Clean or "Dirty" Energy;

Evidence on a Renewable Energy Resource Curse

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This Draft: January 2012

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In this paper we use the dataset on criminal activity constructed by Gennaioli C. and Onorato M. for their project on organized crime joint with Perotti R. and Tabellini G. We are grateful to them for sharing the data.

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Abstract

The aim of this paper is to provide an assessment of the potential for resource curse in the renewable energy sector. Taking a political economy approach, we analyze the link between public support schemes for renewable energy and the potential scope for rent seeking and corruption. The insights of a model of political influence by interest groups are tested empirically using a panel data of Italian provinces for the period 1990-2007. We find the following: i) criminal association activity increased more in windy provinces and especially after the introduction of a more favorable policy regime and, ii) the expansion of the wind energy sector has been driven by both the wind level and the quality of political institutions, through their effect on criminal association. The analysis points out that in the presence of poor institutions, even well designed market-based policies can have an adverse impact. This has important normative implications especially for countries that are characterized by abundant renewable resources and weak institutions, and are thus more susceptible to the private exploitation of public incentives.

JEL:.D73, O13, P16. **Keywords:** Corruption, Natural Resources Curse, Political Economy.

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" ... a lot of people want to jump on board a sure-fire revenue spinner. I wouldn't say the entire sector is corrupt, but there is a small percentage of corrupt projects." J. Wright, senior director of Kroll, an international security firm.

"In Italy, for example, power from wind farms is sold at a guaranteed rate of 180 Euros per kwh, the highest rate in the world. In a country where the Mafia has years of expertise at buying corrupt politicians and intimidating rivals, the result is perhaps inevitable, creating a new breed of entrepreneurs known as the lords of the wind." The Telegraph, 2010

Introduction

Anecdotal evidence in Europe and elsewhere reports the diffusion of corruption practices in the renewable energy sector. For example, several official inquiries made by the Italian police have been published in various newspapers, and have led to the arrest of managers and local politicians who allegedly used corrupt practices and bribes in order to obtain licenses to build wind farms. Similar scandals have occured in Spain, where 19 persons were arrested in 2009 with charges of corruption in the wind sector. In the U.S., the bankruptcy of the solar power manufacturing firm *Solyndra* has led to a controversy over the potential influence of the Department of Energy on the loan guarantee the firm was granted. At the international level, climate energy funds are being established to help developing countries finance the transition to a low carbon economy: hundreds of USD billions are expected to flow through new and untested financial markets and mechanisms, in countries often characterized by abundant renewable resources and weak institutions, thus increasing the risk of corruption. At home, many countries are now evaluating the public support policies which have been implemented over the past several years with the aim of promoting renewables. In most cases, ex post quantitative policy assessment has focused on issues of efficiency and effectiveness, but has often disregarded the role of the main political economy factors at play. The aim of this paper is to fill this gap by taking a political economy approach to the analysis of the renewable energy policies and investigating the potential for rent seeking and corruption in the renewable energy sector. To our knowledge, this is one of the first attempts to study whether renewable energy resources could lead to an increase in illegal activities, and thus generate a so-called 'renewable energy resource curse'.

At the macro-economic level, there is an extensive literature on the natural resource curse, according to which resource abundance can be detrimental to economic growth and the quality of institutions. At the same time, countries or regions with weak institutions are known to be more susceptible to the private exploitation of public incentives. The main theoretical models proposed by Tornell and Lane (1999), and Baland and Francois (2000), establish a channel of causation from natural resources to rent seeking practices; the former study links an improvement in the terms of trade to a voracity effect resulting in pork-barrel politics, while the latter studies the effect of resource booms on rent seeking by private agents. As Vincente (2010) points out, while the theoretical literature on the resource curse is quite exhaustive, the empirical part has mainly provided clear findings in cross country analysis; some (Mauro (1995), Leite and Weidmann (1999), Sachs and Warner (1995), Sala-i-Martin et al. (2003)) found a negative effect on growth via an adverse effect on institutional quality and corruption. Reverse causality is found by Mehlum et al. (2006), who use Sachs and Warner's 1995 data to show that the effect of resources on growth is positive when institutions are of a certain quality. Collier and Hoffler (2002) find that natural resources increase the chances of civil conflicts. On the other hand, Haber and Menaldo (2011) find that increases in resource reliance are not associated with authoritarianism. Hessami (2010) detects a positive relationship between the perceived level of corruption and the share of spending on health and environmental protection. Lapatinas et al. (2011) develop a theory to study the relationship between environmental policy and corruption; using an overlapping generation model with citizens and politicians, they show that corrupted politicians cause increased tax evasion which leads to a reduction of total public funds and thus, of environmental protection activities. Although suggestive, the evidence cannot establish the direction of causality.

The mechanisms behind the resource curse are thus not entirely settled and deserve an empirical assessment at the micro level. Our paper intends to give a contribution in this respect, so that it can be considered in the same spirit of Gennaioli et al. (2010) and Vincente (2010). The former study analyzes the link between public spending and organized crime activity in the Italian context, considering reconstruction funds in the aftermath of the earthquake in the Umbria and Marche regions, as an exogenous increase in public expenditure. Using an instrumental variable approach, they find that an increase in capital expenses per capita raises the incidence of the number of Mafia-related crimes. In the authors' view, organized crime acts as an entrepreneur ready to move wherever economic opportunities arise, exploiting them to promote illegal activity. In this paper we study a different type of crime, namely criminal association activity, to understand the role of illegal associations that entrepreneurs and politicians set up to enter the wind energy sector and be entitled to receive significant amounts of public incentives. Interestingly, while Gennaioli et al. (2010) indirectly look at the building sector, infiltrated by the Mafia a long time ago, we analyze the expansion of a new sector where illegal association activity is not obvious. Vincente (2010) analyzes the effects of an oil discovery announcement on corruption in the Island of Sao Tome and Principe. The author finds that the announcement increased the value of being in power for politicians and this in turn created scope for resources misallocation, as vote-buying. Compared to Vincente, we are interested in the effects of a renewable resource on the behavior of economic and political agents, namely the entrepreneurs operating in the wind energy sector and the local bureaucrats who grant authorization permits. Moreover while Vincente relies on surveys and thus on perceived level of corruption, we are able to use official data on the number of offenses for criminal association activity, which can be considered a proxy for the level of corruption.

Finally, as Sala-i-Martin et al. (2003) point out, not all natural resources necessarily induce a curse, so proving that wind energy causes the same adverse effects at the corruption level as, for example, oil does, is not obvious. Nonetheless, renewable energy provides an interesting test since the electricity sector is known to be both a target and a source of corruption. This is due to the characteristics of the energy resources, the possibility of generating rents, and the key overseeing role played by the government. International organizations such as the World Bank, which have been involved in the financing of energy infrastructure in the developing world, have recognized the need to reduce corruption, often by trying to strengthen governance. The problem is now of international relevance since considerable financing is being mobilized to support developing countries to decarbonize their energy systems. Moreover, policy instruments that promote market flexibility in the regulation of greenhouse gases have incentivized trading of emission reduction credits between developed and developing countries (through the so-called Clean Development Mechanisms -CDM- of the Kyoto protocol). Renewable energy now represents the largest share of the CDM projects in the pipeline. Although the scheme was meant to undertake abatement opportunities where these are cheaper, in practice a large portion of CDM credits have been shown to not represent real emission reductions, mostly as a result of perverse incentives and the quality of institutions (see Victor (2011)).

The contribution of this paper is to analyze the link between renewable energy and criminal association activity. Taking a political economy perspective, we aim at understanding whether the presence of a renewable natural resource, such as wind energy, creates scope for rent seeking practices and corruption. We do so by first presenting a model of political influence by interest groups, which can yield predictions on the relation between corruption, renewable resources, and public support policies. These insights are then tested on a panel dataset of Italian provinces for the period 1990-2007. We are able to find evidence that supports our model, establishing that a wind energy resource curse does exist. The main findings of our analysis are that: i) criminal association activity increases more in high-wind provinces and especially after the introduction of a more favorable public policy regime and, ii) the expansion of the wind energy sector has been driven by both the wind level and the quality of political institutions, through their effect on criminal association. In particular, comparing provinces with a similar (low) quality of institutions, we find that the development of the wind sector has been higher in provinces where economic agents and bureaucrats have engaged more in criminal association activity, due to a high level of wind and so, expected profits.

Overall, the paper points out that, where institutions are poorly functioning, market-based policies, even well designed ones, can have an adverse impact, with a stronger effect in those places with the highest potential for efficiency gains. This has important normative implications especially for countries that are characterized by abundant renewable resources and weak institutions, and thus are more susceptible to the private exploitation of public incentives.

The paper proceeds as follows. First, we introduce a simple theoretical framework which provides testable implications on the relationship between windiness, corruption and the development of the wind sector. Section 2 describes the data and the institutional background. In Section 3 we outline the empirical strategy to test the model, and we present the empirical results. The final Section concludes.

1 A Simple Model of Corruption

The following model is linked to the broad literature on political influence by interest groups and, in particular, it builds on the theoretical framework developed by Dal Bo et al. (2006). While in their model groups can influence policies both through bribes (*plata*) and threat of violence (*plomo*), we only consider bribes as a form of influence. Dal Bo et al. derive predictions on the quality of public officials, while here we make predictions on the equilibrium level of corruption andhe number of active entrepreneurs as a function of windiness and institutional quality. Although the model is simple, it provides us with several testable hypothesis that we assess using empirical evidence for Italy.

The economy is divided in N administrative districts called provinces. Each province is populated by a politician and an exogenously given number n of individuals, characterized by a uniformly distributed ability parameter α, with $U(0,1)$. We consider a two stage game; in the first stage, individuals decide whether investing in wind power generation by building a wind farm, or carrying on their previous activity. If they do not invest in wind, they can earn a wage equal to their ability α. In order to invest, entrepreneurs in the wind energy sector have to ask the politician for a permit. In the second stage, they decide whether to pay the politician a bribe, b, so to increase the probability of obtaining the permit. In this case the entrepreneur bears a cost of bribing, defined as $\lambda\psi(b)$. $\psi()$ is an increasing function of b and the parameter λ captures institutional factors that might affect the cost of paying a bribe, such as the level of effort needed to keep corruption secret, which negatively depends on the degree of social acceptance of bribing (it can also capture the quality of law enforcement, as suggested by Dal Bo et al.). In line with this interpretation, λ can be interpreted as a measure of the level of social capital.

The probability to obtain a permit in case of bribing is p, while in case of not bribing is q, with $p > q$; all other things being equal, if the politician receives a bribe, she will put more effort in the bureaucratic process, increasing the probability of the permit being granted. Once the entrepreneur obtains the permit, she can make the investment and build a wind farm. The return to investment is defined as $I(w, F)$, and depends on the revenues associated with the energy produced (increasing in wind w) on one side, and by the public incentives on the other, F. The public support incentive can either remunerate the actual electricity generated (for example through feed in tariff or a tradeable certificate system) or subsidize the building of the wind farm. In the first case, the introduction of a more favorable regime ($F' > F$) leads to a higher $I_w(), \forall w$. A regime switch from the second to the first support scheme would also make revenues more dependent on the wind level, and thus provide additional incentives to build in the windier sites. The return to investment does not depend on the ability parameter since the wind sector has traditionally been characterized by low levels of competition and revenues were mainly driven by public incentives.

In case of bribing, the entrepreneur gets away with probability c, while with probability $(1 - c)$ she is caught by the police and gets a payoff equal to zero. As in Dal Bo et al, the utility of the politician linearly depends on money and on a moral cost, m, to be corrupted. For simplicity, we normalize the politician's wage to zero. Let the number of available permits in each province be greater than n, such that entrepreneurs do not compete for permits; since we focus our attention on the first period after the introduction of wind power generation in Italy, we do not expect the limit in the number of permissions to be binding. We solve the model for one province, so we can ignore index i in the notation. The following results can obviously be generalized for all provinces.

1.1 Equilibrium

We solve the model backward, starting from the second stage when an entrepreneur active in the wind energy sector has to decide whether to bribe the politician or not. Then we go back to the first stage, analyzing the entrepreneur's decision to enter the renewable energy sector. Following Dal Bo et al., we assume that the entrepreneur holds all the bargain power and makes a "take-it or leave-it" offer to the politician.

1.1.1 Equilibrium Bribes

The politician will accept the bribe whenever the payoff under bribing is higher than the payoff without bribing, which is normalized to be equal to zero;

$$b - m \geq 0 \tag{1}$$

The entrepreneur chooses the level of the bribe, by solving the following problem:

$$\begin{aligned} \underset{b}{Max}\ \pi(b) &\equiv pI(w,F)c - \lambda\psi(b) \\ s.t.\ b - m &\geq 0 \end{aligned} \tag{2}$$

Let b^* denote the value of b that maximizes the profit of the entrepreneur under bribing, and $\pi(b^*)$ be the optimal profit, with $\pi(b^*) = pI(w,F)c - \lambda\psi(b^*)$. The entrepreneur, holding all the bargaining power, will offer the minimum bribe which makes the politician accept it. Let $\overline{\pi}() \equiv qI(w,F)$, be the entrepreneur's expected profit in case of not bribing. Then, the equilibrium bribe can be characterized as follows:

Proposition 1 *An entrepreneur who decides to corrupt the politician offers a bribe $b^* = m$. Therefore whenever $\pi(m) \geq \overline{\pi}()$, we will observe bribing in the wind energy sector.*

For any $\pi < \overline{\pi}$, i.e. when the expected profit from bribing is lower than the one without bribing, the entrepreneur will not offer the politician any bribe. Substituting for $\pi()$ and $\overline{\pi}()$, the bribing condition can be rewritten as:

$$I(w,F) \geq \frac{\lambda\psi(m)}{\Delta POL} \tag{3}$$

where $\Delta POL \equiv (pc - q)$ is defined as an inverse measure of the quality of political istitutions in a given province. ΔPOL represents the difference in the probabilities of getting the permit and so, the net marginal return to bribing compared to non-bribing option, in terms of probabilities. This measure captures the quality of politicians or political institutions in general; the more a politician has been corrupted in the past, intervening in the bureaucratic process, the more she will be able to increase p compared to q, thanks to her connections and experience. Note that ΔPOL can also be interpreted as a measure of the efficiency of the bureaucratic process. Recalling the interpretation of λ, the following definition is introduced.

Definition 1 *Let* $\frac{\lambda\psi(m)}{(\Delta POL)}$*, be defined as a general index of the quality of institutions (GI), where the numerator refers to its social dimension (i.e. social capital), while the denominator measures its political component.*

GI denotes the threshold level for the expected revenues in the wind sector, such that the entrepreneur is indifferent between bribing and not bribing. Note that GI can be interpreted as an inverse measure of the extent of corruption or the likelihood to observe bribing, since it represents the set of possible values for which bribing is not profitable for the entrepreneur. Intuitively, the lower the general quality of institutions in a certain province is, the more likely it is to observe corrupted deals; if GI is sufficiently low, the net marginal return to bribing increases and, as a consequence, the incentive to bribe raises for entrepreneurs active in the wind energy sector. Summing up, taking into account both the political and the social dimension of the GI index, active entrepreneurs have more incentive to bribe the politicians in provinces where political institutions are badly functioning and bribing is socially tolerated (lower social capital), such that less effort is required to keep illegal deals secret.

1.1.2 Entry Decision

Turning to the first stage, we analyze the entry decision. An entrepreneur will decide to enter if the expected return to wind energy investment is higher than her reservation wage, which is equal to her ability type. Let us focus on non trivial solutions, studying the case where $\Delta POL > 0$. Taking into account the condition for bribing, the equilibrium is characterized, distinguishing between two cases:

Lemma 1 *(a) If* $I(w, F) \geqslant GI$*; all entrepreneurs with ability type* $\alpha \leqslant I(w, F)(\Delta POL) - \lambda\psi(m)$*, enter the wind energy market and choose the bribing option. (b) If* $I(w, F) < GI$*; all ability types with* $\alpha \leqslant I(w, F)q$*, enter the wind energy market and do not bribe.*

According to the model, two contrasting types of markets for wind energy can emerge in equilibrium; one in which all agents are corrupted, and the other where all agents behave honestly. First notice that, in both types of markets, the ability type of active entrepreneurs is increasing in the expected revenues of wind investment; as long as the return to investment does not increase much compared to the one in the non-wind sector, only the lower ability type will enter the renewable energy market. These low types would anyway achieve higher profits in the wind sector, thanks to the given amount of public incentives. Whether a province will experience a corrupted wind market or not, depends both on GI and the wind level. The equilibrium outcome, described in Lemma (1), is very intuitive; the level of wind, affecting the returns to investment, leads economic agents to enter the wind energy market. Whether this is correlated with an increase in bribing practices depends on institutional quality; if the politician's intervention significantly increases the probability to obtain the permission and corruption is generally tolerated in the society, high wind is correlated with a higher number of corrupted agents active in the wind energy market; if instead, without the direct intervention of the politician, the entrepreneur faces almost the same probability to get a permit and corruption is badly considered in the society, then a high wind level is correlated to a higher number of honest agents active in the market. From now onwards, we focus on the emergence of the corrupted type of market and study some related comparative statics. Since in the empirical part only the South regions of Italy will be considered, it is reasonable to assume that all provinces in our sample satisfy condition (a), due to a similar, and relatively low, quality of institutions. Let $corr$ be the extent of corruption in a province (belonging to group (a)); since, according to the previous lemma, all entrepreneurs entering the wind sector bribe the politician, we define the level of corruption as the number of entrepreneurs active in the market.

Definition 2 *Given lemma (1), the equilibrium level of corruption in a province belonging to group (a), can be defined as:*

$$corr^* = F\left[I(w,F)\Delta POL - \lambda\psi(m)\right] \tag{4}$$

where F is the Pdf of α. Given the assumption on α's distribution, we can simply rewrite (4) as:

$$corr^* = \left[I(w,F)\left(\Delta POL\right) - \lambda\psi(m)\right] \tag{5}$$

Consistent with the intuition provided above, corruption in this equilibrium depends both on the level of wind and the quality of institutions. In other words, taking the wind level constant, one should observe a higher level of corruption in provinces with worse institutional quality, both in its social and political dimension.

1.1.3 Comparative Statics

Some interesting comparative statics can be derived, in terms of wind level and the type of policy in place.

Lemma 2 *The equilibrium level of corruption is increasing both in the wind level and our measure of quality of political institutions. Formally:*

$$\frac{\partial corr^*}{\partial w} = I_w\left(\Delta POL\right), \frac{\partial corr^*}{\partial\left(\Delta POL\right)} = I(w,F), \text{ and} \tag{6}$$

$$\frac{\partial corr^*}{\partial w \partial\left(\Delta POL\right)} = \frac{\partial corr^*}{\partial\left(\Delta POL\right)\partial w} = I_w \geqslant 0 \tag{7}$$

Condition (7) shows the *complementarity* between windiness and the quality of political institutions, in determining the equilibrium level of corruption; considering two provinces with the same wind level but with a different quality of political institutions, one should expect a higher level of corruption in the province with worse political institutions. On the other hand, comparing two provinces with a similar quality of political institutions, but a different level of wind, one should expect more corruption in the high wind province. The intuition behind these results is simple; since the marginal return to bribing is increasing in the wind level, we should expect a higher number of entrepreneurs entering in high wind provinces and bribing the politician. The negative effect of windiness will be stronger in provinces characterized by a lower political quality. In the same way, a lower quality of political institutions increases the number of corrupted entrepreneurs in the market, and it does so more in high wind provinces that entail a larger margin of profit.

The next result provides interesting policy implications for the Italian case and elsewhere. In principle, a policy promoting renewables can be designed in two ways; i) increase in the subsidies to build the wind farm, through a *lump sum* transfer as development funds (F_1) or, ii) increase in the remuneration of the policy to the actual production, in our case proxied by wind level, which can be interpreted as the introduction of a market-based type of policy such as a feed in tariff or a tradeable certificate system (F_2).

Lemma 3 *Both an increase in the lump sum transfer and in the remuneration of the electricity generated increase the extent of corruption, with: a)* $\dfrac{\partial corr^*}{\partial F_1} = (\Delta POL)$ *and b)* $\dfrac{\partial corr^*}{\partial F_2} = w\,(\Delta POL)$.

If one looks at second order effects, the lemma generates an important result, pointing out a different impact of the two types of policy on the level of corruption. In particular, while an increase in the *lump sum* equally raises the level of corruption in all provinces with similar institutional quality, the introduction of the *market-based system* leads to a greater increase in corruption in provinces characterized by a higher wind level. The logic is the same as before; in general, higher amounts of public incentives increase the return to wind investments, and lead a larger number of agents to enter the market. However, if the quality of political institutions is low (as in the region analyzed in the empirical section), all the entrants opt for the bribing option and, as a consequence, the number of entrepreneurs involved in bribing becomes larger. Moreover, if the public incentive becomes more responsive to the actual energy generated (i.e. to the wind level), this effect becomes stronger in high wind provinces. This result shows that in the presence of poorly functioning institutions, a market based policy has a larger negative impact, particularly where the greatest efficiency gains could be obtained, namely in provinces with the highest producibility.

After having derived conditions on the entry and bribing decision of the entrepreneurs, we finally characterize the wind energy sector, analyzing the expected amount of investments in each province. Also in this stage, we focus on provinces belonging to group (a) in Lemma 1.

Definition 3 *The expected number of projects, $E(P)$, in a certain province, is defined as the total number of active entrepreneurs in the market, weighted by the probability to get the permit. In particular:*

$$E(P) = pc \int_0^{\overline{\alpha}} f(\alpha) d\alpha \tag{8}$$

Given that $\overline{\alpha} \equiv I(w, F)(\Delta POL) - \lambda\psi(m)$ and $f(\alpha) = 1$, previous expression becomes:

$$E(P) = pc\left[I(w,F)\left(\Delta POL\right) - \lambda\psi(m)\right] \tag{9}$$

Using the definition of corruption, we can rewrite (9), as:

$$E(P) = pc\left[corr\right] \tag{10}$$

Expression (10) points out that the expansion of the wind energy sector is a positive linear function of the level of corruption. In other words, marginal returns to corruption, in terms of authorized wind plants and installed capacity, are positive and constant. Recalling the complementarity between the wind level and the political institutions quality in determining the level of corruption, the following result can be derived.

Proposition 2 *The expected number of wind energy projects in a certain province positively depends on its level of corruption. In particular, i) given two provinces with the same wind level, the expected number of wind energy projects will be higher in the province with worse political institutions, and, ii) given two provinces with the same (low) quality of political institutions, the expansion of the wind energy sector will be greater in the higher wind province.*

As we have seen before, an increase in the returns to bribing (due to a change in the wind level, the policies or the quality of political institutions), leads a higher number of entrepreneurs to enter the wind energy sector and bribe the politicians. The level of corruption in equilibrium will be higher and, as a consequence, the actual number of wind projects put in place will increase too. Considering provinces where the quality of institutions is sufficiently low, this section highlights that not only the wind level but also the quality of institutions are crucial determinants of the development of the wind energy sector, through their effect on corruption.

1.2 Discussion

Using a simple model of corruption we have analyzed the main factors which can fuel bribing in the emerging market of wind energy. Given the data available, we cannot test all the model predictions and we will mainly focus on the role of the wind level in determining corruption and wind plant installations. Nonetheless, having data covering a sufficiently long time period, we can analyze the effects of the transition between the two major policy regimes implemented to promote wind energy. The main predictions of the theory which we take to the data are the following:

i) *Ceteris paribus*, the windiest provinces are more likely to experience corruption.

ii) The increase in the remuneration of wind investments, due to the introduction of a market-based policy regime, leads to an increase in the extent of corruption, especially in high-wind provinces.

iii) The number of wind energy projects in a given province increases with the extent of corruption.

As we have seen, the expansion of the wind energy sector is not only driven by the level of wind but also by the functioning of social and political institutions. This suggests that, comparing provinces with the same wind level, the number of wind projects should be higher in provinces where a larger number of agents have been involved in corruption practices, due to a poor quality of institutions. Among provinces with a similar (low) quality of institutions, the expansion of the wind sector should be greater in places where criminal association activity is more frequent due to a high level of wind and the associated expected revenues. A final remark needs to be made on our measure, ΔPOL. In principle, it can be considered a persistent element over the period we analyze, however it might actually change over time and increase with the number of corrupted deals in the wind energy sector; if, after concluding a certain number of (illegal) negotiations, the local politician becomes more skilled in obtaining the permits, ΔPOL would increase over time. In a dynamic perspective, this could imply the presence of a significant path dependence in the level of corruption in provinces characterized by a relatively low quality of political institutions and high wind level.

2 Background and Data

2.1 Wind Power Generation in Italy

The incentives schemes to renewables, including wind power, began in 1992, when a feed-in tariff known as CIP 6 was introduced to support renewables and "assimilated sources"[1]. The feed-in tariff, which is still in place, was calculated by the national energy incumbent ENEL and financed directly through the electricity bill. After the Italian energy market was liberalized at the end of the 1990s, the administration of the CIP6 and all the policies to support renewables were taken over by GSE (Gestore Servizi Elettrici S.p.A.). The feed-in tariff system managed to jump start investments which were important at a time of shortage of available power capacity, but also uncovered several flaws. In particular, the inclusion of"assimilated"sources - which included thermal co-generation - extended the scope, and thus the cost, of the scheme well beyond that of promoting truly renewable sources. Setting the right tariff that would ensure deployment of investment without allowing the extraction of excessive rents also proved difficult. Moreover, the scheme overlapped with additional incentives, in particular with national and European funds for economic development. Some of these funds essentially consisted of grants, or special loans, which aimed at helping with the construction of sites, and thus provided perverse incentives that remunerated the installed capacity and not the actual electricity produced.

[1] The terminology has allowed several other sources, including thermal co-generation, to be included among the beneficiaries of the feed-in tariff, which has undermined the effectiveness of the policy in promoting traditionally renewable energy. Though the exclusion of 'assimilated' sources from the incentives has been mandated in the European directive 2001/77/CE, a series of waivers have allowed this practice to resist to date.

In order to overcome these pitfalls, in 1999 a market-oriented mechanism based on tradable green certificates (known as 'Certificati Verdi', CV) was implemented, which required power producers and importers to have a minimum share of electricity generated by renewable sources. The quota was set for the initial date of operation in 2001 at 2%, gradually increasing over time (it is now 6% and expected to reach 7.5% in 2013). Green certificates can be exchanged on either the Italian electricity market or via bilateral contracts, and can last for several years (12 and 15 years if issued before and after 2007 respectively). In the initial phase, an excess of demand pushed the prices of the green certificates up, above 100Euro/MWh (see Table A). This induced a sizeable increase in the supply of renewable power, mostly wind, hydro and biomass, so that supply started exceeding the allocated quotas from 2006. In order to prevent prices from dropping too low, in 2008 the government intervened and established that the excess permits should be purchased by the GSE (at a cost calculated as the difference between 180Euro/MWh and the average market electricity price of the previous year). This has effectively turned the quota system back into a feed-in tariff one. In addition to the CV incentives, revenues also accrue for electricity generation, thanks to priority dispatch to the electricity market or alternatively to the option of selling electricity to the GSE at a minimum guaranteed price, set each year by the energy authority (this last practice is known as 'Ritiro Dedicato').

	average price (Euro/MWh)	Overall cost (Million Euros)
2003	98.9	243
2004	116.8	263
2005	130.9	332
2006	142.8	488
2007	99.0	306
2008	103.6	400

Table A. Green certificate market (source: GME and AEEG)

The financial incentive regime for investment in renewables in Italy appears to be advantageous by international standards. The Italian energy authority (AEEG) has estimated the cost of the green certificate trade system at 400 million Euros in 2008, with the prospect of passing to 1 billion in 2013. This adds to the aforementioned feed-in tariff scheme CIP 6, estimated at 2.4 billion Euros, though only 1 of which to real (and not assimilated, see note above) renewable sources. In addition, regional and provincial support schemes have also been put into place. As already mentioned, the most important ones for wind are those related to the structural development funds allocated to the disadvantaged areas of the European community and the Italian government (known as law 448/1992). In 2006, the last time this support was dispensed, wind power collected about 470 million Euros in grants or special loans. This level of support is also due to the problems relative to the authorization procedures, which are mostly the responsibility of local municipalities, and which appear to be very complicated and lengthy, a fact that can only be partially attributed to the complex nature of the Italian topography. This authorization bottleneck is responsible for considerable implied costs and entry barriers. Nonetheless, over time the contribution of wind power has managed to take off, totalling almost 5 GW in 2009, 98% of which is concentrated in the South of the country, which hosts the largest wind potential (see Figure 1). In terms of electricity production, wind has generated around 6500 MWh in 2009, roughly 2% of the national electricity consumption. This corresponds to an equivalent utilization factor of about 1300 hours/year, a rather low figure compared to international standards. The reasons for this low productivity are due to the features of the wind resources in the country, characterized by rather exhaustible high quality sites. Moreover, the generous incentives allow the construction of profitable wind parks in areas with rather low operating hours. These effects have led to a significant decline in the load factor, which for example was 25% higher than today in 2004. Virtually all the installed wind capacity is concentrated in the south of Italy, and especially in a handful of provinces. For example, the provinces of Foggia (FG), Benevento (BN) and Avellino (AV), which lie on the windy ridge of the south Appennines, host roughly one third of the whole national capacity (see Figure 2). These sites, together with the ones in Sardinia, were also the first to develop, and are characterized by higher utilization factors. More recently considerable capacity has also been added to the regions of Sicily and Calabria.

In 2009, the price of traded green certificates (CV) was 112 Euro/MWh, but given the condition of excess supply most negotiations actually occurred at the buy back price of GSE, which was set at 89 Euro/MWh. In addition, there are also some older wind parks that benefit from the feed-in tariff mechanism (CIP6). The overall incentives and electricity revenues of wind power are reported for the key regions in Table B. For good site locations, and efficient and modern wind turbines, the generation cost can be estimated in the range of 60-70 Euros/MWh, similar to the electricity price. Thus, the incentives via green certificates and feed-in tariff are essentially profits, though some additional costs such as royalties should also be factored in. Within the provinces, these rents are concentrated in a subset of municipalities, often of small size and located in areas with low population density; thus, the royalties that the wind parks can yield to the local authorities (either legally or illicitly)- in exchange for the construction authorization- can be considerable, enough to induce corruption practices. Until 2010, there were no official guidelines on the rules for determining such royalties, and these were left to the discretion of local authorities, without any national harmonization. In addition, region-wide energy plans have been introduced quite slowly, allowing for a quite unregulated environment, which for example has only been partially able to account for other factors such as the integration with the electricity grids.

Overall, the incentives to wind power generation in Italy appear to be quite significant, though it is important to recognize that they have fostered the deployment of wind electricity in the country. For the sake of our analysis, we assume that the regime change that the green certificate system brought about in 1999 (with effective use from 2001) can be considered the real turning point for policy. In the language of our model, this policy break has increased the return to wind investment $I(w, F)$, and thus motivated more illicit activities. Although, as we have seen in this section, policies supporting renewables were present in the country even before the turn of the century, there are various reasons to support the idea that the green certificate system represented a significant policy regime switch. First, the commitment to renewables of the European Union strengthened markedly around that time, culminating in the RES (Renewable Energy Support) directive which took effect in 2001 and set national indicative targets for renewable energy production from individual member states for the years 2010 and 2020. This increased the certainty of the policy support schemes for renewables, also providing a long term perspective in terms of quotas. Second, the liberalization of the Italian electricity market and the increased dynamics of the international energy markets, with oil prices starting to rise in 1999 and especially after 2001, provided an increased opportunity to enter a sector which was traditionally monopolistic. Finally, the wind turbine technology improved dramatically over time: the investment costs dropped considerably, especially through the 1990s, from roughly 2000 to 1000 US$/kW. The reliability of the technology also increased, as it became better suited to handle times of strong winds. Thus, we believe that the green certificate (CV) system marked a clear change in terms of public support to the deployment of wind power.

The questions of interest for us are, a) whether in general, there is a positive correlation between the development of the wind energy sector and corruption and, b) if corruption practices, fueled by the expectation of huge profits (mostly due to public incentives), are partly responsible for the large expansion of the sector.

	CV Incentive	CIP6 Incentive	Electricity revenues
Campania	82.3	22.9	78.7
Puglia	124.3	31.6	112.8
Basilicata	23.6	19.2	27.1
Calabria	37.1	0	28.9
Sicilia	126.5	0	96.7
Sardegna	51.3	19.4	47.6
Italy	*489*	*112.9*	*457.9*

Table B. Incentives (Millions of Euros) by region for wind power in 2009 (for both the CV and CIP6 instruments), and revenues from electricity sales (source GSE).

2.2 Data Description

We use a panel dataset with annual observations on the 34 provinces of the South Italian region for the period 1990-2007. The data source for the measures of criminal activity is the Italian statistical institute (ISTAT, "Statistiche Giudiziarie Penali"). To compute the extent of corruption we use two measures: a) criminal association activity (CrimAssoc), representing the number of "Criminal Association" offenses brought to justice by the five sectors of the police force, and b) total criminal association (TCrimAssoc), the sum of the offenses related to "Criminal Association" and "Criminal Association of Mafia type". Values are reported as the incidence over 100,000 inhabitants. In the robustness section, a third measure of criminal activity, the index of violent crime, is used. This is computed on the basis of the offenses brought to justice by the five sectors of the police force regarding the following crimes: massacre, homicides, infanticide, lesions, sexual assaults, kidnapping, assassination attempts and theft. Unfortunately, the criminal activity dataset has been discontinued after 2007, and we were thus not able to include the most recent years.

The data on real GDP per capita at the regional level are provided by CRENOS, while the data source for secondary school enrollment at the province level is ISTAT. The expected number of projects, $E(P)$, is proxied by the number of wind plants and the total capacity installed; for this purpose, since official statistics at the provincial level are only available from 2008 onwards, we rely on a dataset compiled by ANEV (National Association for Wind Energy). This covers the totality of wind parks, and provides data on the location, capacity, size, year of initial operation, and ownership. Wind level, w, is computed with data coming from the Italian Wind Atlas constructed by ERSE, which provides the average wind level (at different meters above sea level) per square kilometer for the whole Italian territory. In order to assign each province in our sample to a certain class of wind, we construct a measure of windiness. In particular, we classify the provinces according to their wind level, taking into account the size of the province; considering the quartiles of the wind distribution, we divide the wind measure in four classes, then we compute the fraction of total provincial area lying above the third quartile. For example the 8 windiest provinces are the ones with more than 25% of their area above the third quartile of wind distribution, the following 9 windiest provinces have between 17% and 25% of their area lying above the third quartile of wind distribution, and so on.

3 Methodology and Results

The main hypothesis we want to test is whether the presence of a renewable natural resource, namely wind energy, can favor the spread of corruption practices, especially in the presence of public policies. A dependent question is whether the increase in the expected returns of investments in wind energy drive economic agents to engage more in rent-seeking activities. As we have seen, the profits in the sector started to increase after the introduction of the green certificate CV system, when a significant amount of public incentives were granted to the wind energy sector, so we would expect an increase in corruption especially after that period. But what are the effects of this increase in corruption on the actual expansion of the wind energy sector? To answer this question, in the last part of the empirical exercise we test the third prediction of our analytical model, namely the positive association between the degree of corruption and the actual expansion of the wind sector.

In general it is very difficult to empirically address this set of issues since there may be several confounding factors affecting the level of criminal association activity and it is even more difficult to identify the forces at work. As we have seen, the model gives the wind level and the quality of institutions a central role in determining the extent of corruption. Exploiting the exogenous variation in wind level, we use a difference-in-difference strategy. In particular, we compare the windiest provinces in the area of the South of Italy (*treatment group*) to the neighboring provinces (*control group*) over the whole time sample, focusing on the policy break of 1999-2001, the years in which the tradable green certificate (CV) legislation passed and actually entered into force.

We compare the treatment and the control group in sub periods, because returns to wind energy, which according to the model induce corruption, increased especially after 1999, but have fluctuated over time. As mentioned above, in order to identify the windiest provinces we use a very accurate database to construct a measure of average windiness that takes into account the fraction of total provincial area lying above the third quartile of the wind resource distribution. Our treatment group includes eight provinces[2], whereas the control group is composed of eleven neighboring provinces, so as to avoid the comparison between excessively heterogeneous groups. The choice of the treatment group is not an obvious one, since the wind threshold can be set at different levels. We have thus also experimented with a larger set of 14 provinces. However, as already noted, there is a handful of provinces that by far hosts the greatest wind potential, and only very recently this has begun to expand to other ones. In addition, since our analysis stops in 2007, the restricted group of 8 provinces is likely to be the most meaningful group to look at. We do not have data to measure the quality of institutions, but since this can be considered a persistent element, we partly solve the omitted variable problem using province fixed effects.

We begin our empirical investigation by testing the model predictions i) and ii), namely whether windier provinces are more likely to experience corruption, and whether the introduction of a new policy regime further increased corruption in windy provinces. In section 3.1 we will study the trend in criminal association activity in the treatment compare to the control group and some robustness checks will be provided in section 3.2. Then we turn to the second part of the analysis where we model the link between the level of corruption and the expansion of the wind energy sector (model prediction iii)). The empirical methodology will be introduced in section 3.3, then our empirical results follow (section 3.4).

[2] AV, BN, CA, CZ, FG, PZ, SS, TP

3.1 Evidence on Criminal Association

Let TG denote the treatment group, then in order to study the behavior of the treatment group over time, we estimate the following equation:

$$CrimAssoc_{it} = \sum_{t \in T} \boldsymbol{\alpha}_{t\_t+3} TG_{i_{t\_t+3}} + \mathbf{x}_{it}\ \boldsymbol{\delta} + \gamma_i\ trend_{it} + u_i + v_t + \varepsilon_{it} \qquad \text{(a)}$$

Where $CrimAssoc_{it}$ measures the number of charges made by police forces for criminal association offences in province i at time t, TG_{t_t+3} is a dummy equal to one for the treated provinces between time t and $t+3$, and zero otherwise, $\mathbf{x}_{it}$ is a vector of control variables, namely regional unemployment rate and secondary school enrollment at the province level, $trend_{it}$ is a province specific trend which accounts for time varying unobservable factors, u_i and v_t are province and year fixed effects and ϵ_{it} is an observation specific error term.

Notice that since the treatment is determined according to the wind level, it has to be considered exogenous. In particular the empirical strategy is based on the identification assumption that there are no unobservable factors, correlated with both criminal association activity and wind level. Formally, $Cov(TG_{i_{t\_t+j}}, \varepsilon_{it}) = 0, \forall j$, must hold.

The specification in (a) allows us to study the trend of criminal association in the treatment group throughout the four time windows of 4 years, 1991-1994, 1995-1998, 1999-2002, 2003-2007. Given our hypothesis we expect the coefficients of interest, $\{\alpha_{t\_t+3}\}_{t \in T}$ to become significant after 1999.

Since we want to focus on the period following the approval of the Green Certificates system (CV), we also split the post CV period (after 1999) in time intervals, and we estimate the following equation (b):

$$CrimAssoc_{it} = \sum_{t \geqslant 1999} \beta_{t\_t+j} TG_{i_{t\_t+j}} + \mathbf{x}_{it}\ \boldsymbol{\delta} + \gamma_i trend_{it} + u_i + v_t + \varepsilon_{it} \tag{b}$$

Similarly to (a), $TG_{t,t+j}$ is a dummy equal to one for the treated provinces, between time t and $t+j$, with $t \geqslant 1999$, and zero otherwise. We run two specifications of the equation. (b1): in the first case $j = 3$, such that the post period is divided in two time windows, 1999-2002, 2003-2007. (b2): in the second case we set $j = 1$, considering four time windows (1999-2000, 2001-2002, 2003-2004, 2005-2007). The coefficients of interest are $\{\beta_t\}_{t \geqslant 1999}$. We are confident that equations (a) and (b) do not suffer from an endogeneity problem; the wind level in a certain province is an exogenous factor. Moreover, once the province, the year fixed effects and the province specific time trends are included, it is difficult to imagine any unobservable factor correlated with both our dependent variable and the level of wind.

The final specification used to study the trend of our variables of interest in the treated provinces is the one suggested by Bertrand et al. (2004) to address the problem of serial correlation which might affect the dependent variables. In particular, we take the average of all variables before and after 1999 and we estimate the following equation in a panel with a time dimension equal to two:

$$CrimAssoc_{it} = \alpha\ POST_{i99\_05} + \mathbf{x}_{it}\boldsymbol{\delta} + u_i + v_t + \varepsilon_{it} \tag{c}$$

Where $POST$ is a dummy equal to one for the treated provinces in the second period, and zero otherwise. To keep the before and after period sufficiently balanced, we restrict the sample to ten years (1995-2005), such that the averages correspond to the period 1995-1998 and 1999-2005, respectively.

3.2 Results

We start by providing some inspection and visualization of our database. Descriptive statistics for all the 34 provinces of the South macro area are reported in Table 1. Figure 3 shows the average criminal association activity in the treated provinces (blue line) compared to the control provinces (red line). Both indicate that the gap between the two groups begins to shrink in 1997 only to completely disappears around 2004. A similar pattern for total criminal association activity is shown in Figure 4. Since the method of reporting offenses changed in 2004 (visible as a drop in both treatment and control), in Figure 5 we show the pattern of the ratio between the values in the control and treatment groups, for both measures of criminal activity. Both ratios are characterized by a visible declining trend, from roughly 2 in the first half of the 1990s (e.g. meaning that the control groups had twice as many charges per person) to parity in the later years. However, one can also notice considerable variability and a change in sign for the latest data point available.

Figure 6 displays the development of the wind energy sector in the treated and control provinces respectively, in terms of total capacity installed measured in MegaWatts. As expected, the windier provinces (blue line) have been characterized by a higher level of installed capacity relative to the control provinces (red line) in the whole period. The most significant acceleration occurred after 1999 and 2002, which is not surprising considering that the CV incentive system was established in 1999 and implemented in 2001. Results in Table 2 are consistent with previous figures; control provinces display a significant higher level of criminal association activity compared to treated provinces before 1999, but the difference shrinks and becomes insignificant in the post treatment period. On the contrary, the difference in wind plants and capacity installed between the treatment and control provinces magnifies after 1999. In addition, control and treatment groups appear to be similar in other fundamentals, namely real GDP per capita and secondary school enrollment, both before and after 1999.

Turning to the estimation exercise, Table 3 reports estimates of equations (a) and (b1) for criminal association activity in the first two columns, and for total criminal association activity in columns 3 and 4. All columns report OLS estimates with a full set of year, province fixed effects and province specific time trends. Results for criminal association activity show that one of our coefficients of interest, belonging to $\{\alpha_{t\_t+3}\}_{t\in T}$ in equation (a), is positive and significant; in particular, we find a significant increase in criminal association activity in the treatment group in the period 2003-2007. Column 3 displays a similar trend for total criminal association activity, but we also find a positive and significant coefficient associated to the 1999-2002 period. The estimation results for equation (b1) in which we only focus on the post-1999 period and which was divided into two time windows are shown in Columns 2 and 4; for both measures of criminal association activity, all coefficients of interest belonging to $\{\beta_t\}_{t\geqslant 1999}$ are positive and significant.

Columns 1 and 3 of Table 4 report the results for equation (b2), where the post-1999 period is divided into four time windows; for both dependent variables, the coefficients increase over time in significance and magnitude. In particular, from column 1, it is evident that the treatment group experiences a progressively higher increase in criminal association activity compared to the control group. Columns 2 and 4 of Table 4 display the results of specification (c), the last at this stage of analysis. Recall that we collapse the panel in two time periods (1995-1998, 1999-2007), a method suggested by Bertrand et al. (2004) which represents a simple remedy if variables of interest are serially correlated. Notice that α, the coefficient of interest, is marginally significant both for total criminal association and for criminal association. As described in the model, corruption is driven by the revenues in the wind energy sector. Although the revenues increase substantially after 1999, their trend oscillates over time both before and after 1999. Therefore it is not surprising to find a smaller effect on corruption when looking at long time periods, while it makes more sense to focus on shorter time windows.

All in all, the empirical results in this section are consistent with predictions i) and ii) of the model, suggesting that after 1999 the windiest provinces experienced a significant increase in both measures of criminal association activity, compared to the neighboring control provinces. In an area characterized by weak socio-political institutions, the introduction of the new and more favorable policy regime system had a stronger negative effect (in terms of corruption), especially in the provinces with the highest potential for efficiency gains.

3.2.1 Robustness

Despite a set of strong empirical results, at this stage we cannot completely rule out the presence of an omitted variables bias. In particular, the trend in criminal association activity we observe in the treatment group might be due to a spillover effect from the neighboring provinces. In the next two sections we provide a robustness analysis to address this issue. One could also be concerned about the fact that the measure we use for criminal association activity, indicating the official number of reported offences, might capture the investigation efforts made by the police rather than the actual level of criminal activity. However we do not think this represents a problem; first, the provinces in our sample are very similar in several institutional and economic dimensions (see Table 2), so we do not see any reason to believe there is a systematic over (under) -reporting of offences in our treatment (control) provinces. Second and most important, the inclusion of province fixed effects and time trends also allows for the presence of a persistent and/or time varying, province specific bias in crime recording by the police.

Catching-up between treatment and control? Following Gennaioli et al.(2010), we change our measure of criminal activity to understand whether we are merely capturing a general diffusion of criminal behavior which does not depend on the expectation of rents in the wind energy sector. For this purpose we consider an index of violent crime as described in Section 2. Figure 7 displays the pattern of the violent crime index in the treatment group (blue line) compared to the control group (red line). The graph shows that the gap between the two groups remains constant throughout the period and increases after 2004. In Figure 8 we compare the ratio between the level of our three measures of criminal activity in the control and the treated group; the comparison is quite striking since we do not find the same decreasing pattern in the ratio of the Violent crime index as in the two ratios of criminal association activity.

As an additional step, we also re-estimate equation (a)-(c), changing our dependent variable with the index of violent crime. Results in Table 9 show that in all specifications the coefficients of interest are insignificant and eventually negative, showing a similar trend of the violent crime index in the treated provinces compared to the control provinces. This evidence allows us to reject with confidence the "spillover effect"or "catching-up"explanation, suggesting that in the period under consideration, the treatment group did not experience a general increase in criminal activity.

Using the Actual Wind Measure As noticed above, our results might merely capture the impact of other factors characterizing the treatment group. To address this issue we repeat all the specifications above considering the actual level of our index of windiness; in particular, instead of using the treatment dummy TG_i, we interact TG_i with the value of the wind index in province i, and now use TG_W_i to run the same set of regressions. In this case our identification assumption implies $Cov(TG\_W_{i_{t\_t+3}}, \varepsilon_{it}) = 0$. In Table 7-8 and in Table 10 (for violent crime), we report results for specifications (a)-(c) under this additional specification. Results are consistent with those in Table 3-4 and Table 9 (for violent crime), and we find the effects to be even stronger. These findings provide us with sufficient confidence that we are correctly identifying the impact of the wind level of our treatment group.

3.3 Wind Energy Sector

The aim of this section is to empirically test the third prediction of our theoretical framework. In particular, we try to identify the main drivers of the expansion of the wind energy sector. The mechanism described in the model (and supported by anecdotal evidence) is the following: economic and political agents, expecting a significant increase in the returns to investments in the wind energy sector, started to set up illegal networks (criminal associations). In this way, the entrepreneurs quickly obtained concessions and permits for the installation of wind plants, earning, as a consequence, the associated profits, while local politicians gained consistent bribes in exchange. If this has actually been the mechanism at work, we would expect to find a higher expansion of the wind energy sector in the provinces characterized by a higher level of criminal association activity.

In the model outlined in Section 2 we have seen that corruption practices spread where expected returns to investment are higher (i.e. in provinces with a high wind level) and the quality of institutions is relatively low (*complementarity*). If that is the case, then one should observe that: 1) among provinces with the same level of wind, the expansion of the sector has been greater in provinces with a poor quality of institutions, which fueled corruption practices and, 2) among provinces with a similar (low) quality of institutions, the wind sector developed more in provinces characterized by a high level of wind and so of expected revenues. In addition, this effect should be stronger after 1999, when expected returns of the investment significantly increased. Despite the lack of data on institutional quality, we address the second prediction, exploiting the fact that the provinces in our sample are very similar on institutional dimensions; analyzing groups of provinces with different wind level, we then expect to find a significant (positive) correlation between corruption and the expansion of the wind energy sector for the windiest groups.

Measuring the size of the wind energy sector with the total installed capacity, we analyze whether the level of criminal association activity at time $t-1$ in province i, is correlated with the total installed capacity (MW) in the same province at time t, and how this correlation varies for provinces with different wind levels. In the model, the level of corruption is associated with the expected amount of authorized capacity (number of wind plants), but in the data we observe the actual capacity installed (or wind plants built). Since it is reasonable to assume at least a one year period between authorization and installation, we choose to include the lagged value of criminal association. In this section, the baseline specification is the following:

$$Capacity_{it} = \alpha\ Capacity_{it-1} + \beta\ CrimAssoc_{it-1} + \gamma\ Inter\_CrimAssoc_{it} + x_{it}\ \delta + \gamma_i\ trend_{it} + \varepsilon_{it} \tag{d}$$

Where $Inter\_CrimAssoc_{it}$ represents an interaction term between a post-1999 dummy (=1 for every year between 1999 and 2007), and the lagged value of criminal association activity. ϵ_{it} represents the error term, which in this case is $\epsilon_{it} = u_i + v_{it}$, where u_i is a province specific effect and v_{it} is an observation specific error. Notice that we included the lagged dependent variable since $Capacity$ is characterized by high persistency; indeed our measure of Capacity also accounts for the enlargement of an existing wind park, in terms of Megawatts added. Moreover, given the limited space available in a province for new plants, it is reasonable to assume that existing installations, both in terms of capacity and number of wind parks, influence the installation of future ones.

Since the presence of the lagged dependent variable leads to autocorrelation, we implement the Arellano-Bond (1991) method, estimating equations in first differences and using lagged levels of the dependent variable as instruments. We also run the same regression using $Wind\ Plants$ as a dependent variable and $TCrimAssoc$ as an explanatory variable. The coefficients of interest are β and γ; they illustrate whether criminal association activity influences wind power installations and if this occurred more often after 1999, when the expected returns to wind energy started to increase and so did the attractivity of the sector. We first estimate equation (d) for all the provinces in the sample, then we repeat the estimation separately for the treatment group and for the second 9 windiest provinces, respectively.

To further study the complementarity between windiness and institutional quality, as a second step, we estimate the following equation:

$$\begin{aligned} Capacity_{it} \;=\; & \alpha\ Capacity_{it-1} + \beta\ TG\_CrimAssoc_{it-1} + \gamma\ InterTG\_CrimAssoc_{it-1} + \\ & + x_{it}\ \delta + \gamma_i\ trend_{it} + \varepsilon_{it} \end{aligned} \qquad \text{(e)}$$

Where $InterTG\_CrimAssoc_{it-1}$ represents an interaction term between the post 1999 dummy and the lagged value of criminal association activity in the treatment group, $TG\_CrimAssoc_{it-1}$. Also in this case, the coefficients of interest are β and γ. As before, they illustrate whether criminal association activity influences wind power installations and whether this occurred more often after 1999. However, in comparison to (d), we evaluate whether this correlations are stronger for the treatment group, thus for high-wind provinces, than for: i) the neighboring provinces of the control group and, ii) the 9 provinces with a lower wind level (the ones with a value of wind index between the second and the third quartile). Analyzing the behavior of the two windiest groups of provinces, we can assess more precisely the validity of our prediction; indeed we are able to draw conclusions about the effect of criminal association activity on wind energy installations, for groups of provinces with a different wind level.

3.4 Results

Table 5 reports the estimation results of equation (d) [3]. We look at the simple correlation between the lagged value of criminal association and the total capacity installed, considering all 34 provinces

[3] We only present the results for criminal association activity and installed capacity. Tables for total criminal association and wind plants are available upon request.

in the Center South region in columns 1 and 2, the treatment group in columns 3 and 4 and, in the last two columns, the second 9 windiest provinces. In columns 1, 3 and 5, only the lagged value of criminal association activity is included, while in the second, fourth and sixth column, the baseline specification is enriched with an interaction term to account for the effect of the lagged value of criminal association in the post 1999 period. When we consider the whole sample and the treatment group (columns 1-4), the coefficient of the lagged value of criminal association is positive and significant in the baseline specification but becomes insignificant (or marginally significant) in columns 2 and 4, where the interaction $Inter\_CrimAssoc$ is always positive and significant. This implies that the effect of lagged criminal association activity on total installed capacity is higher after 1999, and this effect appears to be particularly pronounced for the 8 windiest provinces of the treatment group. On the contrary, coefficients of interest are insignificant and much lower when the less windy provinces are considered (columns 5-6). Results in Table 5 show that the level of criminal association at time $t-1$ better predicts the total installed capacity at time t, in the windiest provinces, especially after 1999.

In Table 6 we estimate equation (e), comparing the treatment group, first with the control group and then with the second 9 windiest provinces. In the first two columns we consider again our original sample comprising 19 provinces; it is clear that the lagged value of criminal association activity positively (and significantly) affects the total installed capacity in the treated provinces more than in the control provinces, in the post 1999 period. The same effects, with a similar magnitude, result from columns 3 and 4, where we compare the 8 windiest provinces (treatment group) to the second 9 windiest provinces. Also in this case, the correlation between the lagged value of criminal association activity and the total installed capacity is higher in treated provinces than in control provinces (with a stronger effect after 1999, see columns 2 and 4). These results are quite striking; they indicate that the positive correlation between the level of criminal association activity at time $t-1$, and the total installed capacity at time t, is stronger in the high wind provinces of the treatment group, with a rise of this effect after 1999. Recalling complementarity and that provinces in the South of Italy display a similar quality of institutions, these results document the fact that the wind sector developed more in provinces with higher criminal association activity fueled by a high wind level and by the associated expected revenues.

Overall results in Tables 5-6 strongly support the validity of prediction iii) of our model, showing that the number of wind energy projects increases with the extent of corruption, and, the magnitude of this correlation changes when we compare provinces with different wind level. In particular, in high wind provinces, a greater number of agents, motivated by the high expected profits, engaged in criminal association activity, favoring the expansion of the wind energy sector.

Notice that previous evidence might also be driven by the different degree of heterogeneity in the quality of institutions of different groups of provinces; in particular, there could be a certain heterogeneity in institutional features among the provinces of the treatment group, with some provinces having poorer institutions that fostered a higher level of corruption, while the provinces of the control group should be characterized by a more homogeneous institutional quality. Unfortunately given the lack of data on institutional quality we cannot address this issue; however, taking into account that Southern provinces share a similar institutional background, we strongly believe that our evidence is mainly driven by variation in the wind level.

Summing up, the estimates from the baseline specification (i.e. without the interaction term) generally show a positive and statistically significant correlation between the lagged values of our measures of crime and the level of installed capacity. Once we include the interaction terms, we always find that this relation is stronger after 1999 and among the windiest provinces. We can conclude that, in provinces where economic agents and bureaucrats, motivated by the high expected revenues, have been better "organized" and ready to engage in criminal association activity (resulting in more permits and concessions), the expansion of the wind energy sector has been higher. A word of caution is needed regarding the evidence we find in this section. These results might be biased due to omitted variables or simultaneity; as already pointed out, the first type of bias would arise if there is an unobserved factor correlated with both the level of criminal association activity and the development of the wind energy sector, while the second type of bias arises if our variables of interest are jointly determined, or in other words, each of them exerts an effect on the other. In part, we address these problems adding the lagged value of criminal association as an explanatory variable. Moreover, the inclusion of a full set of fixed effects as well as province specific time trends, and the fact that the treatment group is exogenously determined, mitigate concerns of endogeneity.

4 Conclusions

Recent anecdotal evidence reports the diffusion of corruption practices in the renewable energy sector, especially in the wind energy sector. In Italy, several inquiries have looked into corrupt practices and bribes conceived with the aim of building wind farms and appropriating the associated public support. Taking a political economy approach, this paper has analyzed the link between public support schemes for renewable energy and the potential scope for rent seeking and corruption. To the best of our knowledge, this study is one of the first attempts to determine whether there is a curse related to a renewable energy resource. This is a relevant topic since over the past years several countries implemented public support policies meant to promote renewables, which are now being evaluated.

Using a model of corruption, we show that windier provinces are more likely to experience corruption, especially after the introduction of a more favorable policy regime. Moreover, the number of wind energy projects in a given province increases with the extent of corruption. We test these results using a panel data of Italian provinces in the South region for the period 1990-2007, and are able to find evidence that supports our model, establishing that in the presence of poor institutions, a curse does exist also in the case of wind energy. The main findings are the following: i) criminal association activity increases more in high-wind provinces and especially after the introduction of a favorable market-based regime and, ii) the expansion of the wind energy sector is positively correlated with the extent of criminal association activity; precisely, both the level of wind and the functioning of social and political institutions play a crucial role, through their effect on corruption. In particular we find that, comparing provinces with a similar (low) quality of institutions, the development of the wind sector has been greater in high wind provinces where economic agents and bureaucrats, motivated by large expected profits, have engaged more in criminal association activity. Overall, the paper points out that, where socio-political institutions are poorly functioning, even efficient policies can have an adverse impact, especially in places with the highest potential for efficiency gains. These results draw clear normative implications, particularly for countries which are characterized by abundant renewable resources and by weak institutions.

Since this analysis has been tested on the case of wind power, the external validity of our study cannot be generalized to other types of renewables, such as solar or photovoltaic. In principle, it could be the case that wind energy, being capital intensive, naturally leads to oligopolistic markets, where the establishment of connections between few entrepreneurs and local bureaucrats is easier. Furthermore, when compared to solar, the authorization process is more difficult, since wind farms necessitate vast areas and have in general a bigger environmental impact; as a consequence, local politicians have more discretionary power and the room for corruption is larger. Our research agenda comprises the study of other types of renewable resources, like solar, to address this set of issues. We also plan to analyze the link between the expansion of the renewable energy sector and the budgets of local administrations, to check whether administrations characterized by a high level of debt have been more willing to grant permissions or rent out public land for PVS/wind energy installations, regardless of the actual level of wind/solar energy or producibility of a certain area. In general, assessing the role of political economy for the case of renewable energy is a fruitful area for future research since several issues remain unexplored, and at the same time it is becoming a relevant sector of the economy whose efficient control commands for in depth analysis of all the main economic incentives at play.

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Figure 1.Map of wind resources in Italy (speed at 75m height, source CESI)

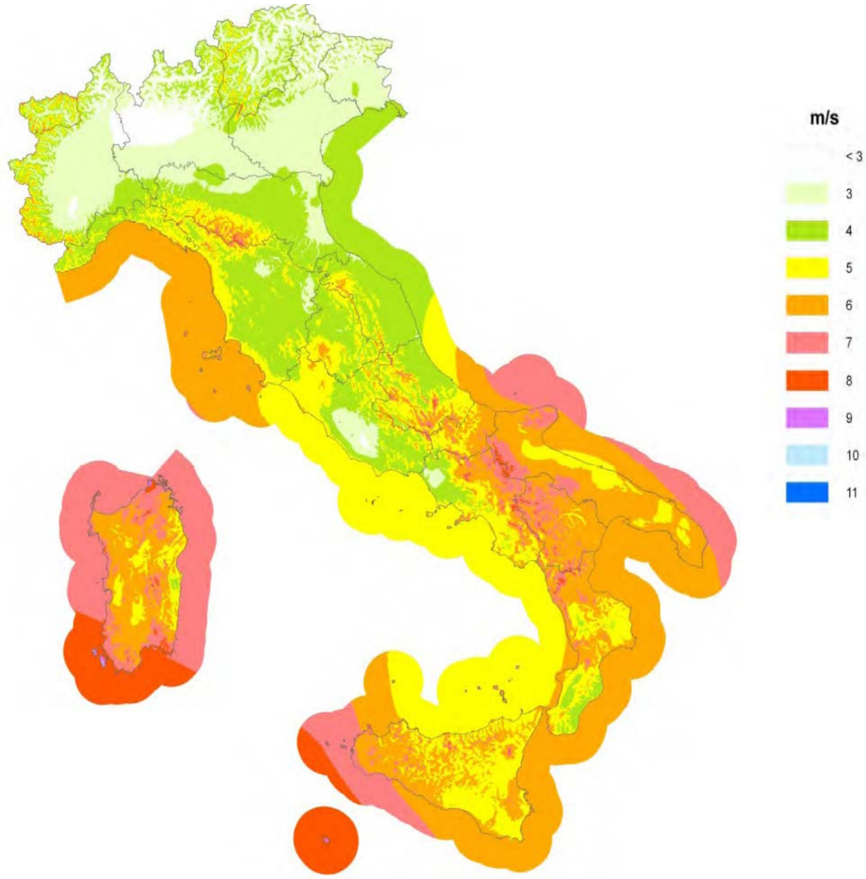


Figure 2.Distribution of wind installed capacity by province at the end of 2009 (source GSE)

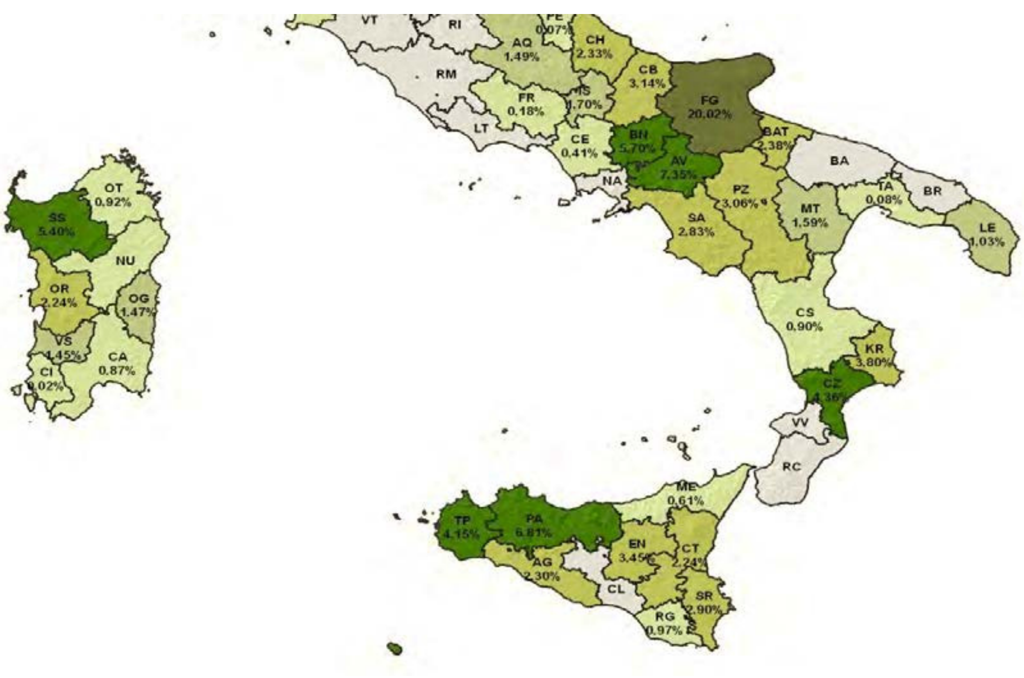


Figure 3. Criminal Association Activity (number of offences over 100,000 inhabitants)[1]

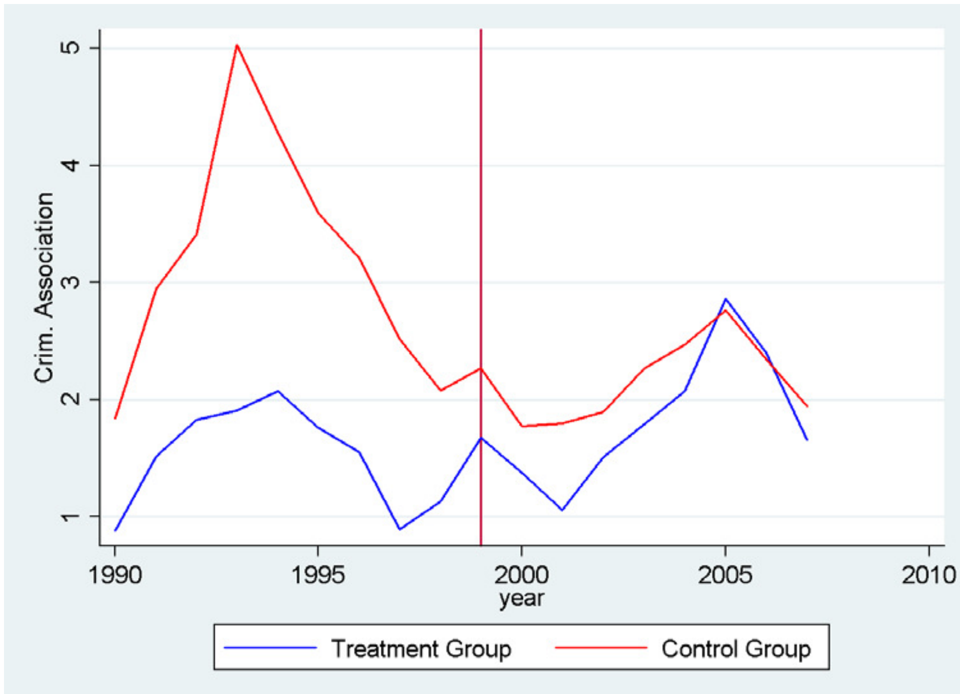
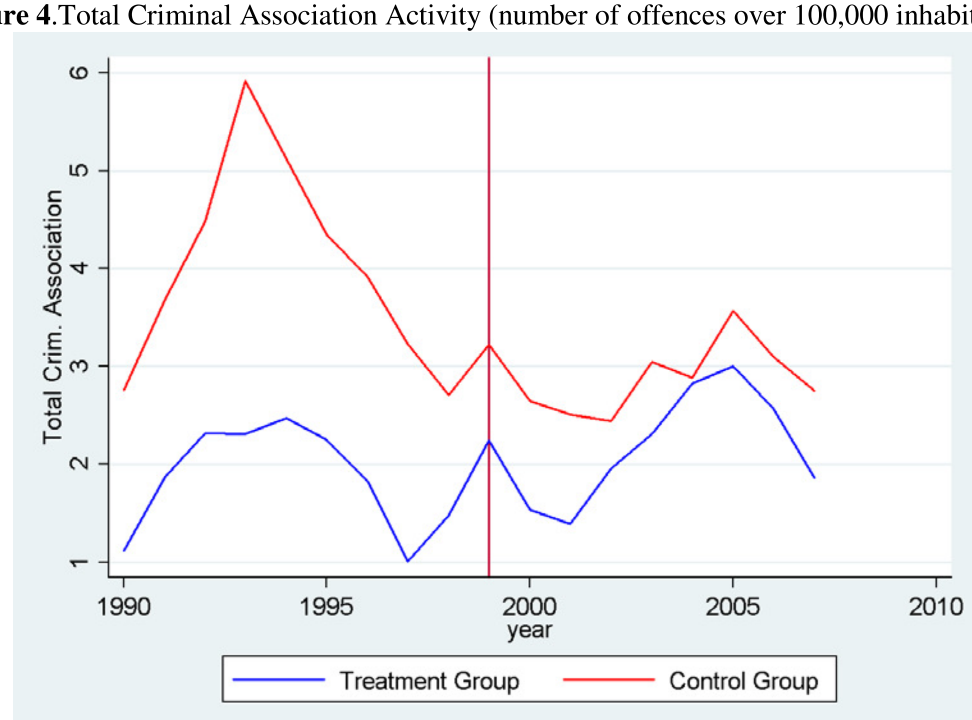


Figure 4.Total Criminal Association Activity (number of offences over 100,000 inhabitants)[1]



[1] **Treatment Group**: Avellino,Benevento,Campobasso,Cosenza,Foggia,Potenza,Sassari,Trapani. **Control Group**: eleven neighbouring provinces. Notice that in **1999** the tradable green certificates system (`Certificati Verdi', CV) was introduced.

Figure 5. Ratios between the level of both measures of criminal association activity in the control and treated provinces[2]

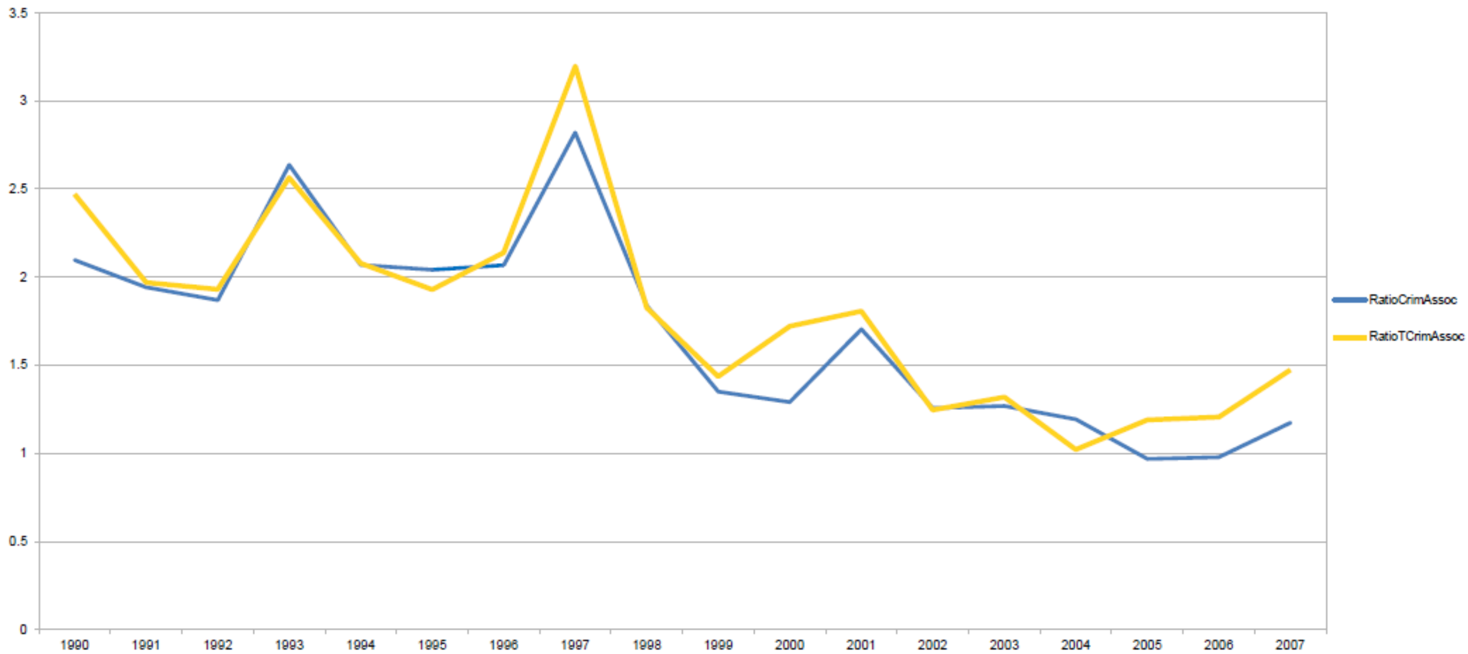
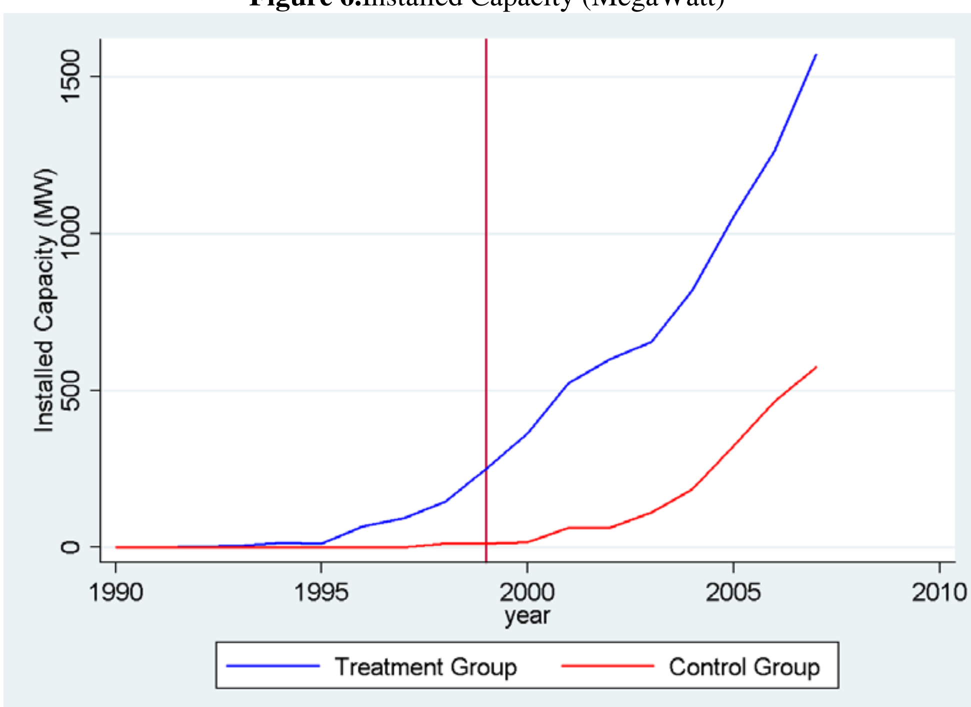


Figure 6. Installed Capacity (MegaWatt)[3]



[2,3] **Treatment Group**: Avellino, Benevento, Campobasso, Cosenza, Foggia, Potenza, Sassari, Trapani. **Control Group**: eleven neighbouring provinces. **CrimAssoc** denotes Criminal Association activity. **TCrimAssoc** denotes Total Criminal Association activity (sum of simple criminal association and criminal association of Mafia type).

TABLE 1.Descriptive Statistics

Variables	Mean
CrimAssoc	1.939 (1.623)
TCrimAssoc	2.463 (1.906)
Violent crime Index	120.465 (85.305)
Wind_Index	0.307 (0.164)
Wind Plants	3.040 (5.922)
Capacity (MW)	27.097 (68.928)
GDP_pc	9.495 (0.127)
School	0.819 (0.116)
Population	744266.8 (663687.4)
N. Obs.	342

Standard deviations in parentheses.

TABLE 2. Balanced Test

	Treated Provinces Mean	Non-Treated Provinces Mean	Mean difference (p-value)
	(1)	(2)	(3)
Panel A. Province Characteristics Before 1999			
CrimAssoc	1.371 (.592)	2.147 (1.153)	0.10
TCrimAssoc	1.681 (.676)	2.735 (1.549)	0.09
Violent crime Index	64.571 (18.274)	117.773 (71.954)	0.05
Wind_Index	0.475 (0.102)	0.186 (0.073)	0
Wind Plants	2.937 (2.363)	0.136 (.258)	0.000
Capacity (MW)	9.942 (15.184)	0.351 (.826)	0.04
GDP_pc	9.483 (0.094)	9.475 (0.092)	0.855
School	0.814 (0.065)	0.777 (0.079)	0.302
Population	531535 (180685.7)	904338.7 (868909.6)	0.251
Panel B. Province Characteristics After 1998			
CrimAssoc	1.896 (1.394)	1.962 (0.838)	0.899
TCrimAssoc	2.355 (1.392)	2.587 (1.126)	0.693
Violent crime Index	99.994 (22.272)	149.669 (103.49)	0.202
Wind_Index	0.475 (0.102)	0.186 (0.073)	0
Wind Plants	8.678 (7.236)	1.233 (1.229)	0.003
Capacity (MW)	76.127 (78.579)	10.064 (12.891)	0.013
GDP_pc	9.511 (0.723)	9.518 (0.129)	0.897
School	0.907 (0.042)	0.874 (0.072)	0.270
Population	525643.4 (178791.6)	908245 (868212.6)	0.239
Obs.	8	11	

Standard deviations in parentheses in columns (1) and (2)

TABLE 3. Trend in simple and total criminal association in the whole period (1990-2007). [equations (a) and (b1)]

VARIABLES	(1) CrimAssoc	(2) CrimAssoc	(3) TCrimAssoc	(4) TCrimAssoc
TG_{91_94}	0.240		0.726	
	(0.656)		(0.760)	
TG_{95_98}	0.358		0.952	
	(0.688)		(0.702)	
TG_{99_02}	1.293	0.842*	2.166*	0.973*
	(0.976)	(0.435)	(1.102)	(0.549)
TG_{03_07}	2.289*	1.710***	3.405**	1.902**
	(1.275)	(0.515)	(1.563)	(0.762)
School	1.510	1.531	2.097	2.112
	(3.402)	(3.379)	(3.759)	(3.686)
GDP_pc	0.216	0.224	2.037	2.072
	(3.161)	(3.149)	(3.397)	(3.346)
Observations	342	342	342	342
R-squared	0.583	0.828	0.616	0.856

TG_i is a dummy equal to 1 for the provinces in the treatment group for the period i, and zero otherwise. OLS regressions with time, province fixed effects, province specific time-trend and clustered standard errors at the province level (in parenthesis). Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

TABLE 4. Trend in simple and total criminal association after the introduction of the green certificate system (1999-2007). [equations (b2) and (c)]

VARIABLES	(1) CrimAssoc	(2) CrimAssoc	(3) TCrimAssoc	(4) TCrimAssoc
TG_{99_00}	0.953		0.885	
	(0.567)		(0.666)	
TG_{01_02}	0.888*		1.015	
	(0.459)		(0.586)	
TG_{03_04}	1.636***		1.969**	
	(0.506)		(0.717)	
TG_{05_07}	1.979**		1.795	
	(0.795)		(1.082)	
$POST_{99\_05}$		0.792*		0.925**
		(0.426)		(0.434)
School	1.484	-4.252	2.172	-0.833
	(3.473)	(7.687)	(3.685)	(7.862)
GDP_pc	0.173	-23.912*	2.106	-26.015
	(3.184)	(12.007)	(3.393)	(17.094)
Observations	342	38	342	38
R-squared	0.584	0.859	0.615	0.894

TG_i is a dummy equal to 1 for the provinces in the treatment group for the period i, and zero otherwise. In first and third column, OLS regressions with time, province fixed effects, province specific time-trend and clustered standard errors at the province level (in parenthesis). In second and fourth column, panel collapsed in two periods as in Bertrand et al. (2004). **$POST_i$** is a dummy equal to 1 for the provinces in the treatment group in the post-1999 period and zero otherwise. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

TABLE 5. Determinants of total installed capacity. [equation (d)]

VARIABLES	(1) Capacity (MW)	(2) Capacity (MW)	(3) Capacity (MW)	(4) Capacity (MW)	(5) Capacity (MW)	(6) Capacity (MW)
Lag Capacity	0.895***	0.901***	0.924***	0.935***	0.354*	0.364**
	(0.159)	(0.160)	(0.154)	(0.158)	(0.186)	(0.184)
Lag CrimAssoc	1.974**	0.733*	5.737***	1.510	1.267	0.867
	(0.871)	(0.413)	(1.171)	(1.848)	(1.007)	(0.581)
inter_ CrimAssoc		1.938*		5.094**		0.560
		(1.119)		(2.194)		(1.496)
School	-78.567*	-70.051	-138.190	-112.230	-16.236	-15.866
	(43.605)	(47.208)	(105.863)	(108.719)	(21.792)	(23.938)
GDP_pc	2.077	8.369	31.253	42.417	-80.404	-82.487
	(33.789)	(33.941)	(84.688)	(75.897)	(56.458)	(56.786)
Observations	544	544	128	128	144	144
Number of prov_id	34	34	8	8	9	9

In first and second column, all 34 provinces of the Center South, in third and fourth column, provinces of the treatment group. In fifth and sixth column, the second 9 windiest provinces. **inter_CrimAssoc** is the interaction between the lagged value of criminal association activity (**Lag CrimAssoc**) and the dummy for the post-1999 period (1999-2007). In all columns GMM-Arellano Bond regressions with year fixed effects, province specific time trends and robust standard errors (in parenthesis). Significance levels: *** p<0.01, ** p<0.05, *p<0.1.

TABLE 6. Determinants of total installed capacity. [equation (e)]

VARIABLES	(1) Capacity(MW)	(2) Capacity(MW)	(3) Capacity(MW)	(4) Capacity(MW)
Lag Capacity	0.863***	0.873***	0.881***	0.891***
	(0.157)	(0.157)	(0.158)	(0.159)
LagTG_ CrimAssoc	5.316***	1.063	5.341***	1.169
	(1.784)	(2.153)	(1.791)	(2.082)
interTG_ CrimAssoc		5.237***		5.130***
		(1.572)		(1.576)
School	-137.321***	-134.940***	-123.318***	-120.892***
	(48.200)	(49.474)	(43.565)	(44.578)
GDP_pc	-19.091	-21.173	-2.678	-4.713
	(53.220)	(51.734)	(61.881)	(59.479)
Observations	304	304	272	272
Number of prov_id	19	19	17	17

In first and second column, comparison between the treatment and the control group, in third and fourth column, comparison between the treatment and the second 9 windiest provinces. **LagTG_CrimAssoc** is the interaction between the treatment group dummy (**TG**), and the lagged value of criminal association activity. **interTG_CrimAssoc** is the interaction between **LagTG_CrimAssoc** and the dummy for the post-1999 period (1999-2007). In all columns GMM-Arellano Bond regressions with year fixed effects, robust standard errors (in parenthesis) and province specific trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

TABLE 7. Trend in simple and total criminal association in the whole period using the actual value of the Wind Index (1990-2007) [equations (a) and (b1)]

VARIABLES	(1) CrimAssoc	(2) CrimAssoc	(3) TCrimAssoc	(4) TCrimAssoc
$TG\_Wind_{91\_94}$	0.949		1.814	
	(1.295)		(1.480)	
$TG\_Wind_{95\_98}$	1.193		2.003	
	(1.253)		(1.304)	
$TG\_Wind_{99\_02}$	3.211*	1.719*	4.475**	1.986*
	(1.834)	(0.912)	(2.046)	(1.108)
$TG\_Wind_{03\_07}$	5.576**	3.711***	7.328**	4.289**
	(2.276)	(1.111)	(2.830)	(1.512)
School	1.880	1.905	2.623	2.599
	(3.322)	(3.269)	(3.639)	(3.526)
GDP_pc	0.392	0.403	2.252	2.275
	(3.086)	(3.060)	(3.117)	(3.086)
Observations	342	342	342	342
R-squared	0.585	0.829	0.619	0.857

TG_Wind_i (interaction term between dummy TG and the actual value of the Wind Index) is equal to the value of Wind Index for each province in the treatment group for the period i, and zero otherwise. **TG_Wind** is the treatment group fixed effect which varies in the level of the Wind Index. In all columns, OLS regressions with time, province fixed effects, province specific time trends and clustered standard errors at the province level (in parenthesis). Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

TABLE 8. Trend in simple and total criminal association after the introduction of the green certificate system using the actual value of the Wind Index. [equations (b2) and (c)]

VARIABLES	(1) CrimAssoc	(2) CrimAssoc	(3) TCrimAssoc	(4) TCrimAssoc
$TG\_Wind_{99\_00}$	2.206		2.068	
	(1.288)		(1.449)	
$TG\_Wind_{01\_02}$	1.640*		2.049*	
	(0.872)		(1.160)	
$TG\_Wind_{03\_04}$	3.355***		4.237***	
	(1.013)		(1.373)	
$TG\_Wind_{05\_07}$	4.521**		4.530*	
	(1.861)		(2.359)	
$POST\_Wind_{99\_05}$		1.570		1.871*
		(0.929)		(0.951)
School	1.844	-4.270	2.610	-0.815
	(3.411)	(7.513)	(3.573)	(7.696)
GDP_pc	0.310	-20.124	2.263	-21.630
	(3.158)	(12.521)	(3.180)	(15.930)
Observations	342	38	342	38
R-squared	0.586	0.858	0.617	0.894

TG_Wind_i is equal to the value of Wind Index for each province in the treatment group for the period i, and zero otherwise. In first and third column, OLS regressions with time, province fixed effects, province specific time trends and clustered standard errors at the province level (in parenthesis). In second and fourth column, panel collapsed in two periods as in Bertrand et al. (2004). **$POST\_Wind_i$** (interaction term between dummy $POST_{99}$ and the actual value of the Wind Index) is equal to the average value of Wind Index in the treatment group for the post-1999 period, and zero otherwise. Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Figure 7. Index of Violent Crime

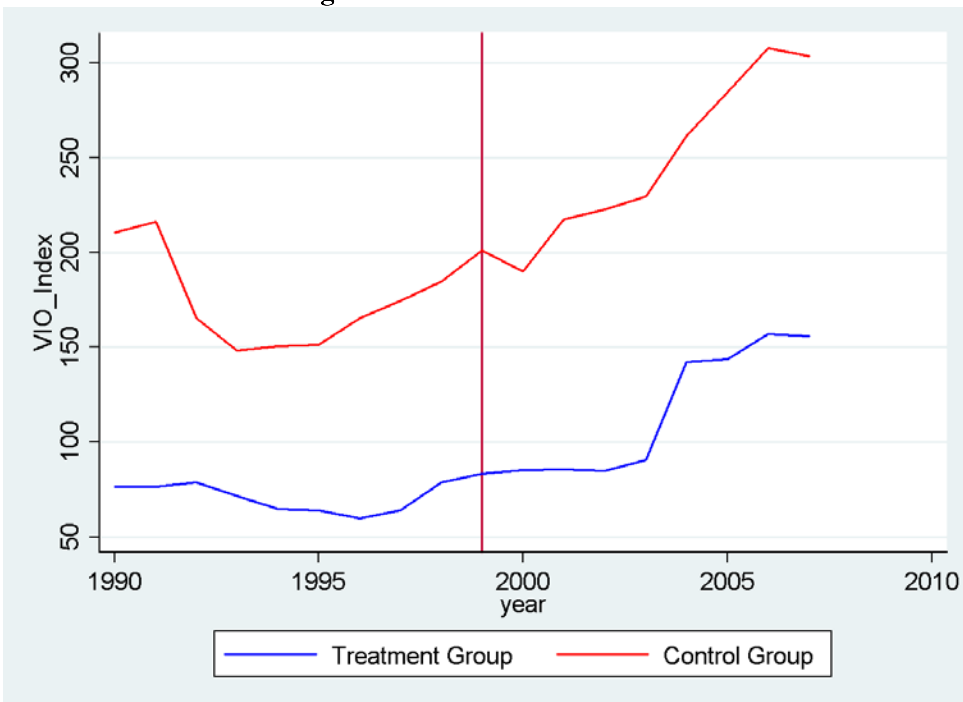
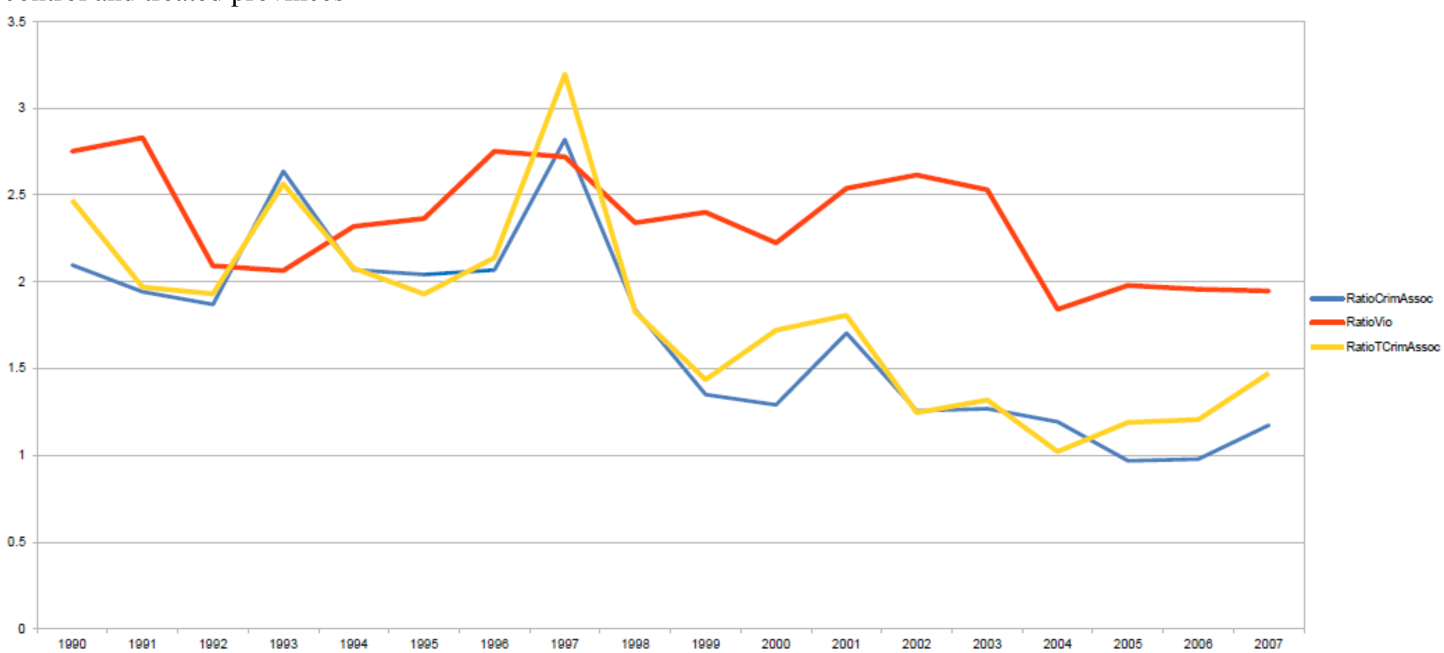


Figure 8. Ratios between the level of both measures of criminal association activity and Index of Violent Crime in the control and treated provinces[3]



[3] **Treatment Group**: Avellino,Benevento,Campobasso,Cosenza,Foggia, Potenza,Sassari,Trapani. **Control Group**: eleven neighbouring provinces. Notice that in **1999**, tradable green certificates system (`Certificati Verdi', CV) was introduced. **Vio_Index** is the index of violent crime, while **CrimAssoc** denotes Criminal Association activity and **TCrimAssoc** denotes Total Criminal Association activity (sum of simple criminal association and criminal association of Mafia type).

TABLE 9. Trend in Violent Crime Index in the whole period (1999-2007)

VARIABLES	(1) Violent crime Index	(2) Violent crime Index	(3) Violent crime Index	(4) Violent crime Index
TG_{91_94}	13.409			
	(15.824)			
TG_{95_98}	7.688			
	(19.572)			
TG_{99_02}	3.219	-5.852		
	(24.692)	(12.164)		
TG_{03_07}	-3.893	-12.798		
	(28.058)	(21.724)		
TG_{99_00}			-7.314	
			(11.442)	
TG_{01_02}			-5.430	
			(19.808)	
TG_{03_04}			-11.709	
			(23.851)	
TG_{05_07}			-14.971	
			(32.008)	
$POST_{99\_05}$				2.900
				(18.391)
School	193.805*	190.300*	191.226*	137.484
	(100.691)	(97.128)	(97.307)	(167.684)
GDP_pc	125.224	126.857	127.453	279.011
	(100.122)	(100.008)	(99.534)	(382.722)
Observations	342	342	342	38
R-squared	0.931	0.931	0.931	0.935

$\mathbf{TG_i}$ is a dummy equal to one for each province in the treatment group in the period i, and zero otherwise. In columns (1)-(3), OLS regressions with time, province fixed effects, province specific time trends and clustered standard errors at the province level (in parenthesis). In fourth column, panel collapsed in two periods as in Bertrand et al. (2004). $\mathbf{POST_i}$ is a dummy equal to 1 for the provinces in the treatment group in the post-1999 period and zero otherwise. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

TABLE 10. Trend in Violent Crime Index in the whole period using the actual measure of the Wind Index (1999-2007)

	(1)	(2)	(3)	(4)
VARIABLES	Violent crime Index	Violent crime Index	Violent crime Index	Violent crime Index
$TG\_Wind_{91\_94}$	26.308			
	(31.663)			
$TG\_Wind_{95\_98}$	10.485			
	(38.535)			
$TG\_Wind_{99\_02}$	-1.817	-13.610		
	(50.185)	(25.215)		
$TG\_Wind_{03\_07}$	-18.571	-27.382		
	(58.385)	(46.862)		
$TG\_Wind_{99\_00}$			-14.515	
			(24.064)	
$TG\_Wind_{01\_02}$			-13.850	
			(40.083)	
$TG\_Wind_{03\_04}$			-26.762	
			(50.487)	
$TG\_Wind_{05\_07}$			-29.408	
			(68.936)	
$POST\_Wind_{99\_05}$				6.888
				(35.029)
School	193.544*	188.423*	188.431*	138.607
	(100.389)	(95.607)	(95.288)	(166.869)
GDP_pc	124.996	125.555	125.712	291.732
	(101.281)	(100.449)	(99.873)	(318.362)
Observations	342	342	342	38
R-squared	0.931	0.931	0.931	0.935

TG_Wind_i is equal to the value of Wind Index for each province in the treatment group for the period i, and zero otherwise. In columns (1)-(3), OLS regressions with time, province fixed effects, province specific time trends and clustered standard errors at the province level (in parenthesis). In fourth column, panel collapsed in two periods as in Bertrand et al. (2004). **$POST\_Wind_i$** (interaction term between dummy $POST_{99}$ and the actual value of the Wind Index) is equal to the average value of Wind Index in the treatment group for the post-1999 period, and zero otherwise. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.