PROFITABILITY, MARKET STRUCTURE AND EFFICIENCY: AN APPLICATION TO THE SPANISH INDUSTRY*

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WP-EC 2000-05

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Editor: Instituto Valenciano de Investigaciones Económicas

First Edition May 2000

Depósito Legal: V-1709-2000

IVIE working papers offer in advance the results of economic research under way in order to encourage a discussion process before sending them to scientific journals for their final publication.

* The authors acknowledge financial support from the Instituto Valenciano de Investigaciones Económicas (Ivie). This study was carried out within the framework of research program SEC98-0895 of the DGICYT and GV99-103-1-08 of the Generalitat Valenciana.

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A B S T R A C T

This paper tests the different hypotheses explaining profitability in the generic framework of hypotheses of collusion versus efficiency, presenting as its main contribution the use of a direct measurement of efficiency. This measurement is obtained by applying frontier techniques using the information provided by the Spanish Ministry of Industry and Energy's Survey of Business Strategies (*Encuesta Sobre Estrategias Empresariales*) for the period 1991-94 and for the 18 sectors of activity in which the sample was divided. The evidence obtained enables us, on the one hand, to clearly reject the hypothesis of collusion in Spanish industry, since in only one sector does concentration positively affect profitability, and furthermore, the results allow us to reject in most cases the pure hypothesis of efficiency, as although efficiency does contribute positively to explaining differences in profitability, the market share, which would capture the effect of market power, also affects it positively. Thus, in many cases the empirical results indicate some limited support for the modified efficient structure hypothesis.

Keywords: profitability, market structure, efficiency, industry

R E S U M E N

En este trabajo se realiza un contraste de las distintas hipótesis explicativas de la rentabilidad en el marco genérico de las hipótesis de colusión *versus* eficiencia, presentando como principal aportación la utilización de una medida directa de eficiencia. Dicha medida se obtiene mediante la aplicación de técnicas frontera utilizando la información proporcionada por la Encuesta Sobre Estrategias Empresariales para el periodo 1991-94 y para los 18 sectores de actividad en los que se ha dividido la muestra. La evidencia obtenida permite, por una parte, rechazar claramente la hipótesis de colusión en la industria española ya que en tan sólo un sector la concentración afecta positivamente a la rentabilidad y, por otra parte, los resultados permiten rechazar en la mayoría de los casos la hipótesis pura de eficiencia, ya que si bien la eficiencia contribuye de forma positiva a explicar las diferencias de rentabilidad, la cuota de mercado, que captataría el efecto del poder de mercado, también afecta de forma positiva. Así, en muchos casos la evidencia obtenida es parcialmente favorable a la denominada "hipótesis de estructura eficiente modificada".

Palabras clave: rentabilidad, estructura de mercado, eficiencia, industria

1. INTRODUCTION

In the field of industrial organisation, the analysis of the relationship between profitability and market structure has given rise to abundant literature of both theoretical and empirical natures, and it is normal to find a chapter on these questions in handbooks on industrial economics.

Generically, two alternative hypotheses have been put forward to explain the positive correlation usually found between performance and concentration. On the one hand, the so-called traditional hypothesis of collusion, or structure-conduct-performance paradigm (Bain, 1951) affirms that concentration favours the adoption of collusive agreements, thus leading to the obtaining of monopoly rents. On the other hand, the hypothesis of efficiency (Demsetz, 1973 and 1974) posits that concentration of the market is the result of the greater efficiency of some firms which consequently gain in market share and are more profitable. In this case, the positive correlation between profitability and concentration is spurious, efficiency being the variable that genuinely explains profitability.

Traditionally, the most usual way of testing both hypotheses has been to introduce concentration and market share as explanatory variables of profitability, on the assumption that market share will reflect the effect of efficiency. In this case, if the market share positively affects profitability, and concentration is not significant, the hypothesis of efficiency is not rejected.

Normally, differences in efficiency are identified with differences in market share, because increasing returns to scale are being assumed. Thus, large sized firms produce with lower unit costs thus obtaining higher levels of profitability. However, this argument implies identifying efficiency with the concept of "efficiency of scale", ignoring other forms of inefficiency such as technical inefficiency. If we bear in mind that the empirical evidence shows the low importance of inefficiency of scale compared to technical inefficiency, the identification of differences in efficiency with differences in market share (size) presents problems.

Furthermore, the market share may not only reflect efficiency but also be a manifestation of the residual influence resulting from market power or other factors unrelated to efficiency. Shepherd (1986) argues that although the advantages of efficiency may increase market share and result in higher profits, market power is not only obtained by collusion; firms may have market power when they enjoy high market shares. Shepherd (1986) also affirms that the empirical results only suggest that market share is more important than concentration in explaining profitability, suggesting that to support the efficient structure hypothesis "would require evidence to be obtained on specific firms, taking into account that all or most high profits reflect higher efficiency" (Shepherd, 1986, p. 1206).

One solution to the problem of the degree of confidence in the use of market share as a proxy of efficiency is to use a direct measurement of efficiency. Thus, as has been done in Berger (1995), Goldberg and Rai (1996) or Maudos (1998 and 2000), the use of frontier techniques allows the problem to be solved by obtaining a direct indicator of X-efficiency, which is different from that associated with the achievement of an optimum production size (efficiency of scale).

In the case of Spanish industry, in recent years several studies have been made to test the various hypotheses explaining the relationship between profitability and market structure. Fariñas and Huergo (1994), using the Survey of Business Strategies for 1990, obtain evidence in favour of the hypothesis of efficiency, presenting the novelty of the use of an indicator of relative labour efficiency. Mazon (1993) using data from the *Central de Balances del Banco de España* (Central Balance Sheet Office of the Bank of Spain), also obtains results that support the hypothesis of efficiency, using market share as a proxy of efficiency. Recently, using data from the Survey of Business Strategies for the period 1990-93, Huergo (1998a) has made a test of the collusion and efficiency hypotheses in Spanish industry, by combining the use of intra-sectorial and inter-sectorial estimates, following the process of Schmalensee (1987). The main methodological contribution of this last paper is the analysis of the implications of relaxing the assumption of constant returns to scale, the evidence obtained leading to a mixed interpretation of the two hypotheses.

This study offers new evidence on the hypotheses that explain the relationship between profitability and market structure, and the interpretation of the relationship between profitability and market share in Spanish industry. For this purpose the study`s main contribution is the obtaining of a direct measurement of productive efficiency, by estimating frontier production functions. This avoids the problem of having to use market share as a proxy variable of efficiency as has been done in other studies.

The study was carried out on a sample of 851 firms of the Spanish industry in the period 1991-1994, using the *Encuesta Sobre Estrategias Empresariales del Ministerio de Industria y Energía* (Ministry of Industry and Energy's Survey of Business Strategies) as a source of information. The estimation of efficiency, and the testing of the various hypotheses explaining the relationship between market structure and profitability, was done at the level of the 18 activity sectors into which Spanish industrial production is divided.

With this aim, the paper is structured as follows. Section 2 details the various hypotheses put forward in the literature to explain the relationship between profitability and market structure, highlighting the role of efficiency. Section 3 describes briefly the frontier approach used for estimating the efficiency of each firm. Section 4 describes the variables and sample used, and section 5 comments on the empirical results obtained. Finally, in section 6 the main conclusions of the study are given.

2. HYPOTHESES

The theory of industrial organisation provides classical models of oligopolistic behaviour as a framework for analysing the determinants of profitability. Firms are considered to compete in the market for a good, maximising their profits. Each of them, in turn, operates in an industry in which the strategies of the other firms can interact with its own. The profit function of firm *i* is as follows:

$$\Pi_i(x_i) = p(X)x_i - C(x_i) \qquad [1]$$

where X and x denote the production of the industry and the firm respectively, p is the price of the product, and C the firm's cost of production. Maximising profits from quantity (x) the following first order conditions are obtained:

$$PCM_i = \frac{p(X) - c_i}{p(X)} = \frac{MS_i(1+\lambda_i)}{\varepsilon} \qquad [2]$$

where PCM_i is the price-cost margin, c_i is the marginal cost, MS_i is the firm's market share, ε is the elasticity of demand and λ_i shows the conjectural variations of the firm. The hypothesis deriving from equation (2) is that the market share and the conjectural variation are positively associated with the profitability of the firm, whereas elasticity of demand is inversely related. If the conjectures indicate the degree of competition existing in a sector, and this competition is proxied empirically by the level of concentration of market j in which the firm operates (CR_j), the following equation can be defined:

$$PCM_i = \alpha_0 + \alpha_1 MS_i + \alpha_2 CR_j \qquad [3]$$

This equation allows the testing, first, of the so-called traditional hypothesis or basic axiom of the structure-conduct-performance paradigm according to which the existence of profits is associated with a higher level of concentration in the market, since it favours collusion agreements among the firms in the market, so that they share out the profits (Bain, 1951). This hypothesis would be confirmed if coefficients $\alpha_1=0$ and $\alpha_2>0$ are obtained in equation (3).

On the other hand, the efficient structure hypothesis affirms that the most efficient firms, with better organisation and management of their resources, are more profitable, gain market share, and consequently the concentration of the market increases (Demsetz, 1974). Thus, the positive relationship between profitability and market concentration is due to greater efficiency in production, and therefore this relationship is spurious: it is efficiency which leads to higher profitability and concentration. Equation (3) enables this hypothesis to be analysed through the significance of the parameter that accompanies the variable that represents market share (*MS*). Specifically, this hypothesis is fulfilled if coefficients $\alpha_1>0$ and $\alpha_2=0$ are obtained.

The studies that test the two alternative hypotheses introduce the market share variable as explanatory of profitability, generally obtaining a positive significant coefficient for this variable, which is interpreted as non-rejection of the efficient structure hypothesis (Smirlock et al., 1984 and 1986; Smirlock, 1985, among others). However, as we pointed out in the introduction, this conclusion depends on the assumption that market share is a suitable proxy for efficiency, and not on other variables such as market power, product differentiation, etc (Shepherd, 1986).

Indeed, as shown by Berger (1995), one theory related to the structure-conduct-performance hypothesis is the relative market power hypothesis, which affirms that only firms with high market shares and differentiated products are capable of exercising market power in the setting of prices, consequently gaining profits higher than normal (Shepherd, 1982)

One solution to the problem would be simply to include in the estimation a direct measurement of efficiency. Timme and Yang (1991) and Berger (1995) carry out a set of tests that incorporate efficiency directly into the model in order to avoid the problems commented on earlier. In particular, we can distinguish several hypotheses based on estimating the following model:

$$PCM_i = \alpha_0 + \alpha_1 MS_i + \alpha_2 CR_j + \alpha_3 EF_i + \varepsilon_i \qquad [4]$$

where EF is a direct measurement of the efficiency of each firm.

According to the pure efficient structure hypothesis the most efficient firms will have lower costs and therefore higher profits, and in this way they gain market share, consequently increasing concentration. Nevertheless, although it is efficiency that leads to a higher market share and concentration, these latter should not bear any relationship to profitability once efficiency has been introduced into the estimation. Thus, according to the hypothesis of efficient structure, the expected signs of the relationship are as follows: EF>0, CR=0, MS=0.

Observe that the efficient structure hypothesis further requires that efficiency leads to a higher market share and greater market concentration. That is to say, that an additional necessary condition for sustaining this hypothesis is that efficiency be an explanatory variable of market share and concentration, and that they be positively correlated.

On the other side, the pure traditional hypothesis requires that the concentration should be the variable that explains profitability, affecting it positively. Thus, the signs that support this hypothesis are CR>0, MS=0, EF=0.

What the relative market power hypothesis postulates is that the moving force of profitability is market share (MS>0, CR=0, EF=0). The difference between the traditional structure-conduct-performance hypothesis and the market power hypothesis is that, according to the latter, the advantages deriving from size may exist even in unconcentrated markets.

Consistent with the contributions of Shepherd (1986), the modified efficient structure hypothesis affirms that the variations in profitability are explained by efficiency and by the residual influence of market share as a consequence of factors such as differentiation of the product and market power. Like the pure efficient structure hypothesis, the modified efficient structure hypothesis affirms that concentration does not directly affect profitability since variations in concentration are explained by the greater efficiency that leads to greater shares in the market. In other words, concentration should not have a positive relationship to profitability once the effects of efficiency and of the residual influence of the market share are included in the estimation. Thus, this hypothesis is consistent with the following signs: EF>0, MS>0, CR=0.

Lastly, following Schmalensee (1987), the hybrid collusion-efficiency hypothesis establishes that efficiency determines profits (EF>0), concentration favours collusion (CR>0), and the influence of market share is residual (MS=0). This residual effect derives from the assumption that any systematic variations of profitability other than that already explained by differences in concentration are related to the differences in efficiency which will already incorporate the impact of market share on profitability.

Control variables

The introduction only of market share, concentration and efficiency as explanatory variables of profitability may give rise to an omitted-variable bias given the possible existence of other variables that explain profitability. These variables are specific to firms or to the markets in which they operate.

It is usual in this type of models to assume that there are constant returns to scale, so that empirically it is possible to proxy the price cost margin by the value of production minus variable costs divided by the value of production. However, as pointed out by Schmalensee (1989) this specification omits capital costs. The traditional solution to this problem is to introduce capital intensity as a further explanatory variable (KI).

Other control variables are also included in the regression so as not to ignore the differences occurring among firms and the sectors in which they work. For the differences among firms, we introduce variables that quantify the entrance barriers associated with advertising intensity (ADV) and the innovation effort made by the firm (R&D), while for the differences among markets we introduce the variables that control for the demand conditions of the market in which the firm operates (stable, expanding or receding market) (STA, EXP, REC) and the possible existence of entrance barriers associated with the minimum efficient size of firms (NCOMP1, NCOMP2).

The advertising effort made by a firm is considered to be an entrance barrier, or production cost to be incurred by a firm that aims to enter an industry but not borne by the firms already installed. It is understood that a higher relative advertising expenditure implies greater differentiation of the product manufactured, and that inelasticity of the cross-price demand curve faced by the firm is greater in this case, so the firm may obtain higher profits per unit of production.

Likewise, in order to test the effects of technological innovation on the price cost margin of the firm, this variable is introduced into equation (4). Product innovations will influence through demand advantages while process innovations will decrease the relative costs of firms, both aspects influencing firms' market share.

We also control for the effects exercised by economic opportunities on the profitability of firms. It is to be expected that those firms that operate in expanding or stable markets will have more economic opportunities than those in markets with receding demand, and therefore, that the profits of the former will be more favoured than those of the latter.

Finally, it is well known that the presence of barriers to the entrance of new competitors reduces the chances of survival of a firm in the market. For this reason, it is necessary to consider the possible effect of these entrance barriers on the profits of firms.

Therefore, the equation to be estimated is as follows:

$$PCM_i = \alpha_0 + \alpha_1 MS_i + \alpha_2 CR_j + \alpha_3 EF_i + \alpha_4 KI_i + \alpha_5 ADV_i + \alpha_6 R + D_i + \alpha_7 STA_i + \alpha_8 REC_i + \alpha_9 NCOMP1_i + \alpha_{10} NCOMP2_i + \varepsilon_i \quad [5]$$

From the estimation of equation (5), the signs of the estimated parameters of the variables CR, MS and EF that support the different hypothesis explaining the relationship between profitability and market structure set out above are as follows:

$$\frac{\partial PCM}{\partial CR} = 0;\ \frac{\partial PCM}{\partial MS} = 0;\ \frac{\partial PMC}{\partial EF} > 0\ ;\ pure\text{-}efficient\text{-}structure \quad [6]$$

$$\frac{\partial PCM}{\partial CR} > 0;\ \frac{\partial PCM}{\partial MS} = 0;\ \frac{\partial PCM}{\partial EF} = 0\ ;\ Structure\text{-}conduct\text{-}performance \quad [7]$$

$$\frac{\partial PCM}{\partial CR} = 0;\ \frac{\partial PCM}{\partial MS} > 0;\ \frac{\partial PCM}{\partial EF} = 0 \quad market\text{-}power \quad [8]$$

$$\frac{\partial PCM}{\partial CR} = 0;\ \frac{\partial PCM}{\partial MS} > 0;\ \frac{\partial PCM}{\partial EF} > 0\ ;\ modified\text{-}efficient\text{-}stucture \quad [9]$$

$$\frac{\partial PCM}{\partial CR} = 0;\ \frac{\partial PCM}{\partial MS} > 0;\ \frac{\partial PCM}{\partial EF} > 0\ ;\ hybrid\text{-}collusion\text{-}hypothesis \quad [10]$$

3. THE MEASUREMENT OF EFFICIENCY

The so-called frontier techniques obtain direct indicators of efficiency by comparing the result obtained by an economic agent with the best possible practice of a firm or firms situated on the reference frontier.

The efficient use of productive factors requires the maximisation of production given the quantity of inputs used, or in other words, that every economic agent should be at the frontier of production. Thus, the efficiency of each firm is the quotient between the production observed and the maximum possible at the frontier.

Economic - or cost - efficiency is formed by two components: technical efficiency and allocative efficiency. The latter implies minimising the costs of producing a certain volume of production at given input prices, which implies choosing that combination of factors that will minimise costs. Nevertheless, in this study we centre our attention exclusively on technical efficiency due to the lack of information regarding capital costs, which is necessary for calculating the price of inputs.

The estimation of efficiency can be done by different methods. Imposing or not imposing a given functional form on the reference frontier distinguishes between parametric or non-parametric methods. Calculating the frontier or estimating it distinguishes between linear programming methods or econometric methods. Allowing or not allowing the existence of a random error term distinguishes between stochastic or deterministic approaches.

Of the range of methods available, the ideal one is (i) non-parametric, so as not to impose an inappropriate functional form, and (ii) stochastic, in order to allow the existence of a random component other than efficiency. The problem at this time is the absence of a method that meets both requirements at once.

Consequently, the method that we will use in this study is a parametric and stochastic method, because we prefer to take into account a random error term so as not to obtain upwardly biased measurements of efficiency, even at the cost of having to impose a given functional form on the data.

The stochastic production frontier model was proposed simultaneously by Aigner et al. (1977) and Meeusen et al. (1977). In this model, production is assumed to be limited at its maximum by the stochastic production function:

$$Y_i \leq X_i'\beta + \varepsilon_i \qquad \varepsilon_i = v_i - u_i \qquad [11]$$

Thus, the composed error term (ε_i) has two parts: a term that reflects the influence of random factors, i.e. factors beyond the firm's control (v_i) and another term that reflects technical inefficiency (u_i). In order to separate these two components it is necessary to impose a given asymmetrical distribution on the inefficiency term, semi-normal distribution being the one most frequently used.

Nevertheless, when a panel of data is available, efficiency can be estimated by using the standard fixed and random effects models, assuming that efficiency is constant over time. The advantage of using these models is that it is not necessary to make assumptions about the functional distribution of the efficiency term, at the cost of assuming that efficiency is constant over time[1]. In the fixed effects model, inefficiency is treated as a constant specific to each individual - fixed effect - the model being estimated by OLS or using intra-group transformation if the number of observations is very large. The assumption made is that the firm with the highest fixed effect (α_i^{max}) is the most efficient in the sample, the efficiency of each firm being estimated as the distance between the fixed effects and the maximum:

$$\begin{aligned} Y_{it} &= \alpha_i + X'_{it}\beta + v_{it} \\ EF_i &= \exp[-(\alpha_i^{\max} - \alpha_i)] \end{aligned} \qquad [12]$$

The main attraction of the fixed effects model is that it is not necessary to assume the absence of correlation between inefficiency and the regressors. However, as Simar (1992) points out, the use of the fixed effects model for the analysis of efficiency presents several disadvantages: 1) it is not possible to estimate the effect of variables that do not vary over time; 2) if the explanatory variables present only slight variation over time, there may be a problem of multicolinearity. Also, as pointed out by Simar (1992), the fixed effects model does not take into account the stochastic nature of efficiency. Indeed, some studies (Simar (1992), Gathon and Perelman (1992), Bauer and Hancock (1993), Berger (1993), etc.) show that the fixed effects model provides estimates of efficiency of very little credibility (reduced values of the efficiency).

The random effects model takes into account the stochastic nature of inefficiencies. Estimation of the model by GLS presents the problem that the estimator is consistent only when the regressors are not correlated with the compound error term. If this is not the case, it is necessary to estimate the model using instrumental variables. So, on the assumption of orthogonality between regressors and inefficiency, the latter is estimated as the distance between the average residual of each firm and the maximum average residual,

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[1] This assumption is credible with short time panels as in the case of this study (1991-94)

$$\hat{\varepsilon}_i = \frac{1}{T}\sum_{t=1}^{T}\hat{\varepsilon}_{it}$$
$$EF_i = \exp\left[-\left(\hat{\varepsilon}_i^{\max} - \hat{\varepsilon}_i\right)\right] \qquad [13]$$

where ε_{it} are the residuals of the estimation of the random effects model by GLS.

4. VARIABLES AND SAMPLE USED

In order to test the different hypotheses put forward above using a direct measurement of efficiency, we used the data for 851 Spanish industrial firms gathered in the Survey of Business Strategies for the period 1991 to 1994. From the original sample available in the Survey, some firms were eliminated on the basis of the following criteria: a) firms whose data are not available for the four years necessary to be able to apply panel techniques; b) firms whose price cost margin or value added was not positive; and c) firms for which there is no information on some of the variables necessary for estimating the frontier function - capital and labour.

The variables used are:

a) Price-cost margin (PCM): this is proxied by the gross income, defined as the sum of sales, stock variation and other current income, minus purchases (after deducting stock variation), outside services and personnel costs (gross wages and salaries, insurance and pension contributions and other personnel costs), expressed as a percentage of the total sum of sales, stock variation and other current income.

b) Efficiency (EF): the following variables were used to determine this variable:

b.1) Value added (Y). Defined as the value represented by the sum of sales, stock variation and other management income minus purchases and outside services. Value added is expressed in constant 1990 pesetas and has been deflated by the Industrial Price Index of the National Statistical Institute for the 18 sectors to two digits composing the Survey of Business Strategies.

b.2) Volume of employment (L). The number of workers operating in the firm.

b.3) Physical capital (K). Defined, following Merino and Salas (1995) as the value of fixed assets except land and buildings. Capital is expressed in constant

1990 pesetas and has been deflated by the capital goods deflator provided by the National Statistical Institute.

c) Concentration (CR) is defined as the percentage of sales represented by the four largest firms within the main market in which the firms compete. The degree of response to the concentration variable in the Survey of Business Strategies is low, and for this reason we have made an estimation of the variable for those firms that do not respond. Following Huergo (1998a) and Fariñas and Huergo (1994) the markets in which these firms that do not respond operate were identified taking into account the 3 digit sector to which they belong, the geographical level at which they operate (local, regional, national, ...) and the number of competitors that they claim to have in their own sector. Once the markets have been identified, we allocate to them the average value of concentration derived from operating with the responses of firms working in the same market.

d) The market share (MS): the sales of the firm as a percentage of the main market in which it operates.

e) The evolution of the market in which the firm operates, proxied by the growth of demand. It is quantified by two dummy variables representing respectively whether the firm perceives the potential market in which it carries out its activity as being in a situation of recession (REC) or stability (STA), the reference category being the expanding market (EXP).

f) The intensity of technological innovation of a firm (R&D) is measured by the ratio of R&D expenditure to the sales of the firm, representing in this way the effort in technical change made by each organisation.

g) The advertising effort made by each firm (ADV) is measured by the ratio of advertising costs to the sales of the firm.

h) The existence of barriers to the entrance of new competitors associated with the minimum efficient size of firm is accounted by the number of competitors that have an optimum size in the 2 digit sector or market. The Survey of Business Strategies offers the information necessary as the firms interviewed indicate whether they have competitors with significant market shares, and how many. Specifically, the following dummy variables are used as explanatory variables: NCOMP1 to denote that the firm considers itself to have more than 25 competitors in its sector with a significant market share, and NCOMP2 if there are between 10 and 25, the reference category being the existence of 10 or fewer competitors with a significant market share.

Finally, following Huergo (1998b), capital intensity is proxied by means of the capital/sales ratio (KI).

5. RESULTS

As we commented above, the absence of information about the cost of capital prevents us from calculating the price of this input, and consequently economic efficiency based on the estimation of cost functions. For this reason, the direct measurement of efficiency used here is technical efficiency, a more restricted concept than economic efficiency[2].

The estimation of the technical efficiency of each firm is done by estimating production functions of the Cobb-Douglas type, because of their advantages in terms of the small number of parameters to be estimated. In order to take into account the heterogeneity among sectors of activity within Spanish industry, frontier production functions were estimated at sector level, the number of sectors considered being 18. The sectors considered, and the number of firms in each sector, appear in table 1.

In particular, the specification of the production function used in each sector is as follows:

$$\text{Ln}\, Y_{it} = \beta_l \,\text{Ln}\, L_{it} + \beta_k \,\text{Ln}\, K_{it} + \gamma t + \alpha_i + v_{it}$$

where Y is the value added, L employment, K the capital stock, and t a trend capturing the effect of exogenous technical progress.

The frontier production functions were estimated by the three panel data procedures commented on in section 4 (fixed effects model, random effects model, and stochastic frontier approach). However, table 2 does not offer the results corresponding to the stochastic frontier approach because in several sectors the skewness of the residuals is incompatible with the production function.

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[2]Nevertheless, the empirical evidence available shows that the greater part of economic efficiency is of the technical type, allocative efficiency being of very little quantitative importance.

Table 1:. Activity sectors

	Activity sector	*Num. Firms*
1	Ferrous and non-ferrous metals	18
2	Non metallic mineral products	61
3	Chemical products	83
4	Metal products	73
5	Agricultural and industrial machinery	35
6	Office and data processing machinery	7
7	Electrical goods	82
8	Motor vehicles	35
9	Other transport equipment	11
10	Meats, meat preparation	29
11	Food products and tobacco	103
12	Beverages	32
13	Textiles and clothing	83
14	Leather, leather and skin goods	24
15	Timber, wooden products	40
16	Paper and printing products	63
17	Rubber and plastic products	55
18	Other manufacturing products	17

The first point to underline is the low levels of efficiency in the fixed effects model. Thus, observe how the maximum average level of efficiency does not even reach 40% (sector 17), with average levels below 20% in most sectors. These levels, too low to be credible, cause us to doubt the reliability of the fixed effects model, this phenomenon being common to other studies. As pointed out by Simar (1992), this result may be because the fixed effects model does not take into account the stochastic nature of inefficiency, capturing as such factors that are different from the inefficiency. Furthermore, as noted by Berger (1993 and 1995), the fixed effects model tends to confuse differences in size with differences in efficiency, the results being less reasonable the greater the differences of size among firms.

Concentrating on the random effects model, there are substantial differences among sectors in the level of efficiency, though it is important to warn that when estimating separate frontiers for each sector, the sector levels of efficiency are not directly comparable with each other. The maximum average efficiency occurs in sector 6, "office machinery, data processing, precision instruments, optics and similar" with 0.93. At the opposite extreme stands sector 11, "Food products and tobacco" with an efficiency of 0.458. In general the average values of efficiency are around 75%, this magnitude being similar to that obtained in Gumbau (1998).

Before commenting on the inter-sector results of the testing of the various hypotheses explaining profitability set out above, it is of interest to analyse the correlation between profitability and concentration. Thus, using average sector values of these variables, a statistically significant positive correlation is obtained between price cost margin and concentration (the coefficient of regression is 0.12 with a t-ratio of 2.48).

At intra-industry level, table 3 captures the results of the estimation of equation (3) and the results of introducing in succession the variables explaining profitability. From the reading of all the results the following can be deduced:

1. When only concentration is included in the estimation as explanatory variable of profitability, a statistically significant positive coefficient is obtained only in two sectors (sectors 6 and 8), the ratio being negative and significant in six sectors (sectors 3, 4, 12, 15, 16 and 17). Consequently, the positive result obtained with inter-industry data hides enormous intra-sector differences, there being no evidence in favour of the collusion hypothesis.

2. When the market share is also introduced into the estimation, this variable has a significant positive effect in eight sectors (1, 3, 4, 8, 10, 11, 12 and 16), the ratio not being significant in other sectors. The introduction of the market share does not affect the estimated parameter associated with concentration.

Table 2 : Technical efficiency. Descriptive statistics

	Random Effects Model				*Fixed Effects Model*			
Sector	**Mean**	**Std. Dev.**	**Max.**	**Min**	**Mean**	**Std. Dev.**	**Max**	**Min**
1	0.789	0.012	1	0.626	0.175	0.250	1	0.048
2	0.770	0.088	1	0.645	0.169	0.182	1	0.063
3	0.746	0.083	1	0.580	0.288	0.233	1	0.083
4	0.685	0.077	1	0.527	0.284	0.118	1	0.126
5	0.809	0.071	1	0.704	0.133	0.260	1	0.046
6	0.930	0.069	1	0.7798	0.269	0.271	1	0.113
7	0.793	0.081	1	0.630	0.091	0.206	1	0.021
8	0.727	0.071	1	0.610	0.122	0.164	1	0.021
9	0.752	0.101	1	0.626	0.153	0.326	1	0.080
10	0.724	0.093	1	0.569	0.280	0.198	1	0.163
11	0.458	0.077	1	0.348	0.002	0.099	1	0.001
12	0.775	0.086	1	0.591	0.121	0.228	1	0.022
13	0.678	0.078	1	0.515	0.110	0.199	1	0.019
14	0.726	0.120	1	0.530	0.025	0.201	1	0.008
15	0.694	0.102	1	0.541	0.049	0.187	1	0.021
16	0.695	0.077	1	0.611	0.102	0.190	1	0.041
17	0.807	0.090	1	0.627	0.368	0.206	1	0.188
18	0.811	0.095	1	0.644	0.267	0.278	1	0.106

Table 3 : Determinants of price-cost margin

	Sector 1 (nobs. 72)				*Sector 2 (Nobs. 244)*			
const.	0.173 (6.510)	0.131 (4.295)	-0.065 (-0.783)	-0.057 (-0.661)	0.187 (15.481)	0.189 (13.866)	-0.258 (-4.794)	-0.180 (-3.223)
CR	-0.415E-03 (-0.849)	-0.252E-03 (-0.530)	-0.245E-03 (-0.536)	0.532E-04 (0.114)	-0.244E-03 (-1.056)	-0.267E-03 (-1.143)	0.161E-04 (0.077)	-0.410E-04 (-0.199)
MS		0.119E-02 (2.566)	0.108E-02 (2.410)	0.791E-03 (1.391)		-0.163E-03 (-0.682)	-0.602E-03 (-2.278)	-0.684E-03 (-3.032)
EF			0.251 (2.514)	0.189 (1.812)			0.570 (5.515)	0.464 (6.734)
R&D				5.199 (1.913)				0.090 (0.286)
ADV				3.343 (0.934)				0.050 (0.180)
REC				0.043 (1.329)				-0.038 (-2.655)
STA				-0.185E-02 (-0.062)				-0.066 (-4.441)
NCOMP1				0.510E-03 (0.012)				-0.625E-03 (-0.045)
NCOMP2				-0.086 (-1.149)				0.628E-02 (0.313)
KI				0.396E-02 (0.097)				0.074 (5.488)
R2 Adj.	0.003	0.058	0.137	0.18	0.004	0.001	0.227	0.342

Table 3 : Determinants of price-cost margin (continuation)

	Sector 3 (nobs. 332)				***Sector 4 (nobs. 292)***			
const.	0.153 (16.504)	0.146 (15.471)	-0.251 (-6.040)	-0.308 (-6.891)	0.162 (16.189)	0.152 (14.394)	0.143 (-2.660)	-0.150 (-2.726)
CR	-0.733E-03 (-3.480)	-0.795E-03 (-3.806)	-0.383E-03 (-2.046)	-0.663E-03 (-3.202)	-0.452E-03 (-1.859)	-0.486E-03 (-2.024)	-03642E-03 (-2.660)	-0260E-03 (-1.152)
MS		0.719E-03 (3.059)	0.753E-03 (3.633)	0.423E-03 (1.911)		0.784E-03 (2.897)	0.547E-03 (2.095)	0.558E-03 (2.168)
EF			0.502 (9.749)	0.570 (10.537)			0.426 (5.592)	0.441 (5.893)
R&D				0.058 (0.446)				-0.916 (-1.515)
ADV				-0.067 (-0.806)				-0.380 (-1.268)
REC				0.611E-02 (0.630)				-0.010 (-0.748)
STA				0.980E-02 (0.819)				-0.025 (-1.703)
NCOMP1				-0.012 (-1.227)				-0.260E-02 (-0.158)
NCOMP2				-0.016 (-1.325)				-0.025E-02 (-1.508)
KI				0.056 (4.429)				0.040 (1.873)
R2 Adj.	0.03	0.056	0.266	0.313	0.11	0.055	0.124	0.148

Table 3 : Determinants of price-cost margin (continuation)

	Sector 5 (nobs. 140)				*Sector 6 (nobs. 28)*			
const.	0.130 (10.959)	0.139 (10.553)	-0.086 (-1.026)	-0.091 (-0.990)	0.081 (3.207)	0.081 (2.937)	0.133 (0.869)	0.789 (0.608)
CR	-0.986E-04 (-0.396)	-0.126E-03 (-0.510)	-0.135E-03 (-0.557)	-0.464E-04 (-0.184)	0.117E-02 (1.961)	0.115E-02 (1.802)	0.113E-02 (1.733)	-0.703E-03 (-0.416)
MS		-0.414E-03 (-1.569)	-0.794E-03 (-2.703)	-0.743E-03 (-2.398)		0.613-04 (0.090)	0.613E-04 (0.088)	0.337E-03 (0.186)
EF			0.283 (2.717)	0.287 (2.636)			-0.056 (-0.347)	-0.644 (-0.457)
R&D				-0.070 (-0.120)				-1.247 (-0.863)
ADV				-0.767 (-1.073)				-0.300 (-0.863)
REC				0.014 (0.794)				0.025 (0.554)
STA				-0.015 (-0.878)				0.012 (0.255)
NCOMP1				-0.015 (-0.832)				-0.023 (-0.337)
NCOMP2				0.015 (0.464)				0.068 (0.750)
KI				0.021 (0.808)				-0.125 (-0.716)
R2 Adj.	0	0.004	0.047	0.05	0.053	0.059	0.025	0.012

Table 3 : Determinants of price-cost margin (continuation)

	Sector 7 (nobs.328)				***Sector 8 (nobs. 140)***			
const.	0.134 (13.248)	0.132 (12.145)	-0.116 (-2.442)	-0.139 (-2.837)	0.108 (7.427)	0.083 (4.953)	-0.022 (-0.331)	0.030 (0.415)
CR	-0.161E-04 (-0.788)	-0.161E-03 (-0.789)	-0.102E-03 (-0.522)	-0.141E-03 (-0.033)	0.585E-03 (1.959)	0.783E-03 (2.610)	0.697E-03 (2.300)	0.589E-03 (1.920)
MS		0.114E-03 (0.533)	-0.810E-04 (-0.387)	-0.286E-03 (-1.342)		0.647-03 (2.791)	0.488E-03 (1.953)	0.437E-03 (1.724)
EF			0.309 (5.354)	0.360 (6.173)			1.547 (1.646)	0.109 (1.114)
R&D				0.297 (1.413)				-0.805 (-2.449)
ADV				-0.531 (-2.124)				-0.724 (-2.523)
REC				-0.021 (-1.875)				0.033 (2.041)
STA				-0.047 (-4.083)				-0.996E-02 (-0.640)
NCOMP1				-0.404E-02 (-0.240)				-0.045 (-2.426)
NCOMP2				-0.026 (-1.747)				0.539E-02 (0.221)
KI				0.077 (3.365)				0.226E-02 (0.123)
R2 Adj.	0	0.002	0.075	0.154	0.02	0.079	0.097	0.155

Table 3 : Determinants of price-cost margin (continuation)

	Sector 9 (Nobs. 44)				*Sector 10 (Nobs. 116)*			
const.	0.142 (10.018)	0.142 (8.802)	-0.021 (-0.273)	-0.187 (-1.260)	0.101 (7.505)	0.088 (6.593)	-0.217 (-3.607)	-0.271 (-4.499)
CR	-0.279E-03 (-0.881)	-0.278E-03 (-0.863)	-0.622E-03 (-1.780)	-0.514E-03 (-1.577)	-0.252E-03 (-0.649)	-0.438E-03 (-1.170)	0.125E-03 (-0.366)	-0.150E-03 (-0.467)
MS		0.971E-05 (0.029)	-0.227E-03 (-0.671)	-0.113E-02 (-2.372)		0.123-E02 (3.475)	0.700E-03 (2.077)	0.228E-03 (0.682)
EF			0.237 (2.114)	0.458. (2.119)			0.413 (5.179)	0.476 (5.912)
R&D				1.628 (2.410)				0.539 (0.218)
ADV				-2.325 (-2.586)				-0.302 (-1.305)
REC				0.601E-02 (0.184)				-0.038 (-2.305)
STA				0.024 (0.742)				-0.841E-02 (-0.353)
NCOMP1				-0.059 (-1.410)				0.695E-02 (0.365)
NCOMP2				-0.000 (-0.000				0.012 (0.429)
KI				0.051 (0.901)				0.194 (5.603)
R2 Adj.	0.018	0.018	0.05	0.274	0	0.003	0.254	0.416

Table 3 : Determinants of price-cost margin (continuation)

	Sector 11 (Nobs. 412)				*Sector 12 (Nobs. 128)*			
const.	0.134 (15.084)	0.119 (12.706)	-0.115 (-3.871)	-0.168 (-5.024)	0.256 (8.539)	0.219 (6.472)	-0.487 (-5.435)	-0.639 (-6.341)
CR	0.240E-05 (0.011)	-0.347-05 (-0.017)	-0.147E-03 (-0.787)	-0.223E-03 (-1.142)	-0.105E-02 (-1.947)	-0.953E-03 (-1.787)	-0.326E-02 (-0.746)	-0.377E-03 (-0.852)
MS		0.915E-03 (4.336)	-0.427E-03 (-2.082)	0.491E-03 (2.263)		0.100-E02 (2.253)	0.894E-03 (2.467)	0.998E-02 (2.594)
EF			0.511 (8.255)	0.596 (9.133)			0.842 (8.273)	0.952 (8.614)
R&D				0.333 (0.279)				0.453 (1.412)
ADV				-0.212 (-1.914)				-0.172 (-0.889)
REC				0.435E-02 (0.374)				0.042 (1.810)
STA				0.584E-02 (0.411)				0.033 (1.316)
NCOMP1				-0.372E-02 (-0.212)				0.050 (1.835)
NCOMP2				0.019 (1.180)				-0.902E-02 (-0.203)
KI				0.046 (2.746)				0.795 (2.953)
R2 Adj.	0	0.043	0.18	0.206	0.021	0.051	0.383	0.445

Table 3 : Determinants of price-cost margin (continuation)

	Sector 13 (Nobs. 332)				***Sector 14 (Nobs. 96)***			
const.	0.130 (19.630)	0.131 (19.579)	-0.059 (-1.527)	-0.084 (-2.013)	0.125 (10.103)	0.125 (10.048)	-0.069 (-1.189)	0.037 (0.471)
CR	-0.209E-04 (-1.066)	-0.145E-03 (-0.714)	-0.227E-03 (-1.149)	-0.196E-03 (-0.952)	0.2107E-03 (0.424)	0.276-03 (0.527)	0.220E-02 (0.447)	0.772E-04 (0.129)
MS		-0.345E-03 (-1.093)	-0.277E-03 (-0.908)	-0.188E-03 (-0.594)		-0.278-03 (-0.401)	-0.351E-03 (-0.533)	-0.262E-03 (-0.349)
EF			0.282 (4.975)	0.278 (4.650)			0.264 (3.411)	0.189 (2.180)
R&D				0.164 (0.616)				0.051 (0.114)
ADV				0.827 (2.961)				-3.148 (-1.599)
REC				0.420E-02 (0.319)				-0.059 (-2.128)
STA				-0.734E-02 (-0.552)				-0.072 (-2.362)
NCOMP1				0.036 (2.734)				0.031 (0.897)
NCOMP2				0.017 (1.246)				0.010 (0.407)
KI				0.027 (2.306)				0.064 (0.675)
R2 Adj.	0	0.001	0.068	0.11	0.053	0.001	0.115	99

Table 3 : Determinants of price-cost margin (continuation)

	Sector 15 (nobs. 160)				*Sector 16 (Nobs. 252)*			
const.	0.136 (13.411)	0.138 (13.216)	0.079 (1.425)	-0.034 (-0.516)	0.184 (15.083)	0.164 (12.667)	-0.253 (-4.054)	-0.321 (-4.377)
CR	-0.714E-03 (-1.962)	-0.645E-03 (-1.740)	-0.668E-03 (-1.799)	-0.729E-03 (-1.832)	-0.847E-02 (-2.834)	-0.728E-03 (-2.479)	-0.440E-03 (-1.609)	-0.548E-03 (-1.968)
MS		-0.847E-03 (-0.944)	-0.925E-03 (-1.028)	-0.124E-02 (-1.376)		0.104-02 (3.361)	0.654E-03 (2.405)	0.831E-03 (2.900)
EF			0.084 (1.074)	0.204 (2.434)			0.586 (6.815)	0.666 (7.162)
R&D				-1.054 (-1.116)				0.983 (1.872)
ADV				-0.423 (-0.814)				-1.110 (-2.941)
REC				0.029 (1.289)				0.306E-02 (0.182)
STA				-0.0132 (-0.537)				-0.534E-02 (-0.302)
NCOMP1				0.021 (1.031)				0.034 (2.086)
NCOMP2				-0.158E-03 (-0.005)				0.615E-02 (0.291)
KI				0.092 (2.720)				0.031 (1.238)
R2 Aj.	0.017	0.016	0.047	0.061	0.027	0.079	0.215	0.25

Table 3 : Determinants of price-cost margin (continuation)

	Sector 17 (Nobs. 220)				*Sector 18 (Nobs. 68)*			
const.	0.163 (15.877)	0.162 (14.931)	0.623E-02 (0.116)	0.229E-03 (0.004)	0.134 (7.975)	0.135 (7.799)	0.090 (0.840)	0.056 (0.418)
CR	-0.518E-03 (-2.134)	-0.524E-03 (-2.150)	-05055E-03 (-2.110)	-0.584E-03 (-2.661)	0.423E-03 (0.800)	0.459E-03 (0.846)	0.437E-03 (0.797)	0.786E-02 (1.217)
MS		0.861E-04 (0.335)	-0.529E-04 (-0.206)	0.173E-03 (0.699)		-0.182-03 (-0.352)	-0214E-03 (-0.406)	-0.588E-03 (-0.888)
EF			0.194 (2.988)	0.194 (3.231)			0.057 (0.430)	0.036 (0.225)
R&D				0.533 (0.961)				0.785 (0.279)
ADV				-0.037 (-0.177)				-0.219 (-0.525)
REC				0.752E-02 (0.591)				0.060 (1.391)
STA				-0.016 (-1.302)				0.059 (1.241)
NCOMP1				0.028 (1.804)				0.055 (0.822)
NCOMP2				0.035 (1.805)				0.000 (0.011)
KI				-0.014 (-0.547)				-0.936E-02 (-0.137)
R2 Adj.	0.015	0.011	0.046	0.081	0	0	0.001	0.001

3. The introduction of efficiency as a further explanatory variable raises considerably the goodness of fit of the regression (R2 adjusted), which shows its high explanatory power. Indeed, efficiency positively and significantly affects the price cost margin in all sectors except numbers 6, 15 and 18.

4. When the direct measurement of efficiency has been incorporated, it is important to point out that the market share maintains its sign and its significance. This result shows the importance of market power in explaining profitability. As pointed out by Berger (1995), the fact that the coefficient accompanying the variable MS maintains its sign and significance when efficiency is introduced into the estimation suggests that in the earlier regressions where this effect is not introduced, the variable MS must not be interpreted as a proxy of efficiency, but as capturing the effect of factors other than efficiency such as market power.

5. The introduction of the control variables in general maintains the above results. More specifically: concentration is only significant in five sectors (3, 8, 15, 16 and 17), and positively affects profitability only in sector 8; the market share has a significant positive effect in 45% of the sectors, negatively affecting two sectors (2 and 5); efficiency affects profitability positively in nearly all the sectors considered, the ratio being significant in 66% of cases. The control variables considered – research expenditure (R&D), advertising (ADV), type of market (STA and REC) and minimum efficient size (NCOMP1 and NCOMP2) – have a significant effect on very few occasions, the sign of the ratio being in general as expected except in variable ADV which presents a significant negative sign in six sectors.

From the above results the hypothesis of collusion in Spanish industry can clearly be rejected, since although efficiency does contribute positively to explaining differences in profitability, the market share also has a positive effect. Thus, in many cases the evidence obtained is favourable to the modified efficient structure hypothesis, efficiency and market power being the explanatory variables of profitability[3]. Finally, another result is the importance of efficiency in explaining the differences of profitability among firms of a sector, this result coinciding with that obtained in those studies that use direct measurements of efficiency (Berger, 1995; Goldberg and Rai, 1996; and Maudos, 1998a and b).

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[3]Recently, Huergo (1998b) finds for a sample of firms from 14 Spanish manufacturing sectors during the period 1983-90 results that support the existence of market power in nine of the sectors analysed. Using the Survey of Business Strategies at aggregate level, Gracia (1999) finds a significant role for the market share in determining the price cost margin of Spanish industry.

Finally, we have to examine whether the other necessary condition for the efficiency hypothesis is met, i.e. that efficiency positively affects the structure of the market, both concentration and market share. As in Berger (1995), when we regress concentration and market share against efficiency, the latter presents a positive effect – though significant only in some sectors – so the empirical results indicate some limited support for the modified efficient structure hypothesis. Furthermore, the low explanatory power of efficiency over the market share also shows how unsuitable it is to use the latter as proxy for the former, as is done in other studies.

6. CONCLUSIONS

This study carries out a test of the different hypotheses explaining the relationship between profitability and market structure in Spanish industry, its principal contribution being the use of a direct measurement of efficiency obtained by application of frontier techniques.

Using the information provided by the Ministry of Industry and Energy´s Survey of Business Strategies for the period 1991-94, the study obtains efficiency values in the 18 sectors of activity into which the sample was divided by estimating sector production frontier functions. The results show the existence of average efficiency levels of 75%, although there are substantial differences between sectors.

These results are the basis for testing the different hypotheses explaining profitability in the generic framework of the hypotheses of collusion versus efficiency. Thus, the price cost margin of each firm is explained by the concentration of the market in which it operates, by its market share, by its level of efficiency, as well as by a set of control variables (innovating effort, advertising expenditure, capital intensity, etc.).

The results at the level of each sector allow us to reject the traditional structure-conduct-performance paradigm given that concentration does not positively affect profitability. Also, the evidence obtained implies rejection of the pure efficiency hypothesis given that the magnitude and significance of the market share in explaining profitability remains unaltered when the effect of efficiency is introduced into the estimation. In other words, if efficiency were the only variable determining profitability, the market share should cease to be significant in the explanation of profitability, since according to the pure efficiency hypothesis the relationship between profitability and market share is spurious, efficiency being the true explanatory variable. In addition, support for the other necessary condition of the efficiencit structure hypothesis, taht efficienciy is positively related to concentration or market share, is much weaker, so that there is only limited support for the modified efficient structure hypothesis.

The latter result shows the importance of market power in the explanation of profitability, a result which agrees with that recently obtained by Huergo (1998b). As pointed out by Berger (1995), the fact that the coefficient accompanying the variable MS maintains its sign and significance when efficiency is introduced into the estimation, suggests that in earlier regressions where this effect is not introduced, the variable MS should not be interpreted as a proxy of efficiency, but as capturing the effect of factors other than efficiency. Thus, the results show the inappropriateness of using the market share as a proxy variable for efficiency.

To sum up, the evidence obtained clearly allows the rejection of the hypothesis of collusion in Spanish industry, as only in one sector does concentration positively affect profitability. The results also allow the rejection in most cases of the pure efficiency hypothesis, as although efficiency contributes positively to explaining differences in profitability, the market share also has a positive effect. Thus, in many cases the evidence obtained offres alimite support for the modified efficient structure hypothesis. Finally, another outstanding result is the importance of efficiency in explaining the differences in profitability among the firms in a sector, this result agreeing with that obtained in other studies that use direct indicators of efficiency

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