New power generation plants and investors' location choices: some evidence from the Italian case

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Abstract

This paper deals with the issue faced by investors on where to locate unwanted polluting plants. In particular, it analyses the location choices for the power generation sector in Italy, with the simplified assumption of considering all the investors as price-takers. In this context, along with market factors, even location-specific socioeconomic characteristics and variations in the regional energy regulation stringency are expected to affect such site decisions. In order to explore these relationships, a logit model of plant location choice is used: while some local socioeconomic characteristics seem to be relevant, inter-Region differences in the energy regulation do not significantly affect the investors' location choices.

Keywords: *Power generation investments; location choice; environmental regulation; externalities, NIMBY.*

Introduction

This paper refers to the issue of the location of unwanted investments; that is those investments in facilities and infrastructures which are generally opposed by the host communities, because of their local environmental impact (so-called "NIMBY" – Not In My Back Yard – effect). This issue is investigated from the point of view of investors, who decide where to locate their facility. In general, this decision is taken in the attempt to maximize the expected profit; in this case, even factors like the attitude of the local community or the stringency in local environmental regulation are expected to enter the profit flow function and to be relevant for the investors' decision.

In particular, this study empirically tests the location choices for new power generation plants in Italy. Since the liberalization reform of 1999 this sector has been characterized by the entrance of new investors besides the national incumbent Enel: their investments are strongly required in order to guarantee both the security and reliability of the electric system and a more competitive market structure. However, these investments are more and more opposed by the local communities, which often are able to delay, hinder or even stop the realization of such investments by legal actions. As to this issue, the main instrument the investors have to reduce and to manage this opposition is offering proper compensations (monetary and non-monetary) to the affected communities. In addition, the Region politics in the energy field have become relevant as well[1]. From one side, Italian Regions have veto power in the process of the siting permit, issued by the Industry Minister, which is needed for building and exercising any energy facilities[2]. From the other side, Regions are quite free in their energy planning choices (for instance in terms of preferred plant' sizes or renewable rather than conventional fuels). Hence, we may affirm that the favourable opinion of the host Region along with the positive (or not too much negative) attitude of the local community are relevant factors for the final outcome of the investment.

Accordingly, this research tries to explore several questions. Fist of all, if the NIMBY effect may delay or hinder the necessary investments for a country, do investors take into account this issue in their location choices and to which extent? Secondly, do local opposition or compensation requests by local communities depend upon socioeconomic characteristics? Moreover, are there differences in the relevance of this phenomenon across Italy? Finally, which can be the effect of a decentralized regulatory approach in terms of geographic distribution of the investments?

Therefore, the thesis we want to explore in this paper is the possibility that variations in the Regions legislation in the energy field and differences in socioeconomic characteristics at Province level may affect the location' choices of investors in the power generation sector.

The rest of the paper is organized as follows. Section 2 presents an overview of the main findings of literature on location choice theory for polluting plants (so called Locally Unwanted Land Uses, LULUs) and then our research strategy based on it. Section 3 describes the model of location choice which has been developed for taking into account those drivers related to local socioeconomic characteristics and Region energy regulation. Then, the econometric model is shown. The organization of the power plants' dataset and the variables are fully described in the Section 4. Based on these data, Section 5 presents the results of simple statistical tests along with the main evidence drawn from the multivariate regression. Section 6 discusses opportunities for future work and provides concluding remarks.

Location choice theory: background and research questions

As summarized by Wolverton (2002), a firm evaluates potential locations for a new plant based on the principle of profit maximization. In doing so, the firm takes into account many location-specific attributes that may affect potential profits in each of these locations. Two types of costs that vary with location, identified in the firm location literature, are production costs and transportation costs, related to the price, to the availability and the quality of input factors and to the issue of market access as well. « Production costs include costs related to relatively immobile inputs such as land, labor, and housing, and costs related to operation such as taxes, public utility fees, and environmental regulations. Transportation costs include freight rates, distance to input markets, and distance to output markets. It is also important to consider any offsetting location benefits from agglomeration economies such as a shared infrastructure or labor pool. » (Wolverton, 2002, 8). For example, Bartik (1985) in analysing the business location decisions in the

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[1] In Italy, there are four different government levels: State, Regions (19), Provinces (103) and Municipalities (more than 8000). Provinces are an intermediary level between Regions and Municipalities.

[2] A comprehensive description of the Italian siting procedure in force since 2002 and of the effects of it on the increase of local opposition phenomena can be found in Groppi (2006)

USA estimates the effects of several characteristics of States and finds that unionization and state taxes do affect business location, although the tax effect is of modest magnitude.

The effect of the local environmental regulation

In particular, for the purpose of this paper we are first interested in better understanding the effect on the business location choices of the local environmental regulation, which may differ among States in stringency and enforcement level. Why do States (even within the same country) show different environmental regulations and how do these differences actually affect the investors' location choices? Different States face different benefits and costs from environmental regulation, so they might be expected to choose different levels of stringency, imposing different level of abatement costs. As pointed out by Gray and Shadbegian (2002) regulatory stringency may influence firms' decisions along many dimensions. « The usual assumption is that production costs are higher in stricter states since firms are required to meet tougher emissions standards, install higher-capacity (more expensive) pollution control equipment, incur higher operating costs, and perform more frequent maintenance. In addition to higher production costs, stringent states may have more complex permit procedures, requiring firms to undertake lengthy negotiations whenever they wish to change their production process, and perhaps imposing uncertainty about whether the changes will be permitted at all. Since these permits are commonly required when opening a new plant, there could also be a direct impact of regulatory stringency on the expenses or time required to open a new plant. » (Gray and Shadbegian, 2002, 4). Accordingly, a variation in the stringency of environmental regulations creates the potential for "polluting havens" in which manufacturers locate where they find more lax environmental regulation, thereby creating geographic areas with relatively high concentrations of polluters.

Despite these compelling theoretical model, empirical studies have found mixed results and the debate over whether firm-location decision are influenced by regional variation in environmental regulation is still open.

From one side, neither Bartik (1988) neither McConnel and Schwab (1990) found significance or strong effects of variations in environmental regulation on location choices. While Bartik (1988) includes plants at the aggregate manufacturing level, McConnel and Schwab (1990) examine the determinants of location decisions for one single industry (motor vehicles), using firm-level data. They find that regulation does not matter, even if they admit that plants in this industry are not particularly footloose. The comprehensive study by Levinson (1996) goes further: he examines manufacturer location choices across most manufacturing industries and employs a wide array of measures of environmental standard stringency. He reports that even if branch plants of large firm (and only these ones) appear to be deterred by stringent environmental regulations, as measured by a variety of different proxies for state environmental stringency, only a few of the coefficients of these measures are statistically significant and none is large. Moreover, counter intuitively, this author finds that « the degree of aversion to stringent states does not seem to increase for pollution-intensive industries », which could suggest that stringency proxies used are capturing some other state characteristic. Levinson (1996) proposes also alternative explanations for the little deterring effect he found: « firms manufacturing products in a variety of jurisdictions find it most effective to operate according to the most stringent regulations, eliminating the necessity of designing a different production process for each location » or « it may simple be that the more pollution-intensive industries also happen to be the least footloose » (Levinson, 1996, 26). In addition, the same author in a previous paper (Levinson, 1995) reports the suggestion of Gladwin and Welles (1976) that regulations are not nearly as important as to industrial location decisions as local public opposition to new plants. Finally, in their recent study Weersink and Eveland (2006) find that livestock facilities instead of locating to reduce environmental compliance costs are being built largely where the livestock sector is concentrated, suggesting the existence of more relevant agglomeration economies.

From the other side, Gray (1997) tests whether differences across States in pollution regulation, measured by several indexes, affect the location of manufacturing activity in the USA and find that States with more stringent environmental regulation do have fewer new manufacturing plants. However, as already found by Levinson (1996), a sub-sample of high-pollution industries gets statistical coefficients similar to those of the whole sample, raising the doubt that differences between states other than environmental regulation might be influencing the results. Anyway, List and McHone (2000) find that manufacturers in pollution-intensive sectors are deterred severely by more stringent county-level environmental regulation (their study refers to the single State of New York). Similarly, Gray and Shadbegian (2002) find that firms in the paper industry allocate smaller production shares to states with stricter regulations. This effect would be due to high compliance costs, which firms tempt to avoid by choosing states with lax regulation. In addition, Becker and Handerson (2000), analysing the impact of air quality regulation on decisions concerning not only plant locations but also sizes and investment pattern in major polluting industries, find that « there has been significant relocation of polluting industries from more to less polluted areas to avoid stricter regulation in more polluted areas; there has been relative proliferation of small-scale, less regulated enterprises in some industries, altering industrial structure; and, in regulated areas, the timing of plants investments by new plants has been dramatically altered » (Becker and Handerson 2000, 380).

In conclusion, it is worth summarizing some important issues: i. a robust empirical evidence for the pollution haven hypothesis lacks; ii. an unique measure of environmental stringency does not exist and, moreover, different measures may give statistically different results; iii. use of plant-level data has to be preferred with respect to aggregate-level observations (which can capture only the net effect of both decisions of building and shutting down plants; in turn, such decisions are differently affected by regulation strength); iv. different industries may react in different ways to the environmental stringency because of the relative weight of compliance costs and the opportunity to shift production.

The effect of local socioeconomic characteristics

As pointed out by Levinson (1995), according to some scholars, the empirical studies of industrial flight have mistakenly focused on the regulations and their compliance costs, when they should have concentrated on public environmental sentiment as a determinant of industry location. Accordingly, Hamilton (1993) finds that noxious firms choose locations that generate the least political opposition; he assumes voting participation as a proxy for the community's propensity to engaging in collective actions. As a consequence, characteristics of the potential host communities do matter in the location decisions of investors aimed at reducing the risk of local opposition. More in general, according to Hamilton (1995), socioeconomic characteristics of local communities may be taken into account by investors because: i. communities can differently evaluate the environmental amenities, and therefore the potential compensation by the firm to the neighbourhood residents may differ; ii. communities can differ also in their ability to negotiate compensations or to organize effective opposition; iii. communities might be deliberately discriminated by firms for example due to racial prejudice. Actually, these economic theories offer different predictions about what socioeconomic variables should be statistically significant in models of the location choices of polluting facilities. The first issue comes from the Coase theorem according to which firms negotiate with local affected residents compensations at least equal to the externalities produced by them. Anyway, as other goods, the willingness to pay for environmental quality is expected to be positively correlated with characteristics like income or education levels. As a consequence, a polluting plant will locate where it does the least damage because this is where compensation is the least. « The firm takes into account the physical and demographic characteristics of the surrounding neighbourhood that influence the "cost" of its externalities: the number of people affected; income; property values; and residents' willingness to pay for environmental amenities » (Hamilton, 1995, 109). This may result in poor communities receiving the polluting facilities more often than wealthier communities because of lower disutility (since they have more to gain from the economic benefits). Regarding the second explanation, communities may vary not only in the amount of negative externalities, but also in the ability of residents to organize politically and overcome free-rider problems. Indeed, though in a world of zero transactions costs each individual may negotiate compensation with the firm, actually compensation demands are typically voiced through the political process. This implies that compensation demands depend on at least two factors: the value placed on environmental amenities and the ability to voice those demands (Hamilton, 1995). As a consequence, as verified by Hamilton (1993), noxious firms choose locations that generate the least political opposition, which may not be the locations that result in the lowest externalities. Finally, according to the third theory, plants locate in poor or minority neighbourhoods because firms gain utility from pure discrimination against a particular demographic group, so they trade-off profits for prejudice. The last pure discrimination model (so called "environmental racism") was advanced following several empirical studies which argued that minority faced significant discrimination in the siting of noxious facilities and disproportionate exposure to various environmental risks in the USA. Hence, this subject received large attention by scholars for its relevant policy implications and so several empirical studies dealt with the impact of the socioeconomic characteristics of the host communities of polluting plants in order to test for the environmental racism hypothesis. For example, Kriesel, Centner and Keeler (1996) survey many studies which find an association between environmental quality and a locality's racial and income characteristics. Moreover, these authors perform a multiple regression analysis in a broad model which include several local characteristics. They find that exposure to noxious materials (and so noxious facilities location) is negatively correlated with the education level (likely related to the degree of NIMBY syndrome) and to the population density (according to Coase predictions about the amount of compensations to be offered to residents). In turn, a positive linkage is found for the percentage of population in poverty (according to both the pure discrimination model and the Coase based-model if firms seek to minimize potential liability) and for the access to transportation infrastructure, according to the standard business location theory. By contrast, neither race nor income factors result statistically significant. Contrary to Hamilton results, this study reports that better political organization (captured by the voting participation) tends to be associated with more locations of toxic-emitting facilities: perhaps in the selected communities industrial recruitment effect prevails on the perceived environmental risk. Vice versa, Hamilton (1995) finds that both Coasean compensation variables and, even more, the variable aimed at capturing community's propensity toward collective actions are significant predictors for the location pattern of waste treatment facilities: lower compensation and less active areas are likely to be targeted for hosting waste treatment plants. Race, in Hamilton work, is never statistically significant. By contrast, the empirical study of Ringquist (1997) gives support to the "environmetal racism" hypothesis: his results provide additional evidence that racial minorities experience disproportionate proximity to a wide variety of environmental risks, even if Coasean variables (like housing value, percentage home ownership, income, urbaneness) are more powerful explanations for the distribution of risks. Similar results are found by Boer et al. (1997). Still related to the issue of "environmental racism" it is the research carried out by Wolverton (2002) who underlines the importance of using socioeconomic variables dated at the same time of the siting of polluting facilities instead of using the *current* neighbourhoods characteristics. Otherwise, it would not be possible to say whether race or poverty may be an important consideration in plant's location decision[3]. A part from this issue, her empirical results give support to both the Coasean and the collective action propensity explanations for the location choices of polluting plants: income; population (larger density may mean larger free-rider problems in negotiating with firms), over 65 aged persons (considered more active residents), housing vacancy rate.

Finally, it is worth mentioning the research of Becker (2004), which first looks at the effects of community characteristics on the pollution abatement expenditure by manufacturing plants. In his model, environmental expenditures is function of formal regulation as well as local characteristics potentially affecting such expenditures, either because facilities behave differently in such areas and/or local regulators regulate more (or less) stringently in such areas. Accordingly, community characteristics may affect local regulatory enforcement, which in turn affects abatement expenditure, which in turn affect plant location. Results show that, after controlling for establishment characteristics and various forms of formal regulation, some community characteristics have an additional effect on abatement expenditure: larger per capita income; higher degree of homeownership (it may mean to care about maintaining properties' values and to lobby for more stringent regulation, also higher sunk costs and lower mobility than renters); a greater concentration of democratic voters; and being located in a metropolitan area

In conclusion, socioeconomic characteristics are supposed to matter because from one side local communities may differ in the utility they achieve from the environment or in the utility they gain from the economic benefits of facilities (like for example jobs or economic development such firms may provide); on the other side communities may differ in their propensity to organize local opposition or in their ability to lobby politicians in order to avoid unwanted facilities siting.

In summary, these results seem to suggest that local opposition against facilities or a more stringent environmental regulation could inhibit investments, and eventually compromise the energy development of a region.

Research questions

As previously mentioned, this study focuses on the power generation sector, which since 1999 has been experiencing a deep increase in the number of power plants' proposals by new entrants in the market. However, this race in the investments resulted in an increase of strong reactions by the local communities because of the perceived pollution burden. As a consequence, local Municipalities very often engage in

[3] Accordingly, Been (1994) claims that most of the studies compare the current socioeconomic characteristics of communities that host LULUs to those of communities that do not host such LULUs. From one side such an approach fails to prove environmental racism in the location decison process; from the other side market dynamics (i.e. property values' decline which in turn attracts poorer and minority people after the sitings) may play a very significant role in creating the uneven distribution of the burdens LULUs impose.

legal actions to prevent the building of these facilities in their territory[4]. Therefore, we suppose that investors, along with factors like for example the zonal electric market attractiveness or the availability of local infrastructures (like the distance to the high voltage electric grid), even consider the attitude of the potential host communities.

Proposition 1: ceteris paribus, the lower the expected compensation costs and the lower the expected local opposition, the more likely the location choice in that Province.

On the other side, we look at the Regions legislation in the energy field because in the siting permit process, Regions have veto power on the final authorization. Indeed, all these investments need a siting permit, which is issued by the Industry Minister only if both positive Environmental Impact Assessment and positive host Region judgment are attained. In this context, it is worth considering the regional energy regulation to the extent that more stringent rules may be expected to delay the issue of permits, to make uncertain the final Region's judgment or even to deny the necessary approval to the projects. As to the environmental regulation, in Italy rules and standard are defined at national level by the Environment Minister, so no differences can be detected at regional level, a part from eventual variations in the enforcement efficiency. Anyway, these possible differences are supposed to be negligible for the purpose of our study. Therefore, investors are supposed to carefully consider in their location decisions the attitude of Regions, as expressed by the regional energy regulation.

Proposition 2: ceteris paribus, the less stringent the regional energy regulation, the more likely the location choice in a Province belonging to that Region.

Theoretical and econometric model of plants' location choice

This study focuses on how the decision to locate a new power plant is influenced by a Province characteristics. Accordingly to Bartik (1988), the key empirical variable that the model seeks to explain is the probability of a particular Province being chosen as the location for an investor's new power plant. In deciding on a new plant's location, investors examine how their potential profit levels vary by location. The probability of a given location's being chosen should, therefore, depend on the levels of its characteristics which affect profits compared to the levels of these characteristics in other locations. An investors has « an unobserved profit function for each possible location that is a function of location-specific variables such as factor prices, fixed inputs (land, labor) » (Wolverton 2002, 9) and the stringency of Region's energy regulation. In addition to the list of location-specific variables considered by the investor, one can add the cost of required compensation and the cost of local opposition in the form of delayed profits[5]. Therefore, an investor i which is considering the location of a new power plant has an unobserved profit function for each feasible location j given by:

$$\pi_{ij} = f(z_j, y_i, s_{ij})$$

where z_j factor represents location-specific characteristics; y_i factor represents investor-specific features; s_{ij} factor represents other investor-specific factors which may vary by location, but which are not observed.

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[4] In order to give some figures on the local opposition phenomenon Groppi (2006) reports that of the 26 new power generation plants authorized by the Italian Industry Minister in the period 2002-2006, 13 has been legally opposed, most by Municipalities or active groups of residents.

[5] Local opposition shifts the time when the plant starts to operate, so to gain profits.

The investor will choose to locate a plant in the location that yields an high potential profit, discounted for the time period needed for the plant to be in operation[6].

More in detail, the z_j factor may be expressed by

z_j = (Relative prices$_j$, Infrastructure$_j$, Energy regulation$_j$, Required compensation level$_j$).

Indeed, increasing output prices or decreasing input prices can both increase relative profitability. Distance to the high voltage electric grid, necessary to dispatch the power generated by the plant, and to the gas network for providing fuel to the plant are both relevant factors for the plant's cost function. Energy regulation gives signals to the investors about the attitude of the host Region: a more "stringent" legislation means either low probability or more time to achieve the necessary siting permit. Required compensation, which enter the profit function, is, in turn, function of two components: the value placed on environmental amenities and the propensity to engage in collective actions against the plant siting.

As to the y_i factor, in the power generation sector the fact that a specific location is chosen among the others depends also upon the characteristics of the single investors (for example its plants' geographic distribution) or on the plant's technology. Indeed, in the actual Italian market structure the incumbent Enel may effectively exercise market power in several areas, along with very few other investors (and these ones only in particular areas), so that their investment decisions can be well relevant for the whole market. Similarly, even the plant's characteristics (namely efficiency or marginal costs) may affect the final market price as well. However, here we are assuming a perfectly competitive market in which all the investors are "price-takers": the decision to build and operate a plant and to locate it in a particular site does not affect the electricity market price at all: undifferentiated price-taker investors and undifferentiated plants hypothesis is assumed. To support this idea, from one side, almost all the new proposed plants are "Cycle Combined Gas Turbine" technology; from the other side, the incumbent Enel since the liberalization has not been allowed to invest in new plants, in order to reduce its market share under 50%.

In this model investors first decide whether a new plant is needed and then decided where to locate it. Most studies (as Bartik 1985; Bartik 1988, McConnel and Schwab 1990; Hamilton 1995; Levinson 1996; Wolverton, 2002) use plant-level data and McFadden's conditional logit model that allows for analysis of the location decision. In conditional logit model it is assumed that firm i faces J possible plant location alternatives and that these J choices are independently and identically distributed. The firm will choose location j when its profits are maximized in that particular location compared to all other possible choices: $\pi_{ij} \geq \pi_{ik} \ \forall \ k \neq j$. Instead, in this research, we are interested in modelling not the fact that an investor chooses a site among all the possible locations, but we want to estimate the probability that a generic location will host a plant. Actually, in our specification this is the empirical variable, which in turn depends on the unobserved latent profit variable. Then, the observed dependent variable is determined by whether profit exceeds a certain threshold. The actual investor's i profits may be written as follows

$$\pi_{ij} = \beta' x_{ij} + e_{ij}$$

where x_{ij} is defined as the set of observed characteristics specific to location j and to investor i. In our specification, as previously discussed, we only observe z_j location-specific characteristics:

z_j = (Relative prices$_j$, Infrastructure$_j$, Energy regulation$_j$, Environmental willingness to pay$_j$, Local opposition propensity$_j$)

[6] Time to be in operation includes the siting permit process and the building stage of the plant.

where *required compensation level* has been replaced by the two determinants that drive it (*environmental willingness to pay* and *local opposition propensity*). Following Bartik (1985) and Levinson (1996), if the firm's underlying production function is assumed to be Cobb-Douglas, then profits will be log-linear.

The geographic unit of analysis chosen for the purpose of this study is the Province, a good compromise between large sized Regions and small sized Municipalities. Indeed, Provinces are an approximation of the neighbourhood characteristics of the area surrounding the plant (Regions too large can mask much of the neighbourhood's variance in socioeconomic characteristics) and they are quite comparable among them, much more than the Municipalities group does.

Data and variables

We developed a novel dataset which monitors all the applications for green-field or re-powering energy investments filed since 1999 up to march 2007. It includes more than 100 procedures, with information on investor, ownership structure, location, technology, size of projects, procedure keydates. In Table 1 and in Figure 1 some general information is provided (type, technology, average authorization rate, power, year).

Table 1: Power plants applications: main characteristics

Applications	#	Power
	115	70GWe
of which green-field	88	
of which already authorized	44 (38%)	31,5GWe
of which CCGT	20	21GWe

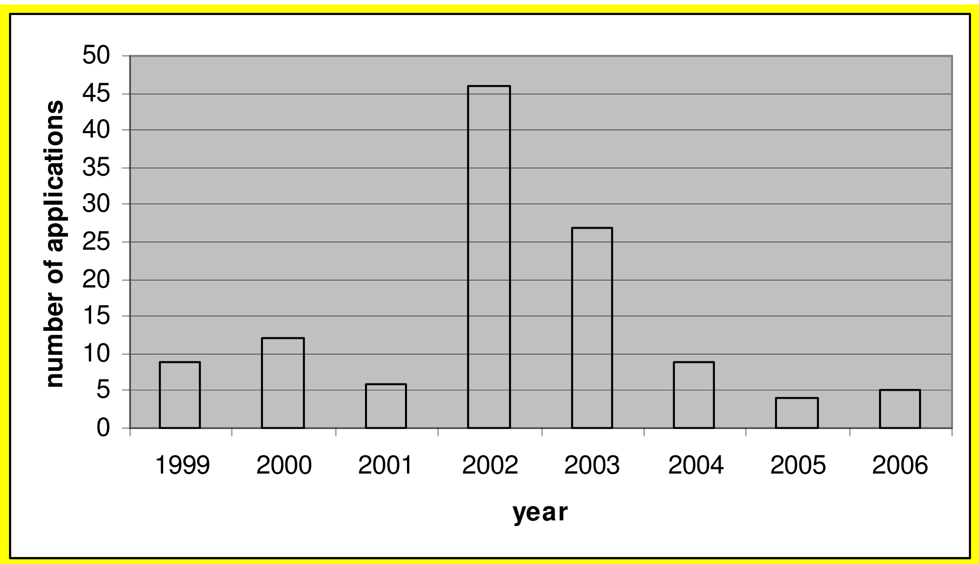

Figure 1: Number of applications per year (source: own elaboration from Bigano, Franci, Groppi 2006)

The dramatic increase in the number of applications in 2002, as shown in Figure 1, may be explained by the introduction of the new Italian authorization law, coming in force in the same year, aimed at reducing the approval time.

Dependent variable

We have used the list of the requests of building permit, presented by the investors to the Industry Minister, as a proxy to represent the location decisions. We had access to the full list of requests for siting permits collected by the Minister since 1999 up to march 2007. The presence of an application in a certain Province represents the investor's purpose to locate there its plant.

We focused on the location of only new plants, both green-field and brown-field, so we dropped from the sample all the applications for re-powering interventions on existing plants. Indeed, we want to investigate what the location choices are driven by, but re-powering interventions are, by definition, on plants previously sited. Moreover, re-powering interventions lead to an improvement of the environmental impact of plants, so in general they are welcomed by both Regions and local communities[7]. This assumption reduced our sample to 88 applications for new plants (compared to the total of 115). 50 are the Provinces affected by at least an application and 43 the Provinces without any siting request[8].

Independent variables

In our specification the probability that a Province$_j$ is actually chosen depends upon the investor's expected profit, which in turn is a function of some location-specific characteristics, previously classified as: *Relative prices$_j$, Infrastructure$_j$, Energy regulation$_j$, Environmental willingness to pay$_j$, Local opposition propensity$_j$.* In the following sub-sections a detailed description of the selected local variables is provided.

Socioeconomic variables

Accordingly to the revised literature some local socioeconomic characteristics may affect either the willingness to pay for the environment either the attitude of host communities to opposition. In Table 2 we present the list of the selected variables with the expected sign of influence on the location choice.

Table 2: List of socioeconomic variables

Variable	Description	Expected sign
POP	Population	- / +
DENS	Density	- / +
INCOME	Average income	-
ENV_ASSOC	Region's environmental	-

[7] Accordingly, also Weersink and Eveland (2006), Levinson (1996), McConnel and Schwab (1990), even if they analyse the impact of the variations in the regional environmental regulation on location choices, do focus on new plants only, because of "grandfathering arrangements" of most environmental legislation. Hence « new operations locating in a particular region tend to face harsher environmental constraints than do existing firms. » (Weersink and Eveland, 2006, 160).

[8] 10 Provinces are excluded from the sample because they belong to Siciliy, Region with additional legislative autonomy: siting applications have to be presented only at regional level and not to the Industry Minister.

	association per inhabitant	
UNEMPL	Percentage of unemployment	+
NOSCHOOL	Percentage of population without elementary education	+
HOMEOWN_ RES	Percentage of residents home owners	-
UPTO6YEARS	Percentage of population younger than 6 years	-
MORE65YEARS	Percentage of population elder than 65 years	-
AGR_FIRMS	Agriculture firms per inhabitant	-
TOURISTS	Tourists' arrivals	-
BAD_AIR_QUAL	Number of municipalities classified as "bad air quality" ones	- / +
RISK_PLANTS	Number of risky classified plants	-

According to the revised literature, these variables belong either to the Coasean category either to the collective action propensity category or to both. More in detail, according to the Coase theorem, a negative effect is expected for population (POP), density (DENS), and INCOME, even if "free-rider" behaviours in organising local oppositions may exist for high values of density and population. The number of environmental associations per inhabitant (ENV_ASSOC) is supposed to act as deterrent as well, whereas the unemployment percentage (UNEMPL) and the education factor (NOSCHOOL) (in terms of less educated people) are both to be supposed to be positively correlated to location choice. High percentages of homeowners (HOMEOWN_RES) and both young (UTO6YEARS) or old (MORE65YEARS) people are supposed to be more active residents in fighting the location of unwanted facilities. Similarly, those areas agriculture- or tourism-oriented are likely to more oppose to polluting plants (AGR_FIRMS and TOURISTS). The existence of risky plants (RISK_PLANTS) in the same territory may perhaps exacerbate the attitude of the affected communities, like the fact of including Municipalities classified as "bad air quality" ones (BAD_AIR_QUAL)[9]. At the same time, those locations characterized by a good quality air may evaluate even more the environmental amenities.

All these data for the Provinces samples are drawn from the 2001 Census, a part from BAD_AIR_QUAL and RISK_PLANTS variables which are available at Environment Ministry website.

[9] "Bad air quality" classification of Municipalities according to the list ex-art. 8 D.lgls 351/99 (Italian Law).

Region energy regulation variables

In order to test for the hypothesis of the effect of variations in the energy regulation, the content of the energy regional plans has been deeply analysed and classified. Indeed, Regions may behave in a different way during the siting process, with the effect of either delaying or speeding-up the investments, and these differences may be predicted by investors on the base of the actual regional energy regulation in force. The variable aimed at capturing this variation is a dummy variable (REG_RANK) which ranks the Region regulations from 1 to 3. In particular, rank 1 means that Regions have clearly declared in their plans not to authorize such power plants; rank 2 means that Regions are willing to authorize plants in order to reduce their energy deficit; rank 3 means that Regions are available to authorize plants even in excess to their energy consumption level. The source is the analysis carried out by Franci (2006). In order to test for the suitability of this variable, the authorization rate (i.e. the number of authorized plants on the total number of applications) was regressed against it, according to:

Authorization rate = c + REG_RANK.

The variable resulted positively correlated (at 5% significance level) to the authorization rate with a coefficient equal to 22.26. The explanatory power represented by the adjusted R^2 was 32%. In other terms, our REG_RANK variable is well positively correlated to the actual authorization rate of the power plant applications.

In addition, a macro-regional dummy variable (ZONE) representing location in North, Center and South of Italy is included. It is aimed at capturing eventual differences in the enforcement of environmental regulation, a part from representing a sort of general business climate index. Anyway, as pointed out by Levinson (1996) several measures of regulation stringency may exist, which, in turn, may provide different statistical results.

Finally, even if we do not test for the environmental regulation effect, the previously described variables BAD_AIR_QUAL and RISK_PLANTS could both take into account a stronger or weaker enforcement activity.

Other explanatory variables

With regard to the category "*Relative prices*" it is here assumed that prices of inputs (labour, land, capital) as well inputs' availability do not vary with location across Italy. Referring to the output prices, the maximum electricity price of the zone[10] the Province belongs to is used as a proxy of the relative attractiveness of the local electric market. This information is drawn from the website of the Italian electricity market which started to operate in April 2004.

With regard the category *"Infrastructure"* it would be useful to know the relative distance to the closest entrance node of the electric high voltage grid and, similarly, to the high pressure gas network as well, but this information is only available for those applications which have already achieved at least the Environmental Impact Assessment. Therefore, the dummy variable EXIST_PLANTS is used as a proxy of it: it assumes value 1 when at least one pre-existing plant is located in the Province, 0 otherwise. Indeed, in that case we may suppose the availability at least of a proper electric infrastructure (it is not the

[10] Because of transport limits in the national grid, the national electric market may be separated in six electric zones (five without Sicily) in which a separated price exists.

same for for gas network). In addition, this dummy variable is expected to capture also eventual agglomeration economies.

Both the variables MAX_PRICE and EXIST_PLANTS are supposed to be positively correlated with the probability of a Province to host a plant.

Results

First of all in Table 3 we provide some statistical information on the variables for the whole sample of Provinces.

Table 3: Statistical information

Variable	Mean	Standard Deviation	Min	Max
POP	557717	628807	89852	3707210
DENS	249.20	344.09	37	2612
INCOME [€]	28346	3344	21807	32313
ENV_ASSOC	1.42	1.27	0.077	5.77
UNEMPL [%]	10.05	7.37	2.32	30.90
NOSCHOOL [%]	9.66	2.72	4.46	18.08
HOMEOWN_ RES [%]	73.52	4.30	55.53	85.23
UPTO6YEARS [%]	5.19	0.730	3.69	7.35
MORE65YEARS [%]	20.08	3.12	12.52	25.91
AGR_FIRMS	35.69	24.86	7	125
TOURISTS	164.1	184.2	19	981
BAD_AIR_QUAL	21.01	39.03	0	239
RISK_PLANTS	78.82	71.44	4	255
REG_RANK	1.89		1	3
ZONE	1.74		1	3
MAX_PRICE [€]	209.4	69.81	176.2	500
EXIST_PLANTS	0.2796		0	1

Descriptive statistics and regression results are presented in the following two sub-sections.

Descriptive statistics

The mean values for the explanatory variables in the two samples of Provinces with and without applications are provided in Table 4. In addition, the *t*-statistics for determining whether the means are statistically different are presented in third column along with the associated *p*-values. For the dummy variables ZONE, REG_RANK and EXIST_PLANTS chi-square tests are reported.

Table 4: Descriptive statistics

Variable	Mean (standard deviation)		t-test (p-values)
	Provinces without any applications (N=43)	Provinces with at least one application (N=50)	
POP	472448.8 (554513.1)	631048.3 (683340.0)	1.22 (0.227)
DENS	255.0 (328.3)	244.2 (360.3)	0.150 (0.881)
INCOME [€]	29218.1 (2377.6)	27596.4 (3861.5)	2.39 (0.0189)**
ENV_ASSOCI	1.54 (1.27)	1.31 (1.28)	0.859 (0.393)
UNEMPL [%]	8.14 (5.67)	11.7 (8.28)	2.38 (0.0195)**
NOSCHOOL [%]	8.97 (2.02)	10.26 (3.09)	2.35 (0.0212)**
HOMEOWN_ RES [%]	74.52 (4.16)	72.67 (4.28)	2.11 (0.0378)**
UPTO6YEARS [%]	5.06 (0.5870)	5.31 (0.822)	1.70 (0.0934)*
MORE65YEARS [%]	20.54 (2.79)	19.69 (3.36)	1.304 (0.195)
AGR_FIRMS	32.4 (21.2)	38.5 (27.5)	1.19 (0.238)
TOURISTS	685391.4 (833224.2)	844166.6 (1369844)	0.650 (0.517)
BAD_AIR_QUAL	22.6 (40.40)	19.64 (38.16)	0.363 (0.717)
RISK_PLANTS	75.79 (71.59)	81.42 (71.93)	0.377 (0.707)
MAX_PRICE [€]	191.89 (5.99)	224.47 (92.83)	2.30 (0.0240)**
Variable	Median (> Overall median)		Chi-square test (p-value)
	Provinces without any applications (N=43)	Provinces with at least one application (N=50)	
ZONE	1 (19)	2 (27)	0.891 (0.3453)*
EXIST_PLANTS	0 (7)	0 (19)	5.42 (0.020)**
REG_RANK	2 (1)	2 (14)	11.27 (0.0008)***

*** significance at 1% level; ** significance at 5% level; * significance at 10% level

Looking at the socioeconomic variables, many of them present the expected sign, even if only few of them are statistically significant. In particular, according to the Coase theorem, DENS, INCOME, ENV_ASSOC variables reduce the probability for a Province to be chosen, due to the higher costs of compensation coming from both the higher number of individuals and the higher attention they should pay to the environment. Further, larger values of unemployment rate are likely to increase the siting probability, as still predicted by the Coase theory. According to Hamilton hypothesis (the importance to look at the attitude of local communities to engage in collective actions) a low educational level, from one side, and more "active" residents (like homeowners and people more than 65 years aged) from the other side, have the expected negative effect. By contrast, the local business orientation (captured by the variables TOURISTS and AGR_FIRMS) have positive effect, even if both are not significant. A compromised environmental quality (measured by BAD_AIR_QUAL and RISK_PLANTS) seems to have a mixed impact As to the regional impact, REG_RANK results in the expected direction. Finally, the market attractiveness' measure (MAX_PRICE) is a relevant predictive factor. The significance of EXIST_PLANTS as well could indicate the importance of agglomeration economies.

However, these differences in the average values of the explanatory variables do not explain the relative importance of the factors affecting the probability for a province to be chosen. These relationships are discussed below.

Regression results

The explanatory variables listed in Table 4 were regressed against the empirical dependent variable representing the probability that a Province would be chosen. The regression results are reported in Table 7. The adjusted R^2 is not really large but it is comparable to many other studies (for example, Wolverton (2002) reports a value of 0.19). Few coefficients resulted statistically significant, probably because of the correlation among independent variables (see Table 5 and Table 6). The Table 7 presents the estimated coefficients for the model BASE (with only *Relative prices* and *Infrastructure* variables included); the model BASE+REG (in which the regional dummy variable is added); and the model BASE+REG+SOCIOEC (in which even the socioeconomic variables are added). None of the other variables tested in a variety of models were significant.

Table 5: Correlation among independent socioeconomic variables

	POP	DENS	INCOME	ENV_ASSOC	UNEMPL	NOSCHOOL	HOMEOWN_RES	UPTO6YEARS	MORE65YEARS	AGR_FIRMS	TOURISTS	BAD_AIR_QUAL	RISK_PLANTS
POP	1.00	0.71	0.027	-0.35	0.13	0.074	-0.43	0.31	-0.36	-0.12	-0.07	0.44	0.22
DENS		1.00	0.045	-0.14	0.11	0.093	-0.48	0.23	-0.23	-0.22	-0.052	0.40	0.23
INCOME			1.00	0.56	-0.81	-0.59	-0.054	-0.38	0.32	-0.81	0.22	0.34	0.61
ENV_ASSOC				1.00	-0.41	-0.23	0.015	-0.35	0.35	-0.50	0.06	-0.015	0.48
UNEMPL					1.00	0.76	-0.014	0.47	-0.55	0.64	-0.29	-0.22	-0.37
NOSCHOOL						1.00	-0.078	0.56	-0.62	0.48	-0.32	-0.047	-0.094
HOMEOWN_RES							1.00	-0.17	-0.0085	0.29	-0.013	-0.27	-0.20
UPTO6YEARS								1.00	-0.87	0.35	-0.023	0.17	0.037
MORE65YEARS									1.00	-0.34	0.11	-0.20	-0.12
AGR_FIRMS										1.00	-0.080	-0.37	-0.62
TOURISTS											1.00	-0.14	-0.17
BAD_AIR_QUAL												1.00	0.61
RISK_PLANTS													1.00

Table 6: Correlation among some independent variables

	INCOME	REG_RANK	ZONE	BAD_AIR_QUAL	RISK_PLANTS	MAX_PRICE	EXIST_PLANTS
INCOME	1.000	-0.49	-0.80	0.34	0.61	-0.48	-0.053
REG_RANK		1.00	0.54	0.057	0.044	0.41	0.029
ZONE			1.00	-0.29	-0.46	0.37	0.097
BAD_AIR_QUAL				1.00	0.61	-0.14	0.047
RISK_PLANTS					1.00	-0.22	0.076
MAX_PRICE						1.00	-0.047
EXIST_PLANTS							1.00

Table 7: Regression results explaining the probability for a Province to be chosen

Coefficient	BASE		BASE + REG		BASE + REG + SOC_EC	
	Parameter	Std error	Parameter	Std error	Parameter	Std error
Costant	-107.5778**	51.72431	-102.2581**	51.05286	-80.02816	69.98576
LOG(MAX_PRICE)	20.38129**	9.823273	19.17758**	9.701308	20.48208*	11.32474
EXIST_PLANTS	1.395439**	0.544186	1.401117**	0.550911	1.249345**	0.579835
REG_RANK			0.560843	0.404859	0.145791	0.479086
LOG(INCOME)					-1.631212	2.474403
HOMEOWN_RES					-0.118726*	0.068641
LOG(TOURIST)					-0.324176	0.303219
MORE65YEARS					-0.062180	0.088194
Adjusted-R^2	0.137235		0.152847		0.191385	

*** significance at 1% level; ** significance at 5% level; * significance at 10% level

It is worth noting that all the explanatory variables have the expected sign, even if few of them are statistically significant. More in detail, the two variables of the BASE model, referring to the output prices and to the presence in the Provinces of other pre-existing plants are significant for all the regressions of Table 7. As already pointed out, the EXIST_PLANTS variable may take into account the existence of agglomeration economies. An alternative explanation is not supported by the regressions results: the fact that communities which already host power plants could be more oriented to oppose to new investments.

By contrast, this result seems to support the idea of investors presuming agglomerations economies' effects more relevant in driving their choices.

The regional dummy variable is never significant in any of the two models, even if it always keeps the expected positive sign. One possible explanation could be that this variable comes from the analysis of Regional Energy Plans which in most cases are subsequent 2002. If we look at Figure 1 (time trend in the applications), we note that a large part of applications was presented before the Region regulation coming in force. Actually, a few of these applications have been later rejected by Regions. In other terms, investors could not have been aware of or could have under-evaluate the attitude of Regions.

Among the socioeconomic variables, only the HOMEOWN-RES variable results significant with the expected sign, according to the theory of homeowners showing a stronger attitude to engage in local opposition and to lobby politicians in order to stop the siting project as well.

As to the classification table, the fraction of Provinces with and the fraction of Provinces without an application that are correctly predicted are respectively 74% e 66%. Overall the estimated model correctly predicts 70% of the observations: the estimated equation is 16 percentage points better at predicting responses that the constant probability model; this change represents a 35% improvement over the 54% percent correct prediction of the default model.

Conclusions

This paper tried to explore the possibility that variations in the regional energy regulation and in local socioeconomic characteristics might affect the location choices of investors in the power generation sector.

Some empirical evidence exists that this may be the case, even if such detected effects are not systematically significant. In particular, among the socioeconomic variables, the statistical results seem to suggest that the attitude of potential host local communities is taken into account by investors: it would seem that more active communities are less targeted by investors, whereas Coasean variables are not so relevant. This fact, if confirmed also for other more polluting sectors, may raise questions about the "environmental equity" issue. Indeed, it may be that some communities are preferred as locations not because they present lower externalities (according to the Coase theorem), but rather because they fail to engage in effective oppositions.

As to the decentralized regulation approach, it seems that Regions succeeded only partially to deterring or attracting investments, according to their real intentions. Anyway, further analysis is needed to better understand this issue. In order to test for a kind of "learning effect" of Regional regulation, experimented by investors, an analogue regression carried out only on more recent applications (namely after 2002) could be carried out.

One limit of our model is that we did not take into account the fact that some Provinces were chosen for hosting more than one plant. Indeed, areas with multiple requests are not distinguished from areas with only a single request, even though multiple plant's requests pose greater environmental burden and are more opposed by local communities. Hence, a further development will model the density of applications in each Province in terms of MW per inhabitant. This indicator would be able to capture both the effects, in terms of number of applications and in terms of size (MW) of each project.

Finally, we could try to understand what explanatory power the socioeconomic variables do have in predicting NIMBY phenomena. One possibility in this research direction could be model the frequency of legal actions against the authorized plants as a function of local socioeconomic characteristics.

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