Journal of Risk and Uncertainty, 17:3 215–242 (1999)

Price Versus Quantity: Market-Clearing Mechanisms When Consumers are Uncertain about Quality

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Abstract

High-quality producers in a market where quality varies can reap superior profits by charging higher prices, selling greater quantities, or both. Empirical analyses of the mutual fund and automobile industries show that high-quality producers sell more units than their low-quality competitors, but at no higher price (or retail markup) per unit. Our theoretical models find that if qualities are known by consumers and production costs are constant, then having a higher quality secures the producer both higher price and higher quantity. The market may clear in a different fashion if there is "quality uncertainty"; that is, if some consumers can discern quality but others cannot. Then, high- and low-quality producers may end up setting a common price, which allows the high-quality producer to sell substantially more. In this context, quality begets quantity.

Key words: vertical differentiation, product quality, mutual funds, automobiles.

JEL Classification: L11, L15, D82, G23, L62

1. Introduction

You need an electrician. If you are fortunate, you are a well-informed consumer and you know who is good, and who is not. A less-informed consumer, perhaps with no recourse beyond the Yellow Pages, must gamble and may well end up with a low-quality electrician.

Markets of this type are common, particularly at the retail level. They are found with professionals such as caterers, doctors, and movers, with services such as mutual funds, airlines, and resorts, and with consumer durables such as automobiles, dishwashers and VCRs. Though quality differs significantly among providers, many consumers do not know which ones are of high quality. In many such markets, gathering the information necessary to resolve this uncertainty may be costly relative to the expected increase in the quality of the product purchased.

In these markets, casual observation suggests, suppliers whose qualities differ may charge similar prices. High-quality firms sell more units, since well-informed consumers gravitate to them. We say that there is "quantity-clearing" in these markets. Numerous magazine and newspaper articles analyze the quality of competing goods such as no-load mutual funds and economy cars; if some goods are found to have higher quality by many sources, would their producers reap their superior rents by raising prices or by selling more units? In Section 2, we empirically analyze the mutual fund and automobile industries and find that the quantity sold by a firm is positively related to its product's quality, while the price (or retail markup) has little or no relationship with quality. These markets exhibit quantity-clearing.[1]

In the remaining sections of the paper, we ask: "Under what conditions would a high-quality producer choose to reap its rents through greater quantity rather than higher price?" Our intuition suggests that the difference lies in the levels of quality uncertainty and imperfect information among consumers, and thus our model stresses these features. Specifically, we focus on a duopoly where the sellers differ in quality and some consumers are uncertain about quality at the time of purchase. Market outcomes with many sellers are discussed in the Appendix. Markets where products differ in characteristics that can be strictly ordered in terms of desirability are called vertically differentiated markets. We use this framework to study the role of quality uncertainty on relative market shares, and we identify subtle and powerful mechanisms that allow different quantities sold, rather than different prices, to be the primary mechanism that clears the market.[2] We focus on duopoly purely for analytical convenience; we make no claim that duopoly characterizes the structure of any of the industries mentioned above. Rather, we focus on the tractable duopoly case to provide insights into the mechanism of quantity-clearing.

The notion that product differentiation can soften price competition has a long and distinguished history. Chamberlain (1933) first suggested a model of product differentiation as a means to avoid Bertrand's (1883) zero-profit duopoly result and to more realistically model monopolistic competition. For almost 50 years after that, the focus was on horizontal differentiation, with "location" the best-studied example. In the late 1970s and early 1980s, several economists began to study vertically differentiated markets. The early literature on this subject focused on the properties of equilibria and tried to find general conditions under which such industries would have a limited number of firms in equilibrium.[3] Researchers subsequently combined models of vertical and horizontal differentiation to study a range of topics.[4] However, there has been relatively little work on the relationship between quality and market share, because even simple models can yield conflicting answers.[5] In this paper, we make no claims of having resolved these conflicts; rather, we aim to identify the strategic incentives that can lead to large differences in quantities in the presence of small (or no) differences in prices.

Section 3 presents our basic model of a vertically differentiated duopoly with perfect information and no costs of production, a framework similar to that chosen by earlier authors. This model provides a benchmark solution for our duopoly setup and differs little from those of other authors. Section 4 presents the main result of the paper. Here, we add a class of imperfectly informed consumers to the model of section 3. The imperfectly-informed consumers are faced with "quality uncertainty", with the key assumption that this uncertainty is impossible or prohibitively costly to resolve. We find that under some reasonable conditions, both firms would prefer to post the same price (pooling) rather than post different prices (separating). Compared to the separating equilibrium, pooling reduces both efficiency and the total number of consumers who are served, but increases the disparity in sellers' quantities; the imperfect information allows the firms to relax their price competition in a tacit but effective manner, leading to an equilibrium in which the two firms may serve significantly different numbers of consumers. Section 5 concludes the paper. An Appendix provides detailed solutions for the models studied in section 4, and presents a many-firm extension of the model presented in section 3.

2. Two empirical examples: mutual funds and automobiles

In this section, we examine two major U.S. industries—equity mutual funds and automobiles—and analyze cross-sectional relationships between price and quality and between quantity and quality. The purpose of this exercise is to move beyond casual empiricism and demonstrate that there are real markets where quantity-clearing occurs. This demonstration then motivates the theoretical models of sections 3 and 4.

2.1 Mutual funds

The financial press generally rates the quality of mutual funds by looking at various measures of past performance. While, the value of these measures as a forecast of future performance is an open question, it is clear that some consumers pay great attention to the ratings.[6] Therefore, we take past performance as a proxy for quality, be it real or imagined. Our goal is to estimate the effects of quality on price and on quantity. We focus our analysis on these relationships and leave aside many other interesting questions that could be asked of this data.

The universe for our study consists of the 982 U.S. domestic diversified equity mutual funds for which data on all the following variables are available:[7]

Price. We use the maximum percentage "load", or charge, paid to the fund. The load is calculated and paid either on the original investment ("front load") or on the asset value when the investor exits the fund ("deferred load"). These loads may sometimes be reduced for large or long-term investors; we use the figures published in the funds' prospectuses.[8]

Quantity. Quantity is represented by net inflows into the fund from January 31, 1996, to April 30, 1996. These inflows are calculated as $\text{Assets}_{\text{april},i} - \text{Assets}_{\text{jan},i}\,(1 + R_i)$, where, $\text{Assets}_{\text{april},i}$ = total assets under management for fund i as of April 30, 1996, $\text{Assets}_{\text{jan},i}$ = total assets under management for fund i as of January 31, 1996, and R_i = 3-month return from January 31 to April 30, 1996.[9]

Quality. The quality variable that we report in our table of results is the 3-year annualized return, January 31, 1993, to January 31, 1996. This is the actual return that investors received net of expenses, and is the performance figure usually cited in the financial press. 3-year returns are, of course, only one reasonable proxy for quality. Returns at other horizons may in some cases be more salient for consumers, and some sophisticated consumers may prefer measures that explicitly adjust for risk; for example, the intercept

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from a regression of fund excess returns on market excess returns, or "alpha", is a well-known risk-adjusted measure and is reported by Morningstar, a widely read and cited rating service.[10] Our discussion of the regression results assesses the effect of using some of these different proxies for quality; all of these measures yield similar results.

The dependent variables we explore are the load and net inflows, our respective proxies for price and quantity. Each regression includes two independent variables: (1) the three-year annualized return and (2) the total assets under management (in $millions) as of January 31, 1996. The latter variable is included in order to capture the role that fund size plays in affecting prices and quantities. Table 1 summarizes the results.

In regression 1, price (load) is regressed on three-year past returns (quality). The coefficient on quality is not significant; that is, "better" funds do not charge higher prices. The results are similar for other performance measures; for one-year, five-year, or ten-year annualized returns, there is no significant relationship between price and quality. The same relationships hold if we use 3-year "alphas" rather than raw returns as the quality variable. Also, there is no qualitative change in results if total assets are either dropped from the regression or if they are replaced by the log of total assets.[11]

The results of regression 2 show a clear positive relationship between quantity (the net inflow of money) and quality. The coefficient on quality is positive and significant, with a t-statistic of 4.58. The point estimate implies $4.55 million in inflows accompanies each additional percentage point of prior three-year annualized returns. This amount is economically significant as well. Similar results are found using one-, five-, and ten-year returns or three-year alphas as the quality variable. Our calculation of net inflows understates true inflows (purchases less redemptions) by the amount of dividends that are not

Table 1. Cross-sectional relationships among price, quality, and quantity proxies in the market for U.S. diversified equity mutual funds.

(1) Regression #	(2) Dependent Variable	(3) 3-Year Return (= quality)	(4) Total Assets	(5) Constant	(6) R^2
1	Load (= price)	.006 (0.34)	.000043 (1.39)	2.13	.002
2	Net Inflow (= quantity)	4.55* (4.58)	.054* (30.69)	−61.5	.513

Notes: Table 1 reports the results of OLS regressions involving price, quantity, and quality proxies. The sample for each regression includes all 982 domestic diversified equity funds for which we could get reliable data for all included variables from Morningstar Inc.'s databases. Column (1) gives the regression # as it is referred to in the text of the paper. (2) gives the dependent variable for each regression. Columns (3) and (4) report the coefficients on each included independent variable: t-statistics for these estimates are given in parentheses. An asterisk (*) next to a coefficient indicates that it is significantly different from zero at the 95 percent level of confidence. Net inflows are for the period January 31 to April 30, 1996, in $millions ($\mu = 1.02$, $\sigma = 5.02$); Total assets under management are for January 31, 1996, in $millions, ($\mu = 780$, $\sigma = 2581$). Load is the maximum total load = front load + deferred load ($\mu = 2.24$, $\sigma = 2.28$); 3-Year return is the annualized return for the three years prior to January 31, 1996 ($\mu = 13.42$, $\sigma = 4.55$). All units are percent unless otherwise noted. The text of the paper discusses each of these variables. Column (5) reports the constant and Column (6) reports the R^2 for each regression.

reinvested; since such dividends are likely to be positively correlated with returns, the effect of this underestimate should be to bias downward the coefficient on returns; hence, adjusting for this bias would strengthen our results. As a further test, we reestimated regression 2 excluding all funds that have the investment objective of "income" or "growth and income"—the objectives most likely to produce high dividends. The results proved similar.

Overall, the market for diversified domestic equity mutual funds displays a positive relationship between quantity (as measured by net inflows), and quality (as measured by past returns.) No significant positive relationship emerges between price (as measured by the load fee) and quality or price and quantity. This suggests that the typical response of firms benefiting from an increase in demand is not to raise their prices, but rather to sell more of their product.[12]

Similar results—where higher quality leads to greater sales but not to price increases—have been found in other studies of financial services. Tufano (1989) finds that investment banks that create innovative products do not subsequently raise their prices, but rather exploit these advantages to capture a larger share of the underwriting market. Gompers and Lerner (1996) show that among venture-capital firms, age and reputation explain large differences in size but only small and economically insignificant differences in price. Finally, Hulbert (1996) finds that price and past performance are uncorrelated for investment–advisory newsletters.

2.2 Automobiles

With the automobile industry, as in our study of mutual funds, we seek only to identify the relationships between price and quality and between quantity and quality.[13] For automobiles, the institutional structure makes this analysis slightly more complicated than it is for mutual funds. Automobile sales in the United States can be divided into wholesale and retail markets. First, manufacturers sell to dealers, who are by law independent of the manufacturers. The price charged to dealers is the "dealer cost" of an automobile, and is publicly available. Next, dealers sell to consumers. Manufacturer's publish a "suggested" price for these retail transactions, but the majority of purchases are at prices negotiated between dealer and consumer with the final price falling somewhere between the dealer cost and the manfuacturer's suggested retail price. One can think of the retail automobile market as segmented by dealer cost, with cars competing within, but not between, cost segments. Within each segment, dealers compete by negotiating "prices" that represent markups over dealer cost. This two-tiered structure and variation in costs across segments are key features that we consider in our analysis.

It would not require any complicated analyses to see that retail prices are related to almost any definition of quality. Luxury cars certainly have higher production costs than economy cars, such costs are reflected in prices paid by consumers, and most consumers would recognize quality differences between these two cost segments.[14] However, our notion of quantity-clearing in markets is really about the capturing of rents above costs. Since our focus is on the retail level, we employ the markup over dealer cost as our proxy for price; it is the price the dealer receives for his services.

We study cars from the 1994 model-year. The "model" is the level of aggregation used throughout. This aggregation is necessary given our data constraints, and takes different forms (discussed below) depending on the variable: price (markup), quantity, or quality. We employ a multi-car database in which 60 different models pass through our data filters. For each of these 60 models, we used the lowest-price version of the model.[15] We employ the following proxies for the variables:

Price. As discussed above, our estimate of the dealer markup is the price proxy. To calculate this estimate, we would like to have transaction prices for every vehicle sold, but such a data set was not available. Instead, we use published estimates of "target prices" calculated by The Complete Car Cost Guide (1994). These target prices are designed to give consumers an estimate of the price that they would actually have to pay for the car. It is based on a proprietary formula that takes into account typical dealer practices and supply and demand conditions in the market.[16] Then, we calculate the target markup as the difference between the target price and dealer cost.[17] To avoid confusing this target markup with actual prices, we will refer to it as a "markup" rather than a "price" for the remainder of this section.

Quantity. Cars sold in the United States, in thousands. (Source: Ward's Automotive Yearbook 1994–95 (1994)). This figure combines the sales of all versions of the model.

Quality. Ratings from Auto Test (1994). Total ratings (out of a maximum of 190) are the sum of individual ratings in nineteen categories, each of which is graded from one to ten.[18] These ratings and their index are subjective and certainly imperfect, but they are the best data we could find for our purposes. The source gives a single rating to apply for all versions of the model, and we follow this lead.

We next estimate two regressions to identify the cross-sectional relationships between markup and quality, and between quantity and quality. In addition to the dependent variables for markup and quantity and the independent variable for quality, we also include dealer cost as an independent variable in both of the regressions. The aim is to capture any quality effects that remains after controlling for the model's cost segment of the market.

Table 2 summarizes the findings of regressions 3 and 4. Regression 3 analyzes markup and quality. The coefficient on quality is neither statistically nor economically significant. The coefficient on dealer cost is positive and significant. If dealer cost is dropped from the regression, the coefficient on quality remains insignificant. Our quality proxy indicates no significant relationship between quality and markup.[19]

Quantity is regressed on quality and dealer cost in regression 4. The coefficient on quality is positive and significant. The point estimate is economically significant: a one-point increase in the quality rating is associated with increased sales of 3,410 cars—this implies that a one-standard deviation increase in the quality variable enables dealers to sell

Table 2. Cross-sectional relationships among price, quality, and quantity proxies in the market for automobiles in the U.S.

(1) Regression #	(2) Dependent Variable	(3) Rating (= quality)	(4) Dealer Cost	(5) Constant	(6) R^2
3	Markup	2.37	0.67*	.042	.056
		(0.65)	(9.13)		
4	Sales	3.41*	−0.01*	86.2	.145
	(= quantity)	(2.07)	(-3.10)		

Notes: Table 2 reports the results of OLS regressions involving price, quantity and quality proxies. The sample includes 1994 model-year data for the 60 different models for which complete data was available. Hence, there are 60 observations in each regression. Cars classified as "sports" (as identified by Auto Test (1994)) and "luxury" (cars with Dealer Cost greater than $25,000) are excluded. Column (1) gives the regression # as it is referred to in the text of the paper. Column (2) gives the dependent variable for each regression. Columns (3) and (4) report the coefficients on each included independent variable; t-statistics for these estimates are given in parentheses. An asterisk (*) next to a coefficient indicates that it is significantly different from zero at the 95 percent level of confidence. Rating is out of 190 for each car (Source: Auto Test; $\mu = 148$, $\sigma = 9$); Dealer cost is the cost paid by dealers to manufacturers for each car, in dollars (Source: The Complete Car Cost Guide (1994), $\mu = 14859$, $\sigma = 4657$); The markup is the difference between "target price" and dealer cost for each car (Source: The Complete Car Cost Guide (1994); $\mu = 946$, $\sigma = 378$); Sales are the total sales in the U.S. for each model, in thousands (Source: Ward's Automotive Yearbook 1994–95 (1994); $\mu = 100$, $\sigma = 91$). Please refer to the text of the paper for discussions of these variables. Column (5) reports the constant and Column (6) reports the R^2 for each regression.

an extra 30,000 cars. As a benchmark, consider that the median level of sales for our sample is 74,857. As we found for mutual funds, quantity and quality are positively correlated.

Overall, the evidence from the mutual fund and automobile industries suggests that firms in these industries reap the rents from selling high-quality products primarily by enjoying higher sales rather than by charging higher prices (mutual funds) or dealer markups (automobiles). In the following sections, we develop a model to provide insight into this phenomenon. This model is not intended to describe either the mutual fund or automobile industries, but rather as an attempt to focus on the key features of quantity-clearing.

3. A basic model of vertically differentiated duopoly

The previous section documents two industries in which quantity-clearing occurs. Why do some markets behave this way? It is a straightforward exercise to write down a simple model of demand that would characterize such industries. For example, we can specify demand curves for each firm in an oligopolistic industry so that profit maximization leads to differential quantities and similar prices. Such a model would not give any insight, however, into why some industries would face such demand curves and others would not. The best way to secure this insight is to step back one level and model the underlying preferences and information structures that leads to these demand curves. We develop such a model in the next two sections. Although this model is too stylized to characterize either of the industries discussed above—for example, it considers but two firms—we believe that it provides a useful way of thinking about the phenomenon of quantity-clearing. In this section, we focus on a simple perfect information and provide some benchmarks. Section 4 adds a class of imperfectly informed consumers, the primary requirement for a pooled equilibrium and quantity-clearing.

Our basic model assumes that there are no costs of production and that both consumers and producers have perfect information. We work in a partial-equilibrium framework, focusing on a single consumption good. There are two producers of this good, indexed by m: a high-quality producer, m = H, with quality θ_H, and a low-quality producer, m = L, with quality θ_L. We assume that $0 < \theta_L < \theta_H \leq 1$, and we define α as the ratio between the qualities of L and H: $\alpha = \frac{\theta_L}{\theta_H}$, hence $0 < \alpha < 1$. For semantic ease, we will use female pronouns for H and male pronouns for L. In equilibrium, our producers will earn profits, but entry will not occur because (by assumption) our industry is made up of producers with scarce skills, which can therefore earn rents. For example, high-quality electricians, mutual funds, and automobile producers earn rents, and these rents will not be dissipated by entry as long as the underlying high capability cannot quickly be reproduced. When quality takes the form of an innate talent or a skill that is costly to acquire, this assumption is reasonable.[20] Once we can safely ignore entry, our task is to model the market for different fixed numbers of producers. Duopoly is the logical first step. The Appendix sketches the solution to the model with multiple firms, and gives an illustration for the special case of a 5-firm industry. The multi-firm intuition is very similar to the duopoly intuition, with the relevant competition in the multi-firm case occurring between firms that are adjacent in the quality hierarchy.

Let a consumer's "valuation" for the consumption good be denoted by v. Each consumer can buy either zero or one unit of the good. There is a continuum of consumers, indexed by their valuation, v, on the interval [0, 1]. The benefit to a consumer from purchasing one unit from producer m is $v\theta_m$; the cost is the price, P_m. Thus, the specified realization of the utility function is

$$U(\theta, v) = v\theta_m - P_m \tag{1}$$

if the consumer buys one unit of the good from producer m, and

$$U(\theta, v) = 0 \tag{2}$$

otherwise. We assume that consumers always have enough money to buy one unit of the good if it is optimal to do so. We also assume that when a consumer is indifferent between buying and not buying, he buys, and when he is indifferent between buying the two types of goods, he buys from H. The utility function used here is similar to the one chosen by earlier writers on vertical differentiation.[21] If there were only one quality available, then this model of consumption would imply a linear market demand curve where the fraction of consumers willing to buy a good of quality θ_m at any price P would be equal to $1 - \frac{P}{\theta_m}$.

The sequence of events is

(1) H chooses her price, P_H.
(2) L chooses his price, P_L.
(3) Each consumer either: (A) purchases one unit from H. (B) purchases one unit from L, or (C) makes no purchase.

This sequential price-setting rule differs from the rule used in most of the previous literature on vertical differentiation, where firms generally set prices simultaneously. We have H set her price first because it is the simplest way to deal with quality uncertainty, our task in section 4. There, we model a subset of the consumers as being unable to ascertain different quality unless they observe different prices; if we were to use simultaneous price-setting, then it would be impossible for either firm to unilaterally force a same-price "imperfectly-revealing" equilibrium. Since markets with quality uncertainty and one price are important in practice, we wanted our model to allow for this. In the next section, we discuss these issues in more detail. For now, we still assume that consumers can costlessly assess the quality of both producers.

We solve the game backwards to find the equilibrium level of prices, quantities, and purchase decisions. First, a consumer will

A) buy the high-quality good if

$$(1)\ v\theta_H - P_H \geq v\theta_L - P_L \rightarrow v \geq \frac{P_H - P_L}{\theta_H - \theta_L}$$

and

$$(2)\ v\theta_H - P_H \geq 0 \rightarrow v \geq \frac{P_H}{\theta_H};$$

B) buy the low-quality good if

$$(1)\ v\theta_L - P_L > v\theta_H - P_H \rightarrow v < \frac{P_H - P_L}{\theta_H - \theta_L}$$

and

$$(2)\ v\theta_L - P_L \geq 0 \rightarrow v \geq \frac{P_L}{\theta_L}; \text{ and}$$

C) not buy, otherwise.

We next turn to L's price-setting problem. L knows the distribution of consumers and their optimal conditions. Production is costless.[22] The sellers maximize profit, π, which absent costs is simply price times quantity. Thus, L seeks to maximize

$$\pi_L = Q_L P_L, \tag{3}$$

where Q_L is L's quantity. Using conditions B.1 and B.2, we can see that the quantity for this producer will be

$$Q_L = \left(\frac{P_H - P_L}{\theta_H - \theta_L} - \frac{P_L}{\theta_L}\right). \tag{4}$$

Therefore, L's profit function can be written as

$$\pi_L = \left(\frac{P_H - P_L}{\theta_H - \theta_L} - \frac{P_L}{\theta_L}\right) P_L. \tag{5}$$

The first-order condition for L is

$$\frac{\partial \pi_L}{\partial P_L} = 0 = \left(\frac{P_H - P_L}{\theta_H - \theta_L} - \frac{P_L}{\theta_L}\right) - \left(\frac{1}{\theta_H - \theta_L} + \frac{1}{\theta_L}\right) P_L. \tag{6}$$

We can then solve for P_L as

$$P_L = \frac{\theta_L P_H}{2\theta_H}. \tag{7}$$

So L's price will always be proportional to H's price, the proportion being $\frac{\theta_L}{2\theta_H}$, one-half the ratio between the two quality levels.

Finally, we turn to H's price-setting problem. From (7) it can be verified that $\frac{P_H - P_L}{\theta_H - \theta_L} > \frac{P_H}{\theta_H}$ for all optimal choices of P_L by L. Thus, for any level of P_L that could be set in equilibrium,

$$Q_H = \left(1 - \frac{P_H - P_L}{\theta_H - \theta_L}\right). \tag{8}$$

Replacing P_L by its optimal value, we can write H's profits as

$$\pi_H = \left(1 - \frac{P_H - \dfrac{\theta_L P_H}{2\theta_H}}{\theta_H - \theta_L}\right) P_H. \tag{9}$$

H seeks to maximize these profits with respect to P_H. Solving for the optimal P_H yields

$$P_H = \frac{\theta_H(\theta_H - \theta_L)}{2\theta_H - \theta_L}. \tag{10}$$

Finally, we substitute (10) into (7) to obtain

$$P_L = \frac{\theta_L(\theta_H - \theta_L)}{2(2\theta_H - \theta_L)}. \tag{11}$$

Figure 1 plots P_H and P_L against θ_L for the case of $\theta_H = 1$. At $\theta_L = 0$, H effectively possesses a monopoly, and thus sets the monopoly price, $P_H = .5$. As θ_L rises, H faces increasing competition, and her optimal price falls. Two counteracting factors affect the level of P_L as θ_L rises: first, increases in θ_L raise the ratio of equilibrium prices $\frac{P_L}{P_H}$; second, increases in θ_L cause P_H to fall. As long as P_H is high enough, the first effect dominates, and P_L increases with θ_L. When P_H falls low enough so that increases in the ratio are not sufficient to offset decreases in the level of P_H, the second effect dominates, and P_L decreases with θ_L. In all cases, however, P_H is greater than P_L.

Substituting the equilibrium levels of P_H and P_L into the profit equations yields equilibrium profits of

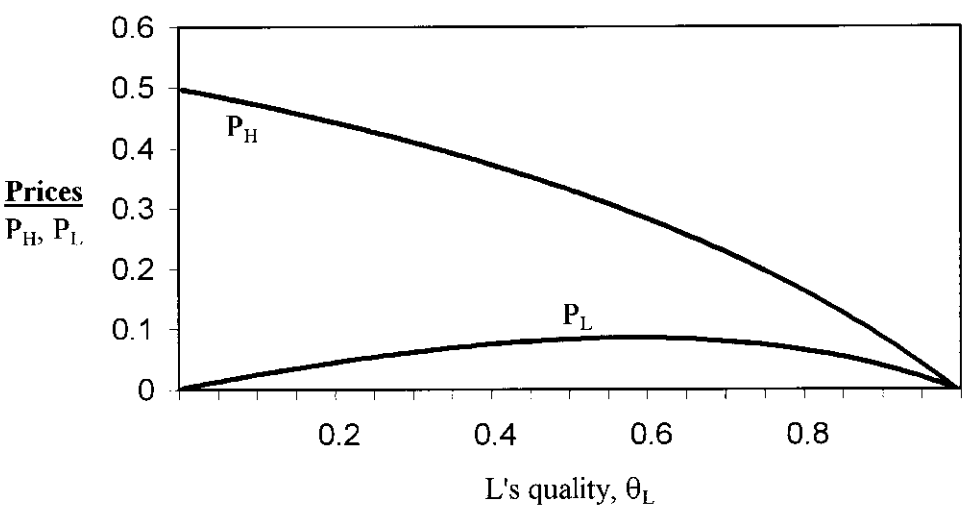

Figure 1. Prices for H and L as a function of L's quality.
Notes: P_H and P_L are the prices for H and L, respectively. θ_L is L's quality. The price curves are drawn for the case of $\theta_H = 1$.

$$\pi_H = \frac{\theta_H(\theta_H - \theta_L)}{2(2\theta_H - \theta_L)} \tag{12}$$

and

$$\pi_L = \frac{\theta_H\theta_L(\theta_H - \theta_L)}{4(2\theta_H - \theta_L)^2}. \tag{13}$$

Figure 2 plots equilibrium profits against θ_L for the case of $\theta_H = 1$. As expected, π_H falls monotonically with θ_L as H faces greater and greater competition. The relationship of π_L and θ_L is more interesting, and is similar to the relationship of P_L and θ_L. At first, π_L increases with θ_L, as L is able to charge higher prices without losing market share. Eventually, as L's quality closes in on H's, the price competition becomes so intense that P_H and P_L both fall to low levels, making π_L diminish. As $\theta_L \to 1 = \theta_H$, prices and profits go to zero for both firms.

A major focus of this paper is the relative market shares of high- and low-quality sellers. What will be the equilibrium ratio of sales for H and L? We denote this ratio as r, where

$$r = \frac{Q_L}{Q_H} = \frac{\left(\frac{P_H - P_L}{\theta_H - \theta_L} - \frac{P_L}{\theta_L}\right)}{\left(1 - \frac{P_H - P_L}{\theta_H - \theta_L}\right)}. \tag{14}$$

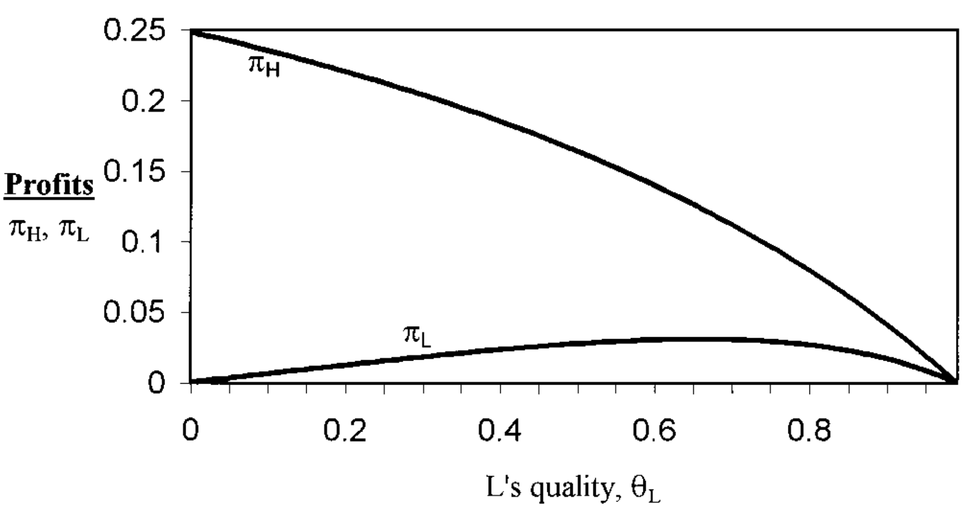

Figure 2. Profits for H and L as a function of L's quality.
Notes: π_H and π_L are profits for H and L, respectively. θ_L is L's quality. The profit curves are drawn for the case of $\theta_H = 1$.

Many of our results can be expressed in terms of $\frac{\theta_L}{\theta_H}$, the ratio between the two qualities. Therefore, we employ the notation

$$\alpha = \frac{\theta_L}{\theta_H}. \tag{15}$$

Substituting our equilibrium values for P_H and P_L yields

$$r = \frac{1}{2 - \alpha}. \tag{16}$$

Thus, (16) reveals that the ratio of the shares of the market going to L and H is a function of the ratio of their qualities, with an upper bound of 1 (when $\alpha = 1$) and a lower bound of $\frac{1}{2}$ (when $\alpha = 0$). Two results follow directly from (16). First, H always has a greater market share than L; that is, $r < 1, \forall\alpha$. Second, the ratio of the market shares increases with the ratio of the qualities; i.e., $\frac{\partial r}{\partial \alpha} = \frac{1}{(2 - \alpha)^2} > 0$. From Figure 1 we saw that the H always sets a higher price than L. Therefore, in this perfect-information/certainty duopoly model, the high-quality producer takes out her rents through both higher price and higher quantity.

These results are consistent with our intuition for wholesale markets such as those for uncut diamonds, raw produce, and livestock, where buyers are relatively well informed and sophisticated. However, the results are not consistent with the evidence on the retail markets for mutual funds and automobiles. There, we observe quantity-clearing in the market; outcomes in which different producers sell vastly different quantities at similar prices. One obvious difference between retail and wholesale markets is that information is often far superior in the latter. The next section introduces uncertainty about quality to the model, and analyzes the relationship between this uncertainty and the phenomenon of quantity-clearing.

4. Quality uncertainty

Consider a market where it is costly or impossible for some consumers to learn the true quality of an item before deciding whether to buy it. For example, a consumer would not necessarily be able to ascertain the quality of the wiring installed by an electrician until some time passed after the job was completed. This section uses a very simple information structure for consumers who are trying to distinguish between H and L; we separate consumers into two types, connoisseurs and dilettantes. A connoisseur can always tell producers apart; that is, a connoisseur will always know the type of producer that he or she is buying from. A dilettante can only tell producers apart if they are charging different prices; otherwise, dilettantes face “quality uncertainty”. If the two producers are charging the same price, the dilettante will be unable to distinguish H from L, at least until after the purchase. Our model allows dilettantes to infer information when different prices are charged since quality may be learned much more easily in markets where prices convey information. Thus, if quality were either positively or negatively related to price we assume that this fact would invariably be known. When prices are the same, our assumption is that dilettantes would need costly additional work to distinguish H from L. There is nothing about this information structure that is inconsistent with dilettantes being rational utility maximizers, and we model them as such.

We denote the fraction of dilettantes by λ. In terms of tastes, dilettantes are drawn uniformly from all consumers.[23] Since connoisseurs can always tell the producers apart, the conditions for their purchase decision remain the same as in section 3. If the producers set different prices, then dilettantes can tell them apart as well, and their purchase decisions will be the same as those of the connoisseurs. However, if producers set the same price, then a dilettante will have to randomly choose a producer (one-half chance of each), and will only purchase the good if his expected utility for this random purchase is nonnegative. More formally, when facing a single price, P, a dilettante will

(1) buy if $\left(\frac{\theta_H + \theta_L}{2}\right) v \geq P$; and
(2) not buy, otherwise.

In this framework, the sequential price-setting rule seems natural; with the possibility of L "fooling" some of the consumers, he will have an incentive to wait until H has already set her price before he sets his. In the extreme, when all consumers are dilettantes, L has nothing to lose by waiting (since no dilettante will buy from him if prices are different), while H, as will be seen, often has little to lose by going first. This set of incentives can coexist because this is not a constant-sum game. Thus, we find price leadership by H to be both logical and analytically convenient.

When it is L's turn to set prices, he knows that he can choose either a pooling equilibrium (same price as H), or a separating equilibrium (different price). If he chooses a separating equilibrium, then all consumers will be able to tell the producers apart, and his profits will be the same as they were in the model studied in section 3. Let the superscripts p and s indicate pooling and separating, respectively. Then L's profits are

$$\pi^s_L = \left(\frac{P_H - P_L}{\theta_H - \theta_L} - \frac{P_L}{\theta_L}\right) P_L. \tag{17}$$

Profits will be maximized here by a choice of P_L of

$$P_L = \frac{\alpha P_H}{2}, \tag{18}$$

which is the same as the solution in section 3, this time written in terms of α. A change of variables here of

$$\beta = \theta_H - \theta_L$$

enables us to write our results more concisely. For example, optimal separating profits for L will be given by

$$\pi^s_L = \frac{\alpha P^2_H}{4\beta}. \tag{19}$$

If L chooses a pooling price, $P_L = P_H$, then his profits will be

$$\pi^p_L = \frac{\lambda}{2}\left(1 - \frac{2P_H}{\theta_H + \theta_L}\right) P_H. \tag{20}$$

There is no maximization here, since there is only one price, $P_L = P_H$, at which there will be pooling. If L selects the pooling price, he will only sell to dilettantes, and among them only to those who have a positive expected utility for purchasing the good. Half of these dilettantes (by chance) will choose H, and half will choose L. This chance process will be familiar to tourists who have tried to pick a Broadway show merely from the listings in the New York Times.

L's decision, then, is whether to choose the separating profits given in (19) or the pooling profits given in (20). He will choose the separating profits, and a separating equilibrium will result if $\pi^s_L \geq \pi^p_L$. This condition implies that

$$P_H \geq \frac{2\lambda\beta\,(1 + \alpha)}{\alpha(1 + \alpha) + 4\lambda(1 - \alpha)}. \tag{21}$$

That is, there will be a cutoff level for P_H, above which L will always prefer to separate; below the cutoff level L will prefer to pool; and at the cutoff level he will be indifferent. The intuition for this is straightforward: L's optimal separating price is always a proportion of P_H, so when P_H is low, L's separating profits will be low as well.

Figure 3 shows the optimal separating profits compared to pooling profits as a function of P_H for the special case of $\lambda = .5$, $\theta_H = 1$, and $\theta_L = .5$ (i.e., $\alpha = \beta = .5$). As P_H rises, separating profits rise monotonically, while pooling profits first rise and then fall as is typical for a monopoly. Pooling profits reach their maximum when demand for the pooled product is unit elastic. The two curves intersect where $\frac{2\lambda\beta\,(1 + \alpha)}{\alpha(1 + \alpha) + 4\lambda\,(1 - \alpha)} = \frac{.5(1.5)}{.5(1.5) + 2(.5)} = .42857$. For low levels of P_H, L is better off pooling, because the low price set by H does not leave much room for L to earn profits by attracting low v customers with a still lower price.

The next step is to solve for H's optimal P_H, given L's known optimal response. H knows that she can bring about either a pooling or separating equilibrium, depending on her choice of P_H. We find her optimal price by solving for her maximum profits in each type of equilibrium, and then comparing the two.

To choose an optimal separating price, H must maximize

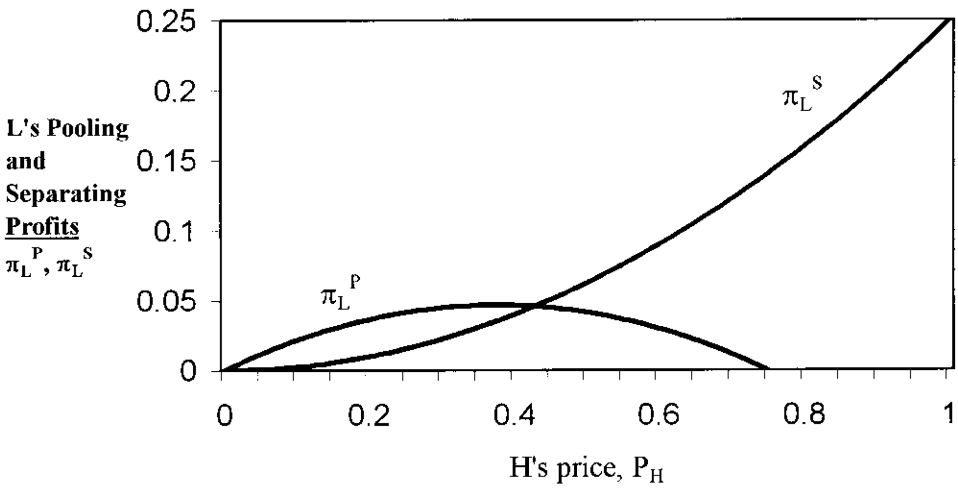

Figure 3. L's profits for pooling and separating as a function of H's price.
Notes: π_L^s is L's profit if he chooses the optimal separating price P_L (eq. 19). π_L^p is L's profit if he chooses to pool by choosing $P_L = P_H$ (eq. 20). The profits curves are drawn for the cause $\lambda = .5$, $\theta_H = 1$ and $\theta_L = .5$ (i.e. $\alpha = \beta = .5$).

$$\pi^s_H = \left(1 - \frac{P_H - \dfrac{\alpha P_H}{2}}{\beta}\right) P_H, \qquad \text{subject to } P_H \geq \frac{2\lambda\beta\,(1+\alpha)}{\alpha\,(1+\alpha) + 4\lambda(1-\alpha)} \tag{22}$$

The constraint must be included because if H chooses a P_H that is too low, then L will choose to pool.

To attain optimal pooling profits, H must maximize

$$\pi^P_H = (1-\lambda)\left(1 - \frac{P_H}{\theta_H}\right) P_H + \frac{\lambda}{2}\left(1 - \frac{2P_H}{\theta_H + \theta_L}\right) P_H, \qquad \text{subject to } P_H \leq \frac{2\lambda\beta\,(1+\alpha)}{\alpha\,(1+\alpha) + 4\lambda\,(1-\alpha)} \tag{23}$$

The first term in (23) is H's profits from connoisseurs. Since all connoisseurs who choose to purchase the good will do so from H, the lower bound for v buying high-quality goods will be $\dfrac{P_H}{\theta_H}$, instead of $\dfrac{P_H - P_L}{\beta}$, as it was in section 3. The second term in (23) is H's profits from dilettantes, a part of the market that she must share with L. Finally, the constraint ensures that H chooses a price low enough that L will actually choose to pool. We say that a pooling [separating] equilibrium is “constrained” if H’s profits cannot be pushed higher without inducing L to separate [pool].

If H’s separating profits (solution to (22)) are higher than her pooling profits (solution to (23)), then she will choose the higher price in a separating equilibrium. If separating profits are lower, then she will choose the optimal pooling price, and quality will beget quantity.

Proposition 1. If quality levels are sufficiently close and dilettantes comprise a sufficient proportion of consumers, then only pooling equilibria will exist. Sufficient conditions here are the set $\alpha \geq .55 \cap \lambda \geq \dfrac{1 + \alpha}{6 - 2\alpha}$.

Proof. See Appendix.

Whenever the duopolists have qualities that are relatively close, a pooling equilibrium will result. The intuition is simple: as qualities converge—as α gets higher—competition becomes more intense in the separating equilibrium; both firms set prices lower, and profits fall for both. In the limit, profits fall to zero, in effect due to a sequential-move variant of Bertrand competition. Thus, H has an incentive to try to reduce this competition by avoiding the low-profit separating equilibrium. She does this by setting a price so low that L might as well engage in a pooling equilibrium. Note that the conditions of Proposition 1 are sufficient but not necessary for pooling equilibria; there are also some ranges of λ when $\alpha < .55$ in which pooling equilibria exist. The main point of the proposition is that for α “high enough”, there will be a level of dilettantes above which only pooling equilibria exist.

A graphical depiction is useful for reinforcing the intution of Proposition 1. Figure 4 shows separating profits, π^s_H ($\pi^{\bar{s}}_H$ when constrained) and pooling profits, π^p_H ($\pi^{\bar{p}}_H$ when constrained) as a function of λ. In the figure $\theta_L = .75$, and thus $\alpha = .75$ and $\beta = .25$. This is the typical case for the range of parameters used in Proposition 1. Here, separating profits are constrained after the point of tangency between π^s_H and $\pi^{\bar{s}}_H$; before that point, separating profits are equal to π^s_H, and after that point they are equal to $\pi^{\bar{s}}_H$. Pooling profits, however, are constrained *before* the tangency point of π^p_H and $\pi^{\bar{p}}_H$; before that point, pooling profits are $\pi^{\bar{p}}_H$, and after that point they are equal to π^p_H. The latter tangency does not occur until λ is approximately equal to 1; hence pooling profits are constrained for almost the entire range. Note that for the $\pi^{\bar{s}}_H$ and $\pi^{\bar{p}}_H$ curves, H sets the same price at any given level of λ, with the difference in profits caused by L’s choice of separating or pooling.

In the figure, H’s constrained pooling profits, $\pi^{\bar{p}}_H$, become greater than separating profits at $\lambda \approx .2$, and stay greater than separating profits for the rest of the range. Therefore, only pooling equilibria will exist for all $\lambda > .2$. Strikingly, even with a small proportion of dilettantes, H sets a price low enough to induce L to pool. L’s market share can be very low in a pooling equilibrium. For example, when dilettantes and connoisseurs

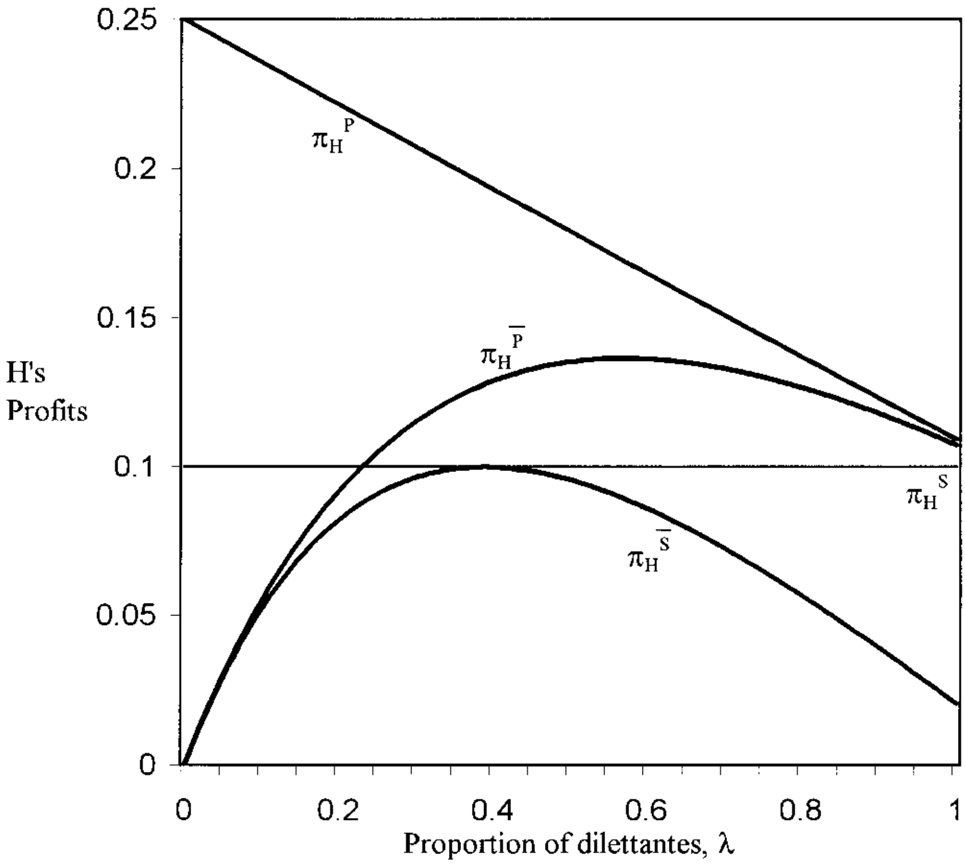

Figure 4. H's profits for pooling and separating as a function of the proportion of dilettantes.
Notes: The profit curves are drawn as a function of λ for the case of $\theta_H = 1$, $\theta_L = .75$ ($\alpha = .75$, $\beta = .25$). The equations for the curves are given in the Appendix - with the equation numbers given below. π_N^s is H's profit when P_H is set at the opimal separating price and L chooses to separate (Eq. 31). $\pi_H^{\bar{s}}$ is H's profit when P_H is set at the optimal price that makes L indifferent between pooling and separating, and L chooses to separate (Eq. 32). π_H^p is H's profit when P_H is set at the optimal pooling price and L chooses to pool (Eq. 37). $\pi_H^{\bar{p}}$ is H's profit when P_H is set at the optimal price that makes L indifferent between pooling and separating, and L chooses to pool (Eq. 38).

are equal in number, $\lambda = .5$, L gets only one-quarter of the market, $r \approx .25$, as he will get one-half of the dilettantes, leaving all of the connoisseurs for H. The two producers will charge the same price but sell vastly different quantities.

The factor that drives H to choose a pooling equilibrium is the intense competition that exists between the two firms as their qualities converge. With dilettantes sufficiently common, H has an opportunity to avoid this competition: by setting her price sufficiently low, she can induce L to pool, and thereby pick up all the business of connoisseurs.

Although H sells at a lower price than she would in a separating equilibrium, she secures a far higher market share. L would be far better off at many pairs of separating prices; however, at the price chosen by H, the best that L can do is to pool.

5. Conclusion

This paper examines the possibility of quantity-clearing in markets; i.e., that sellers offering competing products of different qualities, will set similar prices and therefore sell significantly different quantities. It begins with an examination of the mutual fund and retail automobile markets. This empirical analysis provides unequivocal evidence of quantity-clearing; there is no relationship between quality and mutual fund loads or automobile retail markups, our indicators of price in these markets.

Our principal goal is to develop models that explain why and when quantity-clearing will occur in markets where sellers' qualities differ. We start with buyers well-informed, as they usually are in wholesale markets. Then a high-quality producer will take out her rents through both higher prices and higher quantities. A low-quality seller always gains market share as his quality improves, but surprisingly, his profits may fall. This happens because quality convergence intensifies competition, leading the high-quality seller to lower her price.

In many markets, particularly retail markets, buyers will be uncertain about the qualities of different products. If so, new qualitative phenomena can arise. A low-quality seller may find it optimal to pool, to set the same price as his high-quality competitors. When he does, the high-quality firm makes all the sales to the well informed; but sales to the poorly informed are split. This price-pooling equilibrium is more likely to arise, the closer are the qualities of high and low, and the greater is the proportion of poorly informed consumers.

Price-pooling does more than determine a split in the market. It significantly reduces the degree of competition, raising the profits of both sellers in comparison to the separating equilibrium. Though price-pooling emerges as a result of each player optimizing, it has the same price-boosting effects as does seller collusion in other contexts.

Government regulation is significantly concerned with the information available in markets, and the profit- and quality-setting procedures of sellers within them. Our models identify incentives for sellers to work against competitive forces in all three areas. In both poorly and well-informed markets, low-quality sellers may have a perverse incentive to hold down quality. In poorly informed markets, high- and low-quality sellers can often set a common price, thereby removing competition on price. Finally, holding quality fixed, both sellers will often have an incentive to keep the market poorly informed about quality.

If sellers set a common price, is that good or bad news? Our view should change depending on uncertainty in the market. If information is perfect, a common price represents the outcome of perfect competition, with sellers offering the same quality good. However, if many consumers are poorly informed, a common price may well be the best sustainable price for both high- and low-quality sellers, implying an undesirable price for consumers.

The Federal Trade Commission polices information in markets. It is statutorily charged with fostering truth in advertising, and has often assumed the mission of stimulating greater information in markets, presumably to bolster competition. The FTC has fought successfully against industry-supported and professional-norm advertising bans in such industries as opticians and physicians. Many government programs, such as the Energy Department's energy efficiency ratings or the Transportation Department's airline on-time records, provide information to the market. The usual justification is that consumers will make better choices, and that producers will improve performance on important, but hard to monitor dimensions. Our models suggest that beyond these benefits, greater information may help to increase competition.

Indeed, the behavior of even good firms in many industries to advertise comparative qualities suggests that they understand that information bolsters competition. Political competitions, where price is absent and market share is everything, provide an instructive contrast. Comparative-quality advertising, including much downgrading of the competition, is rife.

This paper chronicles the struggle for resources within markets. Sellers offering different qualities can be thought of as species within an ecosystem, engaging in pricing behaviors of separation and mimicry in their struggle to extract profits from buyers. Information may be the sunlight equivalent for market ecosystems, and ignorance darkness, with uncertainty as the shadowed in-between. When information is abundant, the low-quality seller's identity is exposed: he survives on the pickings in his own price niche. When shadows fall, by contrast, the low-quality seller can masquerade by setting the high-quality price. He thereby secures his share of ignorant buyers, but concedes all knowledgeable buyers to his competitor. This is quantity-clearing, a common phenomenon in shadowed markets.

7. Appendix

7.1 Solution with many firms: extension to section 3

For the case of perfect information and no costs of production, consider an industry with M firms, indexed by their respective qualities θ_m. We arbitrarily order these qualities from highest to lowest as $\theta_1, \theta_2, \ldots, \theta_M$, and we assume that this ordering is strict. Firms set prices sequentially in order of quality, so that the highest-quality firm sets its price first and the lowest-quality firm sets its price last. Consumers' preferences are distributed as in section 3.

We solve the model backwards, beginning with the consumer's problem. The optimal decision rule for the consumer will be

(A) Buy from firm m if

(1) $\theta_m v - P_m \geq \theta_n v - P_n$ for all $n = 1, \ldots m - 1$;
(2) $\theta_m v - P_m > \theta_n v - P_n$ for all $n = m + 1, \ldots M$; and
(3) $I_v + \theta_m v - P_m \geq I_v$.

(B) Do not buy if $I_v + \theta_m v - P_m < I_v$ for all $m = 1, \ldots, M$.

Conditions (A.1) and (A.2) ensure that a consumer who is indifferent between two products always buys the one of higher quality. This optimal decision rule will lead to a segmented market. To see why, consider two consumers indexed by their valuations of v and w, with w > v. One can easily verify that if v buys from firm m, then w would never buy from any firm n < m. This greatly simplifies our problem, as each firm (except for firms 1 and M) will have a demand interval of

$$Q_m = (\frac{P_{m-1} - P_m}{\theta_{m-1} - \theta_m} - \frac{P_m - P_{m+1}}{\theta_m - \theta_{m+1}}). \tag{24}$$

It follows that each firm will have positive market share in equilibrium. As long as firm m does not set a price of 0, firm m + 1 can guarantee itself a positive market share and thus a positive profit. Therefore, no firm would ever set a price of 0, and the positive market share equilibrium is established. We are now ready to solve the M-player game.

The profit function for firm M is

$$\pi_M = (\frac{P_{M-1} - P_M}{\theta_{M-1} - \theta_M} - \frac{P_M}{\theta_M}) P_M. \tag{25}$$

Maximizing these profits with respect to P_M yields an optimal solution of

$$P_M = \frac{\theta_M P_{M-1}}{2\theta_{M-1}}. \tag{26}$$

This optimal solution can then be substituted into the profit function of firm M − 1, which is then solved and substituted into the profit function of firms M − 2, …,. The general form of the profit function for firm m, m = 2, …, M − 1 is

$$\pi_m = (\frac{P_{m-1} - P_m}{\theta_{m-1} - \theta_m} - \frac{P_m - P_{m+1}}{\theta_m - \theta_{m+1}}) P_m. \tag{27}$$

The profit of firm 1 is written the same as in the duopoly case:

$$\pi_1 = \left(1 - \frac{P_1 - P_2}{\theta_1 - \theta_2}\right) P_1, \tag{28}$$

where P_2 would be a function of $\theta_1, \theta_2, \ldots \theta_M$.

Computing the equilibrium is tedious but not difficult. The results yield similar intuition to the duopoly case. We solved a 5-firm game as an example. Figure 5 shows the equilibrium quantities of this game as a function of θ_3, the parameter allowed to vary, drawn

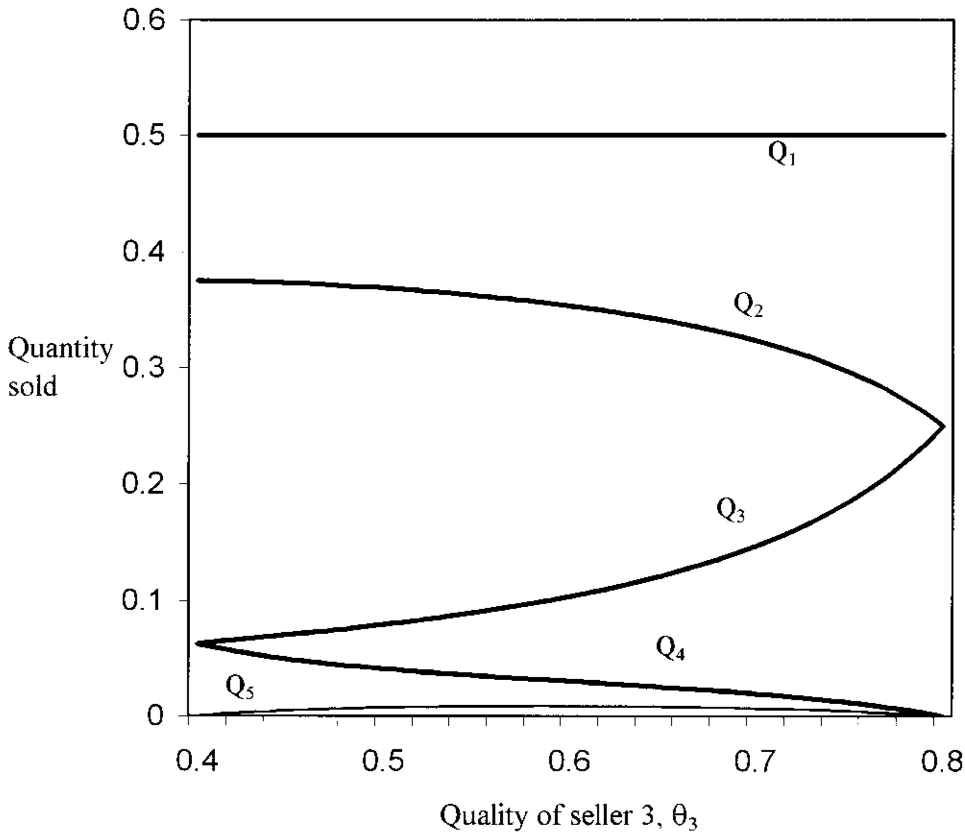

Figure 5. Market share of each seller in a five-firm oligopoly as a function of the third seller's quality. Notes: The quantity curves are plotted against θ_3 for the case of $\theta_1 = 1$, $\theta_2 = .8$, $\theta_4 = .4$, $\theta_5 = .2$. θ_m is the quality of the mth seller. Q_m is the quantity sold by the m$_{th}$ seller.

for the special case of $\theta_1 = 1$, $\theta_2 = .8$, $\theta_4 = .4$, and $\theta_5 = .2$. The range for θ_3 is between .4 and .8, the levels of θ_4 and θ_2, respectively. At the midpoint of its range, $\theta_3 = .6$, and the qualities for all five firms are evenly spaced. When $\theta_3 = .4$, firm 3 engages in ruinous competition with firm 4, driving both their prices and profits down to zero. In this case, firm 5 will also be driven out of business in the limit. As θ_3 rises, firm 3 increases its market share at the expense of its two closest neighbors. Finally, as θ_3 approaches .8, firm 3 begins to engage in more ruinous competition with firm 2. In the limit, both firms' prices and profits fall to zero, and they split all the market not taken by firm 1, with firms 4 and 5 driven from the market.

7.2 Solution with quality uncertainty: proof of proposition 1 from section 4

To prove this proposition, as well as to draw the figures of section 4, we first need to solve for five expressions:

(1) π^s_H—Separating profits for H ignoring the constraint in (22).
(2) $\pi^{\bar{s}}_H$—Separating profits for H when the constraint in (22) binds exactly.
(3) λ^s—The minimum level of λ for which the constraint in (22) holds.
(4) π^p_H—Pooling profits for H ignoring the constraint in (23).
(5) $\pi^{\bar{p}}_H$—Pooling profits for H when the constraint in (23) binds exactly.

After solving for these five expressions, we are able to compare H's pooling and separating profits for all levels of λ and α, and show that when the conditions of the proposition are met, pooling profits will always be higher.

Separating equilibrium. The problem is to maximize

$$\pi^s_H = N\left(1 - \frac{P_H - \dfrac{\alpha P_H}{2}}{\beta}\right) P_H, \qquad (29)$$

$$\text{subject to } P_H \geq \frac{2\lambda\beta\,(1+\alpha)}{\alpha(1+\alpha) + 4\lambda(1-\alpha)}$$

When the constraint does not bind, the solution is

$$P_H = \frac{\beta}{2-\alpha}, \qquad (30)$$

yielding profits of

$$\pi^s_H = \frac{\beta}{2(2-\alpha)}. \qquad (31)$$

The relevant second-order conditions hold here, so whenever the constraint binds, it will bind exactly and profits will be

$$\pi^{\bar{s}}_H = \frac{2\beta\lambda\,(\alpha+1)\,(\alpha^2 + \alpha + 2\lambda - 5\lambda\alpha + \lambda\alpha^2)}{(\alpha^2 + \alpha + 4\lambda - 4\lambda\alpha)^2}, \qquad (32)$$

where $\pi^{\bar{s}}_H$ refers to profits for the high-quality producer in the separating equilibrium when the constraint binds. The constraint will bind when

$$\frac{\beta}{2-\alpha} = \frac{2\lambda\beta\,(1+\alpha)}{\alpha(1+\alpha)+4\lambda(1-\alpha)}. \tag{33}$$

This occurs at

$$\lambda^{s} = \frac{1+\alpha}{6-2\alpha}. \tag{34}$$

Pooling equilibrium. The problem is to maximize

$$\begin{aligned}\pi^{p}_{H} &= (1-\lambda)\left(1-\frac{P_H}{\theta_H}\right)P_H + \frac{\lambda}{2}\left(1-\frac{2P_H}{\theta_H+\theta_L}\right)P_H,\\ &\text{subject to } P_H \leq \frac{2\lambda\beta\,(1+\alpha)}{\alpha(1+\alpha)+4\lambda(1-\alpha)}\end{aligned} \tag{35}$$

When the constraint does not bind, the solution is

$$P_H = \frac{(\alpha+1)\,(2-\lambda)\,\beta}{4(1-\alpha^2-\lambda\alpha+\lambda\alpha^2)}, \tag{36}$$

and pooling profits will be

$$\pi^{p}_{H} = \frac{(2-\lambda)^2\,(\alpha+1)\beta}{16(1-\alpha^2-\lambda\alpha+\lambda\alpha^2)}. \tag{37}$$

When the constraint does bind, profits will be

$$\pi^{\bar{p}}_{H} = \frac{\lambda\beta(\alpha+1)\,(2\alpha^2+2\alpha+4\lambda-9\lambda\alpha+3\lambda\alpha^2-4\lambda^2+8\lambda^2\alpha-4\lambda^2\alpha^2)}{(\alpha^2+\alpha+4\lambda-4\lambda\alpha)^2}. \tag{38}$$

Comparing separating and pooling profits. We need to show that pooling profits are always larger than separating profits whenever we have both $\alpha \geq .55$ and $\lambda > \frac{1+\alpha}{6-2\alpha}$. Since $\lambda = \frac{1+\alpha}{6-2\alpha}$ is exactly the point at which separating profits become constrained, and since $\pi^{p}_{H} \geq \pi^{\bar{p}}_{H}$, it will suffice to show that $\pi^{\bar{p}}_{H} > \pi^{\bar{s}}_{H}$ for the set $\alpha \geq .55 \cap \lambda > \frac{1+\alpha}{6-2\alpha}$. From (32) and (38), we have $\pi^{\bar{p}}_{H} > \pi^{\bar{s}}_{H}$ if and only if

$$\frac{\lambda\beta(\alpha+1)\,(2\alpha^2+2\alpha+4\lambda-9\lambda\alpha+3\lambda\alpha^2-4\lambda^2+8\lambda^2\alpha-4\lambda^2\alpha^2)}{(\alpha^2+\alpha+4\lambda-4\lambda\alpha)^2} >$$

$$\frac{2\lambda\beta(\alpha+1)\,(\alpha^2+\alpha+2\lambda-5\lambda\alpha+\lambda\alpha^2)}{(\alpha^2+\alpha+4\lambda-4\lambda\alpha)^2}.$$

This condition reduces to

$$\lambda < \frac{\alpha + \alpha^2}{4 - 8\alpha + 4\alpha^2}. \tag{39}$$

This will hold for $\lambda \leq 1$ (and, thus, for all possible λ) when

$$\frac{\alpha + \alpha^2}{4 - 8\alpha + 4\alpha^2} > 1 \rightarrow \alpha > .54327. \tag{40}$$

Thus, whenever $\alpha > .54327$, we will have $\pi^{\bar{p}}_H > \pi^{\bar{s}}_H \; \forall \, \lambda$, and, a fortiori $\forall \, \lambda > \frac{1 + \alpha}{6 - 2\alpha}$. (Thus, our condition of the proof that $\alpha \geq .55$ is slightly stronger than we need.)

Acknowledgments

We thank Miriam Avins, Malcolm Brachman, Judith Chevalier, Ed Glaeser, Marc Jacobus, John Sutton, Eddie Wold, and seminar participants at Harvard for helpful comments. Roy Astrachan, Darlene Lin and Jesse Shapiro provided excellent research assistance.

Notes

1. Our foray in quantity-clearing was inspired by the experience of the best contract bridge professionals. They are hired—to be partners and teammates of customers in tournaments—much more regularly than their less talented brethren.
2. In our paper, quantity means “actual quantity sold”. Thus, we are not presenting a model of equilibrium queues and explaining why some restaurants, movies, etc. have persistent excess demand. This famous problem is not our concern. Becker (1991) models this phenomenon. Also, the study of market-clearing mechanisms in many contexts has a long history, which is beyond the scope of this paper. Carlton (1989) surveys this literature and discusses several mechanisms based on long-term relationships between suppliers and customers.
3. See Gabszewicz and Thisse (1979, 1980), Shaked and Sutton (1982, 1983), and Sutton (1986). Tirole (1988) provides a helpful overview of the main results on such markets.
4. For examples of this more recent work see Motta (1993), Hackner (1994), Rosenkranz (1995), and Boom (1995).
5. Sutton (1986) points out that the literature on vertical differentiation can give no general results about the relationship between quality and market share. One attempt to focus on this relationship is Gabszewicz et. al (1981), but their results are for a specific type of consumer utility function. Rosen (1981) studies the “superstar” phenomenon. Many of his insights are also applicable to our problem, although his superstars tend to supply higher quantities and charge higher prices.
6. For some recent papers in this debate, see Hendricks, Patel, and Zeckhauser (1993), Brown and Goetzmann (1995), Malkiel (1995), Gruber (1996), and Carhart (1997) for some recent work on this question. For evidence on the attention paid to performance measures, see Chevalier and Ellison (1997) and Brown, Harlow and Starks (1996).

7. All data was obtained from the Morningstar Inc. Ascent and Principia databases. We study the period between January 31 and April 30, 1996 because, at the time of our study, this was the most recent period for which data was available.
8. Price proxies based on funds' expense ratios are also reasonable. These proxies are discussed below.
9. Note that this net inflow calculation underestimates "true" inflows (= purchases − redemptions) because any dividends paid out by the fund, and not immediately reinvested, will be treated as an outflow in our calculation. We cannot correct for this, unfortunately, because data on true inflows (or dividends) is not readily available. This omission, and the bias it introduces, is discussed below. In any case, the bias should be very small, because our sample period does not include either the year-end or mid-year dividends.
10. "Excess" returns means actual returns minus Treasury-bill returns. Morningstar uses the total return on the S&P 500 as the market return for this calculation.
11. The other logical candidates for price proxies are the annual expenses and fees charged by a fund. If these proxies are used, then it is necessary to use gross returns (before expenses) as the quality proxy in order to avoid identification problems. An earlier version of this paper (Metrick and Zeckhauser (1997)) reported the results of using expense-based price proxies; the results are similar to those reported here for the load fee, and are available from the authors.
12. The quantity-quality relationship is consistent with other studies. See Gruber (1996) and Chevalier and Ellison (1997).
13. Among the recent academic works on the automobile industry are Berry, Levinsohn, and Pakes (1995), and Goldberg (1995, 1996). Bresnahan and Reiss (1985) and Feenstra and Levinsohn (1995) study dealer markups in the automobile market; these are probably the most comparable studies to ours, but these papers offer a much more complete treatment of the automobile industry. Our purpose here is more limited, and this is reflected in the scope of our empirical work.
14. See Dreyfus and Viscusi (1995).
15. For example, take the "Ford Escort", which is one of the 60 "models" included in our analysis. Our data source listed six different versions of the Ford Escort in 1994, as well as many option packages which could be attached to each version. The six are the 2-door hatchback, LX 2-door hatchback, LX 4-door hatchback, GT 2-door hatchback, LX 4-door sedan, and LX 4-door wagon. The 2-door hatchback has the lowest price of these versions and thus is used in our analysis.
16. Private communication with the publisher.
17. Dealers will also sometimes receive rebates from manufacturers for each sale. These rebates are usually about one to two percent of the dealer cost. Unfortunately, the rebates may vary throughout the year, and we do not have reliable data on them for our sample. We discuss below the possible bias resulting from this omission.
18. The categories are acceleration, transmission, braking, steering, ride, handling, driveability, fuel economy, comfort/convenience, interior room, driving position, instrumentation, controls, visibility, entry/exit, quietness, cargo space/liftover, exterior workmanship and interior workmanship. Auto Test (1994) also includes a category of "value", but we exclude it from our total because it is directly related to price. Thus, the original rankings are out of a maximum of 200, and ours are out of a maximum of 190.
19. Results are similar if we use the "markup ratio"—markup divided by dealer cost—as the dependent variable. In that regression, neither the coefficient on dealer cost nor on quality are significantly different from zero.
20. Even for manufactured goods like automobiles, quality may be impossible to reproduce in the short run, and very costly (in investment) to reproduce in the long run.
21. See Gabszewicz and Thisse (1979, 1980) and Shaked and Sutton (1982, 1983). To generate the market segmentation between different qualities, the utility functions used by these authors use differences in income rather than differences in valuations. In fact, the two approaches are isomorphic.
22. This no-cost assumption is a normalization, and all the results of this section would be identical if we used a constant marginal-cost production function as long as the continuum of consumer valuations had some mass above the level of marginal costs.
23. This assumption seems most reasonable for markets such as automobiles, where both dilettantes and connoisseurs may care equally about quality factors like safety and reliability, even though connoisseurs

would be better informed. Nevertheless, relaxing this assumption and drawing connoisseurs more heavily from "high v" consumers would not qualitatively change the results.

6. References

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