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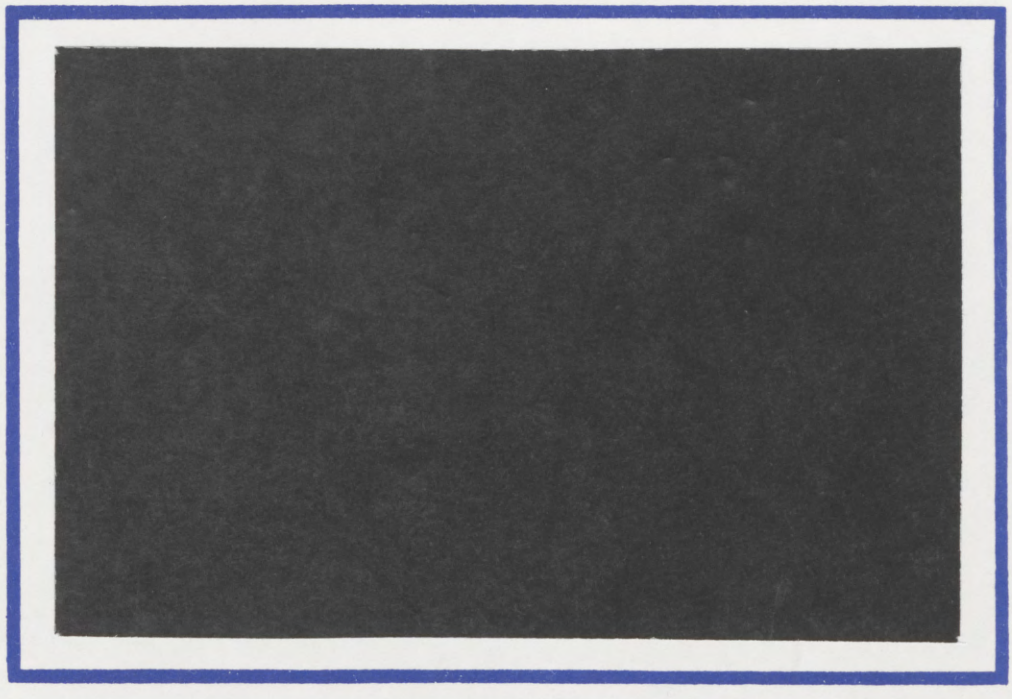

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THE INFORMATIVE ROLE OF PRICES IN MARKETS WITH ENDOGENOUSLY INFORMED BUYERS

by

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ABSTRACT

Sellers are typically better informed about product quality than their customers. Because sellers have an incentive to misrepresent quality, it may not be possible for market prices to effectively convey this information to rational consumers, as was first argued by Akerloff (1970). The purpose of this paper is to argue that even if sellers are initially better informed than buyers, prices may yet be informative if buyers can purchase additional information about quality from an external, reliable source.

In this setting, the informative role of prices is shown to depend crucially on the cost of external information to consumers. In particular, there exists a critical value such that when the cost of information is below this value, the market equilibrium is characterized by two distinct prices and a different pricing strategy for each type of seller. High quality sellers deterministically charge the high price while low quality sellers randomize between the low price, which corresponds to the low quality price that obtains under conditions of complete information, and the high price. The equilibrium frequency with which the high price is mimiced by low quality sellers decreases as the cost of information grows smaller and goes to zero in the limit. Correspondingly, the level of the high price increases as the cost of information decreases and approaches the complete information high quality price in the limit. Thus the less costly it is for buyers to become independently informed, the less noise the low quality seller generates and the more informative about quality the high price is.

Keywords: Prices Signal Quality. Endogenous Information.

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1. INTRODUCTION

In a celebrated seminal paper, Akerloff (1970) analyzed the role of the market price for an experience good in conveying information about product quality to uninformed consumers. In particular, Akerloff argued that rational, uninformed buyers will account for the seller's incentive to misrepresent its quality and will therefore not associate higher prices with superior quality. Thus, under conditions of asymmetric information, the market price cannot reflect a seller's private information about the product.

An implicit assumption contained in Akerloff's analysis is that consumers can only learn about an experience good's quality by consuming it. In many economic situations of interest, however, there exist reliable sources of information which consumers may consult to learn additional information about the product before buying it. For example, it is possible to study consumer literature, such as "Consumer Reports", make enquiries with more experienced consumers or, as in the case of a used car, have the product tested by an independent expert. Of course, since the acquisition of additional information is generally costly, consumers face a tradeoff between the expected benefits from information and its cost.

The objective of the present essay is therefore to analyze the informative role of prices in market settings to which the preceding description applies. I analyze equilibrium price formation in a simple market setting, including a seller which is privately informed about product quality and identically uninformed consumers. The novelty is that although buyers are imperfectly informed ex ante, the extent of their knowledge at the time of purchase is determined endogenously: After learning the purchasing price, buyers may obtain additional but costly information from an external source before buying. It is

shown that under these conditions, the market price is able to serve as a credible signal of product quality if the cost of information to consumers is low enough. Moreover, the accuracy of the information (in the sense made precise below) which the market price transmits is inversely proportional to this cost.

Specifically, when the cost of information to buyers is below a critical level, the market equilibrium is characterized by two distinct prices and a different pricing strategy for the low and high quality seller. The high quality seller deterministically charges the high price. The low quality seller randomizes between the low price, which corresponds to the complete information low quality price and the high quality sellers' price. The equilibrium frequency with which the high quality price is mimiced by low quality sellers decreases as the cost of information grows smaller and goes to zero in the limit. Correspondingly, the level of the high price, which is always below the complete information high quality price, increases as the cost of information decreases and approaches the complete information high quality price in the limit. Thus, the conditional probability that quality is high when the price is high is greater the smaller the cost of information and goes to one in the limit. It is in this sense that the market price conveys increasingly precise information as it becomes less costly for consumers to become informed. Although the low quality seller distorts the information provided by the high price with noise, the quantity of this noise is steadily diminished as the cost of information declines.

Buyers enforce the low quality seller's equilibrium behavior by randomly verifying the actual quality when the price is high.[1] When the low quality seller charges the high

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[1] A related idea in the principal agent literature is explored by, e.g. Guasch and Weiss (1980, 1982A, 1982B), Nalebuff and Scharfstein (1987), Polinsky and Shavell (1979).

price it stands to lose the sale if its customers become informed, and to earn excess profit if they do not. The equilibrium frequency of verification and the level of the high price are designed to balance these opposing effects. Thus, while all buyers are ex ante identical, the equilibrium frequency with which buyers become informed gives rise to an endogenously determined heterogeneity between those buyers who become informed and those who do not. The extent of this heterogeneity is determined in accordance with the consumers' cost of becoming informed. This feature of the model contrasts with other papers which show that prices may be informative if some buyers are exogenously informed (Yuk–Shee Chan and Hayne Leland (1982), Russel Cooper and Thomas W.Ross (1984, 1985), Scott Davis (1989), Joseph Farrell (1980), Michael Riordan (1986), Asher Wolinsky (1983)) and/or consumers are heterogenous with respect to their valuation of high quality (Kyle Bagwell and Riordan (1991), Garey Ramey (1986), Doron Fertig (1988)).

2. THE MODEL

The market consists of a profit maximizing monopoly seller and identical buyers. The seller is able to supply an unlimited quantity of its product at zero cost. The quality of the product, which is determined exogenously,[2] may be either low or high. The value of low and high quality to buyers is V_L and V_H respectively, $V_H > V_L \geq 0$. The seller is costlessly and perfectly informed of the actual quality, but buyers are not and assign a prior probability of β, $0 < \beta < 1$, to high quality and the

[2] Section 3 expands the model to account for endogenous quality selection.

complementary probability to low quality.

The firm sets a price, p, and buyers update their beliefs about product quality on the basis of this signal. Consumers make purchase decisions which maximize their expected surplus (i.e., the expected value minus p), given beliefs. These actions and objectives define an extensive form game of incomplete information. A sequential equilibrium (Kreps and Wilson, 1982) requires that the seller and buyers act in a sequentially rational manner and that buyers update beliefs using Baye's rule on the equilibrium path. In a separating equilibrium, the low and high quality seller choose different prices while in a pooling equilibrium both qualities are sold at the same price.

CLAIM 1: No separating equilibrium exists.[3]

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[3] This is actually only true for the set of equilibria in which all consumers consume in equilibrium. There do exist separating equilibria in which buyers randomize between buying and not buying. Specifically, there exists a separating equilibrium in which the low quality seller's price is V_L and the high quality seller's price is V_H. Buyers accept V_L with probability one but randomize in response to V_H; V_H is accepted with probability $\frac{V_L}{V_H}$ and rejected with probability $1 - \frac{V_L}{V_H}$. Buyers' beliefs are: quality is high if the price is V_H, quality is low if the price is less than V_H. Given these beliefs, the buyers' strategies are optimal. And, given the buyers' beliefs and strategy, both types of seller are indifferent between V_L and V_H. (Since a price between V_L and V_H is believed to signal low quality, it is rejected by buyers with probability one and therefore dominated by V_L and V_H from the firms' point of view.) So this is an equilibrium. However, I feel that this equilibrium is unsatisfactory on several counts.

(i) The equilibrium breaks down if the seller must incur some arbitrarily small cost to discover its quality. Since both types can earn identical profits, the seller would not incur any expense to learn its quality.

(ii) Both types of seller are strictly indifferent between charging V_L and V_H. Nevertheless, buyers infer the quality from the price they observe and spend their money accordingly. Is such an inference reasonable when it is understood that no seller has an

PROOF: Suppose the contrary. Then there are equilibrium prices, p_L and p_H, $p_L \neq p_H$, such that the low quality seller charges p_L and the high quality seller charges p_H. Clearly $p_H \leq V_H$ and $p_L \leq V_L$. If $p_H > p_L$, then, the low quality seller would profit from deviating to p_H. Similarly, if $p_L > p_H$, the high quality seller would deviate to p_L. This completes the proof.

□

Separation is unfeasible because any price which the high quality seller chooses in order to signal its identity is equally attractive to the low quality seller and will therefore be mimicked by it. Let:

$$(1) \qquad \bar{V} = \beta V_H + (1-\beta)V_L.$$

That is, $\bar{V}$ represents the ex ante expected value of a unit to a buyer. It is obvious that $\bar{V}$ is a pooled equilibrium price.

Other pooling equilibria also exist. Specifically, consider p', $V_L < p' < \bar{V}$. Any such price may be supported as an equilibrium price by the following out of equilibrium belief: If the price is greater than p', buyers conclude that the quality is V_L (with sufficiently high probability). This belief effectively restricts the seller from raising its

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incentive to send the correct signal?

(iii)Finally, the out–of–equilibrium beliefs that are necessary to support this equilibrium are arbitrarily prejudiced against high quality (see text below): If buyers offered p', $V_L < p' < \bar{V}$, assign at least their prior probability β to high quality, they will accept p' with probability one. This would make a deviation to p' profitable for the high quality seller.

price. However, $\overline{V}$ seems to be a more natural equilibrium price than prices which are lower than $\overline{V}$. This is because the latter require buyers to maintain out–of–equilibrium beliefs which are arbitrarily prejudiced against high quality. Specifically, a price $p' < \overline{V}$ is an equilibrium only because buyers associate deviations to prices greater than p' with the low quality seller. But contingent on the buyers' ex ante beliefs about quality, the high and low quality sellers have identical incentives for such a deviation. There are therefore no "objective" grounds for buyers to reduce their belief in high quality upon learning that the price is higher than p'. This argument does not, of course, apply to $\overline{V}$; prices higher than $\overline{V}$ are rejected because they yield negative surplus <u>given</u> the buyers' prior. For this reason, the remainder of the analysis shall focus on the properties of equilibria characterized by out–of–equilibrium beliefs which are not arbitrarily prejudicial against high quality. More precisely, we shall be interested in equilibria in which buyers' beliefs about quality are consistent with the following criterion:

<u>Unprejudiced Beliefs</u>:

> Consider an out of equilibrium price which is profitable for the high quality seller if the posterior probability assigned to V_H is <u>at least</u> β. Then the posterior probability assigned to V_H, following such a deviation, must be at least β.

It is clear that only $\overline{V}$ is consistent with the above criterion. Nevertheless it should be stressed that prices less than $\overline{V}$, while inconsistent with unprejudiced beliefs, do satisfy many conventional refinements of sequential equilibrium, such as the "intuitive

criterion" of Cho and Kreps (1987).[4] At any rate, what all the equilibria have in common is that prices are completely uninformative about quality. The objective of what follows is to argue that this is a consequence of assuming that buyers are not only less well informed than the seller ex ante, but are unable to alter their informational status ex post.

Accordingly, I expand the basic setting by allowing buyers to acquire additional information in response to observed prices. Specifically, events unfold as follows. First, the seller sets its price. After buyers observe this price, and revise their beliefs, they may acquire additional information about quality from an external, reliable source at a cost of $s > 0$. For simplicity, it is assumed that information acquired from the external source is perfect.[5]

Thus after learning the price p, a buyer chooses between the following three options:

(i) Buy at p without becoming informed;

(ii) Become informed and then buy if and only if the expected gain from buying is positive;

(iii) Leave the market without becoming informed or buying.

I will refer to this version of the model as the pricing game with endogenous information.

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[4] According to their criterion, the deviation must be unprofitable for a low quality seller for any conceivable beliefs. Such is obviously not the case here.

[5] I am grateful to Bart Lipman for making me aware of his related work (Lipman, 1990). Lipman also considers the case where uninformed buyers may acquire information in response to prices. However, he considers only pure strategy equilibria in which prices are uninformative.

Consider a buyer who, after learning p, $V_L < p \leq V_H$, maintains her prior belief that quality is high with probability β. Her expected gain from choosing option (ii) is:

$$-s + \beta(V_H - p).$$

Her expected gain from choosing option (i) is:

$$\beta(V_H - p) + (1-\beta)(V_L - p).$$

Option (ii) is preferred over option (i) iff:

$$-s + \beta(V_H - p) \geq \beta(V_H - p) + (1-\beta)(V_L - p).$$

Let $p(s)$ be the value of p for which (2) obtains with equality, i.e.,

(2) $$-s + \beta(V_H - p(s)) = \beta(V_H - p(s)) + (1-\beta)(V_L - p(s)).$$

Then this buyer chooses option (ii) over option (i) if $p > p(s)$ and has the reverse preference if $p < p(s)$.

Let s^* satisfy: $p(s^*) = \overline{V}$, i.e. (substituting $\overline{V}$ in (2) and using (1)):

(3) $$s^* = \beta(1-\beta)(V_H - V_L).$$

Thus, $p(s) < \overline{V}$ for $s < s^*$.

PROPOSITION 1: If $s < s^*$, no pooling equilibrium consistent with unprejudiced beliefs exists for the pricing game with endogenous information.

PROOF: Let the pooled price be p' and suppose $p' \leq p(s) < \bar{V}$ (since by assumption $s < s^*$). Consider a deviation to p'', $p' < p'' < \bar{V}$, by a high quality seller. If buyers become informed, they will accept p'' in which case the deviation is profitable. If buyers do not become informed, they will accept p'' if they continue to assign at least β to high quality (because $p'' < \bar{V}$). Since in that case the deviation is profitable for the high quality seller, uninformed buyers with unprejudiced beliefs must indeed assign at least β to high quality. Thus the deviation is profitable in any event. If $p' > p(s)$, then buyers offered p' either become informed or leave the market without buying. In either case, the low quality seller makes no sales. By deviating to V_L, it makes a sale and earns positive profit with probability one. This completes the proof.

□

Our earlier arguments against a (pure strategy) separating equilibrium continue to apply to the pricing game with endogenous information.[6] Thus, we conclude that for $s < s^*$, no pure strategy equilibrium consistent with unprejudiced beliefs exists for the pricing game with endogenous information.[7]

We shall now proceed to characterize a mixed strategy equilibrium in which the extent to which prices are informative is determined by the cost of external information to

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[6]The fact that external information is available does not alter the proof of Claim 1. Buyers will not invest in costly information if prices are perfectly revealing.

[7] Pooling equilibria based on "prejudiced" beliefs continue to exist, however. In particular, any price $p' < p(s)$ survives as a pooling equilibrium in which prices convey no information.

consumers. This equilibrium is characterized by two market prices. The low price is V_L and the (yet–to–be–determined) high price is denoted as $p_H > V_L$. The high quality seller always charges p_H. The low quality seller randomizes between revealing its type – by charging V_L – and masquerading as a high quality type by charging the high quality price, p_H. Of course, if buyers never became informed, there would be nothing to prevent the low quality seller from always charging the high quality price, thereby vitiating any signalling potential it might have. Conversely, if buyers always became informed, the low quality type would never charge more than the perfectly revealing, low quality price. Thus, buyers must randomly monitor the high priced seller's quality by becoming informed with positive probability less than one.

Let α, $0 < \alpha < 1$, be the probability with which a buyer becomes informed and γ, $0 < \gamma < 1$, the probability with which the low quality seller charges V_L. Then, since the high quality seller always charges p_H, a buyer offered p_H revises her probability that quality is high to ξ, using Baye's rule:

$$\xi = \frac{\beta}{\beta + (1-\beta)(1-\gamma)} . \tag{4}$$

Note that for $\gamma < 1$, $\xi > \beta$; observing the high price increases the probability that the uninformed buyer assigns to high quality.

In equilibrium, the low quality seller's profit from charging V_L must equal its expected profit from charging p_H. When its price is V_L, it sells with probability 1. When its price is p_H, it makes a sale only if the consumer does not become informed. Thus

(E.1) $$V_L = (1-\alpha)p_H .$$

Consider a buyer who assigns a posterior probability of ξ to high quality and let $\hat{p}$ be the price at which her expected surplus from buying the product equals her surplus from leaving the market without consuming. That is,

(5) $$\hat{p} = \xi V_H + (1-\xi)V_L.$$

CLAIM 2: If buyers' out–of–equilibrium beliefs are unprejudiced, $p_H = \hat{p}$.

PROOF: Suppose $p_H < \hat{p}$ and consider a deviation by a high quality seller to p', $p_H < p' < \hat{p}$. If buyers become informed, they accept p' (since $p' < V_H$). If they don't become informed but assign at least ξ to high quality, then, since by (5), $p' > \xi V_H + (1-\xi)V_L$, they will also accept p'. Thus deviation to p' is profitable for a high quality seller if buyers continue to assign at least ξ to high quality. But this must be the case if the buyer's out–of–equilibrium beliefs are unprejudiced. This proves that $p_H \geq \hat{p}$. Suppose that $p_H > \hat{p}$. Then uninformed buyers reject p_H, while informed buyers reject $p_H > V_L$ if quality is low. Thus the low quality seller earns zero profits when it charges p_H while it could earn positive profit by charging V_L. The low quality seller would therefore never charge p_H. This proves that $p_H \leq \hat{p}$. Thus $p_H = \hat{p}$.

□

Using claim 1 and (5) yields the second equilibrium condition:

(E.2) $$p_H = \xi V_H + (1-\xi)V_L.$$

Finally, in equilibrium, the buyers' surplus from becoming informed must equal the surplus from remaining uninformed. A buyer who becomes informed incurs an expenditure of s and buys only if she learns that quality is high. Thus the expected gain from becoming informed is $-s + \xi(V_H - p_H)$. If she buys while uninformed, her expected gain is $\xi(V_H - p_H) + (1-\xi)(V_L - p_H)$. She is therefore indifferent between the two options iff:

$$-s + \xi(V_H - p_H) = \xi(V_H - p_H) + (1-\xi)(V_L - p_H).$$

Rearranging gives the equilibrium condition:

(E.3) $$s = (1-\xi)(p_H - V_L) .$$

Define a Random Monitoring Equilibrium (RME) as a sequential equilibrium consistent with unprejudiced beliefs for the pricing game with endogenous information characterized by the quadruple: $\{\gamma > 0, \xi, \alpha > 0, p_H\}$ solving (4), (E.1), (E.2) and (E.3).

PROPOSITION 2: Corresponding to each $s < s^*$, there is a unique RME for the pricing game with endogenous information.

PROOF: Solving (E.2) and (E.3) for ξ gives:

(5) $$\xi = \frac{\Delta + \sqrt{\Delta^2 - 4s\Delta}}{2\Delta}$$

where $\Delta = V_H - V_L$. It is required that $\Delta^2 - 4s\Delta \geq 0$, i.e. that $s \leq \frac{\Delta}{4}$. For each $s \leq \frac{\Delta}{4}$, there are two solutions for ξ, corresponding to the positive and negative roots on the RHS of (5). Since $0 < \gamma < 1$, it is required, by (4), that $1 > \xi > \beta$. Consider the positive root. For this root, the RHS of (5) is monotonically decreasing in s and goes from 1 to $\frac{1}{2}$ as s goes from zero to $\frac{\Delta}{4}$.

Note that (by (3)), $s^* = \beta(1-\beta)\Delta \leq \frac{\Delta}{4}$. Substituting $s^* = \beta(1-\beta)\Delta$ in (5) gives:

$$\xi(s^*) = \frac{1 + \sqrt{(1-2\beta)^2}}{2}. \tag{6}$$

If $\beta \geq \frac{1}{2}$, the positive root in (6) is $2\beta-1$, giving $\xi(s^*) = \beta$. If $\beta < \frac{1}{2}$, the positive root is $1-2\beta$, giving $\xi(s^*) > \beta$. Thus, for every $0 < \beta < 1$, $\xi(s^*) \geq \beta$. This proves that corresponding to the positive root, there exists a unique $\xi > \beta$ (and hence a unique $\gamma > 0$) for each $0 < s < s^*$.

Now consider the negative root. For this root, ξ is monotonically increasing in s and goes from $\frac{1}{2}$ to zero as s goes from zero to $\Delta/4$. So $\xi > \beta$ exists only if $\beta \leq \frac{1}{2}$. For $\beta \leq \frac{1}{2}$, the negative root of (6) is $2\beta-1$, giving $\xi(s^*) = \beta$. Thus corresponding to the negative root, $\xi < \beta$ for $s < s^*$. This proves that for $s < s^*$, ξ and γ are unique.

Solving (E.2) and (E.3) for p_H gives:

$$p_H = V_H - \frac{s}{\xi} \tag{7}$$

which, by the above, defines p_H uniquely for $s < s^*$. Finally, given p_H, α is uniquely defined by (E.1).

It remains to show that the triple: $0 < \gamma < 1$, $0 < \alpha < 1$, $V_L < p_H < V_H$ as determined by (4), (E.1), (E.2), and (E.3) do in fact constitute an equilibrium. To see this, let the buyers' out–of–equilibrium beliefs be as follows: If the price is less than p_H, it is concluded that quality is low with probability 1. If the price is $\geq p_H$, the probability that quality is high is revised to ξ. It is obvious that these beliefs are unprejudiced. A buyer with these beliefs will reject any price greater than V_L and less than p_H. (E.2) implies that an uninformed buyer will not accept $p > p_H$. Her expected gain from becoming informed is $-s + \xi(V_H - p) < -s + \xi(V_H - p_H)$, the last equality following from substituting for p_H from (E.2) and for s from (E.3). Thus buyers optimally leave the market without becoming informed or buying if the price is $> p_H$. Thus a low quality seller earns zero profit if its price is between V_L and p_H or greater than p_H. By (E.1), it is indifferent between V_L and p_H. Therefore the low quality seller has no incentive to deviate from its equilibrium strategy which calls for randomization between V_L and p_H. p_H is accepted from the high quality seller by both informed and uninformed buyers. Thus it certainly prefers p_H to any price less than p_H. Consider a deviation to $p' > p_H$ by the high quality seller. As noted above, (E.2) and (E.3) in concert imply that the consumer's optimal response to this price is to reject it without becoming informed. Therefore p_H is optimal for the high quality seller. This completes the proof.

□

Because $\xi > \beta$, the high price, p_H, provides information about quality. The low quality seller adds noise to this information, however, in proportion to the frequency with which it adopts p_H. The following proposition describes how the accuracy of the information conveyed by p_H, as measured by the posterior probability, ξ, is related to the cost of information.

PROPOSITION 3: For $s < s^*$, the following obtains:

(i) $\frac{d\xi}{ds} < 0$ and $\frac{d\gamma}{ds} > 0$.

(ii) $\frac{dp_H}{ds} < 0$

In the limit, as $s \to 0$, $\xi \to 1$ and $p_H \to V_H$.

PROOF: The first part of (i) has already been proved in the proof of proposition 2. The second part then follows immediately from (4) while (ii) follows immediately from (7). The limit statements then follow directly from (5) and (7).

□

It is natural to measure the amount of information conveyed by the high price, p_H, by the posterior belief in high quality with which it is associated, ξ. If $s \geq s^*$, the equilibrium price is pooled at $\bar{V}$ and the posterior and prior beliefs coincide. In that case, therefore, the market price is completely uninformative. If $s < s^*$, the RME obtains, $\xi > \beta$, and, according to proposition 3, increases as s declines.[8] Thus for this range of information costs, the market price becomes increasingly informative as the cost of

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[8] As shown in the proof of proposition 2, the RME exists only for $s < s^*$ if $\beta > \frac{1}{2}$. If $\beta \leq \frac{1}{2}$, there also exist RME for $s^* \leq s \leq (V_H - V_L)/4$. Corresponding to the positive root, these RME also have the proprties indicated in proposition 3, so the characterization in the text remains valid if $(V_H - V_L)/4$ is substituted for s^*. Corresponding to the negative root, there exist RME for $\beta \leq \frac{1}{2}$ and $s^* \leq s \leq (V_H - V_L)/4$ which have the opposite characterization, i.e. prices are increasingly informative as s grows in this range.

information decreases and perfectly informative in the limit, as s goes to zero. The behavior of ξ as a function of s is described in figure 1.

Figure 1 About here

Note from (E.1) that $\alpha = 1 - \frac{V_L}{p_H}$. Thus, from proposition 3, we have that $\frac{d\alpha}{ds} < 0$. That is, the frequency with which buyers become informed increases as s decreases. Interestingly, α is bounded away from 1 (i.e., never exceeds $1 - \frac{V_L}{V_H}$) no matter how small s is. This is because prices provide increasingly precise information as s grows smaller. Thus as external information becomes cheaper, its value diminishes accordingly, obviating the need to acquire it.

3. QUALITY SELECTION

The preceding analysis has assumed that product quality is exogenous. The model is easily extended to account for endogenous quality selection. Suppose the cost of providing low quality is $C_L < V_L$ and that of providing high quality is C_H, $V_H > C_H > C_L$. It is easy to verify that none of the previous analysis is changed if $C_H \leq \bar{V}$. The interesting case occurs when $C_H > \bar{V}$. In that case, the high quality seller loses money by selling at $\bar{V}$. Thus, if $s > s^*$,[9] so that the RME doesn't exist, high quality will never be provided. This is Akerloff's (1970) lemon principle. Let $\tilde{s}$ be defined by:

$$V_H - \frac{\tilde{s}}{\xi(\tilde{s})} = c_H.$$

[9] See the previous footnote.

Then, by (7), if $s < \tilde{s}$, the RME associated with s gives $p_H > c_H$ and thus enables profitable provision of high quality. So the lemon principle obtains – high quality is never provided – only if the cost of information is sufficiently high, i.e., $s > \tilde{s}$. Otherwise, the availability of exogenous information to consumers, by enabling the price to credibly convey information, allows high quality to be provided.

4. ENDOGENOUS INFORMATION AND PRICE NEGOTIATION

One characteristic of the RME is that there is a positive probability that trade will not take place. In particular, informed buyers will reject the high price from the low quality seller, although ex–post this seller would like to reduce its price to V_L or less. This characterization is consistent with impersonal market settings in which there is no scope for negotiating the price, e.g., most first–hand retail markets where buyers read a posted price and respond by either buying at that price or leaving the store. At the other end of the market spectrum lie full fledged bargaining settings in which the process of price determination is best described by a formal model of bargaining under asymmetric information. The purpose of this section is to address an intermediate setting with the following structure. As in the preceding analysis, the seller has the monopoly power to offer a take it or leave it price. The added ingredient is that in response to this price, the buyer may counteroffer to negotiate the price, an offer which the seller may either reject, in which case the seller's original price remains in effect, or accept, in which case the price is determined through bilateral bargaining. In the latter event, the agreed–upon price will naturally be less than the monopoly price (see below). It is clear that in an RME the high quality seller will never agree to negotiate the price. This is because it knows its original price to be acceptable to both informed and uninformed buyers. Similarly, the low

quality–low price seller has no incentive to agree to negotiate. On the other hand, the low quality–high price seller does have an incentive to negotiate with informed buyers. This is because it knows the latter will credibly refuse its initial offer and should therefore be willing to accept a price less than V_L rather than lose the sale. Observe, however, that this argument is only persuasive if the seller is able to distinguish between informed and uninformed buyers. Suppose the seller is unable to so distinguish. If a buyer's offer to negotiate the price were accepted by the low quality–high price seller with positive probability, it would be a dominant strategy for both informed and uninformed buyers to make such an offer. Therefore the offer to negotiate cannot affect the seller's prior belief (i.e. α) that the buyer is informed. But since the negotiated price must be less than V_L, it would be a dominant strategy for the low quality seller to initially charge V_L with probability one. Therefore it shall be assumed that the seller can distinguish between the informed and uninformed. For example, informed buyers may be able to converse more knowledgeably with the seller about the product's characteristics than the uninformed. I shall leave unspecified the bargaining process which occurs if the seller agrees to negotiate the price, and assume that in this case the price is negotiated to a fraction of the buyer's valuation, ϕ, $0 < \phi < 1$. ϕ is to be interpreted as a reduced form of an unspecified bargaining procedure.

To summarize, this section studies the following version of the pricing game with endogenous information. First, the seller offers an initial price, in response to which the buyers decide whether to become informed. Then the buyer either accepts the initial price, rejects it and leaves the market or offers to negotiate the price. In the latter event, the price is determined as the fraction ϕ of the buyer's valuation if the seller agrees to negotiate. If not, its initial price offer remains in effect and the buyer either accepts it or

leaves the market without further ado. I shall refer to this version of the game as the pricing game with endogenous information and price negotiation. It is illustrated in figure 2.

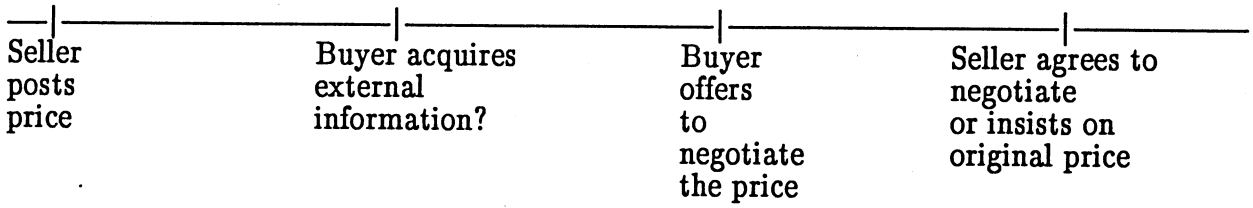

FIGURE 2

It is easy to verify that, as is the case in the previous section, no pure strategy equilibrium consistent with unprejudiced beliefs exists for the pricing game with endogenous information and price negotiation game if $s < s^*$. We therefore proceed to derive an RME. Specifically, let $\tilde{\gamma}$, $\tilde{\alpha}$, $\tilde{\xi}$ and $\tilde{p}_H > V_L$ be defined analogously to γ, α, ξ and p_H of section 2 for the game with price negotiation. The low quality seller randomizes between V_L and $\tilde{p}_H$. If its price is $\tilde{p}_H$ and buyers become informed, its profit is ϕV_L. Therefore the equilibrium condition requiring that this seller be indifferent between the two prices is analogous to (E.1):

$$(\tilde{E}.1) \qquad V_L = (1 - \tilde{\alpha})\tilde{p}_H + \alpha \phi V_L .$$

It is also easy to verify that the analogue of (E.2) obtains:

$$(\tilde{E}.2) \qquad \tilde{p}_H = \tilde{\xi} V_H + (1-\tilde{\xi})\, V_L .$$

The last equilibrium condition, that buyers be indifferent between becoming informed and remaining uninformed is derived as follows. The buyer who is offered $\tilde{p}_H$, becomes informed, and discovers that quality is low, gains $(1-\phi)V_L$. If quality is high, then, of course, the seller will refuse to negotiate. The low quality seller will also refuse to negotiate if its original price was V_L. Thus the expected gain of a buyer who is offered $\tilde{p}_H$ and becomes informed is:

$$-s + \tilde{\xi}(V_H - \tilde{p}_H) + (1-\tilde{\xi})(1-\phi)V_L$$

while her utility from remaining uninformed is:

$$\tilde{\xi}(V_H - \tilde{p}_H) + (1 - \tilde{\xi})(V_L - \tilde{p}).$$

Equating these two options gives the condition:

$$-s + \tilde{\xi}(V_H - \tilde{p}_H) + (1-\tilde{\xi})(1-\phi)V_L = \tilde{\xi}(V_H - \tilde{p}_H) + (1-\tilde{\xi})(V_L - \tilde{p}_H).$$

Solving the preceding equation for $\tilde{p}_H$ gives:

$$(\tilde{E}.3) \qquad \tilde{p}_H = \frac{s + V_L\phi(1-\tilde{\xi})}{(1 - \tilde{\xi})}.$$

PROPOSITION 4: There exists $\tilde{s} > 0$ such that for $s < \tilde{s}$, there exists a unique solution for $(\tilde{E}.1) - (\tilde{E}.3)$ for every $0 \leq \phi < 1$ which constitutes an equilibrium consistent with

unprejudiced beliefs for the pricing game with endogenous information and price negotiation. This equilibrium has the property that $\frac{\partial \xi}{ds} < 0$ and $\frac{\partial \xi}{\partial \phi} < 0$.

PROOF: See the Appendix.

With price negotiation an option, the value of information to buyers is determined, in part, by the outcome of price negotiations. The higher the informed buyer's negotiated share in the event of a high price offer from the low quality seller, the more valuable external information is to the buyer. For a given nominal value of information, s, an increase in the buyer's share, $1-\phi$, by making information more valuable, reduces its effective cost. Just as a reduction of the nominal cost of information increases the precision of the high price signal (i.e., increases ξ), so a reduction in ϕ, which reduces its effective cost, has the same effect. This explains why $\frac{d\xi}{d\phi} < 0$.

CONCLUSION

We have presented a model in which the seller is privately informed of quality but buyers are able to become informed from an external source at a cost. When this cost lies below a critical level, the equilibrium prices are informative and achieve partial separation between the low and high quality seller. The degree of separation achieved increases as the cost of information diminishes, and full separation is attained in the limit as the cost of external information vanishes.

This framework might have some intriguing dynamic implications. Consider the introduction of a new, high quality good about which buyers are poorly informed. If, as is plausible, the cost of learning the true quality decreases over time, then our model predicts the price will increase over time. This is true even if there is no repeat buying, i.e. new

buyers enter the market each period, as in the case of a durable, for instance. This contrasts with other accounts of dynamically increasing prices ("introductory offers") which rely on repeat buying by the same buyers (e.g. Milgrom and Roberts (1986) and Judd and Riordan (1987)).

APPENDIX

PROOF of PROPOSITION 4:

Solving (Ë.2) and (Ë.3) for ξ gives:

$$\text{(A.1)} \qquad \xi = \frac{V_H - 2V_L + \phi V_L \pm \sqrt{V_H^2 - 4(V_H - V_L)\,s - 2V_H V_L \phi + V_L^2 \phi^2}}{2(V_H - V_L)} .$$

Note that for sufficiently small s, only the positive root gives $0 < \xi$ and that by choosing s sufficiently small, ξ can be made to be arbitrarily near 1. Thus there exists $\tilde{s} > 0$ such that for $s < \tilde{s}$, there exists a unique solution for ξ satisfying the requirement that $\beta < \xi < 1$.

Differentiating the RHS of (A.1) with respect to ϕ yields (after some manipulation):

$$\frac{\partial \xi}{\partial \phi} = V_L \left[\frac{\tilde{\Delta} - 2V_H + V_L \phi}{\tilde{\Delta}} \right]$$

where

$$\tilde{\Delta} = \sqrt{V_H^2 - 4(V_H - V_L)s - 2V_H V_L \phi + V_L^2 \phi^2}$$

which is easily verified to be negative. This completes the proof.

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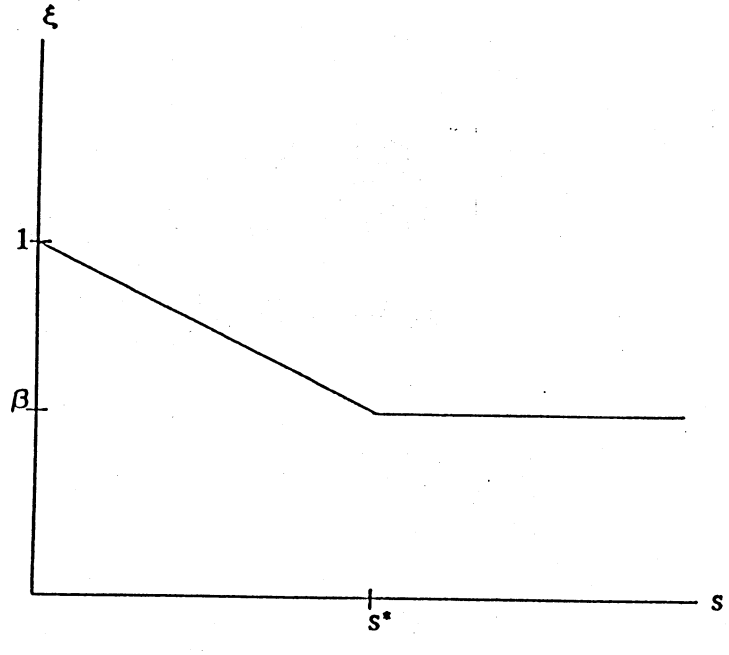
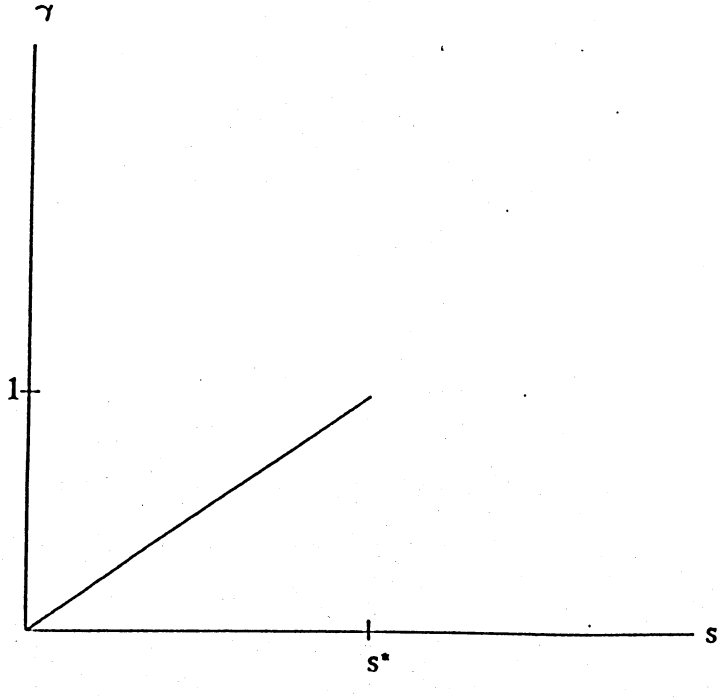
Figure 1





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