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RENT-SEEKING MEASUREMENT IN COAL MINING BY MEANS OF LABOUR UNREST: AN APPLICATION OF THE DISTANCE FUNCTION

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Abstract
We propose a method based on the distance function to empirically estimate the social cost arising from rent seeking behaviour in declining industries. Due to import competition, the factors of a particular industry undergo losses in real income, and have incentives to seek protection. In the case of declining industries, workers play a central role and the losses in output due to strikes are used to quantify the social cost of rent seeking. In our model, strikes are considered as a "bad" input into the production process. We apply our approach to the case of Spanish coal mining. We have estimated a system of equations formed by the input distance function and cost share equations using annual data over the period 1974-1997. This procedure has allowed us to calculate the cost that strikes have imposed on the sector.

Keywords: Production theory, rent seeking, input distance function, shadow prices, coal sector.

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1. Introduction

As is well-known, the concept of rent seeking, introduced by Tullock (1967) and coined by Krueger (1974), refers to the use of economic resources by an agent or group of agents with the aim of obtaining a transfer from the government. Normally arising in the context of monopolies, tariffs, and so on, it is certainly an attractive concept and has generated great deal of literature. However, exact measurement of costs associated with rent seeking has proven to be very elusive, even on a theoretical level (see Rowley, Tollison and Tullock, 1988; and especially the paper of Higgins and Tollison, 1988). Three decades after introducing the concept, Tullock (1997) stresses the empirical difficulty of finding forms of accurately measuring this social loss.

The expansion of international trade over recent decades as a consequence of liberalization has meant that domestic sectors have had to undergo adjustment processes due to the increase in import competition. This is especially relevant in the case of declining industries in developed countries. In these cases, rent seeking on the part of the protectionist lobby can be interpreted as a form of negotiating the productive adjustment, and will generate welfare costs which must be compared with "normal" adjustment costs such as unemployment. A complication that arises in this context of productive adjustment is that the agents affected by the competition of imports i.e. managers and workers, have incentives to invest resources in order to pressure the government into maintaining or increasing protection. This is a clear case in which rent seeking involves social loss.

In the context of declining industries faced with import competition, Baldwin (1984) uses a model of specific factors to analyse how workers and managers see their real incomes reduced due to adjustments in activity. Under such conditions, these agents have many incentives to invest resources in lobbying or other rent seeking activities to obtain trade protection from the government.

The form of rent seeking on which our research is focused is that of labour unrest. The workdays lost by strikes constitute a clear example of the cost of such activity for society. McNutt (1996, chapter 6) establishes two criteria in order to determine whether the expenditure associated with rent seeking is socially desirable or not.The first considers whether production is altered, while the second refers to the social desirability of rent transfers associated with rent seeking. In the context of industries in decline, one cannot determine whether the income redistribution generated by labour unrest is socially desirable or not. However, the first criterion is more important, and here there are no doubts: labour unrest implies a production loss, and therefore a social loss.

The aim of our work is to present and to discuss a form of measuring the cost of rent seeking as a result of labour unrest. To illustrate our method, we carry out an empirical application to the Spanish coal mining sector. The effects of protectionist policy in this sector have been analysed in Del Rosal (2000), while a previous attempt to quantify labour unrest has been carried out in Del Rosal and Fonseca (2001). In the latter study, the main target was to quantify the effects of strikes through the surplus associated with the labour demand in the industry.

We seek to use a more rigorous procedure to measure the effects of labour unrest as a form of rent seeking in the context of declining industries. With this aim, we will estimate the sector's technology in order to evaluate the effects of labour unrest on production. However, while labour unrest constitutes an "input" to production, it does not have a market price. To solve this problem, we propose using the distance function (Shephard, 1953, 1970) in order to obtain virtual or shadow prices and thereby evaluate labour unrest, which can be considered in this context as an undesired input. We follow a procedure similar to that which other authors have used to obtain the shadow prices for undesirable outputs (see Färe, Grosskopf, Lovell y Yaisawarng, 1993; Färe & Grosskopf, 1998), but adapt it to case of undesirable or "bad" inputs.

If firms have to operate with an undesired input which has been imposed upon them, as is the case of labour unrest, the theory of production and duality provides two means by which shadow prices can be obtained: the production function and the distance function. However, the distance function has advantages on both a theoretical and an empirical level. If the technology is multiproduct, it is not possible to use a production function and it is therefore necessary to use the distance function. In econometric applications, on the other hand, the distance function and production function are usually estimated along with a system of share equations, even though this is not essential from the theoretical view point. This is done either to improve the efficiency of the estimation or because a large enough sample is not available (see for example Berdnt, 1991, chapter 9). The use of the production function together with the associated system of share equations requires the assumption that firms are minimising costs, whereas this is not necessary with the distance function. It is very difficult to justify the assumption of cost minimisation in sectors which are highly regulated, in industries protected from import competition, or in economic activities where price controls exist. For these reasons, we opt for an input distance function in order to obtain shadow prices for labour unrest.

The paper has the following structure. In section 2 we outline the main features of the Spanish coal mining sector, paying particular attention to the way in which the sector has been protected from external competition. In section 3 the methodology used, based on the input distance function, is presented, and we discuss its main properties and characteristics and address the issue of how it can be used to quantify the effect of labour unrest. In section 4 the estimation and the main results are presented. Section 5 summarises the main conclusions.

2. Productive adjustment and labour unrest: the case of spanish coal mining

Coal mining in Spain constitutes a paradigmatic example of declining industry. The traditional importance of national coal production has been diminishing to the point of losing its previous strategic position in the energy supply of the country, with the sector having suffered an important reduction in size to a level where it now provides under 20.000 jobs and a turnover of around 150.000 million pesetas. However, the sector is of qualitative importance for a variety of reasons. Firstly, it is one of the most outstanding and complex examples of an economic activity in decline; second, it represents one of the sectors which has traditionally been subjected to one the highest degrees of regulation and public intervention; and finally, it has a unique importance in terms of the social and territorial implications involved, given that it is highly concentrated from a geographical point of view and has generated high levels of economic dependence in some areas of the country. To illustrate this degree of concentration, the central coalfield of Asturias is the leader in bituminous coal production, while the coalfields of Bierzo-Villablino in Leon and Narcea in Asturias are first in anthracite production and these coalfields account for more than half of the national production and most of the employment in the sector (see Vázquez and Del Rosal, 1999; and Del Rosal, 1999).

For four decades, the adjustment process has been continuous, as in other European countries. However, the competition from foreign coal has not led to a complete closure of of the mines, thanks to an active protection policy which has given rise to a series of events that have permitted a more gradual adjustment, such as the nationalization of a part of the sector (creating HUNOSA) and, more importantly, the imposition of obligatory consumption of the so-called national coal (see Del Rosal, 2000) in the electricity industry. With the energy crisis of the seventies, the adjustment process was halted somewhat, allowing a rise in energy prices and a certain preservation of activity and employment. However, in the second half of the eighties the inability of national coal to compete with imports was accentuated by the fall of international prices. From then on the prices paid by the thermal power stations to national coal duplicate the prices of imported coal. In the face of all this, the productive adjustment has intensified.

Table 1: Labour Unrest and Productive Adjustment (1973-1997)

Period	Labour Unrest (% lost days)	Variation in Employment	Variation in no. of exploitations
1973-1983	1,62	+177,6	+9,4
1984-1997	2,77	-2053,8	-9,3

Source: Del Rosal and Fonseca (2001) and Carbunión.

The phases of most intense adjustment have coincided, in general, with periods of more industrial disputes in the sector. Indeed, as is discussed in Del Rosal and Fonseca (2001), a certain relationship can be detected between labour unrest (measured in lost working days as a percentage of the total, according to data obtained in the annual reports of *Carbunión*, the mining management) and certain variables that can be considered as proxies for the adjustment of the sector such as the loss employment and pit closures. This relationship between labour unrest and these variables of production adjustment for the period from 1973 (the first year for which there is data available for lost working days) to 1997 is illustrated in Table 1. As can be observed, labour unrest is on average higher in the sub-period 1984-1997, which includes some years of intense labour troubles (in 1985, 1987 and 1991, for example, the loss of working days was in excess of 5%) and which coincides with times with accelerated adjustment in the sector.

Regardless of the reasons for labour unrest in the sector the loss of working days implies some costs in terms of lost production. With this in mind, we now discuss how the cost of these strikes can be quantified using the distance function.

3. Methodology: the input distance function

3.1. Basic aspects of the input distance function

The distance function is a concept introduced by Shepard (1953) to represent the firm's technology. The distance function allows multiproduct technologies to be modelled and while it does not preimpose any economic behaviour (such as cost minimisation) it does permit tests for such behaviour. This makes it preferable to the traditional cost function in the context of sectors such as that of Spanish coal mining where the assumption of cost minimisation is questionable.The distance function can be defined in terms of inputs or outputs. Given that we want to evaluate inputs which may be considered as non desireable, we have proposed the use of the input distance function.

Our measurement of labour unrest will be carried out by exploiting the duality which exists between the cost function and the input distance function. To explain how the input distance function works, we provide an illustration in Figure 1 below for the case of a firm which uses two factors of production (x_1 and x_2) to produce the output *y*. In the figure, we represent different combinations of factors (P and R) that produce the output *y*. The ratio 0R/0P is the Farrell (1957) input-orientated measure of technical efficiency for the combination P. It is a radial measure and it indicates that one can obtain an identical level of production using only a fraction 0R/0P of each input. The maximum value is 1, which means that the company is operating on the isoquant and is therefore fully efficient from the technical point of view. A value inferior to 1, as in the case above, provides us with information on the degree of technical efficiency reached by the company.

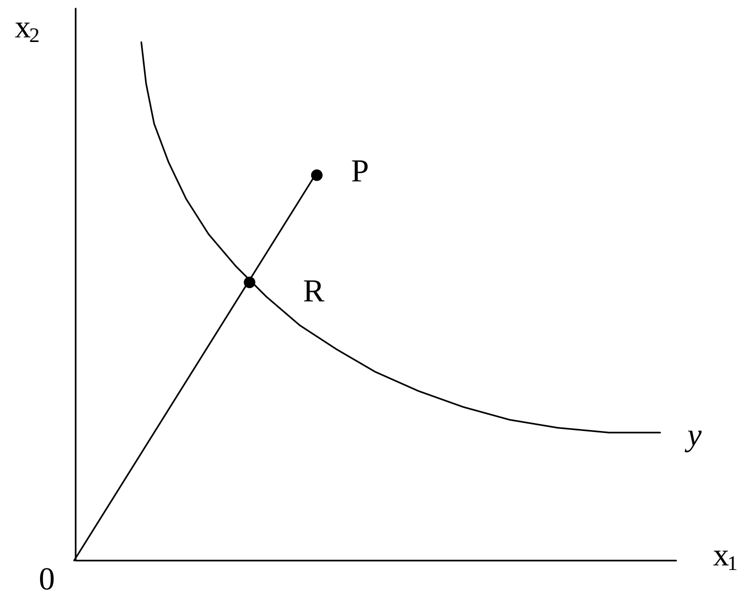


Figure 1: Input Distance Function

Formally, and generalizing for multiple inputs and outputs, the index of technical efficiency is defined as:

$$TE_I(y, x) = \min_{\lambda} \{\lambda : \lambda x \in L(y)\} \quad (1)$$

where L(y) is the input requirement set, *x* is the input vector and *y* is the output vector.

The input distance function (Shephard 1953, 1970) is the reciprocal of the technical efficiency index of Farrell, that is, the ratio 0P/0R, and it can be defined as the highest scale (δ) by which all the factors can be divided proportionally while continuing to produce the same output level. Formally:

$$D_I(y, x) = \max_{d} \{\delta : x/\delta \in L(y)\} \quad (2)$$

When D_I equals 1, production is technically efficient way. A value superior to 1 tells us the degree of efficiency achieved. For example, a value of 2 would imply that half of each of the inputs could be used to obtain the same production. The relationship between the measure of technical efficiency of Farrell and the input distance function can be expressed as:

$$TE_I(y, x) = \frac{1}{D_I(y,x)} \quad (3)$$

The input distance function satisfies the following properties:

1) it is decreasing in outputs.

2) it is not decreasing in inputs.

3) it is homogeneous of degree 1 in inputs.

4) it is concave in inputs.

5) it can represent a multioutput process

6) it is the dual of the cost function. The duality between both functions can be expressed by means of the two following equations (Shephard, 1953, 1970):

$$D_I(y, x) = \min_W \{ Wx : C(y,W) = 1 \} \quad (4)$$

$$C(y, W) = \min_x \{ Wx : D_I(y,x) = 1 \} \quad (5)$$

where W is the input price vector (normalized by the cost), so that the minimum cost of producing *y* equals 1.

From this duality, Shephard (1970, p. 171) defines a relationship between the inputs and their prices through the following dual equations:

Shephard's Lemma:
$$x_i^s(y,w) = \frac{\partial C(y,w)}{\partial w_i} \quad (6)$$

Dual Shephard's Lemma[1]:
$$W_i^s(y,x) = \frac{\partial D_I(y,x)}{\partial x_i} \quad (7)$$

where:

w is the input price vector,

$x_i^s(y,w)$ indicates the input choice under cost minimization given (*y*,*w*)

$W_i^s(y,x) = \dfrac{w_i^s}{C(y,w^s)}$ is the cost minimising price given (*y*,*x*), where the vector $W^s(y, x)$ is

[1] For a proof see Färe and Grosskopf (1990).

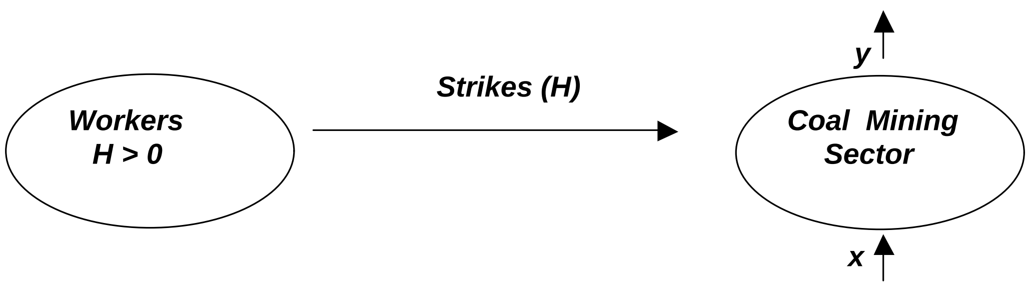
known as (normalized) shadow price vector.

That is to say, the duality that exists between the input distance function and the cost function allows us to identify the (normalized) shadow price vector that minimizes costs given (*y, x*). Therefore, the condition of minimum cost is always satisfied with regard to these shadow prices. However, the vector of shadow prices may or may not coincide with the vector of market prices. Only in the case where the shadow prices coincide with those of the market would the firm be minimizing costs with respect to the market prices. Thus, with this methodology it is not necessary to assume that the firm minimizes costs with regard to the market prices. This property is especially attractive when it comes to the analysis of public sectors, regulated sectors, or those where price controls exist, given that this assumption is inappropriate. Moreover, the input distance function does not assume exogeneity of the market input prices, which constitutes another advantage in non-competitive sectors where a certain degree of price control may exist.

These properties of the input distance function are especially relevant in terms of the objectives of this research, given that the Spanish coal sector, as mentioned above, has been subjected to a high degree of public intervention and regulation.

3.2. Obtaining the cost of the unrest by means of a distance function

In our model, we assume that workers go on strikes to get public sector protection, to maintain their jobs, and to obtain higher salaries or better working conditions. Thus, these strikes are considered as a "undesired intermediate input" into the production process. Strikes (H), which are chosen by the worker, are assumed to be exogenous to the firm:



With the purpose of measuring the labour conflict in the Spanish coal sector in monetary terms, we define the following input distance function:

$$D_I(y, x, H) = \min_W \{ Wx: C(y,W, H) = 1\} \qquad (8)$$

where H is a labour unrest variable, measured by the number of strike hours in the sector due to the industrial disputes. The duality of the input distance function and the cost function, analysed in the previous section, proves useful when it comes to the derivative $\partial D_I(y,x,H)/\partial H$. The expected sign of this derivative is negative. In Figure 2, if strikes increase, the isocuant shifts to the right because more labour is needed to produce the same output (that is to say, strikes are an output-reducing input). In this way, distance decreases.

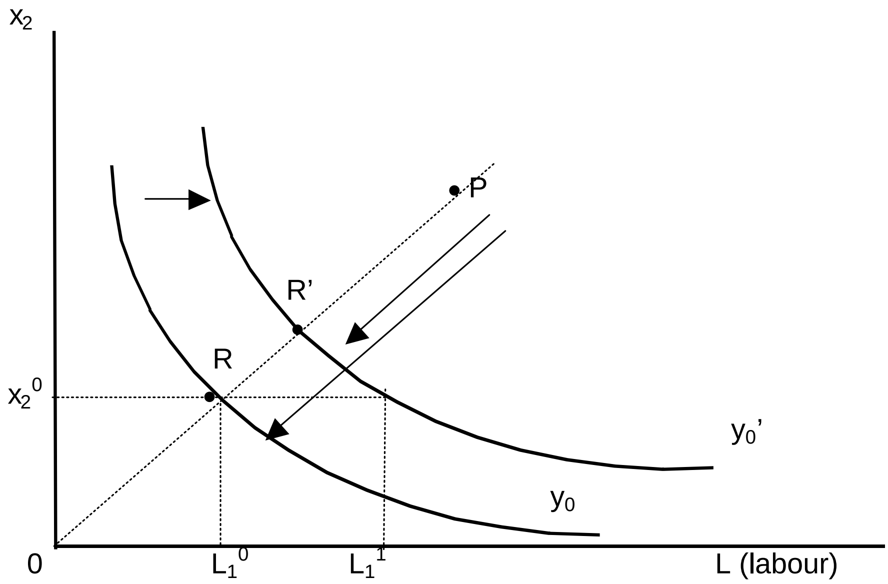


Figure 2: Strikes in the Input Distance Function

Mathematically, according to the envelope theorem $\partial D_I(y,x,H) / \partial H$ is equal to $\partial L (.)/\partial H$, where L(.) it is the Lagrangean associated with equation (8). Then,

$$\partial D_I (y,x,H)/ \partial H = -\lambda\, \partial C (y,W,H)/ \partial H \qquad (9)$$

where λ is the Lagrange multiplier. The first order conditions associated with the minimization problem (8) require that $\partial L (.)/\partial W_i = x_i - \lambda \partial C(y,W, H)/\partial W_i = 0$. If D_I is equal to 1 (i.e., if we are in the frontier), the quantity x_i coincides with the optimal, so that λ= 1. Therefore:

$$-\frac{\partial D_I(y,x,H)}{\partial H}=\frac{\dfrac{\partial C(y,w^s,H)}{\partial H}}{C(y,w^s,H)}=\frac{CMgH}{C(y,w^s,H)} \tag{10}$$

That is, the absolute value of the derivative $\partial D_I(y,x,H)/\partial H$ is equal to the *marginal cost* (normalized by the total cost) of an hour of strike registered in the sector. Therefore, once the technology is estimated, it is feasible to deduce *the annual cost of the conflict*, where this is calculated as the number of hours of strikes in a year by the marginal cost of an hour of strike.The marginal cost of strike hours is an input shadow cost which is non desireable.

4. Empirical model

To estimate the production technology by means of a input distance function, we propose an econometric approach. To improve the efficiency, the estimation of the distance function will be carried out jointly with the share equations that are obtained by differentiating the logarithm of the distance function with respect to the logarithm of each input. A flexible functional form is specified, namely the translog function. With this, the econometric specification of the input distance function in the short run can be written as follows:

$$\begin{aligned}\ln \quad 1 = {} & B_0 + \text{á}_r \ln y_{rt} + \text{á}_{rr}\frac{1}{2}\ln y_{rt}^2 + \sum_{i=1}^{n}\text{â}_i \ln x_{it} + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\text{â}_{ij}\ln x_{it}\ln x_{jt} + \\ & \sum_{i=1}^{n}\text{ñ}_{ri}\ln y_{rt}\ln x_{it} + \text{î}_c \ln h_{ct} + \text{î}_{cc}\frac{1}{2}\ln h_{ct}^2 + \sum_{i=1}^{n}\text{î}_{ci}\ln h_{ct}\ln x_{it} + \text{î}_{cr}\ln h_{ct}\ln y_{rt} + \\ & \text{ç}_f \ln ff_{ft} + \text{ç}_{ff}\frac{1}{2}\ln ff_{ft}^2 + \sum_{i=1}^{n}\text{ç}_{fi}\ln ff_{ft}\ln x_{it} + \text{ç}_{fr}\ln ff_{ft}\ln y_{rt} + \\ & \text{ø}_t \ln T_t + \text{ø}_{tt}\frac{1}{2}\ln T_t^2 + \sum_{i=1}^{n}\text{ø}_{ti}\ln T_t \ln x_{it} + \text{ø}_{tr}\ln T_t \ln y_{rt} + \varepsilon_t\end{aligned} \tag{11}$$

The share equations can be written as:

$$\frac{x_{it}w_{it}}{C_t} = \text{â}_i + \sum_{j=1}^{n}\text{â}_{ij}\ln x_{jt} + \text{ñ}_{ri}\ln y_{rt} + \text{î}_{ci}\ln h_{ct} + \text{ç}_{fi}\ln ff_{ft} + \text{ø}_{ti}\ln T_t + \mu_{it} \tag{12}$$

where:

y is output; x is the input vector (i, j = 1,..., n); h is the index of conflict; ff is a quasi-fixed input; T is a time trend; B_0 is constant; C is total cost; w represents input prices (unit costs); and ε_t and μ_{it} are error terms. ε_t is assumed to follow a normal distribution with zero mean.

If costs are not being minimised, the error term μ_{it} may have a non-zero mean. We therefore assume that the μ_{it}'s have means a_i, and we propose the following transformation of the error term, following Ferrier and Lovell (1990):

$$\frac{x_{it}w_{it}}{C_t} = (\hat{a}_i + a_i) + \sum_{j=1}^{n} \hat{a}_{ij} \ln x_{jt} + \tilde{n}_{ri} \ln y_{rt} + \hat{\imath}_{ci} \ln h_{ct} + \text{ç}_{fi} \ln ff_{ft} + \text{ø}_{ti} \ln T_t + (\mu_{it} - a_i) \qquad (12b)$$

where the transformed error terms ($\mu_{it} - a_i$) have zero means.

Also, homogeneity of degree one in variable inputs has been imposed: that is

$\sum_{i=1}^{n} \beta_i = 1$; $\sum_{j=1}^{n} \beta_{ij} = 0$; $\sum_{r=1}^{n} \rho_{ri} = 0$; $\sum_{i=1}^{n} \eta_{fi} = 0$; $\sum_{i=1}^{n} \Psi_{ti} = 0$; and symmetry: $\beta_{ij} = \beta_{ji}$.

4.1. The data

The estimation of the distance function will be carried out for the coal sector by aggregating three types of coal: coal, anthracite and lignite. The data have been obtained from two statistical publications: *Estadistica Minera de España* (Mining Statistics of Spain), and the annual reports of Carbunión (the employer's organization). The sample period (conditioned by the availability of data) is 1974-1997. The variables used are:

a) Output (Y): production of coal measured in equivalent thermal units. It has not been possible to distinguish between the three types of coal due to lack of degrees of freedom.

b) Labour (L): total potential working hours (total working hours contracted).

c) Capital (K): this factor, which is considered fixed, has been approximated using a Divisia-Törnqvist quantity index, in which the different types of machines have been considered in terms of the corresponding vapor horsepower.

d) Supplies (M): value of the energy and the materials employed. Due to the fact that this variable is in monetary terms, and therefore affected by prices, it has been deflated using the implicit deflator of the GNP with a base in 1986, obtained from the National Accounts elaborated by the National Institute of Statistics (INE) .

e) Labour Unrest (H): number of working hours lost. This variable has been constructed by applying the percentage of lost days, according to Carbunión, to working hours, according to the *Estadistica Minera de España* .

Moreover, we have considered the expenditure on the different variable inputs (expenditure on labour and supplies).

Finally, a time trend has been included in an attempt to capture technical progress.

4.2. Empirical results

The system of equations (11-12b) has been estimated by means of the iterative seemingly unrelated regressions system (ITSUR). Since the share equations sum to 1, the estimation requires dropping one of the input share equations. Nevertheless, the result is invariant to the omitted share equation. Furthermore, an autoregressive first order parameter has been introduced to correct for possible first order autocorrelation in the different equations of the system. Also, to deal with the heteroscedasticity problem, the correction proposed by White (1980) has been used. The estimated parameters of the system of equations (11-12b) are presented in Table 2, where the variables have been divided by their geometric means. Therefore, the first order coefficients can be interpreted as elasticities evaluated at the sample geometric mean.

The coefficients of the inputs and the outputs have the expected signs. That is to say, the estimated distance function is decreasing in outputs and increasing in inputs. The positive coefficient of a_L indicates that systematically too many workers are being employed. That is, at the mean, workers are employed in a proportion different to that which would minimise costs, which would appear to be coherent in a in declining industry such as that under study.

The coefficient of the strikes (H) also has the expected negative sign. From this it can be deduced that labour unrest has a negative influence on the sector's technology. As analysed in the previous section, the absolute value of the derivative $(\partial D_I(y,x, H) / \partial H)$ indicates the marginal cost (normalized by the total cost) of a strike hour.

Table 2: Estimated Input Distance Funtion (sample 1974-1997)

Variable	Coefficient	t-statistic
Constant	-0.0954	-11.1748**
Log(Y)	-1.1043	-15.6322**
Log(L)	0.8856	162.979**
Log(M)	0.1143	21.050**
Log(K)	0.4960	3.1539**
Log(H)	-0.0164	-2.4420**
Log(T)	0.3924	22.9263**
Log(Y) · Log(Y)	0.5722	0.3205
Log(Y) · Log(L)	-0.0539	-6.0999**
Log(Y) · Log(M)	0.0539	6.0999**
Log(Y) · Log(K)	4.8882	1.9419*
Log(L) · Log(L)	0.0881	10.0561**
Log(K) · Log(K)	-20.384	-4.1885**
Log(M) · Log(M)	0.0881	10.0561**
Log(L) · Log(K)	0.0319	1.5507
Log(L) · Log(M)	-0.0881	-10.0561**
Log(K) · Log(M)	-0.0318	-1.5507
Log(T) · Log(T)	0.7080	11.6363**
Log(T) · Log(L)	0.0220	9.9811**
Log(T) · Log(K)	-3.9663	-8.6175**
Log(T) · Log(M)	-0.0220	-9.9811**
Log(T) · Log(Y)	-0.0197	-0.0674
Log(T) · Log(H)	0.0283	2.2829**
Log(H) · Log(H)	-0.0885	-5.0468**
Log(H)... Log(L)	-0.0151	-1.0286
Log(H) · Log(K)	0.0828	0.4011
Log(H) · Log(M)	0.0151	1.0286
Log(Y) · Log(H)	0.1941	2.5610**
AR1 (f. It distances)	0.2739	13.5963**
AR1(f. of L. share)	-0.1536	-1.2699

(*) Statistically significant at 10% level; (* *) stat.sig. at 5% level.

Summary of the empirical results

Equation	R2	DW	S.E. Regression
Distance Function	-	2.554	0.011
Labour share	0.967	1.335	0.003

Given the translog function used in the econometric model we have that:

$$\frac{\partial \mathrm{D_I}(y,x,\mathrm{H})}{\partial \mathrm{H}} = \frac{\partial \ln \mathrm{D_I}(y,x,\mathrm{H})}{\partial \ln \mathrm{H}} \frac{\mathrm{D_I}}{\mathrm{H}} \tag{13}$$

Using equations (10) and (13) we obtain:

$$\frac{\mathrm{CMgH}}{\mathrm{C}(y,w^s,\mathrm{H})} = -\frac{\partial \ln \mathrm{D_I}(y,x,\mathrm{H})}{\partial \ln \mathrm{H}} \frac{\mathrm{D_I}}{\mathrm{H}} \tag{14}$$

and, rearranging terms we have that:

$$\mathrm{CMgH} = -\frac{\partial \ln \mathrm{D_I}(y,x,\mathrm{H})}{\partial \ln \mathrm{H}} \frac{\mathrm{D_I}}{\mathrm{H}} \mathrm{C}(y,w^s,\mathrm{H}) \tag{15}$$

Now, since:

$$\mathrm{C}(y,w^s,\mathrm{H}) = \frac{\mathrm{C}}{\mathrm{D_I}} \tag{16}$$

we finally obtain:

$$\mathrm{CMgH} = -\frac{\partial \ln \mathrm{D_I}(y,x,\mathrm{H})}{\partial \ln \mathrm{H}} \frac{\mathrm{C}}{\mathrm{H}} \tag{17}$$

Therefore from expression (17), we have been able to obtain a shadow price of the strike hours (H) from the derivative of the distance function with respect to the said variable; the costs (C) reconstructed from the information used; and the value of the variable (H), the strike hours. With all this, the ”shadow”marginal cost of one strike hour, on average, amounts to 1,234 pesetas. From this we can directly obtain the (mean) total cost atributable to conflict in the sector by multiplying by the number of strike hours; this yields $\mathrm{CMgH} \cdot \mathrm{H}$ = 1,876 millon pesetas.

Furthermore, it would be especially interesting to be able to compare the salary paid in the sector (known as the market wage), with the wage that the firms would have to pay if they were efficient (that is to say, the shadow wage or the also called competititive wage). This is made possible by applying the Dual Shephard's Lemma (see equation 7). Thus, at the mean, this labour price is 1,576 pesetas. On the other hand, the market wage of labour is 1,852 pesetas. Therefore, at the mean, there is a wage gap of 276 pesetas per hour of labour. This result corroborates the hypothesis that in some industries where rent-seeking is a phenomena, the actual wage paid can prove to be a deceptive indicator of the evaluation of the value of the marginal productivity of labour. Indeed, import protection, public assistance and union action, all habitual features in declining industries, can have the consequence that labour is not correctly allocated in terms of price (wage) and/or quantity. In these cases, the modern theory of protectionism offers powerful tools to reconstruct more adequate shadow prices.

In conclusion, comparing the values at the mean, the results obtained can be interpreted in two directions. Firstly, the quantity of work contracted is superior to that which would minimise costs. This result supports the initial idea that in industries in decline, the workers have incentives to seek protection for their jobs via labour unrest. From these results we can therefore deduce that the assumption of cost minimisation is not valid. This should be taken into account when attempting to estimate the technology with appropriate tools such as the input distance function. On the other hand, the sector's workers receive a wage superior to the competitive wage, implying that they are receiving an effective wage that is above their opportunity cost and which thus constitutes an economic rent. As such, the results would indicate that there is a certain market power in the hands of the workers and mining unions (see for example Lewis, 1986).

All this leads us to suspect that rent-seeking activities exist, and it also supports the idea of using labour unrest to quantify the costs associated with this, as we have stated at the beginning. Thus, this study provides an illustrative example of how an input distance function can be used to obtain shadow prices of factors which have an influence on the activities of the companies but which do not have a market price.

5. Conclusions

Rent seeking refers to the social loss attributable to the agents that spend resources on lobbying or similar activities in order to get a certain transfer of rents. Although it is an attractive concept, its empirical measurement is at an embryonic stage. In this work we provide a measure of the expenditure on rent seeking through labour conflict, understood as working days lost, in the coal sector of Spain. While this approach has previously been adopted (Del Rosal and Fonseca, 2001), the contribution of this work consists of itsuse of the most advanced tools in the theory of productionto obtaina value for the labour unrest in question, without the necessity of having to impose restrictions on behaviour of agents in the sector.

The input distance function has been used to obtain shadow prices for non desireable outputs. We propose the use of this function due to the number of advantages it has when trying to empirically obtain shadow prices of factors which influence production in a negative manner, such as strikes, and which therefore can be considered as non desireable or "bad" inputs. First, it allows us to obtain certain prices or shadow costs, which is especially useful when trying to put a value on concepts that do not have a market price, such as conflict. Second, it is not necessary to assume that the firm minimizes costs, nor that the prices of the inputs are exogenous. These characteristics make the input distance function an appropriate tool with to analyse the coal sector.

In summary, this paper constitutes first step in a line of research that allows the measurement, in the context of production theory, of concepts difficult to quantify in monetary terms, such as strikes. In a certain sense, it consists of evaluating the input equivalent of non desirable outputs.

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