TECHNICAL EFFICIENCY AND SPATIAL EXTERNALITIES: EVIDENCE FROM SPANISH SMALL AND MIDDLE-SIZED INDUSTRIAL FIRMS[••]

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Abstract

The present work sets out to analyse differential performances, regarding efficiency in production processes, among those firms that are located within a hypothetical industrial district and those situated outside of it. This objective has been tackled in recent literature by making use of radial measures of technical efficiency. In this case we present a methodology that allows one to overcome the important limitations that characterise this kind of studies, especially the condition of radiality. A second stage analysis is applied on the results obtained starting from the calculation of non-radial indices of efficiency taking as a reference point the spatial location of each firm and by making use of a series of variables that characterise the business activity. An empirical application has been carried out for a set of industrial Small and Medium Firms (SMF) in the Valencian Region (Spain)

I. - INTRODUCTION

The study of the nature and intensity of spatial externalities of all kinds is shown as a field of increasing interest in the literature, as Fujita, Krugman and Venables (1999) state. Some works insist on the importance of effects derived from geographical location, such as the positive correlation between productivity and density of economic activity (Ciccone and Hall, 1996) or the territorial reach of business links backwards and forwards in time among firms by means of the estimation of a spatial function of work demand (Hanson, 1998). More recently, Keller, (2000) and Caniëls, (2000) emphasise the persistent localised nature of externalities of

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knowledge, still in a growing scene of global interdependence and development of telecommunications.

In this context, Henderson, (1999) underlines that, unlike tertiary activities and high technology, traditional manufacture benefits more from *Marshallian* or MAR externalities (Marshall-Arrow-Romer) than urbanisation or Jacob's externalities. That is to say that the agglomeration of firms from the same industry or similar play a decisive role in the creation of competitive advantages with respect to "isolated" firms, *ceteris paribus*, when dealing with mature technological activities. We think that this is the case for many industries in southern European countries, and in particular, for a great deal of Spanish industry.

Henderson´s approach coincides with an important Italian academic stream of thought which, since the end of the sixties (Becattini, 1979, 2000, 2001), recuperates Marshallian reflections on the industrial district of small and medium firms (which we will call SMF from now on). This approach also involves making headway with the verification of the nature and intensity of competitive advantages that are generated in these territorial environments. In any case, both the Anglo-Saxon and the Italian traditions have been focused upon and cultivated in economic Spanish literature, as shown by De Lucio, Herce and Goicolea (1998) and Costa and Viladecans (1999) respectively.

Overall, despite the fact that the abundant existing literature is of great interest and use in understanding the numerous processes of industrial growth, it has been mainly non-quantitative, due to the fact that some of the variables that are necessary to analyse these territorial environments are difficult to measure. In addition, the causal processes are not directly observable[1].

[1] In fact, the relation between industrial district theory and practice was, to begin with, unusual. This was because the data that deserved attention according to the mainstream criteria of the time were scarce-quantitative statistical data, reliable and abundant enough with which technically robust econometric tests could be constructed. There were data of firm censuses or some sporadic field research. There was not enough information at a microeconomic level of the firm with enough territorial and sectorial disintegration. Moreover, essential components of the district theory were (and continued to be) non-palpable facts, like the quality of information flow or the degree of confidence between the parties in the contract: facts, which are inherently difficult to measure. That's why district theory was initially, and for a long time, non-

The underlying idea of most of those who defend the existence of industrial districts is that the size of the firm may be deceptive in itself. In many industries, it is not the size of the firm but the quality of the local environment that determines the competition of the manufacturing system. For this reason, the emphasis should be moved from the economies of internal scale to localised external economies. Therefore, territory is crucial from this point of view [2].

In a certain way the district performs like a single entity, where the planning structure and control which are typical of the large firm gives way to a market structure even though it is of a particular nature. The "intelligent cluster" (as in the case of bees) of firms from the district reacts to the price system and to all other information interacting with other firms. At first glance, the individual reaction mechanisms may seem very simple and apparently anarchic, but they produce highly organised, complex, flexible and efficient collectives (Signorini, 2000).

In this way, a productive organisation of this type makes economic sense the less it depends on transaction costs. If these are sufficiently low and economies of scale (internal) are sufficiently reduced, a set of SMF that compete among themselves (many for each of the productive stages) will give rise to a more efficient result compared to a simple large firm which has been vertically integrated.

Because of all this, one can affirm that industrial districts are places where transaction costs are limited, thanks to the presence of a specific form of external economies that literature on the district calls "social capital" [3]. That is to say, thanks to the existence of trusting relationships based on productive specialisation and/or on local values and identity.

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quantitative, or to be more precise, non-econometric. This situation, among other motives, contributed to the delay in its acceptance by the mainstream of the economic profession.

[2] The industrial district was defined (Becatttini, 1979; Brusco, 1986) as a territorial agglomeration of small independent manufacturers all specialised in one single industry, in order to obtain idiosyncratic external economies, which were strictly tied to the local community.

[3] One may interpret Brusco´s thesis (1986) in this way. Brusco, in a cordial polemic with Becattini, considers it essential to explain the nature of external economies of the district and the imperfections of the market linked to them, to avoid that "we consider external economies or the Marshallian atmosphere as a

Productive specialisation generates a body of specific technical and commercial knowledge that enables one to understand the norms of common performance. Local identity, the sense of belonging to the collective, creates a favourable climate for the establishment of relations based on mutual trust, which makes the drawing up and enforcement of contracts less costly [4].

In this way, most authors agree that analyses on the industrial district should be based on the most concrete statistical information possible in order to achieve the maximum sectorial disintegration, in a municipal or supramunicipal territorial environment. Of course, whenever possible, it would also be advisable to use individual firm data, as Staber (1997)[5] writes about in an important work on the industrial district of Reutlingen [Baden-Württember] (Germany). This suggestion very often runs into a lack of adequate statistical information.

In recent years, however, significant advances have been made in the quantification of external economies or externalities generated in these spaces and therefore, of the competitive advantages of firms located in them. For example, Signorini (1994a,b, 2000) quantitatively verified a series of district effect features, among which one should highlight the greater productivity of firms from within the district with respect to those from the same sector which

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container where everything that cannot be explained is thrown away and we use this category to academically dress studies which are worthy of the technical section of a mediocre Chamber of Commerce".

[4] In addition, the features evolve. For example, in the Prato district (Tuscany), the paradigm of reference in the Becattinian tradition there appears a growing complexity characterised by an increase in the organisational variety which can lead back to two fundamental processes (Lazzeretti and Storai, 2000):

- A deepening of the degree of division of work among firms that gives rise to the birth of new typologies of economic activities that were formerly developed autonomously within different firms.
- A process of physiological diversification that determines the appearance of specialised firms to produce goods that are not typical of the district.

In the Prato case, this growing complexity has occurred as from the second half of the sixties. This process has been consolidated on the one hand in the birth of new firms and on the other hand, by the increase in *density* of already established firms.

[5] As Costa and Viladecans (1999) also do.

are outside of it [6]. We also cite the works of Soler (2001) and those already mentioned by Ciccione and Hall (1996) and Henderson (1999), which are also along the same lines.

Fabiani et al. (1998) and Fabiani and Pellegrini (1998) *use indices of technical efficiency* obtained via a *parametric* specification to analyse the differences in performance between firms from inside and out of the district for the case of the Italian industrial district [7]. Soler and Hernández (2001) look at the different patterns of performance associated with firms situated inside and outside the industrial district in the Valencian Region (Spain). They have a similar objective but from a *non-parametric* perspective and make use of a methodology based on DEA (*Data Envelopment Analysis*) models.

The present work intends to advance in the evaluation of the *district effect* using *non-parametric* techniques of calculating technical efficiency, but trying to overcome one of the principal limitations of the previous analyses (Soler y Hernández, 2001) such as the condition of *radiality*, that is to say, the need of an equiproportional reduction for the components of the vector of inputs.

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[6] Signorini (1994 a, b) did it with a simple but useful system, valuing the significance of a *dummy* that represents belonging to a district. Signorini applied this method to a particular microsector (the wool industry) to estimate the possible differences in production and profit in favour of firms that belonged to industrial districts. With business data, a production function in which the "dummy district" is presented in the PTF term (total productivity of the factors) or in the interaction with different productive factors. The exercise confirms the theory.

[7] Fabiani et al. (2000) have generalised the exercise to the set of the Italian manufacturing industry. The exercise confirms that belonging to a district affects the inefficiency of firms by reducing it. One should point out that when the definition of the district is less restricted, which is to say when one is referring to the location and not to the location crossed with the sector, the result is clearer. Exercises have also been carried out on the repercussion of the district effect on international competition of Italian industry. Gola and Mori (2000) consider not only the relative factorial intensity but also the location of firms in the sector. They take into account both the economies as well as the district effect, economies of agglomeration and congestion, in opposition to internal economies of scale, to evaluate the performance of each industrial sector in the international market. Heckscher-Ohlin is the reference model, enriched with elements that try to capture both the advantages/disadvantages of location as well as economies of scale. One also distinguishes between general economies of agglomeration (that may include the case of large firms) and those derived specifically from the industrial district. The results of the exercise confirms that there is a correlation between the degree of district effect and the improved performance of the sector in exterior commerce and also confirms that the correlation is less in the case of generic agglomeration or in the presence of large firms.

In order to carry this out a methodology based on the use of *non-radial* measures of technical efficiency was used, which permitted one to obtain an efficiency indicator for each input used in the production process. This helps to identify the determinants of the so-called district effect in the most concrete manner.

A second stage analysis is applied on the obtained results using the calculation of *non-radial* measures of efficiency taking as a reference the spatial location of each firm and using a series of relative variables to business activity. The study is completed using efficiency measures in output to quantify the so-called district effect in terms of the potential output per firm. The empirical application -starting from individual data per productive unit- is carried out for a set of firms belonging to the ceramic industry of the Valencian Region.

Before looking at the empirical verification, the territorial concretion of the industrial district must be considered, that is to say, which industrial agglomeration can be considered district in the sense of Marshall and Becattini. As the literature gives few guidelines in this respect (Sforzi, 1989, 1995), the question remains fairly open and requires an *ad hoc* geography in accordance with those criteria that are considered opportune.

In this present work we will use the criteria adopted by Soler (2001) that objectify and confirm the intuitive approximations with indicators contrasted by the literature. That is to say that the Valencian industrial district of ceramics reaches the areas of the *Plana Alta*, the *Plana Baixa* and the *Alcalatén*.

II. - METHODOLOGY

From the point of view of the productive economy the term efficiency is associated with the rational use of available resources, that is to say it is used to describe that productive process that uses all its production factors in an optimum way, according to existing technology. Although historically it has generated remarkable interest, it is not until the fifties that the measure of efficiency in production is tackled in a rigorous way, thanks to the contributions by Koopmans (1951), Debreu (1951) and specially, Farrell (1957).

This last author becomes the pioneer of the study of *frontier functions* used as reference points to obtain measures of efficiency for each productive unit. According to the model proposed[8] by Farrell, a frontier of the best practice is constructed or, a convex environment constituted by the most efficient firms of the sample. This is obtained by using techniques of linear programming and under the data of constant returns to scale and strong disposability in inputs[9]. In this way, when a firm obtains the maximum output given a vector of inputs, or otherwise uses a minimum of inputs to produce a determined output, it will be situated on the so-called *production frontier*. In this last case, the technical efficiency of a firm can be measured from calculating the maximum possible proportional reduction in the use of factors that are compatible with its output level.

However, a limitation of this methodology is that this reduction should be the same for all inputs. In this way, one can affirm that the radial measures of efficiency use the isoquant curve as reference and not necessarily the subset of efficient points. In this way, the reductions of the radial type can lead towards a point on the isoquant curve that does not belong to the set of efficient points, thus enabling greater reductions in at least one input without affecting output. Therefore, the rationale that sustained the development of a non-radial measure is to find a measure of technical efficiency that allows one to qualify an observation as efficient if and only if it belongs to the subset of efficient points.

As can be seen in Graph *I*, the efficient subset is made up of points that are situated among X^A,X^B and X^C. Under the assumption of strong disposability, the isoquant curve is made up by the subset of efficient points and the vertical and horizontal extensions that appear in the graph. The radial measures could compare inefficient *X'* with point *X**, which does not

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[8] This method of analysis represents the starting point of what is known in economic literature as *Data Envelopment Analysis* (DEA) models.

belong to the subset of efficient points. It represents a serious limitation when knowing the maximum possible reduction in each of the inputs without having to sacrifice output (Russell, 1985).

Using non-radial measures it would not be possible to use point X^* as a reference as if it were chosen, then input X_2 could be maintained at the same level while input X_1 could be reduced to a greater extent until it reaches point X^A. Therefore, the proper minimisation exercise would fix X^A as a reference and not X^*.

Let us assume a production process in which from a vector of inputs $x \in \Re_+^N$ one obtains a vector of outputs $y \in \Re_+^M$ using technology T, so that,

$$T = \{(x,y); x \; can \;\; produce \; y\} \qquad (1)$$

This technology T can also be expressed in an equivalent way from the inputs point of view, which is,

$$(x,y) \in T \Leftrightarrow x \in L(y) \qquad (2)$$

Where $L(y)$ represents the set of inputs vectors x that allow them to reach at least one vector of outputs y.

Under the assumption of constant returns to scale and harsh elimination in inputs, Färe and Lovell (1978) establish four axioms that should be met by any measure of efficiency, $E(y,x)$:

a) If $x \in L(y), y > 0, then \quad E(y,x) = 1 \Leftrightarrow x \in Eff\ L(y).$

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[9] In inputs, the strong disposability is described as that situation in which an input may be increased without any cost in terms of increases in the rest of the inputs, to keep the level of output constant.

b) If $x \in L(y), y > 0, x \notin Eff\ L(y),\ then\ E(y,x)$ could compare x with some $x^* \in Eff\,L(y)$

c) If $x \in L(y),\ \lambda \geq 1,\ then\ E(y, \lambda x) \leq (1/\lambda) E(y,x)$

d) If $x \in L(y)$ and if, $x' \geq x$, $then\ E(y,x) > E(y,x')$

Following Russell (1987, 1998) and Shankar and Hadley (1999), the problems derived from the calculation of radial measures using DEA methodologies could be considered as non fulfilment of axioms a), b) y d). The first of these establishes that a measure of efficiency would assign the greater value, that is to say 1, if and only if the corresponding unit belongs to the efficient subset. Axiom b) establishes that the inefficient units would have their reference point in the efficient subset. Axiom d) monotonicity establishes that if an input vector x' has at least one element which is strictly greater than another vector x, then x' would have a lower efficiency level than x. Axiom c) is denominated homogeneity of minus one and is the only one that the radial measure always satisfies. This axiom establishes that if an inputs vector is multiplied by two, the resulting efficiency level could not be greater than half its original value.

The *non-radial* measures or Russell's measures are designed with the aim of satisfying the set of these axioms. These measures are obtained by minimising the arithmetical mean of the efficiency indices in input per firm and is,

$$MR(y,x) = min\left\{ \sum_{n=1}^{N} \lambda_n / N : (\lambda_1 x_1, \lambda_2 x_2, ..., \lambda_N x_N) \in L(y),\ 0 \leq \lambda_n \leq 1 \right\} \quad (3)$$

That is to say that the different inputs are minimised in different proportion, in contrast with the radial measure in which all inputs are reduced by the same proportion. This degree of flexibility ensures Russell's measure always uses the subset of efficient points as a reference.

Given $K = 1,2,...,k,...,K$ each one of which uses a vector $x^k = (x_1^k, x_2^k, ..., x_N^k)$ (Nx1) of inputs to carry out the production of a vector of outputs $y^k = (y_1^k, y_2^k, ..., y_M^k)$ (Mx1), z being an intensity vector of variables (Kx1). For each firm k we can obtain the values of Russell's measures by resolving the following optimisation problem using linear programming[10]:

$$
\begin{aligned}
& MR(y^{k'}, x^{k'}) = 1/N \min \sum_{n=1}^{N} \lambda_n \\
& s.t. \\
& \sum_{k=1}^{K} z_k y_{km} \geq y_{k'm} \quad m = 1,\dots, M \\
& \sum_{k=1}^{K} z_k x_{kn} \leq \lambda_n x_{k'n} \quad n = 1,\dots, N \\
& z_k \geq 0, \; k = 1,\dots, K \\
& 0 \leq \lambda_n \leq 1, \; n = 1,\dots, N
\end{aligned}
\qquad (4)
$$

where *MR* corresponds to Russell's measures while each λ_n obtained gives us an efficiency indicator for each input considered.

We will now proceed to the empirical application based on the use of this methodology on a sample of firms whose description is described below.

III. - SAMPLE AND VARIABLES

The sample used in this work has been constructed using the statistical information coming from *Ardán Data base* (1996)[11]. It consists of 46 firms located in the Valencian Region each of which carries out a process characterised by the presence of a single *output*, *ceramic tiles* (y_1) and of three *inputs*: *operating costs* (x_1), *fixed assets* (x_2) and *work force* (x_3), measured as the number of workers employed by the firm. The description of these variables can be seen in *Table I*.

IV. - RESULTS

This involves resolving the exercise of mathematical programming (4) where $K = 1,2,\dots,k,\dots,46$ producers that each use a vector $x^k = (x_1^k, x_2^k, x_3^k)_{(3x1)}$ of *inputs* to carry

[10] See Färe, Grosskopf and Lovell (1994)

out the production of an outputs vector $y^k = (y_1^k)_{(1x1)}$, z being a vector of dimension (46x1). The results obtained in the 46 optimisation programmes (one for each productive unit) calculated in the ceramic sector offer us an mean value of 0,6511 for Russell's measures (*Table II*). This means that the set of analysed firms could obtain the same output saving themselves 35 percent of the inputs in total. The indices associated with each of the inputs are fairly divergent among themselves corresponding to the greater value of operating costs (0,9091), which represent a higher efficiency level in the management of this input for the total number of firms from the sample.

Once these indices have been obtained, our aim is to evaluate possible relationships between these non-radial measures and the spatial location of the firms. In order to do this we will carry out a second stage analysis. Among the still scant options that the literature offers us we considered it best to carry out an analysis of variance (ANOVA). This entails identifying whether there are significant differences in the mean values of the efficiency indices obtained, between the two groups into which the firms of the sample were divided in terms of their spatial location.

Two spatial territories were contemplated: the three areas of the Alcalatén and the two Planas, as an area representative of the district on the one hand, and the rest of the Valencian Region on the other. Once the corresponding analysis of variance has been done and considering Russell's measures previously calculated as a variable of reference, we obtains that, with five percent significance, statistic F leads us to reject the null hypothesis of equality of means between the two specified zones. In other words, we can accept that the differences observed in the mean values for the efficiency indices of the different groups do not have a random nature. In particular, the mean efficiency index corresponding to firms located in the areas of the Alcalatén and the two Planas is shown to be clearly higher than those presented, always on mean, by firms situated outside this area[12]. It is, therefore, certainly a logical result

[11] *Ardan Data base* is a Spanish data base created from the public Business Register.
[12] A recent work (Molina, 1999), with another methodology and referring to business results (profits), confirms the existence of competitive advantages in firms located in the ceramic LPS (local productive system) of these regions in relation to the other firms of the sector in Spain.

given the different existing contributions in the literature, for example Soler and Hernández (2001).

Taking as a reference efficiency indicators associated to each input we observe that the differences between the two identified spaces are significant only for the representative indicator of efficiency of the work factor. With these results in mind we can state a more efficient global performance by the firms situated within the district, and in particular, this greater productive efficiency would be associated with the use of the work factor.

Considering the relevant role that this efficiency indicator acquires relative to the work force when characterising an industrial district, we immediately consider identifying those variables that could have some link with this efficient performance of the work input. The results obtained will contribute to more exhaustive knowledge of the complex latticework of elements and interrelation that shape the denominated district effect.

Using once again a methodology based on the analysis of variance, two groups of firms can be contrasted: those with an efficiency indicator associated to the work input higher than the mean of the sample and those whose index is below the mean. A series of variables determinants in business activity is used as a reference. The first to consider is the variable *size*, expressed both in terms of operating revenue as well as the number of workers. In both cases, and with five per cent significance, statistic F stops us from rejecting the null hypothesis of equality of means between the two specified groups. That is to say that we can accept that the differences observed in the mean values for the size of the firm between both groups have a random nature. From this result we can deduce that the influence of the firm size is not significant nor, therefore, are the possible economies of scale associated with it, when it comes to explaining the higher or lower efficiency of the work factor and, by extension, of a hypothetical district effect.

In the second place, the variable used as a reference is the cost per worker (obtained as a quotient between the cost of workers and the number of workers). Also with 5 per cent significance, this time statistic F allows us to reject the null hypothesis of equality of means between both groups. As can be seen in *Table III*, there is a direct association between the higher efficiency of the work factor and its own higher costs. We could interpret, a priori, that these higher labour costs are linked, for example, to greater qualifications, experience or skill of the work force, which could be characterising a possible district effect [13].

The third variable considered is the *fixed assets per worker*. As in the previous case, statistic F induces us to reject the null hypothesis of equality of means between the two groups identified. By observing the corresponding values for each group we can deduce a direct association between the efficiency of the work input and the amount of fixed assets per worker. By extension and, in coherence with this, we could expect a significantly greater endowment of fixed assets per worker in firms located within the industrial district compared to those outside it [14].

Finally, the analysed variable represents the profits of the firm per worker. Again statistic F allows us to reject the null hypothesis of equality of means in such a way that, as seen in *Table III*, we can verify that the profit per worker corresponding to firms with an efficiency indicator for the work input higher than the mean of the sample are significantly higher than those of the other firms. Again it would be logical to think that these profits per worker were significantly higher in the case of the productive units located in the area of the district compared to the others [15].

In summary, according to the methodologies used here, we verify the presence of the *district effect* and its concretion via a series of relative variables to the business activity. By

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[13] The cost per worker, on average, for firms from the sample situated within the district amounts to 25.242 Euros, while the rest totals 17.429 Euros. The value of statistic F (28,56) confirms the significance of the differences between the mean values of both groups.

[14] According to the data of the sample used, this hypothesis is confirmed in such a way that the mean value of fixed assets per worker for firms belonging to the district is 64.308 Euros compared to 15.025 for those outside. Once again, these differences are strongly significant according to statistic F (24,49).

[15] In effect, the information from the sample supports this fact given that the mean of profits per worker for firms located in the district is close to 24.000 Euros, while the figure is 1.200 for the rest. Statistic F (8,33) confirms the significance of these differences between the two groups of firms.

this, we mean that firms located within the *Valencian ceramic district* have an overall more efficient performance than the others do and, in particular, this higher efficiency is associated to the work factor. In turn, there is evidence that a series of variables like costs per worker, fixed assets per worker or business profits per worker are clearly linked with efficiency of the work input and, by extension, with a possible district effect. In contrast, its relationship with the variable size of firm is not significant expressed both in terms of operations income and of number of workers.

Given these results, we can identify the presence of a kind of *virtuous circle* (Assopiastrelle, 1998), in the ambit of the ceramic district, in such a way that competitive advantages on the supply side (due to improved processing technology) together with other factors which have allowed a higher profitability to be reached, enable an aggressive investment and development policy, which helps to consolidate the competitive edge of firms (Budí and Molina, 2001).

Once the district effect has been characterised via a series of variables associated with the business ambit, we decided to go one step further in our analysis and tried to quantify said effect using the efficiency indicator for the work factor. In this way, the mean value of the aforementioned indicator for the firms from inside the district is 0,7605 while it is 0,3997 for those situated outside it. For a given level of income of operation per firm, we now wonder what the repercussions would be in terms of cost if the firms from outside the district had on mean, the same efficiency associated with the work factor as those from within.

Assuming that an improvement in efficiency of the work factor means that it is possible to reach the same output with a lower number of workers, we propose to calculate this reduction via expression (5). This means that: E_t^d represents the mean value of the efficiency indicator for the work input in firms from inside the district; E_t^{nd} refers to the same indicator but for firms outside the district and, T_{med}^{nd} symbolises the mean number of worker for the group of firms located outside the district.

$$\left(E_t^d - E_t^{nd}\right)T_{med}^{nd} \qquad (5)$$

The result obtained is the reduction, always on mean, of 9,7 workers per firm. Once the mean cost per worker is known for firms outside the district, we could obtain the mean saving on costs per firm that this staff cut would suppose at 172.490 Euros. This represents, also on mean, 37 per cent of the division of staff expenses for each firm located outside the district.

Output efficiency

The set of results obtained until here contributed a series of significant aspects when characterising the district effect in a detailed way, always from the viewpoint of efficiency in the use of inputs.

However, this study would surely be incomplete if a new analysis were not studied in a complementary capacity, this time from the perspective of output. In other words, considering the inputs vector of each firm as given, it would be a matter of knowing to what extent the output of each productive unit could be maximised. An efficient performance would involve the impossibility of obtaining a higher potential output while inefficiency would be associated with greater possibilities of maximising said output. Our aim will now be to contrast if there is a differential performance regarding output efficiency between firms inside and outside the district.

To do this we use the traditional measure of efficiency in $E_O(x^{k'}, y^{k'})$, widely used in the literature[16] and in order to obtain it one has to resolve the following maximisation programme for each of the 46 producers that make up the sample:

[16] See Charnes et al. (1996).

$$
\begin{aligned}
& E_O\,(y^{k'}, x^{k'}) = Max\ \lambda \\
& s.t. \\
& \sum_{k=1}^{K} z_k y_{km} \geq \lambda\ y_{k'm}\ m = 1,\dots, M \\
& \sum_{k=1}^{K} z_k x_{kn} \leq x_{k'n}\ \ n = 1,\dots, N \\
& z_k \geq 0,\ k = 1,\dots, K \\
& \lambda\ \geq 1
\end{aligned}
\qquad (6)
$$

According to the results in *Table IV*, the mean value for the technical efficiency index of output is 1,2929, which suggests that, assuming the aforementioned inputs are fixed, the producers of the sample could increase their final output by approximately 30 per cent. Although this is an interesting result that requires a detailed analysis, our priority focuses on evaluating if there are any significant differences in efficiency indices in output between firms from within and those outside the district.

With this aim in mind, we studied the corresponding analysis of variance so that statistic F allows 5 per cent significance to reject the hypothesis of equality of means for efficiency indices of output between the two spaces. By analysing the mean values for each area we observe a reduction in output inefficiency (1,2525) for firms inside the district compared to firms (1,3763). In the first case, the productive units could increase their output levels by approximately 25 per cent, compared to 38 per cent in the second, always with fixed inputs.

From these results that corroborate, once again, the hypothesis of a more efficient performance by firms inside the district compared to those outside, we can calculate to what extent these firms outside the district could increase their final output, given their inputs vector, they could perform at the same level of efficiency in output to firms belonging to the district. To do this we use the following expression,

$$
\left(E_O^{nd} - E_O^{d}\right) O_{med}^{nd} \qquad (7)
$$

where: E_O^{nd} refers to the mean value of efficiency in output for firms outside the district; E_O^{d} symbolises the same indicator but for firms inside the district and, O_{med}^{nd} refers to the mean output (in terms of operating income) for the group of firms outside the district. The result obtained of 218.768 Euros is the increase in amount of output that the group of firms situated outside the district could reach if they performed with the same efficiency as those inside.

V. - REMARKS

The aim of this work is to further the assessment of the *district effect* by using an efficiency analysis. Previous research had dealt with the study of said district effect using a methodology based on radial measures of technical efficiency. One of its principal limitations is the condition of *radiality* in such a way that the technical efficiency of a firm is measured by calculating the maximum possible proportional reduction in the use of inputs (the same for them all), compatible with its output level.

Now, with the aim of overcoming the previous restriction, a methodology is used that permits *non-radial* measures of technical efficiency to be obtained, so that the various inputs can be minimised in different proportions. A second stage analysis is applied on the obtained results, specifically, an analysis of variance (ANOVA), in order to evaluate the relationships between the non-radial indices obtained and the spatial location of the firms.

An empirical application is carried out -from individual information per productive unit- for a set of firms belonging to the ceramic sector of the Valencian Region (Spain). One should mention as principal results the verification of a differential performance in terms of efficiency between firms located in the three areas of the Alcalatén and the two Planas (the area of the *Valencian ceramic industrial district)* compared to the rest of the regional firms in the sector.

Specifically, this higher efficiency of firms situated inside the district is found to have a significant link in the more efficient use of the work factor. Among the variables that could be linked to this higher efficiency of the work input and therefore, with the *district effect*, we find the following: costs per worker, fixed assets per worker and business profits per worker. Finally, the previous analysis is completed by using measures of efficiency in output with the aim of quantifying the possible *district effect* in terms of the potential output per firm.

VI. - BIBLIOGRAPHY

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Table I

SAMPLE DESCRIPTION

(46 firms)

Variable	***Description***	***Unit of measure***	***Arithmetical mean***
y_1	Ceramic tiles	Thousands of Euros	13.111,51
x_1	Operating costs	Thousands of Euros	5.074,31
x_2	Fixed assets	Thousands of Euros	7.154,38
x_3	Work force	Number of workers	84,7

Table II

NON-RADIAL MEASURES OF INPUT EFFICIENCY

FIRM	RUSSELL MEASURE	OPERATING COSTS INDICATOR	FIXED ASSETS INDICATOR	WORK FORCE INDICATOR
1	0,6269	1,0000	0,5291	0,3517
2	0,4583	0,7012	0,4954	0,1783
3	1,0000	1,0000	1,0000	1,0000
4	0,3776	0,6900	0,1950	0,2479
5	0,4387	0,6097	0,4436	0,2629
6	0,4581	0,8632	0,1979	0,3132
7	0,5189	1,0000	0,3806	0,1762
8	0,7397	1,0000	0,3407	0,8784
9	0,5063	1,0000	0,3611	0,1577
10	0,5274	0,8157	0,3796	0,3869
11	0,5302	0,8375	0,3377	0,4155
12	0,5656	0,9597	0,3109	0,4263
13	0,5690	0,8408	0,3710	0,4953
14	0,5584	1,0000	0,3109	0,3642
15	0,5823	0,8461	0,2363	0,6645
16	0,7593	1,0000	0,6823	0,5957
17	0,6266	1,0000	0,3294	0,5504
18	0,6267	1,0000	0,5391	0,3409
19	0,5754	0,8453	0,1807	0,7002
20	0,5929	1,0000	0,2959	0,4829
21	0,7488	1,0000	0,5978	0,6487
22	0,5671	0,7633	0,2259	0,7121
23	0,8267	1,0000	0,8212	0,6588
24	0,6038	0,8916	0,2042	0,7155
25	0,6102	0,8188	0,2929	0,7189
26	0,5703	0,8168	0,1737	0,7204
27	0,6184	0,9421	0,1850	0,7281
28	0,5709	0,8690	0,1099	0,7337
29	0,5949	0,7758	0,2590	0,7499
30	0,5663	0,7725	0,1654	0,7609
31	0,6034	0,8121	0,2244	0,7736
32	0,6240	0,9435	0,1508	0,7775
33	0,6062	0,7627	0,2650	0,7908
34	0,5943	0,8129	0,1766	0,7934
35	0,6662	1,0000	0,2098	0,7889
36	0,6223	0,8434	0,2243	0,7991
37	0,6232	1,0000	0,2159	0,6536
38	0,7484	0,9838	0,3824	0,8789
39	0,7044	1,0000	0,2958	0,8174
40	0,7311	1,0000	0,2648	0,9285
41	0,8378	1,0000	0,8689	0,6445
42	0,6720	1,0000	0,2265	0,7895
43	1,0000	1,0000	1,0000	1,0000
44	1,0000	1,0000	1,0000	1,0000
45	1,0000	1,0000	1,0000	1,0000
46	1,0000	1,0000	1,0000	1,0000
Mean	**0,6511**	**0,9091**	**0,4012**	**0,6429**

Table III
ANALYSIS OF VARIANCE

	RUSSELL MEASURE	*OPERATING COSTS INDICATOR*	*FIXED ASSETS INDICATOR*	*WORKFORCE INDICATOR*
Alcalatén-Planas group mean[*]	**0,6918**	**0,9193**	**0,3956**	**0,7605**
Rest of the Valencian Region. group mean	**0,5668**	**0,8879**	**0,4128**	**0,3997**
Statistic F	**7,6350**	**0,8610**	**0,0408**	**44,1160**
P-value	**0,0083**	**0,3585**	**0,8408**	**0,0000**

*** It includes 31 firms.**

	*OPERATING REVENUE**.*	*NUMBER OF WORKERS*	*FIXED ASSETS PER WORKER***	*COSTS PER WORKER***	*PROFITS PER WORKER***
Input efficiency indicator Workforce above the sample mean*	**15.143,68**	**87,97**	**61,97**	**24,40**	**23,70**
Efficiency input indicator Workforce below the sample mean	**9.301,19**	**78,69**	**22,34**	**19,33**	**2,98**
Statistic F	**1,2519**	**0,0682**	**13,7537**	**10,7690**	**6,8088**
P-value	**0,2693**	**0,7952**	**0,0006**	**0,0020**	**0,0123**

***It includes 30 firms**

****Values in thousands of Euros.**

Table IV
MEASURES OF OUTPUT EFFICIENCY

FIRM	OUTPUT EFFICIENCY INDICATOR
1	1,1364
2	1,6175
3	1,0000
4	1,7102
5	1,7523
6	1,4070
7	1,5348
8	1,0915
9	1,4414
10	1,3404
11	1,3182
12	1,1874
13	1,2871
14	1,5810
15	1,3262
16	1,0386
17	1,3308
18	1,2385
19	1,3802
20	1,4609
21	1,1466
22	1,4482
23	1,0628
24	1,2953
25	1,3225
26	1,4261
27	1,2610
28	1,5017
29	1,3933
30	1,4558
31	1,3649
32	1,3089
33	1,3660
34	1,3866
35	1,2171
36	1,3231
37	1,3226
38	1,0902
39	1,1807
40	1,1345
41	1,0654
42	1,2177
43	1,0000
44	1,0000
45	1,0000
46	1,0000
Mean	**1,2929**

Graph I