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PRICES, PRODUCT QUALITIES AND ASYMMETRIC INFORMATION

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ABSTRACT

Recent developments in the economics of information emphasize the informational content of prices. We examine the degree to which prices convey information on product quality to uninformed agents. Under perfect competition, we show that a rational expectations equilibrium may not exist. When an equilibrium does exist, the information on quality conveyed by prices depends on the shape of the average cost curves and the relative numbers of informed and uninformed agents. If the product market is monopolized, the solution with some uninformed agents will be identical to the perfect information solution when agents have identical tastes. Once agent's tastes differ, the monopolist can randomize quality as a means of extracting additional consumers' surplus.

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I. Introduction

Most amateur oenologists have experienced the dilemma of making a wine purchase without the benefit of full information on the quality of the available goods. Though the difference between whites and reds is easy enough to grasp, even within a given variety one must choose between a number of alternative wines. Many consumers use prices as indicators of quality in making this decision. In doing so they must be reasoning that the wine prices convey information on quality. This phenomenon is not, of course, restricted to the purchasing of wine but is present in the decisions of imperfectly informed agents in a variety of circumstances.

This paper examines the degree to which prices convey information about product quality from informed to uninformed buyers. The role of prices in conveying information in environments of asymmetric information was first explored by Grossman-Stiglitz [1976] and Kihlstrom-Mirman [1975]. These are models of financial markets in which demands of informed agents influence asset prices. Uninformed agents extract this signal from the price in formulating their own asset demands. Generically, rational expectations equilibria will reveal the information of the informed agents.¹

In the Grossman-Stiglitz and Kihlstrom-Mirman models, suppliers of the asset cannot respond to the behavior of the uninformed agents. To investigate the role of prices in conveying information on product quality, we must extend the
earlier models to allow strategic behavior on the part of firms. Once uninformed agents use prices as a signal of quality, profitable opportunities may arise for the entry of firms selling low quality goods at high prices to the uninformed buyers. That is, dishonest firms may enter and "rip off" uninformed buyers. This entry distorts the information conveyed by product prices.

The degree to which prices convey information on product quality is therefore directly related to the entry of dishonest firms. Factors which limit the entry of these firms--such as steeply shaped average cost schedules and a relative abundance of informed buyers--should improve the revelation property of prices in a competitive environment. These results are presented in Section III of the paper following a presentation of the basic model in Section II.

In addition to the factors noted above, competition itself may play an important role in limiting rip-offs. To investigate this possibility, we consider the case of a monopoly in Section IV. In contrast to the competitive market in which rip-offs may occur, we find that with a monopoly there are no rip-offs if all agents have identical tastes.

Section V of the paper extends the model to consider the case of many taste-types. The results of the competitive case do not change dramatically. However, the monopolist may find it profitable to rip off agents once tastes differ.
In this section we also consider the effects of endogenizing the amount of information consumers have. Finally, Section VI contains our concluding remarks.

In terms of related literature, Dybvig-Spatt [1980] and Shapiro [1982] use reputation effects as an incentive for firms not to provide low quality goods. Klein and Leffler [1981] show that these "reputations" need be nothing more than large sunk costs, the returns from which may quickly go to zero if quality is seen to deteriorate. Here however, we choose to focus on a static model in order to make the toughest case possible for the ability of price to signal quality. Our analysis of competitive behavior is similar in some respects to that in recent unpublished work by Farrell [1982] and Chan and Leland [1981] but in terms of its overall structure, our model has more in common with the "bargains and ripoffs" approach in Salop and Stiglitz [1977], with quality as the unknown variable rather than price. To our knowledge no one else has looked at the monopoly problem at all.

II. Overview of the Model

In this model, we consider the market for a good which can be produced with varying quality. We view quality, for example, as a measure of the durability or reliability of a product. Quality is different from variety in that every agent's utility is monotonically increasing in quality while
in variety models agents can have different preferred brands. We refer to the quality varying good as the \( q \)-commodity.

We consider an economy in which agents have income, \( y \), which they can spend on one unit of the \( q \)-commodity and on a composite good, \( z \), which serves as the numeraire. We denote the quality level bought by \( q \) -- an index which is increasing in quality. Using a function \( p(q) \) to represent prices for each quality level, the budget constraint for an individual implies that \( z = y - p(q) \).

We represent the consumer choice problem as one of maximizing utility over the available \((p,q)\) offerings. Substituting the budget constraint into the direct utility function \( U(z,q) \) we get a partially indirect utility function that we label \( W(\cdot) \):

\[
U(z,q) = U(y-p,q) \equiv W(p,q).
\]

We assume that \( U(\cdot) \) is increasing and concave in both arguments, so that we have \( W_p < 0, W_q > 0, W_{pq} < 0 \) and \( W_{qq} < 0 \). Agents can always choose not to buy a unit of the commodity and receive utility \( \bar{U} \)--i.e. their reservation utility. Here, \( q=0 \) is defined to be the greatest level of quality that gives no utility to the consumer (i.e. for which he would be willing to pay nothing). Therefore we have \( \bar{U} = U(y,0) \).

We further simplify our analysis by assuming that there is a single type of consumer in terms of tastes. This
allows us to separate the issue of the informational role of prices from the self-selection problem that arises in a model of many taste-types. Our analysis, however, can be extended to the more general case of many types as discussed in Section V.

In general, we are investigating the properties of an equilibrium when there are some uninformed consumers. These uninformed agents choose randomly over firms selling goods at a given price. They choose at which price to purchase by calculating expected utility at each of the market prices. In this model, we consider rational expectations equilibria in which uninformed consumers use the relative numbers of firms producing each possible quality as probability weights in their expected utility calculations. This is, of course, the essence of the proposition that agents will attempt to infer product quality from price.

Of course, firms take this behavior into account and will try to "rip off" the uninformed agents by providing low quality goods at high prices. In many of the cases we examine, equilibrium is characterized by a probability of ripoff strictly between zero and one. Hence product prices will provide imperfect information on quality.
III. The Competitive Case

In this section we consider the nature of competitive equilibrium under different assumptions regarding costs and the amount of information on quality available to buyers. In particular, we ask whether the equilibrium we observe under full information can ever be preserved when some consuming agents are ignorant of product quality. If it is not preserved, does there exist an equilibrium with ripoffs such that uninformed consumers still purchase, fully aware of the gamble they are taking?

We consider two alternative firm cost structures, both of which are compatible with perfect competition in the industry. Let \( AC(x, q) \) represent the average cost of producing \( x \) units of a brand with quality \( q \). In the first case we assume that \( AC(\cdot) \) is independent of \( x \), that is, we have constant average costs of production. In the second case we allow average costs to be U-shaped (in terms of quantity). Additionally, we assume that if \( q_1 > q_2 \), then \( AC(x, q_1) > AC(x, q_2) \) for all \( x \). We define \( C(q) \) to be the minimum average cost at which a brand of quality \( q \) can be produced i.e.

\[
C(q) = \min_{x} AC(x, q).
\]

Finally, we assume that \( C(q) \) is increasing and convex in \( q \) (i.e. \( C' > 0, C'' > 0 \)).

We first consider equilibrium when all agents are informed about product quality. The following proposition,
due to Rosen [1974] characterizes equilibrium in the constant cost case, and will not be proved here.

**Proposition III.1** In a full information competitive equilibrium with constant costs the only brands sold will be of quality $q^*$ and will sell at price $p^*$ where $(p^*, q^*)$ is defined by,

(i) \[ p^* = C(q^*) \]

and

(ii) \[ -\frac{W_q(p^*, q^*)}{W_p(p^*, q^*)} = C'(q^*). \]

Intuitively, competition guarantees that any $(p, q)$ pair transacted in equilibrium must lie on the $C(q)$ locus (i.e. earn zero profits). Competitive forces will also imply that $(p^*, q^*)$ is the utility maximizing point on the $C(q)$ locus as in (ii).

This equilibrium is illustrated in Figure 1 where $W_1$ represents the maximized consumer utility. The convexity of $C(q)$ and the curvature of $W(p, q)$ guarantee that the tangency (point A) will be unique and that the appropriate second order conditions for a constrained maximum will be satisfied. We shall simply assume that an interior solution
exists, ignoring the (uninteresting) possibilities that consumer welfare is maximized at zero or at infinite quality.

This solution will only change slightly when we consider U-shaped average costs. Ignoring integer problems,\(^3\) equilibrium will still be characterized by conditions (i) and (ii) of the previous proposition. Moreover, with non-constant costs the number of firms becomes determinate since firms will produce at the minima of their average cost schedules. In this case then, we have

\[(1) \quad n^* = I/\bar{x}(q^*)\]

where \(n^*\) is the equilibrium number of firms, \(I\) is the number of consumers and \(\bar{x}(q^*)\) is the efficient scale of production for quality \(q^*\).

We turn now to the case in which some agents are uninformed about the qualities inherent in the brands offered. Will the equilibrium described in Proposition III.1 continue to hold or will there be opportunities for firms to take advantage of the ignorance of some agents? What are the roles of the informed consumers and of non-constant average costs in limiting the number of these ripoffs?

We assume that an exogenous proportion, \(\theta\), of buyers are informed about product quality and price. These informed agents choose randomly among the firms offering
their preferred price-quality pair. The remaining proportion of agents, 1-θ, are essentially uninformed about product quality. These uninformed agents can only determine whether or not quality exceeds some minimum, q.3 Otherwise, these agents rely solely on the information provided through product prices in making their decisions.

Further, we assume that there is no remunerative price at which a buyer would consider purchasing a brand with quality g. That is, buyers would strictly prefer not buying at all to buying (p,g) where p=C(g) or,

\[(2) \quad W(p,g) < U.\]

This last assumption will simplify the exposition somewhat although it is not important to the analysis.

Since uninformed agents can observe only prices, they form rational expectations of quality given information on the number of firms offering each quality at each price. Agents buy at the price yielding maximal expected utility subject to a constraint that \(E_\theta[W(p,q)] \geq U\). Firms are referred to as either honest or dishonest; honest firms sell at prices commensurate with quality and therefore are able to attract informed buyers while dishonest firms exist solely to take advantage of the uninformed agents' ignorance by selling low quality at a high price (i.e. by ripping off customers).
We assume that there are enough firms in this competitive market that each believes that its offering has no effect on the customers' expectations of quality given price. Specifically, no dishonest firm will worry that its entry will, by increasing the probability of their being ripped off, cause the uninformed to drop out of the market. Given this assumption it is easy to see that no dishonest firm will ever offer a quality greater than \( q \) and that in equilibrium we shall observe only one price.

**Lemma III.1:** In a perfectly competitive market equilibrium, dishonest firms can only sell at prices that honest firms charge but their quality will always be just \( q \).

**Proof:** First we show that there is never any incentive for a dishonest firm to offer a quality different than \( q \). Offering \( q \) less than \( q \) will not be profitable since sales will be zero. Increasing quality above \( q \) will not attract additional consumers since the informed do not purchase from dishonest firms and the uninformed chose randomly over all firms regardless, by assumption, of the quality they offer.

To see that there must be a single-price equilibrium, assume to the contrary that only dishonest firms offer goods at some price \( \hat{p} \) distinct from the equilibrium price, \( p^* \). \( \hat{p} \) must be less than \( p^* \) in order for uninformed agents to pur-
chase at it since the only quality available at this price will be $q$. Further, $\hat{p}$ cannot be less than $p = c(q)$ for dishonest firms to make non-negative profits. However,

$$\hat{U} > w(p, q) \geq w(\hat{p}, q)$$

hence these dishonest firms will make no sales.

What then will be the prices and qualities offered by honest firms in this model with asymmetric information? Clearly the informed buyers will get $(p^*, q^*)$ as defined in Proposition III.1, just as they did under full information. There is no asymmetry in their relations with sellers so competition will ensure that they will get $(p^*, q^*)$. Therefore there can only be one price in this market in equilibrium, $p^*$, with honest firms providing quality $q^*$ and dishonest firms providing $q$.

Can there be a competitive equilibrium in this case? The following two propositions present our answers.

**Proposition III.2**: There exists no competitive equilibrium in the constant cost case with asymmetric information.

**Proof**: By Lemma III.1, if there is a competitive equilibrium it will be characterized by a single price, $p^*$, and two qualities, $q^*$ and $q$. Let $\pi$ stand for the probability that an uninformed buyer purchases from an honest firm so that
(3) \[ \pi = \frac{n^h}{(n^h + n^s)} \]

where \( n^h \) and \( n^s \) are, respectively, the number of honest and dishonest firms. The expected utility for an uninformed buyer would be

(4) \[ EW = \pi[W(p^*, q^*)] + (1-\pi)[W(p^*, q)] \]

while the expected profits for a typical dishonest firm would be \( \pi^* \) (calling profits \( R \))

(5) \[ ER = [p^* - C(q)][(1-\theta)I/(n^h + n^s)] \]

where \( (1-\theta)I/(n^h + n^s) \) represents the expected sales for this type of firm. The problem is that (5) will not be driven to zero by the entry of more dishonest firms. Therefore this entry will continue and hence \( \pi \) will continuously fall. There exists a critical \( \pi^* \), at which the uninformed will be just indifferent between taking the market lottery and dropping out, obtaining \( \bar{U} \). \( \pi^* \) is defined implicitly by,

(6) \[ \bar{U} = \pi^*W(p^*, q^*) + (1-\pi^*)W(p^*, q). \]
The entry of dishonest firms will eventually force $\pi$ below $\pi^*$; the uninformed will leave the market and with them will go the dishonest firms. Once the dishonest firms are gone however, $\pi$ again equals one and the uninformed buyers return to the market. As soon as they do, the dishonest firms return and the cycle repeats itself.

Other examples of the nonexistence of rational expectations equilibria can be found in the literature; see, for example, Grossman-Stiglitz [1980]. In our model no equilibrium exists since expected profits for dishonest firms are not driven to zero even as their expected sales get smaller and smaller. It would seem then that nonconstant costs might be able to help, as shrinking output leads to higher average costs. The following proposition spells this out more clearly.

**Proposition III.3:** In the asymmetric information case with non-constant costs, if there exists a competitive equilibrium, it will be characterized by:

(i) $(p^*, q^*)$ from Proposition III.1 offered by honest firms.

(ii) $(p^*, q)$ offered by dishonest firms.

(iii) The expected sales for each dishonest firm are $x^*$ where

$$\text{AC}(x^*, q) = p^*.$$ 

(iv) The expected sales for each honest firm are just its efficient scale, $\mathcal{x}(q^*)$. 

(v) The equilibrium numbers of each type of firm $n^*_h$, $n^*_d$ are determined by

$$\theta I/n^*_h + (1-\theta)I/(n^*_h + n^*_d) = \pi(q^*)$$

and

$$(1-\theta)I/(n^*_h + n^*_d) = x^*.$$

**Proof:** That (i) and (ii) must be true in any equilibrium has already been shown so we start with (iii). Unless expected profits taking $\pi$ as constant are zero, we can expect dishonest firms to continue to enter. Therefore in any equilibrium the average costs for the dishonest firms must have risen up to the level of their average revenues. This means that expected sales must fall to level $x^*$ defined in (iii).

Since the honest firms are competing for the business of knowledgeable consumers they can be expected to be forced toward efficient scale. This is condition (iv). The fifth condition merely tells us how many firms of each type there must be in order to satisfy the third and fourth conditions. Since the expected sales of an honest firm equal its expected sales to informed customers, $\theta I/n^*_h$, plus its expected sales to the uninformed (which the honest firms share with the dishonest), $(1-\theta)I/(n^*_h+n^*_d)$, these two quantities must sum to the firm's efficient scale, $\pi(q^*)$. Simi-
larly the total number of firms must be such that the expected sales of a dishonest firm, \((1-\theta)I/(n^h+n^d)\), just equal the zero profit level in (iii) (i.e. \(x^o\)). \(\Box\)

If the two equations in (v) give us values for \(n^h^*\) and \(n^d^*\) such that \(\pi^* > \pi^c\) (where \(\pi^* = n^h^*/(n^h^*+n^d^*)\)) then equilibrium exists since the uninformed will choose to stay in the market and the entry of dishonest firms has stopped. If, however, \(n^h^*\) and \(n^d^*\) satisfying (iii)-(v) imply that \(\pi^* < \pi^c\) then no equilibrium will exist. Essentially, if average costs rise fast enough as expected sales fall, expected profits may be driven to zero before \(\pi\) has fallen below \(\pi^c\). Otherwise, we cannot have an equilibrium.\(^8\)

The quantities that honest \((x(q^*))\) and dishonest \((x^o)\) firms can expect to sell are illustrated in Figure 2. There we have average cost curves for the two different qualities drawn in such a way that \(C(q^*) > C(q)\) as we have assumed.

Some simple comparative statics will illustrate the effect of changes in two key exogenous elements on the number of dishonest firms in the market.

**Proposition III.4:** In a competitive equilibrium (if it exists) the relative number of dishonest firms (and hence the probability of being ripped off) will be negatively related to the economies of scale in sub-efficient production of \(g\) and to the proportion of customers that are informed, \(\theta\).
Proof: The equilibrium number of firms of each type, $n^*$ and $n^*$, are determined by the equations

\[(i) \quad \theta I/n^* + (1-\theta)I/(n^* + n^*) = \mathcal{R}(q^*)\]

and

\[(ii) \quad (1-\theta)I/(n^* + n^*) = x^*.\]

Substituting the second into the first, we have

\[(iii) \quad \theta I/n^* = \mathcal{R}(q^*) - x^*.\]

Recall that $\mathcal{R}(q^*)$ and $x^*$ are determined solely by tastes and cost functions as in Figure 2.

It would seem intuitive that if the dishonest firms had average cost curves that were very steep at less than efficient scale there would be room for very few of them in equilibrium. In this model we can simulate AC curves getting steeper by increasing $x^*$ relative to $\mathcal{R}(q^*)$. From (iii) this will lead to larger $n^*$ and thus from (ii) we must have a lower $n^*$. Therefore the probability of being ripped off $(1-\pi)$ must have fallen. Indeed, in the extreme case, it is possible that there would not even be room for one dishonest firm and there would therefore be no ripoffs at all.
Increasing the proportion of buyers that are informed, $\theta$, must increase $n^*$ from (iii) and then (ii) implies that $n^*$ must fall again.

Thus we have proved the intuitive proposition that there will be more ripoffs in markets in which there are fewer informed buyers and the cost disadvantages of sub-efficient production are not too great.

Before leaving the competitive model we wish to briefly discuss two ways in which an equilibrium could be achieved when that in Proposition 111.3 does not exist. First, if we allowed firms to be somewhat farsighted, adopting Stackelberg strategies vis-a-vis consumers, we could obtain an equilibrium of the sort described by Salop and Stiglitz [1977] and by Chan and Leland [1981]. That is, if we assumed that firms understood the effect their entry had on $\pi$ then no dishonest firm would enter if its entry were to drive $\pi$ below $\pi^*$. In this case we would always be able to find an equilibrium, although it may involve positive profits for the dishonest firms.

A second way of finding equilibrium in this case involves randomizing the uninformed consumers' strategies regarding staying or dropping out when they are indifferent between the two options. That is, when $\pi = \pi^*$ let only a proportion, $\sigma$, of the uninformed drop out. There will be some critical proportion, $\sigma^*$, such that dishonest firms sales have just fallen to the level where their average
costs equal $p^*$. There will therefore be no further entry
and equilibrium will be preserved.

In both of these cases, price is a very poor signal of
quality, as the uninformed are no better off taking the gam-
ble than they would be by dropping out of the market
entirely. While these two modifications may be theoreti-
cally interesting, neither is very intuitively pleasing. We
expect then that nonexistence problems will be resolved by
the market in other ways, such as through the use of reputa-
tions and warranties.

IV. **Monopoly**

In contrast to the previous section, here we consider
equilibrium when only one firm produces the $q$-commodity. We
again restrict the $I$ consumers to have identical preferences
and allow only a proportion, $\theta$, of them to be informed about
product quality. We first consider equilibrium under full
information ($\theta=1$) and then investigate the consequences of
imperfect information.

If all the agents can observe product quality, the mon-
opolist chooses a price and a product quality to maximize
profits subject to consumers obtaining at least a minimum
utility level. Formally, the monopolist solves

\[
\begin{align*}
\text{maximize} & \quad [p - C(q)]I \\
\text{subject to} & \quad w(p,q) \geq \bar{u}.
\end{align*}
\]
It is easy to see that the solution to this problem, \((p^*, q^*)\), must involve a binding constraint:

\[(9a) \quad W(p^*, q^*) = \bar{U}\]

and that the chosen quality, \(q^*\), satisfies

\[(9b) \quad C'(q^*) = -\frac{W_u(p^*, q^*)}{W_s(p^*, q^*)} .\]

As expected, the monopolist extracts all of the available consumers' surplus and leaves agents indifferent between staying in the market and obtaining a utility level \(\bar{U}\) elsewhere.

Given this solution, we ask whether the monopolist can increase its profits when some of the consumers are uninformed. The existence of informed and uninformed consumers adds a dimension for the separation of agents. In general, the monopolist could offer goods of varying quality at a number of different prices. Informed agents would choose over prices knowing they would select the maximal quality offered at each price. As before, the uninformed only know the distribution of quality at each price. The following proposition indicates, however, that the monopolist cannot improve on the solution to (8) even though there exist some uninformed consumers.
Proposition IV.1: If some agents are uninformed about product quality but all agents have identical tastes, then the monopolist will not randomize quality and the solution will be identical to that of (8).

Proof: Assume that in a profit maximizing solution the monopolist offers \((p_j, q_j)\) for \(j = 1, 2, ..., J\). Here the index \(j\) represents a market with a price \(p_j\) and a lottery over quality \(q_j\). Assume further that at least one of these lotteries is non-degenerate so that some randomization is observed. We denote by \(q^* \in \mathcal{Q}_j\) the upper support of \(q_j\) which the informed acquire at each \(p_j\).

At an optimal solution, the self-selection and individual rationality constraints must hold. In particular, the uninformed must be indifferent between all the available choices and they must be purchasing at each of the prices. Otherwise, at some price(s) there will be no ripoffs, but if there are informed purchasers at that price it must be attractive to the uninformed as well. Obviously, since the uninformed can be getting no less than zero consumer's surplus and \(q^* \in \mathcal{Q}_j\), for at least one \(j\), the informed must be left with a strictly positive amount of surplus.

For each market in which \(q_j\) is not degenerate, we can find some quality, \(q^*_j\), such that the uninformed are indifferent between the lottery \(q_j\) and \(q^*_j\) with certainty at price \(p_j\). That is, \(E_p W(p_j, q_j) = W(p_j, q^*_j)\). Due to consum-
ers' risk aversion, \( q_j < \mathbb{E}q_j \) in these markets. Now, let the monopolist replace \((p_j, q_j)\) with \((p_j, \hat{q}_j)\) for all \( j \). By design, the uninformed consumers are no better and no worse off. This will necessarily be a profitable move for the monopolist, however. Since the monopolist's costs are convex in \( q \), \( \hat{q}_j \) is less costly to produce than the non-degenerate \( q_j \). Furthermore, the informed will now buy a lower quality at each price, \( \hat{q}_j \) rather than \( q_j^{**} \), thereby surrendering their consumers' surplus. Since all agents have identical tastes, they will all be indifferent between the \((p_j, q_j)\) combinations offered.

Hence, any solution with randomization can be dominated. The problem in this case is seen to be effectively identical to that in the full information case, (8), and the solution must, therefore, be that described by (9). □

This result means that randomization of quality will not provide a means of extracting additional surplus from consumers with identical tastes. Using (9), the monopolist already extracts all consumers' surplus. With convex costs and concave preferences, randomization is a cost to both the monopolist and to consumers. Notice that the argument in the proof above holds even if all consumers are uninformed; randomization only serves to increase costs and reduce an uninformed consumer's willingness to pay. Hence in this monopolized market, price will remain a perfect indicator of
product quality. However, as discussed in the next section, once consumers differ in tastes as well as information type, the monopolist may find it profitable to offer a lottery over quality in order to separate consumers by taste type.

V. Robustness

Many of our results are quite robust to generalizations of the model used here. In this section we want to consider the effects of adding more taste-types and of allowing consumers to buy information.

Consider first the competitive model with more than one taste-type. Once again the firms serving the informed buyers will offer them the price-quality pairs that maximize their utility along the C(q) locus. For two taste-types ("H-type", for high willingness to pay for quality and "L-type" for low) the solutions are illustrated in Figure 3. Now the honest market offerings will be \((p_h^*, q_h^*)\) and \((p_l^*, q_l^*)\) and there will again, in general, be profitable opportunities for dishonest firms to offer \(q\) at \(p_h^*\) or \(p_l^*\). The uninformed of each taste-type now have an additional option. They can try the lottery at \(p_h^*\), the lottery at \(p_l^*\) or, as before, drop out of the market.

In the constant costs case we would expect there to be no equilibrium for the same reasons as discussed in the proof to Proposition III.2: dishonest firms will continue
to enter at both prices until finally all the uninformed drop out. With U-shaped average costs we may again be able to get an equilibrium, this time with two probabilities, $\pi_w$ and $\pi_l$. $\pi_w$ will be the probability of not being ripped off if you buy randomly at $p_w^*$ and $\pi_l$ the same for $p_l^*$.

With more than one taste-type we can speak more clearly about the ability of price to signal quality in our market. A typical uninformed buyer in this two taste-type case will observe two prices. He knows that at either there is some chance he will get ripped off and end up with $q$, but he also knows that at $p_w^*$ he has a chance at a higher quality than he could get at $p_l^*$. If $\pi_w$ and $\pi_l$ are fairly high, these prices will give him pretty good information regarding the quality he is likely to get. Therefore we see that price is an imperfect signal of quality and that it is a better signal the larger are the $\pi$'s.

In the previous section we showed that in a model with one taste-type the monopolist would not randomize quality. Intuitively, in the solution with no ripoffs, the monopolist extracts all consumers' surplus and hence there was no further surplus to extract via randomization. Once we allow for more than one taste-type in the non-randomized solution, some agents will have positive consumer's surplus which the monopolist may be able to capture by randomizing quality.

To see this, consider a monopolist facing two consumers. Consumer one, the low-taste agent, has preferences over $(p, q)$ of
\[ W^i(p, q) = bq + V(y-p) \] with \( V' > 0 \) and \( V'' < 0 \)

while the high-taste consumer, has preferences

\[ W^h(p, q) = B(q) + V(y-p) \] where \( B' > 0 \) and \( B'' < 0 \).

The function \( V(\cdot) \) is the same for each of the consumers. The key difference is that the second consumer is risk averse over quality while the first is not. We assume that \( B'(q) > b \) for all \( q \) as a means of ordering the preferences of the two consumers.

If both agents are informed about product quality, the monopolist chooses prices and qualities for each of the taste-types subject to each agent receiving at least \( V(y) = \bar{U} \) utility, and preferring the bundle intended for him to the other one—i.e. self-selection. This is a special case of the Mussa-Rosen [1978] problem and their results indicate that the monopolist will choose \((p^*_h, q^*_h)\) and \((p^*_l, q^*_l)\) such that:

(i) \( W^h(p^*_h, q^*_h) = W^l(p^*_l, q^*_l) \)

(ii) \( W^l(p^*_l, q^*_l) = \bar{U} \).

In these expressions, \((p, q)\) denotes the bundle for taste-type \( i = H, L \). The first condition implies that the high-taste agents are indifferent between the bundle they receive and that purchased by the low-taste agents. The second condition implies that the low-taste agents have zero consumer's surplus.

The key element of the solution is that the high-taste agents obtain positive surplus, i.e. \( W^h(p^*_h, q^*_h) > \bar{U} \). The
monopolist cannot profitably extract this additional surplus since the high-taste agents can always purchase in the low price market.

To see the value of randomization, now assume that both agents are uninformed. In addition, assume that the monopolist's cost function is linear in $q$. Under these conditions, the monopolist can extract additional surplus from the high-taste agents by randomizing quality in the low-price market.

That is, allow the monopolist to offer a lottery over quality, $q$, in the low-price market. Assume that $E q = q_t^*$ so that both the monopolist and the low-taste agents are indifferent between the lottery and its mean. However, since the high-taste agents are risk averse, they now strictly prefer $(p_w^*, q_w^*)$ to the lottery available at $p_l^*$. Hence the monopolist can extract some additional surplus from them by increasing $p_w$ above $p_w^*$. In this admittedly extreme case, the monopolist can rip off consumers and extract additional surplus by exploiting differences in their degrees of risk aversion.

It should be apparent that the linearity of the monopolist's costs and the low-taste agent's preferences over quality played a key role in this result. In a more general framework, we would expect randomization to occur when high-taste agents are more risk averse than both low-taste agents and the monopolist. In addition, the example
assumed that all agents were uninformed. As the relative number of informed agents increases, the profitability of randomization should decrease, since, as we found in Section IV, one of the costs of randomization is the surplus necessarily surrendered to the informed buyers. A complete characterization of this more difficult general problem will be left for further research.11

As a final matter in this section we would like to briefly address the issue of endogenizing the amount of information available to consumers. What would happen if we allowed our uninformed agents to become informed at some cost, c? It is possible that nothing will change. This will be the case if c is so large that the information can never be worth buying i.e.

\[ \bar{U} > W(p^*+c,q^*) \]

If this inequality is reversed, however, a tighter lower bound is placed on how low the expected utility of the uninformed can go before they stop trying the lottery. If the gamble gets bad enough they will simply buy the information they need to guarantee a purchase of q* at p*. Now they do not drop right out of the market but the effect on the dishonest firms is the same as if they had.

Thus we would expect no important qualitative differences in our results if we allowed individuals to become informed at some cost. Clearly we have chosen a very simple model of information acquisition (similar to that in Salop-

VI. Conclusion

The results presented here suggest that non-constant costs and market structure play important roles in determining the degree to which prices convey information about product quality. In competitive (i.e. free entry) situations average costs that rise as expected sales fall can limit the proportion of ripoffs in the market, improving the information on quality provided by prices. Indeed, if these costs rise fast enough there may be no profitable ripoff opportunities at all. If average costs are constant we have seen that we can only get a competitive equilibrium if firms are farsighted enough to stop entering when further entry would cause mass defections by the uninformed consumers. Thus we see that in competitive equilibrium (if it exists) prices will in general convey some, but not all, information on product qualities.

Perhaps our most interesting result is that a monopolist can gain nothing by trying to rip off his customers: in fact, it will cost him. Therefore the monopoly solution with asymmetric information is the same as that for the full information case.
Although these results were obtained in a simple model with only one taste-type, most generalize to a model with many taste-types. An important exception is our finding that a monopolist may be able to profitably randomize quality with more than one taste-type if buyers have different degrees of risk aversion. We also considered allowing uninformed consumers the option of buying information at some cost and saw that this would serve as a further constraint on the number of ripoffs.

Throughout the entire paper we avoided considerations of firms' reputations and the possibilities of warranties guaranteeing quality. This was deliberate and was intended to allow us to determine whether prices alone could convey information on quality in equilibrium. We consider this to be an important first question since we would expect to see reputations (of manufacturers or retailers) and warranties become important in markets in which price, by itself, is a poor indicator of quality.

Possible extensions of this research would include solving explicitly for the conditions under which randomization of quality could be profitable for the monopolist and incorporating a more sophisticated search and learning behavior for buyers. Perhaps more interesting would be a study testing our theory on markets in which quality was difficult to observe and reputations and warranties were not too important. Although it is not important to the theory
that such pure examples of price signalling quality exist, if some could be found they would surely make interesting subjects for study.
Figure 2
Figure 3
Notes

1See, for example, the discussion in Radner [1979] and Allen [1981].

2Some of the consequences of the integer problem are mentioned briefly in footnote five.

3Another interpretation of g is as a minimum legal quality standard but this interpretation would change none of the analysis. It does however suggest questions regarding some of the impacts of changing such legal standards. Notice that by increasing (decreasing) g we can effectively improve (reduce) the amount of information the "uninformed" have. For an interesting related treatment of minimum quality standards see Leland [1979].

4We follow Salop and Stiglitz and invoke the law of large numbers to assume that each dishonest firm gets exactly its equal share of the uninformed buyers.

5Integer problems are another, perhaps more obvious source of nonexistence of equilibrium. Even if all consumers are informed and all firms therefore honest, the fact that the number of firms must be an integer may mean that profits cannot go right to zero. The first K firms may be making small positive profits which turn negative as firm K+1 enters. We can get nonexistence then if firms are not able to predict correctly their sales after entry. In this paper we follow the tradition of assuming these problems away. For our model this is equivalent to assuming that
firms can correctly predict their post-entry sales (given that the uninformed do not drop out) but that they do not correctly perceive their effect on consumers' decisions regarding whether or not to stay in the market.

'It can also involve the offering of another quality level intermediate to $q$ and $q^*$. A more complete description of this equilibrium is included in an earlier version of this paper, available upon request from the authors. It is clearly related to the "reactive" equilibria of Wilson [1977] and Riley [1979].

'We are indebted to Joseph Farrell for suggesting this possibility to us.

'A similar result, in a model of warranties, was obtained by Grossman [1980].

'We are assuming here that it is profitable for the monopolist to serve both types of consumers. This need not be the case. In order to satisfy the self-selection constraints and serve both taste-types the monopolist must leave some consumer's surplus with the high-taste consumers, surplus that it could collect for itself if it was to ignore the low-taste buyers. Therefore if there are few enough low-taste agents it may not be profitable to serve them.

On a related point, it is easy to see that with two taste-types there can never be a pooling equilibrium in this model. As long as the monopoly is going to serve both types it will always be profitable to separate them. The proof of
this statement is quite straightforward and is left to the reader.

10 As an interesting special case it is not difficult to show that if both consumers have linear indifference curves in price-quality space and \( C(q) \) is strictly convex in \( q \) then it will never pay the monopolist to randomize quality. In this case both consumer types are risk neutral over quality gambles while the convexity of the \( C(q) \) function imparts a sort of risk aversion on the firm.

11 Other examples of the role of randomization in separating agents of different types can be found in Stiglitz [1981], Matthews [1981] and Cooper [1982].
References


Chan, Yuk-Shee and Hayne Leland, "Prices and Qualities in Markets with Costly Information," mimeo, 1981.


