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COMPETITIVE PRICE AND QUALITY UNDER ASYMMETRIC INFORMATION

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We present an analysis of equilibrium in markets with asymmetrically informed consumers. Some consumers know both price and quality of all sellers, whereas others know neither but may search among sellers. The equilibrium correlation between price and quality generally increases with the level of information in the market and can be negative when this level is sufficiently small. A meta-analysis of the available empirical studies strongly supports the model's predictions.
(Price; Quality; Consumer Information)

1. Introduction

It is not unreasonable to assert that consumers today are less than perfectly informed about their alternatives in the market place due to the cost of obtaining perfect information (Beales, Mazis, Salop and Staelin 1981; Russo 1978; Shugan 1980). This is primarily due to the large number of brands, the large number of dimensions on which to evaluate them, the complexity of some of these dimensions and of the resultant decision process and the variety of outlets and prices at which these brands may be purchased (Thorelli and Thorelli 1977). While consumer learning over time may redress some of these problems, a full resolution seems unlikely because consumers sample only a small proportion of available brands and stores (Newman 1977), and consumer mobility and product innovation often renders that experience obsolete. Moreover, most markets are likely to have a steady stream of new consumers due to age, preference and income changes. Thus it is quite reasonable to have consumers purchasing with either no information or information on only some of the brands in the market.

At the same time, adequate consumer information about price and quality is essential for the proper functioning of the competitive system, as illustrated by Akerlof (1970). Akerlof argued that because buyers could not ascertain the quality of a used car, they were not willing to pay the price a good used car was worth. As a result sellers of good used cars were not willing to put these on the market. The used car market is thus flooded with "lemons" and the market for quality is destroyed with a loss to both buyers and sellers. Although the market failure in used cars may appear unique due to the extreme difficulty of buyers to ascertain a good buy, Maynes and Assum (Maynes 1975; Maynes and Assum 1982) argue that this is a common phenomenon.

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Since Akerlof's work the literature has suggested several ways in which market collapse can be avoided. Prominent among these are search by consumers. Search models (e.g., Salop and Stiglitz 1977) posit that consumers can acquire information at some cost and that this possibility disciplines the market at least to some extent.

On the empirical side, several studies examined the correlation between price and quality across a large variety of consumer markets (Dardis and Gieser 1980; Friedman 1967; Geistfeld 1982; Hjorth-Andersen 1984; Morris and Bronson 1969; Oxenfeldt 1950; Riesz 1978, 1979; Sproles 1977; Sutton and Riesz 1979). The typical findings from the above studies are that there is a great variation in the price-quality correlation across markets and that several markets have negative correlations. These studies proceed without a formal theory although there is an underlying assumption that the strength of the correlation depends on the extent of information in the market. Nevertheless the variation in the correlations across markets and especially the negative correlation have puzzled several authors and there have been calls for additional theoretical work (Geistfeld 1982; Riesz 1978).

The purpose of this paper is to develop and test a theory which can explain (1) why there are variations in price-quality correlation across markets, and (2) why some correlations are negative. In a search model we show that the price-quality correlation generally is an increasing function of the level of consumer information and that the correlation may be negative. We study the "average" market in a meta-analysis of the available empirical results and find strong support for the intuitive results from the model. The model is presented in §2 and the empirical analysis in §§3 and 4. In §5 we discuss the limitations and implications of the research.

2. Model

We consider an industry with free entry, in which $n \in \mathbb{R}^+$ firm can supply a product of varying quality. Specifically, any firm incurs a cost of $xAC(x, q)$ if it produces x units of a brand with quality q. We assume that $AC(\cdot)$ is U-shaped with respect to quantity, and increasing and convex in quality and has a nonnegative cross derivative. So at any quantity x, better quality can be supplied at an increasing cost. We further define $c(q)$ as the minimum average cost at which a brand of quality q can be produced.

There are I consumers with identical preferences each of whom buys one unit of the product. We assume that a strictly positive fraction θ_1 of the consumers are fully informed or can search at no cost while fractions θ_i, $i = 2, \ldots, m$, pay a fee of g_i utiles ($g_i < g_{i+1}$) for each firm they gain information about. The $\theta_1 I$ informed consumers may be thought of as experienced buyers, or readers of *Consumer Reports* and similar publications. We assume that sampling is with recall and yields perfect information. Because consumers have alternative uses for their income, we can derive a partially indirect utility function $W(p, q)$ representing the utility to a consumer who buys a brand of quality q at price p. As usual we assume that this utility $W(\cdot)$ is increasing in quality, decreasing in price, concave in both arguments, and has a nonpositive cross derivative.

The consumers without search costs search randomly among the firms until they locate one offering their preferred price-quality pair, while the other consumers will try to economize on search given their beliefs about the number of firms offering each quality at each price. We refer to firms as "honest" or "dishonest." The former sell at prices commensurate with quality, while the latter exist solely because consumers' search costs allow them to sell low quality at a high price.

We will now look at the equilibria of this market. We assume the structure of the game to be common knowledge and that firms and consumers are numerous enough, that each believes its own actions have no effect on the strategies of others. An equilibrium is a set of beliefs of the consumers (about the distribution of firm offerings) such that the demand from the various firms that is generated by these beliefs equals the supply of the firms with all firms maximizing yet making zero profits.

In equilibrium, firms will locate in at most m groups in p, q space such that at least one type of consumer just prefers the p, q pair to further search. A firm offering a slightly more attractive deal (i.e., lower p or higher q) would not get a higher market share because no more types of consumers would stop searching after finding such an offer. A fraction a_1 of the firms will cater to the "fully informed" consumers and locate at the full information offer p_1, q_1 given by

$$p_1 = c(q_1) = AC(x_1, q_1), \tag{1}$$

$$-W_q(p_1, q_1)/W_p(p_1, q_1) = c'(q_1). \tag{2}$$

We interpret this equilibrium with the help of Figure 1. These "honest" firms locate at optimum economic scale where price equals minimum cost (equation (1)) and produce at the quality level where the marginal cost of more quality just equals the consumer willingness to pay more (equation (2)). In the nondegenerate case, when the θ_i are sufficiently large, fractions $a_2, \ldots, a_m$ of the firms will locate at p_i, q_i, $i = 2, \ldots, m$, given by

$$W(p_i, q_i) = [\sum_{j=1}^{i-1} a_j W(p_j, q_j) - g_i][\sum_{j=1}^{i-1} a_j]^{-1}, \tag{3}$$

$$p_i = AC(x_i, q_i), \tag{4}$$

$$-W_q(p_i, q_i)/W_p(p_i, q_i) = AC_q(x_i, q_i). \tag{5}$$

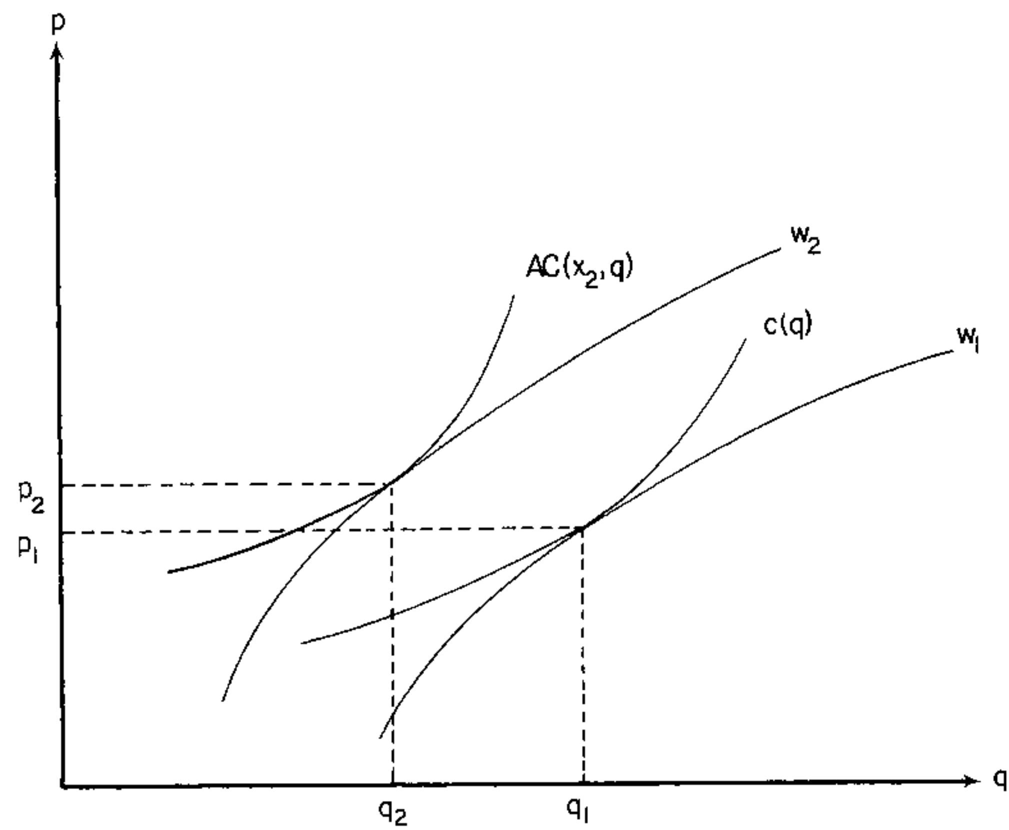

FIGURE 1. Equilibrium in the Search Model.

These "dishonest" firms locate on indifference curves W_i which are just far enough away, that their most sensitive consumer clientele is indifferent between buying (p_i, q_i) and engaging in further random search with an expected payoff $\sum_{j=1}^{i-1} a_j W_j + (1 - \sum_{j=1}^{i-1} a_j)W_i - g_i$ (equation (3)). (Note that the second term comes from the recall option.) Due to free entry, volume declines to x_i and profits are driven to zero until price equals average costs (equation (4)). Each of these $a_i n$ firms do, however, select their position on the indifference curve for maximum profits (equation (5)). Since consumers search randomly, each consumer will end up buying from a random firm offering at least the utility which his search costs, by equation (3), enables him to get.

By equating supply and demand from each group of firms we get the fractions a_i and the total number of firms, n, by

$$x_i a_i n = \sum_{j=i}^{m} a_i I\theta_j (\sum_{k=1}^{j} a_k)^{-1}. \tag{6}$$

To understand (6), note that $a_i n$ firms each supply x_i and that a given group of consumers, say of type j, will distribute their purchases randomly over firms offering deals at least as good as that of firms of type j. If (1)–(6) gives an equilibrium $[(x_i, q_i, p_i, a_i)_{i=1}^{m}, n]$ such that some $a_j \leqslant 0$, the equilibrium is degenerate since some firms are unable to get sufficient volume. In this case only a smaller number of groups of firms exist.

To gain further insights, it is useful to consider the example where $m = 2$, in which case (3) and (6) are

$$W(p_1, q_1) - W(p_2, q_2) = g_2/a_1, \tag{3a}$$

$$a_1 = \min\{1, \theta_1 x_2[(1 - \theta_1)(x_1 - x_2)]^{-1}\}, \tag{6a}$$

$$n = (1 - \theta_1)I/x_2. \tag{7}$$

Note that if $\theta_1 \geqslant (x_1 - x_2)/x_1$, $a_1 = 1$, and $n = I/1$. So the equilibrium becomes degenerate if economies of scale, measured by x_2, are sufficiently large relative to θ. (In this case firms of type 2 cannot get sufficient volume.)

In this model, the correlation between price and quality is 1, 0 or -1, depending on the signs of $p_1 - p_2$ and $q_1 - q_2$. Because of our assumptions on $AC(\cdot)$ and $W(\cdot)$ it is clear that $q_2 < q_1$ so the question revolves around p_2. If we insert (6a) into (3a) we can use (3a), (4) and (5) to consider p_2 as an implicit function of θ_1. This gives us, after very tedious implicit differentiation of these three equations, that

$$dp_2/d\theta_1 < 0 \qquad \text{if} \qquad \frac{g_2(1-\theta_1)x_1}{\theta_1 x_2^2} < AC_x(x_2, q_2)W_p(p_2, q_2).$$

What happens is that the initial utility gains from increasing θ_1 above zero are taken as large increases in quality and some increases in price. *As the market becomes more efficient* (θ_1 *gets larger*), *we do, however, get simultaneous increases in quality and decreases in price. For small* θ_1, it is furthermore easy to develop examples where $p_2 > p_1$, so that *the price-quality correlation is negative.*[1]

In the case where $m > 2$, the correlation is a more complex function and the measurement of information levels needs more thought. The same economic forces are, however, at work and the intuition from the example with $m = 2$ will carry over.

If we consider differences in tastes among consumers, we will again get at most as many types of firms as we have groups of consumers and similar results will obtain, although the correlation in general will be stronger. To see why, note that θI consumers without search costs will induce a stronger positive correlation the more p, q levels their differences support. Another possible extension is to allow consumers to use price as an

[1] These results are proved in the Mathematical Appendix.

indication of quality. In this case, we would expect our conclusions to carry over except under extreme assumptions. (See the Appendix for more on this, including a counter-example.) On the other hand, it is critical that we have U-shaped cost curves and a constant search cost (see Cooper and Ross 1984 and Burdett and Judd 1983 on these points). Let us here turn to the empirical evidence.

3. Empirical Evidence

In §2 we showed that the equilibrium correlation between price and quality increases with the number of informed consumers in a market. In this section we test this result. For this purpose we chose the measures of price and quality as published by Consumers Union (CU) in their periodical, *Consumer Reports*, for several reasons. First, CU is an independent body that is not allied in any way to any group of firms. It should be a fairly objective source for measuring competitive quality. Second, CU has a scientific approach to analyzing quality through blind laboratory studies, which in scope and consistency, is unrivaled in the U.S. and in the world (Thorelli and Thorelli 1977). In addition to these two compelling reasons, we are faced with the advantage of having nine published studies that have analyzed the correlation between price and quality as measured by CU (see Table 1).[2] These studies cover more than 1000 product categories over a wide cross-section of time periods and market conditions, and represent an opportunity for investigating generalizations by a meta-analysis that is superior to what one can achieve by a single study (Glass, McGraw and Smith 1981).

The quality measure used in the published studies is CU's rank measure of quality. This measure is arrived at by CU's judges after taking into account product performance on several dimensions and only if a clear rank order of brands does emerge.[3] The measure of price used in these studies is CU's estimate of the average price a brand sold for in the U.S. Depending on the availability of resources, this average is computed from either (a) CU's surveys of prices (paid or quoted) in selected markets, (b) subscribers' reports of prices paid by them, or (c) manufacturers' list prices. To the extent the CU's average price reflects list rather than actual prices paid, the average price is biased upwards due to its failure to capture local discounts. Since all brands are subject to discounts, this phenomenon may not affect the estimated price-quality coefficient at the national level. However, since only the average national price enters the calculation of the estimated price-quality correlation, we would expect this estimate to have a higher absolute value than that in local markets, where there is greater price variation.

All except two studies published the correlations for each product-market. One study (Dardis and Geiser 1980) published only 61 correlations of the 105 product-markets they investigated. Another study (Riesz 1978) published none but we were able to obtain the results directly from the author.[4] As a result we obtained correlation coeffi-

[2] Besides the nine studies cited in Table 1, until 1984 there were another five studies that examined the price-quality correlation using a substantially different quality measure, competitive context or method so that a meaningful pooling with the above studies was not possible. These studies are Curry (1985), Faulds (1983), Hjorth-Andersen (1984), Maynes and Assum (1982), Phillips, Chang and Buzzell (1983).

[3] The use of a rank measure of quality only, instead of all the original quality measures may involve a loss of information, or seem arbitrary (Hjorth-Andersen 1984). However, this approach is not necessarily invalid for several reasons. First, CU's judges consider consumers' scores on all of the measures when arriving at a rank. Second, there generally is a positive correlation among quality attributes so that the rank measure of quality is independent of the mode of averaging across attributes (Curry and Faulds 1986). Third, when tradeoffs exist across attributes, CU's judges arrive at a ranking of brands on quality only if there is a clear superiority among them; otherwise brands are grouped as approximately equal and groups of brands are ranked, if possible. The rank measure of quality is thus particularly useful because of its simplicity and its formulation by a set of independent judges through blind laboratory studies.

[4] The data Professor Riesz provided us consisted of an additional 247 observations beyond Riesz (1978). We included these data after they satisfied a t-test of homogeneity with the published correlations.

TABLE 1
Studies in the Meta-Analysis

Author	Years Covered	Observations Product Markets
Dardis and Gieser (1980)	1970–1977	61*
Friedman (1967)	1951–1965	39
Geistfeld (1982)	1977	17
Morris and Bronson (1969)	1958–1967	48
Oxenfeldt (1950)	1939–1949	34
Riesz (1978)**	1961–1980	937
Riesz (1979)	1961–1975	40
Sproles (1977)	1972–1974	135
Sutton and Reisz (1979)	1961–1978	54
Total	1939–1980	1365

* 61 correlations published out of 105 product categories in the sample.
** Data supplied by the author.

cients of price and quality from 1365 product-markets, most of which are in the last 20 years of a 40-year period (see Table 1). There was an overlap of about 28% in the product-markets listed in Table 1. We excluded product markets if they were involved in two or more studies by the same author but not if they were covered by two independent authors. This procedure yielded a total of 1271 observations with about a 22% overlap. There were minor discrepancies in the values of the correlation coefficients between authors for the same product markets (possibly because of manual calculations or use of different formulas) and so we retained the correlations which overlapped across authors.

The key precondition to the empirical analysis is whether pooling of all the observations is justified. There are three grounds on which this may not be so: ignorance about the statistical distribution of the correlation coefficients, differences in methods of the principal studies and heterogeneity in the product markets. A version of the Fisher z transformation of the price-quality correlations as described by Rao (1965) provides normalization of the correlation coefficients and provides statistical validity for pooling and subsequent analysis.[5] All the studies included in table 1 calculated the Spearman rank correlation between price and quality for each product category as reported in *Consumer Reports*.[6] As such we have a homogeneous set of studies whose results should vary only by factors intrinsic to the product markets being investigated. The purpose of the analysis is to estimate the average of these correlations over all markets, time

[5] Rosenthal (1978) suggests the use of the standard normal deviate of the coefficients being subjected to meta-analysis. In our case, the z-transformation ensures that the regression error terms are distributed as multivariate normal with zero mean and constant variance. This transformation is defined by Rao (1965, pp. 362–363) as:

$$z = (1/2)\{\ln[(1+r)/(1-r)] - \ln[(1+r')/(1-r')] - r'/(m-1)\}(m-3)^{1/2}$$

where r = the correlation coefficient calculated for each product market, r' = the population value of the correlation coefficient, and m = the number of observations on which r was calculated. Under the null hypothesis that $r' = 0$, the above reduces to:

$$z = (m-3)^{1/2}\tfrac{1}{2}\ln[(1+r)/(1-r)].$$

Subsequent analysis of residuals justified our using the z-transformation rather than the raw correlations as the dependent variable.

[6] Sproles (1977), however, also used quality ranks from *Consumer Research* and in the interest of homogeneity we dropped those observations.

periods and authors, and to explain any heterogeneity across markets by independent variables derived from our theory. This will be achieved by a least squares regression of the normalized correlations on market characteristics. As with all meta-analyses this one suffers from the limitation of "publication bias" (Glass, McGraw and Smith 1981) in that we are less likely to include unpublished studies. Moreover the product markets in our sample are not probabilistic. Neither of these problems is critical in our study for two reasons. First, the published studies did not have to meet any "acceptable significance" level because of the inherent diversity of results in this paradigm. Second, while some of the authors tended to study more nondurables, we do control for this variable.

Since the choice of our independent variables is based on theory, we need to explain three main differences between the theoretical and empirical models. In the real world we will see a richer distribution of price and quality levels due to a richer distribution of preferences than what we modelled theoretically. While this would complicate the algebra in our model, it would not invert the basic dependence of the correlation coefficient on θ. Second, in the real world consumers may resort to several sources of information such as brand names, share of shelf space, word-of-mouth, etc. To the extent that we do not account for these, our explanation of the dependent variables will be weaker. Third, the dependence of r on θ is nonlinear. However, since we do not have any precise estimates of the model parameters for each of the product markets in our sample, we could not investigate that nonlinearity. The linear approximation of these relationships will thus lead to weaker empirical results.

Because our dependent variable is based on information from *Consumer Reports*, we are somewhat restricted by the measures for the independent variables that are available from that source. Since we here pursue a meta-analysis there is a further, though in this case negligible, restriction in that some authors did not provide all possible information. Nevertheless we were able to get information on three important variables. These are (1) the price range in the product category, whether the product category is (2) packaged and (3) durable. The rationale for each of these variables as independent variables is presented below.

Price Range. One would expect more consumers to search and be informed as the spread in prices at which products are sold increases. Thus we expect the correlation between price and quality to be stronger in markets with a higher price range. We use two measures for this variable, absolute price range and relative price range (absolute price range/average of highest and lowest price), because either of these two measures could motivate consumer search. The price range was available for all but 20% of the observations. To avoid loss of observations, we replaced the missing values of price range, by the mean of the nonmissing values in that durability and package class.

Packaged Products. A key source of information for consumers is the ability to inspect products prior to purchase. Nelson (1970) was an early proponent of modelling the consumers' information level as a function of prior search and inspection. High quality firms in particular do have an incentive to let consumers inspect the unpackaged product. Indeed, for a large number of product categories, stores and showrooms are especially designed to assist consumers in making an informed purchase. For nondurables, end-of-aisle taste tests are meant to achieve the same objective. However, for several product categories, especially low cost and food products, this is not possible on a regular basis and consumers do not have the option of inspection prior to purchase. We would expect search costs to be higher for such products, so that less consumers would be informed and the correlation between price and quality would be weaker in these cases.

Packaging was measured by a dummy variable that was assigned a 1 only if it generally could not be sampled or inspected prior to purchase—e.g., canned foods, detergents, sprays, some types of hosiery, frozen foods or finishes. This excluded products such as mattresses, stereos, etc., which are delivered in packages, but for which most stores provide adequate inspection facilities.

Durables. The correlation between price and quality is expected to be stronger for durables because consumers are expected to search more and be better informed than for nondurable products. This is because durables by definition are products that consumers use for extended periods of time. A product of superior quality would thus pay dividends over a longer time period in terms of lower replacement or maintenance costs. Consumers are thus more likely to benefit from being informed on quality when purchasing durables than nondurables. Durability will be measured by a dummy variable that assigns a 1 if the product is durable. In general all products that were not consumed while in use were considered durables. This classification included appliances, tools and apparel.

In summary, we expect to find a stronger price-quality correlation in markets for durables, unpackaged products, and products sold over a wide price range. One could also argue that the whole issue of product quality and our theory is more relevant to durables. We will therefore also carry out the analysis separately for durables.

4. Results

The descriptive statistics of the dependent variable are presented in Figure 2. It can be seen that the distribution of the price-quality correlation is unimodal and moderately skewed, with a mean of 0.27, and a median of 0.31 for 1271 observations. The skewness is typical for distributions of correlation coefficients with a nonzero population mean (Hays 1963, p. 530). The test of the null hypothesis that the mean is zero by Fisher's z-transformation yields a z-value of 25 significant at the 0.0001 level.

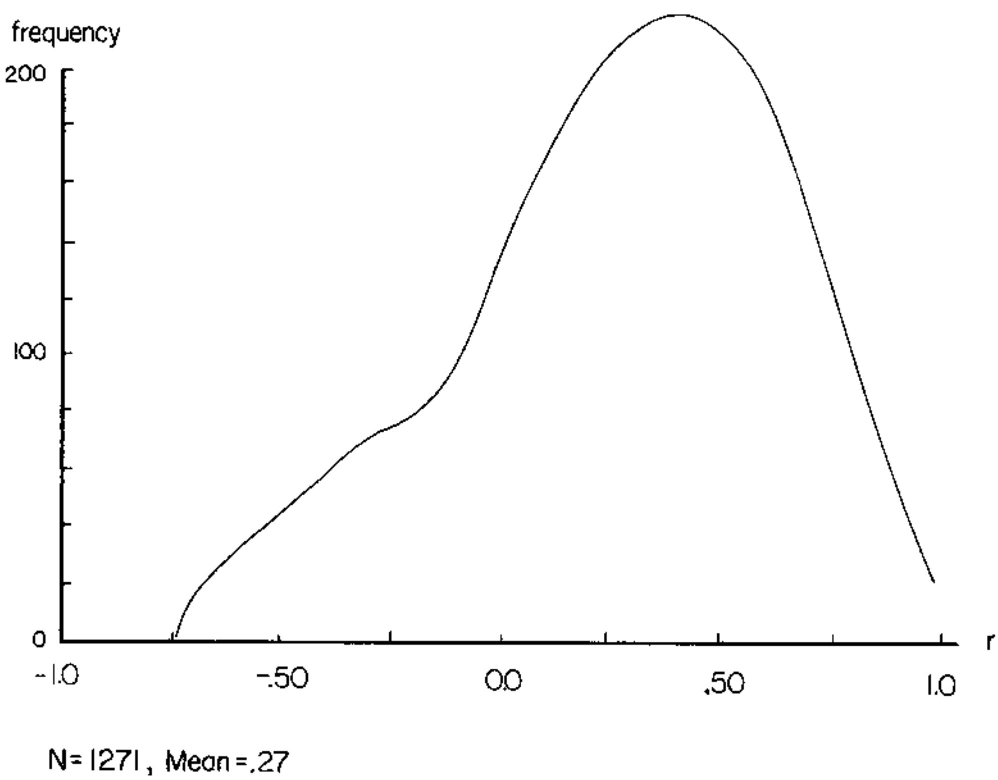

FIGURE 2. Empirical Distribution of Rank Correlations Between Price and Quality.

TABLE 2

Distribution of the Mean Correlation Coefficient by Market Characteristics
(Number of observations in parentheses)

Market Characteristic	Relative Price Range (RPR) Low (0.5 ≥ RPR ≥ 0)	Medium (1.1 ≥ RPR ≥ 0.5)	High (RPR ≥ 1.1)	Total
Nondurable	0.07 (15)	0.11 (140)	0.12 (49)	0.11 (204)
Durable	0.17 (276)	0.31 (622)	0.43 (168)	0.30 (1066)
Total	0.17 (291)	0.28 (762)	0.36 (217)	0.27 (1270)
Packaged	0.08 (28)	0.12 (171)	0.11 (52)	0.11 (251)
Unpackaged	0.18 (263)	0.32 (591)	0.44 (165)	0.30 (1019)
Total	0.17 (291)	0.28 (762)	0.36 (217)	0.27 (1270)

The distribution of the mean correlation coefficient by the market characteristics is presented in Table 2. In support of our hypotheses, one can clearly see the systematic variation of this coefficient from a low of 0.07 in nondurables with a low price range, to a high of 0.43 for durables with a high price range. Similarly the coefficient varies from a low of 0.08 for packaged goods with a low price range to a high of 0.44 for unpackaged goods with a high price range.

The correlation and regression results are presented in Tables 3 and 4, respectively. The simple correlations indicate that all of the independent variables affect the price-quality correlation significantly (at 0.01 level or lower) and in the expected direction. The effects of both measures of price range are very strong, but that for relative price range is much stronger, so we use only this measure in the regression analysis. The regression results confirm the hypothesis regarding the effect of the price range and packaging variables. However, the effect of durables is weaker after controlling for packaging. It may be argued that in our theory, the issue of quality and the effect of price range is more true for durables. This is partly confirmed by the last regression, which presents results for only durable products. Note also that most of the observations (1063 of 1271) are durables. This is because CU evaluates durables more frequently.

There were no important time effects and the results appear very stable over the last three decades. One author contributed a larger number of observations than other authors but there were no significant differences between this and the other sources of data at the 0.1 level. Posterior analysis of residuals indicated that the Fisher-z transformation was necessary to satisfy the standard econometric assumptions about the residuals. Overall the model explains about 11% of the variance. While this is a small fraction, we need to keep in mind that our data is cross-sectional, with over 1200 observations, and only three indirect measures of consumer information as independent variables. Note that the R^2 is significant at the 0.0001 level.

TABLE 3

Correlation Coefficients of Normalized Price-Quality Correlation with Independent Variables

Independent Variables	Coefficient	N	Probability
Durables	0.17	1271	0.0001
Unpackaged	0.20	1271	0.0001
Absolute Price Difference	0.11	1271	0.0001
Relative Price Difference	0.22	1271	0.0001

TABLE 4

Regression Results with Normalized Price-Quality Correlations as Dependent Variables

Model	Sample	Independent Variable	Coefficient	t-stat	*Sig*	R^2	*Sig*	*DF:N/D*
1.	Full	Relative Price Range	0.96	8.15	0.0001	0.05	0.0001	1/1268
2.	Full	Relative Price Range	1.14	9.83	0.0001	0.11	0.0001	2/1267
		Unpackaged	0.93	8.93	0.0001			
3.	Full	Relative Price Range	1.17	10.01	0.0001	0.11	0.0001	3/1266
		Unpackaged	0.67	3.47	0.0005			
		Durables	0.33	1.57	0.1158			
4.	Durables	Relative Price Range	1.40	11.31	0.0001	0.12	0.0001	2/1063
		Unpackaged	0.70	3.55	0.0004			

5. Discussion

The above analysis suggests that superior quality on average does command a higher price and that the price-quality correlation increases with information. Thus the extreme scenario modelled by Akerlof (1970) is not generalizable to all consumer markets. On the other hand, there is considerable variation in the price of quality across markets, a large number of negative correlations and considerable noise in our regression model.

An alternative explanation to this informational argument is that the weak correlation is the result of measurement problems. However, scattered empirical evidence from other studies indicates that a correlation of 0.27 is a fair estimate or may even be inflated. By using the PIMS data, Phillips, Chang and Buzzell (1983) published two estimates of the partial effect of quality on price in consumer markets, that average to 0.30. In this case the measure of quality is obtained by an entirely different approach and the model also controls for other influences on price. Moreover, in as far as low quality firms do not rate themselves in the PIMS surveys as low as they should, this estimate could not be biased upwards. Two other studies using *Consumer Reports* data, but with a more rigorous method based on Thurstone's law of comparative judgment also found the price-quality correlation to be low (Curry 1985; Faulds 1983). Other studies of price and quality variation in local markets have indicated a high price variation for approximately equivalent products and even for the same brand (Maynes, 1978). This latter result should come as no surprise, since even a casual check of prices for the same brand across stores in a single city would indicate considerable price variation. It must be noted, moreover, that price information is generally more easily available to consumers than quality information. Therefore, the variation in prices for brands of different quality could easily be higher. Further, the prices used for our analysis are the average surveyed by *Consumer Reports* for each brand. Our values of the price-quality correlations are thus likely to overestimate the true values in the population.

The hypothesis that the weak correlation is the result of an information problem is supported by our empirical analysis which indicates that the correlation is stronger for products with a high range in prices, durables and unpackaged products. As pointed out in our theory, all of these represent conditions under which consumers are more likely to benefit from being better informed on price and quality.

On the other hand, it may be dangerous to interpret a lower price-quality correlation as unambiguous evidence of a lower level of information in a given market. As shown in this paper, the correlation does measure information in a search model, but this need not be true in all environments. As an example we sketch a "rational expectations" model in the Appendix, in which more information in some special cases leads to lower correlations.

With regard to policy implications, two points need to be made. First, the availability of information on price and quality is a benefit not only to all consumers but also to all those firms that do or can produce a higher quality product at a relatively lower price. The welfare issue is thus not between consumers and firms but between consumers and honest firms versus dishonest firms. Second, it is not necessary that all consumers be informed. As pointed out in the theory, having a small population of informed consumers confers an external economy to all of the uninformed.

From a managerial perspective, the supply of superior quality appears to be one approach to commanding a premium in such markets. In these circumstances, since it is the higher proportion of informed consumers that determines the rewards to quality, the supply of quality should preferably be associated with promotional programs which are informative on the relevant dimensions of quality.

Several limitations with our analysis and with the studies we analyzed suggest areas for future research. At the theoretical level, it would be fruitful to model more ways in which honest firms can signal to consumers. This would include branding, warranties, etc. In developing such models, it would be desirable to avoid the conclusions that all scope for opportunism could be driven out of the market. As illustrated by the empirical evidence, such predictions are likely to fail.

At the empirical level it would be useful to determine the sensitivity of our results to alternate measures of price and quality, such as ratio or interval measures and to alternate levels of measurement such as in individual markets, or at the business unit and firm level. The analysis could also benefit from more direct measures of consumer information. An alternative test of our empirical results would be to determine whether the correlation between price and quality does actually improve when information is supplied to an ongoing system. It would also be interesting to determine whether other factors affect the relationship between price and quality, such as the costliness of quality or consumers' preference for quality as indicated by our theory. However, further studies on the relationship between ordinal price and quality at the brand level do not promise to be any more enlightening. A third approach would be to investigate what other factors drive competitive prices. A partial list would include the order of market entry, product features, advertising or the cost of production. In the context of our theory, the first two could serve as surrogates of quality, the third as a source of information (or misinformation) on quality and the fourth would indicate whether higher costs are passed on to consumers, possibly as a result of incomplete consumer information.[7]

[7] This paper was received June 1986 and was with the authors for 1 revision.

Appendix. Behavior of the Price-Quality Correlation in a Particular Rational Expectations Model

In this appendix we present a model that allows consumers to infer quality from price. The purpose of this presentation is twofold. First, it models what is an interesting problem that has long been researched in marketing, but with relatively inadequate theoretical work (Monroe and Petroshius 1981; Olson 1977). Second, it highlights the conditions under which the results of our search model generalize to other sources of information.

We assume that search is impossible but that θI consumers know all price, quality offerings in the market while $(1-\theta)I$ consumers only know prices. We furthermore assume that the uninformed consumers can tell if a product is of quality less than $\underline{q}$. Otherwise the model is as in the body of the paper and in Cooper and Ross (1984).

The unique pure strategy equilibrium has at most three groups of firms. Some (n^*) produce the full information pair (p^*, q^*), others ($\underline{n}$), offer $\underline{q}$ at $c(\underline{q})$ while the last group (n^0) offer $\underline{q}$ at p^*. The equilibrium is given by the conditions below:[8]

(i) If

$$\theta < \frac{(x^* - x^0)(\underline{W} - W^0)}{x^0(W^* - W^0) + (x^* - x^0)(\underline{W} - W^0)}$$

where $\underline{W} = W(\underline{p}, \underline{q})$, $W^0 \equiv W(p^*, \underline{q})$, and $W^* = W(p^*, q^*)$ then:

A fraction $1 - \nu$ of the uninformed buy at $\underline{p}$, $\nu = \theta x^0(W^* - W^0)/[(1 - \theta)(x^* - x^0)(\underline{W} - W^0)]$. All other consumers buy at p^*.

$$\underline{n} \equiv \frac{I[(1 - \theta)(x^* - x^0)(\underline{W} - W^0) - \theta x^0(W^* - W^0)]}{\underline{x}(x^* - x^0)(\underline{W} - W^0)}, \tag{8a}$$

$$n^* \equiv \frac{I\theta}{(x^* - x^0)}, \tag{9a}$$

$$n^0 \equiv \frac{I\theta(W^* - \underline{W})}{(x^* - x^0)(\underline{W} - W^0)}. \tag{10a}$$

(ii) If

$$\frac{x^* - x^0}{x^*} > \theta \geqslant \frac{(x^* - x^0)(\underline{W} - W^0)}{x^0(W^* - W^0) + (x^* - x^0)(\underline{W} - W^0)},$$

then

All consumers buy at p^*

$$\underline{n} = 0, \tag{8b}$$

$$n^* = \frac{\theta I}{x^* - x^0}, \tag{9b}$$

$$n^0 = \frac{\{(1 - \theta)x^* - x^0\}I}{(x^* - x^0)x^0}. \tag{10b}$$

(iii) If $\theta \geqslant (x^* - x^0)/x^*$, then

All trade takes place at p^*, $\underline{q}^*$.

$$n^* = I/x^*. \tag{10c}$$

To interpret this, it is helpful to look at Figure 3. First, (p^*, q^*) is the perfect information outcome, the point at which all the informed will buy. Secondly, $(p^*, \underline{q})$ is the offer of the inefficient firms selling to uninformed consumers who in turn pay p^* hoping to get q^* (Olson 1977; Monroe and Petroshius 1981). Note that the "gamble" undertaken by the uninformed consumers is more favorable if there are more informed consumers, supporting more (p^*, q^*) firms. Thirdly, $(\underline{p}, \underline{q})$ is the risk free offer made to the uninformed. In effect, an uninformed consumer can infer $\underline{q}$ from $\underline{p}$ and can thus buy a poor quality product at a low price instead of taking a gamble on p^* and risk buying from an inefficient firm.

In case (i), where θ is sufficiently small, the firms selling $(\underline{p}, \underline{q})$ serve to discipline the dishonest firms. In particular, θ is small enough, that a gamble on p^*, if all were to take it, would be very disadvantageous. Accordingly, the uninformed consumers would prefer $(\underline{p}, \underline{q})$. On the other hand, if all did this, such that only informed consumers bought at p^*, then a gamble at that price would be very favorable. The equilibrium ν resolves the tension between these two disequilibria. It is immaterial whether we interpret ν as resulting from a mixed strategy by all consumers or as a segmentation of the consumers. This equilibrium does not appear in the model of Cooper and Ross (1984), since they assume that consumers are unwilling to buy at $(\underline{p}, \underline{q})$. Instead, their equilibrium is that found in case (ii) where there are so many informed consumers that all uninformed want to gamble at p^*. Case (iii) finally depicts a situation where θ is very small and $AC(\underline{q})$ rises very fast as x declines from $\underline{x}$. In this case, inefficient firms cannot gain adequate volume given the high θ so only efficient firms will survive. (While this equilibrium also appears in Cooper and Ross 1984, they do not seem to be aware of it.)

The correlation between price and quality is zero in case (ii) but positive in case (i), because of the safe purchase $(\underline{p}, \underline{q})$. As θ increases, $\underline{n}$ will, however, decrease while both n^0 and n^* will go up. *So the price-quality correlation is nonincreasing in the number of informed consumers.* Further, the correlation can never be negative in this model because the uninformed will buy only at prices at which high quality products are sold. While this result is quite surprising it is very sensitive to our assumptions that the uninformed will buy at $\underline{q}$ and that consumers have identical tastes. *As soon as we allow just two types of price-quality preferences, we get a perfect correlation for $\theta = 1$ and lower correlations for lower values of θ.* Let us again emphasize that this result is prepared in a very special model. It does nevertheless indicate that the use of the price-quality correlation to measure information should be undertaken with some care.

[8] The equilibrium needs the support of an assumption about out-of-equilibrium beliefs of the uninformed. In particular, we need to specify how they would interpret a price not offered in equilibrium. If we assume that they ascribe a quality $\underline{q}$ to such a price, we are home free.

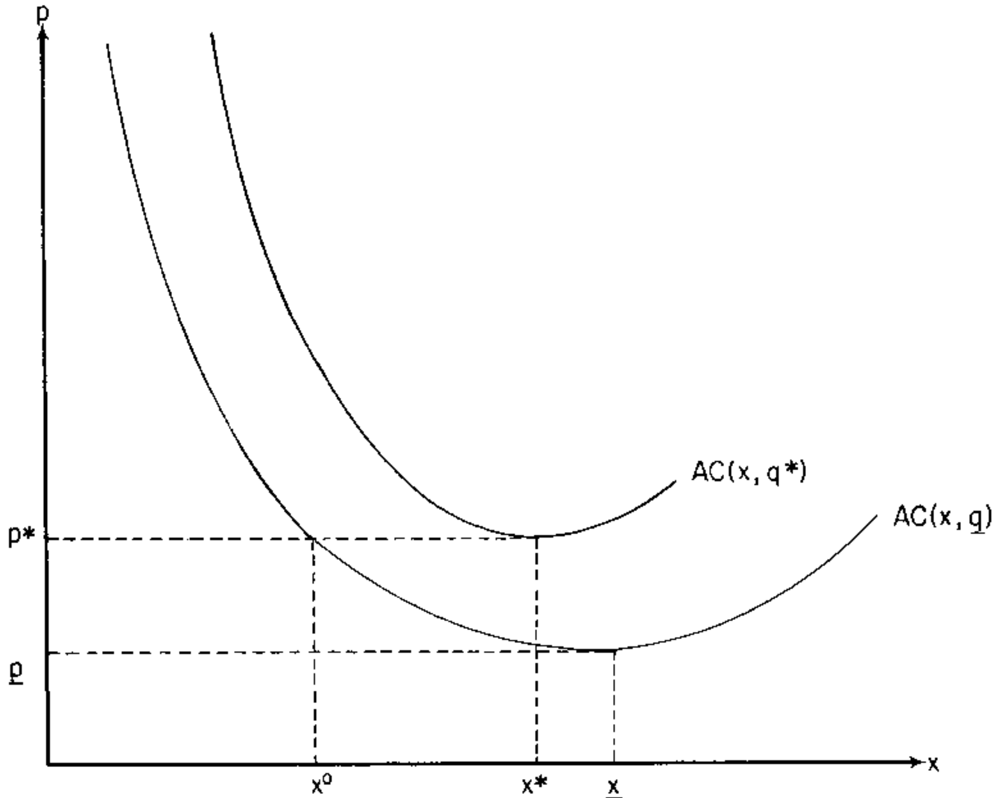

FIGURE 3. Equilibrium in the Signalling Model.

Mathematical Appendix. Sign of $dp_2/d\theta_1$

The triple (p_2, x_2, q_2) is given by

$$F(p_2, x_2, q_2; \theta_1) \equiv \theta_1 x_2(W_1 - W_2) - g_2(1-\theta_1)(x_1 - x_2) = 0,$$

$$G(p_2, x_2, q_2; \theta_1) \equiv p_2 - AC(x_2, q_2) = 0,$$

$$H(p_2, x_2, q_2; \theta_1) \equiv AC(x_2, q_2)W_p(p_2, q_2) + W_q(p_2, q_2) = 0.$$

Drop subscripts 2 and let letter subscripts refer to partial derivatives with respect to p_2, x_2, q_2 and θ_1. From the Implicit Function Theorem:

$$\begin{pmatrix} p_\theta \\ x_\theta \\ q_\theta \end{pmatrix} = \begin{pmatrix} F_p & F_x & F_q \\ G_p & G_x & G_q \\ H_p & H_x & H_q \end{pmatrix}^{-1} \begin{pmatrix} -F_\theta \\ 0 \\ 0 \end{pmatrix} \equiv M^{-1} \begin{pmatrix} -F_\theta \\ 0 \\ 0 \end{pmatrix} \equiv \begin{pmatrix} m_{11} & m_{12} & m_{13} \\ m_{21} & m_{22} & m_{23} \\ m_{31} & m_{32} & m_{33} \end{pmatrix} \begin{pmatrix} -F_\theta \\ 0 \\ 0 \end{pmatrix}.$$

From (6a) $-F_\theta < 0$ so {sign of P_θ} = {sign of $-m_{11}$}.

Now

$$m_{11} = |M|^{-1}(G_x H_q - G_q H_x) = |M|^{-1}(-AC_x)(AC_q W_{pq} + W_{qq} + AC_{qq} W_p + AC_q AC_{qx} W_p).$$

Since the last factor is negative, the sign of P_θ is equal to that of $|M|$. We can write $|M|$ as

$$(AC_{qq}W_p + AC_q^2 W_p + 2AC_q W_{pq} + W_{qq})\left(\theta_1 x_2 W_p AC_x - g_2(1-\theta_1)\frac{x_1}{x_2}\right).$$

Since the first factor is negative, p_θ is negative iff

$$\frac{g_2(1-\theta_1)x_1}{\theta_1 x_2^2} < W_p AC_x. \qquad \text{Q.E.D.}$$

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