EVALUATING THE OPTIMALITY OF SPANISH INDUSTRY

(1980-1993)

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Abstract

This paper tests whether Spanish industry was able to adjust amounts of input and output to levels considered optimal given their respective prices in each time period. In so doing, we employ the short- and long-run equilibrium models drawn from duality theory, and we apply the resulting optimality tests to the case of Spanish manufacturing industry between 1980 and 1993. The results obtained indicate a degree of divergence in the behaviour of the manufacturers, although this discrepancy progressively diminishes in the period under consideration.

Keywords : Duality theory, short- and long-run, manufacturing industries

1. Introduction

The type of production technology and the market structure that might best characterise the various productive sectors, or the whole economy for that matter, is an issue that has come under close scrutiny in recent years. Most notably, the papers written by Hall (1988) and Caballero and Lyons (1990, 1992) developed a method for analysing the rate of returns to scale and the market structure. This approach has subsequently been applied in a range of fields. In the case of Spain, studies undertaken by Suárez (1992) and Goerlich and Orts (1994, 1996) have analysed the size of the economies of scale and the margins between price and marginal cost in Spanish industry. Their most interesting results point to predominantly constant or slightly increasing returns as well as the existence of margins between price and marginal cost that are slightly above one, when external effects are not included and when the variable used is the gross added value. However, when substituting the added value data with those of production, evidence of a divergence between price and marginal cost is insignificant in many sectors, suggesting that the existence of perfect competition is a reasonable characterisation for Spanish industry. A further possibility that has been proposed (Morrison and Siegel, 1997, 1999) involves estimating the rate of returns and the level of competition by using dual approximation, estimating a system of cost equations. Although they place greater emphasis on the estimation of the effect of public infrastructure, several studies have obtained measures for the returns to scale and the market power for the Spanish economy using this method (Boscá *et al.*, 1999; Moreno *et al.*, 2002). Likewise, albeit from the perspective of microeconomics, Huergo (1998) and Moreno and Delgado (1999) have analysed similar questions using samples of firms. Based on the studies conducted in Spain, it can be concluded that perfect competition would appear to be a reasonable market structure in order to characterise Spanish industry as a whole. Nevertheless, the evidence available also indicates deviations from the optimum that characterises this structure in each of the years under consideration. This might suggest that the firms could not adjust their production levels immediately to the optimum levels when required.

Furthermore, a number of the studies that have tackled these questions have considered capital as a factor that the firms can adjust to optimum quantities at any juncture in time. However, Boscá *et al.* (1999) and Moreno *et al.* (2002) have suggested that this productive factor would have the characteristics of a quasi-fixed input for Spanish industry, in such a way that the firms would only be partially able to adjust their stock to optimum levels in each period. This question is important, not only because of its intrinsic value, but also because of the repercussions that it might have on the specification of the empirical model designed to estimate, for example, production technology and the type of market structure that characterises an economy (Berndt *et al.*, 1980).

Thus, the main aim of this paper is to examine whether, in each period, Spanish manufacturing industry was able to adjust its production and use of factors to those levels that *a posteriori* might be considered optimal, taking into consideration their price, and assuming that perfect competition is a reasonable characterisation of this sector. To do this, we use the approach to production technology from dual theory and we apply the sequence of tests proposed by Conrad and Unger (1987) that allows us to determine statistically if the levels of quasi-fixed inputs and output correspond to the optimum levels in the short- or long-run. The basis for these tests lies in the existence of implicit links between a variable cost function and the equations of the optimum demand factor and the optimum level of output derived from it, so that if these links are empirically met, it can be concluded that the firm optimises its behaviour.

Thus, by estimating a translogarithmic specification for the cost function, we can determine whether Spanish industry has operated in equilibrium in terms of both capital and output, in the period between 1980 and 1993. This period is of particular interest for the analysis conducted here since at the beginning of the eighties Spanish industry underwent major changes as a consequence, in the main, of the important steps taken towards industrial maturity, the increase in the skill levels of the labour, and the economic liberalisation of the previous decades. In fact, the periods of greatest growth – the early sixties and the late eighties – are linked to two historic periods in which Spain opened up to the outside world, namely, the end of the post-war autarchy and entry into the European Community. These moves towards the opening up of foreign trade, together with the exposure to foreign competition that this meant, made it necessary to make the most of the advantages brought by specialisation, which favoured the effectiveness of the productive process and, at the same time, the capacity for growth. Thus, during the eighties, the Spanish economy managed to realign itself with those of the west, placing itself among the European economies with one of the highest growth rates. In this setting, one of the most crucial aspects is the ability of the industry to be competitive, that is, the capacity that the firms of the sector possess to compete with their rivals both at home and abroad (Myro, 1999). A greater exposure to competition means that the divergences of the productive agents, and by extension those of the various manufacturing branches and industry as a whole, as regards optimum production technology, have greater consequences than in a situation characterised by a certain degree of protection.

The results obtained in this study lead us to reject the optimum conditions, although as we shall see the behaviour is not homogenous for the various sectors considered, and neither is its evolution through the period.

This paper is organised as follows. In the second section we describe the theoretical framework and outline the empirical specification for use in determining the optimum behaviour of the productive agents, including a brief description of this method. In the third section we describe the data base used and, more briefly, the main variables used in the analysis. In the fourth section, we determine whether the industrial sector has operated in equilibrium as regards capital and as regards output, examining in which years and in which sectors the most marked deviation from the optimum was recorded. The fifth sector discusses the main conclusions to be drawn.

2. Methodological framework

Let us consider a production technology in which to produce a quantity of output Y, a set of variable productive factors, X, are required – factors which are to be found in their optimal quantities at every moment in time, and a sub-group of quasi-fixed inputs, Z, whose observed values do not necessarily have to coincide with their optimal quantities. If the firm minimises the variable production costs CV in each period, conditioned by the prices of the variable inputs (P) and by the vector of inputs Z, this production technology can be described using the following variable (or restricted) cost function

$$CV = F(Y, P, Z, t) \tag{1}$$

where t denotes a trend, included in the function, to describe variations in the technology not incorporated in the factors. We assume that that the function F is monotonously non-decreasing and concave in P, non-decreasing in Y, and non-increasing and convex in Z. The duality between the production and cost functions (Chambers, 1988) allows us to ensure that the production structure can be represented by a restricted cost function.

In this framework, the optimum demand functions of variable inputs are obtained according to

$$X = F_P(Y, P, Z, t) \tag{2}$$

where the sub-index indicates a partial differentiation of the corresponding function as regards the variable that appears in the sub-index. The associated short-run cost function would be represented by

$$SC = CV(\cdot) + P_z Z' \tag{3}$$

where P_Z is the vector of the prices paid for the quasi-fixed factors, where ' denotes the transposed.

If the preceding functions are defined for the observed levels of Z, their levels of equilibrium, Z*, can be defined by the following condition

$$-F_z(Y, P, Z, t) = P_Z \tag{4}$$

where it can be seen that, in equilibrium, the marginal reduction in variable costs due to increases in Z – the shadow value of Z-, is equal to the price of this input. Thus, the quasi-fixed factors are at their equilibrium levels, Z*, if their shadow price is equal to its market price. Therefore, since

$$Z^* = H(Y, P, P_z, t) \tag{5}$$

the solution to the quality in (4), and by substituting (5) in (3) we obtain the cost function in the long-run, or the function of total costs

$$C = F\left(Y, P, Z^*(\cdot), t\right) + P_Z Z^*(\cdot) = C(Y, P, P_z, t) \qquad (6)$$

The equilibrium model, which recognises the existence of adjustment costs for some of the production factors, so that their quantities do not coincide with the optimal levels in each period, that is, the model based on the specification of a function of variable costs, is known in the literature as the model of equilibrium in the short-run or the model of partial static equilibrium. By contrast, the equilibrium model based on a function of total costs is known as the full static equilibrium model or the model of equilibrium in the long-run. The latter should be understood as a specific case of the general model of partial equilibrium; a model in which the quasi-fixed inputs are to be found at all times in their optimum quantities or in equilibrium. In other words, in the model of partial equilibrium the quasi-fixed factors are not adjusted fully to the levels of equilibrium for each time period, but rather they do so only partially, in such a way that when they begin to become adjusted to their optimum quantities, then the partial static model is identical to the full static model.[1]

Let us now widen the framework described above to consider the optimum behaviour of the productive agents in terms of their output levels. In line with Conrad and Unger (1987), let's suppose that the firms establish output price at the same level as the marginal cost,

$$F_Y(Y, P, Z, t) = P_Y \qquad (7)$$

Assuming that the output level is exogenous and quasi-fixed in the framework of partial static equilibrium, the best procedure for the productive units in conditions of imperfect information might be to ensure the price is equal to the marginal cost. Therefore, let us extend the models of equilibrium in the short and long-run derived for the case of quasi-fixed factors to a situation in which Y is considered in the framework of partial static equilibrium as a quasi-fixed output

[1] As Kulatilaka (1985) comments, the long-run, defined by a function of total costs, is a mere construction that allows us to distinguish between the equilibrium observed in the short-run and the equilibrium desired in the long-run, although the latter can never be achieved for the technology available. Similarly, there is no learning mechanism whereby the deviations in the equilibrium recorded in the past might have a bearing on the future levels of quasi-fixed factors. Thus, the model is in essence a static framework. For a detailed description of dynamic models, see Berndt et al. (1980) and Pindyck & Rotemberg (1983).

which the firm is only able to adjust partially to its optimum level in each time period, as was the case with the quasi-fixed production factors. By contrast, in the full static equilibrium the firm is able to adjust, at all times, the output level to that which is optimum in the long-run equilibrium.

Let us consider a translogarithmic short-run cost function, with two variable factors, employment (L) and intermediates (M), and with capital (K) as the quasi-fixed factor[2]:

$$\ln (CV/P_M) = \beta_0 + \beta_L \ln \frac{P_L}{P_M} + \beta_Y \ln Y + \beta_K \ln K + \beta_T t + 0.5\left[\beta_{LL} \ln^2 \frac{P_L}{P_M} + + \beta_{YY} \ln^2 Y + \beta_{KK} \ln^2 K + \beta_{TT} t^2 \right] + \beta_{LY} \ln \frac{P_L}{P_M} \ln Y + \beta_{LK} \ln \frac{P_L}{P_M} \ln K + \beta_{LT} \ln \frac{P_L}{P_M} t + \beta_{YK} \ln Y \ln K + \beta_{YT} \ln Y t + \beta_{KT} \ln K t \quad (8)$$

This expression (8) imposes the conditions of symmetry and of homogeneity on the prices that must fulfil each translog function (see Berndt, 1991). The demand equations of the variable factors that minimise the costs are obtained by differentiating the function (8) with respect to the prices of the input variables, $\partial CV(\cdot)/\partial P_i$, with i=L,M. Given that we are only considering two variable factors, the percentage participation of the variable inputs in the costs are obtained as

$$S_L = \frac{P_L \cdot L}{CV} = \frac{\partial \ln CV}{\partial \ln P_L} = \beta_L + \beta_{LL} \ln \frac{P_L}{P_M} + \beta_{LY} \ln Y + \beta_{LK} \ln K + \beta_{LT} t$$
$$S_M = 1 - S_L \quad (9)$$

Furthermore, if the fixed factors are at their levels of static equilibrium, the following enveloping condition must be fulfilled:

$$-S_K = -\frac{P_K \cdot K}{CV} = \frac{\partial \ln CV}{\partial \ln K} = \beta_K + \beta_{KK} \ln K + \beta_{LK} \ln \frac{P_L}{P_M} + \beta_{YK} \ln Y + \beta_{KT} t \quad (10)$$

by which the marginal reduction in variable costs due to increases in capital is equal to the price of this input, P_K, that is, $-\partial CV(\cdot)/\partial K = P_K$.

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[2] The assumption that capital instantaneously adjusts to its optimal level has come in for fierce criticism For this reason, we suggest considering it as a quasi-fixed input, which implies that the firms are operating under certain restrictions whenever adjusting their capital stocks to optimum levels.

Finally, differentiating logarithmically the function of CV(·) with respect to Y and introducing the condition of equality between the price of the output and the marginal cost, we obtain

$$S_Y = \frac{P_Y \cdot Y}{CV} = \frac{\partial \ln CV}{\partial \ln Y} = \beta_Y + \beta_{YY} \ln Y + \beta_{LY} \ln \frac{P_L}{P_M} + \beta_{YK} \ln K + \beta_{YT} t \tag{11}$$

The set of expressions (8)-(11) would comprise the framework of the full static equilibrium. By contrast, using the model of partial static equilibrium, the parameters in (10) and (11) would not correspond with those in (8), since these expressions would not be the result of the differentiation of the latter expression.

Optimality test

Conrad and Unger (1987) developed a set of tests that enable us to determine whether the observed levels of quasi-fixed inputs and output correspond with the long-term optimal levels. In developing these tests, Conrad and Unger used the implicit relations between a function of variable costs and the equations of demand and optimum output level derived from them; whereby if these relations were empirically met, it might be concluded that the firm behaves optimally. The ex post testing of the optimality of both the output and the quasi-fixed factors can be carried out using different test sequences. The procedure proposed by Conrad and Unger can be summarised in Figure 1. At the outset the only restrictions imposed are those implicit to the model of partial static equilibrium, in other words, the parameters of the variable cost function (8) must be equal to those of the equations of optimal demand of the variable factors, L and M in (9). Using this general model we can then examine the restrictions implicit in the optimality of K and Y.

According to the alternative presented in the right-hand side of the figure, first the null hypothesis H_0^Y should be tested, which involves determining whether the level of output observed is equivalent to that which *a posteriori* maximises the profits given the short-run restrictions imposed by the level of K, P and P_Y observed. This is the same as saying that equation (11) is obtained as a logarithmic derivation of the variable cost function (8). In fact, to determine the validity of this hypothesis, the validity of the restrictions implicit in equation (11) need to be determined, that is, the equality of the 5 parameters in equation (11) with those corresponding to equation (8). Where the validity of these restrictions is not rejected, it is then necessary to determine if the restrictions implied by the hypothesis H_0^{YK} are true, should this be the case the stock of capital observed would be the optimum provided the output optimality condition is met for exogenous values of P, P_K and P_Y. In other words, a test is conducted to determine whether the ex-post level of K is consistent with the model of full static equilibrium, given an optimum level of output in the short-run. In this way, the validity is tested of the equality restrictions of the parameters of equation (10) and those corresponding to equation (8), considering the restrictions implicit in equation (11) to be true. If this hypothesis cannot be rejected statistically, then we would find ourselves in a situation of equilibrium with respect to capital and output at all times.

A further alternative in the equilibrium testing sequence corresponds to that presented in the left-hand side of the figure. First, we need to assess whether the capital stock observed corresponds with that which minimises the total costs in the short-run, the null hypothesis H_0^K, according to which the costs are minimised given values of Y, P, P_K and P_Y. If this hypothesis is verified, the ex-post shadow value of K is equal to its ex-ante market price, so that equation (10) would be obtained as the logarithmic differentiation of the function of variable costs. Therefore, to test the validity of this hypothesis, it is only necessary to test the validity of the equality restrictions of the parameters implicit in equation (10). Should these restrictions not be rejected statistically, the process has to be continued by testing the validity of the restrictions given by the hypothesis H_0^{KY}, for which the observed output level coincides with that which maximises the profit when taking as data the values of P, P_K and P_Y. Validating this hypothesis implies, therefore, that once the implicit restrictions in (10) have been imposed, it is necessary to test the equality restrictions of the given parameters for (11).

As Conrad and Unger note, alternative strategies might still be identified such as, for example, testing H_0^K and H_0^Y in parallel. Similarly, it should be pointed out that when using one of the two strategies proposed in the figure, the testing sequence should, in principle, be halted when the first rejection is obtained on preceding with the taxonomy presented. Independent of the sequence followed, in order to test the validity of the restrictions given for the various hypotheses presented, a statistic can be used based on the ratio of likelihood, λ, so that

$$-2\ln\lambda = N\left(\ln|\hat{\Sigma}_{\omega}| - \ln|\hat{\Sigma}_{\Omega}|\right) \qquad (12)$$

where N is the number of observations, $\hat{\Sigma}_{\omega}$ is the estimator of the variance and covariance matrix of the restricted model, and $\hat{\Sigma}_{\Omega}$ that of the non restricted model. Under the null hypothesis the ratio of likelihood is distributed asymptotically as a chi-square test with as many degrees of freedom as there are restrictions to be tested.

3. The case of Spanish manufacturing industry (1980-1993)

The longest period for which homogenous data are available, and of sufficient size to allow us to carry out this analysis with a certain degree of confidence for the Spanish economy, is that which corresponds to the eighties and the early nineties. This period was one characterised by a process of modernisation and was a time when industry faced increased competition from abroad, which makes it particularly interesting to know the capacity of the sector to behave optimally, at least in the terms defined above.

The data base used is that of BDMORES which, in relation to the industrial sector, uses mainly information from the Regional Accounting of Spain, from the Industrial Survey and the Investments Register of the Spanish Statistical Office. The use of other data bases containing information about Spanish industry for longer periods (for example, Ruiz 1999) was ruled out on the grounds that the estimate of the cost system required for the empirical exercise necessitates information concerning the price of capital and its stocks, as well as the price of intermediates. All this information is available in the BDMORES data base together with the rest of the required variables. In this data base, the statistical information is presented for each productive sector and region, although in this study we shall use the series which is grouped by sector,[3] for the whole of the Spanish state, from 1980 to 1993. We can also obtain employment data, wage rates, private capital, added value and their corresponding price indices. As regards the cost of private capital use, the BDMORES data base considers differences between the different industrial sectors grouped in accordance with R-17 in terms of the rate of depreciation, prices of capital goods, and their rates of growth and tax (Dabán et al., 1998).[4] Similarly the data referring to intermediate consumption are drawn from the work of Díaz (1998), so that the output variable used here is the production value, which is the sum of the added value and the intermediate consumption. Table 1 shows the specific industrial branches considered.

To give the reader an idea of the importance of the manufacturing industries in Spain, in 1993 they represented 20% of the Spanish added value, a figure similar to the average for the countries of the European Community, although were energy and construction to be included, the percentage in Spain would increase to 34%, given the relative importance of these two sectors. However, this does not mean, according to Myro (1990), that Spanish industrial development can be compared to the average recorded in the European Community, since the industrial output per capita was lower. Similarly, the contribution made by Spain to the industrial added value in the European Community rose from 3.5% in 1953 to 7.8% in 1993, so that the relative weakness of industrial activity in Spain was slowly corrected thanks to a rate of expansion that was well above the Community average.

Table 2 shows the evolution in the main figures of Spanish industry used in this study during the eighties and the early nineties. It can be seen that costs and output underwent net growth but that this growth was not even throughout the period. Thus, during the first half of the eighties, both variables recorded a positive but small annual growth rate; during the second half the rates were much higher – around 6% in the case of costs and a little over 5% for the product.

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[3] While traditionally industrial activities are considered to include energy production and the construction sector and public and private works, here, adopting the directives of the European System of Integrated Accounts, a stricter definition is used, whereby no room is left for these activities because of their particular technological and market characteristics – high degree of public control and virtual absence of competition from abroad. For this reason we have reduced the concept of industry to that which is usually defined as manufacturing in its widest sense, including the mining of metallic and non-metallic minerals not destined for the production of energy.

[4] For more information on the prices of the capital input, see the concept of use cost of capital introduced by Jorgenson (1963).

This phase of expansion since 1985 in Spain was no doubt strengthened by the process of opening up to foreign markets which began with the joining of the European Community. In the early nineties, however, the tendency was inverted, with both variables recording average negative annual growth rates. The negative rates being considerably worse in the case of the output .

An uneven evolution in the various production factors was observed during the period. Labour and capital suffered falls in the early eighties, growing during the period of expansion at around 3% and 2% each year, that is, at high rates but not as high as those of the product. In contrast, intermediate consumption grew throughout the eighties, albeit with considerably different intensities in the first and second halves, with the latter recording the higher rates. By the nineties only capital continued to grow, while intermediates and, in the main, employment recorded negative growth rates. Finally, in relation to the prices of the productive factors, it was capital, followed by intermediate consumption which underwent a major price increase at around 6%, though the growth in employment prices was much more moderate, at around 3%. In contrast, an analysis of the evolution of these prices over time, shows that the those of employment saw their annual growth rates increase, while the prices of capital and intermediates fell markedly, especially in the case of capital, where negative growth rates were recorded falling to –11.6% in the early nineties. This slight increase in the price of capital ensured that the capitalisation of Spanish manufacturing industries continued even in the early nineties. This is shown quite clearly in the fact that while the rest of the inputs recorded negative growth rates, the rate of capital growth was positive. In fact, among the factors that account for the process of industrial capitalisation, in addition to the need to introduce technical progress incorporated in capital goods as well as the growing presence of foreign capital firms in Spain and the increasing weight of the industrial product, we can point to a certain increase in the price of the labour factor in relation to that of capital.

Table 3 shows a number of ratios for Spanish manufacturing industries. Specifically, as an indication of productive efficiency it shows the ratio between costs and product. It can be seen that the ratio was relatively stable throughout the eighties and the early nineties, around 0.85. Similarly, the ratio between capital and output recorded a negative growth rate during the eighties, and a fairly high positive growth rate in the early nineties. The reason for this would appear clear being that the capital stock did not increase during the eighties at the same rate as that of the product, despite the capitalisation process. If we analyse the evolution in labour productivity, considered to be a key growth element, an overall growth was recorded in the period of 2.6%, with a stable behaviour. From this perspective, the greater increase in output recorded during the period of expansion of the eighties was accompanied by a very slight increase in productivity. Thus, the increase in productivity in the second half of the eighties was lower than that in the first, and can be considered one of the factors contributing to the recession in the early nineties. In relation to the participation of the productive factors, around 60% of the costs are constituted by intermediate consumption, a proportion that fell gradually throughout the eighties. The remaining percentage is distributed between employment and capital, with employment maintaining its participation throughout the period (at around 31%), and capital growing considerably, above all in the first half of the eighties.

4. Results

4.1 *Test Results*

Below we report the results obtained from an application of the tests described in section two using the data corresponding to the industrial sectors for the period described. Table 4 summarises the value of the tests corresponding to the hypothesis of optimum behaviour for capital and product. Given that the procedure described in Figure 1 involves a sequential process, the level of test significance in each stage is altered. Therefore, in order to absorb this effect the significance level for each of the two stages is fixed at 1%. Moreover, as pointed out in earlier sections, these tests need the estimation of the set of equations given for 8, 9, 10 and 11. We consider this system as a model of seemingly unrelated equations given the interdependence that might exist between the error conditions of the different equations Moreover, in order to incorporate the possibility that the level of exogenous costs might differ from one sector to another, sector dummies were included in the costs equation. Similarly, two dummies were introduced in the intercept of the equations of demand and those of the optimum level of output, which in turn were included in the corresponding coefficients of the cost equation. The first of these variables is assigned a value of one for the sectors that present the highest K/Y ratio (the sectors of metallic minerals and iron and steel, and minerals and non-metal products) while the others are assigned a value of zero, so that a separate effect can be considered in those sectors highly dependent on capital endowment. The second dummy is assigned a value of one for the industrial branches that depend most on employment, in other words, those with a higher than average L/Y ratio over the period (Textiles, leather goods and shoes, clothes, Paper, paper goods printing and Various industrial products).

The results of the tests show that for the Spanish industry the set of implicit restrictions are rejected in the long-run. Thus, if we follow the first of the alternatives described in the second section, we reject the hypothesis H_0^Y at 1%, that is, the hypothesis that the output level observed was that which corresponded to a marginal cost which equalled the price of the output determined exogenously is rejected. Therefore, it no longer makes any sense to conduct a test on the H_0^{YK} hypothesis, since the optimum condition for the output has been rejected. Similarly, the second alternative proposed by Conrad and Unger was followed. Accordingly, we tested whether the hypothesis that the capital stock observed in each period was that of equilibrium, H_0^K, where this hypothesis is rejected at 1%. Consequently, once again we stopped the test sequence at this stage as it made little sense to test the hypothesis of equilibrium in the output imposing the optimum capital condition, H_0^{KY}, given that the latter does not appear likely.

Additionally, we proceeded to test together the hypothesis that both the observed output and capital coincided with their optimum levels, a hypothesis that, as expected bearing in mind the earlier results, was once again rejected. This would seem to indicate that, first, in the eighties and the early nineties Spanish industry did not present a capital stock that coincided with the quantity that corresponded with that which would have allowed costs to be minimised in the short-run, but rather that it was in a situation of over or under-endowment of capital. In addition, there would appear to be imbalances in the choice of the quantity of output, where this could be considered as being quasi-fixed in the sense that it was only partially adjusted in each period.

4.2 *The divergence of capital and output levels from their optimums*

However, these tests only provide a global view of the divergences between the observed quantities and those defined as being optimum, without it being possible to extract any conclusions regarding the evolution of this discrepancy over the period of study, nor in terms of the results for each of the sectors that make up the sample. In order to provide data to answer these questions the partial static equilibrium model was estimated, since it best captures the behaviour of Spanish industry if we take into consideration the earlier test results, and the model provides measures for assessing the degree of imbalance.

First, in the estimation of this model[5], the sector dummies are highly significant, which indicates that, after conditioning the prices of the variable factors and the capital endowment and output, there exist different levels of unitary cost according to the sector considered. This is a consequence, among other possible reasons, of the technological and efficiency characteristics of each sector. In fact, similar conclusions have been drawn in other empirical studies conducted in the Spanish industrial sector, such as those of Suárez (1992) and Goerlich and Orts (1994, 1996), who found considerable differences in production technology between sectors.

We use Tobin's q measure to analyse the divergence of capital and output from their optimum levels. In the case of capital, if the stock was at its equilibrium level at all times, the savings in costs as a consequence of increases in capital stocks (a measure known as he capital shadow price, U_K) would be equal to its price (P_K) – recall that this condition defines the stock at equilibrium. Were this not to be the case, the condition of equality would not be met – a clear indication that the firms are not able to adjust capital to its optimum level instantaneously. In this regard, it is interesting to compare the shadow price, that is, the profits from additional

[5] The results of the parameter estimates, as well as the other statistics, are not included in this paper for reasons of space, but also because in models of this type the individual parameters are not particularly informative, rather it is the elasticities and the other measures calculated from them that have greater significance. However, overall, the estimates showed a good capacity to adjust and the signs and magnitude of the coefficients guaranteed the conditions required of the cost systems. The detailed results are, however, available on request to the authors.

investments in capital, with the costs of these investments, using the ratio U_K/P_K. Should the capital shadow price prove to be greater (lower) than the service price provided for it, we would be facing a clear situation of under-endowment (over-endowment) of capital, resulting in a ration above (below) 1. Clearly, this ratio would have a value of 1 when in equilibrium.

In the case of output, when encountering a situation in which the quantity observed is equal to that of equilibrium at all times, the marginal cost of producing an additional unit of output (MC) will coincide with its price (P_Y), this being the condition of equilibrium in the long-run. Were this not to be the case, this equality would not be met – a clear indication that the firms are not able to adjust output to its optimum level instantaneously. This is why it is interesting to compare the marginal costs of production with the output price, using the ratio MC/P_Y.[6] Divergences from the unitary value of this measure will reflect divergences between the observed and the optimum output, the result of partial maladjustments in each period.

Table 5 shows the degree of imbalance for capital and output levels in Spanish industry as a whole, and in the different branches of industry. The values in both cases correspond to the average throughout the study period. It can be seen that Spanish manufacturers presented a marked degree of imbalance in capital, as shown by a ratio value of 1.50 between its shadow and market prices. This result is similar to that reported by Boscá *et al.* (1999). This result indicates that Spanish manufacturers presented capital endowments that were considerably below optimum levels. However, this average for the whole period hides a substantial variability over time. Figure 2 shows the evolution of U_K/P_K, where it can be clearly appreciated that, beginning from a high level of imbalance, during the first half of the eighties a marked adjustment was made leaving stocks of capital fairly close to their optimum levels throughout the period of growth; although the ratio was always above one.

[6] Note that the measure defined here is the inverse of that usually used to measure market power. We have chosen to define it in this way so that it corresponds to the measure defined for the case of quasi-fixed input, and to distance it from what would be a measure of market power given that, under an assumption of perfect competition, this should be unitary. Recall that in the setting defined here this set of circumstances will be met in the long-run equilibrium, with divergences from the optimum able to occur in each period and being reflected in the Tobin's q measure.

Another aspect that is hidden by the composite industry measure is the marked heterogeneity of the sectors. As can be seen in Table 5, we can find sectors with capital endowments both above and below optimum levels. Thus, the branches that have a ratio above one and which, as a result, would have benefited from greater capital investment are those of Metal products, Transport material, Various industrial products and, above all, those of Textiles leather goods and shoes and Food, drinks and tobacco. By contrast, the sectors of Metallic minerals and iron and steel, Minerals and non-metal products, Chemical products and Paper, paper goods and printing had a ratio below 1, that is, they were paying a higher price for their capital stock services than the costs savings that this capital provided. The greatest imbalance in this respect was recorded by the branch of Metallic minerals and iron and steel.

In the case of output, the average ratio throughout the period between the marginal cost and its price was 0.88 for industry as a whole. This indicates that the output observed was lower than the optimum level, that is, there must have been restrictions and adjustment costs that prevented industry, in each period, from attaining the levels of production that would have been optimum given the market conditions. In fact, if we note the evolution of the ratio MC/P_y as shown in Figure 3, it can be deduced that, particularly after the end of the eighties, Spanish industry was able to progressively adjust its production levels towards those that were *a posteriori* optimum considering the output price levels. Thus, at the end of the period there were virtually no discrepancies between the observed and the optimum levels.

Indeed, what can be seen in the case of output is the increasing approximation of Tobin's q measure to the value of 1 towards the end of the eighties. Although this trend needs to be more carefully analysed, we are interested here in the contribution over time of the components of the measure of maladjustment used for the output market, that is the evolution of the output price and marginal cost in this period[7]. Thus, Figure 4 clearly shows the inflection in the growth of prices while the marginal costs maintain the same evolution shown since the end of the eighties, leading to a situation where the two are almost the same in 1993. This behaviour is typical of a recession, with prices being contained and with the marginal costs maintaining their upward trend, as was the case in the early nineties. This suggests that the adjustment occurred as a result of the reduction in the optimum output level, without there being a substantial modification in the relative level of real output, or, what amounts to the same, that the adjustment was in the main due to the economic cycle.

Finally, the capacity or possibilities of each sector to adjust to optimum levels of production varied, though the divergences here were not as great as those for capital. First, in the period we observed that some sectors presented output levels greater than the optimum levels while others presented levels that were lower. Independently of this factor, the sectors that showed the greatest divergence between marginal cost and price were those of Textiles, leather goods and shoes, Food, drinks and tobacco and Metal products; while the branches of Paper, paper goods and printing and Minerals and non-metal products presented a lower level of imbalance

5. Conclusions

At the beginning of this paper the main aim was stated as being to determine whether Spanish industry was able to adjust production and capital endowment in each period to what *a posteriori* might be considered optimal levels taking into consideration their prices, understood as being exogenous. As indicated, this analysis is of particular interest for the period under study because it was a time during which interesting changes were occurring in the Spanish economy, in general, and its industry in particular. The estimation of a sufficiently general cost system so as to be able to incorporate both the partial and complete static equilibrium models has enabled us to carry out the test suggested by Conrad and Unger (1987), and, thereby, obtain strong statistical evidence to draw conclusions concerning the capacity of the industry to adjust to the levels of production and capital that we have defined as optimum.

The test results clearly point to the rejection of the hypothesis that the levels observed for capital and output correspond to those that ex-post minimised the costs in the short term and those that fulfilled the condition of maximum profit assuming perfect competition, respectively.

[7] We should like to thank R. Myro for having suggested this question.

However, we have shown that this general result conceals interesting trends in terms of the temporal evolution and the behaviour of the individual industrial sectors. This has been possible as we obtained measures of deviation between the quantities observed and the optimum levels, both for the output and the capital, from the estimate of the cost model that showed itself to be most adequate in function of the test results: that is the model of partial static equilibrium.

Thus, in general and as an average for the period, Spanish industry was under-endowed in capital, due to the substantial discrepancy between the levels observed for this factor and the optimums in the first half of the eighties. However, from this moment on the imbalance was much more moderate. Similarly, the under-endowment was not a unanimous feature as in the mineral and chemical sectors and the paper industry the opposite result was obtained, that is the levels of capital observed were higher than the optimum.

The average output level observed in the period was below that defined as optimum, although the indications are that the imbalance was not as great as that recorded for capital. In this case too, the overall result hides different behaviours from one sector to another. Although here again, what is most notable is the evolution in the imbalance, typified by a movement of the levels observed towards optimum levels from the end of the eighties, so that by the end of this period the levels were very close to the optimum levels. This leads us to infer that the various processes described in the recent literature referring to the changes brought about in Spanish industry could have led to a much more competitive behaviour, limiting the impediments according to which the firms adjusted quantities of factors and output to those that minimised costs of production and maximised profits, resulting thereby in more competitive firms in markets more open to competition. However, this assertion should be taken with caution until more is known about the behaviour of industry in the growth period of the nineties, and therefore we can evaluate the robustness of this behaviour in different phases of the economic cycle.

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Figure 1. Sequence of hypothesis tests for optimization

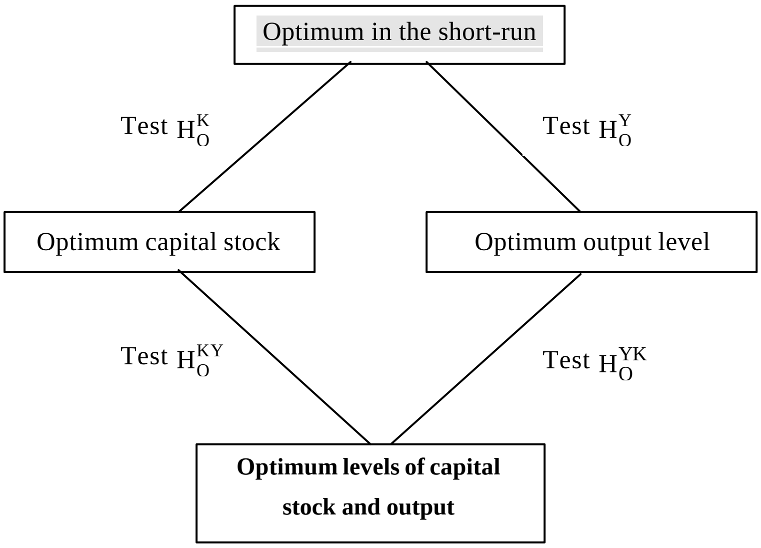

Table 1. Description of industrial sectors

	Name
R1	Metallic minerals
R2	Non metallic minerals and products
R3	Chemistry
R4	Metallic products and metalwork
R5	Transport material
R6	Food products, alcohol, drinks and tobacco
R7	Textiles, leather and shoes
R8	Paper and derivaties and printing
R9	Other manufactures

Table 2. Evolution of main variables for Spanish manufactures (1980-1993)

	C	*Y*	*L*	*M*	*K*	P_L	P_M	P_K
AAGR 80-93	2.71%	1.89%	-0.73%	2.14%	0.75%	3.64%	6.97%	6.40%
AAGR 80-85	1.19%	0.54%	-2.61%	0.58%	-1.34%	1.88%	13.73%	17.78%
AAGR 86-90	6.13%	5.13%	3.02%	6.15%	2.18%	2.38%	3.17%	7.38%
AAGR 91-93	-0.27%	-2.01%	-4.18%	-2.13%	2.03%	10.55%	2.06%	-11.60%

SOURCE: Own elaboration from BD.MORES database.
NOTE: AAGR is the geometrical annual average growth rate.

Table 3. Ratios about the evolution of Spanish manufactures (1980-1993)

	C/Y	*K/Y*	*Y/L*	S_L	S_M	S_K
1980	0.847	0.558	3.046	0.330	0.624	0.046
1981	0.845	0.566	3.168	0.324	0.604	0.071
1982	0.844	0.561	3.317	0.315	0.595	0.091
1983	0.832	0.539	3.456	0.311	0.608	0.082
1984	0.820	0.523	3.588	0.290	0.606	0.104
1985	0.831	0.508	3.573	0.301	0.605	0.094
1986	0.830	0.482	3.688	0.303	0.602	0.095
1987	0.829	0.459	3.784	0.294	0.594	0.113
1988	0.827	0.442	3.920	0.290	0.613	0.097
1989	0.83	0.429	4.019	0.280	0.611	0.109
1990	0.848	0.43	3.999	0.288	0.603	0.110
1991	0.854	0.445	4.086	0.295	0.603	0.102
1992	0.889	0.459	4.201	0.320	0.576	0.104
1993	0.902	0.482	4.274	0.336	0.581	0.083
AAGR 80-93	0.80%	-1.12%	2.64%	0.14%	-0.55%	4.64%
AAGR 80-85	0.64%	-1.86%	3.24%	-1.82%	-0.62%	15.36%
AAGR 86-90	0.94%	-2.81%	2.04%	-1.26%	0.04%	3.73%
AAGR 91-93	1.77%	4.07%	2.27%	6.72%	-1.84%	-9.79%

SOURCE: Own elaboration from BD.MORES database.
NOTE: A GR is the geometrical annual average growth rate.

Table 4. Results for optimality tests

Hypothesis	*Test Value*	*Test probability*
H_0^Y	119.609	0.000
H_0^K	360.065	0.000
Together H_0^Y y H_0^K	407.149	0.000

Table 5. Measure for the deviation with respect to the optimum behaviour of manufactures

U_K/P_K	CMg/P_Y		U_K/P_K	CMg/P_Y
1.50	0.88	R1	0.494	0.897
		R2	0.799	0.923
		R3	0.794	0.787
		R4	1.451	0.730
		R5	1.828	0.879
		R6	2.087	0.716
		R7	2.206	1.347
		R8	0.746	1.116
		R9	1.177	1.232

NOTE: P_i refers to observed price for i (i=Y, K); MC is marginal cost and U_K is the shadow value for capital.

Figure 2. Time evolution for the ratio shadow price/capital price

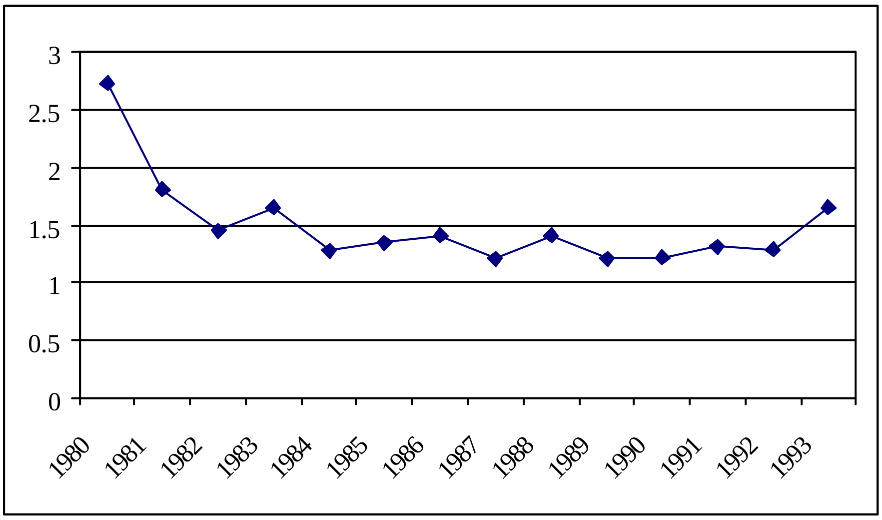

Figure 3. Time evolution for the ratio marginal cost/output price

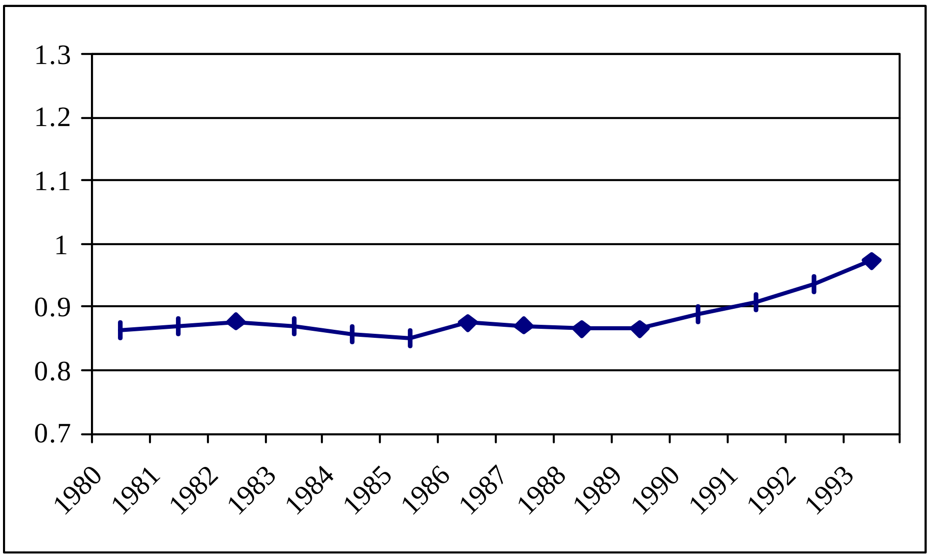

Figure 4. Time evolution for marginal cost and output price