Can High Prices Ensure Product Quality When Buyers Do Not Know the Sellers' Cost?

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Abstract

The Klein-Leffler (1981) model of product quality does not explain why high-quality firms would dissipate the rents they earn from quality-assuring price premia, and it relies on consumers knowing the cost functions of firms. In the present paper, consumers do not know any firm's cost of producing quality goods, so high-quality firms must engage in conspicuous spending to demonstrate they earn a profitable mark-up over cost. Complete rent dissipation occurs only when high and low cost firms have the same cost of producing low quality.

I. The Klein-Leffler Model and Profit Dissipation

Introduction

When consumers are unaware of product quality before they buy, producers can nonetheless be punished for providing low quality by losing repeat business. Benjamin Klein and Keith Leffler (1981) demonstrate that, under fairly general conditions, a price greater than the competitive, zero-profit price will induce producers to deliver the promised quality level. At the zero-profit price, the profit from low quality exceeds the profit from high quality, even if no customers return. If a firm's price equals its average cost, repeat business is a matter of indifference. A higher price, however, increases long-run profit more for firms that provide the promised quality than for firms with lower quality because repeat business does then generate positive profits. At a sufficiently high price, the profit from not shirking on quality will exceed the profit from shirking. At that price, firms will provide the promised quality level.[1]

Two points are of interest in the Klein-Leffler (henceforth K&L) model. First, positive profit apparently exists in a competitive market. K&L assert that all such profit will be

[1] Rasmusen (1994, pp.131-134) contains a game-theoretic approach to the Klein-Leffler model and notes the similarity of a quality-assuring price and an efficiency wage.

competed away as firms invest in firm-specific capital expenditures, but we will cast doubt on that below. Second, because consumers believe a high price gives firms an incentive to produce high quality only if such a price generates a sufficiently high profit, for a price premium to ensure high quality, consumers must know firms' production cost.

In this paper, we address both points. We argue there is no incentive for firms to compete via capital expenditures in the K&L model. Positive profit will indeed persist in equilibrium, even with free entry. Also, while the K&L model assumes producers have identical costs, though they can choose different quality levels each period, we will add the possibility firms do not have the same marginal cost of producing quality and buyers have incomplete information regarding firms' costs. Thus, we will combine moral hazard and adverse selection in a product quality model.

We will show that a price premium is necessary for any firm to produce high quality with either complete or incomplete information. Under complete information, capital spending is neither necessary nor of any value to firms since it neither has a direct benefit nor signals hidden information. Under incomplete information, capital spending may be required for low cost firms to signal their cost since consumers can not observe

the mark up of price over marginal cost and use it to deduce a firm's profitability.

In the rest of this section, we consider profit dissipation in the K&L model. In Section II, we introduce a simple model of quality uncertainty with moral hazard and adverse selection. Further elaboration and concluding comments are in Section III.

Profit dissipation

In the K&L model, a price, P*, above average cost, P_C, is necessary to induce firms to deliver the high level of quality they promise to consumers. Entry cannot eliminate the resulting profit since additional output will drive price below the quality-assuring level of P*. This is a surprising result: an industry known to be earning positive profit, without collusion or conventional barriers to entry, and yet without expanded output or entry.[2]

Almost offhandedly, K&L suggest non-price competition will dissipate this profit. They realize non-price competition cannot reduce the operating margin by driving average cost up closer to

[2] More precisely, P* must exceed not "average cost," but avoidable costs each period after the firm is established. Thus, if "average cost" is defined to include start-up costs, amortized over the lifetime of the firm, P* does not necessarily exceed average cost. If "average cost" is defined to include the total costs of production in a given period divided by the quantity of production, however, while marginal cost is just the incremental cost of one more unit of output in that period, the key to the Klein-Leffler model is for P* to exceed average cost, not marginal cost.

price, but they suggest some kind of fixed cost might absorb the profit:

> *Competition to dissipate the economic profits earned by existing firms must therefore occur in nonprice dimensions... The competition involves firm-specific capital expenditures.*[3]

Such thinking comes naturally to economists, since we hold the maxim that "Markets abhor a profit" as dearly as physics' "Nature abhors a vacuum". Consider two situations with no quality uncertainty. Suppose each firm is a price taker, the long-run, competitive (i.e. market-clearing and zero-profit) price is P_C, and the number of firms is N_1. In Case I, the N_1 firms form a cartel, restrict output, and the resulting price is $\hat{P}$, with $\hat{P}$ greater than P_C. In this well-known problem, each cartel member, as a cheater, has $MR \equiv \hat{P} > MC$ and will try to sell additional output via secret price cuts or non-price methods of attracting additional sales. Moreover, even if the cartel members do not increase their output, entrants will add new output to the market. There will be a strong tendency for profit to fall to zero.[4]

In Case II, government regulates the market: entry is restricted so fewer than N_1 firms are allowed to produce, with the number of firms chosen to again yield $P = \hat{P}$. Now firms will

[3] Klein and Leffler (1981), p.626.
[4] In his analysis of price and non-price competition, Stigler (1968) considers the case of a cartel as in Case I.

earn positive profit and would like to expand capacity (and new firms would like to enter), but, unlike Case I, P (≡ MR) = MC, so firms have no incentive to compete for additional sales via price or non-price competition. Firms earn rents to their favored regulatory status.[5]

Empirical evidence in support of positive profit with capacity restrictions is found in the taxicab "medallion" problem, where the license (medallion) to operate an independent cab in New York City sold for about $17,000 in 1959[6] and about $30,000 in 1969.[7] Also, Breen (1977) found an average value of over $700,000 in 1971 for operating certificates for household movers subject to Interstate Commerce Commission regulation. In either case, presumably the sale price for an operating certificate reflects the discounted value of expected profit using the certificate.

In the K&L model, the high price is not maintained via a capacity restriction. Rather, new firms do not enter and existing firms do not expand capacity because greater output will reduce price below the level that assures product quality,

[5] Airlines may have competed via non-price mechanisms (e.g. zero price drinks, plush seats, etc.) when entry into the airlines industry was regulated by the Civil Aeronautics Board (CAB). However, in addition to entry restrictions, CAB also set price. If price was set above the market-clearing level, there would have been an incentive for firms to compete via non-price mechanisms.
[6] See Friedman (1962), p.282.
[7] See Becker (1971), p.97.

in which case consumers would cease to purchase the product.[8] In Case II above, existing firms want to expand capacity, but will not compete for additional sales without the additional capacity. Like Case II, in the K&L model, P (≡ MR) = MC, so firms will not compete for new customers.

2. A Model of Incomplete Information

Consider a model similar to that proposed by K&L, but in which some firms, *Discount* firms, have higher costs of producing high quality than other firms, *Premium* firms. Consumers cannot directly observe a firm's type. A firm charging a high price might be a Premium firm willing to deliver high quality, or it might be a fly-by-night Discount firm that intends to deliver low quality. Premium firms will have an incentive to distinguish themselves from Discount firms by investing in a signal. We assume Premium firms may invest in conspicuous spending, S, on items that involve sunk cost. Although this investment in assets with sunk cost is similar to that proposed by K&L, the addition of incomplete information to the model is necessary for firms to wish to make this kind of investment.

[8] Presumably, a price below the level which assures high quality will result in zero units purchased by consumers since they realize only low quality is

The Model

(0) Nature chooses a large number (relative to the number of buyers) of firms (*Premium* firms) with a marginal cost of high quality equal to $\underline{c}$. Other firms (*Discount* firms), of which there also is a large number, have a marginal cost of high quality equal to $\overline{c}$, $\underline{c} < \overline{c}$. Each firm has the capacity to produce one unit of output. There is zero cost for low quality.

(1) Each firm chooses a level, S, of conspicuous spending, paid at the end of the period, if this is its first period of entry and it has never chosen S > 0 before.

(2) Each firm chooses a price, P, for the unit it sells.

(3) Each firm chooses a quality, q, of either 0 or 1, unobserved by consumers, paying the cost at the end of the period.

(4) Each consumer decides where to buy, paying at the end of the period.

(5) After one period, each consumer learns the quality of all units purchased.[9]

(6) The game returns to (1) and repeats forever.

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forthcoming at such a price.

Payoffs

Everyone uses the discount rate r. A firm commits to production cost at the start of each period, with the cost incurred at the end of the period. Consumers pay their price and receive their consumption value at the end of the period. Consumers lie on the continuum from 0 to infinity, indexed by their reservation price V for the one unit of a high-quality product of value q = 1 they would purchase, and all consumers place zero value on q = 0. If the price is P, market demand for high-quality goods is X(P), with X' < 0 and X($\underline{c}$) > 2; i.e. market demand slopes down and is strong enough to support at least two firms.

Discussion of Assumptions

We assume each firm can only produce one unit simply for convenience. This fixed capacity assumption (L-shaped MC) allows a simple analysis of the difference between the complete and incomplete information cases.

K&L demonstrated the generality of the existence of a quality-assuring price. We do not disagree with this result, but, as argued in the previous section, we question the K&L

[9] If it takes longer than one period for consumers to learn quality, profit from low quality is higher, so the quality-assuring price would also be higher.

argument that profit will be dissipated in a world of complete information (i.e. a world with no adverse selection).

The Full Information Case: Quality Observable Before Purchase

As a first benchmark, let us consider the case where consumers can observe quality before they purchase. Clearly each firm active in the market will produce one unit of high quality since consumers will not buy low quality. The price must be $P = \underline{c}$, since any higher price would create profit that would induce entry. Output will be $X(\underline{c})$, produced by $X(\underline{c})$ Premium firms.

The Complete Information Case: Just Moral Hazard

As a second benchmark, let us consider the case where all possible firms are Premium firms, but consumers cannot observe quality before they purchase. This is the situation K&L described in their 1981 paper.

If Discount firms do not exist, the problem is to induce Premium firms to set q = 1. A premium firm that sets q = 1 has present value of profit, π, equal to:

$$\pi^{q=1}_{premium} = \frac{P - \underline{c}}{r}. \qquad (1)$$

A firm that cheats and sets q = 0 would be discovered after one period. Suppose such a firm would subsequently have zero sales. Profit from cheating is then:

$$\pi^{q=0}_{premium} = \frac{P}{1+r}. \qquad (2)$$

Assuming consumers exist who will pay such a price, let P* equal the quality-assuring price, that is the price at which Premium firms are just willing to set q = 1. The market clears at output of X(P*) with fewer firms than would result with perfect information since P = P* > $\underline{c}$. Now P* is found by equating eqs. (1) and (2):

$$P^* = (1+r)\underline{c}. \qquad (3)$$

With P = P*, $\pi^{q=1}_{premium} = \underline{c} > 0$. If there are no discount firms, Premium firms will earn positive profit.

More formally, what we have just described is the following perfect Bayesian *Klein-Leffler Equilibrium*.

Firms: A certain X(P*) of the potential firms enter, produce high quality, and charge price P* in the first period. A firm continues to do this in subsequent periods unless it has ever

deviated by producing low quality or charging a price other than P*, in which case it switches to always producing low quality and charging some price P. Unless some firm has thus deviated, no new entry occurs. If some firm does deviate, a new firm enters to replace it, adopting the strategy just described.

Consumers: Consumers buy randomly from the X(P*) firms that enter in equilibrium, except, if any firm ever deviates, consumers never buy from that firm, but are willing to buy from the entrant that replaces that firm.

As argued in Section I, profit persists in this equilibrium. The lucky X(P*) firms that operate in equilibrium all earn positive profits, but no entrant would attract any customers, either matching the price (P*) or charging a lower price. These firms earn a rent to the consumer belief that they will produce quality. How this belief originates is beyond the scope of the model, but it is self-confirming; a firm expected to produce high quality will do so and will continue to do so.

There are many other equilibria in this model, as is common in infinitely repeated games. The most notable is the following simple *Pessimistic Equilibrium* in which reputation does not work.

Firms: No firms enter. If a firm did enter, it would produce low quality and charge some price P.

Consumers: Consumers would not buy from any firm that entered.

In the Pessimistic Equilibrium, consumer beliefs about product quality are pessimistic, and these beliefs are self-confirming. A firm that entered and claimed it was going to charge P* and produce high quality would, rationally, not be believed. This is true despite the fact that, if consumers did believe the firm, and the firm expected them to believe it, the firm would then have incentive to produce high quality.

The Incomplete Information Case: Moral Hazard and Adverse Selection

Now suppose both types of firms exist, Discount and Premium, so consumers cannot be sure which firms they face. The reputation equilibrium just described breaks down. If Discount firms exist, with higher cost than Premium firms, profit for a Discount firm when q = 1 is:

$$\pi_{\text{discount}}^{q=1} = \frac{P - \bar{c}}{r}. \qquad (4)$$

Thus with $\pi^{q=1}_{discount} < \pi^{q=1}_{premium}$, and $\pi^{q=0}_{discount} = \pi^{q=0}_{premium} = \frac{P}{1+r}$,

Discount firms will <u>not</u> set q = 1 if P = P*. To assure that all firms set q = 1, either (a) the price must be above P* to induce Discount firms to set q = 1, or (b) Premium firms must have some method of differentiating themselves from Discount firms to reveal their type.

Condition (a) could support an equilibrium which we will call the *Inefficient Klein-Leffler Equilibrium*. Suppose the price is P** = (1+r)$\overline{c}$, defined as the price high enough to support a reputation equilibrium with just Discount firms. *A fortiori*, P** is high enough to induce Premium firms to provide high quality. However, market output will be smaller because of the higher price, so only X(P**) firms will enter. The identity of the X(P**) firms that consumers expect to produce high quality is arbitrary and can include any mix of Premium and Discount firms. It could even consist entirely of Discount firms, a curious result. Premium firms would not enter and undercut the price for the same reason as in the Pessimistic Equilibrium described in the previous section: the entrants would be expected to produce low quality, and would attract no customers.[10]

[10] In fact, this equilibrium persists even in a model in which there is complete information and consumers know which firms are Premium. Knowing that a firm has low cost of producing high quality is not sufficient to induce consumers to buy from that firm, since consumer know that the firm could make

Condition (b) is required for Premium firms to differentiate themselves. If they can do this, and consumers expect Premium firms to produce high quality, then an efficient Reputation equilibrium can result. The equilibrium is as follows.

Firms: A certain X(P*) of the Premium firms enter, expend S* = (1+r)c in initial costs, and, in the first period, produce high quality and charge price P* = (1+r)c. A firm continues to do this in subsequent periods unless it has ever deviated by producing low quality or charging a price other than P*, in which case it switches to always producing low quality and charging some price P. Discount firms never enter, but if one did, it would choose S = 0 and produce low quality. Unless some firm has deviated, no new entry occurs. If some firm does

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even greater short-term profit with low quality. The successful firm is the one that consumers expect to produce high quality, not the firm that has low costs of producing high quality. Expectations are exogenous to the model, which requires only that they be consistent and self-confirming in any Nash equilibrium. Thus, if Firms 1 and 2 are Discount, and Firms 3 and 4 are Premium, the most intuitive equilibrium has consumers expecting Firms 1 and 2 to produce low quality, if they ever produce, and Firms 3 and 4 to produce high quality. However, an equally valid equilibrium has consumers expecting only Firm 4 to produce high quality, and a third valid equilibrium has consumers expecting only Firms 1 and 2 to produce high quality. This point about Nash equilibrium, though basic, is not generally understood. Many economists use implicit equilibrium refinements such as "Consumers expect identical firms to behave identically," or "Consumers expect a firm with a lower cost of producing high quality to be no less likely to produce high quality than any other firm that they expect to produce high quality." These may or may not be reasonable restrictions on consumer beliefs, but they go beyond well-accepted equilibrium concepts. Note, too, such expectations rely on consumers knowing firms' costs as well as firms' identities, a dubious assumption.

deviate, a new firm enters to replace it, adopting the strategy just described.

Consumers: Consumers buy randomly from the X(P*) firms that enter in equilibrium, except, if any firm deviates in its choice of S, P, or q, consumers never buy from that firm, but are willing to buy from the entrant that replaces that firm.

Let us see why this is an equilibrium. First, discount firms have no incentive to enter. Discount firms that simply plan to hit and run---that is to produce low quality until they are caught at the end of the first period---will not undertake such expenditure if $\pi^{q=0}_{discount} = \frac{P}{1+r} - \frac{S}{1+r} \leq 0$. Thus, with $P = P^* = (1+r)\underline{c}$, the minimum value of S, denoted by S*, that will prevent entry by Discount firms equals P*. Given the equilibrium values of S* and P*, $\pi^{q=0}_{discount} = \frac{1+r}{1+r}\underline{c} - \frac{1+r}{1+r}\underline{c} = 0$. A Premium firm entrant earns profit of $\frac{P-\underline{c}}{r} - \frac{S}{1+r} = \frac{(1+r)\underline{c}-\underline{c}}{r} - \frac{1+r}{1+r}\underline{c} = 0$ if it produces high quality, which we have already shown is an equilibrium operating strategy for them if P = P*. Thus, Premium firms are also indifferent between entering and staying out, and we have a Nash equilibrium.

Notice, in this equilibrium, only Premium firms operate, so production is efficient, but all profit is dissipated by expenditure on sunk items. Thus, the efficiency in operation is offset exactly by the inefficiency in the means by which high-quality firms are identified to consumers. Also, the equilibrium value of S is unique: the smallest value that deters Discount firms from entering equals the largest value that induces Premium firms to enter.

As before, and as is usual in signaling models, other equilibria exist, including pooling equilibria in which Premium and Discount firms behave the same as each other. These include the Pessimistic Equilibrium, in which no firm ever produces high quality, and equilibria in which consumers' strategy is to ignore the conspicuous spending, S, in which case S fails to be a signal of Premium status and merely becomes a sign of odd, non-profit-maximizing behavior by a firm. The equilibrium we have focussed on does, however, show how signaling by conspicuous spending can result in an equilibrium in which quality is high and is produced by the firms that can produce it at least cost.

In the model in this section, Premium firms that invest in conspicuous spending to differentiate themselves from Discount firms earn zero profit, given the level of conspicuous spending.

However, complete profit dissipation need not occur in general, as will be discussed in the next section.

3. Discussion of the Profit Dissipation Result: A Caveat

The preceding section shows that there exists a separating equilibrium in which Premium firms will enter and produce high quality because the price is high enough, but discount firms will not enter and produce low quality because a one-time requirement of conspicuous spending on sunk, firm-specific items deters them.

In our model, we assumed the cost of low quality was zero. In that case, $\pi^{low}_{premium} = \pi^{low}_{discount}$. Thus, in equilibrium, the Premium firms' operating profit is dissipated by the conspicuous spending which deters entry by Discount firms. Not only might Premium firms have a lower marginal cost of delivering high quality than Discount firms, however, they might also be able to produce low quality more cheaply. In that case, in equilibrium $\pi^{high}_{premium} = \pi^{low}_{premium} > \pi^{low}_{discount} = \frac{S^*}{1+r}$. Premium firms earn positive profit, even with the necessity of conspicuous spending at a level that deters Discount firms from imitation. In general, with: a) a quality-assuring price above the competitive, zero-profit level, b) firms differing in the marginal cost of producing high quality, and c) conspicuous spending by low cost

firms to signal quality, profit will be completely dissipated only if all firms have the same marginal cost of delivering the lowest possible quality. Otherwise positive profit remains for firms that produce high quality.

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