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ARE SUTTON'S PREDICTIONS ROBUST?

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ABSTRACT

Are Sutton's Predictions Robust?

Sutton's widely acclaimed book on sunk costs and market structure contains several robust predictions. Sutton's empirical research mainly provides qualitative case insights from 20 food and beverage industries across six nations. The author tests Sutton's robust predictions across 1880 observations from both consumer and industrial goods markets. The empirical results consistently support Sutton's robust predictions. Specifically, concentration's minimum bound is higher in endogenous sunk cost markets than in exogenous sunk cost markets. Increasing market size tends to reduce concentration faster in exogenous sunk cost markets. Increasing the toughness of price competition slows the reduction of concentration in such markets. For endogenous sunk cost markets, the impact of market size on concentration tends to flatten out in relatively large markets. This indicates that in these relatively large markets, entry is effectively blockaded.

1. Introduction

John Sutton's Sunk Costs and Market Structure: Price Competition, Advertising, and the Evolution of Concentration (1991) has received an unusual amount of praise. Bresnahan (1992, p. 138) describes the publication as a "landmark book" and concludes it will "greatly influence the direction of the field." Schmalensee (1992, p. 125) says that Sutton's study is "masterful, innovative and thought provoking" and should be read by "every serious student of industrial economics."

One of the book's major strengths is that Sutton generates robust predictions from strategic entry theory, using variables that are easily operationalized such as concentration, market size, and advertising intensity. In contrast, much recent theoretical work generates predictions that are sensitive to subtle distinctions with concepts that are difficult to operationalize (Bresnahan 1992, p. 138). Such concepts include strategy, information, and irreversibility.

Robust predictions based on Sutton's theory rely on the distinction between exogenous and endogenous sunk costs. A sunk cost is both fixed and cannot be recovered; that is, it has no salvage value. An exogenous sunk cost (σ) is outside a business's control. Sutton classifies the cost to develop a manufacturing plant of minimum efficient scale (MES) as a key exogenous sunk cost. Though a portion of this fixed cost can typically be salvaged, total exogenous sunk costs are assumed to be proportionate to this level. To enter a market, every firm must incur the exogenous sunk cost.

In contrast, an endogenous sunk cost is determined by business strategy. An endogenous sunk cost influences consumers' willingness to pay for an individual firm's product offering. Sutton classifies advertising as a key endogenous sunk cost. Advertising is a sunk cost because it is a fixed cost and often has limited salvage value. Advertising is endogenous because a major portion of spending is influenced by the business's strategy and competitors' spending. R&D spending is another key endogenous sunk cost.

Sutton tests his robust predictions across 20 food and beverage industries in six different countries. Several of these industries have intensive advertising spending. None have intensive

R&D spending. Though his cross-sectional econometric model regresses concentration on market size, most of Sutton's data analysis relies on qualitative industry insights. Hence, Sutton's empirical results are largely based on (1) qualitative insights (2) across various food and beverage industries (3) that focus on intensive advertising spending.

The empirical results reported here are based on (1) more objective measures (2) across a heterogeneous sample of consumer and industrial goods markets (3) that can also have intensive R&D spending. The endogenous sunk cost markets can have intensive advertising spending, intensive R&D spending, or both.

PIMS (Profit Impact of Market Strategies) data are used to test Sutton's predictions. Estimates are developed for (1) the four-firm concentration ratio, (2) market size, and (3) various measures of the toughness of price competition. The sample covers 1880 businesses that all compete in mature markets. Because the PIMS data cover a broad range of industries that are typically located in North America, the robustness of Sutton's predictions can be tested across a large and heterogeneous sample.

The empirical results consistently support Sutton's robust predictions. Concentration's lower bound is the lowest in markets with exogenous sunk costs. Most of the empirical results address the relationship between market size and concentration. Increasing market size leads to a faster decline in concentration in exogenous sunk cost markets than in endogenous sunk cost markets. Tough price competition appears to be relatively important in markets with exogenous sunk costs. This is because in such markets, increasing market size leads to a slower decline in concentration. For endogenous sunk cost markets, the impact of market size on concentration flattens out in relatively large markets. This indicates that entry is effectively blockaded. No evidence of flattening is found in exogenous sunk cost markets.

2. Sutton's robust predictions

Sutton measures concentration by using the traditional four-firm concentration ratio (CR4), which equals the sum of the market share levels for the four largest competitors. Effective market size (S/MES) equals dollar sales (S) divided by the dollar sales potential of a manufacturing plant of minimum efficient scale (MES). This ratio estimates the market's maximum number of efficient sized manufacturing plants.

Concentration's lower bound. The first group of Sutton's robust predictions examine concentration's lower bound. In a market with only exogenous sunk costs, Sutton predicts "The function specifying the lower bound to equilibrium concentration converges monotonically to zero as market size increases" (p. 308). With only exogenous sunk costs, a continuing increase in market size gives additional entrants the opportunity to build a profitable scale of operations.

In Figure 1, the functional relationship is only a lower bound. For example, in a large market, a fragmented equilibrium can arise with many firms each producing from their own single MES plant. In this same large market, if a few firms each produce output from multiple MES plants, a concentrated equilibrium can arise.

In a market that also has endogenous sunk costs, Sutton predicts that "concentration remains bounded away from zero as market size increases" (p. 308). In Sutton's two-stage model, a firm trades losses from endogenous sunk costs in the first stage for long-term revenue gains in the second stage. As market size increases, long-term revenue gains in the second stage increase. Because of these long-term revenue gains, increasing market size leads to a continual increase in endogenous sunk costs. Eventually this spending becomes too high for a new entrant to handle. At this point, entry is blockaded. In Figure 1, entry is blockaded entry at point A.

Sutton's empirical results across 20 food and beverage industries support these predictions in the sense that concentration's minimum value in exogenous sunk cost industries is less than 5%. In endogenous sunk cost industries, where the advertising-to-sales ratio is greater than or equal to 1%, concentration's minimum value is 25%. Because food and beverage industries have low R&D spending, the empirical results only examine endogenous advertising spending.

Model specification. In the model specification, what we ideally want to estimate is the functional relationship between market size and concentration for a given industry. Sutton's cross-sectional data have multiple observations for each of 20 food and beverage industries. The multiple observations arise from as many as six countries. Dummy variables control for industry and country specific differences. His cross-sectional model specification is

$$CR4_{ij} = \alpha_{0,i} + \alpha_{1,j} + \alpha_2 \ln(S/MES)_{i,j} + \varepsilon_{i,j} \quad (1)$$

where $CR4_{ij}$ is the four firm concentration ratio for industry i in country j and ln(S/MES) is market size. $\alpha_{0,i}$ and $\alpha_{1,j}$ are dummy variables that control for industry and country specific differences. α_2 estimates the impact of market size on concentration. $\varepsilon_{i,j}$ is a random error term.

Sutton's model is estimated twice. Across 32 exogenous sunk cost markets, market size has a negative and significant impact on concentration. Across 58 endogenous sunk cost markets, the market size impact is an order of magnitude smaller and is not statistically significant.

For all practical purposes, the PIMS cross-sectional data consist of single observations from multiple industries.[1] Industry and country specific dummy variables therefore cannot be used. Instead, the model specification attempts to model key differences that arise across industries.

Figure 1 illustrates two potential structural relationships between market size and concentration. The endogenous sunk cost relationship has three major components: the downward-sloping component, the point at which the relationship flattens, and the height of the entire curve. This yields three key areas that require model flexibility.

The downward-sloping component is allowed to vary for exogenous and three types of endogenous sunk cost markets. This yields four variables. The downward sloping component also varies by using three measures of the toughness of price competition that interact with market size. Since each of the three toughness of price competition variables apply to the four types of sunk cost markets, this yields 12 variables. Thus, 16 variables help estimate the downward sloping component.

Theoretical guidance is not available to determine the point at which the functional relationship flattens. Thus, the data analysis below examines potential flattening for market size values at the 70th, 80th, and 90th percentiles.

The entire curve's height is influenced by additional variables. While Sutton's predictions do not address the curve's height, the additional variables help model industry specific differences and reduce the chance of specification error. The additional variables are discussed in the model specification section below.

Equation 2 extends Sutton's model specification by continuing to focus on the structural relationship between market size and concentration. The model specification does not estimate a single structural relationship. Instead, a flexible model specification attempts to estimate different structural relationships for different industries.

$$CR4_i = \beta_0 + \beta_{1j} \ln(S/MES)_{i,j} + \beta_{2j}\, STD^*\ln(S/MES)_{i,j} + \beta_{3j}\, Raw\ Mat^*\ln(S/MES)_{i,j} \quad (2)$$
$$+ \beta_{4j}\, IBO^*\ln(S/MES)_{i,j} + \beta_{5j}\, Flattening\ A_{i,j} + \varepsilon_i$$

where β_{1j} to β_{5j} are used to test the hypotheses. The i subscripts identify different industries and the j subscripts distinguish exogenous from endogenous sunk cost markets. When j equals 1, the market has exogenous sunk costs in the sense that both advertising and R&D spending as a percent of sales are low (LA LR). Following Sutton, low spending is less than 1% of sales. When j equals 2, 3, or 4 the market has important endogenous sunk costs. When j equals 2, the market has low advertising and high R&D spending (LA HR), 3 indicates it has high advertising spending and low R&D spending (HA LR), and 4 indicates both spending levels are high (HA HR).

$Ln(S/MES)_{i,j}$ tests for differences in the downward sloping component across exogenous and endogenous sunk cost markets. Differences in the downward sloping component are also tested using three measures of the toughness of price competition. STD equals 1 if the product is standardized, 0 if customized. Raw Mat equals 1 if the product is a raw or semi-finished material, 0 otherwise. IBO equals 1 if the market has infrequent buyer orders, 0 otherwise. Flattening A tests whether increasing market size past point A continues to decrease concentration. ε_i is a random error term with zero mean and variance σ^2_i.

While the model specification highlights key differences that should arise across industries, it is very difficult to generate consistent estimates of structural parameters (see Schmalensee 1989). To reduce the severity of this problem, most of the hypotheses focus on testing differences across exogenous and endogenous sunk cost markets. Coefficient differences are only influenced if excluded industry factors influence the coefficients in different types of sunk cost markets differently. Thus, testing coefficient differences should help eliminate coefficient bias.

Some hypotheses though address the structural relationship between market size and concentration. Because structural coefficients are more prone to bias, these results should be viewed as "ball park" figures. Note, the empirical results below indicate that structural coefficient bias is not an overwhelming problem. This is because the results are generally consistent with Sutton's predictions.

Market size hypotheses. Sutton predicts that for exogenous sunk costs, increasing market size leads to a monotonic decrease in concentration's lower bound ($\beta_{1,1} < 0$). This is because increasing market size continues to provide opportunities for profitable entry. In endogenous sunk cost markets, Sutton predicts "there is no longer any *monotonic* relationship, in general, between market size and minimal concentration levels" (p. 308). For example, with intensive advertising, the directional impact of market size depends on whether the market started with a relatively large or a relatively small number of competitors. If the market starts with a large number of competitors, increasing market size can make endogenous sunk cost spending more cost effective. This can actually increase concentration. In endogenous sunk cost markets, the predicted sign for the impact of market size on concentration is ambiguous. Even so, it should not be as negative as in exogenous sunk cost markets. In other words, $\beta_{1,1} < \beta_{1,2}$, $\beta_{1,3}$, and $\beta_{1,4}$.

Toughness of price competition hypotheses. In exogenous sunk cost markets, as market size increases, tough price competition should discourage entry.[2] The reason is that tougher price competition requires an even greater increase in market size for an additional entrant to be profitable. Thus, in Figure 2, the slope of the relationship between market size and concentration is reduced. Sutton predicts the toughness of price competition is only important in markets with exogenous sunk costs. This is because endogenous sunk costs, which typically include advertising and R&D spending, increase product differentiation. Increasing product differentiation should decrease the importance of price competition.

Each measure of the toughness of price competition interacts with ln (S/MES). Though measuring the toughness of price competition is difficult, three measures are used below. Price competition should be tougher for standardized (STD) than for customized products ($\beta_{2,1} > 0$). Because customized products are often heterogeneous and complex (Scherer and Ross 1990), they are likely to compete on a nonprice or feature basis. Because fewer opportunities arise for nonprice competition among standardized products, price competition should be tougher. Based on a similar lack of nonprice competition, price competition should be tougher for raw or semi-finished material (Raw Mat) than for other types of consumer and industrial products ($\beta_{3,1} > 0$).

Price competition should be tougher when buyers' orders are infrequent (IBO) ($\beta_{4,1} > 0$). Because of buyer power, infrequent buyer orders can generate price concessions by pitting one supplier against another (Scherer and Ross 1990). The dummy variable equals 1 if there are less than 150 key buyer orders per year and 0 otherwise.[3] Key buyer orders come from the largest customers who account for 50% of the business's sales.

As mentioned above, Sutton predicts tough price competition is more important in exogenous than in endogenous sunk cost markets. Thus, $\beta_{2,1} > \beta_{2,2}$, $\beta_{2,3}$, and $\beta_{2,4}$; $\beta_{3,1} > \beta_{3,2}$, $\beta_{3,3}$, and $\beta_{3,4}$; and $\beta_{4,1} > \beta_{4,2}$, $\beta_{4,3}$, and $\beta_{4,4}$.

Flattening hypotheses. Probably the most important extension to Sutton's cross-sectional model examines concentration's lower bound in endogenous sunk cost markets. If spending on endogenous sunk costs in large markets becomes so great that increasing market size no longer influences concentration, then entry is blockaded.

Equation 2 models this relationship with a variable that flattens the impact of market size on concentration (Flattening A). In Figure 1, the value of market size at point A equals $\ln(S/MES)_A$. In endogenous sunk cost industries, Figure 1 predicts that any increase in market size beyond point A will not influence concentration. The increase in market size for any industry i beyond point A equals $\ln(S/MES)_i - \ln(S/MES)_A$. The Flattening A variable equals $\ln(S/MES)_i - \ln(S/MES)_A$ when this difference is positive, zero otherwise.

A perfectly flat relationship yields the concentration level at point A for any value of market size beyond point A. When price competition is not tough, this arises when $\beta_{5,j}$ equals $-\beta_{1,j}$. This is because the total market size impact beyond point A equals the market size impact, $\beta_{1,j}*\ln(S/MES)_i$, plus the flattening impact, $\beta_{5,j}*[\ln(S/MES)_i - \ln(S/MES)_A]$. For the sum of these two values to remain constant, $\beta_{5,j}$ must equal $-\beta_{1,j}$.

Because the flattening arises from escalating endogenous sunk cost spending, no flattening should occur in exogenous sunk cost markets ($\beta_{5,1} = 0$). More flattening should arise in endogenous sunk cost markets. Thus, $\beta_{5,1} < \beta_{5,2}$, $\beta_{5,3}$, and $\beta_{5,4}$.

3. Data

The PIMS data are based at the Strategic Planning Institute. Each observation is from a relatively self-contained business unit or division. Because each business must choose to submit data to the Strategic Planning Institute, the PIMS data are self-selected. Caves (1986, p. 198-199) and Scherer and Ross (1990) provide additional PIMS data insights.

PIMS businesses represent a wide range of firms typically among the Fortune 1000. The vast majority compete in North America. This sample composition is a strength in testing the flattening of the impact of market size on concentration. The PIMS sample covers many of the largest markets in the world. If flattening is not observed in these very large markets, it is not clear where the theoretical predictions would be supported.

The sample composition is a weakness in testing the prediction that in very large exogenous sunk cost markets, concentration's lower bound approaches zero. The reason is that Fortune 1000 firms do not tend to compete in highly fragmented markets. However, some evidence on concentration's lower bound can be obtained by comparing concentration's minimum values in exogenous versus endogenous sunk cost markets.

PIMS market boundaries (1) are based on substitution in consumption rather than similarity of production methods and (2) are not forced to be national in scope. Evaluating market boundaries is often subjective, but the subjectivity can be reduced by following the PIMS Data Manual's (1978) detailed guidelines. In most cases, PIMS market boundaries are narrower than four-digit SIC codes. This is consistent with Scherer and Ross's (1990, p. 423) observation that, "More often than not, four-digit Standard Industrial Classification industries are too broadly defined".

Because Sutton's predictions focus on long-term equilibrium, the sample is composed only of mature markets (young, rapidly growing, or declining markets are deleted). A mature market has "products or services familiar to a vast majority of prospective users; technology and competitive structure (are) reasonably stable" (PIMS Data Manual 978). This corresponds to Gort and Klepper's (1982) Stage V in the diffusion of product innovations, which has approximately zero net entry. More than 80% of the markets in the sample are at least 20 years old. Because start-up ventures are excluded, the market must be at least eight years old.

To provide a relatively homogeneous sample, only consumer and industrial goods manufacturing businesses are examined (service and distribution businesses are deleted). Despite these restrictions, the sample size equals 1880 observations.

Key measurement issues. Table 1 provides definitions and descriptive statistics for the model variables. Whenever possible, the variable definitions follow Sutton. The Appendix describes how four variables are estimated as a function of two or more variables.

How do the PIMS variables used in the hypothesis testing compare to those used in other studies? Concentration equals the sum of the market share levels for the four leading competitors in the market. Because managers supply this information along with the market boundaries, it should be more accurate than studies that have market boundaries based on SIC codes.

Market size or ln (S/MES) equals the natural log of the ratio of served market sales divided by the dollar sales that a minimum economically efficient capacity increment can generate. This engineering based estimate provided by managers should be more accurate than the market's median plant size, which often proxies minimum efficient scale. This is because median plant size can induce a spurious and positive correlation with concentration. For example, see Davies (1980) and Sutton (1992, p. 99).

The PIMS data provide measures of the business's advertising/sales and product R&D/sales. It does not provide industry level estimates. For advertising/sales, an estimate of how the business's spending compares with leading competitors is provided. These two variables are combined to estimate industry advertising/sales. Because managers often do not have an accurate sense of competitors' R&D spending, R&D/sales is provided only for the reporting business. Both industry advertising/sales and R&D/sales should have more random measurement error than other studies with access to industry level spending. This PIMS based random measurement error will tend to weaken the empirical results.

The most challenging variable to measure is the "toughness of price competition". This is because 1) the PIMS data does not provide a direct measure and 2) Sutton does not provide any empirical guidelines. Three industry characteristics attempt to measure the toughness of price competition. These primitive industry characteristics cover standardized products, raw or semi-finished materials, and infrequent buyer orders. While these measures are primitive, they are relatively objective and provide a step in the direction of establishing measurement guidelines.

In the hypothesis testing, the key use of the advertising/sales and R&D/sales variables is to distinguish exogenous from endogenous sunk cost markets. An exogenous sunk cost market has both low advertising and low R&D spending. As in Sutton's work, low or nonintensive spending is less than 1% of sales for both advertising and R&D. On the basis of these guidelines, the sample has observations from 862 exogenous sunk cost markets. The endogenous sunk cost markets cover low advertising and high R&D (n=563), high advertising and low R&D (n=234), and high advertising and high R&D (n=221).

4. Concentration's lower bound

Table 2 compares Sutton's results for concentration's lower bound with the PIMS data results. In exogenous sunk cost markets, Sutton predicts that as market size increases, concentration declines monotonically towards zero. Thus, in a sample with many large markets, CR4's minimum value should be close to zero. For endogenous sunk cost markets, Sutton predicts that concentration should be bounded away from zero, regardless of market size. Sutton's predictions tend to be supported across 20 food and beverage industries.

Are these predictions also supported in the larger and more heterogeneous PIMS data? For markets with low advertising and low R&D spending, CR4's absolute minimum value is 6%. Because measurement error across 1880 observations in terms of defining market boundaries, estimating advertising intensity, and so on could determine the absolute minimum value, the first or second percentile is probably a more accurate lower bound. For low advertising and low R&D industries, the first percentile equals 12%. This is higher than Sutton's minimum value, which is below 5%. As mentioned previously, the lack of extremely fragmented markets in the PIMS data limits the testing of this prediction.

Despite this limitation, we can conclude that concentration's minimum value is the lowest in exogenous sunk cost industries. Across the entire sample of 1880 observations, 16 of the 18 observations with CR4 less than 15% are in the low advertising and low R&D sample. The probability is less than 1% that at least 16 observations are in this sample purely by chance. Hence, it is likely that concentration's lower bound is the lowest in exogenous sunk cost industries.

Recall Sutton's prediction that concentration should be bounded away from zero in endogenous sunk cost industries. In the low advertising and high R&D markets, concentration's first percentile equals 25%. The results for markets with high advertising and low R&D spending are similar. In markets with high advertising and high R&D spending, CR4's first percentile only equals 18%, which is 6 CR4 points higher than the exogenous sunk cost markets. These results consistently support Sutton's predictions.

Note that concentration's lower bound in Table 2 is higher for markets with only one type of endogenous sunk cost than for markets with endogenous sunk costs in both advertising and R&D. One explanation is that the 1% cutoff could ignore important differences in average spending levels in the three endogenous sunk cost samples. This explanation though is not supported. This is because average R&D spending is 2.81% for high advertising and high R&D markets versus 3.04% for the low advertising and high R&D markets. The same conclusion holds in the two high advertising samples where average spending is 3.84% and 3.70%.

An alternative explanation is that greater opportunities arise for product differentiation in markets with endogenous sunk costs in both advertising and R&D. Product differentiation can yield higher prices that help offset cost disadvantages for small-scale firms.

5. Model specification and estimation

The single equation model specified above explains concentration (CR4). To maintain consistency with Sutton's model, CR4 is linear. Differences across markets are examined using dummy variable interaction terms for the three endogenous sunk cost markets. LA HR equals 1 for a low advertising and high R&D market, 0 otherwise. High advertising and low R&D markets (HA LR) and high advertising and high R&D markets (HA HR) use similar dummy variables. The three dummy variables are multiplied by market size, the three toughness of price competition variables, and the flattening variable. This yields 15 dummy variable interaction terms.

Additional explanatory variables. In model estimation, eight additional variables are added to reduce the risk of specification error. The additional variables are advertising/sales, R&D/sales, three measures of first-mover advantages, capital intensity, capital's depreciation rate, and serving a regional market[4]. To reflect diminishing marginal returns, logarithms are taken for each of the continuous variables (though not for the dummies or for the categorical variables).[5] The reasoning behind their selection is briefly described below.

While dummy variables for advertising/sales and R&D/sales are used in the interaction terms, additional information may also be present in their continuous functional form. Increasing advertising/sales and R&D/sales beyond the 1% level used in the dummy variables can increase concentration by increasing sunk costs. Also, by spreading fixed costs, increasing advertising/sales and R&D/sales increases scale economies, which should tend to increase concentration. See Curry and George's (1983), Schmalensee (1989), and Scherer and Ross (1990).

Sutton (1991, Ch. 9) highlights the importance of first-mover advantages in increasing concentration. By helping to preserve a first-mover advantage, product patent protection can also increase concentration. Market pioneers in consumer markets tend to have higher shares when the product's purchase price is less than $10 (Robinson and Fornell 1985). This finding is consistent with Schmalensee's (1982) model of informational advantages for first movers in markets where consumers tend to buy from habit. Market pioneers in industrial markets tend to have higher shares when the product's purchase price exceeds $10,000 (Robinson 1988). When the level of perceived risk is high for big-ticket items, a switching-cost advantage accrues because customers tend to rely on known suppliers.

Schmalensee's (1989) survey concludes that capital intensity is positively correlated with concentration. Sunk capital costs can deter entry when an incumbent makes preemptive investments in capacity. For example, see Dixit (1980) and Eaton and Ware (1987). Kessides (1990) reports that rapidly depreciating capital tends to decrease concentration. Rapidly depreciating capital reduces the effectiveness of a preemptive investment to deter entry.

Schwartzman and Bodoff (1971) report lower concentration in regional versus national markets. Factors such as scale diseconomies and high transportation costs which lead to a fragmented geographic scope can also lead to a fragmented competitive structure.

Endogeneity. While the results are mixed, some research indicates that advertising/sales and R&D/sales have a simultaneous relationship with concentration. See Schmalensee (1989) and Scherer and Ross (1990). This is because spending levels can change as an industry moves from being fragmented to oligopolistic to a near monopoly. The predicted impact of concentration on spending has a functional form similar to an inverted-U. If advertising/sales and R&D/sales have a simultaneous relationship with CR4, then the single equation model above will yield an inconsistent coefficient estimator.

Recall the hypothesis testing is based on dummy variables that are functions of advertising and R&D spending. The hypothesis testing results will be influenced if a simultaneous relationship exists and this relationship has an important influence on the classification of high and low spending. I. e. there are frequent changes in the classification of exogenous and endogenous sunk cost markets.

If a simultaneous relationship exists, it appears to be statistically fragile. This is based on the mixed results in the literature and Sutton's conclusion that "the estimation of simultaneous equation systems in this area have not proved fruitful" (p. 125). Thus, it seems unlikely that a statistically fragile relationship would have an important impact on the hypothesis testing results.

Also, if a simultaneous relationship exists, instrumental variables are needed for the two linear terms and for each of the fifteen interaction terms. Unfortunately, the PIMS data are not rich enough to develop effective instruments for these seventeen variables[6]. Thus, the single equation model assumes that advertising/sales and R&D/sales do not have a simultaneous relationship with CR4. A single equation modeling approach is also used by Kessides (1986), Sutton (1991), and Lieberman (1993).

Heteroscedasticity. In cross-sectional models, one often encounters a heteroscedastic random error term (ε_i). Heteroscedasticity arises when $E(\varepsilon_i^2) = \sigma_i^2$ for i = 1, . . . , n and $\sigma_i^2 \neq \sigma_t^2$ for some t > 1. With heteroscedasticity, it is well known that the ordinary least squares (OLS) coefficient estimator is unbiased, but inefficient. Because the t-statistics are biased, hypothesis testing often yields faulty inferences.

Glejser's (1969) test regresses the absolute value of the OLS residuals on the independent variables. This test does not point to any single variable or simple combination of variables that determine the heteroscedasticity. Heteroscedasticity though is inversely related to the expected value of the dependent variable. To correct this problem, generalized least squares (GLS) estimation specifies:

$$\sigma^2{}_i = \sigma^2/[E(CR4)_i]^2 \qquad (3)$$

where $E(CR4)_i$ is the expected value of CR4. In model estimation, $E(CR4)_i$ is the forecasted value of CR4 from the OLS model (see Kmenta 1986).

6. Results

Table 3 provides the OLS and GLS results. The first model specification is limited to variables that are used in empirical studies prior to Sutton (1991). It explains 21% of CR4's variation. The second model specification only includes variables used in testing Sutton's hypotheses. It explains 26% of CR4's variation. Thus, Sutton's predictions yield meaningful gains in explained variation versus other explanations of concentration. The third specification combines the two sets of variables. It explains 29% of CR4's variation.

The GLS results in the fourth specification test the hypotheses. Because each hypothesis has a specific sign prediction, statistical significance is based on one-tail tests. Note the similarity of the individual coefficient estimates across the last three sets of results. This shows the hypothesis testing results are robust in terms of both the additional explanatory variables and OLS versus GLS estimation.

Market size hypotheses. Market size in low advertising and low R&D markets has the expected negative impact (-8.04) on CR4. Also, as expected, this impact is dampened in markets with low advertising and high R&D (2.13) and high advertising and low R&D (3.49). Given these results, it is surprising the impact in high advertising and high R&D markets is not dampened (.41). Even so, two out of three estimates support Sutton's prediction that market size has the strongest negative impact in exogenous sunk cost markets.

How fast does CR4 decline as market size increases? As discussed below, most evidence for flattening arises at the 80th percentile of market size or higher. Thus, to estimate the decline in the downward sloping component, the comparison is made from the 20th to the 80th percentile. Across the entire sample, market size ranges from 13 MES plants at the 20th percentile to 191 MES plants at the 80th percentile.

For exogenous sunk cost markets, CR4's predicted structural decline multiplies the difference of ln(191) minus ln(13) by the coefficient estimate -8.04. This yields a 22 CR4 point decline. A 22 point decline also arises for high advertising and high R&D markets. The predicted decline for low advertising and high R&D markets is 16 CR4 points. For high advertising and low R&D markets, it is 12 CR4 points. Because there are almost 15 times more MES plants at the 80th percentile than at the 20th percentile, these structural declines seem modest.

Toughness of price competition hypotheses. Table 3's results consistently support Sutton's prediction that tough price competition is important in exogenous sunk cost markets. This is because the impact of market size on concentration is dampened when products are (1) standardized rather than customized (2.30), (2) raw or semi-finished materials (1.15), and (3) there are infrequent buyer orders (3.24). The results also support Sutton's prediction that price competition is tougher in exogenous than in endogenous sunk cost markets. Eight of the nine interaction terms have the expected negative sign and five are statistically significant.

Does tough price competition also increase concentration in endogenous sunk cost industries? The structural impact for the toughness of price competition sums the coefficients for the exogenous sunk cost variable plus the interaction term. For example, the sum for standardized products in low advertising and high R&D markets is 2.30 minus 1.39 or .91. It is not statistically significant, indicating this form of tough price competition does not increase concentration.

The three types of endogenous sunk cost markets and the three measures of the toughness of price competition yield nine structural estimates. At the 10% level or better, only three of the nine structural estimates are significantly greater than zero[7]. Thus, tough price competition in endogenous sunk cost markets has a relatively modest structural impact on CR4.

Across markets, how frequently do these aspects of tough price competition arise? Table 4 shows that standardized products are sold by 75% of the low advertising and low R&D markets, 74% of the low advertising and high R&D markets, 95% of the high advertising and low R&D markets, and 94% of the high advertising and high R&D markets. Most markets do not sell raw or semi-finished materials and do not face infrequent buyer orders[8].

For a typical market that sells standardized products, how much less will CR4 decrease when market size increases from the 20th to the 80th percentile? For exogenous sunk cost markets, the structural increase multiplies 2.30 by ln(191) minus ln(13). This yields 6 CR4 points. For the endogenous sunk cost markets, the CR4 impact ranges from plus 2 to minus 2 CR4 points.

Flattening hypotheses. Sutton predicts the impact of market size on concentration flattens only in endogenous sunk cost industries. To test this prediction, flattening points are tested that correspond to the 70th, 80th, and 90th percentiles. The values correspond to markets that can potentially hold 115, 191, and 390 MES plants. If flattening occurs, it is most likely to be at the 90th percentile. Therefore, Table 3 reports the 90th percentile results.

As predicted, even at the 90th percentile there is no evidence of flattening in exogenous sunk cost markets (-.25). Clear evidence of flattening arises in the two endogenous sunk cost markets that have high advertising. The flattening estimates of 11.49 and 9.17 are both positive and statistically significant. Only modest evidence arises for flattening in low advertising and high R&D markets. The evidence is modest because the coefficient estimate is economically significant, but it is not statistically significant (6.43, t=1.08).

While the evidence points to flattening, does the flattening completely offset the downward sloping component? I. e. the structural relationship is not significantly different from zero. This question is complicated because the toughness of price competition yields different downward sloping components for different markets. Even so, the typical market sells a standardized product, but does not sell raw materials and does not face infrequent buyer orders. Thus, the typical structural flattening impact sums the market size, standardized product, and flattening impact.

Table 5 shows the typical structural flattening impact. As expected, no evidence of flattening arises in the low advertising and low R&D markets. Evidence of flattening arises though in all three endogenous sunk cost markets. This is because all three estimates are positive rather than negative. (In comparison to the individual flattening estimates, this indicates that flattening also arises in low advertising and high R&D markets.) Also, note the estimate for high advertising and low R&D markets is significantly greater than zero. Thus, the structural relationship may actually turn up in high advertising and low R&D markets.

While these results support flattening at the 90th percentile, at what point does flattening arise? One approach assumes the flattening point arises when the typical structural flattening impact equals zero, i. e. when increasing market size has no predicted impact on CR4. While the exact flattening point is difficult to determine, Table 5 summarizes the typical structural flattening impact at the 70th, 80th, and 90th percentiles.

In low advertising and high R&D markets, the typical structural flattening impact should equal zero between the 80th and 90th percentiles. This is because the structural estimates are -3.40 and 1.18. The 80th to 90th percentile result also arises for high advertising and high R&D

markets. In high advertising and low R&D markets, the typical structural flattening impact appears to equal zero between the 70th and 80th percentile.

This approach though assumes the structural relationship does not turn up in very large markets. If it does turn up, a structural estimate that equals zero averages a negative downward sloping component and a positive upward sloping component. Because the flattening point should exclude the downward sloping component, the flattening point estimate will be too low.

Recall the structural relationship appears to turn up in high advertising and low R&D markets. Thus, the flattening point is probably higher than the 70th to the 80th percentile. While a more specific point can not be determined, it is more likely to arise between the 80th and 90th percentiles.

7. Summary and conclusions

The robustness of Sutton's predictions is tested across both exogenous and endogenous sunk cost industries. The endogenous sunk cost industries have either intensive advertising spending, intensive R&D spending, or both. The PIMS sample of 1880 observations includes many of the largest markets in the United States.

Sutton's predictions are consistently supported. First, concentration's lower bound is the lowest in the exogenous sunk costs markets. Excluding very fragmented markets from the PIMS sample though limits insights into the specific lower bound. Lower bound insights for endogenous sunk costs markets should be more accurate. This is because the vast majority of markets with very low concentration are in the exogenous sunk cost sample. Also, Sutton's lower bound of 25% is consistent with the PIMS first percentile values that range from 18% to 25%.

Second, increasing market size tends to reduce concentration faster in exogenous sunk cost markets. Increasing market size from the 20th to the 80th percentile in such markets decreases concentration by 22 points. This compares to a predicted decline of 16 CR4 points in low advertising and high R&D markets and 12 points in high advertising and low R&D markets. An exception though is high advertising and high R&D markets where CR4 also declines by 22 points.

Third, the toughness of price competition is relatively important in exogenous sunk cost markets. (Price competition is assumed to be tougher in markets with customized products, raw or semi-finished materials, and infrequent buyer orders.) This is because increasing market size leads to a slower decline in concentration.

Fourth, the impact of market size on concentration tends to flatten in all three endogenous sunk cost markets. Because this finding indicates that entry is effectively blockaded in very large endogenous sunk cost markets, this is probably the most important empirical result. While it is difficult to estimate the point at which the functional relationship flattens, it appears to flatten between roughly 200 and 400 plants of minimum efficient scale.

One set of surprising results relates to markets that have both intensive advertising and intensive R&D spending. Because these markets have the highest average sunk cost spending, they should generate the strongest empirical results. The empirical results though are not stronger. Some results are actually weaker. For example, CR4's first percentile value is 25% for low advertising and high R&D markets and 24% for high advertising and low R&D markets. Instead of being higher, the first percentile value for high advertising and high R&D markets is actually lower at 18%.

While it is not clear why high advertising and high R&D markets do not generate the strongest results, it may be because these markets provide many opportunities for product differentiation. Product differentiation can yield higher prices that help offset the cost disadvantages for small-scale firms.

Alternative explanations. While Sutton's theory emphasizes the important role of endogenous sunk costs in the first period of commercialization, dynamic sunk cost competition could also be at work. As a market's size increases over time, competitive rivalry can increase annual fixed spending levels for both advertising and R&D (Schmalensee 1992, p. 130). This type of dynamic sunk cost competition is closely related to Sutton's sunk cost competition, but is different because it is not limited to the first period of commercialization.

Only primitive measures such as standardized products, raw or semi-finished materials, and infrequent buyer orders assess the toughness of price competition. Of course, this type of primitive measure may also proxy other variables. For example, instead of reflecting the toughness of price competition, raw or semi-finished materials may reflect cornering scarce natural resources. This can also limit market entry. While alternative explanations can be provided for individual measures, the overall pattern of results is consistent with Sutton's predictions.

Conclusion. This study illustrates a fundamental research tradeoff described by Sutton as precision of prediction versus breadth of application (p. 7). Sutton's in-depth industry research in conjunction with an econometric model that controls for industry specific differences yields relatively precise research insights into 20 food and beverage industries. In contrast, the PIMS data provide a much greater breadth of application. A broad application is especially useful to test robust predictions. While more research remains to be done, this broad empirical evidence indicates that Sutton's predictions are in fact robust.

Footnotes

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1 Because the PIMS data include detailed and confidential financial data, the businesses and industries are not identified. Donald J. Swire, Director of Research at the Strategic Planning Institute, says that a precise estimate of the degree of overlap of observations from the same market is not available. Even so, he estimates that the overlap in the PIMS sample should arise in less than 5% of the sample.

2 If price competition gets tougher after firms have already entered the market, financial losses can eventually force some competitors to either exit or, if permitted by law, merge. Exit or merger typically increases concentration.

3 Theory does not specify the functional relationship between the number of key buyer orders and CR4. The dummy variable functional form is based on visually examining the descriptive relationship between these two variables, which is more dichotomous than linear.

4 Other variables in Curry and George (1983) and Sutton (1991) that appear to influence concentration are average firm size, the average number of plants per firm, initial capital requirements, and government regulation. These variables are not available in the PIMS data.

5 To avoid taking the logarithm of zero, 1.0 is added to each variable whose minimum value is zero. These variables are advertising/sales, R&D/sales, and depreciation/gross book value.

6 Instrumental variables were developed to classify advertising and R&D spending as either high or low. These classifications were then used to develop instrumental variables for the fifteen interaction terms. An instrumental variable for advertising/sales was based on the statistically significant industry level variables in Caves (1986). An instrumental variable for R&D/sales was based on the statistically significant variables in Angelmar (1981). Because each instrument explained less than 50% of the variation in the original variable, they were not effective.

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7 Two of the three significant sums are in low advertising and high R&D markets. These are for standardized products (.91, $t = 2.09$) and infrequent buyer orders (2.11, $t = 4.80$). The third is for raw or semi-finished materials in high advertising and high R&D markets (2.28, $t = 1.47$).

8 Note, the high advertising markets have relatively little variation across the three measures of the toughness of price competition. This is a key reason why their interaction terms have relatively large standard errors.

Appendix

Four of Table 1's key variables that are used in the hypothesis testing must be estimated as a function of two or more variables.

Concentration: PIMS provides estimates of the business's market share, the market share levels for the three leading competitors, and the business's market share rank. When the business is among the top four competitors, the sum of the four market shares equals CR4. Such is the case for 88% of the sample.

For the remaining 12% of the sample, an estimate is needed for the fourth highest market share. Empirically, a competitor's market share tends to be a constant ratio relative to the share of the next highest ranking firm. Across the PIMS data, Buzzell (1981, p. 46) estimates the size ratio typically equals .6. Thus, the fourth highest market share is estimated by multiplying .6 times the third highest market share.

Ln (S/MES): Each reporting PIMS business provides two ratios, (1) the sales potential from a minimum economically efficient capacity addition (MES) divided by the sales of business's standard capacity (STD CAP) and (2) the ratio of the sales potential of the business's standard capacity (STD CAP) divided by served market sales (S). Multiplying these two variables and taking the inverse equals served market sales (S) divided MES or S/MES. The sample's median value for S/MES equals 20. This value is consistent with estimates of minimum efficient plant scale, which tend to be less than 10% of United States market demand (see Scherer and Ross 1990, p. 115).

Advertising/Sales: Approximate industry advertising as a percentage of sales equals the business's media advertising as a percentage of sales weighted by its market share plus competitors' approximate media advertising as a percent of sales weighted by their market share. (Competitors' market share equals 100-less the business's market share.)

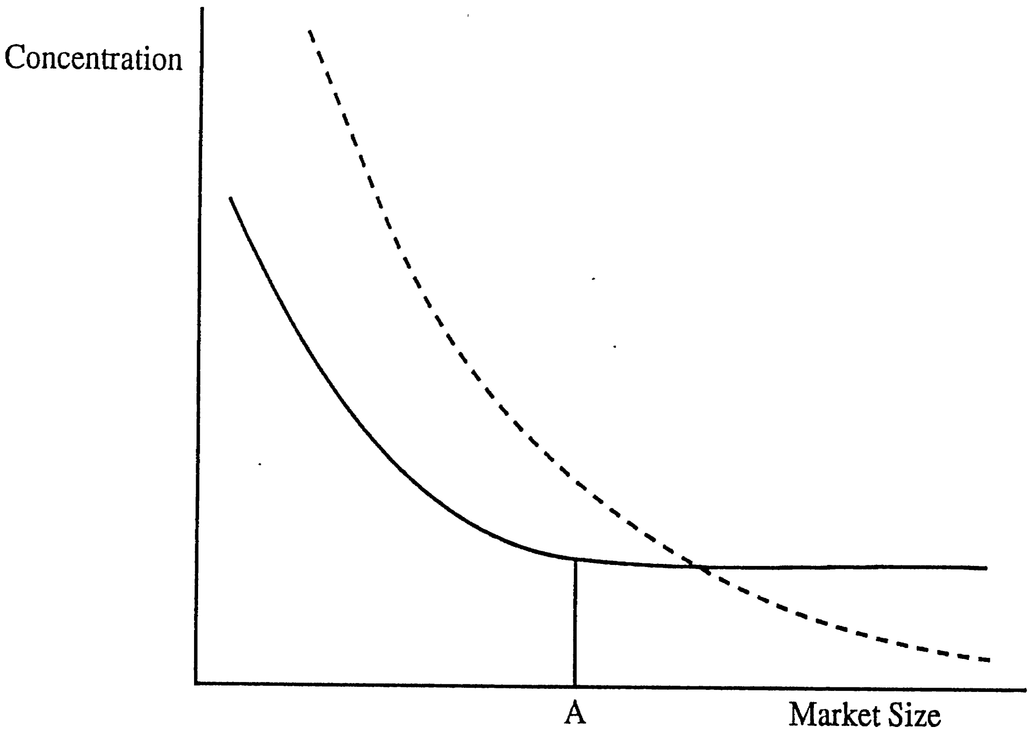
Competitors' approximate media advertising as a percentage of sales is determined by the business's media advertising as a percentage of sales and the business's spending on a 5-point scale relative to the leading competitors'. The PIMS question asks, "Did the business spend much less, somewhat less, about the same, somewhat more, or much more on media advertising as a percent of sales than the leading competitors?" Each category difference is assigned the value of .5%. For example, if the business's spending is somewhat higher than the competitors' and the business's spending is 2% of sales, competitors' spending is approximately 1.5% of sales.

Infrequent Buyer Orders: A dummy variable equals 1 if the market's approximate number of orders from key buyers per year is less than 150, 0 otherwise. The number of orders from key buyers is approximate because it is based on PIMS variables that are expressed in discrete categories. Following Caves (1986), the estimate for each discrete category equals the midpoint of the category range.

The number of the business's orders from key buyers equals the business's approximate number of key customers multiplied by their approximate purchase frequency. (The approximate number of key customers equals the approximate number of immediate customers multiplied by the smallest percentage of customers that account for 50% of the business's sales.) The market's approximate number of orders from key buyers equals the business's approximate number of key orders divided by their market share.

FIGURE 1

THE RELATIONSHIP BETWEEN MARKET SIZE AND CONCENTRATION'S LOWER BOUND IN ENDOGENOUS AND EXOGENOUS SUNK COST INDUSTRIES



NOTES: The solid line represents concentration's lower bound in endogenous sunk cost industries. The hatched line shows the equivalent bound for exogenous sunk cost industries. Adapted from Sutton (1991, Figure 3.9).

FIGURE 2

THE IMPACT OF THE TOUGHNESS OF PRICE COMPETITION ON CONCENTRATION'S LOWER BOUND IN EXOGENOUS SUNK COST INDUSTRIES

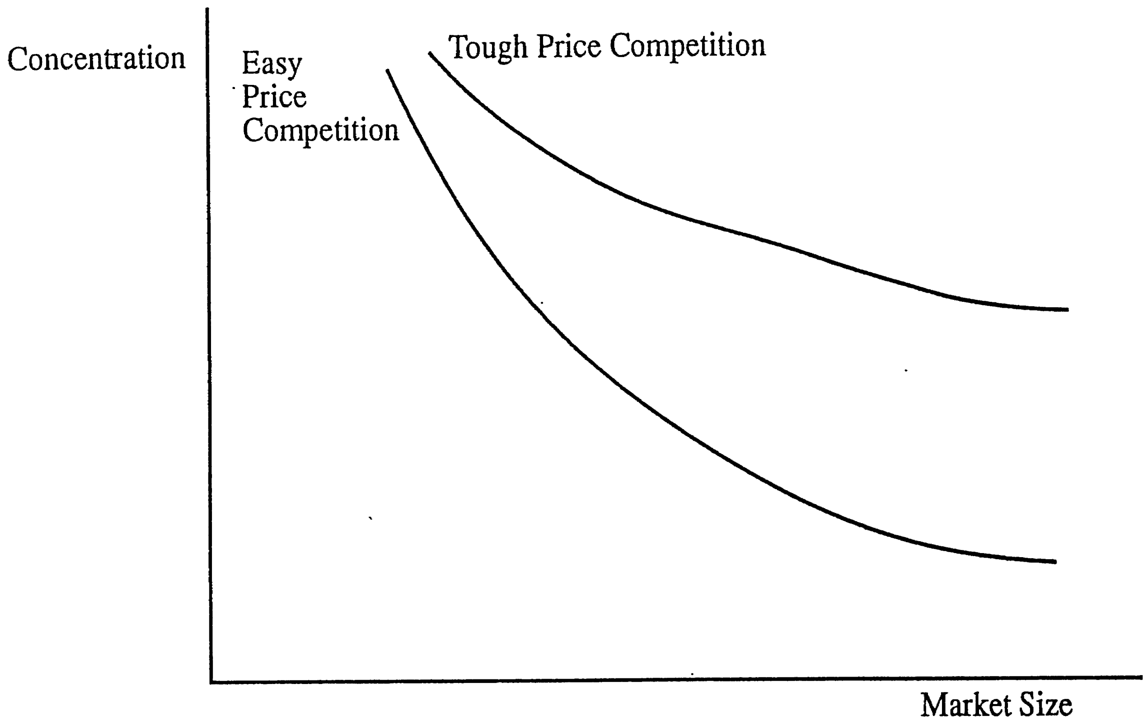


TABLE 1 **Definitions and Descriptive Statistics for the Model Variables**

Variable	Definition	Mean	S. D.
Concentration	The sum of the market share levels for the four leading competitors in the market. When the reporting business is not among the four leading competitors, the fourth largest market share is approximate.	70.47	21.74
Ln (S/MES)	The natural log of the ratio of served market sales divided by the dollar sales that a minimum economically efficient capacity increment can generate.	3.92	1.51
Ln (S/MES) * LA HR	Ln (S/MES) if the market has low advertising and high R&D spending, 0 otherwise	1.15	1.94
Ln (S/MES) * HA LR	The same as above, except for high advertising and low R&D spending	.48	1.39
Ln (S/MES) * HA HR	The same as above, except for high advertising and high R&D spending.	.48	1.42
STD * Ln (S/MES)	Ln (S/MES) if the business sells standardized products, 0 if customized.	3.07	2.08
STD * Ln (S/MES) * LA HR	Ln (S/MES) if products are standardized and the market has low advertising and high R&D spending, 0 otherwise.	.83	1.71
STD * Ln (S/MES) * HA LR	Same as above, except for high advertising and low R&D	.45	1.35
STD * Ln (S/MES) * HA HR	Same as above except for high advertising and high R&D	.45	1.37
Raw Mat * Ln (S/MES)	Ln (S/MES) if the business sells raw or semi-finished materials, 0 otherwise.	.50	1.38
Raw Mat * Ln (S/MES) * LA HR	Ln (S/MES) if the business sells raw or semi-finished materials and the market has low advertising and high R&D spending, 0 otherwise.	.08	.52
Raw Mat * Ln (S/MES) * HA LR	Same as above except for high advertising and low R&D spending	.01	.21

TABLE 1 (Cont.)

Variable	Definition	Mean	S. D.
Raw Mat * Ln (S/MES) * HA HR	Same as above, except for high advertising and high R&D spending	.02	.27
IBO * Ln (S/MES)	Ln (S/MES) if the market has less than 150 approximate key buyer orders each year, 0 otherwise.	.64	1.47
IBO * Ln (S/MES) * LA HR	Ln (S/MES) if the market has less than 150 approximate key buyer orders each year and the market has low advertising and high R&D, 0 otherwise.	.28	1.05
IBO * Ln (S/MES)* HA LR	Same as above except for high advertising and low R&D spending	.02	.28
IBO * Ln (S/MES) * HA HR	Same as above, except for high advertising and high R&D spending	.02	.29
Flattening 90%	Ln (S/MES) less 5.97 if ln (S/MES) exceeds 5.97, 0 otherwise. The 90th percentile value for ln (S/MES) equals 5.97.	.07	.28
Flattening 90% * LA HR	Ln (S/MES) less 5.97 if ln (S/MES) exceeds 5.97 and the market has low advertising and high R&D spending, 0 otherwise.	.01	.10
Flattening 90% * HA LR	Same as above, except for high advertising and low R&D spending	.01	.14
Flattening 90% * HA HR	Same as above, except for high advertising and high R&D spending	.01	.11
Ln (Advertising/Sales)	The natural logarithm of 1.0 plus the industry's approximate advertising as a percent of sales.	.52	.59
Ln (R&D/Sales)	The natural logarithm of 1.0 plus the business's product R&D as a percent of sales.	.66	.61
Product Patent	1 if the business benefits to a significant degree from product patents or trade secrets, 0 otherwise	.16	.37

TABLE 1 (Cont.)

Variable	Definition	Mean	S. D.
Consumer: Price<$10	1 if the product is a consumer good and the typical purchase amount paid by end users is less than $10, 0 otherwise.	.16	.36
Industrial: Price>$10,000	1 if the product is an industrial good and the typical purchase amount paid by end users is greater than $10,000, 0 otherwise.	.30	.46
Ln (Capital Intensity)	The natural logarithm of the book value of the business's plant and equipment, net of depreciation, as a percent of sales.	2.98	.70
Ln (Depreciation/GBV)	The natural logarithm of 1.0 plus the business's average annual depreciation on plant and equipment as a percent of its gross book value.	6.05	1.26
Regional Market	1 if the business serves a regional market in the U.S., Canada, or within Europe, 0 otherwise.	.18	.38

The variable definitions are derived from the PIMS data forms.

TABLE 2 Concentration's Lower Bound By Type of Market

	Low Advertising		High Advertising	
	Low R&D (n = 862) (%)	High R&D (n = 563) (%)	Low R&D (n = 234) (%)	High R&D (n = 221) (%)
<u>Sutton's Data</u>				
Absolute minimum value	<5	n. a.	25	n.a.
<u>PIMS Data</u>				
Absolute minimum value	6	10	18	16
1st percentile	12	25	24	18
2nd percentile	15	31	28	25
3rd percentile	19	34	33	29
4th percentile	21	35	35	32
5th percentile	22	39	36	34

TABLE 3 Ordinary and Generalized Least Squares Results

Variable and Expected Sign	Dependent Variable: Concentration (CR4)			
	OLS	OLS	OLS	GLS
Constant (+)	96.89 (28.84)***	92.62 (68.10)***	98.27 (28.90)***	96.58 (30.96)***
Ln (S/MES) (-)	-5.45 (-18.12)***	-9.12 (-20.41)***	-8.35 (-18.04)***	-8.04 (-15.16)***
Ln (S/MES) * LA HR (+)		3.41 (6.36)***	2.19 (3.60)***	2.13 (3.24)***
Ln (S/MES) * HA LR (+)		4.07 (3.15)***	3.66 (2.84)***	3.49 (2.68)***
Ln (S/MES) * HA HR (+)		2.46 (1.93)**	.94 (.73)	.41 (.28)
STD * Ln (S/MES) (+)		2.54 (7.31)***	2.45 (7.15)***	2.30 (5.33)***
STD * Ln (S/MES) * LA HR (-)		-1.77 (-3.12)***	-1.50 (-2.67)***	-1.39 (-2.28)**
STD * Ln (S/MES) * HA LR (-)		-2.98 (-2.25)**	-3.49 (-2.66)***	-3.32 (-2.52)***
STD * Ln (S/MES) * HA HR (-)		-2.14 (-1.65)**	-2.01 (-1.57)*	-1.49 (-1.04)
Raw Mat * Ln (S/MES) (+)		1.08 (2.87)***	1.35 (3.50)***	1.15 (2.84)***
Raw Mat * Ln (S/MES)* LA HR (-)		-2.05 (-2.18)**	-2.48 (-2.68)***	-2.17 (-2.35)***
Raw Mat * Ln (S/MES)* HA LR (-)		-.76 (-.36)	-.51 (-.24)	-.48 (-.24)
Raw Mat * Ln (S/MES)* HA HR (-)		.97 (.58)	1.11 (.67)	1.13 (.71)
IBO * Ln (S/MES) (+)		3.50 (7.95)***	3.24 (7.20)***	3.24 (7.79)***
IBO * Ln (S/MES) * LA HR (-)		-1.16 (-1.78)**	-1.18 (-1.81)**	-1.13 (-1.90)**
IBO * Ln (S/MES) * HA LR (-)		-1.66 (-.96)	-1.20 (-.71)	-1.57 (-1.00)
IBO * Ln (S/MES) * HA HR (-)		-2.65 (-1.61)*	-2.41 (-1.47)*	-2.73 (-1.63)*

TABLE 3 (Cont.)

Variable and Expected Sign	Dependent Variable: Concentration (CR4)			
	OLS	OLS	OLS	GLS
Flattening 90% (Zero impact)		1.20 (.46)	.55 (.21)	-.25 (-.06)
Flattening 90% * LA HR (+)		4.76 (.95)	6.35 (1.28)*	6.43 (1.08)
Flattening 90% * HA LR (+)		9.54 (2.18)**	10.81 (2.47)***	11.49 (2.21)**
Flattening 90% * HA HR (+)		5.48 (1.09)	9.48 (1.87)**	9.17 (1.43)*
Ln (Advertising/Sales) (+)	.71 (-.73)		.48 (.39)	.79 (.68)
Ln (R&D/Sales) (+)	3.51 (4.47)***		2.92 (2.43)***	2.51 (2.28)**
Product Patent (+)	1.63 (1.33)*		2.01 (1.69)**	1.98 (1.80)**
Consumer: Price<$10 (+)	6.66 (4.24)**		5.90 (3.84)***	5.18 (3.56)***
Industrial: Price>$10,000 (+)	6.01 (5.70)**		3.21 (2.92)***	3.06 (2.93)***
Ln (Capital Intensity) (+)	-.74 (-1.14)		-1.11 (-1.75)*	-.93 (-1.53)
Ln (Depreciation/GBV) (-)	-1.13 (-3.16)***		-1.02 (-2.97)***	-.90 (-2.92)***
Regional Market (-)	-5.70 (-4.69)***		-5.51 (-4.66)***	-4.93 (-4.10)***
R^2	.21	.26	.29	.29

The values in parentheses are t-statistics with * = 10%, ** = 5%, and *** = 1% significance. The GLS R^2 value is calculated from the raw variables and the GLS estimates by multiplying and summing these values to predict CR4 and then squaring the correlation with actual CR4. The total number of observations is 1880.

TABLE 4 **Frequency Distribution for the Toughness of Price Competition Measures By Type of Market**

Toughness of Price Competition Measures	Full Sample (n=1880)	Low Advertising		High Advertising	
		Low R&D (n = 862)	High R&D (n = 563)	Low R&D (n = 234)	High R&D (n = 221)
	(%)	(%)	(%)	(%)	(%)
Standardized Product	79*	75	74	95	94
Raw or Semi-Finished Materials	14	23	10	1	3
Infrequent Buyer Orders	19	21	26	3	4

* The table reads 79% of the full sample sells standardized rather than customized products.

TABLE 5 **Flattening Results at the 70th, 80th, and 90th Percentiles for Market Size**

	Dependent Variable: Concentration (CR4)		
	70%	80%	90%
I. Flattening Impact			
Low Advertising and Low R&D Markets	.85 (.49)	.61 (.27)	-.25 (-.06)
Low Advertising and High R&D Markets	.19 (.08)	1.03 (.31)	6.43 (1.08)
High Advertising and Low R&D Markets	5.02 (1.90)**	7.08 (2.14)**	11.49 (2.21)**
High Advertising and High R&D Markets	4.73 (1.53)*	5.64 (1.43)*	9.17 (1.43)*
II. Typical Structural Flattening Impact			
Low Advertising and Low R&D Markets	-5.09 (-3.42)***	-5.22 (-2.51)***	-5.99 (-1.56)*
Low Advertising and High R&D Markets	-4.07 (-2.37)***	-3.40 (-1.39)*	1.18 (.27)
High Advertising and Low R&D Markets	-.10 (-.05)	1.90 (.83)	5.67 (1.70)*
High Advertising and High R&D Markets	-1.74 (-.76)	-.81 (-.26)	2.10 (.43)

The typical structural flattening impact sums the market size, standardized product, and flattening impact. The values in parentheses are t-statistics with * = 10%, ** = 5%, and *** = 1% significance. The total number of observations is 1880.

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