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ABSTRACT

Price Competition and Market Structure: The Impact of Cartel Policy on Concentration in the UK *

This Paper examines the impact of firms' conduct on market structure. It studies the evolution of concentration in UK manufacturing following the abolition of cartels using a theoretical framework based on Sutton's theory of market structure and a panel data set of four-digit industries over 1958–77. The econometric results suggest that the intensity of price competition has a positive impact on concentration in exogenous sunk cost industries as well as in advertising-intensive and R&D-intensive industries. The concentration–market size relationship, while negative in exogenous sunk cost industries, breaks down in industries with high advertising or R&D intensity.

JEL Classification: L10
Keywords: price competition, market structure, exogenous and endogenous sunk costs, cartels, UK manufacturing

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NON-TECHNICAL SUMMARY

Does tougher price competition increase market concentration? A rare opportunity to address this issue in an empirical context is provided by a 'natural experiment' that came up in the UK in the 1960s. As a result of the 1956 Restrictive Trade Practices Act, restrictive agreements between firms, covering a wide range of industries, were cancelled. This caused an intensification of price competition in many industries during the 1960s. These can be compared to a 'control' group of industries that had not been subject to agreements significantly restricting competition and were therefore not affected by the Act.

This Paper looks at the empirical evidence regarding the impact of the 1956 Act on concentration in the UK. It is part of a larger research project that involves a theoretical and empirical analysis of the effects of tougher price competition on market structure, non-price competition, profits, productivity and the labour market, using evidence from the UK following the 1956 legislation (see Symeonidis, G., *The Effects of Competition*, MIT Press, forthcoming).

The theoretical framework used in the present Paper distinguishes, following Sutton (1991), between exogenous sunk cost industries, i.e. industries where the fixed investment cost of successfully entering the market is to a large extent exogenously determined by technology, and endogenous sunk cost industries, i.e. industries where firms can spend on R&D or advertising to reduce unit costs or enhance the quality or the brand image of their product.

One of the key results to emerge from the recent literature on market structure is that, in exogenous sunk cost industries, an intensification of price competition, brought about by institutional changes such as the introduction of cartel laws or a higher degree of economic integration, is expected to cause an increase in long-run equilibrium concentration through a process of exit and merger (Selten 1984, Sutton 1991). The reason is that the intensification of price competition causes gross profit margins to fall, given the initial industry structure, so firms (or less efficient firms) can no longer cover their fixed costs. This leads to a restructuring of the industry until the gross profit of each of the remaining firms rises again to a level that covers fixed costs.

In endogenous sunk cost industries, things can be more complicated. In particular, if tougher price competition causes firms to spend less on advertising or R&D, then fixed cost as well as gross profit will fall given the initial industry structure, so the effect on long-run equilibrium market structure can be ambiguous.

This Paper provides an econometric analysis of the impact of cartel policy on market structure in the UK. Part of the data set used was constructed by examining the restrictive agreements registered under the 1956 Act in order to identify the industries that were affected by the legislation. Other sources were also used to identify non-registered agreements. Data on concentration were available for 6 different years between 1958 and 1977. As the Act did not have any significant effect until 1959, the year 1958 is the 'before' date in the 'natural experiment'.

The results from the analysis of a panel data set of four-digit industries support the hypothesis of a strong positive effect of the intensity of price competition on concentration both in exogenous and endogenous sunk cost industries. In other words, competition policy on restrictive agreements has been an important factor in increasing concentration in UK manufacturing. The estimated magnitude of the effect is a rise in the five-firm concentration ratio of about 6 percentage points in exogenous sunk cost industries. The effect does not seem to have been any weaker in advertising-intensive or R&D-intensive industries.

A second finding is that the concentration–market size relationship was negative during the period examined both for exogenous sunk cost industries and for industries with medium advertising intensity, but not for industries with high advertising or R&D intensity. Thus two key aspects of firms' conduct, namely the intensity of price competition and the level of endogenous sunk costs, are important determinants of market structure.

A key policy implication of these results is that higher concentration need not be associated with less price competition; in fact, the opposite may be the case. This means that concerns with the level of concentration need not take precedence over the need to ensure that competition remains effective, i.e. firms do not engage in collusive practices and no barriers to entry are created. Moreover, the view taken in this Paper is that the rise in concentration following an intensification of price competition, brought about by a change in cartel policy or otherwise, is the result of a structural mechanism and cannot therefore be avoided through the exercise of strict antitrust and merger policy. In fact, this view implies that there are important economic constraints in the exercise of these policies, since it would be impossible to impose a market structure so fragmented that it is not sustainable under more competitive conditions.

1. Introduction.

The impact of firms' conduct on market structure has been emphasised in recent studies. Selten (1984) predicted that a switch from collusive to non-collusive behaviour caused by a toughening of competition policy would result in a higher level of concentration in a homogeneous goods industry. More recently, Sutton (1991, 1997, 1998) identified two key aspects of firms' conduct as being significant determinants of concentration: the intensity of price competition and the level of endogenous sunk costs. In industries where the only important sunk costs are the exogenously determined setup costs, he predicts that there is a lower bound to concentration which declines indefinitely with the ratio of market size to setup cost and rises with the intensity of price competition. In industries with significant endogenous sunk costs, such as advertising or R&D, the lower bound to concentration does not converge to zero and does not even necessarily decline as market size increases; this is because endogenous sunk expenditures increase with market size. The role of the intensity of price competition in endogenous sunk cost industries has not been discussed in these studies.

The empirical evidence on the competition-concentration relationship has been rather inconclusive. Studies of the impact of cartel policy on the structure of industry in the US and the UK have been subject to methodological problems or data limitations and have produced mixed results (Bittlingmayer 1985, Nelson 1959, Elliott and Gribbin 1977, O'Brien et al. 1979). On the other hand, the literature on economic integration has found some evidence of a positive effect of the reduction of trade barriers on concentration (for example, Caves 1988, Sleuwaegen and Yamawaki 1988). However, since economic integration involves

more than just an intensification of price competition, it is not easy to draw implications for the competition-concentration relationship from these results.

This paper provides an econometric analysis of the impact of firms' conduct on market structure. It examines the evolution of concentration in UK manufacturing between 1958 and 1977. A "natural experiment" that occured during this period offers a unique opportunity to study the relationship between price competition and concentration. As a result of the 1956 Restrictive Trade Practices Act, restrictive agreements between firms, covering a wide range of industries, were cancelled. This caused an intensification of price competition in many industries during the 1960s. These can be compared to a "control" group of industries which had not been subject to agreements significantly restricting competition and were therefore not affected by the Act.

Part of the data set used in this study was constructed by examining the restrictive agreements registered under the 1956 Act in order to identify the industries which were affected by the legislation. Data on concentration were available for 6 different years between 1958 and 1977. As the Act did not have any significant effect until 1959, the year 1958 is the "before" date in the experiment. The econometric results from the analysis of a panel data set of four-digit industries support the hypothesis of a strong positive effect of the intensity of price competition on concentration both in exogenous and endogenous sunk cost industries. In other words, competition policy on restrictive agreements has been an important factor in increasing concentration in UK manufacturing. A second finding is that the concentration-market size relationship was negative during the period examined both for exogenous sunk cost industries and for

industries with medium advertising intensity, but not for industries with high advertising or R&D intensity. These results suggest that key aspects of firms' conduct, such as the intensity of price competition and the level of endogenous sunk costs, are important determinants of market structure.

The paper is organised as follows. The next section presents a theoretical framework for analysing the competition-concentration relationship based on Sutton (1991). Sections 3 and 4 describe the evolution of competition in UK manufacturing industry and the construction of the data set. The econometric model and results are presented in section 5. The final section concludes.

2. Theoretical framework.

Consider first the case of an exogenous sunk cost industry producing a homogeneous product. A two-stage game can be used to model competition in such an industry. At stage 1 firms simultaneously decide whether or not to enter at a given sunk cost f. At stage 2 those firms that have entered set prices.

The *equilibrium* outcome of the second-stage subgame can be represented by a vector of (gross) profits $\pi_i(s_1,..., s_i,..., s_N, S, t)$, where s_i is the market share of firm i, N is the number of firms that have entered at stage 1, S is market size, an exogenous demand-shift parameter, and t is a measure of the intensity of price competition. In particular, t captures the idea that, for a *given* vector of s_i's, π_i will depend on the firms' pricing strategies, which will in turn partly depend on exogenous institutional factors, such as the climate of competition policy or the degree of economic integration. In fact, t can be thought of as an inverse measure

of the "degree of collusion".[1] Note, however, that it is not equivalent to the price-cost margin, which is endogenous. Consider first the case of symmetric single-plant firms, where $s_i = 1/N$, $\forall i$, and define also a concentration measure C whose value increases in 1/N, such as the concentration ratio. We assume $\partial\pi_i/\partial S > 0$, $\partial\pi_i/\partial t < 0$, and also that π_i is increasing in 1/N.

At stage 1, the equilibrium level of C* is determined, in the symmetric case, by the free-entry condition $\pi_i(1/N, S, t) = f$, $\forall i$. Assume that this equation has a unique solution (this is the case if the average cost curve is either U-shaped or everywhere declining). Then it is easy to see that an increase in the intensity of price competition t will cause a rise in C*: gross profit, which has fallen following the increase in t, can only be restored to a level equal to f through an increase in 1/N. Also, an increase in market size S will cause a fall in C*.

In industries consisting of multi-plant firms, or where the average cost curve becomes horizontal after a certain production level, or in exogenous sunk cost industries producing a horizontally differentiated product, there exists a multiplicity of equilibria. The most fragmented equilibrium is the one where each firm operates only one plant, or produces at minimum efficient scale, or produces one variety of the product, while various more concentrated equilibria, symmetric or asymmetric, can occur if firms operate more than one plant each, or produce at a level higher than m.e.s., or produce more than one variety each. More

[1] It is well known that, under certain conditions, any individually rational and feasible payoff vector can be sustained as an equilibrium of an infinitely repeated pricing game (Fudenberg and Tirole 1991). It seems then natural to assume that the climate of competition policy or other institutional factors will considerably affect the probability of any particular outcome being realised.

concentrated equilibria can also occur when part of the fixed cost is incurred at the price competition stage (Vickers 1989); or when the zero-profit condition is violated because of the existence of barriers to entry or the use of entry-deterring strategies (Lyons and Matraves 1996). In all these cases, the free-entry condition above defines the minimum level of concentration as a function of S, f and t.

Next consider an endogenous sunk cost industry. Following Sutton (1991), this case can be analysed as a three-stage game. At stage 1 firms decide whether or not to enter at a given sunk cost of entry f. At stage 2 each firm i chooses to incur a sunk cost A_i, which increases the consumers' willingness to pay for the firm's variety or reduces marginal cost. A_i may represent advertising or R&D expenditure. Finally, at stage 3 firms set prices. The equilibrium gross profit of firm i in the third-stage subgame is again assumed to be increasing in S and C and decreasing in t. Moreover, $d\pi_i/dA_i > 0$, since an increase in A_i increases the consumers' willingness to pay for firm i's product or reduces its marginal cost.

The equilibrium minimum concentration C* and level of endogenous sunk costs A* in this model are determined by a free-entry condition and a first-order condition for the optimal choice of A (see Sutton 1991, Symeonidis 1999a, 1999b for a detailed analysis). However, little can be said about the effect of a change in t (or S) on C* and A* without imposing more structure on the model. Intuitively, if advertising/R&D rises or does not change following a rise in t, then minimum concentration must also rise. But if advertising/R&D decreases as a result of an increase in t, then the fall in sunk costs may or may not offset the fall in gross profit at the initial equilibrium, so minimum concentration may rise or fall.

In conclusion, this theoretical framework provides clear predictions for the

case of exogenous sunk cost industries; the question for this type of industries is whether the empirical evidence is consistent with the theory. There are no strong predictions for endogenous sunk cost industries; here the question is whether any empirical regularities can be established despite the inconclusiveness of the theory.

A final remark is in order. The assumption of exogeneity of the intensity of competition t is clearly a simplification. It is, however, probably justifiable in the present context for two reasons. First, the key determinant of changes in t during the period under study was the exogenous change in the institutional framework (see section 3 below). Second, cartelisation in the 1950s, i.e. the initial value of t, seems to have been a function of exogenous industry-specific factors rather than endogenous variables like concentration (see Symeonidis 1998a and the discussion in section 5). In any case, to the extent that t is observable and the increase in t can be established empirically, it would be easy to derive theoretical predictions *conditional on the known change in t*, even if t were made endogenous. Suppose that t is a function of the exogenous institutional variable T and a vector of other variables $\underline{Z}$, which may include a measure of concentration, and consider, for simplicity, the case of an exogenous sunk cost industry with symmetric firms. The free-entry condition can then be written as $\pi_i [1/N, S, t(T,\underline{Z})] = f, \forall i$, and the conditional prediction that a change in T must cause C to rise if and only if t is larger at the new equilibrium easily follows.

3. Competition in UK manufacturing industry.

At the time the 1956 Restrictive Trade Practices Act was passed, nearly half

of UK manufacturing industry was subject to agreements significantly restricting competition. These were not enforceable at law, but they were not illegal. As a result of the 1956 legislation, the agreements were abandoned. This section briefly describes the evolution of competition in UK manufacturing from the 1950s to the early 1970s. A more detailed discussion can be found in Symeonidis (1998b, forthcoming).

The 1956 Act required the registration of restrictive agreements between firms on goods, including both formal, written undertakings as well as informal, verbal or even implied arrangements. Registered agreements were presumed to be against the public interest and should therefore be abandoned, unless they were successfully defended in the newly created Restrictive Practices Court or considered by the Registrar of Restrictive Trading Agreements as not significantly affecting competition. The Act did not then at once make restrictive agreements illegal: an agreement could be upheld if the Court was convinced that it produced positive benefits which outweighed the presumed detriment. Since the attitude of the Court could not be known for certain until the first cases had been heard, the large majority of the existing agreements were registered rather than being immediately dropped or secretly continued. The hard line taken by the Court, however, especially in its initial judgments, induced most cartels to voluntarily abandon their agreements. Of those which were defended by the parties in the Court, only a few were upheld. As the first Court cases were heard in 1959, it was not until 1959 that industries, on the whole, started cancelling their agreements.

A large number of agreements contained minimum or fixed producer prices, conditions of sale, and often ancillary restrictions such as collective exclusive

dealing or the maintenance of common resale prices. Some agreements, however, only contained restrictions which were probably much less significant for competition, e.g. conditions of sale or the maintenance of resale prices without any regulation of individual prices or trade discounts.

In general, there were no restrictions on media advertising or R&D expenditure. Also, the evidence suggests that there were no significant restrictions on entry in most cartelised industries. Note that free entry and absence of collusion in non-price variables were key elements in the model of the previous section.

Were the agreements effective? This depended both on the extent to which the parties conformed to the agreement and on the extent of competition from outside firms. The evidence suggests that in most industries the agreements had been operated honourably before cancelation. Also, the effectiveness of outside competition was limited in many industries by the fact that the cartels tended to contain most or all of the largest and best known domestic firms; or by practices aimed at discouraging distributors from buying from outside firms; or because imports were hampered by tariffs and quantitative controls, transport costs or the operation of international restrictive agreements.

To what extent did the intensity of price competition increase following the abolition of cartels? Case-study evidence suggests, first, that price competition intensified in the short run in many industries; however, in several cases agreements to exchange information on prices, price changes etc replaced the former restrictive arrangements and were usually successful in restricting competition. Second, in many industries with information agreements price competition emerged after these were abandoned or changed into post-notification

arrangements in the mid-1960s, following adverse decisions of the Restrictive Practices Court; in these industries, then, competition emerged about a decade after the 1956 Act was passed.

The available evidence then indicates that the majority of industries with restrictive agreements in the 1950s did experience, sooner or later, an intensification of price competition as a result of the 1956 legislation. Furthermore, the impact seems in several cases to have been significant. Hence it is, on the whole, legitimate to think of this evolution as a change of competition regime induced by an exogenous shock. A more cautious conclusion, which still permits an empirical analysis of the competition-concentration relationship, would be that for industries with restrictive agreements in the 1950s there is a high probability that there has been a change of competition regime as a result of the legislation, while this probability is zero for industries not affected by the Act. [2]

4. Construction of the data set.

The empirical analysis in this paper essentially involves a comparison of the evolution of concentration after 1958 between those industries affected by the restrictive practices legislation and those not affected - controlling for other factors that may have influenced concentration during the period examined. The only years for which UK concentration data are available at the level of aggregation used in this study are 1958, 1963, 1968 and 1975-1977. As the legislation did not

[2] To the extent that some agreements were ineffective and others were replaced by tacit arrangements even in the longer term, the results of section 5 below would understate, if anything, any effect of price competition on concentration.

have any significant effect before the first Court cases were heard in 1959, the 1958 observations are all before the "natural experiment" took place. Moreover, as competition did not break out immediately in several industries, the impact of the Act was felt at least until the late 1960s. This section describes the construction of the data set. Further details are contained in the Appendix.

Concentration and market size. The concentration measure used is the share of total sales revenue of UK firms in any given industry accounted for by the five largest producers. I used Census-based data at the four-digit (or "product group") level of aggregation for 1958, 1963, 1968, 1975, 1976 and 1977. The concentration ratio, which is the only concentration measure available at the four-digit level for the period under study, has been widely used in the literature on the determinants of market structure (see Curry and George 1983, Sutton 1991).

Hannah and Kay (1977) also point out that an advantage of the concentration ratio is the fact that it is not very sensitive to the number of small firms (which affects both the degree of inequality of firm sizes and the overall number of firms, but is not a key feature of market structure). This is important in the present context for several reasons. First, the evidence from the various data sources on competition (see below) suggests that the British cartels did not usually include all firms in any given industry and it was often the smaller firms who were not cartel members. Hence the effect of the 1956 Act on many small firms in cartelised industries may have been relatively weak. Second, many smaller firms in advertising-intensive and R&D-intensive industries spend little or nothing on advertising or R&D and hence the endogenous sunk cost model is not relevant for

these firms. This implies that it would be more difficult to clearly identify any differences between classes of industries using a measure of market structure which is too sensitive to the number of firms. Finally, small firms often do not produce core industry products.

There are two possible proxies for market size: sales revenue deflated by the general producer price index, and sales revenue deflated by an industry-specific producer price index. Both were tried in the empirical models of section 5 and gave similar results.

Competition. The main source of data on competition were the restrictive agreements registered under the 1956 Act. A number of other sources were also used to identify products subject to unregistered agreements or agreements modified prior to registration: the various industry reports of the Monopolies Commission; the 1955 Monopolies Commission report on collective discrimination; the 1949 report of the Lloyds' Committee on resale price maintenance; industry studies contained in Burn (1958) and Hart et al. (1973); the Board of Trade annual reports from 1950 to 1956; and the Political & Economic Planning (1957) survey of trade associations, as well as unpublished background material for this survey.

Two alternative ways of modelling the competition effect are used in this paper. The first involved constructing an empirical measure of the "intensity of price competition" for each industry-year pair in the sample. To this end, all industry-year pairs were classified as "collusive", "competitive" or "ambiguous" on the basis of four criteria: the reliability of the data source; the types of

restrictions; the proportion of an industry's total sales covered by products subject to agreements and, for each product, the fraction of the UK market covered by cartel firms; and, finally, the timing of the effects of the Act.

In particular, the various types of restrictions were classified as significant, non-significant or uncertain, according to their likely impact on competition. Next, the products which were subject to agreements were assigned to the various headings of the classification used in the concentration statistics. Now certain products within a particular four-digit industry were subject to significant restrictions, while others were not. An industry-year pair was classified as collusive if the products subject to *significant* restrictions accounted for more than 50% of total industry sales. It was classified as competitive if the products subject to *significant or uncertain* restrictions accounted for less than 10% of industry sales. And it was classified as ambiguous in all remaining cases.[3] It was assumed, for agreements of nationwide application, that the parties accounted for a substantial fraction of the relevant market. For important regional agreements, an estimate of the fraction of industry sales subject to restrictions was made.

Finally, some assumption had to be made about the timing of the effects of the legislation. There was a great deal of variation across industries, but in the absence of any systematic information only a general criterion could be applied. As mentioned above, the agreements were still in place in 1958 and, although industries started abandoning their agreements in 1959, competition did not

[3] Most industries classified as competitive were free from any restrictive agreements. Most industries classified as collusive had agreements covering all industry products. Small variations in the cut-off points do not significantly affect the results reported in section 5.

emerge in several cases until the mid-1960s (and there must have also been a time lag between the emergence of competition and the realisation of any impact this may have had on concentration). It seemed then reasonable to assume that the effect of the Act on concentration in industries classified as collusive or ambiguous in 1958 was, in general, fully or mostly realised by 1968, but not, in many cases, by 1963. Hence the 1963 observation was typically classified as ambiguous for industries which were cartelised in the 1950s, while for industries with ambiguous state of competition in the 1950s all observations before 1968 were classified as ambiguous.

All industry-year pairs classified as ambiguous were excluded. The intensity of competition could then be modelled by means of a dummy variable taking the values 0 for "collusive" and 1 for "competitive" industry-year pairs. Table 1 describes in detail the construction of the competition dummy *COMP*, covering all the different cases encountered. Industries A and B represent those few cases where a restrictive agreement was upheld by the Court and continued until after 1977 or was abandoned after 1963 (but before 1966). Industry C represents a typical cartelised industry, in which any agreements were cancelled between 1958 and 1963. The 1963 observation is excluded because of the uncertainty about exactly when competition emerged in each case. Industries D1, D2, and D3 represent various special cases where an agreement was abandoned at some date after 1958 but other arrangements were subsequently made (either immediately or at a later date) which *may* have restricted competition (and were either dropped well before 1975 or were still in force by 1975). Industry E is an industry classified as ambiguous for 1958, and in which any agreements were abandoned

before 1963. Finally, industry F is an industry which was not cartelised. The large majority of the industries in the sample fall under C, E or F.

The exclusion of "ambiguous" industry-year pairs resulted in a final sample containing 291 industries and 1265 observations. Only industries with at least two unambiguous observations were included in the final sample, provided at least one of these was for 1958, 1963 or 1968 (i.e. industries with observations for 1975-1977 only were not included). The sample is unbalanced, with a much smaller number of observations for the two earlier years, i.e. 1958 and 1963.

While the competition variable *COMP* is a direct empirical measure of the intensity of price competition, the way it is constructed may seem somewhat ad hoc. This is especially the case for the assumptions made about the timing of the effect of the Act. The second approach to modelling the competition effect in the present context involved distinguishing between those industries with a change of competition regime following the 1956 Act and those without a change in regime (excluding industries with ambiguous state of competition in 1958). To this end, the dummy variable *CHANGE* was defined. This takes the value 1 for all industries with a change in competition regime sometime after 1958 and 0 otherwise. Note that, unlike *COMP*, *CHANGE* is an industry-specific variable. An analysis of the competition effect on concentration can then be performed by testing whether the time effects on concentration after 1958 are different for the two groups of industries in a regression that controls for other factors, such as market size and setup costs. An advantage of this procedure is that it allows a direct evaluation of the short-run and the long-run impact of the 1956 Act without the need to make any assumptions about the timing of the effect. A disadvantage

is that some of the information about dates where particular agreements were abandoned cannot be used. Thus, no distinction is made between industries falling, in table 1, under categories B, C and D2: for all these industries, *CHANGE* takes the value 1 in all years. Similarly, for all industries falling under categories A, D3 or F, *CHANGE* takes the value 0.

For the specification using *CHANGE* an alternative sample was constructed. Industries with ambiguous state of competition in 1958 were excluded, as were industries with a switch of regime but for which concentration data were not available for at least 1958, 1963 and either 1968 or 1975 (since one of the main purposes of this specification was to compare the short-run and long-run impact of the legislation). For other industries all available observations were included. This sample contains 218 industries and 1034 observations.

Setup cost. There are no data for setup costs, so two different proxies were constructed. The first was constructed by defining a measure of minimum efficient scale relative to industry size and multiplying it by the total value of capital stock in the industry (see Sutton 1991). I used the simplest possible measure of m.e.s., namely the size of the average plant. Divided by industry size, this becomes equal to the inverse of the number of plants in the industry. Hence the first proxy used for setup cost is the capital stock of the average plant. A measure of m.e.s. based on the size distribution of plants might be more appropriate, but such a measure could not be used because of data limitations. Even the data on plant numbers and capital stock were only available at the three-digit level of aggregation (i.e. for Census "minimum list headings" or "industries") and, moreover, the capital stock

figures are estimates rather than primary data. As a result, this proxy is a rather imperfect one.

These difficulties should not be overemphasised, however. For instance, if an empirical model of concentration with industry-specific effects is used, one need not assume that all four-digit industries within any given three-digit industry are similar with respect to setup cost f or that the capital stock of the average plant is an adequate measure of f. All we need is that the *change* in the average capital stock is an adequate measure of the *change* in f. In particular, assume that $K_{it} = \gamma_i K_{Jt}$, $N_{it} = \delta_i N_{Jt}$ and $f_{it} = \theta_i (K/N)_{it}$, where K is capital stock, N is the number of plants, and i denotes a four-digit industry within the three-digit industry J. It follows that $\ln f_{it} = \ln\theta_i + \ln\gamma_i - \ln\delta_i + \ln(K/N)_{Jt}$. Hence the three-digit ln(K/N) can be used as an explanatory variable, while the term $\ln\theta_i + \ln\gamma_i - \ln\delta_i$ will be part of the four-digit industry-specific effect provided that θ_i, γ_i and δ_i are constant over time for each industry i.

A standard argument against using measures of m.e.s. based on the number or the size distribution of plants is that such measures are correlated with concentration (Davies 1980). To avoid this, the capital-labour ratio K/L has sometimes been used as a proxy for technical economies of scale. It also seems plausible that the change in K/L is a measure of the change in setup cost f. The arguments made in the previous paragraph for K/N are therefore valid for K/L as well.

Advertising-sales and R&D-sales ratios. Each four-digit industry was classified on the basis of its typical or average advertising-sales ratio and R&D-

sales ratio over the relevant period. Four different sub-samples were defined: exogenous sunk cost industries (ADS < 1% *and* RDS < 1%), advertising-intensive industries (ADS > 1%), high-advertising industries (ADS > 2%), and R&D-intensive industries (RDS > 1%), where ADS and RDS denote the advertising-sales ratio and the R&D-sales ratio respectively. The 1% cut-off point was chosen since it is commonly used to classify industries according to advertising or R&D intensity. The 2% cut-off point for high-advertising industries was the result of a trade-off: on the one hand, this sub-sample should contain a non-negligible number of industries with a change of competition regime and, on the other, it should be sufficiently different from the ADS > 1% sub-sample. In addition, the 2% cut-off point splits the group of advertising-intensive industries into two groups of equal size: of the 291 industries in the first of the two samples used, there were 218 with ADS < 1%, 36 with ADS between 1% and 2% and 37 with ADS > 2%. Also, 204 industries had RDS < 1% and 87 had RDS > 1%. Note that the endogenous sunk cost sub-samples are not mutually exclusive.

The construction of advertising-sales and R&D-sales ratios involved adjusting and combining data from various sources. These ratios are reasonably accurate and in any case they were only used to assign the industries to the various sub-samples.

5. Empirical model and results.

Two implications of the theoretical framework of section 2 for the empirical analysis of concentration are, first, that an appropriate empirical model should be of the general form

$$Concentration = C(S, f, t, \underline{w}),$$

where $\underline{w}$ is a vector of variables, some of which may be non-measurable industry-specific characteristics, and, second, that the model should be estimated separately for exogenous and endogenous sunk cost industries.

Given that the theoretical predictions are for minimum concentration, should a lower bound be estimated rather than a regression line? The estimation of a deterministic lower bound does not allow for disequilibrium levels of concentration below the bound, so it is probably not appropriate in the present context. On the other hand, estimating a stochastic lower bound by maximum likelihood methods is possible only when the least squares residuals are positively skewed, otherwise the ML estimates are actually the same as the LS estimates (cf. Waldman 1982). As it turns out, the LS residuals from the least squares dummy variable (LSDV) models used in this paper are negatively skewed for all the sub-samples defined. This is due to the fact that some industries have experienced large increases in concentration during the period examined, so the observations for the early years have large negative residuals. There may be, however, a more fundamental problem with estimating a lower bound in the present case because of the panel structure of the data. In particular, it may not be appropriate to control for industry effects when estimating a bound; on the other hand, failure to do so would essentially reduce the data set to a pooled time-series cross-section, and it would then be much more difficult to identify a competition effect on concentration because of the prevalence of industry effects. This discussion suggests that standard least squares regressions is the most appropriate approach

in the present case. Note that an implicit assumption made under this approach is that the predictions for minimum concentration C_{min} also apply to actual concentration C_{act}.

Some descriptive statistics on initial levels and changes in concentration are reported in tables 2 and 3. Table 2 reports means and standard deviations of the concentration ratio *C5* in 1958, i.e. prior to any impact of the legislation on competition, for industries which experienced a change of competition regime after 1958 as well as for industries not affected by the legislation (the latter group includes three industries where the agreements continued throughout the period covered in this study). Statistics for three sub-samples of industries defined on the basis of advertising and R&D intensity are also presented, as are correlation coefficients between the concentration ratio and the dummy variable *CHANGE*.

On the whole, there is little evidence of any significant difference in initial concentration levels between the two groups of industries. This may seem puzzling, if one expects that price competition has a positive effect on concentration. However, a competition effect on concentration will be difficult to identify in a cross-section of industries because of the importance of industry-specific characteristics for concentration. Another factor that blurs the competition effect on concentration in a cross section is that the two variables are also negatively associated because of a third variable, namely capital intensity, which has a positive effect on concentration (see the regression results below) but also increases the likelihood of collusion. In the present data, the mean of 1958 *lnK/N* for 64 industries with collusive agreements in 1958 is -0.03 (with a st. deviation of 1.04), while it is -0.88 (with a st. deviation of 1.15) for 85 industries without

agreements. The correlation coefficient between *COMP* and *lnK/N* in 1958 is -0.36. The respective means (and standard deviations) for 1958 *lnK/L* are 1.22 (0.67) for cartelised industries, 0.76 (0.81) for non-cartelised industries and the correlation coefficient between *COMP* and *lnK/N* in 1958 is -0.29. These figures clearly suggest that collusive industries had higher capital intensity in 1958. [4]

Table 3 presents statistics on the average change in *C5* over 1958-1968 and also over 1958-1975. The table suggests that the intensity of price competition has a significant impact on market structure. For example, the average change in *C5* between 1958 and 1975 in industries affected by the Act and for which observations are available for both these years was 14.7 percentage points. This compares to 7.4 percentage points for industries not affected by the legislation. Statistics are also presented for sub-samples of industries defined on the basis of advertising and R&D intensity. In all cases, the change in *C5* was quite larger for industries with a change of competition regime. However, the figures must be interpreted with caution since changes in some of the other determinants of concentration were not similar in the two groups over the relevant periods (and were also not similar across the sub-samples). [5]

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[4] See also Symeonidis (1998a) for an econometric analysis that confirms that capital intensity increases the likelihood of collusion. The correlation between *COMP* (or *CHANGE*) and capital intensity should not create any problems for the econometric specifications used in this paper since a setup cost proxy is always included among the regressors.

[5] In particular, in the endogenous sunk cost sub-samples (but not in the exogenous sunk cost sub-sample) market growth was slower in industries with a switch of regime than in industries not affected by the legislation. Note that

We now turn to the econometric analysis of the determinants of market structure. Two alternative specifications are used below, of which the first uses the variable *COMP* while the second does not. The first is a panel data model, with concentration as the dependent variable and an intercept varying over industries to control for industry-specific effects. Three time dummies, for 1963, 1968 and 1975-77, are also included among the regressors. There are good reasons for this. The average five-firm concentration ratio across UK manufacturing industries increased by about 8 percentage points between 1958 and 1968, then changed very little between 1968 and the mid-1970s (Hart and Clarke 1980, Hart 1985). Now it was during the 1958-1968 period that the impact of the 1956 Act on competition was mostly effected. If the rise in concentration was partly or mainly caused by other factors, then the coefficient on the competition dummy would be seriously biased if the model were specified without time effects. Changes in the tax system in the mid-1960s that are thought to have encouraged mergers, economies of scale in distribution and the raising of finance, and the progressive opening of the British economy are some of the factors often cited as having contributed to the rise in concentration during the 1960s. It is very difficult to measure these factors at the industry level, but it may be plausible to assume that their impact would have been more or less realised across all industries; hence they should be largely captured by the time dummies.

An argument sometimes made in empirical studies of concentration is that,

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comparing the 1958-1968 figures with those for 1958-1975 may also be somewhat misleading since the industries are not exactly the same in the two cases due to missing or excluded observations.

as the concentration ratio is bounded between zero and one, it may be appropriate to take a transformation which is not bounded (see Wright 1978). The logistic transformation *logitC5* = ln[C5/(1-C5)] was therefore also tried as an alternative to the untransformed concentration ratio. The two sets of results were similar, and in fact heteroskedasticity was more pronounced in the regressions using *logitC5*. Hence only results for *C5* are reported below.

The above discusion suggests the following specification:

$$C5_{it} = \alpha_i + \beta_1 \ln DS_{it} + \beta_2 \ln(K/x)_{it} + \beta_3 COMP_{it} + \beta_4 Y63 + \beta_5 Y68 + \beta_6 Y75\text{-}77 + u_{it}$$

where *C5* is the four-digit industry five-firm sales concentration ratio, *DS* is four-digit industry sales revenue deflated by an industry-specific price index, "K/x" is either the three-digit capital stock of the average plant *K/N* or the three-digit capital-labour ratio *K/L*, *COMP* is a dummy variable which is equal to 0 for "collusive" and to 1 for "competitive" industry-year pairs, and *Y63*, *Y68* and *Y75-77* are time dummies for 1963, 1968 and 1975-77 respectively. As explained in section 4 above, for 1958 *COMP* takes the values 0 and 1 for cartelised and non-cartelised industries respectively, while for later years it typically takes the value 1 (except for a small number of industries where agreements continued). Industry-year pairs with ambiguous state of competition were excluded.

A possible objection to the above model is that some of the independent variables may be endogenous. This is probably not a serious problem for the market size and setup cost proxies, as the variation in these empirical measures across industries and five-year periods is likely to be mainly driven by the variation in the corresponding theoretical variables. *COMP*, while exogenous in

later years, may be endogenous in 1958. It is not possible to test formally for exogeneity since there are no appropriate instruments for the competition dummy. The fact, however, that there is no evidence from table 2 of any significant difference in market structure in 1958 between industries affected by the legislation and those not affected is reassuring. In addition, it can be argued that even if *COMP* is influenced in 1958 by certain variables which also affect concentration and are not included in the model, these variables are more likely to be part of the industry-specific effect than of the error term, thus causing no econometric difficulties. Hence, there is no reason to believe that endogeneity is likely to be a serious problem in the present context.

The second specification has again *C5* as the dependent variable, but adopts a more flexible approach in the modelling of the competition effect. The model is

$$C5_{it} = \alpha_i + \delta_1 \ln DS_{it} + \delta_2 \ln(K/x)_{it} + \delta_3 Y63 + \delta_4 Y68 + \delta_5 Y75\text{-}77 +$$
$$\delta_6 CHANGE * Y63 + \delta_7 CHANGE * Y68 + \delta_8 CHANGE * Y75\text{-}77 + \eta_{it}$$

where the interaction terms should capture any differences in the evolution of concentration after 1958 between industries with a change of competition regime (*CHANGE* = 1) and industries without such a change (*CHANGE* = 0). Thus the coefficient on *CHANGE*Y63* measures the effect of the 1956 Act on *C5* by 1963; the coefficient on *CHANGE*Y68* measures the effect by 1968; and the coefficient on *CHANGE*Y75-77* measures the effect by the mid-1970s. As already mentioned, this specification does not impose any structure on the competition data regarding the timing of the effect of the legislation, and allows for a comparison of short-run and long-run effects; on the other hand, it cannot take into

account some of the information about dates where particular agreements were abandoned.

Each of the two models was estimated for four different sub-samples of industries and the results are reported in tables 4 and 5. Results for a fixed effects specification are presented.[6] All the t-statistics are based on heteroskedasticity-consistent standard errors, adjusted for finite-sample bias following MacKinnon and White (1985). Note that in tables 4 and 5 two different R^2's are reported: the first is derived from transforming the data to obtain deviations from industry means and applying OLS to the transformed data, while the second is from applying OLS to the untransformed data after including a set of industry dummies among the regressors (the LSDV model). The difference between the two R^2's imply that industry-specific characteristics explain much of the cross-industry variation in concentration levels.

The first two columns in each of tables 4 and 5 contain regression results for exogenous sunk cost industries, including 38 industries with cancelled agreements.[7] The coefficients on the explanatory variables are generally

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[6] Results from the random effects model were very similar to those obtained from the fixed effects model with respect to the market size variable and the competition dummy, but not regarding the respective explanatory power of the time dummies and the setup cost proxies, which may imply that the random effects estimates are inconsistent. Also, the Hausman test typically rejects the random effects model.

[7] This number may seem small compared to the assertion (section 3) that nearly half of UK manufacturing was cartelised in the 1950s. The main reason for this apparent inconsistency is the fact that all sub-samples are unbalanced. The sub-sample of exogenous sunk cost industries for table 4, for example,

significant and have the expected sign. The coefficient on *COMP*, in particular, is positive and always statistically significant at the 1% or the 5% level. Moreover, the results from table 5 suggest that, while the effect of the legislation was only partly realised by 1963 (presumably because in many cases competition had still not emerged), it was almost fully realised by 1968 in exogenous sunk cost industries. The magnitude of these coefficients imply that the intensification of price competition following the 1956 legislation has raised, on average, the five-firm sales concentration ratio by about 6 percentage points in exogenous sunk cost industries. This may understate the impact of price competition on concentration to the extent that there is measurement error in the construction of *COMP* and *CHANGE* as a result of ineffective of unregistered agreements. On the other hand, the market size effect on concentration is everywhere negative and statistically significant at the 1% level.

The third and fourth columns in tables 4 and 5 contain results for industries with typical advertising-sales ratio higher than 1%, including 10 industries with cancelled agreements. The coefficient on *COMP* is positive and statistically significant at the 10% level, thus providing some evidence that the competition-concentration relationship holds in advertising-intensive industries. The results in table 5 again suggest that the effect of the Act was only partly realised by 1963. Moreover, there seems to have been some effect of the legislation even after 1968, although this is partly due to a few agreements continuing until the late 1960s. A second result from these regressions is the negative, large and typically significant coefficient on the market size variable. To test whether this might be related to the

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contains only 88 observations for 1958.

downward trend in advertising expenditure in UK manufacturing during the late 1960s and early 1970s, the model was re-estimated for the period 1958-1968 only. The market size coefficient had almost the same magnitude and the t-statistic was only slightly lower.

Note also the use of interaction variables to control for possible differences between advertising-intensive and R&D-intensive industries. In particular, *RD*lnDS, RD*lnK/N* and *RD*lnK/L* are equal to 0 for industries with typical or average R&D-sales ratio over the period lower than 1% and to *lnDS, lnK/N* and *lnK/L* respectively for industries with R&D-sales ratio higher than 1%.[8] No such interaction variable for the competition dummy was included in the model. As the number of industries with a change of competition regime in this sub-sample is only 10 (4 of which are also R&D-intensive), this variable would probably pick up random inter-industry differences in the magnitude of the competition effect rather than any systematic difference between advertising-intensive and R&D-intensive industries.

These results provide no evidence of any significant differences between exogenous sunk cost industries and industries with ADS > 1%. This may be because the 1% cut-off point is too low. Columns five and six in each of tables 4 and 5 contain results for industries with typical ADS > 2%. The market size coefficient in these regressions is nowhere statistically significant, suggesting that

[8] Whether an industry's typical R&D-sales ratio over a 10- or 20-year period is higher or lower than 1% is largely determined by exogenous characteristics, namely "technological opportunity". Hence these interaction variables are exogenous. The same can be said for the typical advertising-sales ratio (the exogenous characteristic being in that case "advertising effectiveness").

the concentration-market size relationship breaks down in industries with high advertising intensity. Nevertheless, the competition effect is statistically significant and large, although its magnitude should be interpreted with caution since the number of industries with a change of competition regime in this sub-sample is only 5. In any case, the 95% confidence intervals for the coefficient on *COMP* in this and the previous tables largely overlap, so there is no evidence of any difference in the magnitude of the competition effect on concentration across classes of industries. To check whether any of the 5 industries with a change of regime has a disproportionate impact on the results, the model was re-estimated excluding each of the 5 industries in turn. The coefficient on the competition variables or on *CHANGE*Y75-77* remained significant at the 5% level in most of these regressions, and was significant at the 10% level in all cases.

Finally, results for industries with typical R&D-sales ratio over the period higher than 1% are presented in the last two columns of each of tables 4 and 5. There are 10 industries with cancelled agreements in this sub-sample. *AD*lnDS*, *AD*lnK/N* and *AD*lnK/L* are interaction variables equal to 0 for industries with ADS < 1% and to *lnDS*, *lnK/N* and *lnK/L* respectively for industries with ADS > 1%. The results indicate that the competition effect on concentration persists even though the market size effect breaks down in R&D-intensive industries. In particular, the coefficient on *COMP* is everywhere positive, large and typically significant at the 5% level, while the coefficient on the market size variable is nowhere statistically significant. The results from table 5 show again some effect of the legislation after 1968, and, moreover, they show no effect by 1963. It should be noted, however, that this sub-sample includes two industries where agreements

were not abandoned until after 1963, two where competition did not fully emerge until after 1968, and one with a change of regime but for which *C5* is not available for 1968 although it is available for 1975 (so *CHANGE*Y75-77* picks up all the effect between 1963 and the mid-1970s in this industry).

These results are not driven by industries with medium R&D intensity. To check that the competition effect persists at high levels of R&D intensity, the model was also estimated using a sub-sample of industries with typical RDS > 2% over the period under study. There were 4 industries with a change of competition regime in this sub-sample. *COMP* and *CHANGE*Y75-77* (and even *CHANGE*Y68*) were everywhere positive and statistically significant at the 5% level.

6. Concluding remarks.

The empirical literature on the impact of price competition on market structure has so far been rather inconclusive. Although it seems plausible that competition policy has been a major factor behind the great US merger wave of the years 1898-1902, it has been difficult to isolate this effect from other influences on mergers, such as changes in corporation law and the growth of the stock market (Nelson 1959, Bittlingmayer 1985). And while it has been argued that differences in the evolution of concentration in the US and the UK can be partly attributed to differences in cartel policy in the two countries (Hannah 1979, Freyer 1992), previous studies of the impact of UK restrictive practices policy on concentration have produced mixed results.

In particular, Elliott and Gribbin (1977) examined restrictive agreements

between manufacturers' registered before 1960 and found that in industries with terminated agreements the rise in concentration between 1958 and 1968 was, on average, significantly greater than the rise in concentration in industries without agreements. They also noted, however, that market size was growing faster for industries in the latter group, so the cause of the difference between the two groups is not clear. Moreover, the criteria used to classify industries to one or the other group were not made explicit. O'Brien et al. (1979), on the other hand, examined a sample of about 30 industries and found no difference in merger activity during the 1960s between industries affected by the 1956 Act and industries not affected. Their sample was perhaps too small to be representative, however. Overall, the impact of restrictive practices policy on concentration in the UK has remained an unresolved issue (Walshe 1991).

This paper has analysed the evolution of concentration in British manufacturing following the termination of price-fixing agreements using a panel data set of four-digit industries over the period 1958-1977. The results support the hypothesis of a positive effect of the intensity of price competition on concentration both in exogenous and endogenous sunk cost industries. The concentration-market size relationship, on the other hand, while negative in exogenous sunk cost industries, breaks down in industries with high advertising or R&D intensity. Two implications can be drawn from these results. First, two key aspects of firms' conduct, namely the intensity of price competition and the level of endogenous sunk costs, are important determinants of market structure. Second, in endogenous sunk cost industries the market size effect and the competition effect on concentration are not analogous: the former breaks down as

the level of endogenous sunk costs increases, while there is no evidence that this generally happens for the latter (note, however, that data limitations have precluded testing in the present context whether the competition effect may break down at *very* high levels of endogenous sunk costs).

A key policy implication of the results on the competition-concentration relationship is that higher concentration need not be associated with less price competition; in fact, the opposite may be the case. This means that concerns with the level of concentration need not take precedence over the need to ensure that competition remains effective, i.e. firms do not engage in collusive practices and no barriers to entry are created. Moreover, the view taken in this paper is that the rise in concentration following an intensification of price competition, brought about by a change in cartel policy or otherwise, is the result of a structural mechanism and cannot therefore be avoided through the exercise of strict antitrust and merger policy. In fact, this view implies that there are important economic constraints in the exercise of these policies, since it would be impossible to impose a market structure so fragmented that it is not sustainable under more competitive conditions.

Table 1. Construction of the competition variable *COMP*.

	COMP			
	1958	1963	1968	1975-77
Industry				
A	0	0	0	0
B	0	0	1	1
C	0	E	1	1
D1	0	E	1	E
D2	0	E	E	1
D3	0	0	0	E
E	E	E	1	1
F	1	1	1	1

Note: *COMP* takes the value 0 for collusion and 1 for competition, while E denotes that the observation was excluded. The table covers all the different cases encountered in the sample of 291 industries. The large majority of industries fall under C, E or F.

Table 2. 1958 concentration and change of competition regime after 1958.

	Mean C5 in 1958 (St Dev. C5)
All industries:	
With change of regime (n=61)	0.585 (0.209)
No change of regime (n=86)	0.542 (0.282)
Exog. sunk cost industries:	
With change of regime (n=45)	0.544 (0.212)
No change of regime (n=42)	0.445 (0.279)
Industries with ADS > 1% :	
With change of regime (n=10)	0.737 (0.131)
No change of regime (n=34)	0.609 (0.270)
Industries with ADS > 2%:	
With change of regime (n=5)	0.707 (0.158)
No change of regime (n=17)	0.686 (0.231)
Industries with RDS > 1%:	
With change of regime (n=10)	0.704 (0.170)
No change of regime (n=21)	0.676 (0.193)

	Correlation between C5 and CHANGE in 1958
All industries (n=147)	0.084
87 exog. sunk cost industries	0.200
44 industries with ADS > 1%	0.217
22 industries with ADS > 2%	0.043
31 industries with RDS > 1%	0.074

Notes: The figures are based on 147 industries with unambiguous state of competition in 1958. *CHANGE* takes the value 1 for industries affected by the 1956 Act and 0 for those without change of competition regime after 1958. n indicates the number of industries.

Table 3. Average change in C5, 1958-1968 and 1958-1975.

	ΔC5 1958-68	ΔC5 1958-75
All industries with CHANGE = 1	0.119 (n=50)	0.147 (n=42)
All industries with CHANGE = 0	0.064 (n=76)	0.074 (n=71)
Exogenous sunk cost industries with CHANGE = 1	0.126 (n=36)	0.164 (n=27)
Exogenous sunk cost industries with CHANGE = 0	0.087 (n=37)	0.115 (n=34)
Industries with CHANGE = 1 and ADS > 1%	0.098 (n=9)	0.120 (n=9)
Industries with CHANGE = 0 and ADS > 1%	0.049 (n=31)	0.038 (n=30)
Industries with CHANGE = 1 and RDS > 1%	0.089 (n=8)	0.111 (n=9)
Industries with CHANGE = 0 and RDS > 1%	0.034 (n=19)	0.034 (n=17)

Notes: The figures in the first column are based on 126 industries with unambiguous state of competition and available observations for both 1958 and 1968. The figures in the second column are based on 113 industries with unambiguous state of competition and available observations for both 1958 and 1975. n indicates the number of industries.

Table 4. Regression results for C5. (Fixed effects estimation.)

	ADS, RDS <1%		ADS > 1%		ADS > 2%		RDS > 1%	
No. of observations:	657		354		180		372	
No. of industries:	155		73		37		87	
No. of industries with change of regime:	38		10		5		10	
lnDS	-0.072	-0.069	-0.093	-0.092	0.010	-0.001	0.013	0.014
	(-5.92)	(-5.26)	(-4.65)	(-4.52)	(0.04)	(-0.04)	(0.99)	(1.13)
COMP	0.053	0.049	0.056	0.056	0.115	0.108	0.075	0.074
	(2.48)	(2.22)	(1.86)	(1.89)	(2.30)	(2.23)	(2.26)	(2.30)
lnK/N	0.093	-	-0.005	-	-0.010	-	0.007	-
	(4.55)		(-0.21)		(-0.25)		(0.31)	
lnK/L	-	0.045	-	-0.019	-	-0.039	-	-0.016
		(1.36)		(-0.64)		(-0.76)		(-0.56)
Y63	0.010	0.028	0.049	0.051	0.033	0.039	0.007	0.011
	(0.75)	(1.84)	(2.46)	(2.70)	(1.03)	(1.28)	(0.34)	(0.51)
Y68	0.042	0.076	0.080	0.087	0.037	0.053	0.016	0.025
	(2.14)	(3.20)	(3.13)	(3.55)	(0.83)	(1.21)	(0.62)	(1.04)
Y75-77	0.041	0.086	0.108	0.120	0.037	0.065	0.017	0.030
	(1.68)	(2.52)	(3.40)	(3.82)	(0.59)	(1.01)	(0.60)	(1.06)
AD*lnDS	-	-	-	-	-	-	-0.072	-0.064
							(-2.73)	(-2.53)
RD*lnDS	-	-	0.023	0.027	0.014	0.024	-	-
			(0.74)	(0.87)	(0.34)	(0.59)		
AD*lnK/N	-	-	-	-	-	-	0.064	-
							(2.16)	
AD*lnK/L	-	-	-	-	-	-	-	0.074
								(2.37)
RD*lnK/N	-	-	0.022	-	0.004	-	-	-
			(0.79)		(0.12)			
RD*lnK/L	-	-	-	0.020	-	-0.004	-	-
				(0.62)		(-0.09)		
R^2	0.468	0.444	0.292	0.291	0.232	0.239	0.194	0.189
R^2_{LSDV}	0.956	0.954	0.954	0.954	0.944	0.945	0.947	0.947
Hausman:	6.46	25.62	54.60	53.92	21.02	25.05	27.61	19.80
Prob. value:	0.374	0.0003	≈0	≈0	0.007	0.001	0.0006	0.011

Note: t-statistics based on heteroskedasticity-consistent standard errors in parentheses.

Table 5. Regression results for C5. (Alternative specification, fixed effects estimation.)

	ADS, RDS <1%		ADS > 1%		ADS > 2%		RDS > 1%	
No. of observations:	542		301		153		294	
No. of industries:	116		57		29		64	
No. of industries with change of regime:	38		10		5		10	
lnDS	-0.069	-0.066	-0.098	-0.097	0.021	0.022	0.010	0.012
	(-5.55)	(-4.91)	(-5.18)	(-4.98)	(0.80)	(0.76)	(0.68)	(0.88)
lnK/N	0.099	-	-0.016	-	-0.014	-	0.029	-
	(4.87)		(-0.63)		(-0.31)		(0.91)	
lnK/L	-	0.043	-	-0.032	-	-0.048	-	-0.011
		(1.32)		(-1.04)		(-0.90)		(-0.32)
Y63	0.004	0.023	0.051	0.053	0.031	0.037	0.001	0.004
	(0.30)	(1.57)	(2.45)	(2.67)	(0.93)	(1.19)	(0.02)	(0.18)
Y68	0.030	0.069	0.093	0.100	0.044	0.060	0.008	0.022
	(1.54)	(2.97)	(3.46)	(3.90)	(0.91)	(1.33)	(0.28)	(0.83)
Y75-77	0.033	0.087	0.117	0.128	0.024	0.053	0.005	0.024
	(1.37)	(2.57)	(3.39)	(3.81)	(0.35)	(0.79)	(0.16)	(0.79)
CHANGE*Y63	0.039	0.035	0.025	0.025	0.034	0.030	-0.009	-0.009
	(1.70)	(1.49)	(0.65)	(0.66)	(0.62)	(0.56)	(-0.23)	(-0.22)
CHANGE*Y68	0.058	0.053	0.044	0.044	0.092	0.086	0.075	0.072
	(2.57)	(2.27)	(1.29)	(1.32)	(1.75)	(1.68)	(1.80)	(1.77)
CHANGE*Y75-77	0.061	0.058	0.063	0.063	0.128	0.122	0.098	0.096
	(2.74)	(2.50)	(2.12)	(2.19)	(2.58)	(2.53)	(2.69)	(2.72)
AD*lnDS	-	-	-	-	-	-	-0.066	-0.061
							(-2.24)	(-2.16)
RD*lnDS	-	-	0.021	0.024	-0.002	0.002	-	-
			(0.68)	(0.76)	(-0.05)	(0.05)		
AD*lnK/N	-	-	-	-	-	-	0.043	-
							(1.26)	
AD*lnK/L	-	-	-	-	-	-	-	0.065
								(1.94)
RD*lnK/N	-	-	0.032	-	0.013	-	-	-
			(1.15)		(0.36)			
RD*lnK/L	-	-	-	0.034	-	0.014	-	-
				(1.05)		(0.35)		
R^2	0.495	0.469	0.321	0.321	0.266	0.273	0.270	0.262
R^2_{LSDV}	0.952	0.950	0.950	0.950	0.935	0.936	0.926	0.925
Hausman:	3.24	22.58	50.20	56.45	41.10	26.05	14.98	16.76
Prob. value:	0.918	0.004	≈0	≈0	≈0	0.004	0.133	0.080

Note: t-statistics based on heteroskedasticity-consistent standard errors in parentheses.

DATA APPENDIX

The concentration data were mostly obtained from official publications: Summary Table 5 of the 1963 Census of Production; Summary Table 44 of the 1968 Census of Production; *Statistics of Product Concentration of UK Manufacturers for 1963, 1968 and 1975*, Business Monitor PO 1006 (HMSO, 1979); and *Statistics of Product Concentration of UK Manufacturers for 1975, 1976 and 1977*, Business Monitor PO 1006 (HMSO, 1980). Some additional unpublished concentration data for 1976 and 1977 were kindly made available by David Elliott from the Office of Fair Trading.

Data on value of manufacturers' sales at current net producer prices at the four-digit (or "product group") level of aggregation were obtained from the same publications as the concentration ratios, from the individual industry reports of the Census of Production (various years) and from Business Monitors. The figures are sales by all plants (or, for 1958 and 1963, firms) employing 25 or more persons.

Producer price indices for several four-digit industries have been published in the *Annual Abstract of Statistics*, in various issues of the *Board of Trade Journal* and *Trade and Industry*, in the *Annual Bulletin of Construction Statistics* and in Business Monitors. An alternative set of price indices can be constructed on the basis of data on volume of sales often reported, along with data on sales revenue, in the individual industry reports of the 1958, 1963 and 1968 Censuses of Production and in Business Monitors. Both sets of price indices are incomplete and have various shortcomings. The series of industry-specific price indices used in this study was constructed from all available information, after an evaluation of the likely accuracy of the figures on a case by case basis.

Estimates of the capital stock at the three-digit level of aggregation were taken from O'Mahoney and Oulton (1990). I have used their net capital stock figures after adjusting them by their estimate for the extent of premature scrapping of capital assets for all manufacturing industry after 1973. Capital stock was defined as plant and machinery,

because buildings and vehicles are to a large extent recoverable on exit. Data on the number of plants and employment at the three-digit level were taken from the relevant Summary Tables and from individual industry reports of the Census of Production (various years). Some figures were adjusted to ensure comparability over time in the light of changes in the definition of a number of three-digit industries, the treatment of very small plants, and the definition of "establishment". Plants employing less than 25 persons were not taken into account.

R&D expenditure data for the UK are available for various years since 1964 at a level of aggregation between the two-digit and the three-digit (the "sub-sector" level) and also for the mid- and late 1950s. They have been published in *Research and Development Expenditure*, Studies in Official Statistics no. 21 (HMSO, 1973); *Research and Development: Expenditure and Employment*, Studies in Official Statistics no. 27 (HMSO, 1976); *Industrial Research and Development Expenditure and Employment*, Business Monitor MO14 (various years); *Industrial Research in Manufacturing Industry: 1959-60* (Federation of British Industries, 1961); *Estimates of Resources Devoted to Scientific and Engineering Research and Development in British Manufacturing Industry, 1955* (HMSO, 1958); and *Industrial Research and Development Expenditure 1958* (HMSO, 1960). A comparison of the various sources suggests that there have not been many significant changes in R&D intensity at the sector level between the late 1950s and the mid-1970s, so all the sources were used to classify the industries according to their R&D intensity (measured as the ratio of company-funded R&D to sales). To derive R&D-sales ratios for four-digit industries, the UK data were used to determine R&D intensities at the sub-sector level and, in addition, US data were used as a guide for *relative* R&D intensities of industries within any UK sub-sector. R&D expenditure data for the US, at a level of aggregation between the three-digit and the four-digit, have been published by the Federal Trade Commission in the Annual Line of Business reports from 1973 to 1977.

Data on manufacturers' advertising expenditure come from a number of sources.

Summary Table 9 of the 1963 Census and Summary Table 4 of the 1968 Census contain data on advertising expenditure for "industry groups", i.e. at a level of aggregation between the two-digit and the three-digit. Data on press and TV advertising are also available for all years from the *Statistical Review of Press and TV Advertising*, published by Legion Information Services Ltd. until the early 1970s, and the *MEAL Monthly Digest of Advertising Expenditure*, published since 1968. The Legion/MEAL data are reported both for individual brands and for industries at a relatively low level of aggregation, but are often not available for low-advertising industries and relate to the domestic market rather than to UK firms. Finally, data on aggregate advertising expenditure by type of advertising have been published by the Advertising Association in *Advertising Expenditure 1960* (Advertising Association, 1962) and, subsequently, in the *Advertising Quarterly*.

A comparison of the various sources suggested that the Census figures probably include some expenditure which represents sales promotion rather than media advertising, and that the Legion/MEAL figures are both downward-biased due to incomplete coverage or non-coverage of certain media and upward-biased because they do not take into account discounts from published rates for TV advertising. The following procedure was adopted for deriving advertising-sales ratios at the four-digit level for industries covered by Legion/MEAL. A minimum ADS was derived using Census sales data, approximately adjusted for net imports using the *Annual Statement of the Trade of the United Kingdom*, and Legion/MEAL advertising data, adjusted to account for discounts from published rates. Also, a maximum ADS was estimated using Census sales and advertising expenditure data. The average of the two estimates was then taken, since this seemed, on the basis of a comparison of aggregate advertising expenditure figures reported in the various sources, to be a reasonable approximation to the true ADS. Industries for which Legion/MEAL data were not available were generally easy to classify as low-advertising industries.

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