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Abstract

This paper develops a game-theoretic model of a market for a high quality product that is subject to moral hazard. It uses "introductory offers" to reconcile free entry with existence of premia necessary for the maintenance of high quality. Buyers boycott sellers who cheat and continue purchasing from established sellers whose offers are not dominated by those of entrants. In equilibrium, entrants charge a lower price than established sellers and provide the high quality with a smaller frequency. The entry price is sufficiently low to render the expected profits from entry equal to zero, despite high quality premia. The model avoids the restrictive assumptions of previous models such as irrational expectations on the part of buyers and time inconsistency on the part of sellers.

I. Introduction

This paper develops a game-theoretic model of a market for a high quality product that is subject to moral hazard. It uses "introductory offers" to reconcile free entry with the existence of premia necessary for the maintenance of high quality while avoiding the restrictive assumptions of previous models.

In markets where product quality is observable only after purchase, sellers have an incentive to sell "lemons" in place of more costly high quality products (Akerlof, 1970). However, if purchases can be repeated, there is a potential for this seller moral hazard to be overcome through buyers' use of a trigger strategy. If buyers boycott sellers who cheat, then sellers will have an incentive to produce high quality products as long as they expect to earn sufficiently high rents from their continued operation in the market. In the presence of large exogenous entry costs, expected future profits from reputation maintenance may be large enough to outweigh the short-run benefits of cheating and, thus, to make high quality production a profitable strategy.

When exogenous nonsalvageable entry costs are small, sustainable profits may be too low to induce high quality production.[1] In this situation, high quality products will be sold only if other mechanisms exist to maintain the necessary incentives. Third party verification is one such mechanism. However, given the difficulties for a third party to verify the claims of sellers and buyers concerning quality, which often consists of a number of hard-to-measure product characteristics, the existence of the market for high quality products ultimately hinges upon "endogenous" mechanisms. Several examples of such mechanisms have been modeled in the literature on

reputation and product quality (Klein and Leffler, 1981; Shapiro, 1983; Allen, 1984; Farrell, 1986).

In a seminal paper, Klein and Leffler (1981) argued that when exogenous entry costs are too low to sustain the premia necessary for high quality maintenance, sellers will precommit themselves to the provision of "free" services that are valuable to buyers. This precommitment is achieved by sellers investing in nonsalvageable assets that render those services. However, as Allen (1984) points out, for most industries such services are either not feasible or have the nature of public goods and, therefore, are unlikely to attract buyers to the firm providing them.

Allen (1984), in turn, develops a model in which there are no endogenous entry costs and the problem of excessive entry in the high quality market is solved by sellers operating at scales that are suboptimally small for the price they charge. Sellers do not cut their prices because it makes cheating more profitable, and buyers--who are aware of this relationship--would not buy their products. In equilibrium, established sellers earn sufficient premia over their recurrent average costs to have the necessary incentives to provide the high quality. The equilibrium number of firms in the market is such that the sales of each firm are just sufficient to provide entrants with zero discounted long-term profits, given some exogenous entry costs. The exogenous entry costs must be positive, but not necessarily large, for the equilibrium output of each firm to be greater than zero.

An implicit assumption crucial for the existence of an equilibrium in Allen's model is that sellers must be able to precommit themselves to a price in all future periods. In the absence of such an assumption, a seller can claim that he is reducing his price and expanding his output only for one period and will go back to the "equilibrium" path thereafter. If buyers

believe that such an equilibrium exists, it becomes possible to deviate in this way without violating the seller moral hazard condition, since it is only the future profits that provide sellers with the necessary incentive to maintain their reputations. Therefore, the deviating strategy has the potential to make the seller as well as his customers better off. Obviously, this possibility encourages deviation from the equilibrium path in each period by every seller, which ultimately upsets the equilibrium.

Shapiro (1983) analyzes an alternative mechanism for generating endogenous entry costs. He builds an "adaptive expectations" model in which in any given period buyers expect each seller to supply a quality similar to what he has marketed in the past. In the case of entrants, buyers expect the worst quality. This forces entrants to offer low introductory prices while they provide high quality products. Shapiro shows that the endogenous entry costs generated in this way may be sufficient to support a high quality equilibrium. However, if buyers are rational, the equilibrium collapses since in this case buyers would prefer to purchase from entrants and not from established sellers.

Farrell (1986) argues that moral hazard itself may serve as an entry barrier if entrants are expected to have low profits in the future. This may happen if firms are large and entry by each single firm has a non-negligible impact on the market. In this case, entry with the promise of high product quality may not be credible if buyers do not find switching sellers worthwhile or anticipate effective reactions by incumbents.

In the model developed in this paper, buyers' expectations are assumed to be rational and the existence of equilibrium does not depend on exogenous entry costs, large firm sizes, or sellers' ability to commit themselves to

free services or fixed prices. The main assumption of the model that gives rise to a mechanism for endogenous entry costs is that each buyer continues to purchase from the same seller as long as the seller does not cheat or make offers that the buyer finds inferior to those he expects from other sellers. This type of buyer behavior puts entrants at a slightly disadvantaged position vis-à-vis incumbents and forces them to offer a lower price and incur an "entry" cost. Competition among entrants then reduces the entry price to a level just sufficient to sustain the premiums necessary for quality maintenance. Despite this price difference, entrants and incumbents have the same incentives to produce the high quality since the quality decision by sellers depends only on future profits. In equilibrium, all sellers are indifferent between providing the high quality and cheating and, thus, randomize their quality decision. Even though the price offered by entrants is lower than that of incumbents, buyers remain indifferent between the two groups and continue purchasing from incumbents because entrants provide the high quality with a smaller frequency. This happens because any increase in the expected probability of high quality provision by entrants makes their offers more attractive to buyers and forces incumbents to lower their prices, which in turn diminishes the value of becoming established and induces entrants to cheat more often.

II. The Model

Consider a product that can be produced with two different qualities; a high quality (H) and a low quality (L). Suppose that each seller produces one unit of the product in each period, with the cost depending on quality. Let c_q be the unit cost of producing quality q, q = H,L, where $c_H > c_L > 0$. Assume that in each period, each buyer purchases one unit of the product and

deals with only one seller. Let u_q be the buyers' monetary valuation of quality q, q = H,L. To simplify the analysis, we assume that $u_L = 0$ and $u_H > c_H$ so that only the high quality is worth producing. All buyers and sellers are infinitely-lived and risk neutral. For sellers who leave the market or those who remain outside, the per-period expected profits are normalized to zero. Similarly, the utility of buyers who do not purchase the product is assumed to be equal to zero.

At the beginning of each period, first each buyer decides whether to consider the offer of the seller from whom he has purchased in the previous period or to seek another seller. We will call a seller who has a continuing customer an established seller. All other sellers are considered entrants. Each established seller first announces the price and the quality of his product to his current customer. If the buyer accepts the offer, trade takes place, otherwise the buyer costlessly searches out offers from among the pool of entrants. In the latter case, the established seller becomes an entrant. After the fate of the offers by established sellers is determined, all entrants announce their price-cum-quality offers. We model the buyer search behavior among entrants by assuming that buyers are randomly matched among entrants so that if there is any unmatched seller, then his offer provides buyers with an expected consumer surplus that does not exceed the expected consumer surplus implied by the offers of the matched sellers. After this matching, there is another stage where offers are accepted or rejected. Finally, buyers experience the actual qualities of the products they have received and, then, the play proceeds into the subsequent period.

Because we wish to focus on the seller moral hazard, we posit the following in regard to buyer strategies. First, at the beginning of a

period, a buyer decides not to consider the offer of the seller from whom he has purchased in the previous period if at any time in the past that seller has cheated by announcing the high quality and delivering the low quality. Second, when a buyer decides to consider the offer of an established seller, he rejects it if the expected consumer surplus implied by the offer is less than the expected consumer surplus that would result if the buyer sought the offer of an entrant. Finally, when a buyer is matched with an entrant, the buyer accepts the entrant's offer if the expected consumer surplus resulting from the offer is nonnegative, otherwise the buyer does not trade at all in that period. Given the behavior of sellers modeled below, it is not hard to show that this buyer behavior is consistent with perfect equilibrium.

Since the low quality product has no value for buyers, when a seller announces the low quality, he is better off not producing the product at all. Thus, it seems reasonable to assume that an offer which includes the low quality simply involves a payment (a nonpositive price) from the seller to a buyer who promises to consider the seller's offer at the beginning of the following period. A close examination of the model should make it clear that changing this assumption to a case where the low quality product has to be produced and delivered in order for buyers to stay with their current sellers who offer the low quality does not change the basic results of the paper.[2]

The goal of the following analysis is to show that if the high quality is sufficiently valued by buyers such that

$$(1) \qquad u_H \geq c_H + (1+r)(c_H - c_L),$$

then the model described above has a subgame perfect equilibrium where the entry is free and established sellers always produce the high quality.

As we will show below, condition (1) simply states that the utility of buying the high quality from an established seller should exceed the cost of production by at least $r(c_H-c_L)$, which is the minimum premium necessary to overcome the seller moral hazard, plus c_H-c_L, which is the maximum bonus that in equilibrium entrants are willing to offer to lure away customers from established sellers.

To analyze the equilibria of the model, let us begin by considering an established seller who offers quality q at price p to his customer in period t. Let V be the discounted present value of the seller's expected profits from period t+1 onwards if he remains established in that period. Since we are going to assume free entry, the value of being an entrant in period t+1 can be set equal to zero. Note that an established seller can always choose to become an entrant. Therefore, we will have $V \geq 0$. Suppose the buyer accepts the offer (p,q). Let α be the probability that the seller chooses the high quality. If q = L, the seller will not supply the high quality product since it will cost him c_H in the current period without providing any further benefit in future. Therefore, in this case $\alpha = 0$. However, if q = H, the seller will supply the high quality only when the benefits of remaining established do not fall short of the gains from cheating; that is, when

$$(2) \qquad \frac{1}{1+r} V \geq c_H - c_L,$$

where r is the rate of interest. If (2) holds with a strict inequality, the seller can do best by setting $\alpha = 1$, while if (2) holds with an equality, α can be anywhere between 0 and 1. In light of these observations, it is reasonable to assume that after observing the offer (p,q), the buyer will expect the high quality to be supplied with probability β defined by

(3) $\beta = 1$ if $q = H$ and $\frac{1}{1+r} V > c_H - c_L$;

$0 \leq \beta \leq 1$ if $q = H$ and $\frac{1}{1+r} V = c_H - c_L$; and

$\beta = 0$ otherwise.

Note that the current price, p, does not play any role in the buyer's belief formation since once the price is paid, it is sunk and does not enter the seller's quality decision. However, p does play a role in the buyer's decision whether to accept the offer or not. Suppose that the buyer expects net utility $u_0 \geq 0$ if he goes to an entrant. Then he accepts (p,q) only if

(4) $p \leq \beta u_H - u_0$.

It should be noted that since an established seller has a first-mover advantage, the buyer cannot expect any rents from being attached to the seller and, therefore, any price higher than $\beta u_H - u_0$ is not worthwhile for him to accept.

Among acceptable offers, given q, the seller can do best by choosing p such that (4) holds with an equality. When $q = H$, the long-term profits of the seller can be written as $\pi_H = p - \alpha c_H - (1-\alpha)c_L + \alpha V/(1+r)$. The maximum value of these profits is

(5) $\pi_H^* = \beta u_H - u_0 - c_L + \alpha[\frac{V}{1+r} - (c_H - c_L)]$.

In this case, the seller will be interested in making an acceptable offer only if $\pi_H^* \geq 0$, otherwise he will be better off becoming an entrant. Therefore, when $q = H$, the seller will choose p such that

(6) $p = \beta u_H - u_0$ if $\pi_H^* \geq 0$; and

$p > \beta u_H - u_0$ if $\pi_H^* < 0$.

When $q = L$, the expected profits are $\pi_L = p + V/(1+r)$ with the maximum value of $\pi_L^* = -u_0 + V/(1+r)$. In this case, the price will be chosen according to

(7) $p = -u_0$ if $\pi_L^* \geq 0$; and

$p > -u_0$ if $\pi_L^* < 0$.

Note that as pointed out above, when $q = L$, acceptable prices are nonpositive.

The optimal choice of q depends on the relative values of π_H^* and π_L^*. When π_H^* and π_L^* are both negative, the choice of q does not matter in equilibrium, because the seller will not make acceptable offers anyway. However, by taking into account the possibility of an out-of-equilibrium move by the buyer to accept an offer that violates (4) we can restrict the choice of q in this case to L since for any given price, p, we always have $\pi_H < \pi_L$. Therefore, we have

(8) $q = H$ if $\pi_H^* \geq \pi_L^*$ and $\pi_H^* \geq 0$; and

$q = L$ otherwise.

It is assumed that when $\pi_H^* = \pi_L^* \geq 0$, the seller chooses $q = H$.

We now need to specify what happens if the buyer goes to an entrant. Suppose that the buyer is considering an offer (p_E, q_E) from an entrant. Since an entrant who finds a customer has exactly the same incentives as those of an established seller, the quality decision of the entrant, γ, and

the belief of the buyer regarding the probability of high quality provision by the entrant, μ, can be summarized by

(9) $\gamma = \mu = 1$ if $q_E = H$ and $\frac{1}{1+r} V > c_H - c_L$;

$0 \leq \gamma$ and $\mu \leq 1$ if $q_E = H$ and $\frac{1}{1+r} V = c_H - c_L$; and

$\gamma = \mu = 0$ otherwise.

The buyer accepts the offer (p_E, q_E) from the entrant only if $\mu u_H - p_E \geq 0$, otherwise he is better off not buying at all, in which case $u_0 = 0$. Therefore, u_0 is given by

(10) $u_0 = \mu u_H - p_E$ if $\mu u_H - p_E \geq 0$; and

$u_0 = 0$ if $\mu u_H - p_E < 0$.

Under a free entry condition, entrants should not be able to make positive profits. This implies that when $q_E = L$, $p_E + V/(1+r) \leq 0$. Since in this case acceptable offers must satisfy $p_E \leq 0$, the optimal choice of p_E from the entrant's point of view is

(11) $p_E = -\frac{1}{1+r} V$.

When $q_E = H$, we must have $p_E - c_H + V/(1+r) \leq 0$ and $p_E - c_L \leq 0$. Given the acceptability condition $p_E \leq \mu u_H$, the choice of p_E associated with $q_E = H$ can be described by

(12) $p_E = c_L - \gamma[\frac{1}{1+r} V-(c_H-c_L)]$ if $\mu u_H \geq c_L - \gamma[\frac{1}{1+r} V-(c_H-c_L)]$; and

$p_E > c_L - \gamma[\frac{1}{1+r} V-(c_H-c_L)]$ otherwise.

The entry strategy that dominates should yield the highest consumer surplus for buyers. Therefore, taking into consideration the implications of the out-of-equilibrium moves as in the case of established sellers, we may write

(13) $q_E = H$ if $\mu u_H \geq \frac{1}{1+r} V + c_L - \gamma[\frac{1}{1+r} V-(c_H-c_L)]$; and

$q_E = L$ otherwise.

Given V, a <u>one-period rational expectations equilibrium</u> of the model is defined by a set of values for p, q, α, β, p_E, q_E, γ, μ, and u_0 that satisfy $\alpha = \beta$, $\gamma = \mu$, (3), and (6)-(13). It is easy to see that for $V > (1+r)(c_H-c_L)$, the equilibrium conditions yield $\alpha = \beta = \gamma = \mu = 1$, $q = q_E = H$, $p = p_E = c_H - V/(1+r)$, and $u_0 = u_H + V/(1+r) - c_H > 0$. For $V < (1+r)(c_H-c_L)$, an equilibrium exists at $\alpha = \beta = \gamma = \mu = 0$, $q = q_E = L$, $p = p_E - V/(1+r)$, and $u_0 = V/(1+r)$. Finally, for $V = (1+r)(c_H-c_L)$, two sets of equilibria exist. In the first set of equilibria, $\gamma = \mu = 0$, $q_E = L$, $p_E = c_L - c_H$, and $u_0 = c_H - c_L$. In this case, either $\alpha = \beta \geq c_H/u_H$, $q = H$, and $p = \beta u_H - (c_H-c_L)$, or $\alpha = \beta = 0$, $q = L$, and $p = c_L - c_H$. In the second set of equilibria, $\gamma = \mu \geq c_H/u_H$, $q_E = H$, $p_E = c_L$, and $u_0 = \mu u_H - c_L$. In this case, if $\alpha = \beta \geq \mu$, established sellers trade at $q = H$ and $p = (\beta-\mu)u_H + c_L$, and if $\mu = c_H/u_H$ and $\alpha = \beta = 0$, they trade at $q = L$ and $p = c_L - c_H$, otherwise they set $q = L$ and make unacceptable offers.

The stationary equilibria of the model can now be characterized by determining V. Obviously, in a stationary equilibrium we must have either $V = \pi_H^*$ or $V = \pi_L^*$, depending on the value of q. Note that the model does not have a stationary equilibrium where all sellers provide the low quality since buyers are not interested in purchasing the low quality at any positive price. Therefore, if the market is active at all, β or μ must be positive.

In particular, β must be positive since $\beta = 0$ implies either $V = \pi_H^* < 0$ or $V = \pi_L^* < 0$, which are both inconsistent with an equilibrium that involves trade. From $\beta > 0$ and condition (3) it immediately follows that in equilibrium we must have $q = H$ and $V \geq (1+r)(c_H - c_L)$. However, $V > (1+r)(c_H - c_L)$ can be ruled out since in that case, $V > 0 = \pi_H^* > \pi_L^*$. Thus, in a stationary equilibrium, $V = (1+r)(c_H - c_L)$. Since $V = \pi_H^* = p - c_L$, we must also have

$$p = c_H + r(c_H - c_L). \tag{14}$$

In light of our analysis of one-period equilibria, it is easy to see that two types of stationary equilibria exist. First, when $\gamma = \mu = 0$, we have $q_E = L$, $p_E = c_L - c_H$, and $u_0 = c_H - c_L$. Also, from (6) we find $p = \beta u_H - (c_H - c_L)$, which, when compared with condition (14), shows that the equilibrium values of α and β are

$$\alpha = \beta = \frac{c_H + (1+r)(c_H - c_L)}{u_H}. \tag{15}$$

Obviously, condition (1) is sufficient to guarantee that $\alpha = \beta \in [0,1]$.

The second type of stationary equilibrium exists for $\gamma = \mu \geq c_H/u_H$. In this case, as we have seen above, $q_E = H$, $p_E = c_L$, and $u_0 = \mu u_H - c_L$. Since $q = H$, we must have $p = (\beta - \mu)u_H + c_L$, which together with (14) requires

$$\alpha = \beta = \mu + \frac{(1+r)(c_H - c_L)}{u_H}. \tag{16}$$

Given the range of μ, equilibrium α and β must satisfy

$$\alpha = \beta \geq \frac{c_H + (1+r)(c_H - c_L)}{u_H}. \tag{17}$$

Again, condition (1) is sufficient for an equilibrium $\alpha = \beta \in [0,1]$ to exist. For any α and β that satisfy (17), a corresponding

$\gamma = \mu \in [c_H/u_H, 1 - \frac{(1+r)(c_H-c_L)}{u_H}]$ can be found from (16) such that all equilibrium conditions are met. This completes the characterization of the model's stationary equilibria.

It is clear from condition (17) that the model has a continuum of the second-type stationary equilibria parametrized by $\beta \in [\frac{c_H+(1+r)(c_H-c_L)}{u_H}, 1]$. In particular, $\beta = 1$ is always an equilibrium value, representing the case where established sellers produce the high quality with certainty and maintain their reputations. In this equilibrium, entrants are expected to produce the high quality with probability $\mu = 1 - \frac{(1+r)(c_H-c_L)}{u_H} < 1$. However, unless there are new buyers each period, no entrant actually makes a sale. This equilibrium obviously Pareto dominates all other equilibria, which have lower β's and μ's.

Note that in equilibrium, the price charged by established sellers includes a premium of $r(c_H-c_L)$ over the cost of production. This is the minimum premium necessary for inducing sellers to maintain the quality of their products. Alternatively, the premium can be interpreted as a normal return on investment in reputation by entrants, $c_H - c_L$, which is the cost of becoming established in one period by charging $p_E = c_L$ and supplying the high quality. Thus, the investment takes the form of an introductory bonus for buyers who are willing to accept an entrant's offer. For a nontrivial equilibrium to exist, as stated by condition (1), buyers must value the high quality product more than its cost of production, its moral hazard premium, and the bonus offered by the entrants.

While these results are quite similar to those of Shapiro (1983), they are derived from a rational expectations model, whereas Shapiro's argument is based on adaptive expecations on the part of buyers. The endogenous entry cost in Shapiro's model is due to buyers' misperception of entrants'

incentives, while in the present model buyers' beliefs about entrants' behavior are correct and competition lowers the entry price to a level that reduces the expected profits of entrants down to zero. The difference between the prices offered by entrants and established sellers is maintained because the former provide the high quality with a smaller probability. In equilibrium, both entrants and established sellers are indifferent between providing the low and the high qualities and choose the high quality with a probability such that buyers remain indifferent between the two types of offers. The behavioral assumption that buyers purchase from established sellers when they are indifferent assures established sellers that they can keep their customers and continue operation indefinitely as long as they produce the high quality.

III. Extensions and Generalizations

The simple model developed above demonstrates an endogenous market mechanism that can potentially resolve the dilemma of markets for high quality products where moral hazard calls for positive premiums but entry costs are negligible. The model assumes that entry costs are zero, but it is easy to show that the presence of positive exogenous entry costs does not change the essence of our results. Let entry costs be denoted by f. As long as $f \leq (c_H - c_L)(1+r)$ the equilibrium price offered by established sellers will remain at $p = c_H + r(c_H - c_L)$ and the entry price will be $p_E = c_L + f$. If $f > (c_H - c_L)(1+r)$, then $p = p_E = c_H + rf/(1+r)$, and the expected profits from continued operation will be high enough to guarantee the production of the high quality with certainty by both entrants and established sellers.

Note that the equilibrium in the above model does not depend on whether the actual quality of each seller's product remains private information for the buyer who has experienced it or becomes public. Also, if production is constant returns to scale, the results are unaffected by permitting each seller to produce more than one unit and to deal with several buyers at the same time.

If production does not exhibit constant returns to scale, it is necessary to specify in greater detail the process by which sellers become established and the information buyers receive about the quantity and quality of each seller's product. However, the principle mechanism demonstrated by the above model can be put in work in most circumstances: The offers of established sellers will be determined by a moral hazard condition and the offers of entrants by a zero profit condition, with all sellers being indifferent between maintaining their reputations and cheating. In equilibrium, buyers expect established sellers to provide the high quality with a higher probability and remain indifferent between different offers despite price differences. Then, buyers' decision to continue with established sellers is sufficient to guarantee that a high quality equilibrium is maintained.

Notes

[1]By "exogenous" entry costs we mean all nonsalvageable costs of setup and information provision, including signalling costs when adverse selection among sellers à la Kihlstrom and Riordan (1984) and Milgrom and Roberts (1986) is a possibility. While many categories of such costs may be endogenously determined in the market, they are exogenous to the moral hazard problem. All such costs are, of course, barriers to entry, but they may not be large enough to help the seller moral hazard be overcome.

[2]In fact, under this alternative assumption, the sufficient condition for the existence of a high quality equilibrium is much weaker than the one derived in this paper. Instead of condition (1), we would require $u_H \geq c_H + r(c_H - c_L) + \max[0, c_H - 2c_L]$. The difference between this condition and (1) is due to the reduction in the introductory bonus by c_L when the low quality product has to be produced.

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