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Reviewed work(s):

Source: *Economica*, New Series, Vol. 43, No. 171 (Aug., 1976), pp. 267-274

Published by: [Wiley](#) on behalf of [The London School of Economics and Political Science](#) and [The Suntory and Toyota International Centres for Economics and Related Disciplines](#)

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## Price–Cost Margins and Market Structure

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Industrial economists following from Mason and Bain have run innumerable tests (largely using US data) of the relation between various market structural variables and various dimensions of performance. The most popular activity has been to relate profit rates, variously defined, to measures of concentration and barriers to entry, but this activity has not always been clearly based on a well-defined theoretical model. When the theoretical model is spelled out it becomes obvious that some inter-industry relationships of this sort are meaningless because of certain omitted variables. A prime example is the omission of the industry price elasticity of demand, an omission that implies the strong assumption that demand elasticity is constant across industries within the cross-section. However, if we shift our focus to *changes* in structure effecting *changes* in performance, then it may be reasonable to assume that the omitted-variables problem is less severe; i.e., assuming the constancy of industry price elasticities over time may be less heroic than assuming that they are constant across industries.

This paper will therefore proceed by setting up an explicit theoretical model of the relationship between structure and performance. The derived estimating equation relates change in price–cost margins to changes in concentration.

### I. THE BASIC MODEL

Consider an industry with  $N$  firms producing a homogenous product. We can write down the profit equation for the  $i$ th firm as

$$(1) \quad \Pi_i = pX_i - c(X_i) - F_i$$

where  $\Pi_i$  is profit,  $X_i$  is output rate,  $p$  is price,  $c$  is variable cost and  $F_i$  is fixed cost, assuming for the moment the same cost conditions for each firm. The inverse market demand function is

$$(2) \quad p = f(X) = f(X_1 + X_2 + \dots + X_N)$$

Now the assumptions made in previous work of this type have not always been clearly specified, but myopic profit maximization appears to underly most models and seems a reasonable basis from which to start. Thus, assuming profit-maximizing behaviour and neglecting the problem of potential entry at present, the first-order conditions for a maximum are

$$(3) \quad \frac{d\Pi_i}{dX_i} = p + X_i f'(X) \frac{dX}{dX_i} - c'(X_i) = 0 \quad (i = 1, \dots, N)$$

where

$$(4) \quad \frac{dX}{dX_i} = 1 + \frac{d \sum_{j \neq i} X_j}{dX_i} = 1 + \lambda_i$$

If we now sum over the  $N$  firms in the market we get

$$(5) \quad Np + \sum_{i=1}^N X_i f'(X)(1 + \lambda_i) - Nc'(X_i) = 0.$$

Dividing through by  $p$  and writing  $\sum X_i \lambda_i / \sum X_i$  as  $\lambda$  yields

$$(6) \quad N + \frac{1 + \lambda}{\eta} - \frac{Nc'(X_i)}{p} = 0$$

where  $\eta$  is the industry price elasticity of demand.

We can rewrite (6) to give

$$(7) \quad \frac{p - c'(X_i)}{p} = -\frac{1 + \lambda}{N\eta}.$$

Thus we have the prediction that the mark-up of price over marginal cost, Lerner's measure of monopoly power, is inversely related to the number of firms in the industry and to the industry price elasticity of demand. If for example a firm leaves the industry, then output should fall and price rise, so that  $N$  falls while the price-cost margin rises.

More generally, we may wish to accommodate the existence of unequal size firms as dictated by their different marginal cost functions. We can then rewrite (3) as

$$(8) \quad \frac{d\Pi_i}{dX_i} = p + X_i f'(X) \frac{dX}{dX_i} - c'_i(X_i) = 0.$$

Then multiplying by  $X_i$ , and summing over the  $N$  firms, we have

$$(9) \quad \sum p X_i + \sum \frac{X_i^2}{X^2} f'(X)(1 + \lambda_i) X^2 - \sum c'_i(X_i) \cdot X_i = 0$$

or

$$(10) \quad \frac{\sum p X_i - \sum c'_i(X_i) \cdot X_i}{pX} = -\sum \left(\frac{X_i}{X}\right)^2 \frac{f'(X)X^2}{pX} (1 + \mu),$$

where

$$\mu = \frac{\sum_{i=1}^N \lambda_i X_i^2}{\sum_{i=1}^N X_i^2}$$

(see Rader, 1972, pp. 271–272). If we assume the firms have constant marginal cost, equal to average variable cost, then the left-hand side of the equation is the ratio of profit plus fixed costs ( $\Pi + F$ ) to revenue ( $R$ ). On the right-hand side the first term is the Herfindahl (or Hirschmann–Herfindahl) index of concentration ( $H$ ), so the equation can be rewritten as

$$(11) \quad \frac{\Pi + F}{R} = -\frac{H}{\eta} (1 + \mu)$$

or

$$(11a) \quad \frac{\Pi + F}{R} = -\frac{(v^2 + 1)}{N\eta} (1 + \mu)$$

where  $v$  is the coefficient of variation in  $X$ .

The case of differentiated products is similar but slightly more complex, and has been omitted for reasons of space. Interested readers should consult the authors for details.

We therefore have the prediction that the profit-revenue ratio is related directly to the Herfindahl index of concentration in the industry and inversely to the industry price elasticity of demand. This result has some similarity with the Stigler (1964) theory of collusion in that it again stresses the relevance of the Herfindahl measure of concentration in explaining the market outcome. The problem with testing this prediction is that good measures of price elasticity of demand by industry are not available at a reasonable level of disaggregation. One approach to this dilemma is to change the focus of analysis away from explaining inter-industry differences and towards explaining intra-industry changes over time. This in fact is highly relevant in the current situation in the United Kingdom and the rest of Europe, where we are observing very significant changes in concentration over time, in contrast to the situation in the United States, where concentration in product markets has recently remained fairly constant.

Thus, taking ratios of the variables over time and assuming that all price elasticities of demand and  $\mu$ 's, the conjectural variations terms, are constant over the relevant period of analysis, we have

$$(12) \quad \frac{(\Pi'/R)_{k(t)}}{(\Pi'/R)_{k(t-1)}} = \frac{H_{k(t)}}{H_{k(t-1)}}$$

where  $k=1, \dots, M$  industries and  $\Pi + F$  is written  $\Pi'$ . In fact  $\eta_k$  may vary through the business cycle as suggested by Harrod (1936), and so we will experiment with various control variables to try and account for these cyclical changes both on a macro and on an industrial level. Also, we might well expect  $\mu$  to increase as  $H$  increases, as a result of an increasing degree of collusion. An appropriate specification would then be a relationship linear in logarithms:

$$(13) \quad \frac{(\Pi'/R)_{k(t)}}{(\Pi'/R)_{k(t-1)}} = \left\{ \frac{H_{k(t-\theta)}}{H_{k(t-\theta-1)}} \right\}^\beta.$$

Here, the subscript  $\theta$  is included to allow for the possibility of considerable, though ill-defined, lags in the effects of structure on performance; for example Singh (1971) has suggested that the effect of a change in structure, via merger, on profits is not fully realized until a five-year period has elapsed. Also,  $\theta$  deals with the identification problem of whether we are in fact measuring a structural effect on performance or the reverse.

## II. OTHER DETERMINANTS OF PRICE-COST MARGINS

We have constructed a very simple model by which changes in price-cost margins may be explained. We must now consider the effect of other variables that may be changing in the real world and that may need to be taken into account in our empirical work. However, some potentially important variables had to be ignored empirically because data were unavailable. Thus, *changes* in entry barriers to the extent that they were not reflected in our measures of concentration were not considered, nor was the growth of countervailing power possessed by buyers of industrial products. We did, however, experiment with a variable measuring the change in unionization by industry in order to capture the growth of countervailing power by sellers of inputs.

There remains the problem of allowing for inter-industry changes in price-cost margins owing to scale economies and cyclical effects. In terms of long-run

unit cost some people may argue for the existence of scale economies. However, if we look at the actual performance of firms, rather than engineering analyses of plants of differing size, we find little evidence in the United Kingdom to support such conjectures. The results of Samuels and Smyth (1968) show no relationship between profit rates and firm size, although the variability of profit rates declines with size.

In our model, cyclical effects would work through the industry price elasticity of demand or through the divergence of short-run marginal cost from average cost with changing capacity utilization if we consider the industries to be in equilibrium. There is the associated possibility that the extent to which equilibrium is attained will be determined by the severity of the cyclical fluctuations in demand and the related factor of the frequency of purchasing. We have experimented with various measures of cyclical variability and also have divided the sample into durable and non-durable goods industries on the assumption that durable goods show much more pronounced cyclical fluctuations in demand, and are less frequently purchased. However the durable–non-durable good split may pick up other cyclical phenomena. Rather than reduce price directly firms may improve the quality of the product, but the extent to which they adopt such a strategy depends on the expected retaliatory lag. For complicated durable goods this may be considerable and thus this type of competition is encouraged. This may allow durable goods industries to approach more closely to equilibrium price–cost margins in times of recession (see Cubbin, 1975).

Of the variables mentioned above, barriers to entry and countervailing power affect the basic model by moving the actual market power in an industry away from that given by the concentration measure. Cyclical effects work most directly on the industry price elasticity of demand. Thus, a multiplicative form for the extended relationship seems most applicable, and applying coefficients to the variables in question then implies testing the extended model in logarithmic form. Further discussion of the precise specifications is left to Section IV.

### III. DATA

Most of the data used in the analysis derive from the Census of Production for the years 1958, 1963 and 1968. The observations relate to Minimum List Heading (MLH) industries, which define a maximum of 119 observations. Our sample will fall below that level because of various data difficulties discussed below.

#### *Concentration*

Our theory defines the Herfindahl measure of concentration as the relevant one, but unfortunately this is not published. We are grateful to Malcolm Sawyer for allowing us to use his estimates of the Herfindahl index which are based on the average firm shares for each employment size category in the Census of Production. We should note immediately that this method of estimation will understate the true level of the Herfindahl and that the extent of understatement may vary over time. One possible alternative would be to assume that firm size within an industry is lognormally distributed so that precise values for  $H$  would be obtainable, but the evidence for this assumption is rather sparse (see

Scherer, 1970, for references). Since we only have lower bound estimates of the Herfindahl index available we also experimented with concentration ratios where, unlike the previous case, theoretical maximum and minimum values are obtainable from the size distribution tables. (The figures available in the Census of Production are at the wrong level of aggregation.) We took the mean of these values; for the estimates and methods of calculation, see Sawyer (1971). He gives concentration ratios for 117 industries (leaving out MLH 384 and 385 in 1958) for 1958 and 1963.

#### *Profit-revenue ratio*

The sum of profit and fixed cost is measured as gross output minus raw materials purchases and wages and salaries, and obviously this measure of profits is too broad. Although it is possible to correct for some of the variable cost omissions in 1963, it was not possible to do so for 1958, nor yet for 1968. Thus we are making the implicit assumption that omitted costs as a proportion of total variable costs is a constant within each industry over the time period in question, or that this effect is picked up by cyclical variables.

The data on  $\Pi'/R$  were collected for the census years 1958, 1963 and 1968. Because of changes in some MLH descriptions, a final total of only 94 observations was possible. In collecting the data the principle of using the latest available source was used. Thus, for the 1958 data the 1963 Census of Production was used, while for the 1963 and 1968 data the *Board of Trade Journal* (31 December 1969) was used. (Since the empirical work was performed, final results for 1963 and 1968 have appeared in the 1968 Census of Production series.)

The sources of data and the precise definition of the other variables relating to unionization and durable goods is given in Table 1.

#### IV. RESULTS

A simple version of the theory was tried first and appeared to give good results. Taking simple changes in concentration, measured by either the Herfindahl or the four-firm concentration ratio, there was a significant relationship with change in the price-cost margin, where some lag in adjustment was allowed. By nature of the data source, only very limited exploration of lag structures is available, the only other one tried was  $(\Pi'/R)_{68}/(\Pi'/R)_{58}$  as the dependent variable. Results were inferior, and there are theoretical objections to this formulation anyway. A specification linear in logarithms was chosen following the earlier discussion. The theory does not explicitly provide for a constant in the relationship, but since we cannot hope to observe equilibrium positions we cannot really expect that with no change in concentration within an industry price-cost margins will not change. Thus including a constant term allows for those macro-economic changes that affect all industries in approximately the same way and extent. The results are reported in Table 1. As it turns out (see columns (1) and (2)), the constant is insignificant and alters the results only slightly. Comparing columns (1) and (2), the Herfindahl measure of concentration appears preferable as our theory would suggest; a conclusion that runs right through the results.

TABLE 1  
PRICE-COST MARGIN EQUATIONS: ALL-INDUSTRY SAMPLE (94 OBSERVATIONS)

	(1)	(2)	(3)	(4)
Constant	0.0220 (0.728)	0.0258 (0.809)	0.0333 (0.683)	0.0177 (0.354)
Log ( $H_{63}/H_{58}$ )	0.2501 (2.572)		0.2957 (2.942)	
Log ( $CR4_{63}/CR4_{58}$ )		0.2956 (1.900)		0.3489 (2.180)
Log ( $TU_{63}/TU_{58}$ )			0.4985 (1.480)	0.4464 (1.299)
Durable good			0.0344 (0.619)	0.0205 (0.364)
$F$	6.615	3.611	3.188	1.876
Degrees of freedom:	(1,92)	(1,92)	(3,90)	(3,90)
$R^2$	0.067	0.038	0.096	0.059

Note: The dependent variable is  $\log \{(\Pi'/R)_{63}/(\Pi'/R)_{58}\}$ ;  $t$ -ratios are given in parentheses.  
Definitions and Sources

$\Pi'$ : value added minus wages and salaries, adjusted for inventory change. Source: *Census of Production* (1963 and 1968), *Board of Trade Journal* (31 December 1969).

$R$ : sales revenue. Source as for  $\Pi'$  above.

$CR4$ ,  $H$ : explained in text.

$TU$ : union density, i.e. proportion of total employees who are union members. Data provided by the Industrial Relations Research Unit, University of Warwick. The level of aggregation is chosen as the appropriate one from the point of view of the wage bargain. In some cases this involves the aggregation of MLH industries into broader groups.

Durable good: a zero-one variable taking a value of one of industries producing what we consider to be durable goods.

The sample included all MLH industries on which comparable data were obtainable with the exception of Bread and Brewing. In the case of these two industries it was felt that the national change in concentration was not a good indication of the change in structure of the relevant local market. After processing the data it was apparent that two industries (Abrasives and Jewellery and Plate) had changes in price-cost margins well outside the range for the rest of the sample. However, since no errors were apparent and there was no other reason for excluding them they were retained in the sample and the results reported refer to the full sample. The parameter estimates associated with the concentration variables are reduced when the latter two industries are excluded but they remain significant.

TABLE 2  
PRICE-COST MARGIN EQUATIONS: DURABLE AND NON-DURABLE GOODS INDUSTRY SAMPLES\*

	Durables		Non-Durables	
	(1)	(2)	(3)	(4)
Constant	0.0507 (0.820)	0.0265 (0.399)	0.0438 (1.572)	0.0340 (1.157)
Log ( $H_{63}/H_{58}$ )	0.5560 (3.313)		0.0095 (0.134)	
Log ( $CR4_{63}/CR4_{58}$ )		0.5294 (1.982)		0.0742 (0.624)
Log ( $TU_{63}/TU_{58}$ )	0.8679 (1.563)	0.6324 (1.085)	0.0031 (0.013)	0.0482 (0.192)
$F$	6.028	2.442	0.010	0.196
Degrees of freedom	(2,51)	(2,51)	(2,37)	(2,37)
$R^2$	0.191	0.087	0.001	0.011

\*Notes as in Table 1.

Columns (3) and (4) indicate that the trade union and durable dummy intercept variables add little to the analysis. For unionization the lack of significance of the results may be due to problems of measurement since the problem of the allocation of general union membership to constituent industries is a very difficult one. There was in fact very little change in the measure over the period 1958 to 1963. Additional cyclical variables, such as the change in percentage unemployed and in sales, were tried without success.

It has also been suggested to us that we should test whether the coefficient on  $\log(H_{63}/H_{58})$  varies with the starting concentration. While we have not performed a formal test of this hypothesis, plots of the residuals from the equation reported in column (3) Table 1 (and that in column (1) Table 2) against  $H_{58}$  were inspected and revealed no evidence to support the suggestion.

Although the  $R^2$  values are low, this is not unexpected since we are comparing price-cost margins between two single year observations, and the actual outcome in each of these specific years could have been affected by a multitude of factors. In an effort to eliminate some of these we also split the sample into two, the Durable Goods Industry sample (50 observations) and the Non-Durable Goods Industry sample (43 observations), and estimated each separately. The results are presented in Table 2. For durable goods changes in price-cost margins are significantly related to changes in concentration, whereas in the case of non-durables our equations offered no explanation of changes in the price-cost margin. The results are consistent with the view that durables show greater price flexibility via quality change than do non-durables, rather than simply affecting the intercept term. In the case of non-durables we appear to be picking up disequilibrium situations rather than responses to changes in concentration.

Obviously an extended run of time series data on profit-to-revenue ratios is required for an adequate test of the model in the case of non-durables. Looking more closely at the results for durables, we again see that while the Herfindahl performs much better than the concentration ratio, the size of the coefficient on the Herfindahl would suggest that either price adjustment is falling below that implied by Cournot's assumption that  $\mu$  is zero, or alternatively that costs are rising with increased concentration. However, the empirically significant relationship between changes in concentration and changes in price-cost margins is a result that runs counter to many of the recent findings, which tend to cast doubt on the significance of this link (e.g. Brozen, 1971).

#### ACKNOWLEDGMENTS

Among others we should like to thank John Cubbin and David Morris for valuable comments.

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