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## A wind energy policy design: lessons from the Galician case.<sup>†</sup>

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### **Abstract:**

This note is concerned with the success of the wind energy policy undertaken by the Galician regional government from 1995, which turned Galiza into the 6th world wind energy producer. On account of windfarms require a site to operate, such a policy promoted eolian energy by affecting landownership and land uses: windfarms are considered of “public use,” so sites can be condemned via eminent domain unless a rental agreement is reached. The available data report the bargaining process between landowners and eolian firms resulted in few condemnations, and agreement rents lower than the (discounted) condemn compensation. We present a partial equilibrium analysis of the land market that is able to reproduce this outcome, under the assumption of landowners’ lack of information on i) the new policy setting, and ii) the condemn monetary compensations. Our main findings refer to the consequences of the failure of the renewable policy chosen to design an efficient market of land. First, landowners’ shortage of information may account for the achievements of such a policy; and, second, the low rents of the land input went with an inefficient overprovision of competitive land allocation for energy production. Finally, as more information on prices will be available in the future, we predict a higher agreement rents or a dramatic increase in the number of condemnations.

*Key words:* Wind energy, imperfect information, condemnations, land uses.

**JEL Codes:** D50, D82, Q42, Q48, R14

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# 1 Introduction

A growing public concern on pollution emissions have been led policymakers to encourage renewable energies actively. In fact, technology developments are becoming renewable energy production, especially wind energy, a realistic alternative. Promoting clean energies may be desirable as a policy that aims to substitute other highly pollutant energy production technologies. However, it is not without costs. For example, some sites are more suitable than others for energy production, so some kind of agreement with private landowners is required; or some negative externalities may arise, such as smell, visual or aesthetic impact. Accordingly, develop such policies needs special care, as an institutional setting inadequately designed may entail market misallocations.

This note inquires into the causes of the success of the wind energy policy undertaken by the Galician regional government from 1995. Regional governments are able to promote renewable energies in Spain, within the economic environment designed by the Spanish Laws *2366/1994*, *54/1997* and *436/2004*. The regional government of Galiza, a region placed at the northwest of Iberian peninsula, pioneered wind energy regulation in Spain first passing the Law *205/1995*, and later the Laws *302/2001* and *513/2005*. Table 1 reports that such a renewable policy turned Galiza into the 6th world wind energy producer despite her small extension. It also accounts more than one fourth of the installed capacity in Spain, likewise the 2nd world wind energy producer. For the sake of cross-country comparison, we will make use the homogeneous unit *Kw per square km*. Figures 1 and 2 display the achieving of the renewable policy chosen with regard to the Galician installed capacity: the former exhibits the steady high-level of Galician annual installed capacity per sq.km; while the latter shows the Galician installed capacity per sq.km left Danish's path of Kw per sq.km to catch up Germany's.

In the following Section 2, we show the main features of the Galician brand of wind energy policy contained in the Galician Laws *205/1995* and *302/2001*. On the account that windfarms require a site to operate, such a policy promoted eolian energy by explicitly affecting the landownership and land uses. Land uses because low-valued wild mountains became potential profitable locations. Land property because windfarms are considered of "public use," so wild mountains can be condemned via eminent domain and give them to eolian firms, unless a rental or a sale agreement is reached. The available data reports that this renewable policy resulted in a bargaining between landowners and wind energy producers with few condemnations, and agreement (discounted) rents lower than the condemn compensations. We interpret these results at the light of the economic theory and put forward that informational imperfections existed in such a bargaining process. Besides, our interpretation leads us to raise some doubts on the effectiveness of the Galician Law *513/2005*.

In Section 3 we present a simple partial equilibrium model that is able to reproduce the observed outcomes under the assumption of landowners' lack of information on i) the new policy setting, and ii) condemn monetary compensations. For such a *short-run* setup, we find that both the flow of rents and the sale price are lower than the condemn compensation. This would suggest the impressive success of the Galician renewable policy stems from how the market of wild mountain for energy production was designed, which caused landowners' shortage of information. Previous works, however, state that a "suitable regulation" has been the main reason for the Spanish achievement, and in particular the incentives to the

production adopted by the Spanish government that guarantee a price of wind energy over the market price along several years.<sup>1</sup> Given that Galician regulation must be developed under the Spanish legal framework and she accounts for almost one fifth of the Spanish installed capacity, this conclusion should also apply to the Galician accomplishment. There is no doubt the economic incentives gathered in the Spanish Laws *2366/1994* and *54/1997* have been a key for the Galician wind energy development; yet, we stress in this note the way the Galician government designed the market of wild mountains additionally entails a cheap input for eolian firms, hence its success. Besides, because of the failure of the policy chosen to design an efficient market of land, we show the low rents of the land input went with an inefficient overprovision of competitive land allocation for energy production. Finally, as more information on prices will be available in the future, we predict a higher rents or a dramatic increase in the number of condemnations.

We summarize in Section 4 and suggest several extensions.

## 2 A wind energy policy: the Galician case.

### 2.1 Pre-renewable-energy-policy setting

Rough weather make difficult to develop economic activities in the Galician wild mountains, placed at areas with population that abandon rural economic style life, so very often no alternative uses for such a land exist. There are two types of land property. Some mountains are private property; others are communal ownership, a Middle Ages Germanic institution for which a mountain belongs to the members of a parish. This property cannot be sold, but it could be rented or condemned. Before the energy policy was undertaken, the economic outcome was a small price of land, denoted by  $p_0$ , because of the scarce demand for wild mountains to rural economic uses, denoted by  $D_0(p)$  (see Figure 3). Yet, the smooth shape of the Galician mountains made them suitable sites for wind energy production.

### 2.2 The Galician wind energy policy

Galician regional government pioneered in developing a renewable energy regulation in Spain when passing the Law *205/1995*. This law regulated the exploitation of wind energy at the Galician region, and it was later updated by the Galician Law *302/2001*, yet preserving its main characteristics.<sup>2</sup> This regulation is still in effect except for a slightly update at the Law

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<sup>1</sup>See, for example, Sáenz-de-Miera (2004a). Martín and Sáenz-de-Miera (2003) and Sáenz-de-Miera (2004a,b) enumerate the three main elements that promote the wind energy a) the windfarm entitlement to connect to the energy main network; b) the windfarm entitlement to sell all the energy produced; and, c) the economic compensations for the energy produced. While the first two are common in all countries, these works assert the economic incentives make the difference.

<sup>2</sup>Previously to issue this new law, the Galician government requested an opinion to the Galician consultative institution CES concerning its energy policy. Such a report CES (2001, pp.21-23) arose several warnings on the wind energy policy, included the weakness position of the landowners in the bargaining with eolian firms, or the advice to promote joint ventures between landowners and firms to mitigate the conflicts involving eminent domain. None of them were considered in the Law *302/2001*.

513/2005. For the purposes of our work, we will focus on three main features involving the Galician Wind Energy Policy:

GWEP-I. First, firms are allowed to propose wind energy plans and exploitation at any area belonging the Galician territory.<sup>3</sup>

GWEP-II. Second, this policy enumerates the requisites for a firm to propose an *Eolian Plan* for some specific area, which has to include a wind research project to be developed in such an area.<sup>4</sup> The Galician government will approve for each area only one firm's Eolian plan.<sup>5</sup> This approval also entails the exclusive right to operate windfarms to the entitled firm in the corresponding area.<sup>6</sup>

GWEP-III. Finally, a third feature deals with setting up windfarms. After studying the suitable locations for wind energy production within the granted area, the eolian firm proposes to set up a windfarm at a particular site to the Galician government.<sup>7</sup> Simultaneously with the proposal, the firm must claim to declare the windfarm of *public use*, enumerating those goods and rights eventually subject to eminent domain.<sup>8</sup> After governmental approval, a period is open to reach a rent or sale agreement before condemnation.<sup>9</sup>

### 2.2.1 The Galician wind energy policy: some comments from the economic theory

The economic theory may account for three flaws of the Galician wind energy policy just described. First, observe that the feature GWEP-II involves a free transfer of property rights to each firm's owner;<sup>10</sup> also, it is a free income transfer to each firm's owner as the rights entitled could be sold without any constraint on reselling.<sup>11</sup> Hence, this legal setup allowed for speculation, and it was reported the case of firms initially granted with these rights that resold windfarms making huge profits.

Second, the Galician regional government did not receive any money in exchange of granting these property rights to firms. This could be interpreted as a risk sharing of the new wind industry between firms *and* the government. However, two issues should be borne in mind. On the one hand, the risks assumed by firms were very low, as the demand of

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<sup>3</sup>See Law 205/1995 Chap.I, and Law 302/2001 Chap.II.

<sup>4</sup>See Law 205/1995 Chap.II art.5-6, and Law 302/2001 Chap.III, art.6-7.

<sup>5</sup>See Law 205/1995 Chap.II art.7, and Law 302/2001 Chap.III, art.8.

<sup>6</sup>See Law 205/1995 Chap.II art.8, and Law 302/2001 Chap.III, art.9.

<sup>7</sup>See Law 205/1995 Chap.III art.10-12, and Law 302/2001 Chap.III, art.16.

<sup>8</sup>See Law 205/1995 Chap.IV art.18, and Law 302/2001 Chap.VII, art.27. The Spanish Law 54/1997 allows for eminent domain to those goods and properties related to energy production, transport and distribution gathered under the concept of "public use" (art.52). Recently, the Galician Law 513/2005 modified the simultaneous requirement allowing for delaying the firm's claim to declare the windfarm of public use. See below our scepticism about the effectiveness of this new law.

<sup>9</sup>While the time span is unspecified at Law 205/1995, the Law 302/2001 Chap.III, art.18 required from firms to report, within one month after governmental approval, whether an agreement was achieved with landowners, or whether the site must be condemned, without the need to justify why a rental or a sale agreement was not reached.

<sup>10</sup>See Law 205/1995 Chap.II art.5-6, and Law 302/2001 Chap.III, art.6-7.

<sup>11</sup>See Law 205/1995 Chap.II art.7-8, and Law 302/2001 Chap.III, art.8-9.

the wind energy produced was guaranteed and subsidized above the energy market price as enacted by the Spanish Law 2366/1994 and later by Laws 2818/1998 and 436/2004; and, on the other hand, none of Galician Laws 205/1995 or 302/2001 included any procedure to remunerate the Galician government by the share of risk assumed (for example, a rent rate income).<sup>12</sup>

Finally, it is important to realize that landowners were out of the picture for the Galician wind energy policy, and this has been resulted in a strong rejection by the population affected (see for example CES, 2001, p.21). This is an inadequate way of designing the market of land, as it entails informational imperfections on the market functioning: one side of the market is fully informed, in fact the one that chooses its own supply of land, while the other is initially uninformed. For example, the feature GWEP-III forced unexpectedly to landowners to bargain with eolian firms to rent or sell their properties for no longer than one month, as otherwise they will be condemned. One month of deadline, or none, seem not to be an enough span to gather relevant information for bargaining.<sup>13</sup> Another example refers to feature GWEP-II, which points out the approval of a firm's Eolian plan for some area also entitles it to operate windmills in such an area. Such an entitlement allowed firms to avail themselves of the information collected from their own studies of suitable sites for wind energy production. Therefore, some eolian firms bought in advance wild mountains to uninformed private owners, previously to propose to set up a windfarm at such a site to the Galician government (feature GWEP-III).

### 2.3 The new setting after implementing the wind energy policy

After the Galician government accepted a firm's proposal, eolian firms and landowners are involved in a bargaining and, if no agreement is achieved, the site will be condemn via eminent domain. The available data show there was an important rate of private ownership sold to eolian firms. In what respects the communal ownership remember that it must not be sold, despite eminent domain is possible. However, communal mountains have been massively rented, and condemnation was a seldom option. The following table reports the ratio of agreement reached by type of ownership, and average price.

Outcome/Ownership	Private	Communal	Average prices
% Hire	25%	99%	n.a.
% Sold	70%	0%	n.a.
% Condemnation	5%	1%	n.a.

*Source* : Own estimations from available data.

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<sup>12</sup>The introduction of a new taxes on this economic activity not expressly written in the law to burden eolian firm's benefits is not an appropriate signal for future firm investments. The rules of how markets work designed by the government must be clearly displayed from the very beginning to encourage credibility and security for any business enterprise. The macroeconomics literature in the 70's showed that rules rather than discretionary policies should be preferred by policymakers to harm the less the economy (see, e.g., Kydland and Prescott, 1977).

<sup>13</sup>See Law 205/1995 Chap.V art.18 and Law 302/2001 Chap.III, art.18

We draw attention to the fact that there is no information on prices, as these data are not available.<sup>14</sup> In particular, the condemn compensations are ruled by a condemnation jury (called Xurado Provincial de Expropiación), whose sentences are not publicly available. However, the available sentences report condemn monetary compensations agreement higher than (discounted) rents.

## 2.4 An interpretation from the economic theory: an imperfect information setting.

We could interpret these results at the light of the economic theory. The Galician Laws *205/1995* and *302/2001* promoted eolian energy by explicitly affecting the land uses, as low-valued wild mountains became potentially profitable locations. Accordingly, in addition to the initial demand for wild mountains to rural economic uses,  $D_0(p)$ , a new demand for wild mountains arise, denoted by  $D_{wind}(p, p_e)$ .<sup>15</sup> This moves rightwards the aggregate demand of land  $AD(p, p_e)$ . Observe that such a new demand depends on the price of the wild mountains,  $p$ , as well as on the price of the energy sold by windfarms,  $p_e$ .

Designing this new market of land as a decentralized competitive equilibrium,<sup>16</sup> may fail in terms of efficiency provided an externality exists: the social benefits due to the reduction of pollution, because of wind energy substitutes other highly pollutant energy technologies, are still to be considered and public intervention could be needed to improve efficiency. This was precisely the motivation of the renewable energy price incentives scheme in the Spanish legislation, i.e., Spanish Laws *2366/1994*, *2818/1998* and *436/2004*. This regulation aims to internalize such a social demand, so that the price of the energy sold by windfarms will be above the market price,  $\bar{p}_e = p_E + \lambda$ , where  $p_E$  is the energy market price, and  $\lambda$  is a price subsidy.<sup>17</sup>

Within this regulatory setup, if the design of this new market of land allows for a framework close to a (second-best) efficient allocation, we will expect a rise in the price of the wild mountains,  $p' > p_0$ . Provided energy production uses of wild mountains take over from the rural economic ones, landowners will be remunerated for both the equilibrium marginal productivity and the social marginal benefits of land. Finally, the allocation of land devoted for wind energy production is (second-best) efficient, and denoted by  $L' = D(p', \bar{p}_e)$  (see Figure 3).

In what follows, however, we demonstrate that the design of the land market by the Galician wind energy policy did not create the conditions for obtaining a decentralized

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<sup>14</sup>Some of this data should be available at Xunta de Galicia, as Galician Law *302/2001* art.18 requires the agreements achieved must be reported.

<sup>15</sup>Despite it is not important for the developments of this note, it is worth mentioning that there is an additionally characteristic that makes Galiza appealing for wind energy production. Due to the scattered population, the electricity line is spread all over the Galician territory, so it is easier, and cheaper, for a windfarm to connect to the energy main network.

<sup>16</sup>Several requirements would be needed, for example, landowners and eolian firms supply and demand land freely, no market power or externality exists, and market participants are fully informed.

<sup>17</sup>We are assuming that a price subsidy  $\lambda$  is the suitable policy to best improve efficiency in this second-best environment. How the government sets this price subsidy is an issue beyond the scope of this note.

(second-best) efficient equilibrium outcome. Initially, we aim to analyze simultaneously, and within the same framework described in Figure 3, the three possible outcomes resulting of the bargaining by landowners and eolian firms: a rental agreement for wild mountains of  $P_r$  monetary units per year along  $T$  years; a sale agreement at price  $p_s$ ; and, a condemn compensation  $p_c$  via eminent domain if no agreement is reached. Observe that the first one is a flow of income, while the other two are stocks. To compare simultaneously these incomes, we will assume an exogenous and constant (real) discount rate  $1 + r$  to find the total discounted amount of rents as

$$p_r = \sum_{t=1}^T \frac{P_r}{(1+r)^t} + \frac{1}{(1+r)^{T+1}} V(p_{T+1}) = \frac{P_r}{r} \left(1 - \frac{1}{(1+r)^T}\right) + \frac{p_0}{(1+r)^{T+1}},$$

where  $V(p_{T+1}) = p_0$  is the residual value of the wild mountain when no wind energy production activities cease, that is, the price for rural economic uses  $p_0$ . Because of Law *52/1997, art. 52* allows for “public use” succesively in the future, the rental span  $T$  will be large enough, so  $p_r \simeq P_r/r$ . Accordingly, the price  $p$  at vertical axe in Figure 3 will be reinterpreted along the identification of the total amount of monetary resources received, whether renting,  $p_r$ , selling,  $p_s$ , or the condemn compensation,  $p_c$ . If landowners and eolian firms were fully informed, these incomes should be very close.

Next, being aware of the difficulties of finding data to understand the bargaining process and opportunity costs for the market participants, we would like to point out that the economic theory provide us a powerful tool to understand their behavior. Our crucial starting point is the following operative assumption of *rationality* (see Frank, 2001, Ch.1): an economic agent will undertake an action if her benefits are higher than her costs; otherwise, she will not. As we observe that the reported rate of agreements was the preferred option for market participants, i.e. land was mainly rented or sold, we may deduce that such an action made their benefits higher than costs. Costs are determined by participants’ *opportunity cost* of an agreement, which is given by their *expectations* on the condemn compensation,  $p_c$ . Accordingly, we may infer the following:

- Firms minimize the cost of renting (or buying), so a firm will accept a rental (or selling) agreement because of the discounted rents (or the buying price) is lower than what it would be paid otherwise under condemnation. So the *firms expected* condemn compensation is a ceiling for firms bargaining.
- Landowners maximize income, so each will reach an agreement because they receive more income than under condemnation. So the *landowners expected* condemn compensation is a floor for landowners bargaining.

However, the condemn monetary compensation,  $p_c$  is an objective price determined by the Spanish Law *6/1996*. The fact that available data report dissimilarities between agreement (discounted) rents and the condemn compensations, allow us to infer that the expectations on condemn compensation do not coincide for the participants of the market, i.e., firms’ expected compensation is higher than landowners’. This suggests of the existence of informational imperfections in the bargaining between firms and landowners. In this note we rely the explanation of the Galician accomplishment on the existence of imperfections on

the informative set of landowners, which stem from the inadequate design of the market of land at the Galician wind energy policy. These imperfections concern landowners in what respects two issues:

- i) Landowners have no information about the extend of the new demand,  $D_{wind}(p, p_e)$ ; and,
- ii) Landowners have an informational shortage regarding the expropriation value determined at the Spanish Law 6/1996 (*art.26*). This law states how the condemn compensation is set as follows:

art.26.1 The value of land will be set by comparing with the value of **similar sites**.

art.26.2 Whenever there do not exist similar sites, the value of land will be found as the **capitalization of real or potential income** yielded by the land, regarding its state at the time of the valuation.

We may consider that firms are probably more informed than landowners. Provided firms' expected condemn compensation is higher than landowners' expected condemn compensation, we infer that firms would expect that art.26.2 is in effect. Given that firms know their technology, so that their demand  $D_{wind}(p, p_e)$  is known, they can compute accurately the condemn compensation, which would be close to  $p'$ .

Landowners, however, have the informational shortage enumerated above that make them computing the condemn compensation a difficult task. In addition, as mentioned, the sentences of the condemnation jury are not publicly available. They may make use art.26.1, owing to similar sites value almost nothing (see Section 2.1), then  $p_0$  is the expected condemn compensation; in the other hand, computing this value making use art.26.2 is difficult because marginal productivity of eolian energy technology, and then the new demand for wild mountain  $D_{wind}(p, p_e)$  is unknown for landowners. So the landowners' expected condemn compensation will be above but close to  $p_0$ .

Several evidences seem to support our argument.

1. First, the available passed sentences of condemnation provide case reports for the condemn compensation. The condemn compensation seems to be much higher than the available (discounted) rents.
2. Second, the fact that those firms involved in condemnation files, keep appealing against the sentences with the arguments of a high condemn compensation would also suggest that the flow of agreement rents were lower than the condemn compensation.

A final comment is in order. The Galician Law 513/2005 modifies the requirement to firms for claiming to declare the windfarm of public use (i.e., the feature GWEP-III), in order to encourage voluntary rental or selling agreements. The arguments developed in this section lead us to raise some doubts on the effectiveness of this regulatory modification, as eolian firms may exert their right to eminent domain at any time, so condemn compensation always sets an upper limit for the bargaining with landowners.



### 3 A model.

Next we present a simple setting to understand the facts and intuitions displayed above. Firstly we present a model for the market of wild mountains, where some agents have informational shortage concerning the new policy environment and the condemn monetary compensation; and, next we will consider that information is available in the long-run.

#### 3.1 The short-run setting with informational imperfections.

We present a partial equilibrium model that analyzes the market of the commodity “wild mountain” that is demanded for two alternatives uses: rural economic activities and wind energy production. The set defining such a commodity is the continuum  $[0, \bar{L}]$ .

There are four types agents in the economy: a continuum of landowners represented by the set  $[0, 1]$ ; agents that demand land for rural economic activities; eolian firms; and, a government. Each landowner is characterized by i) her ownership of a wild mountain; ii) a reservation price for renting her property, which represents an individual supply of land; and, iii) her information set. Aggregation of individual supplies results in the Aggregate Supply of land  $L = S(p)$  as represented in Figure 3. Eolian firms are represented by i) a technology for wind energy production, and ii) their information set. The technology results in an aggregate demand for wild mountains to energy uses,  $L = D_{wind}(p, p_e)$ . Adding up this demand with the exogenous demand for wild mountains to rural economic activities,  $L = D_0(p)$ , make up the Aggregate Demand  $L = AD(p, p_e) = D_0(p) + D_{wind}(p, p_e)$  (see Figure 3). Finally, there exists a governmental office characterized by its information set.

Each landowner seeks to rent (or sale) her wild mountain the highest from her reservation price, while the eolian firms minimize the cost of renting (or buying). The governmental office, in turn, sets the condemn monetary compensation with its available information.

##### 3.1.1 The information sets.

Agents take decisions at the wild-mountain market, regarding renting or selling, based on their available information on the prepolicy market setting, and their knowledge about the new policy environment (i.e., the wind energy demand and the condemn compensation).

The **Landowners information set** gathers three elements,

- a) *the pre-energy-renewable-policy wild mountain price,  $p_0$ , which is known.*
- b) *the firms technology, and therefore the firms demand for wild mountains,  $D_{wind}(p, p_e)$ , which is not known by landowners in the short-run.*
- c) *the monetary compensation to be awarded by the condemnation jury,  $p_c$ , a value unknown as condemnation jury sentences are not publicly available. Accordingly, to find her opportunity cost of bargaining, each landowner has to make an estimation on this award making use the Spanish Law 6/1996, art.26. Provided her lack of information, she will consider the value of her wild mountain are to be set by the jury considering the value of similar sites. That is, landowners consider that art.26.1 only applies.*

This means that each landowner likely expects a condemn compensation  $p_c^l$  above but close to  $p_0$ , which sets a floor to the bargaining price. We will consider that landowners are heterogeneous on their reservation prices for achieving a rental (or sale) agreement, which is given by  $p_c^l = p_0 + l$ , where  $l$  is an stochastic and positive valued variable. We will assume the positive deviation from  $p_0$  is represented by a triangular distribution  $l \sim T[0, d]$ , for some  $d > 0$  representing the maximum amount of condemn compensation any landowner expects to receive.<sup>18</sup> Therefore, the heterogeneous reservation prices for agreements are a triangular distribution, i.e.,  $p_c^l \sim T[p_0, p_0 + d]$ , whose density function is given by

$$f(p_c^l) = \begin{cases} 0 & p_c^l \leq p_0 \\ 2 \frac{(p_0+d)-p_c^l}{d^2} & p_c^l \in [p_0, p_0 + d] \end{cases} .$$

Then, a landowner's probability of accepting a rental (or sale price)  $p$  proposed by a firm is given by the cumulative distribution function (see figure 4)

$$\pi(p) = \int_{p_0}^p f(p) dp = \begin{cases} 0 & p \leq p_0 \\ 1 - \left[ \frac{(p_0+d)-p}{d} \right]^2 & p \in [p_0, p_0 + d] \end{cases} . \quad (1)$$

Note that  $\pi(p)$  also represents the ratio of landowners that would accept a rental (or sale price)  $p$ , while  $1 - \pi(p)$  would report the ratio of landowners that do not accept such an agreement at price  $p$ . Observe also that the triangular distribution represents the intuition that landowners expect a condemn compensation  $p_c^l$  close to  $p_0$ . (For example, 3/4 of the landowners accept an agreement at a price  $p = p_0 + d/2$ ).

The **Eolian firms information set** is characterized by four elements,

- a) Eolian firms know the *pre-energy-renewable-policy wild mountain price*,  $p_0$ ;
- b) Eolian firms know both the supply of land  $L = S(p)$  as well as the Aggregate Demand for wild mountains,  $L = AD(p, p_e)$  found from their knowledge on the firms technology. This would allow them to obtain the decentralized equilibrium (second-best) price, that will be denoted by  $p'$ .
- c) Their opportunity cost of bargaining, that is *the monetary compensation to be paid to landowners as commanded by condemnation jury*,  $p_c$ , is likely **known** because of its own experience on past condemnations, as energy firms are entitled to this right (see Spanish Law 54/1997). Their estimation on this value, making use the Spanish Law 6/1996, *art.26*, will set a ceiling to the bargaining price. Provided no similar sites exist, the value of land will be expected as the "capitalization of real or potential income" yielded by the land. That is, firms consider that *art.26.2* most probably applies, so they likely expects a condemn compensation  $p_c^f$  equal to  $p'$ .

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<sup>18</sup>This stochastic variable could be also interpreted as other idiosyncratic elements that affects the reservation price to achieve a rental (or sale) agreement.

- d) Finally, firms can know the probability of acceptance of landowners is given by (1), but they could not know the maximum amount of condemn compensation landowners expect to receive,  $d$ . This parameter must be estimated, and will be denoted by  $d^f$ .

Finally the **Governmental office information set** has two elements,

- a) It knows the *pre-energy-renewable-policy wild mountain price*,  $p_0$ ;  
 b) It knows both the supply of land  $L = S(p)$  as well as the Aggregate Demand for wild mountains,  $L = AD(p, p_e)$  found from their knowledge on the firms technology. This would allow the governmental office to obtain the decentralized equilibrium (second-best) price,  $p'$ .

As reported by the available sentences, the condemnation juries are choosing the Spanish Law 6/1996, *art.26.2* as the criterium to compute the *monetary compensation to be paid to landowners*; thus,  $p_c = p'$ .

### 3.1.2 The firms problem

To find the solution of the model can be reduced to solve the firms problem, that is, to determine the *rental proposal*  $p^*$  that minimizes the wild mountains input costs, for a given estimated parameter  $d^f$ . For any rental price  $p$  proposed by firms, such input costs are the addition of the money to be paid to landowners if an agreement is reached at  $p$ , plus the monetary condemn compensation  $p_c$ , set by the condemnation jury, to be paid to those landowners that did not accept the rental agreement. Then, the firms problem is the following,

$$\min_p C(p, d^f) = \min_p \left\{ (1 - \pi(p, d^f)) p' + \pi(p, d^f) p \right\}$$

for a given estimated  $d^f$ . First order conditions provide us the optimal rental proposal, which depends on the estimation of the landowners maximum expectation value for the condemn compensation,  $d^f$ :

$$p^*(d^f) = (p_0 + d^f) + \frac{\varepsilon - \sqrt{\varepsilon^2 + 3d^{f2}}}{3} < p_0 + d^f,$$

with  $\varepsilon = p' - (p_0 + d^f)$ . This is an increasing function in the firms estimation  $d^f$ , i.e.,  $\partial p^*(d^f)/\partial d^f = 1 - d^f/\sqrt{\varepsilon^2 + 3d^{f2}} > 0$ . Note that even in the case that firms correctly estimate the correct parameter  $d$ , the firms will never find it profitable to propose a rental price  $p^*(d)$  that make all landowners to accept such a proposal. In such a case  $d^f = d$ , the firms rental proposal  $p^*(d)$  will allow for an agreement with over 2/3 of the landowners:

$$\pi(p^*(d)) = \frac{2}{3} + \frac{2\varepsilon}{9d^2} \left[ \sqrt{\varepsilon^2 + 3d^2} - \varepsilon \right] \geq \frac{2}{3},$$

Note also that the probability  $\pi(p^*(d^f))$  defined in (1) is also an increasing function in  $d^f$ , i.e.,  $\partial \pi(p^*(d^f))/\partial d^f = 2[\{p_0 + d - p^*(d^f)\}/d] \partial p^*(d^f)/\partial d^f > 0$  for all  $p^*(d^f) < p_0 + d$ . Consequently, given that the available data report a tiny number of condemnations, our

guess is that firms overestimate the landowners' maximum expectation value for condemn compensations, that is,  $d^f \gg d$ .

In Figure 5 we depict the market of land designed by the laws comprising Galician wind energy policy. The landowners do not know the aggregate demand of land. The firms find a rental proposal  $p^*$  such that  $L^*$  units of land will be rented where  $L^* = AD(p^*, p_e)$ . Finally, observe that the wind energy policy implemented in Galiza resulted in a number of sites higher than would be found under a (second-best) competitive equilibrium framework under perfect information, i.e.,  $L^* > L'$ . That is, the wind energy policy chosen by the Galician government fails to design an efficient market of land, so that low rents of the land input went with a competitive land allocation for energy production higher than in the efficiente set-up. In consequence, our model suggests that an inefficient overprovision of land for energy uses is the outcome of the Galician wind energy policy.

### 3.2 The long-run setting with perfect information.

In the long-run, landowners turn to be informed about the eolian firms technology, and then the aggregate demand, and also that condemn compensation is set making use the Spanish Law 6/1996, art.26.2; thus,  $p_c^l = p'$ .

Given the condemn compensation  $p_c$  sets an upper bound to firms proposals, and a lower bound for landowners acceptance, we may deduce the following prediction from this model: it will be expected a rise in future rent proposal,  $p^{**} = p'$ , or a dramatic increase in condemnations.

## 4 Conclusions and final comments.

In this note we studied the economic consequences of the Galician pioneer Law 205/1995, and its update 302/2001, in promoting wind energy technologies. We suggest the impressive success of the Galician renewable policy stems from an inadequate design of the market of wild mountain for wind energy production use, as informational imperfections arose. This also suggest that this policy caused landowners have been de facto those promoting the renewable energy policy in Galiza, as they are supplying to firms an input at a price below its marginal productivity. We present an economic model to find that landowners receive lower rents than in a (second-best) competitive case with perfect information. In addition, the number of sites are higher than in the (second-best) competitive market equilibrium case, so that we find an inefficient overprovision of land for energy uses.

This note also highlights the need of sound technical advice as a requirement for any new law issued. This would allow policymakers to understand the economic consequences of a particular design with respect of any alternative one in what respects allocation and income distribution.<sup>19</sup> For the Galician wind energy policy, however, we would like to express our concern on completely ignoring the CES (2001) report in the successive changes

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<sup>19</sup>For example, economists have been recommended auctions to sell property rights, instead of granted for free as in the Galician Laws 205/1995, Chap.II and 302/2001, Chap.III. It remains open to research if this would be a suitable allocation mechanism for the Galician case, or there would exist better alternatives.

of the law, which otherwise would avoid many conflicts along these years. Our note goes along with this report to urge changes in the Galician Laws *205/1995* and *302/2001* still in effect. Besides, it presents an economic sound theoretical framework to support several recommendations found at the CES report. For example, improve the weakness position of the landowners by encouraging joint ventures with eolian firms would mitigate their informational imperfections: landowners and firms would share risks, but also profits. Our economic model also allow us to understand the most likely failure of the Galician Law *513/2005*, which modifies the requirement to firms for claiming to declare the windfarm of public use to promote agreements. The theoretical framework presented in this note shows that this law will be ineffective as claiming for condemnation is always an option entitle to firms.

Yet, we intend to give a warning about the possibility of public authorities to modify the agreements reached in the past, and increase the present and future landowners rents, despite the Galician wind energy promoting laws have resulted in undesirable outcomes. First, this public intervention could create some legal insecurity on any other rental agreements achieved (e.g., house rents). Additionally, if rents would be changed, those landowners who sold their land could also require a rise on sale prices. A public intervention of this kind can seriously harm the Galician economy, and refrain (any) firm from further investments. To understand the risks involved, economic agents require laws that adequately design the market functioning, as well as explicitly indicate the monetary compensations. Rules rather than discretion must be the norm.

Two lines are open for further research. The first one deals with creating a detailed database on Galician windfarms in what respects the timings for setting windfarms, rent or sale price paid, etc. A second interesting future research would be to study the allocation and distributional consequences of alternative institutional settings, as well as study their welfare effects.

## References

1. CES-Galicia (2001) “Sobre o Libro Blanco da Enerxía en Galicia,” *Informe de opinión* 1/01, Santiago de Compostela.
2. CIA (2003) *The World Factbook 2003*, Washington.
3. Global Wind Energy Council (2006) *Global Wind 2005 Report*, Belgium
4. Frank, Robert (2001) *Microeconomics and Behaviour*, McGraw-Hill.
5. IDEA (2004) “Boletín IDAE: Eficiencia Energética y Energías Renovables,” n.6, Ministerio de Economía, Madrid.
6. IDEA (2005) “Boletín IDAE: Eficiencia Energética y Energías Renovables,” n.7, Ministerio de Economía, Madrid.
7. International Energy Association (2001) *Windpower Monthly*, April.
8. INE (2006) *Anuario Estadístico de España*, Madrid.

9. Kydland, Finn; and Edward Prescott (1977) “Rules Rather Than Discretion: The Inconsistency of Optimal Plans,” *Journal of Political Economy* 85, pp.473-91.
10. Martín, Miguel; and, Gonzalo Sáenz de Miera (2003) “Energía eólica: con el viento a favor,” *Economía Exterior*, n.26 pp.123-132.
11. Sáenz de Miera, Gonzalo (2004a) “Energía eólica: con el viento a favor,” *Tecno ambiente*, n.140, pp.5-8.
12. Sáenz de Miera, Gonzalo (2004b) “La energía eólica en el contexto energético-ambiental actual,” in Javier Franco Rodríguez, Francisco Javier Calvo Martín, Manuel Luengo Rodríguez, and Pedro Alfonso Ramos Criado (eds.) *Energías y medio ambiente*, Ediciones Universidad de Salamanca, Salamanca, pp. 251-260.

## **Appendix. Tables and figures**

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Area (sq.km)
Germany	1.137	1.576	2.082	2.874	4.445	6.113	8.754	11.994	14.609	16.629	18.428	357.021
Spain	126	216	421	834	1.539	2.235	3.337	4.825	6.203	8.263	10.027	504.782
US	1.770	1.794	1.741	1.890	2.455	2.578	4.275	4.685	6.374	6.725	9.149	9.629.091
India	550	820	933	968	1.095	1.220	1.456	1.702	2.125	3.000	4.430	3.287.590
Denmark	630	785	1.100	1.400	1.752	2.338	2.489	2.889	3.116	3.118	3.122	43.094
<b>Galiza</b>	<b>n.a.</b>	<b>n.a.</b>	<b>115,0</b>	<b>257,0</b>	<b>486,0</b>	<b>618,1</b>	<b>974,3</b>	<b>1.301,7</b>	<b>1.614,2</b>	<b>1.829,8</b>	<b>2.062,2</b>	<b>29.574</b>
Italy	22	70	103	180	282	427	682	788	905	1.265	1.717	301.230
Global	4.887	6.118	7.579	9.625	13.598	17.653	23.900	31.100	39.341	47.620	59.084	

Table 1: Total installed wind power capacity (Mw) per country, *Source*: IEA (2001) and GWEC (2006), except for Galiza in ER IDEA (2004, 2005); and country area, *Source*: CIA (2003) and INE (2006).

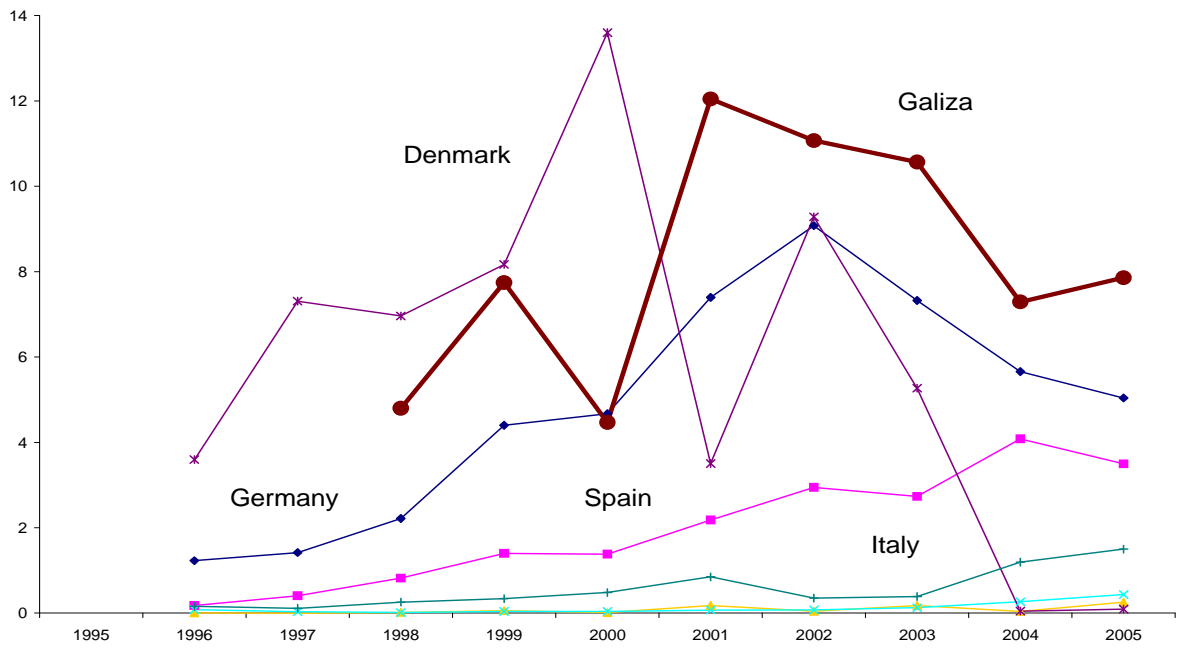


Figure 1: Annual installed capacity in Kw per square kilometer.



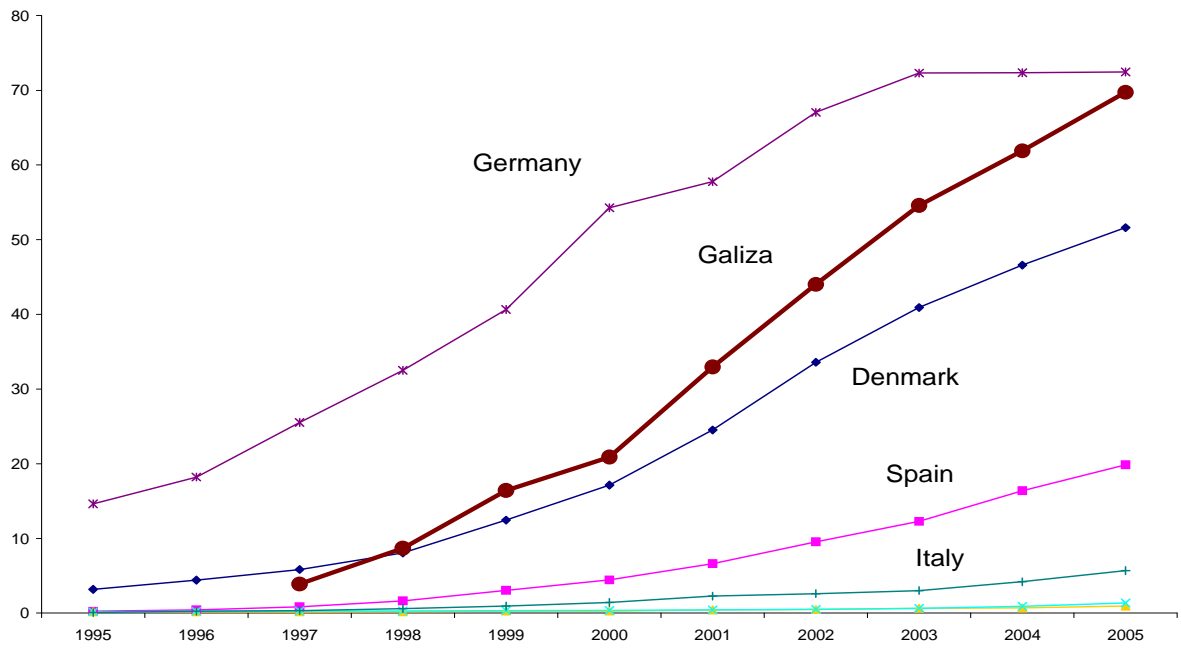


Figure 2: Installed capacity in Kw per square kilometer.

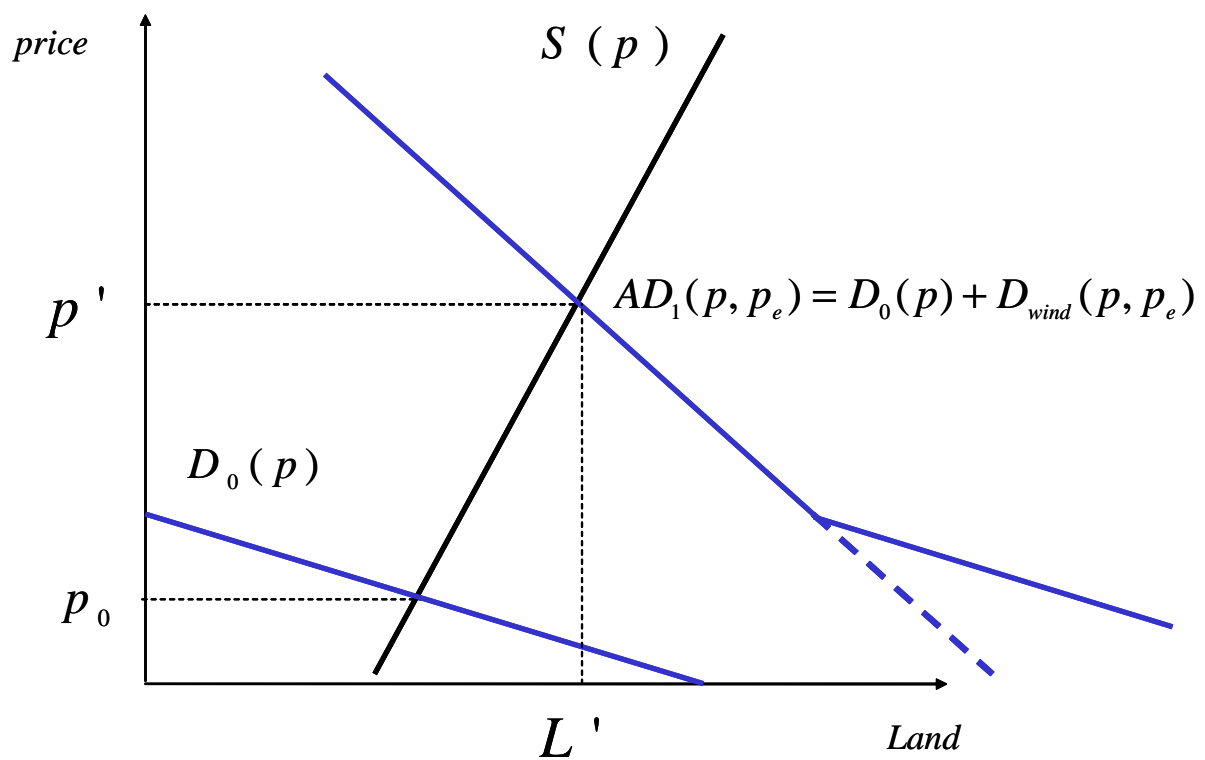


Figure 3: Competitive equilibrium setting of the wild mountain market before and after implementing a wind energy policy.

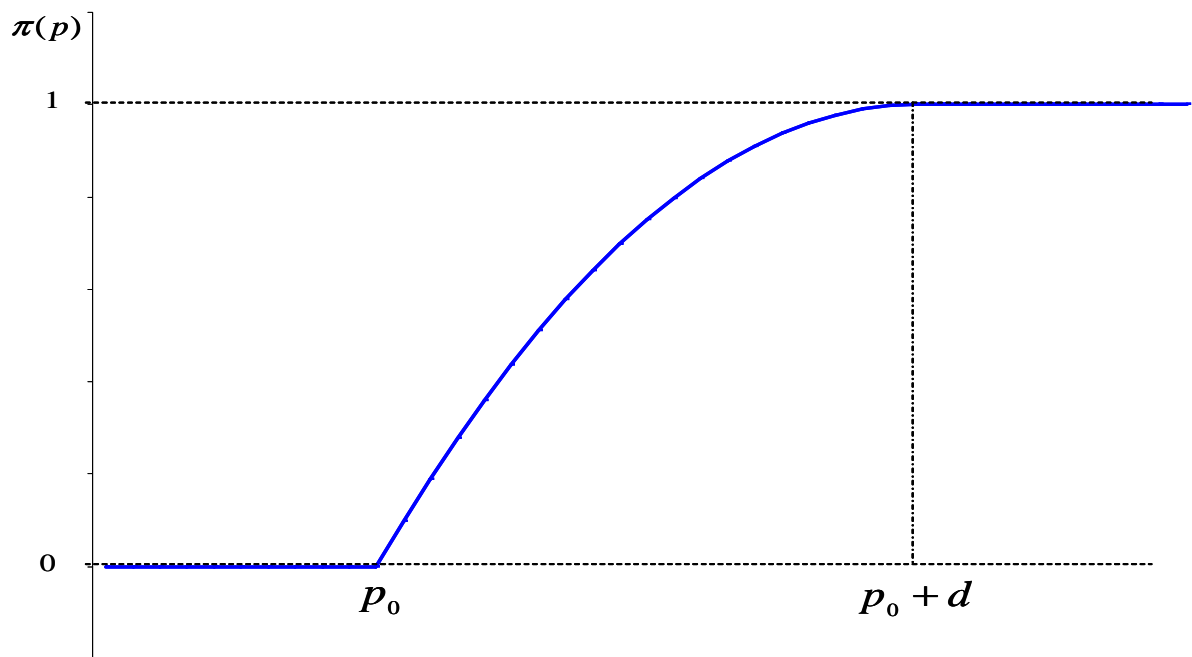


Figure 4: The triangular cumulative distribution function  $p_c^f \sim T[p_0, p_0 + d]$ .

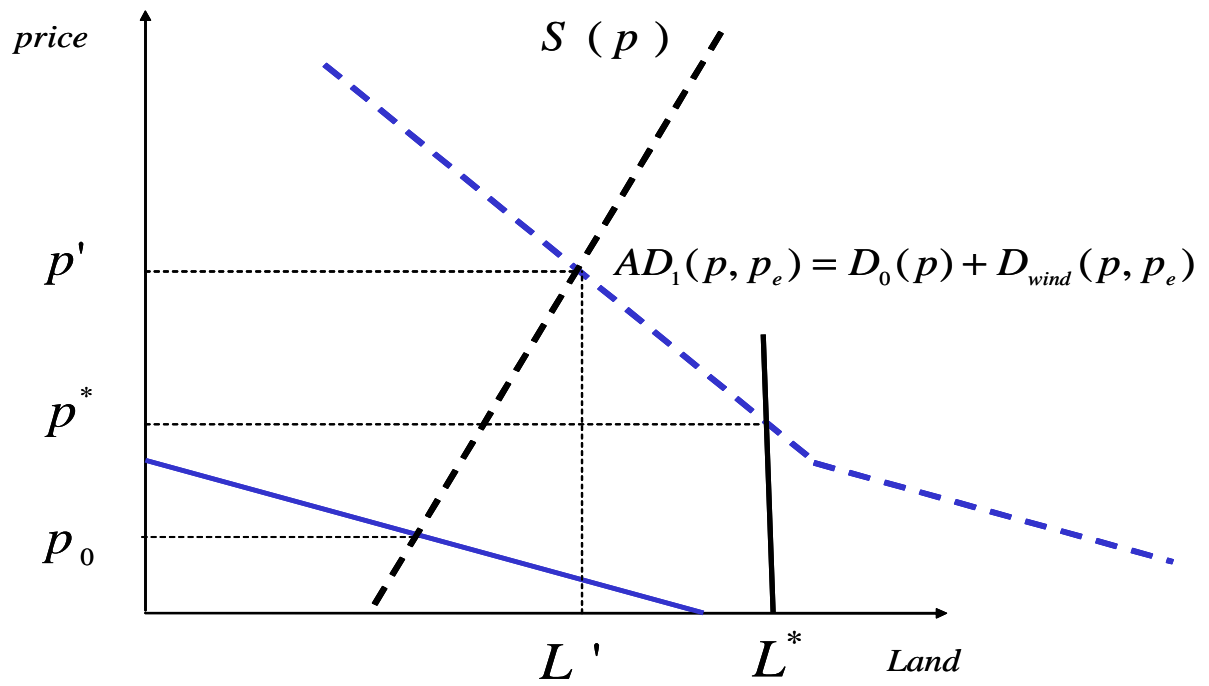


Figure 5: The allocation outcome found in the market designed by the Galician Law 302/2001.