependence. The negative population growth rate for some EU countries is not a surprise, given the low birth rate of the last decades. A negative capacity growth rate for some EU countries is also possible in some years if there are long shut downs of wind and/or solar PV farms for maintenance or due to technical problems.

-Table 2 -

Table 3 provides our results for the impact of the FIS policy on the wind energy added capacity. Panel A of Table 3 reports the main results without including control variables, while Panel B reports

[6] These are various policies implemented by different governments as incentives to specifically enhance capacity development of wind and solar energy. Some countries implement FIS in addition to some of the incentives above, see Tables A.2 and A.3 in the Appendix. Therefore, we control for these incentives in countries (years) they exist and expect a positive impact on wind energy and solar PV capacity development.
[7] These are socio economic, environmental and political factors that are expected to affect wind energy and solar PV capacity development. The available literature reports conflicting relations between these factors and the wind and solar energy capacity development (see e.g., Carley, 2009; Jenner et al., 2012; and Bolkesjø et al., 2014).

the results with the control variables. The coefficients of the main explanatory variables in Panel A are qualitatively similar to those reported in Panel B. As per Panel B, the results show that there is a statistically significant relationship between the existence of the FIS policy and the wind energy added capacity. However, if we look at the type of FIS contract, FIT and FIP, we conclude that the coefficients for both contracts are negative and only that of the FIP is statistically significant (see Model 1). Additionally, when we replace the FIT and FIP dummy variables by the respective subsidy monetary values, we find that there is a positive and statistically insignificant relation between the FIT_ABS and the wind energy added capacity, and the same does not happen for the FIP_ABS (see Models 2 and 3). Regarding the FIP_ABS we find that there is a negative and statistically significant impact on wind energy added capacity.

If the policy variable is replaced with our subsidy performance indicator (PvRev), we find that its relation to the wind energy added capacity is positive and statistically significant (Model 4). This means that there is a strong correlation between the PvRev and the wind energy added capacity even in countries where there is no FIS policy. Furthermore, when we split the PvRev according to the PvRev_1, PvRev_2, PvRev_3, and PvRev_4 (Models 5, 6, 7, and 8), in order to segregate the policy components from non-policy components and to capture the effect of the design of the policies, we observe a different impact of the policy components on wind energy development. The PvRev_1 indicator, which captures only FIT and FIP policies, shows a positive and non-significant relationship with the added capacity of wind, whereas PvRev_2, which captures the existence of FIT policy only, shows a positive and significant relationship with the wind added capacity. Both PvRev_3 and PvRev_4 show no significant relationship with wind energy capacity development. Therefore, while the FIP policy has a negative effect on the wind energy capacity development (Model 1), the revenue from FIP policy (PvRev_3) has no statistically significant effect on wind energy capacity development (Model 7). This means that wind energy capacity development is very sensitive to the type of FIS policy that is in place and it is only driven by the FIT policy with guarantees revenue for a specified period of time. In the absence of a FIT policy, the uncertainty with electricity prices affects the development of wind energy since both FIP and revenue from the market does not have significant impact on wind energy capacity development.

We also observe a positive and significant effect of the Quota policy on wind energy capacity development. Tax exemptions, Tender and Cap policies, represented by dummy variables, have no significant impact on the capacity development of wind energy.

-Table 3-

Table 4 presents the results for the impact of the FIS policy on the solar PV added capacity. Panel A reports the main results without including control variables, whereas Panel B reports the results with the control variables. The coefficients of the main explanatory variables in Panel A are qualitatively similar to those reported in Panel B. As per the results in Panel B, we conclude that neither the mere existence of FIS policy as a whole or each of its schemes (FIT or FIP) affect the Solar PV energy capacity development (Model 1). We also find an insignificant relationship between the monetary amount that is assigned to solar PV energy through both the FIT and the FIP policies and the solar PV capacity development (Model 2 and 3).

Furthermore, when we replace the FIS policy dummy variables by our subsidy performance indicator PvRev, we observe a positive and stronger impact of the FIS policy on the capacity growth of solar PV energy (Model 4). This indicates the sensitivity of solar PV capacity development to changes in the revenue provided by either the policy and or the energy market. From Model 5, we observe that the PvRev_1 affects positively the solar PV capacity development.

The PvRev_1 variable reflects the impact of the revenue provided by the FIS policy alone on capacity development. Countries who have active FIS (FIT and/or FIP) policy will have an average of 29.2% more additional capacity of solar PV installed than countries-years without the policy when there is a change in PvRev_1. We also observe that when we disaggregate the FIS into (FIT and FIP), there is a positive and statistically significant relationship between the present value of revenue provided by FIT and FIP alone on solar PV capacity development (Models 6 and 7). This means that the solar PV capacity development is very sensitive to the revenue provided by the FIT and FIP policies alone and would increase the capacity of solar PV by 33.2% and 29.5% respectively when there is a unit change in revenue respectively. This shows that solar PV capacity development is more sensitive to the FIT incentive alone than to the simultaneous incentive of the FIP policy and the energy market.

We also observe that the present value of the revenue when there is no FIS policy does not affect the solar PV capacity development (Model 8). This means that there is no statistically significant relationship between the capacity development of solar PV and the present value of revenue when energy from solar PV sources is sold in the open competitive market - the market return without the FIS does not enhance the solar PV capacity development, similar to the case of wind energy. We also find that the dummy variable representation of other RES-E policies does not have a significant impact on solar capacity development.

-Table 4-

From Table 4, we also observe a significant negative relationship between solar PV development and *GDP*, which indicates that larger or wealthier countries do not support solar PV energy capacity development. This finding is in line with the Jenner et al. (2013) who advocate that the effect of the *GDP* on capacity development depends on the renewable energy source. Wealthier and larger countries might be able to support the production of energy from some energy sources considering certain factors and country characteristics. For instance, countries with less potential of solar would support other renewable energy sources with a higher potential. We find insignificant relationship between wind energy capacity and GDP. For both wind and solar PV energy (Tables 3 and 4), we observe a non-significant relationship with energy consumption per capita.

The energy production from renewables has a significant and positive impact on the capacity development of solar PV. As expected, the more energy is generated from renewable sources, the greater the capacity increment in solar PV. This indicates the growing interest of investments in solar PV. A possible reason could be associated with the declining cost of the technologies, making it gradually more competitive in relation to the traditional sources of energy even without government subsidies. Thus, most environmentally friendly countries would rather increase their renewable energy capacity through solar sources.

We find no significant relationship between electricity production from natural gas and capacity development of wind and solar PV (Tables 3 and 4). We also find no significant link between the percentage of energy generated from coal sources and wind and solar PV energy capacity development. This contradicts the findings of Marques et al. (2011), who report a positive relationship between the coal share of energy generation and renewable energy development. We find no association between the percentage of energy generated from oil and the development of solar PV energy, but find a positive association between the percentage of energy generated from oil and wind energy. However, Nuclear share has a positive and statistically significant impact on capacity development of wind energy and solar PV capacity development.

We also find a positive and significant relationship between energy import dependence and capacity development of solar PV energy. This implies that the more countries depend on the import of energy to supplement their energy needs, the higher the solar PV energy capacity that is added. Perhaps this is the result of higher import-dependent countries investing in solar to reduce the amount of energy being imported. Our findings also show a statistically significant positive impact of the population growth on solar PV capacity development, and no relationship for the wind energy capacity development. This implies that population growth leads to higher solar PV energy capacity development. We find no consistent significant relationship between coal price or natural gas price and the wind and solar PV energy capacity developments. Further, higher oil prices negatively affect the solar PV energy capacity development.

Carbon emissions have significant and positive impact on wind capacity development, while it has a significant and negative effect on the capacity development of solar PV energy. Surprisingly, this means that rising CO2 retards capacity development of solar PV, which means that despite the increase of CO2, countries would prefer to pay the correspondent penalty or invest in wind energy rather than investing in solar PV energy capacity. This could be possible, especially when the amount to pay for emitting CO2 is less than the amount needed to support solar PV capacity development.

5. Conclusion

Using a panel dataset of 27 EU countries for the period between 1992 and 2015, we employ a fixed-effects model to determine the effectiveness of the FIS policy on the capacity development of wind and solar PV, controlling for country and time-specific effects. Our analysis also introduces a new indicator (PvRev) that captures the incentive provided by the investment incentive policy and the market conditions pertaining to individual countries over time.

Our results show that for a change of 5% and 1% in our subsidy performance indicator (PvRev), leads, respectively, to a 33.4% and 28.9% change in wind and solar PV energy capacity. We conclude that the FIS policy affects positively the wind and solar PV capacity development in the EU. Our findings imply that policy design features and market conditions are often more important to enhance wind and solar PV energy capacity development than the mere existence of the policy. We show that the specificities of the FIS policy, such as the tariff price, tariff premium, duration, digression rate of tariff, market electricity price, production costs, and interest rate play a key role in the decision to invest in renewable energy.

Our findings provide important information for policymakers in the sense that they reveal that the adoption poorly designed renewable energy subsidy policies are very ineffective in enhancing renewable energy investments. Investors react to the investment incentive provided by the subsidy policies, but their behaviour is also largely affected by other factors such the country renewable energy development and the market conditions, which also should be considered.

The revenue uncertainty underlying renewable energy investments plays a key role in the development of wind energy and solar PV and it is determined by various independent, and possibly correlated, types of uncertainty (e.g., economic, political, and technological, among others). Thus, an empirical study on the role of each of these uncertainties on the overall revenue uncertainty underlying the EU renewable energy investments would be of great importance. We suggest this study as a future research.

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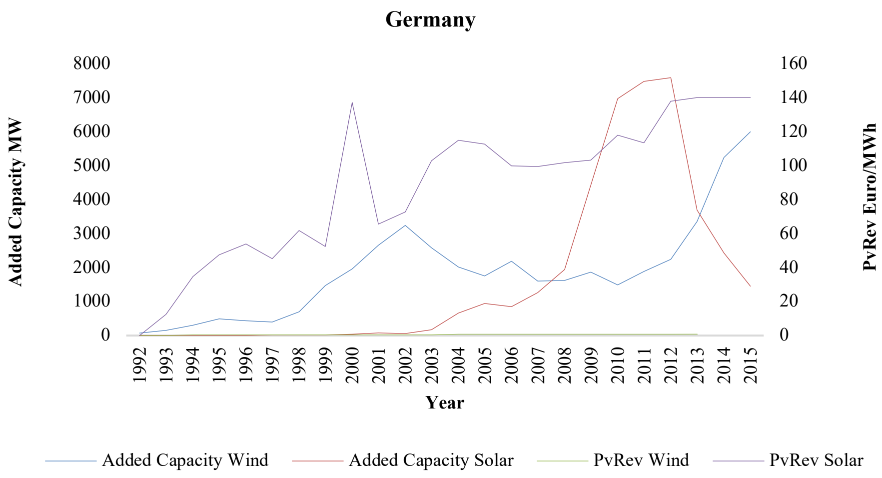
Table 1: *Specification test statistics*

Panel A: Specification test statistics for wind energy models									
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Wooldridge Test (autocorrelation)	15.939***	14.580***	15.020***	13.097**	13.335***	17.984***	13.474***	16.276***	14.961***
Breusch-Pagan (heteroscedasticity)	72.21***	68.71***	81.49***	150.44***	101.97***	62.56***	93.40***	155.12***	68.87***
LM	73.611***	103.05***	135.53***	42.72***	46.73***	86.41***	133.18***	95.05***	102.50***
Hausman Test	262.93***	102.83**	122***	138.32***	133.41***	134.66**	119.45***	272.39***	212.19***
Panel B: Specification test statistics for solar photovoltaic models									
Wooldridge Test (autocorrelation)	68.184***	73.191***	66.869***	58.758***	58.430***	66.104***	67.096***	49.065***	66.650***
Breusch-Pagan (heteroscedasticity)	293.37***	271.11***	267.09***	356.83***	356.19***	350.00***	290.90***	284.40***	271.91***
LM	64.69***	81.83***	92.26***	37.14***	40.30***	44.01***	104.22***	100.06***	74.37***
Hausman Test	149.71***	123.44***	135.05***	49.51***	51.28***	48.87***	158.91***	162.82***	146.01***

Figure 1 - *Summary Statistics*: This figure shows information on the present value of the subsidy revenue (PvRev) and the added capacity for Germany and France over the time period between 1992 and 2015.



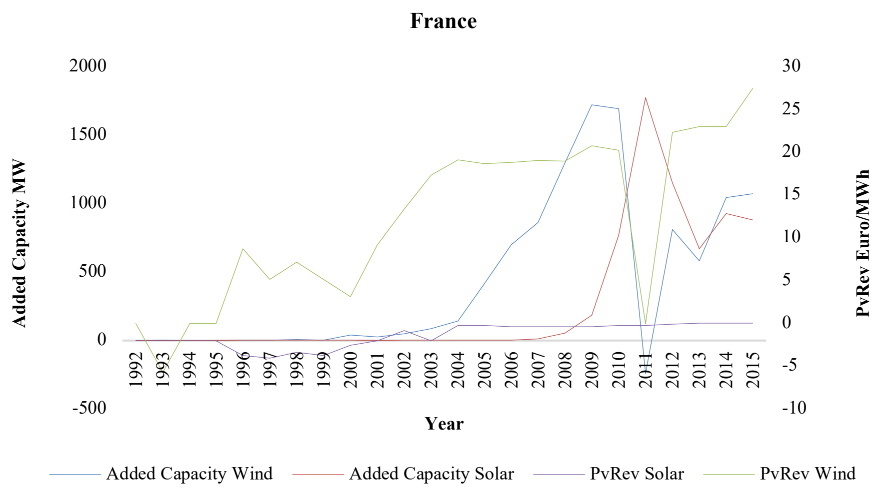


Table 2 - *Descriptive Statistics*: This table presents some basic descriptive statistics of our regression variable. For the definition of the regression variables and respective acronyms, see Table A.1 in the Appendix.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Added Capacity Wind (MW)	621	197.4545	483.9258	-240	3356
Added Capacity Solar (MW)	621	133.9529	742.3365	0	9303
FIS_Dummy Wind	621	0.410774	0.492389	0	1
FIS_Dummy Solar	621	0.343434	0.475255	0	1
FIS_Dummy Wind	621	0.346801	0.476353	0	1
FIS_Dummy Solar	621	0.304714	0.460674	0	1
FIS_Dummy Wind	621	0.121212	0.326649	0	1
FIS_Dummy Solar	621	0.082492	0.275344	0	1
FIT_ABS Wind (€ million)	621	29.91302	49.80023	0	275
FIT_ABS Solar (€ million)	621	112.0985	187.1577	0	575
FIP_ABS wind (€ million)	621	9.071645	26.0383	0	166
FIP_ABS Solar (€ million)	621	16.91808	67.40139	0	464
PvRev Wind (€/MWh)	621	11.18308	20.66477	-15.1691	159.3843
PvRev Solar (€/MWh)	621	-2.0149	48.77736	-358.324	140.3267
PvRev_1 Wind (€/MWh)	621	9.022559	19.88312	-1.98157	159.3843
PvRev_1 Solar (€/MWh)	621	10.99126	30.00311	-83.5639	140.3267
PvRev_2 Wind (€/MWh)	621	5.189274	13.23256	-8.37169	122.7217
PvRev_2 Solar (€/MWh)	621	10.03024	30.20766	-83.5639	140.3267
PvRev_3 Wind (€/MWh)	621	0.261527	0.86276	-0.20535	4.4856
PvRev_3 Solar (€/MWh)	621	1.395294	9.651141	0	100.5120
PvRev_4 Wind (€/MWh)	621	8.346009	14.42219	-15.1691	88.7383
PvRev_4 Solar (€/MWh)	621	-24.6009	42.86847	-358.324	16.37275
Quota_Dummy	621	0.144781	0.352177	0	1
Tax_Dummy	621	0.166667	0.372992	0	1
Tender_Dummy	621	0.069024	0.253708	0	1
CAP_Dummy	621	0.090909	0.287722	0	1
GDP (€ million)	621	24272.47	16756.37	2460.654	86127.24
Elect.Consumption (MW)	621	6196.756	3603.961	1935.561	17212.95
Coal Share (%)	621	30.62511	26.62496	0	97.33103
Natural Gas Share (%)	621	1.06E+07	6.68E+07	0	5.93E+08
Nuclear Share (%)	621	20.57517	24.22304	0	87.98622
Oil Share (%)	621	9.32348	19.55767	0	100
Renewable Share (%)	621	4.28701	6.303238	0	48.62688
Population Growth (%)	621	0.200702	0.825395	-3.82017	3.732596
CO2 (MT)	621	8.291522	3.644724	2.636157	27.14212
Oil Price (€)	621	89.4082	15.7421	27.9	140.1
Electricity price (€/MWh)	621	74.32273	28.61197	24.25	224.95
Natural Gas Price (€)	621	106.364	47.88678	18.7	342.3
Coal Price (€)	621	95.77542	33.2181	32.2	276.7
Energy Import (€ million)	621	45.87417	25.97881	-49.8	102.5

Table 3 - *Effect of the FIS Policy on the Wind Energy Capacity*: This table reports our results of the Fixed Effects model, following the regression Equations (5) to (9). Regressions in Panel A does not include any control variables while regressions in Panel B controls for the effects of other policy enactments such as tax exemptions, investment grants, and soft loans. Also, regressions in Panel B controls for socio-economic, environmental and political factors. Below, $PvRev\_1$, $PvRev\_2$, $PvRev\_3$ and $PvRev\_4$ represent the existence of a FIS policy (FIT or FIP), a FIT policy, a FIP policy, and the absence of a FIS policy, respectively. The Robust standard errors are in parentheses and *, **, *** denote 10%, 5% and 1% significant levels, respectively. For the definition of the regression variables and respective notation, see Table A.1 in the Appendix.

Panel A – Without control variables									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FIS_dummy	1.038								
	(0.906)								
FIT_dummy	-0.506								
	(0.866)								
FIP_dummy	-1.775**								
	(0.543)								
FIT_ABS_Wind		0.108							0.119
		(0.084)							(0.069)
FIP_ABS_Wind			-0.312*						-0.319*
			(0.128)						(0.132)
PvRev				0.334**					
				(0.119)					
PvRev_1					0.029				
					(0.129)				
PvRev_2						0.469*			
						(0.191)			
PvRev_3							0.184		
							(0.108)		
PvRev_4								-0.354	
								(0.290)	
Constant	0.960***	0.964**	1.039***	0.964***	-0.599	0.987***	1.000***	1.000***	1.001***
	(0.253)	(0.261)	(0.231)	(0.240)	(0.769)	(0.242)	(0.252)	(0.234)	(0.241)
Controls	No	No	No	No	No	No	No	No	No
Observations	617	617	617	617	617	617	616	617	617
R-squared	0.448	0.438	0.448	0.448	0.443	0.448	0.438	0.447	0.469
Number of Countries	27	27	27	27	27	27	27	27	27

Panel B – With control variables									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FIS_dummy	1.038								
	(0.906)								
FIT_dummy	-0.506								
	(0.866)								
FIP_dummy	-1.775**								
	(0.543)								
FIT_ABS_Wind		0.108							0.119
		(0.084)							(0.069)
FIP_ABS_Wind			-0.312*						-0.319*
			(0.128)						(0.132)
PvRev				0.334**					
				(0.119)					
PvRev_1					0.029				
					(0.129)				
PvRev_2						0.469*			
						(0.191)			
PvRev_3							0.184		
							(0.108)		
PvRev_4								-0.354	
								(0.290)	
Quota	1.408**	1.294*	0.952*	0.940*	1.230*	1.282*	1.121*	0.985*	1.135*
	(0.498)	(0.481)	(0.443)	(0.439)	(0.481)	(0.470)	(0.467)	(0.447)	(0.464)
Tax	-0.355	-0.275	-0.318	-0.310	-0.347	-0.261	-0.427	-0.310	-0.223
	(0.291)	(0.303)	(0.278)	(0.306)	(0.304)	(0.283)	(0.297)	(0.311)	(0.276)
Tender	0.514**	0.373	0.350	0.422	0.438	0.393	0.168	0.400	0.316
	(0.179)	(0.254)	(0.219)	(0.356)	(0.293)	(0.244)	(0.233)	(0.335)	(0.210)
CAP	-0.724	-0.565	-0.404	-0.569	-0.631	-0.571	-0.586	-0.576	-0.472
	(0.383)	(0.408)	(0.445)	(0.421)	(0.457)	(0.423)	(0.387)	(0.417)	(0.438)
GDP	-1.315	-0.905	-0.648	-0.562	-0.702	-0.741	-1.095	-0.421	-0.808
	(0.903)	(1.009)	(0.985)	(1.010)	(1.072)	(1.039)	(1.063)	(1.049)	(0.920)
ElecConsumption	-0.062	-0.118	-0.046	-0.103	-0.124	-0.105	2.361	-0.116	-0.048
	(0.193)	(0.188)	(0.191)	(0.219)	(0.217)	(0.195)	(1.864)	(0.203)	(0.170)
CoalShare	0.245	0.216	0.223	0.263*	0.249	0.237	0.197	0.244	0.209
	(0.125)	(0.130)	(0.137)	(0.125)	(0.126)	(0.127)	(0.134)	(0.129)	(0.137)
RenShare	0.129	0.123	0.141	0.169	0.156	0.151	0.130	0.164	0.117
	(0.102)	(0.107)	(0.114)	(0.112)	(0.116)	(0.106)	(0.112)	(0.116)	(0.099)
OilShare	2.103	0.255	1.414	0.274*	0.254	0.282*	0.213	0.287*	0.313*
	(1.065)	(0.135)	(1.387)	(0.118)	(0.125)	(0.127)	(0.133)	(0.118)	(0.116)
NuclearShare	0.246*	0.259*	0.234*	0.176	0.190	0.224	0.235	0.181	0.277*
	(0.109)	(0.120)	(0.108)	(0.118)	(0.123)	(0.119)	(0.125)	(0.119)	(0.114)
NatGasShare	0.138	0.170	0.147	0.162	0.170	0.149	0.123	0.148	0.145
	(0.093)	(0.099)	(0.096)	(0.089)	(0.101)	(0.100)	(0.108)	(0.091)	(0.094)
PopulationGrowth	0.098	0.124	0.055	0.089	0.096	0.102	0.085	0.090	0.087
	(0.069)	(0.078)	(0.059)	(0.069)	(0.069)	(0.069)	(0.071)	(0.067)	(0.065)
CO2	2.501*	2.575*	2.396*	0.283*	2.274*	2.358*	0.285*	2.293*	2.655*
	(0.950)	(1.083)	(1.060)	(0.121)	(1.080)	(1.072)	(0.107)	(1.074)	(1.031)
OilPrice	-0.956	-0.812	-1.321**	-0.915	-0.923	-0.879	-0.868	-0.992	-1.104*
	(0.499)	(0.550)	(0.469)	(0.518)	(0.519)	(0.536)	(0.556)	(0.526)	(0.476)
NatGasPrice	-0.041	-0.248	0.058	-0.148	-0.213	-0.229	-0.175	-0.105	0.052
	(0.393)	(0.365)	(0.340)	(0.329)	(0.355)	(0.360)	(0.355)	(0.343)	(0.344)
CoalPrice	0.795	0.663	1.074	0.625	0.730	0.802	0.903	0.677	0.893
	(0.664)	(0.631)	(0.648)	(0.553)	(0.606)	(0.638)	(0.620)	(0.578)	(0.668)
EnergyImport	0.208	0.212	0.184	0.281	0.283	0.204	0.213	0.282	0.117
	(0.200)	(0.185)	(0.133)	(0.209)	(0.193)	(0.193)	(0.151)	(0.182)	(0.154)
Constant	0.960***	0.964**	1.039***	0.964***	-0.599	0.987***	1.000***	1.000***	1.001***
	(0.253)	(0.261)	(0.231)	(0.240)	(0.769)	(0.242)	(0.252)	(0.234)	(0.241)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	617	617	617	617	617	617	616	617	617
R-squared	0.555	0.525	0.533	0.531	0.512	0.524	0.520	0.512	0.512
Number of Countries	27	27	27	27	27	27	27	27	27

Table 4: *Results of the Impact of FIS policies on Solar Photovoltaic Capacity Development:* This table reports our results of the Fixed Effects model, following the regression Equations (5) to (9). Regressions in Panel A does not include any control variables while regressions in Panel B controls for the effects of other policy enactments such as tax exemptions, investment grants, and soft loans. Also, regressions in Panel B controls for socio-economic, environmental and political factors. Below, $PvRev\_1$, $PvRev\_2$, $PvRev\_3$ and $PvRev\_4$ represent the existence of a FIS policy (FIT or FIP), a FIT policy, a FIP policy, and the absence of a FIS policy. The Robust standard errors are in parentheses and *, **, *** denote 10%, 5% and 1% significant levels, respectively. For the definition of the regression variables and respective notation, see Table A.1 in the Appendix.

Panel A – Without control variables									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FIS_dummy	-0.977								
	(0.936)								
FIT_dummy	1.080								
	(0.905)								
FIP_dummy	0.285								
	(0.678)								
FIT_ABS_Wind		0.050							0.051
		(0.079)							(0.080)
FIP_ABS_Wind			-0.013						-0.020
			(0.112)						(0.108)
PvRev				0.361***					
				(0.095)					
PvRev_1					0.353**				
					(0.096)				
PvRev_2						0.408***			
						(0.104)			
PvRev_3							0.170		
							(0.168)		
PvRev_4								0.000	
								(0.000)	
Constant	0.084	0.069	0.092	0.092	0.092	0.092	0.092	0.092	0.069
	(0.198)	(0.196)	(0.199)	(0.151)	(0.152)	(0.145)	(0.200)	(0.199)	(0.197)
Controls	No	No	No	No	No	No	No	No	No
Obs.	617	617	617	617	617	617	617	617	617
R-squared	0.540	0.540	0.556	0.540	0.593	0.601	0.558	0.540	0.558
Nº of countries	27	27	27	27	27	27	27	27	27

Continue next page

Panel B – With control variables									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FIS_dummy	-0.050								
	(0.848)								
FIT_dummy	0.582								
	(0.834)								
FIP_dummy	0.441								
	(0.514)								
FIT_ABS_Wind		0.086							0.083
		(0.053)							(0.051)
FIP_ABS_Wind			0.130						0.126
			(0.086)						(0.083)
PvRev				0.289***					
				(0.062)					
PvRev_1					0.292***				
					(0.062)				
PvRev_2						0.332***			
						(0.082)			
PvRev_3							0.295*		
							(0.107)		
PvRev_4								0.000	
								(0.000)	
Quota	0.157	0.088	0.056	0.291	0.304	0.312	0.068	-0.022	0.160
	(0.309)	(0.290)	(0.315)	(0.252)	(0.250)	(0.253)	(0.298)	(0.302)	(0.299)
Tax	-0.135	-0.138	-0.185	-0.081	-0.084	0.007	-0.222	-0.212	-0.113
	(0.368)	(0.370)	(0.369)	(0.326)	(0.326)	(0.319)	(0.373)	(0.376)	(0.365)
Tender	0.131	0.133	0.270	0.134	0.136	0.118	0.205	0.236	0.169
	(0.484)	(0.483)	(0.490)	(0.415)	(0.419)	(0.410)	(0.508)	(0.504)	(0.470)
CAP	-0.933	-0.891	-1.018*	-0.755	-0.731	-0.735	-0.789	-0.937	-0.972*
	(0.507)	(0.456)	(0.468)	(0.450)	(0.447)	(0.441)	(0.488)	(0.484)	(0.436)
GDP	-4.221***	-4.085***	-4.096***	-3.677***	-3.718***	-3.503***	-4.133***	-3.986***	-4.188***
	(0.758)	(0.768)	(0.744)	(0.791)	(0.795)	(0.828)	(0.752)	(0.737)	(0.756)
ElecConsumption	0.116	0.137	0.073	0.027	0.038	0.034	0.109	0.121	0.090
	(0.183)	(0.181)	(0.183)	(0.175)	(0.168)	(0.172)	(0.175)	(0.175)	(0.189)
CoalShare	-0.008	-0.004	-0.002	0.010	0.014	0.009	-0.000	0.007	-0.013
	(0.127)	(0.129)	(0.126)	(0.119)	(0.119)	(0.123)	(0.123)	(0.128)	(0.127)
RenShare	0.148**	0.148**	0.167***	0.156***	0.155***	0.154***	0.182***	0.167***	0.149***
	(0.040)	(0.040)	(0.037)	(0.040)	(0.041)	(0.041)	(0.036)	(0.037)	(0.038)
OilShare	0.121	0.146	0.090	0.143	0.145	0.165	0.092	0.122	0.114
	(0.146)	(0.156)	(0.157)	(0.154)	(0.155)	(0.164)	(0.152)	(0.157)	(0.156)
NuclearShare	0.290**	0.289**	0.265*	0.277*	0.283**	0.291**	0.281*	0.266*	0.287**
	(0.100)	(0.102)	(0.103)	(0.103)	(0.101)	(0.103)	(0.102)	(0.104)	(0.101)
NatGasShare	0.133	0.127	0.136	0.100	0.100	0.094	0.131	0.121	0.141
	(0.079)	(0.082)	(0.079)	(0.075)	(0.075)	(0.075)	(0.082)	(0.083)	(0.078)
PopulationGrowth	0.271**	0.268**	0.258**	0.250**	0.251**	0.253**	0.245**	0.246**	0.279**
	(0.082)	(0.082)	(0.081)	(0.070)	(0.070)	(0.070)	(0.080)	(0.082)	(0.081)
CO2	-1.143*	-1.135	-1.101*	-1.258	-1.276	-1.364*	-1.244	-1.291	-1.172*
	(0.537)	(0.793)	(0.492)	(0.619)	(0.621)	(0.600)	(0.775)	(0.772)	(0.502)
OilPrice	-1.472*	-1.609*	-1.612**	-1.663**	-1.692**	-1.734**	-1.624*	-1.745**	-1.485*
	(0.593)	(0.589)	(0.574)	(0.557)	(0.553)	(0.537)	(0.593)	(0.609)	(0.577)
NatGasPrice	0.687	0.801*	0.687	0.603	0.588	0.598	0.672	0.833*	0.661
	(0.345)	(0.348)	(0.349)	(0.321)	(0.320)	(0.307)	(0.335)	(0.358)	(0.348)
CoalPrice	-1.138	-1.035	-1.412	-0.672	-0.658	-0.639	-1.016	-0.956	-1.258
	(0.787)	(0.541)	(0.741)	(0.494)	(0.496)	(0.498)	(0.503)	(0.535)	(0.765)
EnergyImport	0.316*	0.321**	0.370*	0.333**	0.333**	0.333**	0.352*	0.356*	0.336**
	(0.117)	(0.115)	(0.136)	(0.116)	(0.115)	(0.110)	(0.138)	(0.131)	(0.119)
Constant	48.022***	46.097***	48.058***	42.860***	43.302***	41.481***	47.502***	45.637***	48.425***
	(8.415)	(8.607)	(8.437)	(8.788)	(8.841)	(9.049)	(8.633)	(8.324)	(8.551)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	617	617	617	617	617	617	616	617	617
R-squared	0.682	0.682	0.699	0.682	0.717	0.720	0.682	0.695	0.703
Number of Countries	27	27	27	27	27	27	27	27	27

Appendix – **Table A.1**: *Definition of the Regression Variables:* this table provides the definition of the regression variables and their respective acronyms.

Acronym	*Variable name*	*Definition*
AC_{ijt}	Added capacity	Natural log of the added capacity using the technology *i* (wind or solar photovoltaic).
$PvRev_{ijt}$	Present value of the revenue per MWh	Natural log of the present value of the revenue per MWh of electricity generated with technology *i* over its life time in country j from the year t when the technology was adopted whether there is FIS policy or not.
PvRev_1	Present value of the revenue per MWh	Natural log of the present value of the revenue per MWh of electricity generated with technology *i* over its life time, in country *j* from the year t onwards being the FIS policy the only source of revenue.
PvRev_2	Present value of the revenue per MWh	Natural log of the present value of the revenue per MWh of electricity generated with technology *i* over its life time, in country *j* from the year t onwards being the FIT policy the only source of revenue.
PvRev_3	Present value of the revenue per MWh	Natural log of the present value of the revenue per MWh of electricity generated with technology *i* over its life time, in country *j* from the year t onwards being the FIP policy the only source of revenue.
PvRev_4	Present value of the revenue per MWh	Natural log of the present value of the revenue per MWh of electricity generated with technology *i* over its life time, in country *j* from the year t onwards being the market rate of electricity price the only source of revenue.
FIS_dummy	Dummy variable	Dummy variable that accounts for the existence of a Feed-in-System (FIT or FIP) support scheme, which takes the value of "1" it exists and "0" otherwise.
FIT_dummy	Dummy variable	Dummy variable that accounts for the existence of a Feed-in-Tarif (FIT) support scheme, which takes the value of "1" if it exists and "0" otherwise.
FIP_dummy	Dummy variable	Dummy variable that accounts for the existence of a Feed-in-Premium (FIP) support scheme, which takes the value of "1" if it exists and "0" otherwise.
FIT_ABS	Amount paid per kwh by the government using a Feed-in-Tarif	The amount paid by governments per kwh of electricity generated from wind or solar PV sources under Feed-in-Tarif contract.
FIP_ABS	Amount paid per kwh by the government using a Feed-in-Premium	The amount paid by the government per kwh of electricity generated from Wind or Solar PV sources under Feed-in-Tarif contract.
Quota_dummy	Dummy variable	Dummy variable which takes the value of "1" if a Quote trade certificate exists and "0" otherwise.
Tax_dummy	Dummy variable	Dummy variable which takes the value of "1" if there are Tax benefits and "0" otherwise.
Tender_dummy	Dummy variable	Dummy variable which takes the value of "1" if a there is a Tender mechanism and "0" otherwise.
CAP_dummy	Dummy variable	Dummy variable which takes the value of "1" if there is an electricity price CAP and "0" otherwise.
GDP	Gross Domestic Product	It is a monetary measure of the market value of all final goods and services produced annually in a given country.
Elect_consumption	Electricity Consumption per Capita	Total electricity consumption per capita in KWH
Coal Share	Coal Energy Production Share	% of electricity produced from coal source.
Natural Gas Share	Natural Gas Energy Production Share	% of electricity produced from Natural Gas source.
Nuclear Share	Nuclear Energy Production Share	% of electricity produced from Nuclear source.
Oil Share	Oil Energy Production Share	% of electricity produced from Oil source.

Renewable Share	Renewable Energy Production Share	% of electricity produced from renewable sources.
Population Growth	Annual percentage change in the Population	Annual percentage growth in the population of a country: [Population in year t – Population in year t-1]/Population in year t-1
CO2(MT)	Carbon Emissions	Total carbon emissions metric tons per capita
Oil Price	Market Oil Price	Average annual Oil prices in Euro
Electricity Price	Electricity Price	Average annual electricity prices in Euro
Natural Gas Price	Natural Gas Price	Average annual Natural Gas prices in Euro
Coal Price	Coal Price	Average annual Coal prices in Euro
Energy Import	Energy Import Dependence	Amount of energy a country needs to satisfy its energy consumption, computed by dividing net energy imports by gross inland energy consumption plus maritime bunkers

Table A.2 - *Summary of Renewable Energy Subsidy Policies in the EU Countries:* This table presents information regarding the various RES-E policies adopted by EU 28 countries and commentary regarding policy changes, generosity and eligibility among others. This table is adapted from Huber et al. (2004) and updated with information from Haas et al. (2011), Winkel et al. (2011), and IEA Policies and Measures Database.

Country	*Support Type*	*Note*
Czech Republic	Feed-in Systems (since 2002), plus investment grants	Relatively high feed-in tariffs with lifetime guaranteed duration of support. Producer can choose fixed feed-in tariff or premium tariff (green bonus). For biomass cogeneration only green bonus applies. Feed-in tariff levels are announced annually but are at least increased by two percent annually.
Denmark	Premium feed-in tariff for onshore wind, tender scheme for offshore wind, and fixed feed-in tariffs for others	Duration of support varies from 10 to 20 years depending on the technology and scheme applied. The tariff level is generally rather low compared to the formerly high feed-in tariffs. Recently the support scheme got revised and RES generators receive again a higher premium on top of the market price. A net metering approach is taken for solar photovoltaics.
Estonia	Feed-in tariff system	Feed-in tariffs paid for 7–12 years, but not beyond 2015. Single feed-in tariff level for all RES-E technologies. Relatively low feed-in tariffs make new renewable investments very difficult.
Finland	Energy tax exemption combined with investment incentives	Mix of tax refund and investment subsidies: Tax refund of 6.9 €/MWh for Wind and of 4.2 €/MWh for other RES-E. Investment subsidies up to 40% for Wind and up to 30% for other RES-E.
France	Feed-in tariffs plus tenders for large plants	Feed in tariff for RES-E plant < 12 MW guaranteed for 15 years (20 years PV and Hydro). Tenders for plant >12 MW. FITs in more detail: Biomass: 49-61 €/MWh, Biogas: 46-58 €/MWh, Geothermal: 76-79 €/MWh, PV: 152.5-305 €/MWh; Landfill gas: 45-57.2 €/MWh; Wind3: 30.5-83.8 €/MWh; Hydro: 54.9-61 €/MWh. Investment subsidies for PV, Biomass and Biogas (Biomass and Biogas PBEDL 2000-2006). 2% annual reduction of tariff introduced in 2012.
Germany	Feed-in tariffs	Feed in tariff guaranteed for 20 years. In more detail, Feed in tariff for new installations (2004) are: Hydro: 37-76.7 €/MWh; Wind6 : 55-91 €/MWh; Biomass & Biogas: 84-195 €/MWh; Landfill-, Sewage- & Mine gas: 66.5-96.7 €/MWh; PV & Solar thermal electricity: 457-574 €/MWh; Geothermal: 71.6-150 €/MWh.
Greece	Feed-in tariffs combined with investment incentives	Feed in tariff guaranteed for 10 years (at a level of 70-90% of the consumer electricity price depending on location and type of producer) and a mix of other instruments: a) Up to 40% investment subsidies combined with tax measures; b) Up to 50% investment subsidies depending on RES type.
Hungary	Feed-in tariff (since January 2003, amended 2005) combined with purchase obligation and grants	Fixed feed-in tariffs recently increased and differentiated by RES-E technology. No time limit for support defined by law, so in theory guaranteed for the lifetime of the installation. Plans to develop TGC system; at that time that the feed in tariff system will cease to exist.
Ireland	Feed-in tariff scheme replaced tendering scheme in 2005	New premium feed-in tariffs for Biomass, Hydropower and wind started 2006. Tariffs guaranteed to supplier for up to 15 years. Purchase price of electricity from the generator is negotiated between generators and suppliers. However, support may not extend beyond 2024, so guaranteed premium tariff payments should start no later than 2009. Tendering scheme – currently with technology bands and price caps for small wind (<3 MW), large Wind (>3 MW), small Hydro (<5 MW), Biomass, Biomass CHP and Biogas. In addition, tax relief for investments in RES-E.
Italy	Quota obligation system with TGC and Fixed feed-in tariff for PV	Obligation (based on TGCs) on electricity producers and importers. Certificates are issued for RES-E capacity during the first 12 years of operation, except biomass which receives certificates for 100% of electricity production for first 8 years and 60% for next 4 years. Separate fixed feed-in tariff for PV, differentiated by size and building integrated. Guaranteed for 20 years. Increases annually in line with retail price index.
Latvia	Feed in tariff and Quota obligation system (since 2002)	Quota system (without TGC) typically defines small RES-E amounts to be installed. High feed-in tariff scheme for wind and small hydropower plants (less than 2 MW) was phased out from January 2003. Nowadays a favourable feed in system is installed for small-scale RES generators, whereas for mid-scale generators a tendering scheme is installed for most technologies.
Lithuania	Feed-in tariffs	Relatively high fixed feed-in tariffs for RES-E technologies.
Luxembourg	Feed-in tariffs	Feed in tariff guaranteed for 10 years (PV: 20 years) and investment subsidies for Wind, PV, Biomass and small Hydro, feed in tariff for Wind, Biomass and small Hydro: 25 €/MWh, for PV: 450 €/MWh.
Malta	Low VAT rate and very low feed-in tariff for solar	Very little attention to RES support so far. Very low feed-in tariff for PV.
Netherlands	Feed-in tariffs plus Tax exemption	Mixed strategy: Green pricing, tax exemptions and feed in tariff. The tax exemption for green electricity amounts 30 €/MWh and feed in tariff guaranteed for 10 years range from 29 €/MWh (for mixed Biomass and waste streams) to 68 €/MWh for other RES-E (e.g. Wind offshore, PV, Small Hydro).
Poland	Quota obligation system and excise tax incentives	Obligation on electricity suppliers with targets specified from 2005 to 2010. Penalties for non-compliance were defined in 2004, but were not sufficiently enforced until the end of 2005. The RES electricity producer is entitled to sell it to the grid at least at the average market price from a previous year (published by the regulatory authority). The price was about 38 D /MWh in 2007. The fulfilment of the national targets can be done either by submitting a relevant quantity of TGC's for redemption or by paying a substitution fee (about 74 D /MWh in 2008).

Portugal	Feed-in tariffs combined with investment incentives	Feed in tariff and investment subsidies of roughly 40% within program for Economic Activities (POE)) for Wind, PV, Biomass, Small Hydro and Wave. Feed in tariff in 2003: Wind: 43-83 €/MWh; Wave: 225 €/MWh; PV: 224-410 €/MWh, Small Hydro: 72 €/MWh. Tariff depends on the quality of site and time of generation.
Romania	Quota obligation with TGCs, subsidy fund (since 2004)	Obligation on electricity suppliers with targets specified from 2005 to 2010. Minimum and maximum certificate prices are defined annually by Romanian Energy Regulatory Authority. Non-compliant suppliers pay maximum price.
Slovakia	feed-in tariffs and tax incentives	Fixed feed-in tariff for RES-E was introduced in 2005. Prices set so that a rate of return on the investment is 12 years when drawing a commercial loan.
Slovenia	Feed-in tariffs and public funds for environmental investments	Renewable electricity producers choose between fixed feed-in tariff and premium feed-in tariff. Tariff levels defined annually by Slovenian Government (but have been unchanged since 2004). Tariff guaranteed for 5 years, then reduced by 5%. After 10 years reduced by 10% (compared to original level). Relatively stable tariffs combined with long-term guaranteed contracts makes system quite attractive to investors.
Spain	Feed-in tariffs	Electricity producers can choose a fixed feed-in tariff or a premium on top of the conventional electricity price. No time limit, but fixed tariffs are reduced after either 15, 20 or 25 years depending on technology. System very transparent. Both are adjusted by the government according to the variation in the average electricity sale price. In more detail (only premium, valid for plant < 50 MW): Wind: 27 €/MWh; PV15: 180-360 €c/kWh, Small Hydro: 29 €/MWh, Biomass: 25-33 €/MWh. Soft loans, tax incentives and regional investment incentives are available.
Sweden	Quota obligation system with TGCs	Obligation (based on TGCs) on electricity consumers. Obligation level defined to 2010. Non-compliance leads to a penalty, which is fixed at 150% of the average certificate price in a year. Investment incentive and a small environmental bonus available for wind energy.
UK	Quota obligation system with TGCs and FIT	Quota obligation (based on TGCs) for all RES-E: Increasing from 3% in 2003 up to 10.4% by 2010 – penalty set at 30.5 £/MWh. In addition to the TGC system, eligible RES-E are exempt from the Climate Change Levy certified by Levy Exemption Certificates, which cannot be separately traded from physical electricity. The current levy rate is 4.3 £/MWh. Investment grants in the frame of different programs (e.g. Clear Skies Scheme, Offshore Wind Capital Grant Scheme, the Energy Crops Scheme, Major PV Demonstration Program and the Scottish Community Renewable Initiative)

Table A.3: *Policies and Year of the Adoption of the Policy by Country*: This table comprises information on the renewable energy subsidy schemes in the EU countries for each year over the time period between 1990 and 2013. *The information obtained in this table is based on our own computation, information obtained from Huber et al. (2004), Haas et al. (2011), Winkel et al. (2011) and IEA Policies and Measures Database, 2014. The columns (apart from that for the "Year") represent a policy type and the notation for the countries is as follow: AT, Austria; BE, Belgium; BG, Bulgaria; CY, Cyprus; CZ, Czech Republic; DK, Denmark; EE, Estonia; FI, Finland; FR, France; DE, Germany; GR, Greece; HU, Hungary; IE, Ireland; IT, Italy; LV, Latvia; LT, Lithuania; LU, Luxembourg; MT, Malta; NL, Netherlands; PL, Poland; PT, Portugal; RO, Romania; SK, Slovakia; SI, Slovenia; ES, Spain; SE, Sweden; UK, United Kingdom; HR, Croatia; NO, Norway; CH, Switzerland.*

Year	Wind		Solar		Quota and Green Trading Certificate	Tax and Investment Grants	Tender	First Cap Introduced
	FIT	FIP	FIT	FIP				
1990	DE		DE				UK	
1991								
1992			IT					
1993	LU	DK	LU	DK				
1994	ES, GR	ES	ES, GR			SE		
1995							IE	
1996								
1997						FI, NL	FR	
1998	AT		AT					
1999								
2000					PL	PL		
2001	FR, PT		FR, PT		IT			
2002	CZ, HU, LT	CZ	CZ, HU, LT	CZ	BE, UK, LV	HR		
2003	BG, NL	EE	BG, NL		SE	SK		
2004	SI	SI	SI	SI		CY		
2005	SK	SK	SK	SK		HU	PT	
2006	IE	CY, IE	IE, MT	CY, IE		MT		IT, PT
2007								EE, NL
2008					RO			CY, ES
2009	LV			LV			LV	LV
2010	UK			UK				
2011		FI, DE		FI, DE				
2012								
2013	HR			HR				