Quality-Ensuring Profits

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In the reputation model of Klein & Leffler (1981) firms refrain from cutting quality or price because if they did they would forfeit future profits. Something similar can happen even in a static setting. First, if there exist some discerning consumers who can observe quality, firms wish to retain their purchases. Second, if all consumers can sometimes but not always spot flaws, firms do not want to lose the business of those who would spot them on a given visit. Third, if the law provides a penalty for fraud, but not one so high as to to make fraud unprofitable, firms may prefer selling high quality at high prices to low quality at high prices plus some chance of punishment.

Properties of the Klein-Leffler Model

1. Quality is high, even though it is cheaper to sell low quality and consumers cannot see quality at the time of purchase.

2. Price is above marginal cost.

3. Firms make positive profits even ex ante and with free entry.

4. The equilibria depends on expectations and can be strictly pareto- ranked.

The Model

Firms and consumers are atomistic, lying on the [0,1] interval.

First, the firms simultaneously choose qualities and prices. Second each consumer observes the prices, but not the qualities, and decides which one of the firms, if any, to visit.

Third, after visiting a firm, each consumer decides whether to buy one unit or not based on what he observes about quality and the government may intervene.

If the consumer does buy, the firm produces the unit and the consumer pays.

Finally, the firm pays the production cost, each consumer consumes what he has bought, and all consumers discover the quality of all firms.

This process is repeated an infinite number of times.

Payoffs

A firm pays $c = c_h$ per unit to produce high quality and $c = c_l$ to produce low quality, with $0 < c_l < c_h$.

Consumers value high quality at $v = v_h > c_h$ and low quality at $v = v_l = c_l$, so high quality is efficient.

Thus, the per-period payoff functions are, if a firm sells N units

$$Payoff(firm) = (p - c)N \tag{1}$$

and

$$Payoff(consumer) = \left| \begin{array}{ll} v - p & \text{if he buys} \\ 0 & \text{if he does not buy} \end{array} \right. \tag{2}$$

We will assume that all payments are made at the start of periods and that the discount rate is $r > 0$.

Special Assumptions

(A1) (Consumer Error) If the quality is low, then with probability $0 \leq \alpha < 1$ the consumer observes that fact– he "spots the flaw," but with probability $(1 - \alpha)$ he receives no information. If the quality is high, he receives no information.

(A2) (Informed and Uninformed Consumers) If a consumer is one of the fraction $0 \leq \beta < 1$ of consumers that are "discerning" he observes quality perfectly once he visit the seller.

(A3) (Weak Laws) If a firm tries to sell low quality as high, then with probability $0 \leq \gamma < 1$ independent of α and β the government interrupts the transaction and fines the seller amount F.

Assume: Government Punishment Is Low

Unless the expected government punishment γF is high enough for a fraudulent firm, there is no equilibrium in which quality is high and the price equals marginal cost. In such an equilibrium, $p = c_h$ and firms would earn zero profits. A firm could deviate to low quality and make positive profits, because its deviation payoff would be:

$$\pi_{firm}(low\ quality) = \theta(p - c_l) - \gamma F, \tag{3}$$

which is positive if γF is low enough, since $p = c_h$ and $\theta > 0$. We will assume that

$$\gamma F < \theta(c_h - c_l), \tag{4}$$

Lost Production Cost as a Punishment

Note that if we had assumed that the firm paid the production cost *before* the government detected and cancelled the fraudulent sale, and that the firm could not resell the product, then the payoff from low quality would be:

$$\pi_{firm}(low\ quality,\ ) = \theta(p - c_l) - \gamma F - \gamma c_l. \tag{5}$$

In effect, the lost production cost would be part of the punishment, and it would allow γF to take a lower value than the bound in inequality (4) and still deter low quality.

The Pessimistic Equilibrium

The Firm: The firm chooses its quality to be low and its price to be $p = c_l$.

The Consumer: A consumer visits any of the firms with the lowest price.
He buys if $p \leq v$ and he observes the quality.
He buys if $p \leq c_l$ if he does not observe the quality.

Consumer out-of-equilibrium beliefs: If $p > c_l$, quality is low.

The Optimistic Equilibrium

The Firm: In equilibrium, the firm chooses high quality and the price $p = p^*$, where if we define the probability of successfully completing a sale as: $\theta \equiv (1-\alpha)(1-\beta)(1-\gamma)$, then the price is:

$$p^* \equiv c_h + \frac{r\theta(c_h - c_l)}{1 + r - r\theta} - \frac{r\gamma F}{1 + r - r\theta}. \tag{6}$$

If the firm has ever deviated to low quality or to $p < p^*$ in the past, it chooses low quality and $p = c_l$.

The Consumer: The consumer never visits a firm that has produced low quality or charged $p \neq p^*$ in the past. Of the remaining firms, he visits the firm with the lowest price such that $p \geq p^*$, or no firm if all prices are less than p^*. If he observes the quality, he buys if $p \leq v$. If he does not observe the quality, he buys if $p \in [p^*, v_h]$.

Consumer out-of-equilibrium beliefs: If $p < p^*$, the consumer believes that the quality is low. If $p > p^*$, he believes that the quality is high.

The Quality-Ensuring Price

If the price is p, then in equilibrium a firm will receive a profit of $(p - c_h)$ immediately and at the start of each future period. This is equivalent to an undiscounted $(p - c_h)$ plus an immediate gift of a perpetuity of $(p - c_h)$ per period, so

$$\pi_{firm}(high\ quality) = (p - c_h) + \frac{p - c_h}{r}. \tag{7}$$

A firm's expected payoff per customer is a one-time payoff of $(p - c_l)$ if it gets away with fraud, which has probability θ, minus the expected government punishment, which is γF:

$$\pi_{firm}(low\ quality) = \theta(p - c_l) - \gamma F. \tag{8}$$

Thus, the firm is willing to produce high quality if

$$(p - c_h) + \frac{p - c_h}{r} = \theta(p - c_l) - \gamma F. \tag{9}$$

Solving equation (9) for p yields the value of p^* in equation (6) above.

Rent Dissipation

It is possible, as Klein and Leffer suggested, but not essential, to add some feature of rent-dissipating competition to the model, in which case the optimistic equilibrium becomes less efficient but still better than the pessimistic equilibrium.

E.g.: Fixed entry fee, free entry with optmistic expectations

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Proposition 1: Comparative Statics

Proposition 1: The quality-ensuring price p^* falls in the probability of spotting a flaw α, the fraction of discerning customers β, and the government punishment's probability γ and size F . It rises in the discount rate r.

$$p^* = c_h + \frac{r\theta(c_h - c_l)}{1 + r - r\theta} - \frac{r\gamma F}{1 + r - r\theta}. \tag{10}$$

Proposition 2: No Last-Period Problem

Proposition 2: Even in a one-period model, for big enough consumer reservation value v_h any one of assumptions A1, A2, and A3 yields an optimistic equilibrium in which quality is high and the equilibrium price is some p^* exceeding marginal cost.

Now the payoffs from high and low quality become

$$\pi_{firm}(high\ quality) = (p - c_h) + 0 \tag{11}$$

and, just as before,

$$\pi_{firm}(low\ quality) = \theta(p - c_l) - \gamma F. \tag{12}$$

Solving for p^*, these two payoffs are equal when

$$p^* = c_h + \frac{\theta(c_h - c_l)}{1 - \theta} - \frac{\gamma F}{1 - \theta}. \tag{13}$$

Thus, the temptation to produce low quality can be overcome.

Static Version 1: The Flaw Detection Model

(A1) A Probability of Flaw Detection. If the quality is low, then with probability $0 \leq \alpha < 1$ the consumer observes that fact– he "spots the flaw." If the quality is high, he receives no information.

One might think that if all consumers can spot a flaw in a product with high probability, competitive forces would lead to an equilibrium with price equal to marginal cost.

The mistake in that reasoning is that when price equals marginal cost and marginal cost is constant, profits are zero and lost sales volume is no disincentive.

In the pessimistic equilibrium, firms produce low quality at a low price, and consumers believe that any firm which deviates to a high price will produce low quality nonetheless.

Multiple Optimistic Equilibria

The single-period equilibrium is unique if and only if $p^* > v_h$, in which case only the pessimistic equilibrium survives. If flaws are so infrequently spotted that the quality-maintaining profit margin becomes too high, consumers switch to preferring low quality at a low price, even though high quality remains socially efficient.

Otherwise, a continuum of other optimisic equilibria with prices in the range $p' \in [p^*, v_h]$ exists.

High Price Equilibria Are Implausible

The equilibria with $p' > p^*$ lack plausibility.

The Cho-Kreps Intuitive Criterion doesn't eliminate them. Both types would benefit from belief-changing deviation.

But once a firm charges p^*, it has incentive to produce high quality. Otherwise it loses flaw-spotting consumers.

Formally, one way to exclude the implausible optimistic equilibria with $p' > p^*$ would be to allow firms to revise their quality choice after they make their price public.

Static Variant 2: The Discerning Consumers Model

(A2) The Discerning Consumers Model. If a consumer is one of a fraction $0 \leq \beta < 1$ of consumers who are "discerning" he observes quality perfectly once he visit the seller.

The discerning-consumers model differs in one important respect from the flaw-spotting model: besides the pessimistic and optimistic equilibria described already, it has an additional category of equilibrium, one which exists even if $p^* > v_h$ and the optimistic equilibrium is infeasible.

Three Classes of Equilibrium

Class 1: Pessimistic Equilibria $p = c_l$ and quality is low. Consumers are pessimistic and believe that quality is low regardless of what prices they see.

Class 2: Optimistic Equilibria. $p \in [p^*, v_h]$ and quality is high.

$$p^* = c_h + \frac{(1-\beta)(c_h - c_l)}{\beta}. \tag{14}$$

Class 3: Mixed-strategy Equilibria. Firms charge $\hat{p}$ with $\hat{p} > c_h$ and $\hat{p} \leq p^*$. They produce high quality with probability ϕ. Undiscerning consumers stay home with probability $(1-\mu)$. They visit a random store charging $\hat{p}$ and buy from it with probability μ, so the fraction of consumers who visit firms who are discerning is

$$d = \frac{\beta}{\beta + (1-\beta)\mu} > \beta. \tag{15}$$

Out-of-equilibrium consumer belief: any firm charging more or less than $\hat{p}$ has low quality.

A Curious Feature of the Mixed-Strategy Equilibrium

Firms charge some single $p \in (c_h, p^*)$ and mix over quality; undiscerning consumers mix over whether to shop.

The mixed-strategy equilibria are discontinuously different from the optimistic equilibrium.

Suppose $p = p^* - \epsilon$. The firm would cut quality and sell only to the low- quality consumers. The mixed-strategy equilibria works by having some undiscerning consumers refrain from buying, which by increasing the percentage of discerning consumers in the buying population allows the quality-ensuring price to fall.

Since undiscerning consumers are earning strictly positive consumer surplus in the optimistic equilibrium, to induce them to not buy with only a slightly lower price requires a discontinuously greater probability of low quality.

Existence Even when the Reservation Value Is Low

If $p^* > v_h$, the optimistic equilibrium does not exist, but the mixed-strategy equilibria do.

The fraction of undiscerning buying consumers becomes endogenous and falls to as low as necessary to support an equilibrium.

Tirole (1988) shows this in the monopoly context.

Robustness of the Mixed-Strategy Equilibrium

If $p^* < v_h$, both the optimistic equilibrium and the mixed- strategy equilibria exist as perfect bayesian equilibria.

The argument I made earlier against the optimistic equilibria with $p > p^*$ was that they depended critically on out-of-equilibrium beliefs and on whether the firm was able to choose quality after price or not.

The high-price equilibria were fragile because both a firm and consumers would be willing to deviate to a $p = p^*$ equilibrium if they believed the other would be following it.

Does that apply here? Maybe.

Payoffs in the Pure and Mixed-Strategy Equilibria

Undiscerning consumers like the pure-strategy equilibrium with $p = p^*$ and high quality– their payoff is positive. In the mixed-strategy equilibrium their payoff is zero.

Firms like the pure-strategy equilibrium better too. Compare with the mixed-strategy eq. payoff from high quality, $p \in (c_h, p^*)$. With p^*, the firms have a higher price AND higher quantity.

Discerning consumers have positive payoffs in both equilibria. They like the lower prices of the mixed-strategy equilibria, but then quality might be low and they wouldn't buy, for ex post payoff of zero.

Discerning Consumers

Discerning consumers have positive payoffs in both equilibria. They like the lower prices of the mixed-strategy equilibria, but then quality might be low and they wouldn't buy, for ex post payoff of zero. Their expected payoff is:

$$\pi_{discerning}(p) = \gamma(v_h - p) = \left(\frac{p - v_l}{v_h - v_l}\right)(v_h - p) = \frac{pv_h - v_l v_h + v_l p - p^2}{v_h - v_l}, \tag{16}$$

Their preferred price (given the price-quality tradeoff) and payoff is:

$$\tilde{p} = \frac{v_h + v_l}{2} \qquad \pi_{discerning}(\tilde{p}) = \frac{v_h - v_l}{4} \tag{17}$$

The discerning consumer's pure-strategy payoff is

$$\pi_{discerning}(p^*) \quad = v_h - p^* = v_h - c_h - \tfrac{(c_h - c_l)(1-\beta)}{\beta} \tag{18}$$

If c_h is small, they prefer the mixed-strategy equilibrium, otherwise, the pure-strategy.

Static Variant 3: The Weak Law Model

(A3) The Weak Law Model: A Small Probability of Punishment by the Government. If a firm tries to sell low quality as high, then with probability $0 \leq \gamma \leq 1$ independent of α and β the government interrupts the transaction and fines the seller amount F.

In the optimistic equilibrium,

$$p^* = c_h + \frac{(1-\gamma)(c_h - c_l)}{\gamma} - F. \tag{19}$$

A consumer randomly chooses a firm charging $p = p^*$ and buys the product. Out of equilibrium, we postulate that the consumer believes that prices below p^* imply low quality and prices above p^* imply high quality.

The Importance of Forfeiting Profits

Consider the alternative assumption A3′:

(A3′) If a firm tries to sell low quality as high, then with probability $0 \leq \gamma \leq 1$ independent of α and β the government fines the seller amount F. The firm is allowed to keep its profit from the transaction.

It remains true under Assumption (A3′) that a large enough penalty F will deter fraud, and that $\gamma > 0$ is needed for the penalty to have any effect. If F is even slightly too small to deter fraud, however, the equilibrium moves from the first-best of no fraud and high quality to the pessimistic equilibrium.