Product Quality with Information Dissemination and Switching Costs.

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Abstract

Klein & Leffler (1981) construct a model in which expected future prices exceed marginal cost so that sellers are willing to maintain high quality for the sake of future profits. How profits are dissipated under free entry, and whether there is a continuum of equilibria, are questions not fully resolved. I construct a formal model simpler than any now existing in which free entry and exogenous fixed costs uniquely determine the price of output and the amount sold per firm.

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1. Introduction

THIS PAPER WAS SHORTENED AND SUBMITTED TO ECONOMICS LETTERS, WHERE IT APPEARED WITH A MISTAKE IN THE DISCOUNTING. THE EL VERSION IS IN ANOTHER FILE, WHERE i HAVE FIXED UP THE DISCOUNTING.

2. The Basic Model.

Let there be n firms that are labelled "high-quality," and an infinite number of other firms that are labelled "low-quality." All firms are identical except for their labels. Each firm can produce either high quality, at a constant marginal cost of c_h, or low quality, at a constant marginal cost of c_l. Each firm chooses a price p and can sell up to its capacity of k. Price and quality are chosen in each of an infinite number of periods. The discount rate is $r > 0$. There is a continuum of identical consumers. Each period a consumer picks one firm from which to buy. His demand is $q(p)$ if he believes the product is low-quality, and $\alpha q(p)$ if he believes it is high quality.[1] A consumer observes the quality of products produced in the past by every firm, but not the quality of the product he is currently buying.

The Folk Theorem tells us that this game has a wide range of perfect outcomes, including a large number with erratic quality patterns like (*High, High, Low, High, Low, Low*...). If we confine ourselves to pure strategy equilibria with the stationary outcome of constant quality and identical behavior by all firms in the market, then the two outcomes are low quality and high quality. Low quality is always an equilibrium outcome, since it is an equilibrium of the one-shot game. If the discount rate is low enough, high quality is also an equilibrium outcome, and this will be the focus of our attention. Consider the following strategy combination:

Firms. Each firm labelled "high-quality" produces high quality and sells at price $\tilde{p}. =$??? If a firm ever deviates from this, it thereafter produces low quality and sells at price c_l. Each firm labelled "low-quality" produces low quality and sells it at price c_l.[2]

Buyers. Buyers start by choosing randomly among the high-labelled firms charging $\tilde{p}$. If they cannot be served at some such firm, they go to a low-labelled firm. Thereafter, they remain with their initial firm unless it changes its price or quality, in which case they switch randomly to a high-labelled firm that has not changed its price or quality.

This strategy combination is a perfect equilibrium. Each firm is willing to produce high quality and refrain from price-cutting because otherwise it would lose all its customers. If it has deviated, it is willing to produce low quality because the quality is unimportant, given the absence of customers. Buyers stay away from a firm that has produced low quality because they know it will continue to do so, and they stay away from a firm that has cut the price because they know it will produce low quality. For this story to work, however, the equilibrium must satisfy

[1] xxx Iw ill need a conditon on α.

[2] xxx This strategy is weakly dominaed for lwo-labelld firms by producing low quality and offering it at the high price. But this is another exmple of how friction sar e useufl to markets: if there is any production that has to be done, this selling zero strategy is bad.

three constraints: incentive compatibility, competition, and market clearing.

The incentive compatibility constraint says that the individual firm must be willing to produce high quality. Given the buyers' strategy, if the firm ever produces low quality it receives a one-time windfall profit, but loses its future profits. The tradeoff is represented by constraint (1), which is satisfied if the discount rate is low enough.

$$(\textbf{Incentive Compatibility}) \qquad q_i p \leq \frac{q_i(p-c)}{r}. \tag{1}$$

Inequality (4.2) determines a lower bound for the price, which must satisfy

$$\tilde{p} \geq \frac{c}{(1-r)}. \tag{2}$$

We could write (2) as an equality rather than an inequality because any firm trying to charge a price higher than the quality-guaranteeing $\tilde{p}$ would lose all its customers and receive a payoff of $-F$.

3. Trembles, Switching Costs, and Information Dissemination.

The Folk Theorem applies, but in the standard eq. firms pick high quality, and consumers switch away from the firm if it produces low by mistake. Let's assume that a firm can survive picking low quality; it just sells at a low price. Consumers live forever.

There is a little noise, so sometimes a firm that picks HI, picks LO by mistake. (Cite Boyd).

Baseline model. Consumers know all past qualities. No switching cost. Firms start with HIGH, which is more profitable. Then if a firm picks LOW by accident, it will always pick LOW thereafter, and get no customers. Eventually, all firms are LOW. (realistically,w ith upward sloping MC, the HIGH firms hit capacitya dn consuemrs go back to LOW.)

INFO: (1) Now let consumers forget all past qualities. No Switching cost. All firms always pick LOW.

(2) No swtiching cost. Some consumers know past qualtiies. Find key percentage. Now the firm will not pick LOW after it picks LOW once, because it wants to keep its fresh customers. NO— it will cheat on purpose if this is the case.Ah,no: it does lose something by cheating, because it loses a bunch of customers.

SWITHCING COST. All consuemrs know past records. (could also be thought of as that some customers are locked in, of old generation, but new custoemrs are arrivign).

(1) All have switching costs. Oops: we have high quality here because of the rational monopolist. No we dont: if consumers expect low quality, that is what they pay for and that is what they get. That may kill this paper. Even with moderate switching costs, if the firm accidentally produces low quality, it will continue to do so.

(2) Some have switching costs. We have high quality ehre even after a mistake, because it is costly to switch, adn some will stay. In fact, after one mistake, there is less temptation to cheat becaue the others will not leave.

4. An Endogenous Number of High-Quality Firms

$\tilde{n}$ firms enter.

The second constraint is that competition drives profits to zero, so firms are indifferent between entering and staying out of the market.

$$(\textbf{Competition}) \qquad \frac{q_i(p-c)}{r} = F. \tag{3}$$

Treating (4.3) as an equation and using it to replace p in equation (4.4), we obtain

$$q_i = \frac{F(1-r)}{c}. \tag{4}$$

We have now determined p and q_i, and only n remains, which is determined by the equality of supply and demand. The market does not always clear in models of asymmetric information (see Stiglitz [1987]), and in this model each firm would like to sell more than its equilibrium output at the equilibrium price, but the market output must equal the quantity demanded by the market.

$$(\textbf{Market Clearing}) \qquad nq_i = q(p). \tag{5}$$

Combining equations (4.3), (4.5), and (4.6) yields

$$\tilde{n} = \frac{cq(\frac{c}{(1-r)})}{F(1-r)}. \tag{6}$$

We have now determined the equilibrium values, the only difficulty being the standard existence problem caused by the requirement that the number of firms be an integer.

The equilibrium price is fixed because F is exogenous and demand is not perfectly inelastic, which pins down the size of firms. If there were no entry cost, but demand were still elastic, then the equilibrium price would still be the unique p that satisfied constraint (4.3), and the market quantity would be determined by $q(p)$, but F and q_i would be undetermined. If consumers believed that any firm which might possibly produce high quality paid an exogenous dissipation cost F, the result would be a continuum of equilibria. The firms' best response would be for $\tilde{n}$ of them to pay F and produce high quality at price $\tilde{p}$, where $\tilde{n}$ is determined by the zero profit condition as a function of F. Klein & Leffler note this indeterminacy and suggest that the profits might be dissipated by some sort of brand-specific capital. The history of the industry may also explain the number of firms. Schmalensee (1982) shows how a pioneering brand can retain a large market share because consumers are unwilling to investigate the quality of new brands.

Any of the usual assumptions to get around the integer problem could be used: allowing potential sellers to randomize between entering and staying out; assuming that for historical reasons n firms have already entered; or assuming that firms lie on a continuum and the fixed cost is a uniform density across firms that have entered.

The model has been made as simple as possible to illustrate the basis for reputation models of quality, but several extensions would be easy to include. The minimum quality could be greater than zero, its production could be costly, and consumers could be willing to pay more than zero for a low quality product.

The sunk entry cost F cannot be replaced by a fixed cost paid every period that a firm is in the market, because then either no firm can ever make zero profits (if $F > q_i(p-c)$), or it is too tempting to cut quality and take the one-time gain (if $F \leq q_i(p-c)$, because $q_i(p-c) < q_i p$).

Assuming that marginal costs are rising in quantity instead of constant would not change the model significantly. The same three equilibrium conditions would have to be solved for the same three unknowns, p, q_i, and n, but the diseconomies of scale would tend to increase n and p and decrease q_i. Note also that decreasing marginal cost is also compatible with equilibrium, because it merely intensifies the decreasing average cost already contained in the model.

The equilibrium price is fixed because F is exogenous and demand is not perfectly inelastic, which pins down the size of firms. If there is no entry cost, but demand is still elastic, then the equilibrium price is still the unique p that satisfies constraint (**??**), and the market quantity is determined by $q(p)$, but F and q_i are undetermined. A continuum of equilibria is possible in which consumers believe that any firm which might possibly produce high quality pays a dissipation cost F, where F is arbitrary and indexes the equilibrium. The firms' best response is for n of them to pay F and produce high quality at price p, where n is determined by the zero profit condition as a function of F. This version of the model is closer to Klein & Leffler (1981) and Rogerson (1987).

5. Game Theory and the Literature on Product Quality

This has not usually been considered as a game, but it is.

Consider a seller who can choose between producing costly high quality or costless low quality products, and a buyer who cannot determine quality before he purchases. If under symmetric information the seller would produce high quality, we have what might be called a "one-sided prisoner's dilemma." Both players are better off when the seller produces high quality and the buyer purchases it, but the seller's dominant strategy is to produce low quality and the buyer will not purchase. The difference from the conventional prisoner's dilemma is that not purchasing is only a Nash strategy for the buyer, not a dominant strategy. The equilibrium is nonetheless stronger than Nash: it is an iterated dominant strategy equilibrium because deletion of the dominated *High Quality* makes *Do Not Buy* dominant for the buyer. The ordinal rank of the payoffs is shown in Table 1.

Table 1: The One-Sided Prisoner's Dilemma.

		Buyer	
		Buy	Do Not Buy
Firm:	High Quality	1,1	0, 0
	Low Quality	2,-1	**0,0**

Payoffs to: (Firm, Consumer).

The situation may also be viewed as a principal agent model of moral hazard. The seller (an agent), takes the action of choosing an action (quality) that unobserved by the the buyer (the principal), but which affects the buyer's payoff. This interpretation is used in much of the Stiglitz (1987) survey of the links between quality and price.

Under either interpretation, a potential solution to the dilemma is to repeat the game, allowing the firm to choose quality at each repetition. If the number of repetitions is finite, however, the equilibrium outcome of low quality does not change, an example of the Chainstore Paradox (Selten [1978]). In the last repetition, the subgame is identical to the one-shot game, so the firm chooses low quality. In the second-to-last repetition, it is foreseen that the last period's outcome is independent of current actions, so the firm also chooses low quality. The argument can be carried back to the first repetition.

There are two main escapes from the Chainstore Paradox. One escape is incomplete information: in this context, the possibility that the seller is exogenously bound to produce high quality. We will not consider incomplete information here, but for its effect upon the Prisoner's Dilemma see Kreps, Milgrom, Roberts, & Wilson (1982) and Section 5 of Fudenberg & Maskin [1983]. The other escape is to specify that the model has infinite periods, so that the Chainstore Paradox fails to apply. The Folk Theorem (see Fudenberg & Maskin [1983], Rasmusen [1988]) says that a wide range of outcomes can be observed in the perfect equilibrium of an infinitely repeated game with sufficiently little discounting. The Folk Theorem is primarily a destructive result, saying that the infinite period model is so ill-specified that the modeller can generate any equilibrium he desires. More constructively, it tells us that in infinite period models we must go beyond satisfaction of the mere technical criterion of perfect Nash equilibrium and justify the equilibrium on intuitive grounds.

Klein & Leffler (1981), while not using the paradigm of game theory, in effect construct a plausible equilibrium for an infinite period model. Firms are willing to produce high quality products because they can sell them at a high price, but consumers refuse ever to buy again from a firm which has once produced low quality. The equilibrium price is high enough that the firm is unwilling to sacrifice its future profits for a one-time windfall from deceitfully producing low quality and selling it at a high price. Although this is only one of a large number of equilibria for the game, consumer behavior is rational, and it is simple enough to be intuitively plausible. The model does have the problem, however, that in equilibrium the seller makes positive profits, which cannot be the case in the competitive industry of identical firms that Klein & Leffler wish to model. They suggest that the profits might be dissipated in by brand-specific capital, without being very clear about how that happens.

A related paper is Shapiro (1983), which more formally looks at the same problem as Klein & Leffler. Shapiro reconciles a high price with free entry by requiring that firms build up a reputation by pricing under cost during the early periods of production. Shapiro says that in his model consumers do not have fully rational beliefs because they do not believe that a firm will produce high quality until the firm has done so at a loss for several periods. In accordance with the Folk Theorem, however, these beliefs actually are rational for some equilibria of the infinite period model used. If consumers believe, for example, that any firm charging a high price for any of the first five periods has produced a low quality product, but any firm charging a high price thereafter has produced high quality, then provided that the high price is high enough, firms will behave accordingly and the consumer beliefs are confirmed. That beliefs are self-confirming hardly makes them irrational; it only means that different beliefs are rational in different equilibria.

A source of awkwardness for both Klein & Leffler and Shapiro is their assumption that market demand is perfectly inelastic. As Rogerson (1987) notes, inelastic demand generates a continuum of even the limited classes of equilibria that they consider, each equilibrium consisting of a different price and dissipation cost (for Klein & Leffler) or reputation-building cost (for Shapiro). Rogerson constructs a new model of inelastic market demand with the aim of justifying a unique level of advertising that is not directly productive but dissipates quality-inducing profits. My model resolves the problem more simply, by making market demand elastic and specifying an entry cost for new firms.

6. Concluding Remarks

Not written yet.

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