Energy 62 (2013) 277–284

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Understanding local adoption of tax credits to promote solar-thermal energy: Spanish municipalities' case

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ARTICLE INFO

Article history:
Received 7 March 2013
Received in revised form
18 September 2013
Accepted 23 September 2013
Available online 18 October 2013

JEL Code:
H3
H71
Q42
Q58

Keywords:
Urban sustainability
Local policy implementation
Real estate tax incentives
Solar thermal energy

ABSTRACT

Spanish local governments may offer, in accordance with Royal Decree 2/2004, tax credits up to 50% in Real Estate Tax for those with installed solar powered thermal or electrical energy systems. This paper analyzes by logistic regression estimation which factors influence the decision of governments to implement this tax credit. Factors included as explanatory variables are related to the characteristics of municipalities, fiscal stress, environmental stress, the environmentally friendly nature of municipalities, the neighboring effect, and economic motivations. Results show that municipalities applying these measures are mostly large in size, with high solar potential, with predominantly collective-housing buildings, with low fiscal stress, mainly rural, environmentally friendly, surrounded by municipalities implementing similar measures and with higher unemployment rates.

1. Introduction

Spain was ranked fifth among the EU-27 countries in installed solar-thermal power capacity at the end of 2010, with 1542.54 MWth [1,2]. However, the installation rate of collectors has decreased significantly in recent years. The installed capacity increased fivefold in the period 2004–2008, while in the last few years the growth rate has decreased by 25% [3].

Around 83% of total capacity installed during 2010 was related directly to the TBC (Technical Building Code). This code, in force since 2006, requires new construction or renovation projects to cover between 30 and 70% of domestic hot water needs using solar-thermal energy systems. Without such requirements, only 15% of the new installations in households or buildings are self-motivated. One of the main reasons for this low percentage is due to the high initial outlay and long payback periods for investors [4], with a payback period of about seven years [5]. The current crisis in the construction sector in Spain has caused a decline in the construction of new buildings, which are governed by the TBC. As such, the installation of new solar panels has tended to decrease, and consequently forced the establishment of promotion measures to enhance the installation of these collectors on existing buildings to achieve the targets set out in Spain's national renewable energy action plan 2011–2020 [6].

In Spain, such measures are articulated around three jurisdictions. The national government provides tax incentives and direct aids. Regional governments can set up additional subsidies and manage those granted by the central government. Finally, according to Royal Decree Law 2/2004, local governments can provide tax credits on business tax, on construction tax and on *RET* (real estate tax) for those with installed solar-thermal or solar-photovoltaic systems. Thus, the local government is given authority to promote the installation of solar systems in buildings.

In reality, in spite of local government interest in implementing environmental policies, because it is estimated that cities produce more than a third of total greenhouse emissions [7], and that building infrastructure plays a central role in the energy demand [8], only 314 out of a total of 7587 municipalities had adopted, by 2010, tax credits on *RET* [9]. Though this proportion –314 out of

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http://dx.doi.org/10.1016/j.energy.2013.09.051

7587– is very low, the population of these municipalities represents 32.20% of the Spanish total, as among these municipalities involve large cities such as Madrid and Barcelona.

The aim of this paper is to analyze the factors that have motivated only a few municipalities to adopt this tax credit to promote solar-thermal systems in existing buildings in Spain. An empirical model is formulated to describe the behavior of Spanish local governments related to the adoption of tax credits on *RET*, this being a binary choice model which is a function of various political, economic and technical factors. A cross-section logit model is used with 2010 data, for which sufficient statistical information is available. Probabilistic or logit models have been used in several previous studies which analyze the behavior of local governments in relation to the adoption of specific environmental decisions [10–12].

Research into reasons which explain the diffusion of policies across political jurisdictions has given rise to a wide range of literature [13,14]. Recently, such research has been expanded to include the diffusion and adoption of environmental measures [15]. In the field of national environmental policies, we can highlight the studies of Matisoff [10] and Lyon and Yin [11], in which they analyze the factors that are considered by state governments to adopt *RPS* (renewable portfolio standards) [16]. These factors include air quality, interest in renewable energy and unemployment rates. In the specific case of national measures to promote solar-thermal systems, we highlight the study of Yong and Sarzynski [17], which examines how these decisions are affected by solar potential, electricity prices, real income, population, citizen ideology and environmental friendliness.

In the field of local policies, some studies have examined the motivations which lead local governments to join city-networks which promote climate change action, such as that created in the early 1990s: the ICLEI (International Council on Local Environmental Initiatives). Among these studies may be mentioned [12,18–21]. Factors which influence this decision-making, include political preference, environmentalism, fiscal capacity or neighboring actions. However, these studies refer to the factors affecting the adoption of political commitments without analyzing the factors affecting the adoption of specific environmental measures [22]. The present paper attempts to go beyond analyzing the motives that induce local governments to adopt one of these specific measures [23]. In particular, it examines what leads the local governments to offer a tax credit on *RET* to promote the use of solar-thermal systems.

Understanding these motives could help to remove barriers and allow wider dissemination of local environmental measures. In this sense, as stated in Brandoni and Polonara [24], several authors [25,26] have highlighted the importance of decentralizing energy planning and adopting measures to foster renewable energy use [27,28]. Then, understanding what truly drives the voluntary actions at the local level may help policy makers design policies that are more compatible with local incentives [22]. Consequently, state support may increase the number of municipalities which adopt these incentives, and their application could provide a stimulus for solar-thermal systems to be installed in buildings, given the tax savings in addition to the energy cost savings that citizens make when they use solar energy. These economic savings are particularly relevant to consumer decisions. One of the reasons why citizens do not install these energy systems in their homes is because they do not sufficiently reduce the energy cost in the years following the installation [29]. In the same way, Welsch and Kühling [30] point out that the adoption of solar-thermal systems is related to economic factors more than to environmental factors. This is because the typical user of a solar system is not very environmentally oriented.

The paper is structured as follows. Section 2 shows the model built to examine what leads the local governments to offer a tax credit on *RET* to promote the use of solar-thermal systems. The decision is based on a set of explanatory variables. Results are contained in Section 3. Section 4 shows a discuss of those results. Section 5, concludes.

2. The model: variables and data

In the application of article 74.5 from RDL 2/2004, the Spanish municipalities may offer up to a 50% discount on the full fee of *RET* to those who have installed solar-thermal or solar-photovoltaic systems, provided that the facilities meet certain technical standards stipulated by the municipal administration.

However, only a proportion of municipalities have decided to establish this tax credit. In order to analyze the causes behind this decision, a model has been built in which the decision to establish this tax credit is based on a set of explanatory variables which relate directly to environmental circumstances and the socio-political context of the municipalities. A dichotomous variable has been created as the explained variable of the model. This variable takes on the value 1 if a tax credit is applied and 0 otherwise.

For this purpose, data provided by DOC [9] for 2010 has been used. This sample excludes data from the municipalities of the Autonomous Communities with a special fiscal regime (those from the Basque Country and Navarra). Out of a total of 7587 municipalities considered, only 314 had chosen to apply this tax credit in 2010.

A total of 14 explanatory variables are included in the model. For a better understanding, these variables have been grouped into five blocks.

2.1. Characteristics of the municipality

The first set of explanatory variables concerns the characteristics of the municipalities. First, the context of each municipality is checked by using the *Population* variable (as has been done in Young and Sarzynski [17] and in Feiock et al. [19]. It is expected that this variable will prove positively related to the adoption of a fiscal measure, as Lubell et al. [31] finds that large cities are more likely than smaller ones to have sustainability policies. In Spain, there are some small municipalities with only 5 inhabitants, in contrast to municipalities with more than 3 million inhabitants [32]. Thus, checking this aspect seems relevant.

Another factor included in the literature among the reasons that lead people to install solar-thermal energy systems in their homes is the type of housing, i.e. house or apartment [29,30]. Individuals with a family dwelling have a greater autonomy to decide if they install these systems, while the decision of establishing them in multi-storey apartments with several owners may be more complex. Thus, it seems that the adoption of these systems is more likely if households live in stand-alone detached residences, with less need for incentives to install them. To analyze this fact, a *Houses* variable has been included in this study, which shows the proportion of single-family dwellings as a fraction of the total number of buildings in the municipality. This variable has been created by using data from Caja España [33].

Within this first set, a *Solar Intensity* variable is also considered. The solar potential of an area may affect public decisions to adopt these technologies as it affects the system performance, and thus affects the production of renewable energy [34]. Therefore, it is expected that the greater the solar potential of an area, the more inclined will be the local government to adopt these decisions [11]. This variable is set according to the criteria established in RD 314/2006, by giving each municipality a value from 1 to 5.

2.2. Fiscal stress

This second set of explanatory variables is to measure the fiscal stress of each municipality. The overall financial capacity of a local jurisdiction affects the likelihood of implementing environmental programmes, since richer local governments have more funds available to enhance incentives to promote renewable energy [22]. In this sense, Pitt and Randolph [20] find that one of the primary obstacles to preparing a community climate protection plan are funding and resource constraints.

Sharp et al. [12] point out that there is a wide range of indicators that have been used to measure the fiscal or financial health of a municipality. Some indicators are quite simple, such as the collection of property taxes [35], or others are more complex [36]. Nevertheless, the added value from the more complex indicators is not demonstrated. Therefore, a single indicator such as the property tax, may be sufficient to show the fiscal health of a municipality.

In any case, the financial health of the municipalities depends not only on these property taxes, since municipalities have additional income streams such as other taxes, fees, non-tax income, and transfer payments received from other public administrations or entities. Therefore, current income per capita in the municipality at the time of making the yes/no decision on tax credit has been taken as an indicator of the resources available, and named the *Income* variable. However, the financial situation of the municipalities may also be conditioned by the current debt level. For this reason, the value of the debt of the municipalities in per capita terms is also included by means of a *Debt* variable.

In addition, the tax rate of *RET* that is applied in each municipality (*RET* variable) has also been considered. Since the analyzed measure directly affects this tax, it is possible that municipalities with higher rates are more favorable to its adoption. The elaboration of these three variables has been carried out from the data collected in SGCAyL [32].

2.3. Environmental stress

A third set of explanatory variables is used to measure the environmental stress as an indicator of the level of environmental damage each municipality suffers. Zahran et al. [18] consider that climate change stress is a relevant factor in analyzing the causes that determine a municipality's commitment to undertake environmental protection measures. It includes the effects of transport, energy consumption and production practices that adversely affect climate systems.

In the same vein, Lyon and Yin [11] point out that a state's pollution levels were an important factor for the adoption of *RPS* by states in the USA from 1997 through 2005. Likewise, Matisoff [10] states that the motivation for energy efficiency and renewable energy adoption will primarily be because of the motivation to improve air quality and reduce harm from air pollutants.

In order to measure the environmental stress, the first variable which has been included is the *Population Density*. From a collective action perspective, areas of high population density are more likely to commit to the Cities for Climate Protection campaign because of the lower expected costs of climate policy enactment, due to their higher effectiveness [18]. However, this variable has been considered subsequently in Feiock et al. [19] who showed it to be not significant. The reason for this could be that, while the per capita pollution generated in densely populated towns is less because of efficiency reasons, the pollution per unit area would be higher. Therefore, the expected effect of this variable is initially uncertain.

The incentive to participate in environmental programs may also be affected by vehicule use, which is a mobile source of climate stress. The transportation sector accounts for a large fraction of air pollutant emissions. Mobile sources have a significant influence on both NO_x and VOC pollution that subsequently results in secondary particulate matter and ozone formation [37]. For this reason, a *Vehicles* variable is used, which is defined as the number of vehicles per km^2, as a proxy for the level of pollution in a municipality.

Thirdly, the variable *Industrial Companies* is used as an indicator of the proportion of industrial companies in the municipality. A similar variable has been previously used in Sharp et al. [12], who consider that such companies generally perform activities which generate pollutants that cause environmental damage, thereby increasing the level of environmental stress.

Finally, the variable *Agricultural Companies* has also been included, which represents the proportion of companies in the primary sector, considering that they reflect the rural character of the municipality. In Spanish urban areas, the particle-bound composition of PAH (polycyclic aromatic hydrocarbons) is 10 times greater than that measured in rural areas [38]. One of the reasons for the higher PAH concentrations is due to domestic heating. Because of this, local governments in urban municipalities may be more interested in ensuring that non-polluting heating systems are used, and so, may be more willing to establish fiscal measures to encourage the use of such systems.

The development of these four variables has been made from data collected in Caja España [33].

2.4. Environmentally friendly municipalities

The fourth set of explanatory variables refers to the "friendliness" of municipalities to adopt environmental measures and, in particular, the fiscal measures analyzed.

In the early study of Sawyer and Friedlander [39], as well as in subsequent studies such as Matisoff [10], the ideology of the citizens appears as a determining factor in the development of environmental promotion programmes in general, and the promotion of solar incentives in particular [11]. In this sense, they found that the relative liberalness of the citizenry is an important factor to determine if solar system promotion measures are applied. Also, many studies show that politically liberal individuals are more likely to engage in sustainable consumption habits [30,40–42].

So, the *Conservative Ideology* variable has been developed as an indicator to show the ideology of each municipality, measured as the percentage of votes obtained by the parties of conservative ideology in the municipal elections of 2007 by using data from the Interior Ministry [43]. It is expected that municipalities of conservative ideology would show greater resistance to adopting the measure of promotion analyzed.

Another factor to take into account is whether the municipalities are already applying other sets of measures aimed at enhancing the use of renewable energy and to reduce their emissions levels – in short, if they can be considered *greener* municipalities. Stoutenborough and Matthew [44] affirm that states of the USA which are more likely to adopt solar incentives are those which already have a higher adoption of environmentally-friendly policies. At a local level, Wang [22] agrees with this.

In this study, environmentally friendly municipalities are considered to be those which had signed the Covenant of Mayors before January 2010 (moment of decision for the establishment of analyzed tax credit). This is a European movement involving the mayors of municipalities that wish to participate. The signatories undertake to reduce CO_2 emissions by at least 20% in their respective territorial areas before 2020 through the implementation of a Sustainable Energy Action Plan.

In order to consider this factor, the binary variable *Covenant Mayors* has been created by using data from Covenant of Mayors

[45]. It takes on the value 1 if the municipality participates in this covenant and 0 otherwise.

2.5. Neighboring effect and economic motivations

The neighboring effect hypothesizes the positive correlation between a city and its surrounding jurisdictions with respect to climate actions and, in particular, with the establishment of measures to promote solar-thermal energy systems. This factor measures whether municipalities are more willing to offer the tax credit analyzed if they find that their neighbors have already adopted it. A similar effect has been reported in Feiock et al. [19] when estimating the effects of climate actions of neighboring jurisdictions, and the career incentives of local officials on the adoption of climate policies in Florida cities. Also, the influence of neighboring jurisdictions are found to have the greatest impact on climate mitigation policy adoption in Pitt [46] when examining the impact of fifteen demographic, political – institutional, economic, and environmental variables on the adoption of climate mitigation plans and policies in 255 US municipalities.

The *Neighboring effect* variable shows the number of municipalities applying the tax credit in the same province. To this extent, there is a certain concentration of municipalities with the tax credit in some provinces, which may suggest that this effect really exists. This variable has been developed by using data from DOC [9].

Finally, the variable *Unemployment* has been included, which shows the level of unemployment in each municipality by using data from Caja España [33]. This variable serves as an indicator of the economic motivation which may be behind the decision of municipalities to implement the tax credit. Nevertheless, it is possible to find empirical evidence showing that the municipalities with a high unemployment rate are more likely to establish these measures [47], and also the opposite [11].

For some municipalities, environmental policies can have a positive effect on the creation of employment because they stimulate a new industry and the development of new services associated with new technologies. Thus, areas with higher unemployment rates would be more willing to adopt these measures. For others, areas with higher unemployment rates may be preoccupied with the task of stimulating economic growth, and have little interest in considering these measures, because they are fundamentally an environmental policy tool.

Table 2
Variables and their descriptive statistics for municipalities which had adopted tax credits on *RET*.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Population	314	45.291	217.623	0.027	3273.049
Houses	314	73.300	15.054	23.524	97.326
Solar intensity	314	3.444	1.073	1	5
RET	314	0.669	0.172	0.354	1.141
Income	314	339.596	190.862	0.000	1931.959
Debt	314	55.289	47.730	0.000	324.036
Agricultural companies	314	9.390	13.074	0.000	85.714
Industrial companies	314	11.990	8.689	0.000	53.333
Vehicles	314	497.100	948.510	0.554	9483.713
Population density	314	766.778	1549.987	1.036	16401.670
Conservative ideology	314	25.075	21.997	0.000	94.44
Covenant Mayors	314	0.261	0.440	0	1
Neighboring effect	314	23.964	19.369	1	55
Unemployment	314	11.535	4.152	2.127	24.672

Table 1 shows the main descriptive statistics of described variables.

In general terms, the data presented in Table 1 manifest a large variability in the values of the explanatory variables between the municipalities, indicating that there is significant diversity in the types of municipalities present in Spain.

On average, the population of the municipalities is slightly higher than 5000 inhabitants, they are mainly made up of detached houses (which does not mean that the majority of people in Spain live in such housing), and their levels of solar intensity are medium–high. The tax rate of *RET* applied is around 60%. Also, these municipalities have a relatively low average level of income per capita, and the municipalities are in debt.

Percentages of agricultural (17%) and industrial companies (10%) are low, so the tertiary sector tends to be the predominant sector. Both the population density and the number of vehicles are highly variable. The average percentage of conservative voters is less than 50% and, in this data set, there are few municipalities that have signed the Covenant of Mayors.

Finally, Spanish municipalities have an average above seven of neighboring municipalities that have adopted the tax credit, although this value has a high variability from one municipality to another, and they have an average unemployment rate of around 10%, reaching a maximum value of 37 percentage points.

Table 1
Variables and their descriptive statistics.

Variable	Description	Obs.	Mean	Std. Dev.	Min.	Max.
Explained variable						
Tax credit	1 = tax credit is applied; 0 = otherwise	7587	0.041	0.199	0	1
1. Municipality characteristics						
Population	Number of inhabitants (in thousands)	7586	5.8045	48.759	0.005	3273.049
Houses	% of single-family dwellings of the total number of buildings	7584	83.664	11.511	2.488	100
Solar intensity	Level of direct solar radiation (from 1 –lowest- to 5 –highest-)	7587	3.213	1.021	1	5
2. Fiscal stress						
RET	Tax rate of RET applied	7587	0.583	0.153	0.100	1.230
Income	Local current income per capita	7586	254.061	341.947	0.000	10328.470
Debt	Local debt per capita	7586	35.981	113.114	−1.874	6399.023
3. Environmental stress						
Agricultural companies	% of agricultural companies of the total number of local companies	7587	17.081	19.838	0.000	100
Industrial companies	% of industrial companies of the total number of local companies	7587	10.159	11.510	0.000	100
Vehicles	Vehicles registered by surface area km^2 of the municipality	7586	109.638	548.750	0.179	17025.220
Population density	Number of inhabitants divided by surface area km^2 of the municipality	7586	161.659	871.246	0.340	30750
4. Environmentally friendly						
Conservative ideology	1 = if conservative ideology; 0 = otherwise.	7587	40.841	26.417	0	100
Covenant Mayors	1 = Covenant of Mayors has been signed; 0 = otherwise.	7587	0.079	0.269	0	1
5. Neighboring effect and economic motivations						
Neighboring effect	Number of municipalities applying the tax credit in the same province	7587	7.791	13.260	0	55
Unemployment	Local % unemployment rate	7587	9.893	5.235	0	37.500

Table 3
Logistic regression models summary: estimating probability of application of tax credit on real estate tax.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	−0.459 (0.392)	−2.348*** (0.512)	−2.577*** (0.531)	−2.531*** (0.517)	−1.757*** (0.540)	−3.474*** (0.617)	−3.644*** (0.599)
1. Municipality characteristics							
Population	0.007*** (0.002)	0.007*** (0.002)	0.007*** (0.002)	0.006*** (0.002)	0.007*** (0.002)	0.007*** (0.002)	0.007*** (0.002)
Houses	−0.043*** (0.004)	−0.036*** (0.004)	−0.031*** (0.004)	−0.031*** (0.004)	−0.027*** (0.004)	−0.022*** (0.005)	−0.021*** (0.005)
Solar Intensity	0.202*** (0.060)	0.170*** (0.063)	0.222*** (0.065)	0.224*** (0.065)	0.209*** (0.069)	0.401*** (0.087)	0.355*** (0.094)
2. Fiscal stress							
RET		2.101*** (0.374)	1.990*** (0.369)	2.020*** (0.368)	1.363*** (0.373)	0.788** (0.393)	0.694* (0.398)
Income		0.0003*** (0.0001)	0.0003*** (0.0001)	0.0003*** (0.0001)	0.0002*** (0.0001)	0.0002** (0.0001)	0.0002** (0.0001)
Debt		0.0005** (0.0002)	0.0004* (0.0002)	0.0004* (0.0002)	0.0002 (0.0002)	0.0004** (0.0002)	0.0004** (0.0002)
3. Environmental stress							
Agricultural Companies			−0.022*** (0.005)	−0.022*** (0.005)	−0.026*** (0.005)	−0.019*** (0.005)	−0.018*** (0.005)
Industrial Companies			0.005 (0.004)				
Vehicles			0.0001 (0.0001)				
Population Density			−0.0001 (0.0001)				
4. Environmentally friendly							
Conservative Ideology					−0.023*** (0.003)	−0.008*** (0.003)	−0.008*** (0.003)
Covenant Mayors					0.731*** (0.172)	0.394** (0.180)	0.351** (0.180)
5. Neighboring effect and economic motivations							
Neighboring effect						0.039*** (0.004)	0.040*** (0.004)
Unemployment							0.025** (0.013)
Number of obs.	7583	7583	7582	7583	7583	7583	7583
Log. pseudolik.	−1186.1	−1164.2	−1149.7	−1150.9	−1097.7	−1049.4	−1047.9
Pseudo-R^2	0.0905	0.1073	0.1184	0.1175	0.1583	0.1953	0.1964
Wald Chi^2 (*p-value*)	232.82 (0.000)	285.98 (0.000)	295.98 (0.000)	292.57 (0.000)	352.36 (0.000)	499.24 (0.000)	516.82 (0.000)

Note: Standard errors robust to heteroskedasticity in brackets. One, two, or three asterisks indicate coefficient significance at the 10-percent, 5-percent, and 1-percent levels, respectively.

Table 2 shows the main descriptive statistics of described variables for the municipalities which had adopted the tax credit on *RET* by 2010. These municipalities have a population that is larger than the average of Spain municipalities (about 45,000 inhabitants), they have a lower percentage of single family homes, and a solar intensity level that is slightly higher. The applied *RET* tax rate is slightly higher, and likewise these municipalities have income and debt levels that are slightly higher as well. The average percentages of agricultural and industrial companies are lower than the average for Spanish municipalities, and they have considerably higher values of population density and number of vehicles. The average percentage of conservative voters is less than 25%, and the average number of municipalities that have signed the Covenant of Mayors is much higher with a mean value of 24 neighboring municipalities that have adopted the tax credit. Ultimately, the average unemployment rate in these municipalities is less than half the overall average of Spanish municipalities.

There are other explanations for local voluntary climate actions. In this sense, it has been suggested that the potential importance of the measured welfare of the community, for example, from the per capita income or the electrical energy usage may be used. However, relevant data is very difficult to obtain, so this study can only provide indicative evidence of the possible effects that variables shown in Table 1 may have on the decision of a municipality to apply a tax credit on *RET*.

3. Results

After describing the variables, a micro-econometric analysis is performed to assess the factors that influence the probability that a tax credit will or will not be applied in a municipality. In this case, the binary variable *Tax Credit* takes the value 0 or 1.

For this purpose, we have to consider the case of binary outcome models, which are used to estimate relationships between a dependent variable with only two possible outcomes, and the considered explanatory variables. The two commonly used binary outcome models are the probit and the logit models, which specify different functional forms for the probability of observing one particular outcome (0 or 1) of the explained variable as a function of regressors.

Table 3 shows the results obtained in the context of the variables from Table 1. Regressions are carried out in stages by groups of variables in order to take into account the possible multicollinearity between exogenous variables. Both the probit and logit models have been used. Table 3 shows the results of the Logit specification, since it maximized the log pseudolikelihood compared to a Probit specification for all regressions made.

Column 1 illustrates the logit regression results only the variables related to the characteristics of the municipality are included. The three explanatory variables are significant.

The coefficient of *Population* is positive. This indicates that the larger the municipality, the greater the willingness of governments to implement a tax credit on *RET*. These results are in line with Lubell et al. [31], indicating that generally larger cities adopt favorable environmental policies. Likewise, *Solar Intensity* has a positive coefficient. Thus, it can be considered that as the potential solar energy increases, the performance of technological systems is higher and raises the environmental benefits of the policy. Therefore, the greater the solar potential, the easier are these policies to be implemented in these areas, because their cost-benefit ratio is more favorable.

Finally, the coefficient of the *Houses* variable is negative, indicating that a higher prevalence of single-family homeowners in a municipality reduces the predisposition to implement this policy. This negative relationship can be explained according to Mills and Schleich [29] and Welsch and Kühling [30]. These authors consider that single-family homeowners are more likely than those living in multifamily housing to adopt solar energy systems for their homes. Accordingly, it is necessary to provide more encouragement with respect to the latter type of housing, for which there is greater reluctance to install this technology.

Column 2 shows the results obtained when adding the second set of explanatory variables, which show the fiscal stress. First, the positive sign of *RET* and *Income* is consistent with the results of

Lubell et al. [31]. Environmental policies are carried out by cities which are in good fiscal health, these being municipalities with higher tax revenues.

However, the positive sign of *Debt* seems to indicate otherwise. This seems to indicate that a municipality with a higher debt will be more willing to provide tax credits on *RET* and surrender some of its income. However, we may assume that the municipalities with less aversion to debt are those who are ready to give up revenue, since they do not fear debt. In this sense, it must be clarified that this study has been done based on 2010 data, not considering the current circumstances of zero-deficit budgets. In the actual economic framework, the volume of debt may be an important limiting factor in applying these tax credits. In fact, in 2012 some municipalities have had to eliminate them for budgetary reasons.

Column 3 shows the results obtained when adding environmental stress variables. Of these, only *Agricultural Companies* is statistically significant. The other three variables (*Industrial Companies, Vehicles* and *Population Density*) are not.

Population Density may not be significant because population density does not adequately reflect the level of pollution in the municipality, as there may be heavily populated neighborhoods with low pollution and vice versa. In addition, the density of population may not be, in some cases, indicative of the size of the population, as there may be municipalities covering a large territory that combine very sparsely populated areas with small areas of high population concentration. Moreover, *Population Density* may not be significant because of the problems of correlation that arise in this study with both *Population* and *Houses* variables. Municipalities with a higher population density are generally those with higher population and a lower prevalence of single-family homeowners.

Failure of significance of *Vehicles* may be due to the fact that the pollution caused by them is not related to pollution from heating and cooling systems. Thus, local governments do not associate the increased production of solar energy with a reduction of pollution caused by vehicles. The lack of significance of *Industrial Companies* may be explained by the high correlation it has with *Agricultural Companies*. Removing this latter variable, *Industrial Companies* is significant with a positive sign. The negative and significant coefficient of *Agricultural Companies* show that, in rural areas, which are a less stressful environment, local governments have less need to implement measures to reduce the polluting impact of domestic heating.

Column 4 shows the results when variables which are not significant are removed to avoid potential problems of correlation, without affecting significantly the coefficient R^2.

Column 5 illustrates the results when the *Environmentally friendly* variables are included. Both are significant. *Conservative Ideology* has negative coefficient meaning that local governments are less willing to adopt such environmental measures in municipalities with a prevalence of conservative ideology. Similarly, *Covenant Mayors* has the expected positive sign. Thus, municipalities that have already made an environmental commitment consider these tax credits as a means to fulfill this commitment.

Column 6 shows the results including *Neighboring Effect*. Its sign is positive and significant, showing that there is a spillover effect among neighboring municipalities – either by the mere effect of following the mainstream, or for the convenience of local environmental actions to be taken jointly with nearby municipalities.

Column 7 shows the results by including *Unemployment*, which is significant and positive. This shows that local governments consider the tax credits as an incentive measure to strengthen an industry which generates growth and employment, as indicated in Rabe [47].

It should be mentioned that, as expected, the inclusion of the last two variables modifies slightly the significance of some of the other variables, without modifying their sign. The variables that are more sensitive to this decrease in significance are those associated with fiscal stress. This may be due to the interdependence between fiscal policy measures and *Neighboring effect* and *Unemployment*. In fact, as stated in Matisoff [10], neighboring localities often have very similar characteristics, so that it is sometimes difficult to know whether there is truly a neighboring effect or simply an adoption of the same measures because their features are very similar.

Finally, the results obtained from the analysis show that all variables included in column 7 contribute significantly to explaining the adoption of the tax credit on *RET*, as manifested by the upward trend of the Pseudo-R^2 as new variables are incorporated into the model. Nevertheless, there is a group of factors which seems to be more relevant to sway the decision towards a favorable position on tax. As can be seen in the evolution of the Pseudo-R^2, the largest explainable increases in its value are achieved by introducing initial variables associated with the *Characteristics of the municipalities*, and subsequently by introducing the *Environmentally friendly y Neighboring effect* variables. As such, the overriding importance of these variables must be highlighted.

4. Discussion

The European Renewable Energy Directive [48] states that national governments must take savings and energy efficiency measures and promote an increase in the consumption and production of renewable energy. As the production of these energies often depends on the actions of local agents, States should support local actions to promote renewable energies in their jurisdiction. This is also the case for solar-thermal energy production.

The production of this energy depends on the sum of small and numerous installations located throughout the territory. In these cases, the factors closely linked to specific local circumstances are those that affect the decision to establish these installations and therefore, the final production of solar-thermal energy [29,30,42,49]. Thus it appears appropriate that local governments adopt measures to promote this energy in terms of these specific characteristics [50].

This paper shows that existing factors behind the decision of local governments to implement measures to promote solar power are many [51]. The results of the analysis performed show that the municipalities implementing these measures are: large municipalities, with a high solar potential, whose inhabitants live mostly in multi-owner buildings, with liberal ideology, which have already implemented other environmental measures, are surrounded by other municipalities which have already implemented similar measures, whose economic circumstances are favorable and who believe that the promotion of these measures may also have a positive effect on economic activity in the area, creating new employment opportunities.

As a starting point, it seems logical that those areas with low solar potential do not apply these measures. As evidenced by the EU Renewable Energy Directive [48], the development of energy from renewable sources should be closely linked to increases in energy efficiency. In the case of low solar potential, central government actions to stimulate local government to promote solar-thermal installations are not recommended.

Apart from this circumstance, other considerations may help remove obstacles to the promotion of these measures.

First, the results suggest that the larger municipalities are most likely to apply tax credits. In this sense, central or regional governments should pay special attention to smaller municipalities, offering help to local governments so that they can conveniently

assess the adoption of this measure. Often, small municipalities do not have the institutional capacity, political environment, or socioeconomic resources to adopt and implement these policies, because they lack the necessary elements to evaluate the impact of this measure. In this sense, it may be very beneficial for small municipalities to have the support of higher institutions to address these barriers, which the larger municipalities do not have. Therefore, as stated in Brandoni and Polonara [24], it is fundamental the role of coordinator played by the regional government, which can guarantee that municipalities concentrate their efforts in the right direction. In this regard, the Committee of the Regions [52] found that higher level government may have a decisive role to play in providing strategic guidance, and technical and financial support. Perhaps for this reason, municipalities which are more likely to adopt these measures are those which have already adopted environmental policies, as they have overcome the barrier of knowing how they can apply them and their costs and benefits.

Second, the results show that rural municipalities, or those with a smaller number of industrial companies, are those who are least likely to apply this measure. If rural municipalities are the least polluted, then urban municipalities are worse, and therefore more likely to adopt such a tax credit.

However, the establishment of measures to promote solar energy has an effect not only on pollution, but also on renewable energy production. In this regard, Young and Sarzynski [17] show that as the price of electricity increases, the states with a RPS in place adopt more incentives to promote solar energy with a view to reduce the non-renewable energy consumption.

In Spain, a country highly dependent on imported oil, it may be appropriate for all municipalities to increase their production of solar energy independently of the environmental benefits on the grounds of energy security. In this sense, municipalities which have signed their adherence to the Covenant of Mayors commit to the development of an action plan. This plan sets targets for increased percentage of renewables energy consumption. The need to achieve these targets favors the adoption of concrete measures. Perhaps for this reason, the results of the analysis performed show that municipalities which have signed the Covenant of Mayor are more likely to implement tax credits because they are used as means of achieving the committed targets.

Third, the results show that municipalities favoring a conservative ideology are less likely to adopt this type of energy measure. This fact may have a negative effect in the long term [17] as a change of government, with a different ideology may alter the policy undertaken previously. Moreover, a tax measure that is not maintained over time may have limited results. In this sense, it may be desirable to establish measures that force municipalities to meet targets in the medium and long term.

Finally, the results also suggest that municipalities with less fiscal stress have a greater disposition to the adoption of such policies. In short, those with a more favorable economic situation are those that will be able to establish tax credits more easily, while the poorer municipalities are constrained by their budgets, and have fewer choices [53]. In a context like the present global financial crisis, in which municipalities have clear financial difficulties, this is a very serious obstacle to the implementation of tax credits. Probably the only way to overcome this difficulty is making the benefits from these measures visible and quantifying them in terms of increased renewable energy production, increased pollution abatement and increased employment and production. Along these lines, it is worth noting the study by Lund and Hvelplund [54], which shows how the economic crisis enables the implementation of essential elements of future sustainable energy solutions, which generate jobs without having a negative influence on government expenditure.

In this sense, it may be said that although to date there have been several studies assessing the effect of renewable energy on a general level [55–57], there is great lack of studies evaluating these energy measures in specific municipalities. These studies are needed to visualize the effects of these policies and their future returns, so that local leaders can make the correct decisions.

5. Conclusions

Through implementation of a logistic regression model, this study analyzes the factors which may influence the decision of local governments to establish tax credits up to 50% on *RET* where thermal or photovoltaic solar systems are installed. Various factors have been used as explanatory variables related to the characteristics of municipalities, fiscal stress, environmental stress, the environmentally friendly nature of municipalities, the neighboring effect and economic motivations.

This study shows that municipalities applying these measures are mostly large in size, with high solar potential, with predominantly collective-housing buildings, with low fiscal stress, mainly rural, environmentally friendly, surrounded by municipalities implementing similar measures and with higher unemployment rates.

It was found that there was no significance in two of the factors considered – those related to the environmental stress level, such as population density and the number of vehicles registered per km^2 in the municipal area. The lack of significance of these variables does not allow one to say that local pollution does not affect to the willingness of governments to implement tax credits on *RET*, since another indicator used to measure this issue, the rural character of the municipality, has a significant positive effect. Thus, it might be desirable to analyze this further with more reliable indicators of pollution or environmental pressure – for example, indicators which measure air quality, for which it would be necessary to develop previously homogeneous databases of these indicators at the municipal level, making these suitable for guiding public decision-making at a municipal level.

Finally, it can be considered also that governments are very sensitive to their financial situation. The present situation in which Spanish municipalities find themselves, with declining financial resources and with a zero deficit agenda imposed by the central government, puts this tax measure at risk. Under such conditions, it may be desirable for specific studies to be performed to help assess the real effects of this tax credit measure.

Acknowledgments

The authors acknowledge the financial support received by the Cátedra de la Economía de la Energía y del Medio Ambiente (Chair of Energy and Environmental Economics) of the Fundació Roger Torné and by the Andalusian Energy Agency and by SEJ 132. They also acknowledge the suggestions made by two anonymous reviewers and the participants of the IV Workshop on Public Economics and Renewable Energy, University of Seville, April, 2012.

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