FONDAZIONE ENI ENRICO MATTEI

NOTA DI LAVORO

63.2011

Clean or "Dirty" Energy: Evidence on a Renewable Energy Resource Curse

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Energy: Resources and Markets Series
Editor: Giuseppe Sammarco

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Summary

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Keywords: Corruption, Natural Resources Curse, Wind Energy, Political Economy

JEL Classification: D73, O13, P16

The authors are grateful to Vincenzo Galasso, Tommaso Nannicini and Marcella Nicolini for very helpful comments.

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Clean or "Dirty" Energy;

Evidence on a Renewable Energy Resource Curse

Caterina Gennaioli and Massimo Tavoni*

This Draft: July 2011

Abstract

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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

1 Introduction

Growing anecdotal evidence in Italy reports the diffusion of corruption practices in the renewable (wind) energy sector. Starting from last year, several official inquiries made by the Italian police have been published in several newspapers, and have led to the arrest of managers and local politicians who allegedly used corrupt practices and bribes in order to build wind farms. Similar scandals have happened in Spain, where 19 persons were arrested in 2009 with charges of corruption in the wind sector. This paper aims at investigating the potential for resource curse in the renewable energy sector. To our knowledge, this is one of the first attempts to study 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.

There is an extensive literature on the natural resource curse, according to which resource abundance can be detrimental for economic growth and 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) found that natural resources increase the chances of civil conflicts. Hessami (2010) finds 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 a high level of 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.

In general the mechanisms behind the resource curse are much less clear and deserve an empirical assessment at the micro level. Our paper intends to give a contribution on this dimension, so 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 their illegal activity. In this paper we use the same data source to measure criminal association activity in the Italian provinces, but we take the opposite perspective; in our framework, entrepreneurs and politicians set up illegal associations to enter the wind energy sector and be entitled to receive significant amount of public incentives. In other words, while in Gennaioli et al. (2010) organized crime activity represents an effect of public spending, here criminal association activity represents an instrument to enter the wind energy market and get the associated public incentives. 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. Compare 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 so, 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 the natural resources necessarily induce a curse, so it is not obvious to prove that wind energy causes the same adverse effects on corruption level as oil does. 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 in their transition to low carbon economies.

Taking a political economy perspective, this paper analyzes the link between renewable energy and criminal association activity. Specifically, we aim to understand whether the presence of a renewable natural resource, in this case wind energy, creates the scope for rent seeking practices and corruption. We sketch out a simple model of political influence by interest groups, which yields predictions on the relation between corruption, wind resources, and public support policies. These insights are then tested on a panel dataset of Italian provinces in the South regions 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 are that: i) criminal association activity increases more in high-wind provinces and especially after the introduction of a more favourable 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, taking the wind level constant, 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 poor quality of institutions.

Overall, the paper points out that, where institutions are poorly functioning, even well designed, market based policies, can have an adverse impact, with a stronger effect precisely in 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 wind sector. Section 3 describes the data and the institutional background. In section four we outline the empirical strategy to test the model, and we present empirical results. The final section concludes.

2 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 and number of active entrepreneurs as a function of windiness and institutional quality. Although the model is very 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 to invest in wind power generation by building a wind farm, or carrying on their previous activity. If they do not enter the wind energy sector, 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 to obtain 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 captures 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 getting the permit. Once the entrepreneur obtains the permit, she makes the investment and builds a wind farm. The return to investment defined as $I(w, F)$, depends on the revenues associated with the energy produced (increasing in w) on one side, and an exogenous amount of public incentives on the other. For simplicity the first component is captured by the level of windiness, w, while the second is captured by the fix amount F. $I()$ is an increasing function in both arguments. Notice that the policy put in place to promote the wind energy sector, affects both the function $I()$ and the fix component F; for example, if a policy is introduced, making wind revenues more dependent on wind energy effectively produced, we should expect a higher $I_w(), \forall w$. If instead only the amount of incentives increases but the type of policy remains the same, we just have $F' > F$. The return to investment does not depend on the ability parameter since the wind sector, especially in the first phase, has been charaterized 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.

2.1 Equilibrium

We solve the model backward, starting from the last 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.

2.1.1 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 accepting 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, has to offer a bribe* $b^* = m$. *Therefore whenever* $\pi(m) \geq \overline{\pi}()$, *we will observe bribing in the wind energy sector.*

Not surprisingly, 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 $\overline{\pi}()$, condition for bribing 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 probabilities of getting the permit and so the net marginal return to bribing compared to not 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 compare to q, thanks to her connections and experience. Recalling the interpretation for 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. Notice 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 is the general quality of institutions in a certain province, the more likely 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.

2.1.2 Entry Decision

Turning to the first stage, we analyze entry decision. Generally an entrepreneur will decide to enter if the expected return to wind energy investment is higher than her reservation wage, that it is equal to her ability type. Let us focus on non trivial solutions, studying the case where $\Delta POL > 0$. Taking into account 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 not bribe.*

According to the model, two types of markets for wind energy can emerge in equilibrium; one in which all agents are corrupted, and the other where all agents honestly behave. First notice that, in both types of markets, the ability type of active entrepreneurs is increasing in the expected revenues of wind investment; untill the return to investment does not increase much compared to the one in the non-wind sector, only the lower ability type would enter the renewable energy market. These low types would anyway achieve higher profits in the wind sector, thanks to the fix amount of public incentives. Whether a province will experience a corrupted wind market or not, depends both on GI and on 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 on, we focus on the emergence of corrupted type of markets 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 the 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 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 before, equilibrium corruption level depends both on the level of wind and the quality of institutions. In other words, taking wind level constant, one should observe a higher level of corruption in provinces with worse institutional quality, both in its social and political dimension. Interesting comparative statics can be easily derived, in terms of wind level and the type of policy in place.

Lemma 2 *The equilibrium level of corruption is increasing both in wind level and in 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), formally shows the complementarity between windiness and 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, it is straightforward to 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 (*complementarity*). 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 change in two ways; i) increase in the fixed component, F, which can be considered as a *lump sum* transfer (as development funds), and, ii) increase in the responsiveness of the policy to the actual production, in our case proxied by wind level, I_w, which can be interpreted as the introduction of a tradable certificate system (or market-based) type of policy.

Lemma 3 *Both an increase in the lump sum transfer and the introduction of a tradable certificate system, increase the extent of corruption, with: a)* $\frac{\partial corr^*}{\partial F} = (\Delta POL)$ *and b)* $\frac{\partial corr^*}{\partial I_w} = w\,(\Delta POL)$.

If one looks at second order effects, the lemma derives 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* equallyraises the level of corruption in all provinces with similar institutional quality, the introduction of the *tradable certificate 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 choose the bribing option and, as a consequence, the number of entrepreneurs involved in bribing gets larger. Moreover, if the public incentive becomes more responsive to the energy actually produced (i.e. to the wind level), this effect becomes stronger in high wind provinces. This result is extremely relevant, showing that in the presence of poorly functioning institutions, a market based policy has a larger negative impact, precisely where the greatest efficiency gains could be obtained, namely in provinces with the highest producibility. After having derived conditions on entry and bribing decision by 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). As we have seen, the concession of permit is necessary to put an investment in place.

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 wind level and 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 wind level, in policies or 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, also the actual number of wind projects put in place. Considering provinces where the quality of institutions is sufficiently low, this section highlights that, not only wind level but also the quality of institutions are crucial determinants of the development of the wind energy sector, through their effect on corruption.

2.2 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 predictions and we will mainly focus on the role of 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 we take to the data are the following:

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

ii) The raise in the returns to wind investments, following the introduction of the new policy regime based on the *green certificates*, led 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 wind energy sector is not only driven by the level of wind but also by the functioning of social and political institutions. This implies 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. 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 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.

3 Data and Background

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 ISTAT, "Statistiche Giudiziarie Penali". To compute the extent of corruption we use two measures: a) criminal association activity (ASSO), representing the number of charges made by the five sectors of the police force to the judiciary for the crime "Criminal Association", and b) total criminal association (ASSOTOT), the sum of the charges made for the crimes of "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 charges made by the five sectors of the police force to the judiciary for the following crimes: massacre, homicides, infanticide, lesions, sexual assaults, kidnapping, assassination attempts and theft. Values are reported as the incidence of the above mentioned crimes over 100,000 inhabitants. Unfortunately, the criminal activity dataset has been discontinued after 2007, and we were not able to include the two more recent years.

The data on regional unemployment rate and secondary school enrolment at the province level are provided by ISTAT. The expected number of projects, $E(P)$, is proxied with the number of wind plants and total capacity installed; for this purpose, since official statistics are available at the provincial level only from 2008 onwards, we rely on a dataset compiled by ENEA/ANEV (National Association for Wind Energy). This covers essentially the totality of wind parks, and provides data on location, capacity, size, year of 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 the 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.

3.1 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 for extracting excessive rents also proved difficult. Moreover, the scheme permitted overlap with

[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.

additional incentives, in particular with national and European funds for economic development. Some of these funds essentially consisted of grants, or special loans, to help with the construction of sites, and thus provided perverse incentives that remunerated the installed capacity and not the actual electricity produced.

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 energy 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 up the prices of the green certificates, above 10cEuro/kWh (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, for wind the most important ones are related to the structural development funds 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 load factor of about 1300 hours, 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, which is characterized by rather exhaustible high quality sites. Moreover, the generous incentives allow building 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 Apennines, 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 been also added in Sicily and in the Calabria region.

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 be conducive to corruption practices. Till 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 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).

4 Methodology

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 policy commitment. 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 flooded 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 that question, in the last part of the empirical exercise we test the third prediction of our model, namely the positive association between the degree of corruption and the 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) on the whole time sample, focusing on the periods after 1999 and 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, that 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 (AV, BN, CA, CZ, FG, PZ, SS, TP), 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 bar can be set at different levels, and thus we have 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 has this 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 one to look at[2]. Since the treatment is determined according to wind level, it has to be considered exogenous. The empirical strategy is based on the identification assumption, that there are no unobservable factors, correlated with both criminal association activity and wind level. Unfortunately we do not have data to measure the quality of institutions; however, since it can be considered a persistent element, we partly solve the omitted variable problem using province fixed effects.

[2]Results for the larger treatment group are available upon request.

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 increased corruption more in windy provinces. In the second part of the analysis we provide evidence on the link between the level of corruption and the expansion of the wind sector.

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

$$Crim.\ Association_{it} = \boldsymbol{\alpha} \sum_{t \in T} TG_{i_{t\_t+3}} + \sigma\ TG_i + \mathbf{x}_{it}\ \delta + \gamma\ trend_{it} + u_i + v_t + \varepsilon_{it} \tag{a}$$

Where $Crim.Association_{it}$ measures the number of charges made by the 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, TG_i is the treatment group fixed effect,$\mathbf{x}_{it}$ 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. This specification allows the study of the criminal association trend in the treatment group throughout the four time windows of 4 years, 1991-1994, 1995-1998, 1999-2002, 2003-2007. The coefficients of interest belong to vector $\boldsymbol{\alpha}$. Since we want to focus on the period following the approval of the Green Certificates system (CV), we then split the post CV period in time intervals, and we estimate the following equation:

$$Crim.Association_{it} = \boldsymbol{\beta} \sum_{t \geqslant 1999} CV_{i_{t\_t+j}} + \sigma\ TG_i + \mathbf{x}_{it}\ \delta + \gamma trend_{it} + u_i + v_t + \varepsilon_{it} \tag{b}$$

Similarly to the (1), $CV_{t,t+j}$ is a dummy equal to one for the treated provinces, between time t and $t+j$, and zero otherwise. We run two specifications of equation (b); in the first case we set $j = 1$, considering four time windows (1999-2000, 2001-2002, 2003-2004, 2005-2007), in the second case $j = 3$, such that the post period is divided in two time windows, 1999-2002, 2003-2007. The coefficients of interest belong to vector $\boldsymbol{\beta}$. We are confindent that equations (a) and (b) do not suffer from an endogeneity problem; wind level in a certain province is an exogenous factor. Moreover, once province and year fixed effects and province specific time trends are included, it is difficult to imagine any unobservable factor correlated with both our dependent variable (criminal association) 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 our dependent variables. In particular, we take the average of our variables before and after 1999 and we estimate the following equation in a panel with time dimension equal to two:

$$Crim.\ Association_{it} = \alpha\ POST_{i99\_07} + \sigma\ TG_i + \delta\ x_{it} + u_i + v_t + \varepsilon_{it} \qquad \text{(c)}$$

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 restricted the sample to ten years (1995-2005), such that the averages correspond to the period 1995-1998 and 1999-2005, respectively. All previous specifications are also estimated with the measure of total criminal association activity, which also includes Mafia type of charges.

4.1 Results

Descriptive statistics for all the 34 provinces of the South macro area are reported in Table 1. Data inspection in figure 3 shows an increasing pattern of the average criminal association activity in the treated provinces (blue line) compared to the control ones (red line). In particular, the gap between the two groups begins to shrink in 1997 and completely disappears around 2004. Figure 4 shows a similar pattern for total criminal association activity. Since the method of reporting offenses changes in 2004, in figure 5 we show the pattern of the ratio for both measures of criminal activity, between the values in the control group and in the treatment. 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 and figure 7 display the development of the wind energy sector in the treated and control provinces respectively; while Figure 6 shows the pattern in the number of wind plants installed, Figure 7 reports the capacity installed measured in MegaWatts. As expected, the windier provinces (blue line) have been characterized by a higher level of installed capacity/wind plants relative to the control provinces (red line) in the whole period. However, 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. Considerable additional capacity (more than 2 GW) was added in the years since 2007. Results in Table 2 are consistent with previous figures; control provinces display a significant higher level of criminal association activity before 1999 compared to treated provinces, but the difference shrinks and becomes insignificant in the post treatment period. On the contrary, the difference in wind plants and capacity installed between treatment and control provinces magnifies after 1999. Additionally, control and treatment group appear to be similar on other fundamentals, namely unemployment rate and secondary school enrollment, both before and after 1999.

Turning to the estimation exercise, Table 3 reports estimates of equation (a), for criminal association activity in the first two columns, and for total criminal association activity in the third and four columns. The first and third columns report OLS estimates with a full set of year and province fixed effects, while in the second and fourth columns province specific time trends are also included. Results for criminal association activity show that when the time trends are included, one of our coefficients of interest, belonging to vector $\boldsymbol{\alpha}$ 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. Columns 3 and 4, display a similar trend for total criminal association activity, but when time trends are included, we also find a positive and significant coefficient associated to the 1999-2002 period. Including several time windows, we perform a significance test of the difference in the coefficients before and after 1999, to exclude the possibility that our results are driven by a preexisting trend[3].

Table 4 and 5 show estimation results of equation (b) in which we only focus on the post-1999 period. In Table 4, the post period is divided in two time windows; for both measures of criminal association activity, all coefficients of interest belonging to vector $\boldsymbol{\beta}$**,** are positive and significant when the province time trend is added. In Table 5 the post period is divided in four time windows; also in this case, all coefficients become significant when a province specific time trend is accounted for. Notice that for both dependent variables, the coefficients increase over time in significance and magnitude.

Table 6 displays the results of specification (c), the last at this stage of the 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 significant for total criminal association, and is only marginally insignificant 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

[3] Results are available upon request.

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. Summing up, in an area characterized by weak socio-political institutions, the introduction of the new and more favourable policy regime system had a stronger negative effect (in terms of corruption), especially in provinces with the highest potential for efficiency gains. Despite a set of suggestive correlations, at this stage we are unable to exclude 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 section we address this issue.

4.2 Robustness

4.2.1 Using the Actual Wind Measure

As noticed above, our result might just 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 Table 11-14 we report results for specifications (a)-(c) under this additional specification. Results are consistent with the ones in Table 3-6, and the effects are even stronger. These suggestive findings increase the confidence that we are actually identifying the impact of wind level of our treatment group.

4.2.2 Catching-up between treatement and control?

Following Gennaioli et al.(2010), we change our measure of criminal activity to understand whether we are just 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 8 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 9 we compare the ratio between the level of our three measures of criminal activity in the control and in the treated group; the comparison is quite striking since we don't find the same decreasing pattern in the ratio of the Violent crime index as in the two ratios of criminal association activity. Results in tables 15-16 are consistent with the figures; in particular, we estimate equation (a)-(c) as we did before, now changing our dependent variable with the index of violent crime. In all specifications the coefficients of interest are insignificant and eventually negative, showing a similar trend of violent crime index in the treated 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.

4.3 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 association). 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 could gain 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. We have seen that corruption practices spread where expected returns to investment were higher (i.e. in provinces with high wind level) and the quality of institutions is relatively low (*complementarity*). Then one should observe that, 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. In addition, this effect should be stronger after 1999, when expected returns of the investment significantly raised. Despite the lack of data on institutional quality, we try to say something on complementarity; analyzing groups of provinces with the same wind level, we expect to (not) find a significant correlation between corruption and the expansion of the wind sector, when provinces display a sufficient (homogeneity) heterogeneity in the quality of institutions.

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 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 to 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:

$$Capacity_{it} = \alpha \; Capacity_{it-1} + \beta \; Crim.\; Association_{it-1} + \gamma \; Inter\_ASSO_{it} + \mathbf{x}_{it} \; \delta + \varepsilon_{it} \qquad \text{(d)}$$

Where $Inter\_ASSO_{it}$ 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 intallation of future ones.

Since the presence of the lagged dependent variable leads to autocorrelation, we implement the Arellano-Bond (1991) method, estimating equations (d) and (e) in first differences and using lagged levels of the dependent variable as instruments. We also run the same regression using *Wind Plants* as dependent variable and *TotCrim. Association* as explanatory variable.as explanatory variable. The coefficients of interest are β and γ; they tell us whether criminal association activity influences wind power installations and if this happened more after the 1999, when the expected returns to wind energy started to increase and so the attractivity of the sector. We first estimate (d) for all the provinces in the sample, disregarding their wind level. As a second step we estimate the following:

$$Capacity_{it} = \alpha\ Capacity_{it-1} + \beta\ TG\_Crim.\ Association_{it-1} + \gamma\ InterTG\_ASSO_{it-1} + \mathbf{x}_{it}\ \delta + \varepsilon_{it} \tag{e}$$

Where $InterTG\_ASSO_{it-1}$ represents an interaction term between the post 1999 dummy and the lagged value of criminal association activity in the treatment group, $TG\_Crim.\ Association_{it-1}$. Also in this case, the coefficients of interest are β and γ. As before, they tell us whether criminal association activity influences wind power installations and if this happened more after the 1999, but compared to (d), we evaluate whether this correlations are stronger for the treatment group, thus for high-wind provinces, than for the control group. As a further check, we separately estimate (e), for the treatment group, and for the 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 most windy groups of provinces, we can assess the validity of our prediction more precisely; indeed we are able to draw conclusions about the effect of criminal association activity on wind energy installations, for groups of provinces with different wind levels. Finally, the last specification we consider is similar to (c), so that we collapse the panel in two periods, studying the correlation between the means of our variables of interest. However, we study the correlation between the mean of capacity/wind plants and the lagged mean of criminal association activity/total criminal association. The "before" and "after" period for our measures of criminal association activity are 1995-1998 and 1999-2005, while for our measures of capacity and wind plants are 1995-2000 and 2001-2005, respectively. Then our last specification is:

$$Capacity_{it} = \alpha \ Crim.\ Association\_TG_{it-1} + \delta \ x_{it} + u_i + v_t + \varepsilon_{it} \tag{f}$$

where $Crim.\ Association\_TG_{it-1}$ indicates an interaction between the lagged value of criminal association and the treatment group dummy. The coefficient of interest is α; this measures the correlation between the lagged value of criminal association and the amount of installed capacity, in the windy provinces of the treatment group compared to the control group.

4.4 Results

Table 7 reports the estimation results of equation (d) [4]. We look at the simple correlation between the lagged value of criminal association and total capacity installed, considering all 34 provinces in the Center South region. In the second and fourth columns we add the province specific trend. While in the first two columns only the lagged value of criminal association activity is included, in the third and fourth columns 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. The coefficient of the lagged value of criminal association is positive and significant in the baseline specification but becomes insignificant in the last two columns, where the interaction $Inter\_ASSO$ is always positive and significant. This implies that the effect of lagged criminal association activity on total installed capacity is higher after 1999.

In Table 8 we estimate equation (e), and we compare the treatment with the control group. In this specification we consider again our original sample comprising 19 provinces. The results are similar to the previous ones, but the magnitude of the coefficients of interests is larger. Looking at the third and fourth columns, 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 results are quite striking; they indicate that the positive correlation between the level of criminal association activity at time $t-1$,and total installed capacity at time t, is stronger in the windiest provinces of the treatment group, with a rise of the effect after 1999. This highlights the presence of 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.

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

The same effects, with an even higher magnitude, result from specification in Table 9, where we compare the 8 windiest provinces (treatment group) to the second 9 windiest provinces (control group), in our sample. Also in this case, the correlation between lagged value of criminal association activity and total installed capacity, is higher in treated than in control provinces (with a stronger effect after 1999, see columns 3 and 4), suggesting a different degree of heterogeneity in the quality of institutions among the two groups of provinces. From this result, we expect the provinces of the control group to be characterized by a more homogenous institutional quality than the treatment group. Results in Tables 7-9 strongly support the validity of prediction iii), 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, dectecting a different degree of homogeneity in their institutional quality.

As a further check, we run specification (d), separately for the treatment group (columns 1-2) and the second 9 most windy provinces (columns 3-4). Table 10[5] shows the results, which are consistent with the previous ones; criminal association at time $t-1$, better predicts total installed capacity at time t in the windiest provinces, especially after 1999. Indeed, coefficients of interest are insignificant and much lower when the less windy provinces are considered (see columns 3 and 4). In the last two columns of Table 10, we also implement the method à la Bertrand et al. as we did in (c), now regressing the means of our dependent variable on the lagged mean of our measure of criminal association. In the last column, we include an interaction between lagged criminal association and the treatment dummy, to compare treatment and control provinces. Notice that the coefficient of the interaction term is positive and highly significant.

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

[5] For simplicity, only regressions with province specific trends are included. The ones without the trends are available upon request.

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, regardless of wind level, in provinces where economic agents and bureaucrats were better "organized" and ready to engage in criminal association activity (resulting in more permits and concessions) due to a poorer quality of political institutions, the expansion of the wind energy sector has been higher. A word of caution is needed regarding the suggestive 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. 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, partly mitigate concerns of endogeneity.

5 Conclusions

Recent anecdotal evidence in Italy and abroad reports the diffusion of corruption practices in the renewable energy sector, especially in the wind energy sector. In the past two years several inquiries have looked into corrupt practices and bribes in order to build wind farms and thus to appropriate of the associated public support. 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. 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 simple model of corruption, we show that windier provinces are more likely to experience corruption, especially after the introduction of a more favourable 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 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 the new policy regime based on a green certificates system 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 played a crucial role, through their effect on corruption. In particular, taking the wind level constant, 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 poor quality of institutions.

Overall, the paper points out that, where socio-political institutions are poorly functioning, market based 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. A remark should be made on the external validity of our study, since we are not able to establish whether the same results would apply to other renewables, such as solar or phovoltaics. For example, it could be the case that wind energy, requiring huge initial investments, 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 exactly comprises the study of other types of renewable resources, like solar, to address these set of issues. We also plan to analyze the link between the expansion of the renewable energy sector and 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, renewable energy is a fruitful area for future research since several issues still remain unexplored.

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

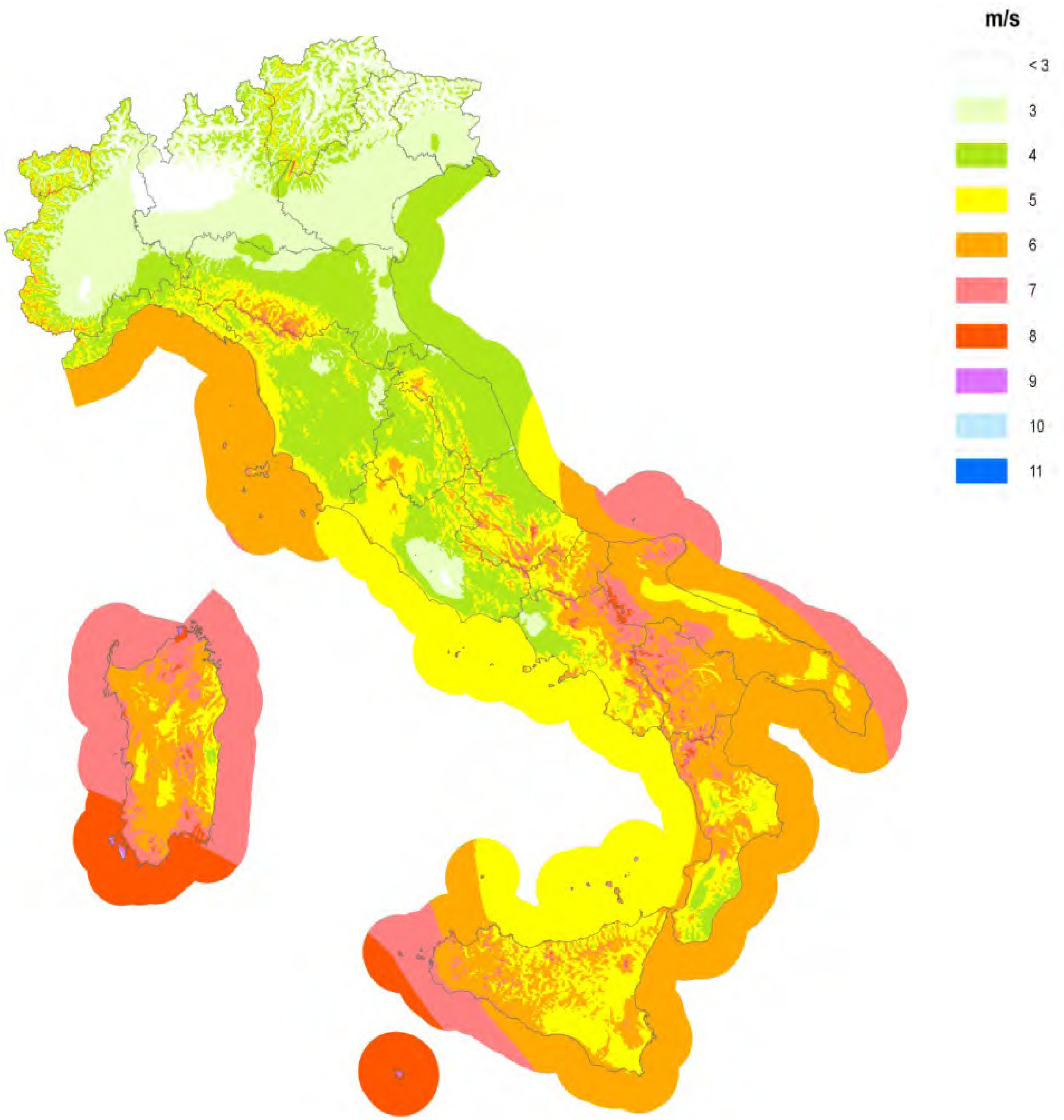


Figure 2. Distribution of wind installed capacity by province at the end of 2009 (source GSE)

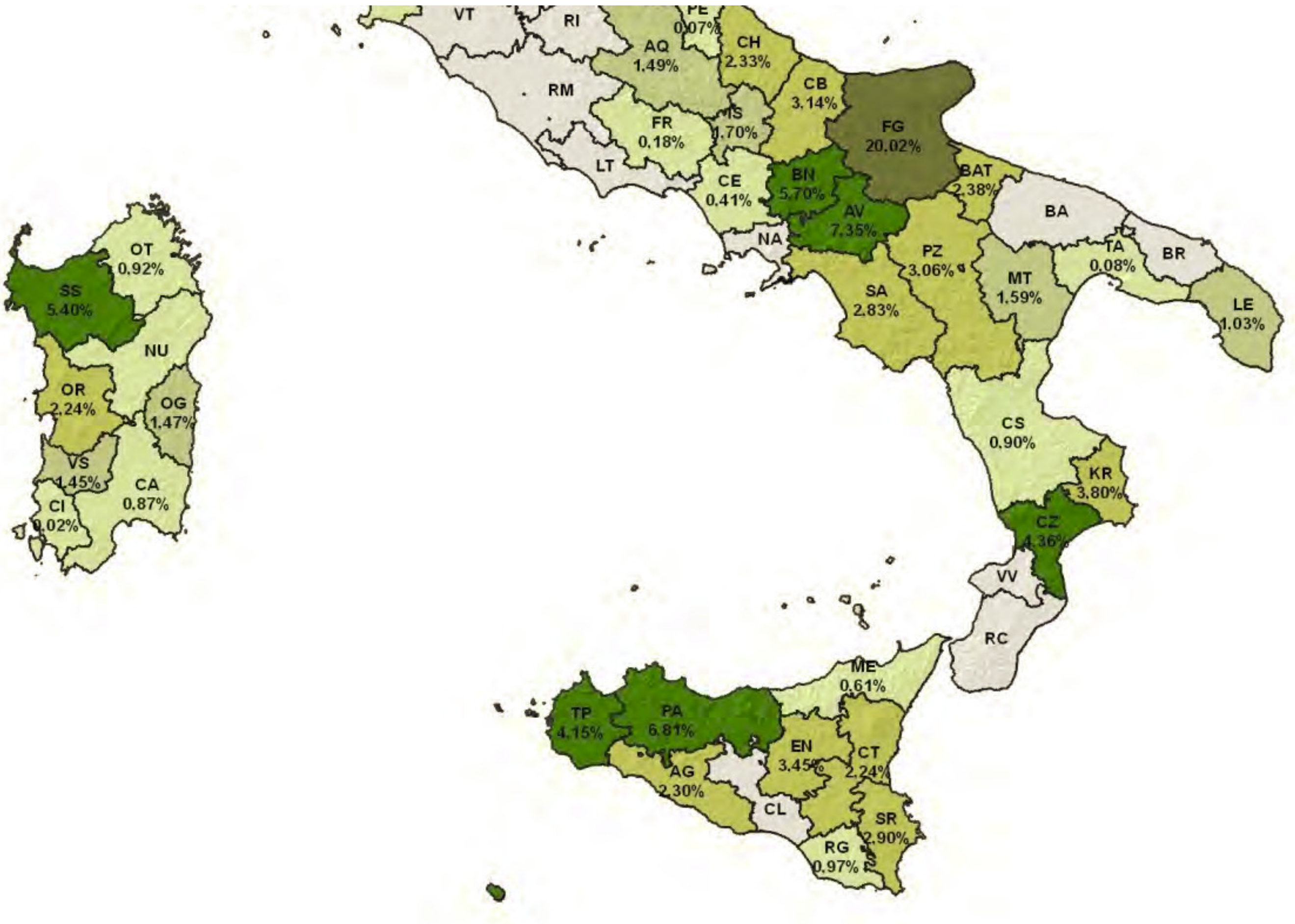


Figure 3. Criminal Association Activity (number of offences over 100,000 inhabitants)[1]

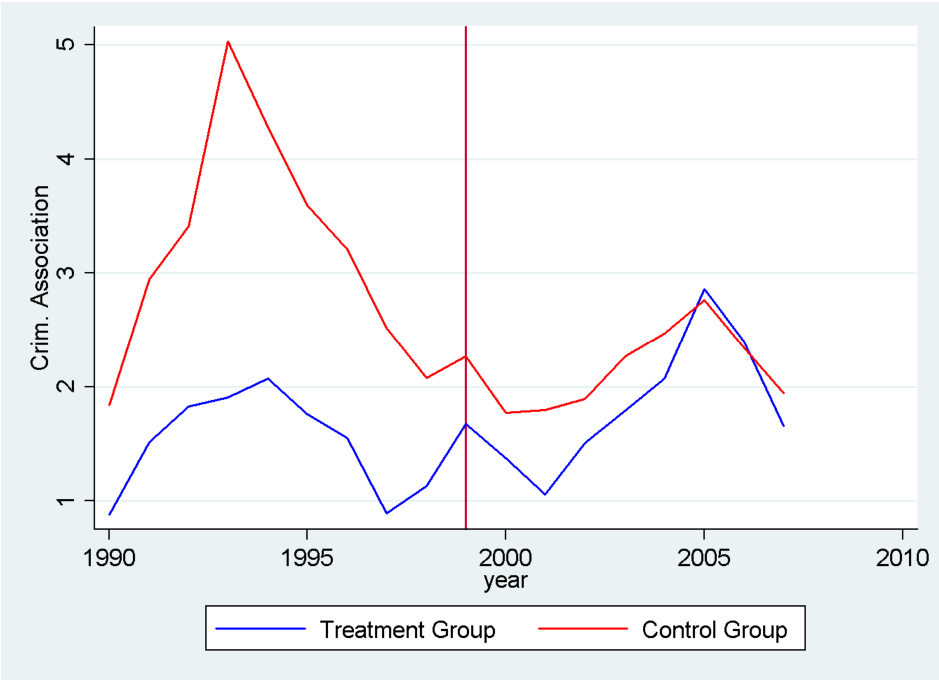
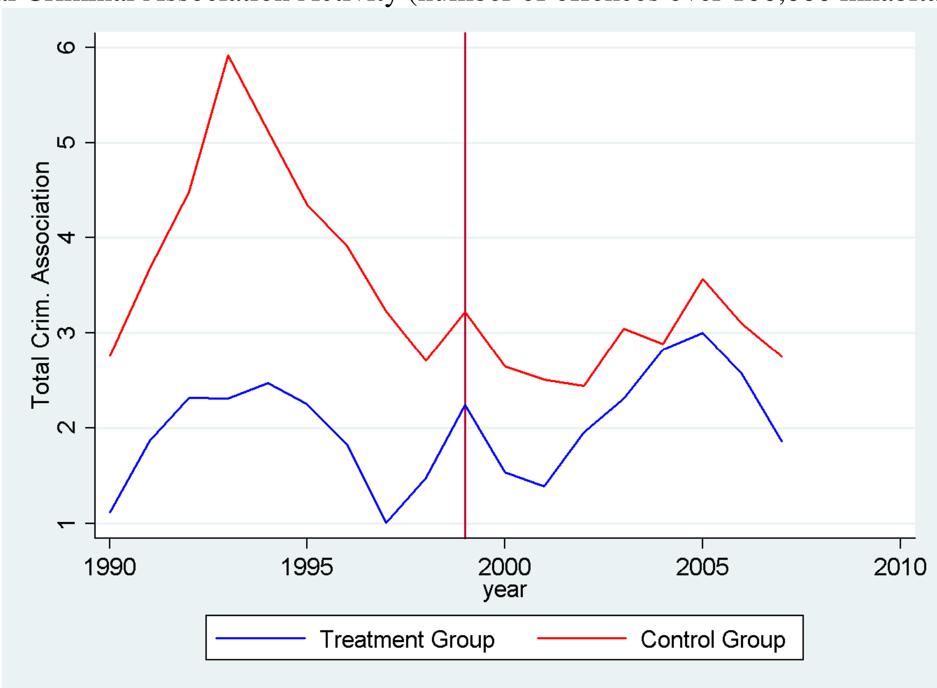
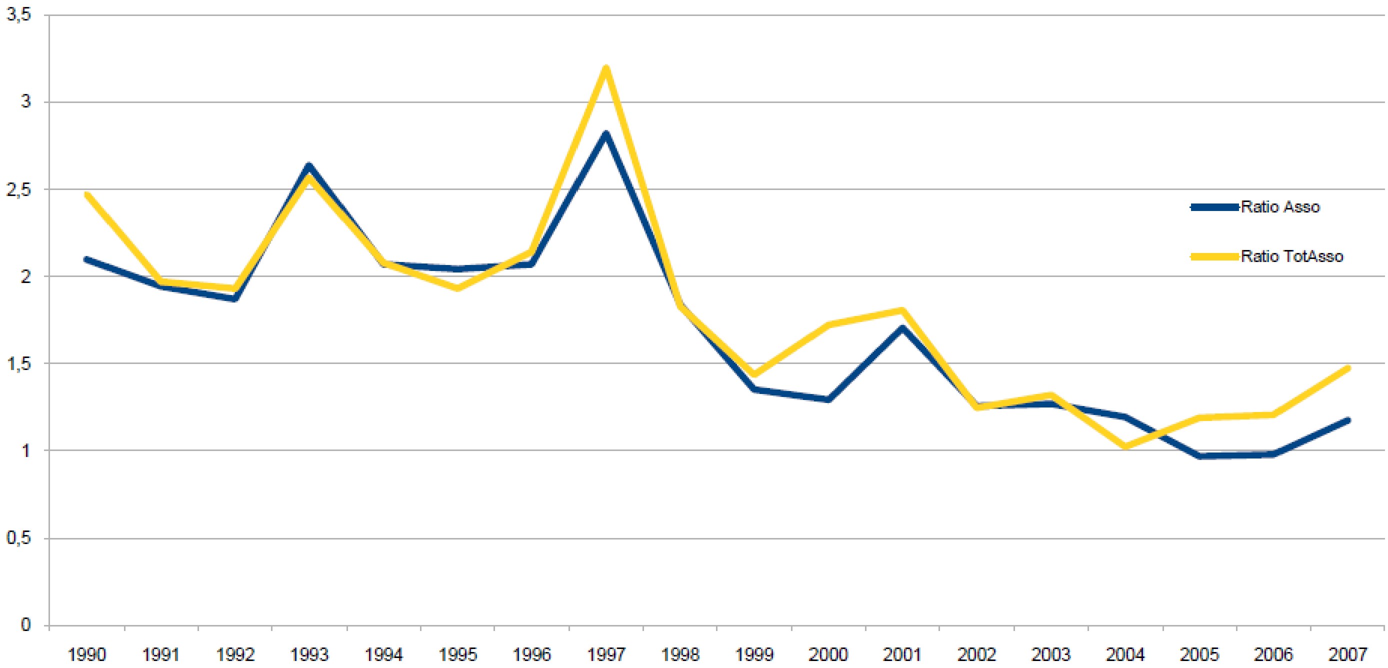


Figure 4. Total Criminal Association Activity (number of offences over 100,000 inhabitants)[1]



[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]



[2] **Treatment Group**: Avellino, Benevento, Campobasso, Cosenza, Foggia, Potenza, Sassari, Trapani. **Control Group**: eleven neighbouring provinces.

ASSO denotes Criminal Association activity. **ASSOTOT** denotes Total Criminal Association activity (sum of simple criminal association and criminal association of Mafia type).

Figure 6. Number of Wind Plants Installed[3]

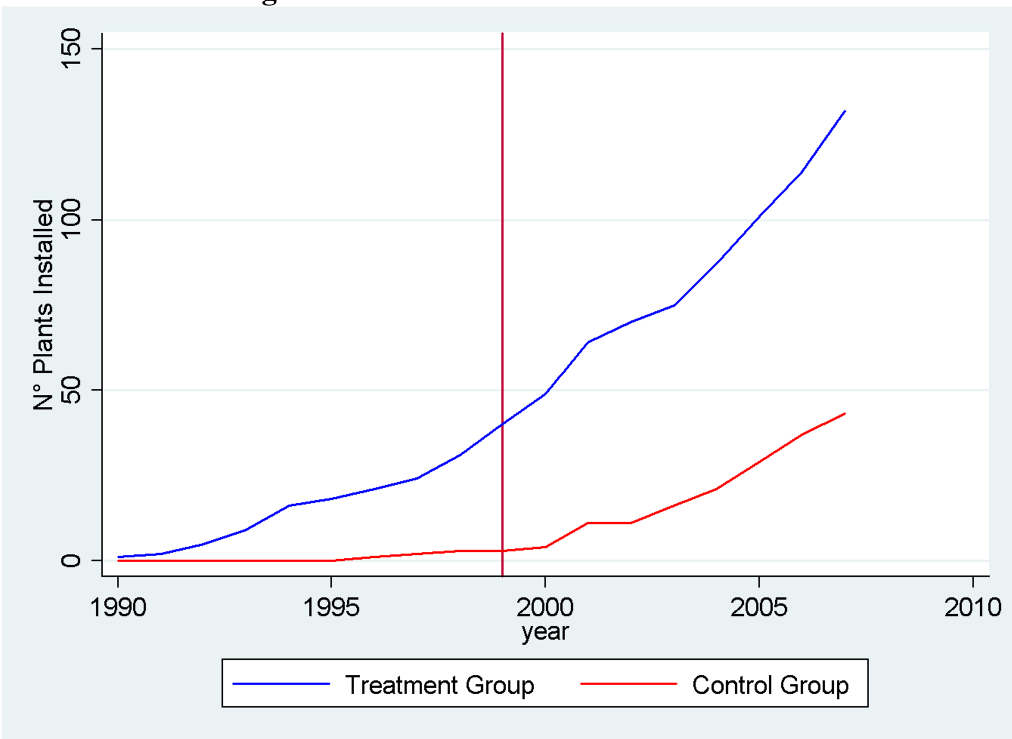
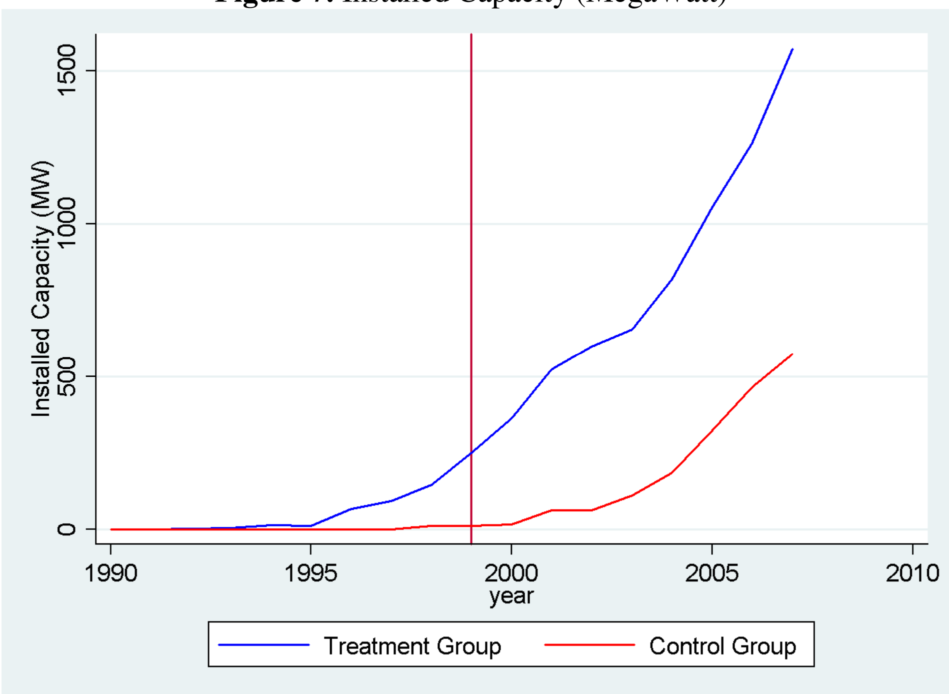


Figure 7. Installed Capacity (MegaWatt)[3]



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[3] **Treatment Group**: Avellino, Benevento, Campobasso, Cosenza, Foggia, Potenza, Sassari, Trapani. **Control Group**: eleven neighbouring provinces in the South of Italy.

TABLE 1. Descriptive Statistics

Variables	Mean
ASSO	1.939 (1.623)
ASSOTOT	2.463 (1.906)
Violent crime Index	127.977 (85.241)
Wind_Index	0.307 (0.164)
Wind Plants	3.040 (5.922)
Capacity (MW)	27.097 (68.928)
Unemployment	17.635 (5.257)
School	0.819 (0.116)
Population	744266.8 (663687.4)
N. Obs.	342

Standard deviations in parentheses.

TABLE 2

	Treated Provinces Mean	Non-Treated Provinces Mean	Mean difference (p-value)
	(1)	(2)	(3)
Panel A. Province Characteristics Before 1999			
ASSO	1.371 (.592)	2.147 (1.153)	0.05
ASSOTOT	1.681 (.676)	2.735 (1.549)	0.045
Violent crime Index	70.437 (18.537)	126.139 (72.559)	0.025
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)	0.024
Unemployment	17.921 (3.048)	18.095 (3.642)	0.914
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			
ASSO	1.896 (1.394)	1.962 (0.838)	0.899
ASSOTOT	2.355 (1.392)	2.587 (1.126)	0.693
Violent crime Index	105.082 (22.926)	158.082 (103)	0.089
Wind_Index	0.475 (0.102)	0.186 (0.073)	0
Wind Plants	8.678 (7.236)	1.233 (1.229)	0.001
Capacity (MW)	76.127 (78.579)	10.064 (12.891)	0.006
Unemployment	16.362 (2.413)	16.324 (3.108)	0.977
School	0.907 (0.042)	0.874 (0.072)	0.291
Population	525643.5 (178791.6)	908245.5 (868212.6)	0.236
Obs.	8	11	

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

TABLE 3. Trend in ASSO and ASSOTOT in the whole period (1990-2007) [equation (a)]

VARIABLES	(1) ASSO	(2) ASSO	(3) ASSOTOT	(4) ASSOTOT
TG_{91_94}	-0.019	0.226	0.304	0.693
	(0.551)	(0.668)	(0.716)	(0.775)
TG_{95_98}	-0.422	0.344	-0.221	0.916
	(0.394)	(0.708)	(0.455)	(0.734)
TG_{99_02}	0.022	1.288	0.292	2.152*
	(0.536)	(0.983)	(0.522)	(1.120)
TG_{03_07}	0.472	2.284*	0.761	3.393**
	(0.637)	(1.287)	(0.676)	(1.574)
TG	-1.438*	1.850**	-2.669***	1.247
	(0.695)	(0.716)	(0.763)	(1.004)
School	3.158	1.285	5.164*	1.619
	(2.358)	(3.333)	(2.665)	(3.667)
Unemployment	-0.040	-0.028	-0.053	-0.073
	(0.048)	(0.060)	(0.054)	(0.088)
Observations	342	342	342	342
R-squared	0.784	0.829	0.823	0.857

TG_i is a dummy equal to 1 for the provinces in the treatment group for the period i, and zero otherwise. **TG** is the treatment group fixed effect. In first and third columns, OLS regressions with time, province fixed effects and clustered standard errors at the province level (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 4. Trend in criminal association after the introduction of the green certificate system (1999-2007), divided into two time windows. [equation (b)]

VARIABLES	(1) ASSO	(2) ASSO	(3) ASSOTOT	(4) ASSOTOT
TG_{99_02}	0.218	0.854*	0.256	1.004*
	(0.506)	(0.433)	(0.553)	(0.531)
TG_{03_07}	0.668	1.726***	0.723	1.946**
	(0.546)	(0.506)	(0.579)	(0.679)
TG	-0.154	1.958***	0.087	1.609*
	(0.279)	(0.560)	(0.285)	(0.886)
School	3.124	1.304	5.024*	1.623
	(2.397)	(3.309)	(2.705)	(3.581)
Unemployment	-0.037	-0.029	-0.051	-0.075
	(0.048)	(0.059)	(0.054)	(0.084)
Observations	342	342	342	342
R-squared	0.783	0.829	0.822	0.857

TG_i is a dummy equal to 1 for the provinces in the treatment group for the period i, and zero otherwise. **TG** is the treatment group fixed effect. In first and third columns, OLS regressions with time, province fixed effects and clustered standard errors at the province level (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 5. Trend in criminal association after the introduction of the green certificate system (1999-2007), divided into four time windows. [equation (b)]

VARIABLES	(1) ASSO	(2) ASSO	(3) ASSOTOT	(4) ASSOTOT
TG_{99_00}	0.351	0.966	0.287	0.922
	(0.585)	(0.561)	(0.600)	(0.642)
TG_{01_02}	0.084	0.904*	0.225	1.054*
	(0.529)	(0.467)	(0.636)	(0.579)
TG_{03_04}	0.626	1.652***	0.988*	2.009***
	(0.448)	(0.495)	(0.500)	(0.630)
TG_{05_07}	0.695	2.002**	0.547	1.858*
	(0.721)	(0.795)	(0.760)	(1.009)
TG	-1.599**	2.012***	-2.603***	1.600*
	(0.673)	(0.552)	(0.731)	(0.893)
School	3.097	1.248	5.037*	1.686
	(2.415)	(3.405)	(2.717)	(3.575)
Unemployment	-0.037	-0.030	-0.051	-0.075
	(0.048)	(0.058)	(0.054)	(0.085)
Observations	342	342	342	342
R-squared	0.783	0.829	0.822	0.857

TG_i is a dummy equal to 1 for the provinces in the treatment group for the period i, and zero otherwise. **TG** is the treatment group fixed effect. In first and third columns, OLS regressions with time, province fixed effects and clustered standard errors at the province level (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 6. Difference in difference regression *a la* Bertrand et al. (2004) [equation (c)]

VARIABLES	(1) ASSO	(2) ASSOTOT
$POST_{99\_07}$	0.708	0.859*
	(0.424)	(0.414)
School	-7.425	-5.715
	(8.337)	(7.780)
Unemployment	-0.118	-0.274*
	(0.148)	(0.153)
Observations	38	38
R-squared	0.843	0.894

$POST_i$ is a dummy equal to 1 for the provinces in the treatment group in the post-1999 period and zero otherwise. OLS regressions with time and province fixed effects. Panel collapsed in two periods as in Bertrand et al. (2004). Robust standard errors in parenthesis. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 7. Determinants of total installed capacity. All 34 provinces of the Center South [equation (d)]

VARIABLES	(1) Capacity (MW)	(2) Capacity (MW)	(3) Capacity (MW)	(4) Capacity (MW)
Lag Capacity	1.094***	0.895***	1.102***	0.901***
	(0.099)	(0.157)	(0.099)	(0.158)
Lag ASSO	2.255***	1.960**	0.834	0.673
	(0.821)	(0.868)	(0.559)	(0.413)
inter_ASSO			2.147*	2.000*
			(1.284)	(1.179)
School	-12.889	-81.696*	-11.582	-73.206
	(44.321)	(42.886)	(44.274)	(46.529)
Unemployment	-0.155	-0.446	-0.228	-0.535
	(0.353)	(0.401)	(0.338)	(0.421)
Observations	544	544	544	544
Number of prov_id	34	34	34	34

inter_ASSO is the interaction between the lagged value of criminal association activity (**Lag ASSO**) and the dummy for the post-1999 period (1999-2007). In all columns GMM-Arellano Bond regressions with year fixed effects and robust standard errors (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 8. Determinants of total installed capacity. Comparison between Treatment and Control [equation (e)]

VARIABLES	(1) Capacity (MW)	(2) Capacity (MW)	(3) Capacity (MW)	(4) Capacity (MW)
Lag Capacity	1.093***	0.862***	1.071***	0.870***
	(0.097)	(0.152)	(0.096)	(0.153)
Lag ASSO	2.164	1.719	1.864	1.511
	(1.370)	(1.200)	(1.364)	(1.218)
interTG_ASSO			7.761***	5.057***
			(1.053)	(1.625)
LagTG_ASSO	3.550*	3.635	-2.781	-0.275
	(1.959)	(2.306)	(1.984)	(2.384)
School	-27.942	-146.338***	-33.464	-144.535***
	(79.340)	(47.077)	(76.832)	(48.033)
Unemployment	0.365	-0.887*	0.403	-0.998*
	(0.678)	(0.485)	(0.650)	(0.519)
Observations	304	304	304	304
Number of prov_id	19	19	19	19

LagTG_ASSO is the interaction between the treatment group dummy (**TG**), and the lagged value of criminal association activity (**lagASSO**). **interTG_ASSO** is the interaction between **LagTG_ASSO** and the dummy for the post-1999 period (1999-2007). In all columns GMM-Arellano Bond regressions with year fixed effects and robust standard errors (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 9. Determinants of total installed capacity. Comparison between the 8 most windy and the second most windy provinces [equation (e)]

VARIABLES	(1) Capacity (MW)	(2) Capacity (MW)	(3) Capacity (MW)	(4) Capacity (MW)
Lag Capacity	1.102***	0.879***	1.085***	0.888***
	(0.098)	(0.155)	(0.097)	(0.156)
Lag ASSO	1.107	1.196	1.257	1.098
	(0.966)	(0.942)	(0.999)	(0.952)
interTG_ASSO			8.236***	5.387***
			(1.098)	(1.670)
LagTG_ASSO	4.652***	4.087**	-2.537*	-0.211
	(1.328)	(1.860)	(1.461)	(2.164)
School	-2.940	-129.503***	-24.611	-128.892***
	(71.404)	(44.725)	(64.802)	(45.474)
Unemployment	0.728	-0.475	0.529	-0.746
	(0.626)	(0.616)	(0.621)	(0.628)
Observations	272	272	272	272
Number of prov_id	17	17	17	17

LagTG_ASSO is the interaction between the treatment group dummy (**TG**), and the lagged value of criminal association activity (**lagASSO**). **interTG_ASSO** is the interaction between **LagTG_ASSO** and the dummy for the post-1999 period (1999-2007). In all columns GMM-Arellano Bond regressions with year fixed effects and robust standard errors (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 10. 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	0.921***	0.928***	0.325	0.335*		
	(0.153)	(0.156)	(0.200)	(0.198)		
Lag ASSO	5.583***	0.988	0.918	0.255	16.515***	
	(1.298)	(1.899)	(0.975)	(0.490)	(6.485)	
inter_ASSO		5.488**		0.881		
		(2.437)		(1.422)		
School	-159.252	-139.942	-22.689	-22.014	445.208	463.608
	(109.312)	(110.127)	(23.312)	(25.374)	(677.108)	(670.446)
Unemployment	-0.925*	-1.334**	-0.838	-0.925	-4.543	-5.436
	(0.505)	(0.618)	(0.810)	(0.733)	(7.716)	(8.358)
interTG_ASSO						18.954***
						(9.06)
Observations	128	128	144	144	38	38
Number of prov_id	8	8	9	9	19	19

LagTG_ASSO is the interaction between the treatment group dummy (**TG**), and the lagged value of criminal association activity (**lagASSO**). **interTG_ASSO** is the interaction between **LagTG_ASSO** and the dummy for the post-1999 period. In 1-4 columns GMM-Arellano Bond regressions with year fixed effects, robust standard errors (in parenthesis) and province specific trends. In the last two columns OLS regressions with time and province fixed effects. Panel collapsed in two periods as in Bertrand et al. (2004). Robust standard errors in parenthesis. Significance levels:*** p<0.01,** p<0.05,* p<0.1

TABLE 11. Trend in ASSO and ASSOTOT in the whole period (1990-2007)

VARIABLES	(1) ASSO	(2) ASSO	(3) ASSOTOT	(4) ASSOTOT
$TG\_Wind_{91\_94}$	0.258	0.956	0.943	1.835
	(1.188)	(1.303)	(1.469)	(1.476)
$TG\_Wind_{95\_98}$	-0.767	1.197	-0.449	2.018
	(0.762)	(1.258)	(0.871)	(1.328)
$TG\_Wind_{99\_02}$	0.110	3.203*	0.559	4.453**
	(1.113)	(1.840)	(1.040)	(2.059)
$TG\_Wind_{03\_07}$	1.301	5.568**	1.889	7.299**
	(1.502)	(2.288)	(1.554)	(2.833)
TG_Wind	2.014	1.940	0.421	1.244
	(1.235)	(1.268)	(1.377)	(1.570)
School	6.350**	1.701	7.060**	2.181
	(2.928)	(3.232)	(3.350)	(3.530)
Unemployment	-0.009	-0.024	-0.037	-0.070
	(0.076)	(0.062)	(0.090)	(0.089)
Observations	342	342	342	342
R-squared	0.479	0.585	0.530	0.621

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 first and third columns, OLS regressions with time, province fixed effects and clustered standard errors at the province level (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 12. Trend in ASSO and ASSOTOT in the post-1999 period (1999-2007)

VARIABLES	(1) ASSO	(2) ASSO	(3) ASSOTOT	(4) ASSOTOT
$TG\_Wind_{99\_02}$	0.389	1.706*	0.373	1.946*
	(1.028)	(0.904)	(1.124)	(1.073)
$TG\_Wind_{03\_07}$	1.515	3.697***	1.661	4.242***
	(1.231)	(1.069)	(1.295)	(1.355)
TG_Wind	2.119*	2.478**	0.887	2.356**
	(1.172)	(0.989)	(1.261)	(1.118)
School	3.120	1.728	5.033*	2.161
	(2.437)	(3.179)	(2.761)	(3.408)
Unemployment	-0.037	-0.024	-0.051	-0.069
	(0.048)	(0.061)	(0.055)	(0.086)
Observations	342	342	342	342
R-squared	0.784	0.829	0.823	0.857

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. **TG_Wind** is the treatment group fixed effect which varies in the level of the Wind Index. In first and third columns, OLS regressions with time, province fixed effects and clustered standard errors at the province level (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 13. Trend in ASSO and total ASSO in the post-1999 period (1999-2007)

VARIABLES	(1) ASSO	(2) ASSO	(3) ASSOTOT	(4) ASSOTOT
$TG\_Wind_{99\_00}$	0.896	2.196	0.625	2.041
	(1.292)	(1.281)	(1.329)	(1.423)
$TG\_Wind_{01\_02}$	-0.117	1.623*	0.122	1.988*
	(0.968)	(0.849)	(1.208)	(1.103)
$TG\_Wind_{03\_04}$	1.166	3.339***	1.862*	4.179***
	(0.888)	(0.956)	(0.994)	(1.180)
$TG\_Wind_{05\_07}$	1.747	4.505**	1.527	4.476*
	(1.687)	(1.838)	(1.780)	(2.241)
TG_Wind	2.140*	2.649**	0.894	2.407*
	(1.172)	(1.082)	(1.260)	(1.235)
School	3.071	1.659	5.015*	2.163
	(2.468)	(3.319)	(2.779)	(3.454)
Unemployment	-0.036	-0.024	-0.051	-0.069
	(0.049)	(0.060)	(0.055)	(0.086)
Observations	342	342	342	342
R-squared	0.785	0.830	0.823	0.857

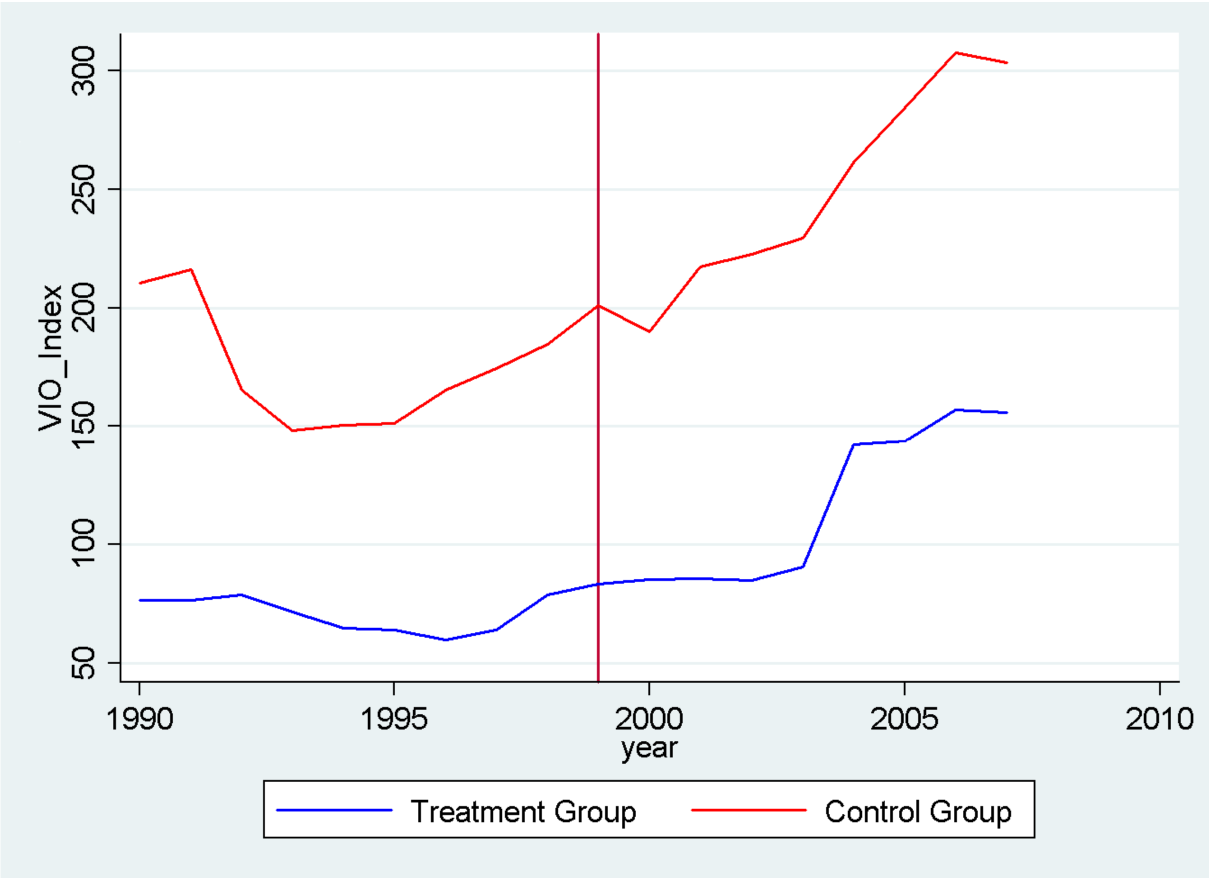
TG_Wind_i is equal to the value of Wind Index for each province in the treatment group for the period i, and zero otherwise. **TG_Wind** is the treatment group fixed effect which varies in the level of the Wind Index. In first and third columns, OLS regressions with time, province fixed effects and clustered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

TABLE 14. Difference in difference regression *a la* Bertrand et al. (2004)

VARIABLES	(1) ASS	(2) ASSTOT
$POST\_Wind_{99\_07}$	1.061	1.413*
	(0.738)	(0.752)
School	-4.580	-2.144
	(6.307)	(6.353)
Unemployment	-0.022	-0.151
	(0.151)	(0.167)
Observations	38	38
R-squared	0.852	0.902

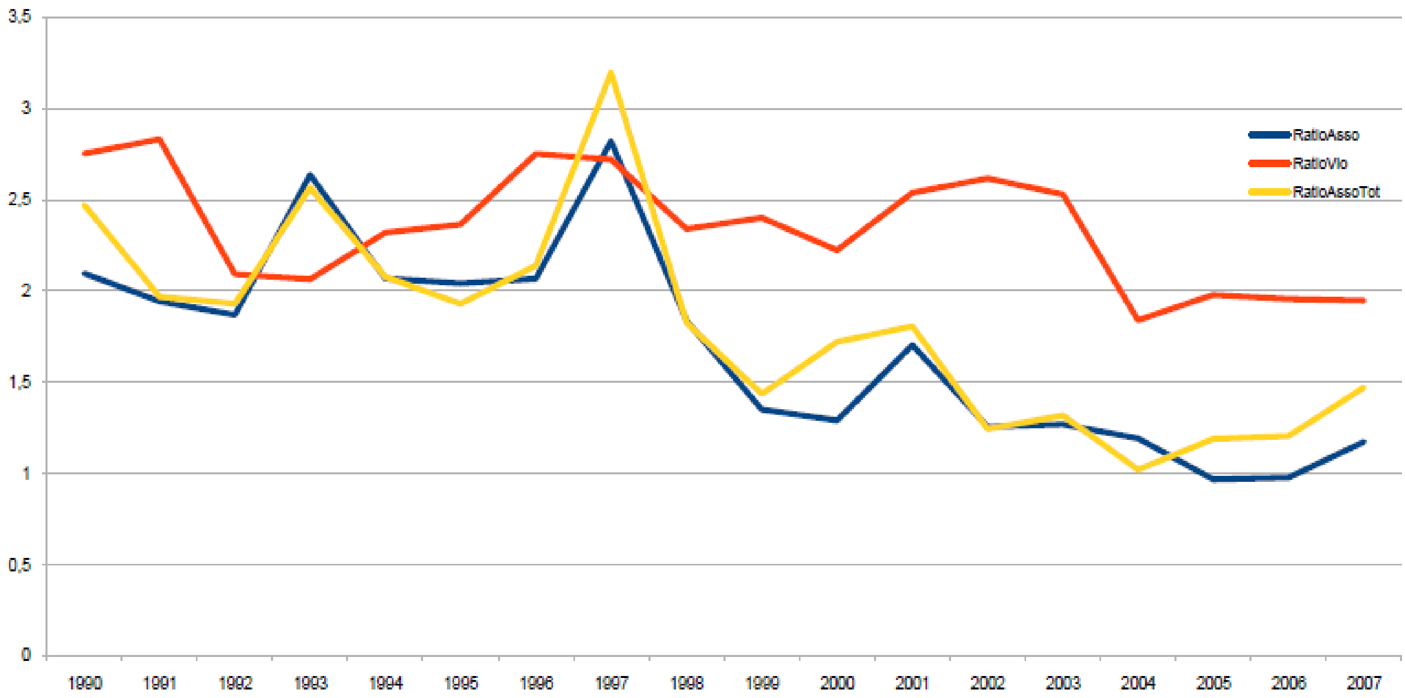
$POST\_Wind_i$ (interaction term between dummy $POST_{99}$ and the actual value of the Wind Index) is equal to the average value of Wind Index in the treatment group for the post-1999 period, and zero otherwise. OLS regressions with time and province fixed effects. Panel collapsed in two periods as in Bertrand et al. (2004). Robust standard errors in parenthesis. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Figure 8. Index of Violent Crime[4]



[4] **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.

Figure 9. Ratios between the level of both measures of criminal association activity and Index of Violent Crime in the control and treated provinces[5]



[5] **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 **ASSO** denotes Criminal Association activity and **ASSOTOT** denotes Total Criminal Association activity (sum of simple criminal association and criminal association of Mafia type).

TABLE 15.: 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}	18.060	12.366		
	(11.420)	(16.045)		
TG_{95_98}	19.805	6.389		
	(13.517)	(18.368)		
TG_{99_02}	24.058	2.729	7.281	-4.701
	(18.136)	(23.433)	(15.861)	(12.383)
TG_{03_07}	26.570	-4.316	9.745	-11.170
	(29.361)	(27.404)	(28.747)	(21.942)
TG	-22.091	-15.185	3.878	-6.671
	(17.961)	(20.434)	(12.448)	(12.252)
School	228.711***	180.181*	223.651***	176.459*
	(51.457)	(94.100)	(48.445)	(90.226)
Unemployment	-1.888	-2.624**	-2.019*	-2.663**
	(1.138)	(1.043)	(1.096)	(1.016)
Observations	342	342	342	342
R-squared	0.942	0.977	0.942	0.977

TG_i is a dummy equal to 1 for the provinces in the treatment group for the period i, and zero otherwise. **TG** is the treatment group fixed effect. In first and third columns, OLS regressions with time, province fixed effects and clustered standard errors at the province level (in parenthesis). Second and fourth columns include province specific time trends. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

TABLE 16.: Trend in Violent Crime Index in the post-1999 period (1999-2007) and difference in difference regression *a la* Bertrand et al. (2004)

VARIABLES	(1) Violent crime Index	(2) Violent crime Index	(3) Violent crime Index
TG_{99_00}	4.259	-5.897	
	(10.438)	(11.738)	
TG_{01_02}	10.304	-4.070	
	(23.238)	(20.048)	
TG_{03_04}	8.369	-10.255	
	(28.500)	(24.145)	
TG_{05_07}	10.669	-12.558	
	(30.312)	(31.549)	
$POST_{99\_07}$			4.421
			(16.318)
TG	-5.748	-6.831	
	(14.531)	(12.719)	
School	224.099***	177.358*	144.374
	(48.626)	(89.911)	(198.108)
Unemployment	-2.027*	-2.660**	-1.689
	(1.090)	(1.038)	(6.245)
Observations	342	342	38
R-squared	0.942	0.977	0.934

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

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