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Quality Control in the Service Firm and Consumer Learning

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Introduction

Quality control in the management of service firms has been discussed extensively, but subjected to little formal modeling. Several authors have stressed the unique importance of quality for the service firm. For example, Normann (1984, p. 105) states that "the cost of inconsistent quality and the value of . . . consistent quality are . . . of burning interest in the world of management today;" and Shaw (1978, p. 6) notes that "lasting competitive success . . . lies in . . . deliver[ing] quality services."

In virtually every industry, quality matters to customers, and their choice among vendors depends on an assessment of quality, even (perhaps especially!) in the absence of the ability to make prepurchase observations. The intangibility of the service purchase puts the service customer at risk in every transaction, placing a special burden on the marketing strategy of service firms to reduce that risk, to make it easier for the customer to buy its service rather than that of its competitors. This might explain why service firm managers seem to be obsessed with quality control; in many industries, the customers' belief that a particular firm will deliver high-quality service is the principal competitive advantage the firm possesses. The service firm's market strategy will stand or fall on its ability to assure quality *and its customers' beliefs about that quality*.

A service firm's ability to command a premium price in its markets may depend critically on the beliefs that its potential customers hold regarding its ability and willingness to provide consistent quality. How can the firm help shape those beliefs? Clearly, advertising can play a role in informing the market of the intentions of the firm. But ultimately, only one way exists for a firm to convince customers it provides high quality, it must establish a high-quality track record with that customer and with those to whom he or she talks. In other words, the firm's *reputation* in the minds of customers depends on the firm's past performance.

It is useful to view the reputation of a firm as an asset, just as the more traditional manufacturing firm views its plant and equipment. Because reputation is intangible, its value does not show up on the balance sheet. But in economic terms, it may be far more important than the physical assets of the service firm, likely to be minimal. Like any asset, reputation must be carefully maintained; for the service firm, stringent quality control is the long-run investment needed to maintain the firm's quality reputation.

Nelson (1970) referred to goods consumers must actually use to assess their quality, like services, as *experience* goods. Recently, a number of articles have appeared in the economics literature on reputation. In the context of rational choice models, customers will pay a premium for firms with reputations for producing high quality, and the fear of losing future profits from this premium price may dissuade firms from cheating on quality (see, for example, Klein and Leffler (1981), Shapiro (1982, 1983), Dybvig and Spatt (1983), Rogerson (1983), and Allen (1984)).

However, this literature presumes that the quality of the firm's delivered service is perfectly correlated with its input choices. In other words, if a firm has good people, trains them well, and buys the best equipment, then it produces high quality service 100 percent of the time. In fact, even the best-run service firms produce lemons from time to time, and even poorly run firms can have moments of glory. Quality control is never perfect, no matter how much effort is devoted to it. Adding noise to a reputation model would seem to be a trivial generalization. At first blush, it would be expected that the product of a firm delivering high quality only 90 percent of the time to be worth roughly 90 percent of the value of the product of a firm that had perfect quality control, and it could overcome its disadvantage by reducing its price.

In Allen and Faulhaber (1988) a model was investigated with a monopoly firm that was not able to perfectly control its quality. This chapter extends the model to consider competitive markets in which firms likewise cannot perfectly control their quality. The market for high quality may not be sustainable in the presence of such noise. Because customers cannot observe the quality of a firm's inputs, such as human capital (assumed to be fixed and sunk), they must infer this quality from observed outputs. In market equilibrium, customers' initial beliefs about the quality of the firm's inputs are determined by what they (correctly) predict to be the firm's strategy; observations of the output lead them to revise these beliefs, according to Bayes' law.

In keeping with modern microeconomic theory, the model assumes fully rational customers and firms, in which each type of agent maximizes value by making use of all information available, including their knowledge of the structure of the model. The model is characterized by information asymmetry; customers do not know the quality of the firm's inputs although the firm does. Of course, all firms would be willing to claim their inputs are good, but customers do not find "cheap talk" credible. In this model, advertising does not pay. Customers base their beliefs about firms on experience via Bayesian learning. Buyers can predict the strategies that the firm will adopt to maximize profit, and the firm can predict the beliefs of customers, conditional on the firm's output quality, and therefore customers' willingness to pay. The model might best describe markets for business services in which both buyers and sellers are sophisticated market players.

In the second section, the analysis is extended in Allen and Faulhaber (1988) and shown that for competitive market structures, the market for high quality may collapse with even a small amount of noise. Because consumers cannot observe the quality of firms' inputs, they must infer this quality from observed outputs. Thus are firms' reputations established. If input quality is perfectly correlated with output quality, then a single observation suffices for consumers to deduce input quality. However, with quality noise, the consumers' decision problem is Bayesian. The authors require consumers to have consistent conjectures, so that in equilibrium their prior distribution of input quality is correct.

In brief, this result follows from the fact that if consumers are sure that firms will produce high quality, then it pays for the firms to "cheat" and produce low quality because Bayesian learning will be slow (or zero). Consumers know that optimistic beliefs invite deception. Hence, the only consistent conjecture is that all firms will produce low quality. This offers a possible explanation for the emphasis placed by firm managers on the quality control issue and may also explain the puzzling absence of markets for high quality good in situations where both the demand and the potential for market supply seem to be present.[1]

To clarify the exposition, a model is presented in which firms purchase an input (a machine or an education) with one of two quality levels (good or bad); a good machine costs more than a bad machine. The input is sunk for two periods, and in each period will produce either high- or low-quality output, with high-quality output more highly valued by consumers than low-quality output. Good machines produce high-quality output with higher probability than bad machines. The analysis presented in this chapter is limited to two input quality levels, two output quality levels, and two periods. However, it is important to note all results are obtained in a model with a continuum of input quality levels, a continuum of output quality levels, and any number of periods. The generalizations are straightforward (though lengthy) and are omitted from the chapter.

In the third section, the model is extended to include firms' imperfectly choosing inputs, either because the choice process is subject to error or because of quality noise in the upstream production of machines. This extension softens the stark results of the second section, but leads to the paradoxical result that the fewer incompetent firms there are, the more likely it is that a given level of quality noise in production will lead to high-quality market collapse. The fourth section contains concluding remarks.

The Model

First considered are firms that each purchase a machine that will produce output (normalized to one unit) in each of two subsequent periods, at zero marginal cost. A firm can choose either a good machine at a cost c_G or a bad machine at a cost of c_B, with $c_G > c_B$. Both good and bad machines can produce high-quality output, but good machines yield high quality with probability π_G, and bad machines yield high quality with probability π_B with $\pi_G > \pi_B$. Firms are risk neutral and maximize expected profits, discounting second period receipts by the factor δ.

Consumers are (homogeneous) price-takers and expected utility maximizers; they value high quality output at v_H, and low quality output at v_L, with $v_H > v_L$. They know both π_G and π_B, so they are willing to pay

$$w_i = \pi_i v_H + (1-\pi_i)v_L \tag{1}$$

for the output of a machine they know to be of type i.

It is Pareto optimal for the firm to buy a good machine if the total value of a good machine exceeds both zero and the total value of the bad machine; that is,

$$(1+\delta)\, w_G - c_G > 0, \tag{2}$$

$$(1+\delta)\,(w_G - w_B) > c_G - c_B. \tag{3}$$

It is assumed throughout that these inequalities are satisfied.

In general, consumers may not know the firm's machine type, but they do know the level of quality noise: $1 \geq \pi_G > \pi_B \geq 0$. If these inequalities are strict, consumers cannot tell for sure whether the firm's machine is good or bad, even after observing the first period's output.[2] Consumers have a prior probability r_0 that the firm's machine is good. Using Bayes' rule, consumers' posterior probability that the machine is good, having observed a high quality output, can be expressed as:

$$r_H = \frac{r_0\pi_G}{r_0\pi_G + (1-r_{0)}\pi_B}, \tag{4}$$

and the probability that the machine is good, having observed a low quality output,[3] as:

$$r_L = \frac{r_0(1-\pi_G)}{r_0(1-\pi_G + (1-r_0)(1-\pi_B)}. \tag{5}$$

Consumers' willingness to pay for the output of a machine in the first period (j = 0), or the second period, given that outcome j = H,L was observed, is

$$W_j(r_0) = r_j w_G + (1-r_j)w_B, \qquad j = 0,H,L. \tag{6}$$

Rational expectations are assumed: consumers and firms both know the structure of the model. In equilibrium their expectations must be correct given this knowledge.

The authors assume that firms as well as consumers are price-takers. Each firm buys one (and only one) machine, so supply changes occur through entry/exit, not expansion of existing firms. Because firms are capacity constrained, price can exceed marginal cost in equilibrium. Firms enter or exit if expected profits at market prices are positive or negative, respectively; so in equilibrium, expected profits are zero. Machines (and hence firms) last two periods; previous market growth ensures that in any period new firms coexist with firms with high-quality and low-quality records. In equilibrium, relative prices must be such that consumers are indifferent among these three types of firms. Denoting first period price as p, and second period price, conditional on the outcome j = H,L of the first period's production, as p_j, relative prices must satisfy

$$W(r_0) - p = W_H(r) - p_H = W_L(r) - p_L, \tag{7}$$

so that relative prices depend on consumers' beliefs about firms' quality r_0.

Expected profits for the firm from a machine of type i are

$$EZ_i(r_0) = p(r_0) + \delta\{\pi_i p_H(r_0) + (1-\pi_i)p_L(r_0)\} - c_i. \tag{8}$$

Equation (8) is written to show the explicit dependence of expected profits on the consumers' prior r_0.

The zero profit competitive equilibrium condition is

$$\max_{i=G,B} EZ_i(r_0) = 0. \tag{9}$$

The equilibrium prices are determined from equations (7) and (9) as functions of r_0.

Firms will install a good machine if and only if

$$\Delta EZ(r_0) = EZ_G - EZ_B > 0 \; . \qquad (10)$$

Clearly, the choice of machine affects profits only insofar as it affects the likelihood of a high quality output in the first period, and thus a higher price in the second period.

Three cases are considered.

1. Firms' machine types are observable, that is, the baseline case of complete information.
2. Firms' machine types are not observable, and $\pi_B = 0$, $\pi_G = 1$, that is, information asymmetry but no quality noise.
3. Firms' machine types are not observable, and $0 < \pi_B < \pi_G < 1$, that is, information asymmetry and quality noise.

In case 1, the firm can control r_0 because its machine type can be observed by the consumer. Thus, r_0 is either zero or one, depending on whether the firm installs a good or bad machine. From (4) and (5), it can be seen that $r_H = r_L = r_0$, so that the consumer has no need of further information. In this case, condition (10) is identical to (3), and the firm will always install a good machine: the first-best outcome is always achieved.

In case 2, it is noted from (4) and (5) that $r_H = r_L = 0$ independent of r_0,[4] which expresses the "no noise" assumption that a single observation of output suffices to establish quality. Hence, second period prices p_H and p_L are also independent of the consumers' prior r_0, and therefore so is condition (9). Both consumers as well as firms will know whether or not (9) obtains; good machnes are either profitable or not. Therefore, the only two possible consistent consumer priors are $r_0 = 0$ and $r_0 = 1$. Without consumer observability of the firm's machine type, the firm cannot affect consumers' priors; in evaluating (9), the firm takes r_0 as independent of its choice of machine type. In this case, the firm installs a good machine if and only if

$$\Delta EZ = \delta(v_H - v_L) - (c_G - c_B) \geqslant 0 \qquad (11)$$

(assuming that if the firm is indifferent, it chooses a good machine). If this incentive compatibility condition obtains, the first-best outcome is achieved. However, if it is not met, then the firm will not install a good machine because a bad machine is more profitable. Thus, the firm will install a bad machine if it is profitable to do so ($(1+\delta)v_L > c_B$), and otherwise will install no machine. The result here is similar to Allen (1984), in which information asymmetries may or may not lead to an inefficiency, in contrast to Shapiro (1983), in which asymmetries always lead to an inefficiency.

In the most general situation, case 3, both consumers and firms know whether or not condition (10) obtains for any given r_0, and therefore whether the firm will install a good or bad machine. Again, the only consistent consumers' priors are $r_0 = 1$ and $r_0 = 0$. Evaluating condition (10) at these points, we have

$$\Delta EZ(0) = \Delta EZ(1) = -(c_G - c_B) < 0 \; . \qquad (12)$$

If consumers have the optimistic prior of $r_0 = 1$, then it is more profitable for the firm to install a bad machine, and hence this prior is not consistent. The only consistent prior is $r_0 = 0$.[5]

These results can be summarized as follows:

Proposition 1:

In a free-entry, zero-profit competitive market,

1. if machine types are observable, then firms always install good machines (case 1).
2. if machine types are not observable and if $\pi_B = 0$ and $\pi_G = 1$, then firms install good machines if and only if $\delta(v_H - v_L) > c_G - c_B$; otherwise, the firm installs a bad machine if profitable at a competitive $p \leqslant w_B$, and no machine if not (case 2).
3. if $0 < \pi_B < \pi_G < 1$, then firms never install good machines; they install bad machines if profitable at a competitive $p \leqslant w_B$, and no machine if not (case 3).

A comparison of parts 1, 2, and 3 of Proposition 1 shows the sharp discontinuity in the equilibrium outcome as a result of introducing even the smallest amount of quality noise. This rather surprising collapse of high quality equilibria with less than perfect quality control is suggestive of a moral hazard version of Akerlof's (1970) lemons market. The reason for the part 3 result is that consumers' ability to deduce from the model firms' optimal behavior leads them to have these extreme priors, which in turn leads them to ignore learning. No track record could be so poor as to discourage the optimistic consumer, and no track record could be so outstanding as to impress the jaded skeptic. Consumers know, as do firms, that optimism invites deception. They thus choose the skeptic's role, and firms find it optimal to fulfill their expectations. Because all real production processes involved some measure of quality noise, this result suggests that this "optimism invites deception" problem may be at the base of managers' concerns about quality control, quoted in the introduction.

This discontinuity result seems too strong. Though the concerns of managers regarding quality consistency suggest strong forces at work, intuition says that high-quality producers do exist in many markets. The next section introduces yet more randomness into the model, softening the strong discontinuity result and still explaining potential market failures and real firms' concern for quality control.

Imperfect Input Selection

The analysis of the previous section assumed that all firms are identical, have access to the same technology, and are able to choose which type of machine to install. Once installed, the machines are subject to quality noise; but firms are assumed to make their input choice faultlessly. Clearly, this assumption is neither realistic nor in keeping with the spirit of this chapter. This section introduces noise into the input selection process and analyzes the effects on the equilibrium outcomes. Several possible sources of input selection noise exist.

1. There may be quality noise in the upstream production of machines; even if the firm buys its machine from a reputable machine firm, it may still be a "lemon."
2. The internal process by which firms choose machines may be inherently noisy.

In either case, it is assumed that the fraction λ of firms intending to buy a good machine will end up with a good machine, $0 < \lambda < 1$,[6] and the fraction $1 - \lambda$ of such firms will end up with a bad machine. Both firms and consumers know λ.

A firm's expected profits from installing what it hopes is a good machine are

$$EZ_{\lambda G} = p + \delta\lambda\{\pi_G p_H + (1-\pi_G)p_L\} + \delta(1-\lambda)\{\pi_B p_H + (1-\pi_B)p_L\} - c_G \quad (13)$$

and expected profits from installing a bad (for sure) machine are

$$EZ_{\lambda B} = p + \delta\{\pi_B p_H + (1-\pi_B)p_L\} . \quad (14)$$

The zero profit condition is

$$\max_{i=G,B} EZ_{\lambda i}(r_0) = 0 , \quad (15)$$

which, combined with (7) determine equilibrium prices.

Subtracting (14) from (13), and using (6) and (7), to obtain

$$\Delta EZ_\lambda(r_0) = \delta\lambda(\pi_G - \pi_B)(r_H - r_L)(w_G - w_B) - (c_G - c_B) . \quad (16)$$

As before, if r_0 is zero or one, then $p_H = p_L$, and the expected difference in profits from installing a good machine is the negative of the cost difference of the two machine types, as in (12). However, interest now turns to the behavior of $\Delta EZ_\lambda(r_0)$ between these two extremes. Using (7) and (9) it can be shown that $d^2\Delta EZ_\lambda/dr_0^2 < 0$, so that $\Delta EZ_\lambda(r_0)$ is a concave function of r_0. The example in figure 19–1 shows a situation in which $\Delta EZ_\lambda < 0$ for $r^* < r_0 < r^{**}$. It is also possible that for all r_0, $\Delta EZ_\lambda < 0$.

Because consumers as well as firms know λ, the only consistent priors are $r_0 = 0$ (if consumers believe firms will choose a bad machine) and $r_0 = \lambda$ (if consumers believe firms will try to install a good machine and will be successful with probability λ). Because $\Delta EZ_\lambda(0) < 0$ for all λ a consistent equilibrium always exists in which the firm installs a bad machine if profitable and no machine if not. If $\Delta EZ_\lambda(\lambda) < 0$, no other equilibrium exists. However, if $\Delta EZ_\lambda(\lambda) \geq 0$, then λ is a consistent prior, and an equilibrium exists in which the firm intends to install good machines and is successful with probability λ. This good machine equilibrium Pareto dominates the bad machine equilibrium because (1) consumers prefer the case in which firms attempt to buy good machines (generalizing (3) to $(1+\delta)\lambda(w_G - w_B) > c_G - c_B$), and (2) firms are indifferent because they earn zero profits in either equilibrium.

These results can be summarized as follows.

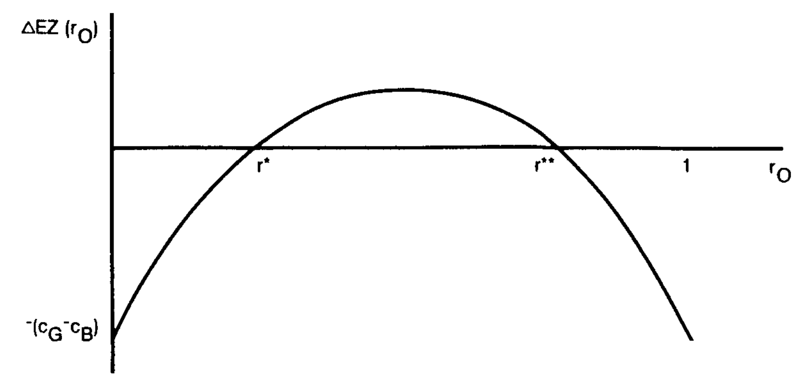

Figure 19–1. Expected profits for a good machine conditional on consumers' expectations.

Proposition 2:

In a free entry zero profit competitive market, if firms who intend to install good machines are successful with probability λ, then

1. an equilibrium exists in which no firm intends to install good machines.
2. an equilibrium exists in which all firms intend to install good machines, if and only if $\Delta EZ_\lambda(\lambda) \geqslant 0$. This equilibrium Pareto dominates the equilibrium of part 1.

Comparing Propositions 1 and 2 reveals that accounting for noise in the input selection process allows the possibility of a high quality equilibrium, even with quality noise in the production process. Introducing an additional source of noise has reestablished the good machine equilibrium. However, Proposition 2 is a paradoxical result: only if enough bad machines are chosen will a high quality equilibrium be sustainable in the presence of quality noise. Only the possibility of enough bad machines will ensure that there will be any good machines!

The intuition behind this result comes from the nature of the "optimism invites deception" result; if consumers are too optimistic ($r_0 = 1$), they know that firms will take advantage of that optimism and install bad machines. However, if consumers expect a certain number of firms to have bad machines (or equivalently, they expect that the monopoly firm will have a bad machine with a certain nonzero probability). Consumers are then sufficiently skeptical, so they do not fall into the "optimism invites deception" trap. Their prior is not so strong that they ignore the data, and thus they reward high quality in the first period with higher prices in the second period. It is this rational skepticism that permits high quality to be sustained.

A high quality equilibrium obtains under Proposition 2 if and only if $\lambda \in [r^*, r^{**}]$. It can be shown that higher π_G (better quality control) leads to higher r^{**}, and it is therefore more likely that the good machine equilibrium will obtain. This leads to

Proposition 3:

Given some exogenous $\lambda < 1$, a critical π_G exists such that $r^{**} = \lambda$; for $\pi_G < \pi_G$, the bad machine obtains, and for $\pi_G \geqslant \pi_G$, the good machine equilibrium obtains.

Profit consequences for the monopoly firm are shown in figure 19–2. Profits change discontinuously at the critical π_G, which suggests a reason for the concern of managers for quality consistency. A small change in the quality control level may lead to a large change in profits.

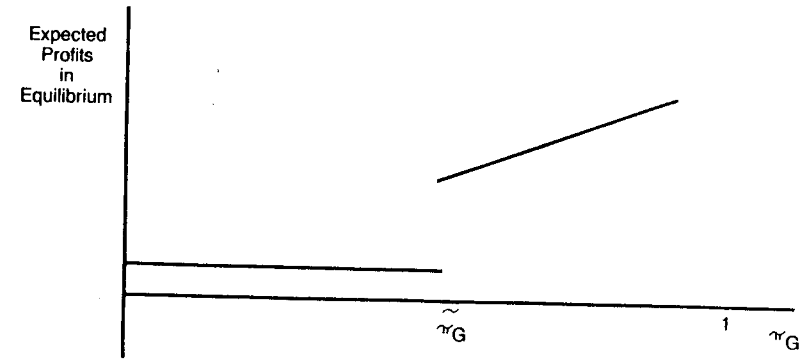

Figure 19–2. Expected profits as a function of quality control results.

Conclusion

Adding quality noise to the production process can drastically alter the nature of the equilibrium, as shown in the context of a simple reputation model. If every firm can choose without error the type of machine to install, then no good machine equilibria exist in the presence of any quality noise. A good machine equilibrium exists only if firms make imperfect input choices so that consumers are sufficiently skeptical for their priors to adjust rapidly in the light of firms' performance.

The results suggest that not all industries need be successful at sustaining a high-quality equilibrium. Examples were cited of markets in which both demand and supply conditions would appear to be ripe for a high-quality market, but none can be sustained.

Even those industries successful at sustaining a high-quality equilibrium have no guarantee of its permanence. An exogenous shift in either quality control or in input selection noise may destroy an existing high-quality (more profitable) equilibrium. The profit penalty from even small changes may be quite severe.

This chapter has illustrated the "optimism invites deception" result in the context of a simple model. However, it seems clear from the nature of the argument that the result is applicable in many other rational expectations models with learning.

Notes

1. One hundred percent of the authors' unscientific sample of two-career families with young children agree on the uniformly low quality of private for-hire day-

...re services, although non-profit day care, or day care bundled as part of employment, is reported to be superior. A more exotic, and more tragic, example is given in Rashid (1988). He describes the adulteration of milk, and consumers' correct expectations of adulteration, in Dacca, Bangladesh. Newspapers regularly publish photographs of farmers diluting milk with filthy canal water on their way to market, so consumers are well aware of the problem. However, no market for unadulterated (high quality) milk seems to be sustainable.

2. Another interpretation of this model is possible: the "noise" may be in consumers' ability to perceive the quality of output rather than in the firms' quality control. For example, a doctor with a high-quality education (a good "machine") may always deliver high-quality output to patients, but patients may make errors in judging the quality they receive.

3. It is assumed that each consumer sees a single draw from the Bernoulli distribution in the first period. This would be true if all units produced by the machine in a single period were of the same quality. A more realistic model would have each consumer experiencing a separate draw from the distribution and consumers sharing information, so that the first period would generate a sample size of $n > 1$. All the results would obtain for this model as well; we use the simpler approach to avoid unnecessary complexity.

4. This follows directly for $0 < r_0 < 1$. At $r_0 = 0$, equation (4) is of the form "0/0" and is undefined. However, taking the limit as $r_0 -> 0$, we have that $r_H -> 1$. Similarly, at $r_0 = 1$, equation (5) is undefined, but as $r_0 -> 1$, $r_L -> 0$.

5. There may exist other consistent priors; suppose that if good machines and bad machines are equally profitable firms choose a good machine with probability α, and suppose further that at $r_0 = \alpha$ good machines and bad machines actually are equally profitable; then $r_0 = \alpha$ is a consistent prior, and a mixed strategy equilibrium exists. In this chapter as in Allen and Faulhaber (1988) we focus on pure strategy equilibria.

6. If quality noise π^*_G in the upstream production process caused this selection error, then $\lambda = \pi^*_G$.

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