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Analysis of Public Subsidies to the Solar Energy Sector: Corruption and the Role of Institutions

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Summary

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Keywords: Renewable Energy, Corruption, Public Subsidies, Legal Institutions

JEL Classification: O13, D73, P47, H23

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Abstract

This study investigates the connection between rent-seeking behaviour, corruption activity and quality of institutions to empirically evaluate the unexpected implications of an energy policy for criminal activity. The object of this research is a program of public subsidies introduced in Italy in 2005, which successfully boosted the solar energy sector but seems to have generated a growth of corruption activity, arisen from the opportunity of rent extraction. In particular, according to the main hypothesis of this research, bribery is expected to rise significantly where big photovoltaic plants are concentrated and administrative procedures are more complicated. To determine the causal effect of the subsidies on corruption, the study employs a Difference-in-Difference methodology on a sample of 76 Italian provinces and exploits solar radiation as exogenous variable to discriminate the profitability of investments and bribing. Results confirm that, in poor-institutions areas, the growth of the solar sector in sunniest provinces has gone hand in hand with increasing corruption. Results suggest that policy makers should pay additional attention to the potential distortions of public policies implying large rent opportunities, in areas where the weakness of institutional settings and the bureaucratic complexities encourage illegal behaviour.

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1 Introduction

The *Resource Curse Theory* refers to the apparently counter-intuitive evidence of a negative association between rich endowments of natural resources and countries' economic development (Corden et al., 1982). Most literature on this matter has been focusing on fossils (Torvik, 2002; Bulte et al., 2005), but parallel arguments can be put forward for renewable resources. This reasoning applies in particular when government policies aiming to encourage the diffusion of clean energy production come into play. Indeed, public expenditure produces opportunities for rent-extraction and this, under certain conditions, may represent a trigger for bribery (World Bank, 1997). The case analysed here concerns a policy implemented in Italy since 2005 to promote investments in photovoltaic plants, and its potential impacts on criminal activity. The study retraces an empirical research by Gennaioli et al. (2016) that focuses on the wind energy sector and evaluates the consequences of a similar solar energy policy for criminal activity.

This study finds justification in a context of growing emphasis on climate change and rapid increase of public policies aiming at fostering the production of clean energy and reducing greenhouse gas emissions. Indeed, the fact that the human responsibilities for climate change have been scientifically demonstrated (IPCC, 2014) impose a radical change of route for the economic model that has led to the current level of development. The year 2015 was the first in history in which the concentration of CO2 in the atmosphere exceeded the threshold of 400 parts per million (World Meteorological Organization, 2016). In the same year, at the Paris Agreement, World's decision makers officially declared their intention to turn their agendas towards an effective conversion of the economic systems towards sustainable development. During the last decades, environmental policies and social transformations along with deeper concern for ecology have already given positive results in the attempt to decouple economic growth from environmental damage[1]. The case of the solar sector in Italy is emblematic: if in the year 2000 solar energy contributed to the national renewable energy production for the 0,1%[2], in 2015 Italy is ranked at the first place in the world for the use of the photovoltaic[3]. However, economic theory predicts that rapid changes in an economy or a market may imply the emergence of negative externalities, such as corruption, and this is what this study aims to investigate.

The next section reviews the literature on the relationship between natural resources and development, with a particular focus on explanations that involve rent-seeking and corruption. The empirical part below transposes these arguments to the case of Italy, where the introduction of public subsidies to investments in solar energy represents an opportunity for rent extraction.

[1] http://www.wri.org/blog/2016/04/roads-decoupling-21-countries-are-reducing-carbon-emissions-while-growing-gdp

[2] Gestore Servizi Energetici, (2016). Rapporto statistico UE 27 Settore Elettrico. [online] Available at: http://www.gse.it/it/Statistiche/RapportiStatistici/Pagine/default.aspx?Page=1 [Accessed 28 Oct. 2016].

[3] International Energy Agency, (2016). 2015 SNAPSHOT OF GLOBAL PHOTOVOLTAIC MARKETS. [online] Available at: http://www.iea-pvps.org/index.php?id=trends0 [Accessed 29 Oct. 2016].

The study adopts a Difference-in-Difference strategy, where solar radiation at province level is exploited as an exogenous source of variation to distinguish between a Treatment and a Control group. In this particular case, solar radiation is considered as the natural resource giving to the sunniest provinces the chance to gain the most from the public policy and the empirical assessment investigates if criminal activity is somehow related to the profitability of rent extraction. The empirical findings reveal that an increase in corruption activity effectively occurred in the sunniest provinces after the introduction of the public subsidies. Also, such an evidence only appears in southern Italy, where institutional quality is the poorest in the country. Finally, robustness checks strengthen the validity of the results.

2 Related Literature

The major economic explanations for the *Resource Curse* may be traced back to the *Dutch disease* theory, to rent-seeking models and to the relationship between resource endowments and institutional settings (Bulte et al., 2005). Dutch disease models posit that resource booms affect the inter-sectorial allocation of productive factors, so that countries with comparative advantage in natural resources end up deviating their long term productive activities through a contraction in their manufacturing sector (Corden et al., 1982). As for rent-seeking models, natural resources booms make the availability of easy rent opportunities an attractive premise for entrepreneurs to quit productive activities (Torvik, 2002). The allocation of human capital between entrepreneurship and rent-seeking is a primary driver for the distortion of the economy and the possible adverse effect on growth (Francois et al., 2000; Murphy et al., 1991). The third explanation for the *Resource Curse*, focusing on the case of fossil fuels, considers the low quality of institutions as the main reason for economic underdevelopment. Specifically, countries abundant in oil and minerals, which are geographically concentrated and not owned by many, exhibit oligarchic forms of government and unequal division of the economic benefits of resource extraction (Auty, 2001). Accordingly, fossil-abundant countries display lower levels of institutional quality because the elitist owners of resources tend to resist industrial development and repress democratic movements trying to affect policy making to maintain the control of the natural endowments (Boix, 2003; Bulte et al., 2005).

Leite et al. (1999) argue that the negative effect of resource endowments on growth depends on how economic interests interact with policy instruments. Specifically, since the availability of natural resources encourages rent-seeking behaviour, corruption[4] may arise in the attempt to obtain shares of the rent, thus negatively affecting this interaction. In this regard, there is evidence that resource-abundant countries display higher corruption rates and that natural resources constitute barriers to trade that soften foreign competition (Ades et al., 1999).

[4] According to the definition by the World Bank, corruption is *the abuse of public power for private benefit* (World Bank, 1997, p. 8).

However, the likelihood that rent-seeking activity in capital intensive industries translates into actual corruption strongly depends on the *quality of institutions* (Leite et al., 1999), that is, on the rule of law and on monitoring activities. In fact, weak institutional settings increase the attractiveness of rent extraction and illegal behaviour (Murphy et al., 1991). Conversely, strong institutions can impede politicians to sub optimally exploit resources, through the expansion of public expenditure and patronage, i.e. the offer of public employment and favours for political support (Robinson et al., 2006). In economic terms, the reason why strong institutions are crucial in limiting corruption depends on the fact that, when agents evaluate the opportunity of undertaking illegal behaviour, they take into account of the expected cost of punishment, i.e. the probability of being caught and the entity of penalties (Becker, 1968). Hence, institutional weakness translates, among other things, into scarce rule enforcement by the government and little credibility of the severity of punishments, emerging from a gap between the officially declared penalties and their actual implementation (Tanzi, 1998). In the specific case of public subsidies, as analysed here, corruption is positively associated with public officials' monopoly power and to discretion in allocating rents, while it is negatively associated with their degree of accountability (Klitgaard, 1998).

To summarise, corruption can be conceived as an important factor for the negative association between natural resource endowments and economic growth, when rent-seeking and institutional explanations are taken together. Indeed, corruption is detrimental to policy outcomes and growth, as it can be viewed as a form of taxation with strong distortionary effects on the economy (Shleifer et al., 1993; Fisman et al., 2007). However, some scholars emphasise the efficiency gains of bribery in dealing with excessive bureaucratic rigidities (Lui, 1985; Lien, 1986), while others oppose that bureaucratic procedures are often voluntarily complicated by public officials, in order to obtain bribes (Wilson, 1989; Banerjee, 1997; Banerjee, 2012).

The Case of Renewable Energies

As emerges from the above literature review, most studies regarding the *Resource Curse* focus on the case of concentrated resources, with little consideration for diffuse resources, i.e. those spread over large territories and available to many (Bulte et al., 2005). The purpose of this study is to apply the arguments described so far to the case of diffuse resources, in particular to solar energy, assuming that a policy intervention on diffuse resources, such as renewables, may have the same effects in terms of rent-seeking opportunities that characterise concentrated resources. This kind of research is what Gennaioli et al. (2016) carried out, under the premise that public plans, especially market-based forms of environmental regulation, introduce elements of scarcity in an otherwise diffuse resources scenario. In turn, scarcity implies the creation of value and, accordingly, encourages economic agents to adopt rent-seeking behaviour, with potential negative consequences for corruption activity. In particular, the introduction of a quota mechanism in Italy for the exchange of green energy certificates increased the attractiveness of investments in wind plants, providing wind energy producers with a surplus of licenses that translated into an opportunity for rent extraction. As the authors demonstrate, since investments' permissions are

crucially conditioned by local politicians' discretion, investments in wind plants are associated with higher levels of corruption. The empirical exercise achieved here tries to retrace the basic idea and the methodological steps employed by Gennaioli et al. (2016), focusing on a policy designed to subsidise photovoltaic plants.

3 Empirics

3.1 Policy Description

In 2005, the Italian government set up a program to promote the production of solar energy, known as "Conto Energia" (D.M. 28/7/2005). The incentives scheme was modified and progressively enlarged by following laws in 2007, 2010, 2011, 2012. By the end of the program, in July 2013, subsidies were granted to more than 530,000 plants at the annual cost of 6.7 billion euros[5]. The grant takes the form of the so-called *feed-in premium,* an incentive scheme that consists in a premium tariff linked to the amount of energy produced, as a supplement to the earnings deriving from selling the energy. The tariff is ensured for twenty years, since the opening of the photovoltaic plant, and remains constant for the whole period, with no modifications due to macroeconomic factors. The aim of the policy was to incentivise the set-up of 500MW of solar plants at the national level, but only plants with a capacity between 1kW and 1000kW could have access to the subsidy. The first modification of the scheme (D.M. 19/2/2007) abolished the limit of 1000kW for plants that could receive the payments and enlarged to 1200MW the cumulate power that could be subsidised at the national level. Since the object of this study are plants with considerable capacities, the actual beginning of the policy is considered to be 2007, when large-scale incentives' distribution was introduced in the law and plants with more than 1MW of were involved. To request the subsidies, agents (private, public, firms or households) had to put in an application to the designated authority (Gestore Servizi Energetici, GSE) responsible for verifying the conditions to admit plants to the program and making checks. The Italian law (D.M. 5/5/2011) defined as *Big* all plants with a minimum capacity of 200kW, while, since the first draft of the policy, all plants with nominal installed capacity of at least 20kW are considered *Industrial.* The distinction between big and industrial plants is linked to different burdens. For instance, the authorization for these investments was subject to the evaluation of the environmental impacts of the project (d.p.r. 12/4/1996). For industrial plants, the 2007 law set a subsidy between 0,36 and 0,44€/kWh of energy produced, to be added to the revenues deriving from the sale of energy in the market. All requests for grants had to respect bureaucratic procedures, and the attribution of the tariffs followed the chronological order of the demands. This way to allocate the subsidies made requestors compete on a temporal dimension to acquire all possible authorizations as quickly as possible. On the other hand, for each request the authority evaluated the compliance with a great number of standards. Specifically, it accomplished an assessment on technical restrictions and an administrative evaluation. The latter implied a check on permissions for,

[5] http://www.gse.it/it/Conto%20Energia/ContatoreFTV/Pagine/default.aspx#&panel1-1

among others, investment planning and uniformity to bureaucratic procedures. The assessment of the requests' validity involved a close cooperation of the GSE authority with local police forces and administrative bodies. In particular, the GSE could obtain an anti-Mafia certification directly from provinces' prefectures.

Overall, complicated procedures and unclear rules represented an obstacle to the obtainment of the grant, in particular for bigger plants. In this regard, guidelines that concern agricultural areas deserve a more detailed explanation. Legal dispositions in 2005 and 2007 allowed photovoltaic investments in agricultural areas, in contrast to previous Regional laws, which do not permit such investments unless they were strictly linked to the agricultural activity. Such legal collision provoked uncertainty regarding the law prescriptions and bureaucratic procedures. In 2010, new legal dispositions (D.M 10/09/2010) clarified that investments in agricultural areas are constrained by the authorisation of local governments, responsible for individuating areas suitable for photovoltaic plants. In other words, the approval was rejected if the investment projects did not respect environmental standards, landscape and cultural protection, according to Regional government's discretion.

To summarise, the program was a chance for entrepreneurs to get an attractive rent linked to the production of solar energy and a potential source of illegal activity. Some preliminary findings reported by the GSE[6] are indicative in this concern. Between 1/1/2011 and 30/09/2012 the authority denied or interrupted the supply of grants to 8593 plants over 315000 controls, for not respecting technical, legal and temporal requirements. Moreover, it denied the grants to 45 plants (with 1MW of power capacity on average) for the specific reason of having provided false documentation (ex-art 23 D.Lgs 28/2011). A rich anecdotal evidence[7] in the years 2010 – 2012 reports cases of frauds concerning the falsification of certificates to obtain the authorizations to place photovoltaic plants. Also, national and local papers often dealt with cases of bribery that led to the arrest of members of the public administration, especially in southern regions.

3.2 Hypotheses

The structure of the program *Conto Energia*, the need of local government's authorizations and the complexity of procedures represent suitable premises for the occurrence of corruption

[6] http://www.gse.it/it/salastampa/news/Pages/nota-informativa-attivita-verifica-e-controllo-gse-2011-2012.aspx

[7] http://palermo.repubblica.it/cronaca/2011/03/12/news/mazzetta_per_il_fotovoltaico_arrestato_il_deputato_vitrano-13491922/
http://www.brindisioggi.it/fotovoltaico-10-arresti/
http://palermo.repubblica.it/cronaca/2016/02/15/news/corruzione_condannato_l_ex_deputato_dell_ars_bonomo_a_sei_anni_e_mezzo-133483857/?ref=search
http://www.ilfattoquotidiano.it/2014/07/23/fotovoltaico-frode-da-37-milioni-3-arresti-pannelli-cinesi-spacciati-per-europei/1070003/
http://www.ilfattoquotidiano.it/2013/10/13/distratta-dalla-crisi-italia-perde-terreni-agricoli/734064/

activity related to the obtainment of public subsidies. Indeed, notwithstanding the role of surveillance of the GSE, local governments had sufficient discretionary power to alter the outcome of the controls. According to Gennaioli et al. (2016), bribing could emerge in this case if agents wanted to obtain the authorizations quickly and "cut through the red tape". Hence, the higher the expected revenues, the higher the expected returns of bribing. On this matter, notice that bigger plants required more complex requisites to obtain the authorizations but also could ensure higher subsidies and attractive rents. On the whole, *Conto Energia* allowed for a great distribution of subsidies with little constraints for beneficiaries, but more significant investments necessarily translate into higher barriers to entry. In turn, in markets characterised by barriers to entry, such as solar energy, it is more likely for criminal associations and mafia-related associations to come into play.

The hypotheses this study aims to test are the following:
The policy *Conto Energia*, aiming at subsidising photovoltaic energy production through a fixed 20-years rent, increases the likelihood of corruption activity, related to significant investments in the sector. Therefore,

1- Corruption is more likely to rise in areas where returns to investments in solar plants, and hence those of bribing, are higher. Thus, more corruption activity should be observed where solar radiation is stronger, namely, where productivity of photovoltaic plants is higher and rents more profitable.
2- The emergence of corruption activity encouraged by rent-seeking is conditioned on a favourable environment for this to occur. Hence, bribing is more likely to be observed where institutions are particularly weak.

3.3 Empirical strategy

These hypotheses can be tested through a Difference-in-Difference (DiD) model, comparing changes in criminal activity between two groups, before and after the distribution of public subsidies. The DiD model is often employed in labour and development economics to evaluate the impact of policies that do not uniformly affect similar geographical areas or groups of individuals. Although the policy analysed here does not formally exclude specific territories from receiving the public subsidies, relevant photovoltaic investments are subject to the presence of the resource of *solar radiation.* Indeed, photovoltaic plants are more productive where radiation is stronger, which makes returns to big investments more convenient and attractive. Yet, due to geographical reasons, solar radiation is not uniformly distributed among Italian provinces. Thus, it will be employed here as an exogenous source of variation in the profitability of photovoltaic investments. For the same reason, there are no clear boundaries that define areas where solar radiation is higher than others, because it does not vary substantially from a province to another, and this represents a further challenge for the identification of the model. However, it is possible to divide the sample of Italian provinces in groups that differ almost exclusively for their level of solar radiation and consider these groups *as if* differently affected by the policy.

3.4 Data

The empirical analysis is performed on a panel dataset including 76 Italian provinces in the period 2004-2012. Since corruption is by its nature characterised by secrecy and actual data is and not fully reliable, several strategies have been adopted to approximate its measure (Olken et al., 2012; Olken, 2007). In the dataset employed here, information is provided by ISTAT ("Statistiche Giudiziarie Penali") and captures the number of offences reported to the judicial authority by the police forces. Specifically, the focus here is on criminal association offences reported every 100,000 inhabitants (*CAssoc*). The dataset also contains analogous measures for Mafia-related associations (*MafAssoc*) and the total of the previous two (*TotAssoc*).

Regarding investments in photovoltaic plants, all data are made available by GSE, in *Atlasole*[8], a database containing all plants in Italy that receive the incentive tariffs or have applied for it. This dataset allows for the construction of the following variables: *Capacity* (kW) yearly installed at province level every 100000 inhabitants; Number of plants with a minimum capacity of 20kW (*Industrial plants*), 200 kW (*Big Plants*) or 1000 kW (hereafter referred to as 1MW plants) every 100000 inhabitants at province level. Data on solar radiation is estimated by the agency ENEA[9] ("national agency for new technologies, energy and sustainable economic development") exploiting satellite imagery. Hence, the variable *Av_Radiation* (kWh/m2) is the average level of solar radiation to the ground over the period under scrutiny, registered for each province. As Figure 1 displays, solar radiation is not uniformly distributed on the country's surface and the highest levels are registered in the islands: Sardinia and Sicily.

FIGURE 1: GLOBAL HORIZONTAL IRRADIATION (GHI) IN ITALY (AVERAGE IN 1994-2013)

Source: http://solargis.com/products/maps-and-gis-data/free/download/italy

[8] http://www.gse.it/it/Statistiche/Atlasole/Pagine/default.aspx

[9] "Radiazione solare globale orizzontale annua 2006-2015, per 119 capoluoghi delle provincie italiane". ENEA - Dipartimento Tecnologie energetiche - Divisione Solare Termico e Termodinamico, Roma. URL: http://www.solaritaly.enea.it

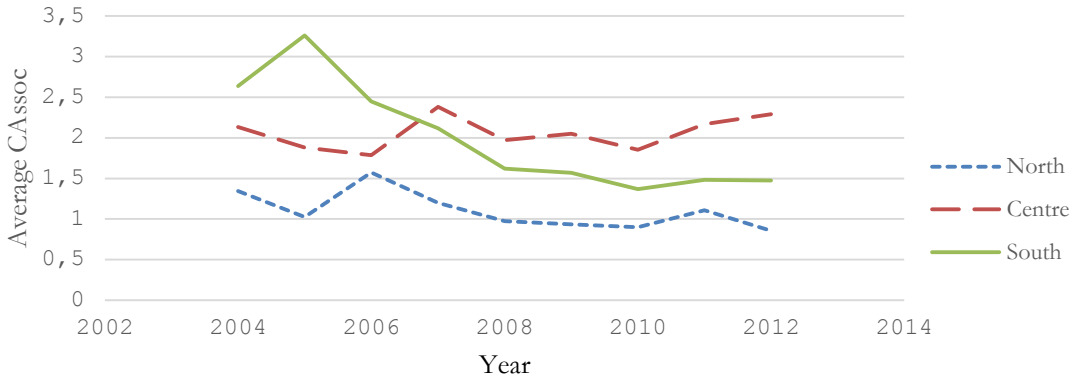
Control variables include the logGDP per capita in euros (*lnGDP*) and population density (*Pop_density*), which is considered a relevant determinant of criminal activity (Glaeser et al., 1999). Also, data includes an index for institutional quality (*IQI*), computed on provincial base by Nifo et al. (2014), and specific measures regarding the agricultural sector: the number of firms in the agricultural sector per square kilometre (*Fac_Farms*); the percentage of soil devoted to agricultural production (*Soil*) and their respective variations between 2000 and 2010 (*⊿Fac_Farms*, *⊿Soil*); the level of education of the leader of each factory farm in the territory (*H_Educ* aggregates high school diploma and Degree, *L_Educ* aggregates no education or primary school license). Apart from the *IQI*, all data for the controls is available from ISTAT.

Table 1 displays the mean value of each variable in the dataset, computed separately for northern central and southern provinces. Such a distinction is justified by historical systematic differences between southern and northern Italy, as regards the level of economic development, living standards and institutional quality. Indeed, the division of the sample into three areas does not only reflect progressively stronger solar radiation (*Av_Radiation*) from northern to southern provinces, but also progressively lower income (*GDP*), quality of institutions (*IQI*) and criminal activity (*CAssoc, MafAssoc, TotAssoc*). Such differences may imply a biased estimation of the changes in criminal association activity related to the introduction of the public program. Nevertheless, as Figure 2 shows, the trend in average criminal association activity after 2007 is constant in the three areas and even decreasing in southern Italy since 2005. As investments in photovoltaic plants dramatically increased in the same period (see Figure 5), such an evidence apparently rules out that a positive correlation exists between the level of average criminal activity in the three areas and the growth of the solar sector.

TABLE 1

	North Mean	**Centre Mean**	**South Mean**
GDP	28009	23089	17166
IQI	0.69	0.63	0.32
Av_Radiation	1373	1473	1587
AreaKm2	2326	2821	3283
Pop_ density	217	139	233
Population	468578	331323	584025
CAssoc	1.10	2.06	1.99
MafAssoc	0.02	0.03	0.40
TotAssoc	1.12	2.01	2.40
Capacity	129852	176201	110191
Num20kW	70.90	53.54	41.38
Num200kW	11.80	14.93	12.95
Num1000kW	0.88	1.58	1.19
Fac_Farms	3.87	5.34	9.11
⊿Fac_Farms	-28.33	-32.59	-30.96
Soil	42.07	40.40	49.53
⊿Soil	-6.76	-9.61	2.14
H_Educ	58.72	58.08	59.17
L_Educ	36.70	37.31	37.55
N	270	137	278
N Provinces	30	16	35

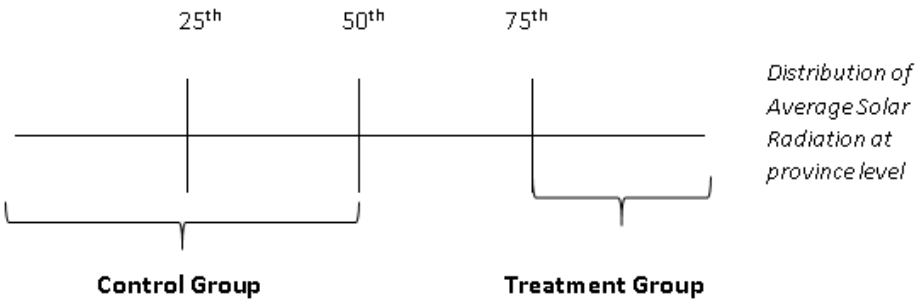
FIGURE 1: TREND IN AVERAGE CRIMINAL ACTIVITY IN NORTH, CENTRE AND SOUTH (INJURIES REPORTED EVERY 100 000 INHABITANTS)



3.5 Selection of the Treatment

The first step for the Difference-in-Difference is to identify a Treatment and a Control group, which will be compared before and after the introduction of the policy. The Treatment group is selected by considering all the provinces where the profitability of photovoltaic investments, proxied by solar radiation, is high enough to observe a larger amount of photovoltaic plants. The two groups need to be as similar as possible, concerning socio-economic characteristics and all dimensions that influence corruption activity, so that any observed difference could be traced back to the policy. Precisely, the Control group must be a reliable counterfactual of the Treatment, that is, it should provide accurate information about what the behaviour of the Treatment group would have been in the absence of the policy. The exogeneity of a geographical peculiarity, such as solar radiation, on criminal activity is helpful in this matter. However, the previous paragraph highlights substantial differences in all the relevant magnitudes in southern, central and northern Italy. Hence, to overcome estimation biases, the analysis is run separately in each area, so that Treatment and the Control groups are identified separately in southern, central and northern Italy. The groups compared in the analysis are chosen by considering the distribution of average solar radiation in each area, which is arbitrarily divided into four equal parts, defined by the 25th, the 50th and the 75th percentiles. The Treatment group of each area includes the provinces in the fourth quartile of the average solar radiation distribution, computed separately in North, Centre and South. The Control group contains all provinces that exhibit average radiation in the first half of the distribution. Provinces in the third quartile of average solar distribution are initially excluded from the comparison and will be employed to accomplish robustness checks.

FIGURE 3: TREATMENT AND CONTROL PROVINCES ON THE SOLAR RADIATION'S DISTRIBUTION



To ensure similarity of the groups thus obtained, these are compared with respect to the mean value of different socio-economic variables. The means are computed separately before and after the treatment year, 2007, in order to capture if any relevant changes occurred after the implementation of the policy. Table A1 in the Appendix reports the differences, and the related t-statistic, between Control and Treatment provinces in North, Centre and South, in the period before the policy (2004-2007) and the following one (2008-2012). There is no significant difference in most dimensions reported between Control and Treatment provinces, especially in the period 2004-2007, apart from the average solar radiation. Hence, the two groups can be considered homogeneous, and group-specific characteristics should not bias the comparison.

Figure 4 illustrates the trends in the yearly average of the variable *CAssoc* in the Treatment and the Control groups, aggregated at the national level. The pattern of the variable appears to be trending downward and in a similar way in both groups before 2008. After 2008 the lines diverge and follow different directions. Interestingly, the decreasing trend in criminal associations in treated provinces is interrupted in 2008, while the same occurs in the Control group in 2010 only. Most importantly, the graph seems to validate the parallel trend assumption, the necessary prerequisite for a correct specification of the Difference-in-Difference[10]. The Difference-in-Difference model attempts to attribute the explanation for the sudden divergence in criminal activity's trends between the Treatment and Control groups to the introduction of the policy. Specifically, the setup of big investments might be pointed as the strongest channel of transmission between public subsidies and corruption. Therefore, together with the quality of institutions, the profitability of investments and the linked expected rewards of bribing are considered the main determinants of corruption.

[10] A more formal strategy to verify the parallel trend is implemented in Section 4.

FIGURE 2: TREND IN CRIMINAL ACTIVITY IN TREATMENT AND CONTROL PROVINCES, WHOLE COUNTRY (INJURIES REPORTED EVERY 100 000 INHABITANTS)

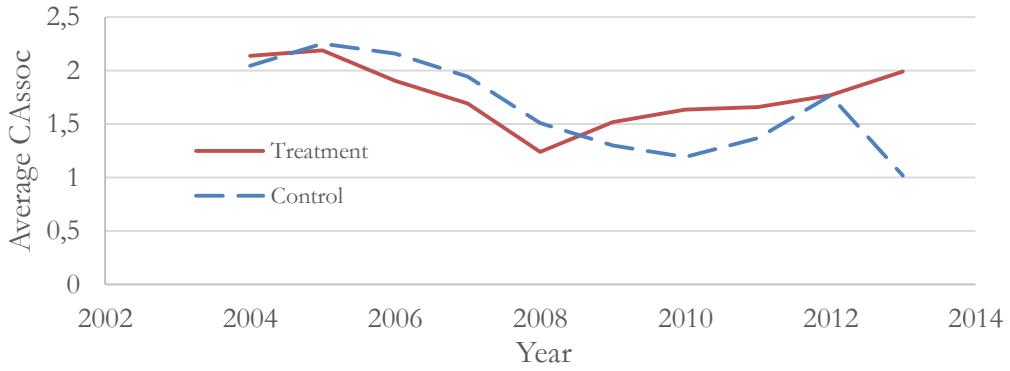
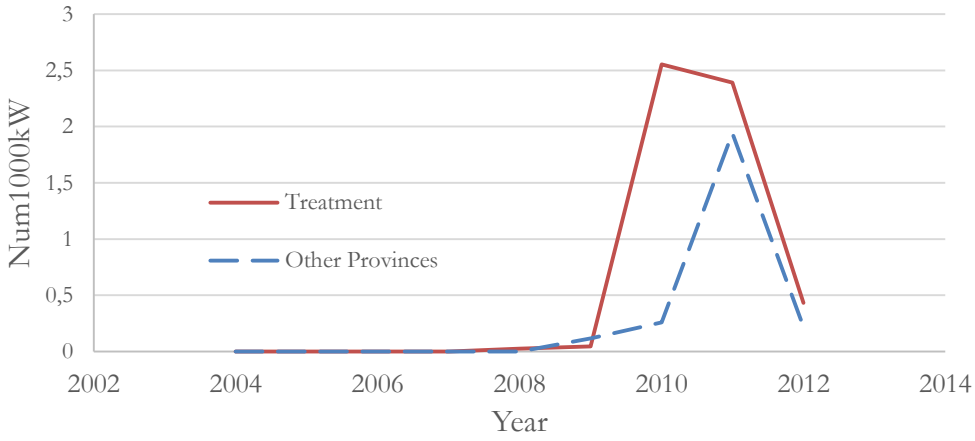


Figure 5 displays the difference in the average number of 1MW plants every 100000 inhabitants set up every year, between Treatment provinces and all other provinces. It gives encouraging information about the validity of the assumption behind the selection of the Treatment: in the sunniest provinces, the number of relevant investments (≥1MW) grows faster and more than in other provinces. The econometric evaluations in the following paragraphs try to demonstrate the link between the growth of the solar sector and the increase in criminal association activity, given the evidence obtained so far.

FIGURE 3: AVERAGE NUMBER OF 1MW MINIMUM CAPACITY PLANTS SET UP IN TREATMENT VS. ALL OTHER PROVINCES (COUNT EVERY 100000 INHABITANTS)



3.6 Results

The DiD is specified both employing Pooled OLS and Fixed Effects estimators. The models take the following form:

Model 1 (POLS):

$$CAssoc_i = \beta_1 T\_POST07_i + \beta_2\, Treat_i + \beta_3\, POST07_i + \beta_4\, X_i + v_t + \varepsilon_i$$

Model 2 (FE):

$$CAssoc_{i,t} = \beta_1\, T\_POST07_{i,t} + \beta_2\, X_{i,t} + Trend_{i,t} + u_i + v_t + \varepsilon_{i,t}$$

Where the first is the specification for a POLS estimation and the second model allows for a Fixed Effect estimation. The two models are equivalent with respect to the computation of a DiD, but the Fixed Effect estimation overcomes the omitted variable bias due to province-specific characteristics. Indeed, the identifying assumption of the models is the absence of unobservable factors, captured by the error term, that affect both the dependent and the independent variables. The Fixed Effect estimator allows to take into account all time-invariant province characteristics that might make the correlation between unobservable factors and the model covariates different from zero, causing a biased estimation. In Model 1, *Treat* is the dummy variable for the Treatment group; *Post07* is the dummy variable indicating the years following 2007 and *T_POST07* is the interaction term between the previous two, which expresses the Difference-in-Difference, when controlling for the two variables separately. In other words, β_1 expresses if the number of criminal association offences reported to justice after 2007 in provinces belonging to the Treatment group is significantly different from what approximately would have been in the absence of the policy. X is the set of controls and v_t indicates year fixed effects. In the Fixed Effect model, the coefficient of the interaction term *T_POST07* still expresses the DiD, but the *Treatment* dummy is implicitly included as one of the province fixed effects, indicated by the term u_i. The dummy *Post07* is substituted by the province-specific time trend (*Trend*) and year fixed effects (v_t).

Table 2 reports the results of the DiD for the three areas of Italy considered separately. The coefficient of *T_POST07* is similar in the POLS and in the Fixed Effect model. However, it seems that the difference in criminal association activity between Treatment and Control groups reported to justice across the introduction of the policy is only positive and significant in southern provinces. It is negative in north and positive in central Italy, but in both cases, it has no statistical significance. In addition, compared to the other areas, the adjusted R^2 reveals that the model explains a more relevant share of variation in criminal activity in southern provinces.

TABLE 2

	North CAssoc POLS	Centre CAssoc POLS	South CAssoc POLS	North CAssoc FE	Centre CAssoc FE	South CAssoc FE
T_POST07	-0.53	0.37	1.10*	-0.50	0.46	1.21**
	(-1.44)	(0.42)	(1.79)	(-1.62)	(0.35)	(2.15)
T	0.52	-0.05	-0.01			
	(1.61)	(-0.08)	(-0.02)			
Post07	-0.10	0.75	-1.61***			
	(-0.27)	(0.40)	(-2.65)			
Trend				0.04	0.12	-0.19**
				(0.84)	(0.31)	(-2.72)
GDP	-0.65	4.88	5.30***	-2.00	0.13	2.04
	(-0.66)	(1.31)	(3.18)	(-0.90)	(0.01)	(0.29)
Pop_ density	0.00	-0.01	-0.00***	-0.03*	-0.04	0.10
	(0.03)	(-0.94)	(-3.44)	(-1.74)	(-0.34)	(0.82)
IQI	-1.29	-2.97	-2.01	-0.53	8.37*	8.47**
	(-0.91)	(-0.91)	(-1.61)	(-0.19)	(2.16)	(2.78)
H_Educ	-0.01	-0.01	0.04			
	(-0.16)	(-0.14)	(0.74)			
L_Educ	-0.00	0.05	0.04			
	(-0.09)	(0.57)	(0.87)			
Soil	-0.00	-0.03	0.02			
	(-0.35)	(-0.51)	(1.43)			
⊿Soil	-0.02	0.04	-0.10***			
	(-1.17)	(0.78)	(-4.27)			
Province FE	No	No	No	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	198	90	207	198	90	207
N prov	22	10	23	22	10	23
Adj R2	0.047	-0.120	0.230	0.056	-0.092	0.170
R2_within				0.113	0.0555	0.219

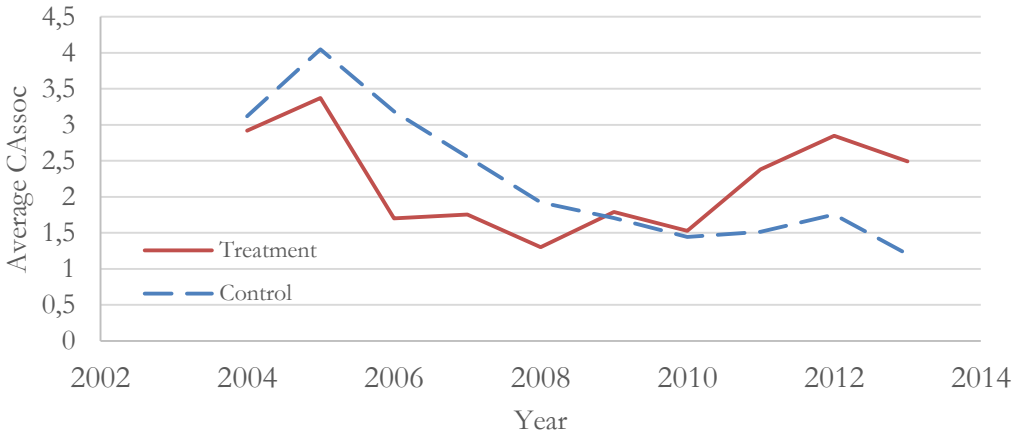
t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Standard errors are clustered at province level.

The evidence seems to suggest that the introduction of the policy in 2007 favoured an increase in in criminal association activity, observed in the sunniest provinces within the South of Italy, the area displaying the lowest score of institutional quality. Given all other province characteristics, the feature of high solar radiation is pointed as the discriminant for the different impact of the subsidies on the rates of criminal activity. According to the main hypothesis, the higher profitability of the investments implied a higher payoff of bribing related to the setup of big photovoltaic plants. Also, the results reinforce the hypothesis that the opportunity for rent-seeking here examined is a driver for corruption only if bribes are profitable enough and if the weakness of institutions offers a favourable environment for illegal behaviour. Such an observation justifies a deeper focus on southern Italy.

3.7 A Focus on the South of Italy

Figure 6 reports the trend in average criminal association activity in the Treatment and in the Control groups, focusing on the sample of southern provinces. This graph, together with the results of the DiD reported in Table 2, seem to confirm that the evidence of diverging trends in criminal activity in Treatment and Control provinces aggregated at country level (Figure 4) is mainly driven by a phenomenon characterising southern Italy.

FIGURE 4: TREND IN AVERAGE CRIMINAL ACTIVITY IN TREATMENT AND CONTROL PROVINCES, SOUTHERN ITALY (INJURIES REPORTED EVERY 100 000 INHABITANTS)



In this section, the impact of the policy on criminal association activity in southern provinces is investigated more cautiously. Following the approach by Autor (2003), the DiD is computed dividing the period of analysis into yearly time windows to observe the growing impact of *Conto Energia* overtime, due to subsequent modifications to the policy design. In addition, considering the interaction term in the time windows preceding the policy is a useful approach to verify more rigorously the parallel trend assumption. Indeed, such a strategy allows to observe if a difference in criminal association activity between the Treatment and the Control group appears before 2008. As the policy has been modified several times in the period 2005-2012, the *Treatment* dummy interacts with every single year dummy, indicated by d_t. Apart from this modification, the model employed in this case is similar to Model 2, presented in the previous paragraph.

Model 3:

$$CAssoc_{i,t} = \sum_{t=2005}^{2012} \beta_t d_t T_{i,t} + \beta_2 X_{i,t} + Trend_{i,t} + u_i + v_t + \varepsilon_{i,t}$$

Results are shown in Table 3. In column one, the coefficient of the interaction between *Treatment* and year is negative for years 2005 to 2008, while it is positive from 2009 to 2012. This evidence gives useful information and confirms what Figure 6 shows graphically. Firstly, there are no significant coefficients before 2008, meaning that criminal association activity is slightly - but not

significantly - higher in the Control than in the Treatment group before the introduction of the policy. Hence, the parallel trend assumption is confirmed. The only significant coefficient after 2007 appears in the interaction between the *Treatment* dummy and year 2011. In fact, this is the year in which the majority of new plants was set up in the whole country, because the end of the programme was anticipated and a steep growth of investments occurred in all provinces. This evidence might explain why the difference between the groups is no more significant in 2012. Overall, the change of sign in the pattern is indicative of the movement in criminal associations reported in the Treatment provinces. Indeed, the value of the dependent variable was lower in Treatment provinces than in Control ones before 2007 and the sign turn suggests that the increase has been big enough to offset the initial gap and overturn the comparison.

TABLE 3

	South CAssoc FE	**South CAssoc FE**	**South CAssoc FE**
T#2005	-0.84	-0.86	
	(-0.83)	(-0.81)	
T#2006	-1.05	-0.84	
	(-1.38)	(-1.11)	
T#2007	-0.44	0.04	
	(-0.63)	(0.05)	
T#2008	-0.48		1.76*
	(-0.71)		(1.83)
T#2009	0.29		1.67*
	(0.50)		(1.91)
T#2010	0.40		1.96**
	(0.72)		(2.28)
T#2011	1.52*		3.25**
	(1.99)		(2.73)
T#2012	1.64		3.20
	(0.86)		(1.52)
Trend	-0.22**	-0.99**	-0.07
	(-2.09)	(-2.14)	(-0.48)
GDP	3.13	17.39*	12.00
	(0.45)	(1.80)	(0.83)
Pop_ density	0.09	0.03	0.37
	(0.78)	(0.18)	(1.50)
IQI	9.22**	11.93*	10.21*
	(2.71)	(1.89)	(1.78)
Province Year Fixed Effects			
N	207	92	112
N Provinces	23	23	23
Adj R2	0.172	0.095	0.122
R2_within	0.248	0.185	0.225

t statistics in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at province level. The Treatment group includes Agrigento, Cagliari, Caltanissetta, Catania, Ogliastra, Oristano, Ragusa, Trapani.

To obtain clearer results, the sample is restricted to only take account of Big plants (≥200 kW), as reported in Column 3. Since plants of such dimensions are only observed from 2007 onwards, all years before 2007 are excluded from the estimation. Hence, to make a comparison, Column 2 reports the results obtained by reducing the period of scrutiny to years 2004-2007. The evidence conveys once more that the difference in criminal association activity in the groups is negative but not significant before 2008, while it is positive and significant between 2008 and 2011. In 2012, the difference is no more significant, supporting the initial conjecture that the solar sector started growing in Control provinces as well, but in delay with respect to the Treatment.

4 Robustness Checks

Intensity of Treatment

The main shortcoming of employing a DiD to evaluate the policy under analysis is that it needs two clear groups to be compared: where the policy is implemented and where it is not. The identification strategy that exploits the level of solar radiation to approximate where the policy has had major effects seems to provide positive results. Nonetheless, such an approach can be challenged, as the Treatment is collapsed in a binary variable, which does not capture the continuous nature of the discriminant "solar radiation".

In the next exercise the average solar radiation (*Av_Radiation*) of each province interacts with the dummy *Treatment* and the year dummies d_t. This means detecting the intensity of treatment, to rule out the possibility that all results in the previous section are due to specific features of the Treatment group. Notice that, for a correct interpretation of the interaction term, the model needs to include all the pairwise interactions between the terms *Av_Radiation, Treatment,* d_t and the single terms[11]. In this case, the time-invariant terms $Treat_{i,t}$ and $Av\_Radiation_{i,t}$ are implicitly included as province fixed effects. Year fixed effects are included as well. All results in Table 4 confirm that the actual level of solar radiation in Treatment provinces is positively associated to criminal activity, confirming the initial hypothesis.

[11] The full specification of the model results as follows:

$$CAssoc_{i,t}=\sum_{t=2005}^{2012} \beta_t d_t T_{i,t}\, Av\_Rad_{i,t} + \sum_{t=2005}^{2012} \gamma_t d_t\, Av\_Rad_{i,t} + \sum_{t=2005}^{2012} \delta_t d_t\, T_{i,t} + \beta_2 X_{i,t} + Trend_{i,t} + u_i + v_t + \varepsilon_{i,t}$$

TABLE 4

	CAssoc FE	CAssoc FE	CAssoc FE
T#Av_Radiation#Post07	0.000713**		
	(2.29)		
T#2005#Av_Radiation		0.03	
		(1.20)	
T#2006#Av_Radiation		0.01	
		(0.70)	
T#2007#Av_Radiation		0.02	
		(1.15)	
T#2008#Av_Radiation			0.20*
			(2.07)
T#2009#Av_Radiation			0.16
			(1.51)
T#2010#Av_Radiation			0.17
			(1.55)
T#2011#Av_Radiation			0.15
			(1.38)
T#2012#Av_Radiation			0.21**
			(2.15)
Trend	-0.19**	-2.84	8.78
	(-2.33)	(-0.47)	(1.37)
Controls			
T # d_t			
Av_Radiation # d_t			
Province and Year Fixed Effects			
N	207	92	112
N Provinces	23	23	23
Adj R2	0.064	0.111	0.124
R2_within	0.219	0.258	0.306

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at province level. The first column reports the simple Difference-in-Difference as shown in the last column of Table 5. Here, the terms *Treat* and *Av_Radiation* only interact the dummy *Post07*. The following two estimations repeat the comparison between pre-treatment and post-treatment periods with yearly time windows. In this case, in the last column, the sample is restricted to the presence of at least one *Big* plant.

Changing the Treatment and the Control

As a further check, the Difference-in-Difference presented in Model 2 is run by changing the composition of the Treatment and the Control groups. Results are reported in Table 5. Firstly, the Treatment group is enlarged to include all provinces with average solar radiation beyond the median value and it is compared with the previous Control group. The difference between them is expected to be mitigated, and this is exactly what Column 1 illustrates. Similarly, Column 2 shows if the coefficient of the DiD changes when all the provinces in the last quartile of the solar radiation distribution are excluded. Here, those in the third quartile are taken as the Treatment group and compared with the provinces in the previous Control group. As expected, the

difference is reduced, along with the reduction of the gap in solar radiation. In Column 3, the nine provinces with lowest average solar radiation are taken as Treatment and compared to all other provinces, excluding those in the initial Treatment group (above the fourth quartile). Not surprisingly, the difference is overturned and becomes negative, indicating that lower solar radiation is associated to lower criminal activity after 2007, in comparison with provinces with higher radiation. Lastly, Column 4 shows the outcomes of the original DiD changes when Ragusa is not included in the Treatment group. Indeed, the province of Ragusa displays an average criminal association activity (6.2 reports every 100000 inhabitants) more than three times higher than the average of the treated provinces, as well as the highest number of photovoltaic plants. However, despite the magnitude being reduced, the coefficient of the Difference-in-Difference remains significant, suggesting that the phenomenon of rising corruption related to public subsidies is not an isolated case.

TABLE 5

	South CAssoc FE	**South CAssoc FE**	**South CAssoc FE**	**South CAssoc FE**
T_Post07	1.02**	0.95*	-1.09*	0.77*
	(2.30)	(1.89)	(-1.91)	(1.77)
Trend	-0.19***	-0.15**	-0.072	-0.16**
	(-3.38)	(-2.36)	(-0.93)	(-2.62)
GDP	2.05	-2.78	0.02	-4.25
	(0.44)	(-0.66)	(0.00)	(-1.10)
Pop_ density	0.10	0.00	0.13	0.01
	(0.89)	(0.01)	(1.06)	(0.11)
IQI	7.46***	7.70**	6.96**	7.26**
	(3.07)	(2.32)	(2.60)	(2.56)
Province and Year Fixed Effects				
N	279	216	207	198
N prov	31	24	23	22
Adj R2	0.174	0.228	0.169	0.243
R2_within	0.209	0.271	0.217	0.289

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Standard errors are clustered at province level.

5 Conclusion

This study explores a specific application of resource curse theory: that of subsidies to renewables. Abundant literature investigates the channels that make fossil-rich economies exploit their endowment inefficiently, causing undesired effects on economic development. Rent-seeking and corruption activity - which may emerge accordingly - are pointed as common channels for the misuse of natural resources. However, there is limited research about similar mechanisms regarding the exploitation of renewable resources, although governments' policies in the last decades - especially in western countries - have devoted funds and efforts to the development of

such sectors. The case of solar energy in Italy is emblematic: the share of energy produced by solar panels was negligible before the implementation of dedicated policies, while, ten years later, the country is one of the world leaders in solar energy exploitation. Yet, if the policy has proven successful in reaching its primary scope, it cannot be ignored that such a sudden transformation of the energy market might have implied distortive outcomes in other domains. The empirical exercises put forward in this paper point to a rise in criminal activity in those provinces where the growth of the solar sector, promoted by the distribution of public subsidies, was more intense. Nonetheless, these results are conditional to the existence of the preconditions that favour the spread of criminal activity, identified in a series of factors signalling institutional quality: law enforcement, the efficiency of the police forces and of the bureaucratic body, politicians' accountability, among others. The analysis leads to conclude that, in a weak institutional setting, the introduction of a program of public subsidies that represents an opportunity for rent-seeking may indeed favour the spread of bribery. The empirical evidence supports that the growth of photovoltaic investments goes together with criminal activity only in provinces of southern Italy and not in central and northern ones, where the quality of institutions scores better.

6 Appendix

TABLE A 1

	North C-T Before 2008	North C-T After 2007	Center C-T Before 2008	Center C-T After 2007	South C-T Before 2008	South C-T After 2007
CAssoc	-0.50	0.00	0.02	-0.19	0.67	-0.34
	(-1.75)	(-0.07)	(-0.05)	(-0.20)	(-1.45)	(-0.96)
TotAssoc	-0.53	-0.02	0.02	-0.20	0.38	-0.39
	(-1.86)	(-0.11)	(-0.05)	(-0.22)	(-0.77)	(-1.03)
GDP	-588	-1826**	928.60	1983**	-309	-423
	(-0.88)	(-2.88)	(-1.24)	(-3.43)	(-0.72)	(-0.98)
IQI	0.03	0.00	0.07*	0.01***	0.05	0.06*
	(-0.50)	(0.00)	(0.02)	(-0.19)	(0.67)	(-0.34)
Population	32705	34024	-54106	-56461	225780	202866
	(0.52)	(0.57)	(-1.11)	(-1.24)	(1.79)	(1.79)
Pop_ density	4.45	4.45	12.01	10.95	140	133
	(0.18)	(0.19)	(0.64)	(0.63)	(1.35)	(1.43)
Av_Rad	-72.12***	-72.12***	-137.0***	-137.0***	-179.0***	-178.5***
	(-10.56)	(-11.84)	(-16.21)	(-18.22)	(-19.13)	(-21.60)
Capacity	-15.15	-3969.7	-16.47	164576.9	13.90	-45591.8
	(-1.20)	(-0.06)	(-0.43)	(0.87)	(0.60)	(-0.48)
Num20kW	-0.59	-8.10	1.43	79.03	-0.35	20.29
	(-0.96)	(-0.23)	(0.99)	(1.75)	(-0.56)	(1.15)
Num200kW	-0.02	-4.83	0.02	21.83	0.07	9.34
	(-0.45)	(-0.76)	(0.18)	(1.51)	(0.74)	(1.41)
Num1MW	0	-0.78	0	-2.14	0	-1.42
	(.)	(-0.90)	(.)	(-1.24)	(.)	(-1.11)
N	92	115	40	50	98	123
N provinces	23	23	10	10	24	24

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

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