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# Competition and the Incentive to Produce High Quality

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Previous literature indicates that, when quality is a choice variable, firms have an incentive to produce high quality to maintain their reputations with consumers. The strategic interaction among firms and competition for market share is not considered. This paper finds that, when firms compete for market share, perfect equilibria in which firms produce high-quality goods need not exist. Competition for customers can eliminate the price premium needed to induce firms to maintain a reputation for high-quality production. In this case, economists and policy analysts should pay greater attention to the interaction among firms and the institutions, such as professional associations, that structure interfirm relations when considering whether firms have an incentive to produce high-quality goods.

## INTRODUCTION

The legal treatment of firms' associations in the United States is quite different from that in Europe. In the United States, for the most part, only the government is allowed to regulate relations among firms.[1] In Europe, in contrast, there is a strong corporatist tradition of industry self-regulation. Industry associations, especially in the professions, have the ability to limit entry, set quality standards and 'punish' those that do not comply with their guidelines (Heidt 1989; Van Den Bergh and Faure 1991).

This paper shows why industry associations may be important to sustain high-quality production when the quality of the good is not observable to the consumer prior to purchase. The formal analysis shows that, when firms compete for customers and choose whether or not to produce high-quality goods, competitive pricing can eliminate the price premium needed to induce firms to produce high quality. In this case competition for market share can be 'ruinous', not only for firms' profits, but also for high-quality production.[2] Accordingly, the institutional structure within which firms compete is critical for the incentives for firms to produce high quality goods. Guilds and professional associations may have played a role historically in guaranteeing product quality, and I discuss examples below. I also discuss the small empirical literature concerning the impact of competition and deregulation on quality.

The theoretical finding in this paper is different from the basic result reached in the literature on 'quality-assuring prices' (Klein and Leffler 1981; Shapiro 1983; Allen 1984). The aim of this literature is to reconcile high-quality production with competitive markets when (unobservable) quality is a choice variable. In these analyses consumers and firms interact repeatedly. Consumers decide whether to buy from a firm on the basis of its past quality decisions, that is on the basis of its 'reputation'. When consumers are perfectly informed about firms' past quality decisions, they can punish a firm that has produced

low quality by not patronizing it thereafter. The quality-assuring price gives firms enough positive profits from producing high-quality goods to induce them to establish and maintain a reputation for high-quality production: it is not in their interest to cut quality and earn only a one-period gain. Thus, consumers serve, in some sense, as a disciplinary body, punishing firms that 'cheat' and sell low-quality goods.

This result would lead us to believe that industrial structure and interfirm relations are inconsequential to firms' incentives to produce high quality. Consumers with sufficient information can always ensure that firms produce high-quality goods. Yet, if a consumer-enforced reputation mechanism is not sufficient to sustain high quality, as the present paper shows, the interaction among firms is critical in sustaining high-quality production.[3] In this case, economists and policy analysts should pay greater attention to the interaction among firms and the institutions that structure interfirm relations when considering whether firms have an incentive to produce high-quality goods.

In this paper I ask whether a consumer-enforced reputation mechanism is indeed sufficient to sustain high-quality production. I formally analyse strategic competition for market share and its impact on quality. The focus on strategic competition for market share is a departure from the previous literature. In the Klein–Leffler and Shapiro models, firms face a perfectly elastic demand at the quality-assuring price. In Allen's model, consumers choose randomly among firms charging the lowest price, given that this price weakly exceeds the quality-assuring price. In the model developed here, firms can compete in price for market share. I provide a general representation of a firm's demand. A firm that lowers its price may be able to attract new consumers and increase its current and future clientele. I show under what conditions on demand the results in the previous literature hold, and under what conditions they do not.

The key condition is the whether a firm can increase and consolidate its market share by attracting new consumers with a price cut. If a firm can permanently increase its market share by attracting new consumers, it will have an incentive to produce high-quality goods. That is, its offer of high-quality goods will be credible, despite the lower current-period price. The profits from selling to a larger set of consumers in the future is greater than the one-shot gain from cheating and producing low quality. On the other hand, if the firm does not enjoy a sufficiently large permanent increase in market share, it has an incentive to produce low quality in the current period, taking advantage of the temporary increase in the number of consumers.

To impose dynamic consistency in the repeated interaction between consumers and firms, I use the equilibrium concept of subgame perfection. At any point in time, a firm must produce high-quality goods if the discounted profits from producing high-quality goods exceed the discounted profits from producing low-quality goods. When evaluating a firm's offer, rational consumers must believe that a firm will produce high-quality if it is in its interest to do so. Consequently, a firm can increase its market share if it can credibly promise to sell high-quality goods at a price low enough to induce consumers to switch firms.

The assumption of consumer rationality and focus on the credibility of a firm's offer to produce high quality are also crucial departures from the

previous literature. In the Klein–Leffler and Allen models, since demand is assumed to be perfectly elastic, competition for market share is ruled out by assumption. In Shapiro (1983), each firm in the market faces a perfectly elastic demand curve, but entry is possible. The main point of the analysis is to show why there is an equilibrium in the market and why entering firms will not cut their prices to attract consumers. It is assumed (p. 667) that consumers will not patronize an entering firm that charges a price below the quality assuring price because they believe that such a firm will not produce high quality. Accordingly, a firm will not charge below that price. Shapiro states explicitly that the consumer beliefs that sustain this equilibrium are irrational: 'consumers expectations are not fully rational: on average entrants' quality is above [the minimum quality]' (p. 667)'.[4]

This paper asks whether, with rational consumers, a consumer-enforced reputation mechanism is sufficient to sustain high-quality production in a perfect equilibrium. To do so, I restrict attention to a setting where firms do not use 'collusive' strategies. As defined here, a collusive strategy is a strategy conditioned on firms' past prices.[5] When firms do not use collusive pricing strategies, firms can be 'punished' only for cutting quality, not for cutting price. This corresponds to the environment depicted in the quality-assuring price literature cited above. On the other hand, when firms use collusive pricing strategies, firms can punish a firm that deviates from a tacit pricing agreement. Such an agreement could simultaneously secure each firm its market share and fix the price above the quality-assuring price.[6]

If a firm can build market share by cutting prices, a consumer-enforced reputation mechanism is not sufficient to sustain high quality. A firm could lower its price in one period, *credibly* offer high-quality goods at a strictly lower price than all other firms, and increase its market share.

The key insight behind this result is that a firm's price in a given period need not affect its incentives to produce high-quality goods *in that period*. When firms have constant marginal costs of production, then for any given price the gain from cheating is the same: namely, the difference in cost between producing a high-quality good and a low-quality good.[7] The benefit from not cheating, from producing high quality, is the discounted value of *future* profits from producing high-quality goods for repeat buyers. Thus, the credibility of a firm's promise to provide high-quality goods depends not on its current price but on its anticipated future prices. As a result, when all firms are charging the quality-assuring price and firms are not using collusive pricing strategies, an individual firm could gain by cutting its price in one period.

The results in this paper indicate that the way firms in an industry behave can be crucial to sustaining incentives to produce high quality. Explicit industry self-regulation sanctioned by the government may be necessary to maintain quality standards. Historically, much self-regulation has involved restrictions on competition, with the stated goal of quality control. This paper gives a theoretical basis to the idea that self-regulation, and limits on entry may indeed increase the quality produced by firms.

These results extend directly to the case where firms incur a sunk cost to increase their clientele. In the previous literature, the quality-assuring price gives firms strictly positive profits for producing high-quality goods. In a competitive equilibrium, of course, firms cannot earn strictly positive profits

because they would have an incentive to enter the industry. Klein and Leffler (1981) suggest that these profits are dissipated by competition in non-price dimensions, such as advertising costs to establish a brand name. In Allen (1984) firms incur sunk costs to enter the industry, and profits are dissipated by entry. In equilibrium, each firm's market share is such that firms earn zero *ex ante* profits, and thus no firm has an incentive to enter the industry. In the model in the present paper, it is the availability of productive capacity and, consequently, the cost of building capacity that affect the extent to which firms can compete for market share. It is clear that, if the profits earned from an increased market share outweigh the costs of building additional capacity, a firm still has an incentive to cut its current price to attract new consumers.

The rest of the paper is organized as follows. Section I presents a model where firms compete for market share and choose whether or not to produce high quality. Section II shows when a consumer-enforced reputation mechanism is not sufficient to sustain high quality. Section III presents examples of industry associations. Section V discusses the small empirical literature on the effects of competition on product quality and considers the implications of this analysis for anti-trust policy and the study of institutions that govern interfirm relations.

## I. The Model

I model the interaction between firms and consumers as an infinitely repeated game.[8] There are $I \geqslant 2$ firms and many consumers, normalized to size 1. Each consumer demands one unit of the good in each period. A consumer values a high-quality good at $v^H$ and a low-quality good at $v^L$, where $v^H > v^L > 0$. A firm incurs cost $c_H$ for each high-quality good it produces and $c_L$ for each low-quality good it produces, where $c_H > c_L > 0$. I assume that $v^H > v^L$, $c_H > c_L$, and $v^H - c_H > v^L - c_L > 0$, so that it is socially desirable to produce high-quality goods.

In each period the interaction between firms and consumers proceeds as follows.[9] Firms set their prices simultaneously. Each consumer then chooses a firm and pays the firm's specified price, or chooses not to buy at all. Firms then choose to produce high-quality or low-quality goods. If it has no customers, a firm does not produce at all.

The structure of the game is common knowledge, and after each move all players' actions are observable by all players. Consequently, all consumers observe all firms' prices, and firms can compete in price. At the end of each period, all consumers also learn of firms' quality choices and can use this information in subsequent periods when selecting a firm. Let $p_i^t \in [0, v^H]$ be firm $i$'s price choice in period $t$, and let $Q_i^t$ summarize the quality history of firm $i$ until period $t$, where $Q_i^t = H$ indicates that firm $i$ has never produced low quality in the past, and $Q_i^t = L$ indicates that firm $i$ has produced low quality in the past.

I consider a general formulation of competition for market share. I assume that a firm's market share in period $t$ depends on its and its rivals' prices in period $t$, firms' past market shares, and firms' past quality choices. A firm's market share depends on past prices to the extent that past prices affect past market share.[10] The key relationship will be the extent to which a firm can

attract new consumers today and into the future by decreasing its current price. Let $\sigma_i^t \in [0, 1]$ be firm $i$'s market share in period $t$: $\sigma_i^t$ is a random variable with conditional joint distribution $G(\sigma_i^t, \sigma_{-i}^t \mid p_i^t, \mathbf{p}_{-i}^t, \sigma^{t-1})$ where $\sigma_{-i}^t$ is a vector of other firms' market shares in period $t$, $p_i^t$ is a vector of firm $i$'s price in period $t$, $\mathbf{p}_{-i}^t$ is the vector of other firms' prices in period $t$, $\sigma^{t-1}$ is the history of all firms' market shares, and $\sum_i \sigma_i^t = 1$ in each period $t$. With the consumer strategies defined below, market shares will also summarize quality histories; if ever a firm has produced low quality in the past, its market share falls to zero. Let $\bar{\sigma}_i^t$ denote a firm's expected market share, and let $\tilde{\sigma}_i^t$ be the highest possible realization of $\sigma_i^t$. The ratio $\tilde{\sigma}_i^t/\bar{\sigma}_i^t$ will play an important role in the analysis below. I call this ratio the *dispersion* of a firm's market share. Intuitively, as the dispersion decreases—and approaches 1—there is less 'uncertainty' in a firm's market share.

This general model can capture various forms of consumer behaviour, such as switching costs, brand loyalty, etc. If consumers face switching costs, for example, they are locked into particular firms; they buy from the same firm period after period, unless some other firm offers a price sufficiently low so that they are willing to incur the switching cost. In this case, the ratio $\tilde{\sigma}_i^t/\bar{\sigma}_i^t$, the *dispersion* of a firm's market share, is low. The same could be true when consumers are loyal to a particular brand. They buy from the same firm, unless they are induced to switch brands. On the other hand, if consumers base their purchasing decision on price alone, and, say, choose randomly among same-priced firms, then the dispersion of a firm's market share could be high. A firm that enjoys a high demand draw in the current period expects its future demand to be lower. The demand assumed in previous literature can also be represented by this model. Klein and Leffler's and Allen's perfectly elastic demand, for example, would correspond to a $\sigma_i^t(p_i^t, \mathbf{p}_{-i}^t, \sigma^{t-1}) = \hat{\sigma}$ if $p_i^t = \hat{p}$ and $\sigma_i^{t-1} = \hat{\sigma}$, and $\sigma_i^t(p_i^t, \mathbf{p}_{-i}^t, \sigma^{t-1}) = 0$ otherwise, where $\hat{\sigma}_i$ is a fixed percentage of consumers, $\hat{p}$ is the 'market price', and $\sigma_i^{t-1}$ summarizes the firm's quality history, given the consumer strategies below.

The game begins in period 0 with a $\sigma_i^{-1}$ consumers assigned to firm $i$. Firm $i$'s profits in period $t$ are $(p_i^t - c_H) \cdot \sigma_i^t(p_i^t, \mathbf{p}^t, \sigma^{t-1})$ when it produces high quality and $(p_i^t - c_L) \cdot \sigma_i^t(p_i^t, \mathbf{p}_{-i}^t, \sigma^{t-1})$ when it produces low quality. (A firm that produces nothing earns zero profits.) In the infinitely repeated game, firm $i$'s payoffs are the discounted value of its per-period profits, with a common discount factor $\delta \in (0, 1)$.

Subgame perfection requires that players' strategies be optimal at each point in time, i.e. at each move. To determine whether strategies are subgame-perfect, we must know a firm's continuation payoffs—its payoffs in the current period and expected discounted stream of future payoffs, taking into account how other players will react in the future to its current move. Let $\prod_i^H(p_i^t, \mathbf{p}_{-i}^t, \sigma^t)$ be the continuation profits for firm $i$ when $\sigma_i^t(p_i^t, \mathbf{p}_{-i}^t, \sigma^{t-1})$ consumers have chosen $i$ in period $t$ and $i$ produces high-quality goods in period $t$. Similarly, let $\prod_i^L(p_i^t, \mathbf{p}_{-i}^t, \sigma^t)$ be firm $i$'s payoffs if it produces low-quality goods. Note that the firm chooses quality after observing its current market share $\sigma_i^t$ and all other firms' market shares. Hence it is an argument of $\prod_i^H$ and $\prod_i^L$.

Subgame perfection requires that firms maximize their continuation profits when they choose quality in each period. In other words, a firm produces high-quality goods whenever its profits from producing high quality exceed its

profits from producing low quality. If $\prod_i^H(p_i^t, \mathbf{p}_{-i}^t, \sigma^t) > \prod_i^L(p_i^t, \mathbf{p}_{-i}^t, \sigma^t)$, firm $i$'s strategy must be to produce high quality, and if $\prod_i^H(p_i^t, \mathbf{p}_{-i}^t, \sigma^t) < \prod_i^L(p_i^t, \mathbf{p}_{-i}^t, \sigma^t)$, firm $i$'s strategy must be to produce low quality. As a technical assumption, I assume that, whenever $\prod_i^H(p_i^t, \mathbf{p}_{-i}^t, \sigma^t) = \prod_i^L(p_i^t, \mathbf{p}_{-i}^t, \sigma^t)$, firm $i$ produces high-quality goods. If $\prod_i^H(p_i^t, \mathbf{p}_{-i}^t, \sigma^t) \geqslant \prod_i^L(p_i^t, \mathbf{p}_{-i}^t, \sigma^t)$, I say a firm $i$'s 'offer' (or 'promise', of high-quality goods is 'credible'. Call $\prod_i^H(p_i^t, \mathbf{p}_{-i}^t, \sigma^t) \geqslant \prod_i^L(p_i^t, \mathbf{p}_{-i}^t, \sigma^t)$ firm $i$'s 'no-quality-cutting condition'.

The first step in the analysis is to determine the prices that can support high-quality production. I find the analogue in this game to the 'quality-assuring price', defined in the literature cited above. Suppose—only for the moment—that, if a firm produces low quality at any time, it earns zero profits forever thereafter. Suppose too that all firms always charge the same price. Given these suppositions, let the 'quality-assuring price' be the minimum price such that *all* firms have the incentive to produce high-quality goods. In other words, when firms charge the quality-assuring price, all firms' no-quality-cutting conditions are satisfied in every period. Denote the 'quality-assuring price' $p^*$.

The quality assuring price, $p^*$, must give each firm $i$ an incentive to produce high-quality goods for every realization of its current market share. A firm has the greatest incentive to cheat its consumers and produce low quality when the realization of its current market share is at its upper bound: $\tilde{\sigma}_i^t(p^*, \mathbf{p}^*, \sigma^{t-1})$. If firm $i$ produces high quality in a period $t$ when it has $\tilde{\sigma}_i^t(p^*, \mathbf{p}^*, \sigma^{t-1})$ consumers, its current profits and expected future profits are

$$(1) \qquad \prod_i^H(p^*, \mathbf{p}^*, \boldsymbol{\sigma}^t) = (p^* - c_H) \cdot \tilde{\sigma}_i^t(p^*, \mathbf{p}^*, \boldsymbol{\sigma}^{t-1}) + \sum_{\tau=t+1}^{\infty} \delta^{\tau-t}(p^* - c_H) \cdot \overline{\sigma}_i^{\tau}(p^*, \mathbf{p}^*, \sigma^{\tau-1}).$$

If firm $i$ produces low-quality goods in period $t$, by supposition firm $i$ will earn zero profits in all future periods. So, firm $i$ would earn at most

$$(2) \qquad \prod_i^L(p^*, \mathbf{p}^*, \boldsymbol{\sigma}^t) = (p^* - c_L) \cdot \tilde{\sigma}_i^t(p^*, \mathbf{p}^*, \boldsymbol{\sigma}^{t-1}) + 0.$$

Setting $\prod_i^H = \prod_i^L$ and solving for $p^*$ yields the minimum price that would assure that firm $i$ has the incentive to produce high quality:

$$p_i^* = \left(\frac{1-\delta}{\delta}\right)\left(\frac{\tilde{\sigma}_i}{\overline{\sigma}_i}\right)(c_H - c_L) + c_H.$$

In a high-quality equilibrium, every firm must have the incentive to produce high quality. Therefore, every firm $i$ must charge a price at least equal to $p_i^*$. If all firms charge the highest of these prices, then all firms will have the incentive to produce high quality. That is, the quality assuring is $p^* = \max\{p_1^*, \ldots, p_i^*, \ldots, p_i^*\}$. We see that, when firms discount future profits (i.e., $\delta < 1$), firms must earn a price premium in order to have the incentive to produce high quality: $p^* > c_H$. We also see that the quality-assuring price is increasing in the dispersion of firms' market shares, $\tilde{\sigma}/\overline{\sigma}$. When firms receive a high number of consumers relative to their

averages, they have a greater incentive to cheat these consumers and exit the industry. The price it earns on future consumers must be sufficiently high to overcome this temptation. For the rest of analysis, I assume for simplicity that firms are symmetric so that $p^* = p_i^*$ for all $i$.[11]

So that consumers would prefer to buy high quality at price $p^*$ than low quality at price $c_L$, I assume that $v^H$ is sufficiently high that $p^* \leqslant \bar{p}$, where $\bar{p}$ is the price for high quality such that a consumer is indifferent between purchasing a high quality at price $\bar{p}$ and purchasing low quality at price $c_L$: $v^H - \bar{p} = v^L - c_L$.

## II. High-Quality Equilibria Without Collusive Pricing Strategies

I analyse here how price competition affects product quality. In this section firms do not use 'collusive' pricing strategies, which are strategies based on firms' past prices or consumers' past firm choices.[12] Without collusive pricing strategies, firms cannot tacitly collude on price and, thus, may compete for market share. Accordingly, 'non-collusive' strategies represent firms' inability (owing to regulation, say) to act collectively (tacitly or otherwise) to set prices or limit entry. In this section I ask whether, in this situation, there exists in this game a perfect (pure-strategy) equilibrium in which firms produce high quality in every period.

To do this, I follow the method of Abreu (1988). I ask whether high-quality production on the equilibrium path can be supported by a punishment that gives a firm, after it produces low quality, the worst payoffs possible in any perfect equilibrium. By Propositions 4 and 5 in Abreu (1988), if high-quality production cannot be sustained by such a punishment, it cannot be sustained by any punishment.

The analysis proceeds as follows. First, I construct a perfect strategy profile that gives a firm zero profits in all periods subsequent to producing low quality. This is the worst possible payoff for any firm in a perfect equilibrium. Second, I show that, without collusive pricing strategies, the case where all firms set $p^*$ on the equilibrium path does not create a perfect high-quality equilibrium, given this punishment. Since the proof that there is no $p^*$-equilibrium is at the heart of the paper, I discuss it extensively. Finally, I show that, if there exists a perfect high-quality equilibrium without collusive pricing strategies, the price on the equilibrium path is $p^*$. Therefore, there does not exist a perfect high-quality equilibrium with non-collusive pricing strategies.[13]

Consider the following punishment for producing low quality. After any firm produces low quality, consumers refuse to buy from the firm at a price above $c_L$ in the future. They choose among the firms offering the highest surplus.[14] All other firms set their prices and quality levels optimally, given their new market shares. If ever there is a single firm that has never produced low quality, it sets its price at $\bar{p}$.[15]

*Lemma 1.* The punishment specified above is an optimal penal code that ensures zero profits in future periods $\tau \geqslant t + 1$ for any firm that produces low quality in period $t$.

*Proof.* See Appendix. □

This punishment gives a firm that has produced low quality the worst payoffs possible in any perfect equilibrium. In this game, zero profits are firm *i*'s 'minimax' payoffs (that is, the lowest payoffs other firms can force on a rival)[16] because, no matter what the circumstances are, firm *i* can always guarantee itself at least zero profits.[17] Since in any subgame-perfect equilibrium no player can receive a payoff lower than his minimax payoffs, zero profits are the worst payoffs possible in any perfect equilibrium in this game.

Given the above punishment for producing low quality, I ask next under what conditions setting a price $p^*$ or higher is not an equilibrium outcome. I identify the necessary and sufficient condition on the distribution of market shares for which an individual firm can find it optimal to set its price strictly below $p^*$ for one period. In this case, there does not exist a high quality equilibrium without collusive strategies.

The condition is simple: $p^*$ cannot be an equilibrium price if and only if when a firm *i* cuts its price in one period, (A) the loss in current profits is more than outweighed by an increase in firm *i*'s current and future market share, and (B) the dispersion of firm *i*'s market share (weakly) decreases. The intuition behind these conditions is also straightforward. Condition (B) concerns the firm's incentive to produce high quality after cutting its current price. The derivation of $p^*$ above shows that a firm has a greater incentive to produce low, rather than high, quality when its current market share is higher than its average market share. Condition (B) supposes that, when a firm cuts its price, it consolidates its market share: it increases the average, $\bar{\sigma}$, and (weakly) decreases the dispersion, $\tilde{\sigma}/\bar{\sigma}$. The firm will then have less temptation (than it did before) to cheat a large realization of consumers. In this case, if its offer of high-quality goods was credible previously, it will also be credible with the current price cut. The first condition (A) concerns the trade-off between a current price cut and greater future market share. Given condition (B) is satisfied, consumers may be attracted by the low-price–high-quality offer. If the increase in market share outweighs the losses from the price cut, the firm will have an incentive to cut its price.

*Proposition 1*. Without collusive pricing strategies, the situation whereby all firms set $p^*$ in every period on the equilibrium path does not lead to a perfect high-quality equilibrium, given the above punishment, if and only if, for a firm *i* that cuts it price, (A) its expected market share, $\bar{\sigma}$, increases by enough, and (B) the dispersion, $\tilde{\sigma}/\bar{\sigma}$, weakly decreases.

*Proof*. Consider a *one-period* deviation in price by firm *i* in period *t*: $p_i^t = p'$ where $p' < p^*$. Notice first that under condition (B), and only under this condition, firm *i* is credibly offering high-quality goods in period *t*. Again, we look for the most restrictive no-quality-cutting condition; that is, where a firm has the highest possible number of consumers in the current period. The maximum market share it can have in the current period is $\tilde{\sigma}_i^t(p', \mathbf{p}^*, \sigma^{t-1})$ and its profits from producing high quality are

$$\prod_i^H (p', \mathbf{p}^*, \sigma^t) = (p' - c_H) \cdot \tilde{\sigma}_i^t(p', \mathbf{p}^*, \sigma^{t-1}) + \sum_{\tau=t+1}^{\infty} \delta^{\tau-t}(p^* - c_H) \cdot \bar{\sigma}_i^t(p^*, \mathbf{p}^*, \sigma^{\tau-1}(p')),$$

where the firm's expected market share in the future, $\bar{\sigma}_i^t(p^*, \mathbf{p}^*, \sigma^{\tau-1}(p'))$, depends on the effect of the current price cut on market shares, as denoted (with some abuse of notation) $\sigma^{\tau-1}(p')$. If a firm produces low quality given a market share $\tilde{\sigma}_i^t(p', \mathbf{p}^*, \sigma^{t-1})$, its profits are

$$\prod_i^L (p', \mathbf{p}^*, \sigma^t) = (p' - c_L) \cdot \tilde{\sigma}_i^t(p', \mathbf{p}^*, \sigma^{t-1}) + 0.$$

The firm has an incentive to produce high quality when $\prod_i^H \geqslant \prod_i^L$. Solving for $p^*$, this incentive condition becomes

$$p^* \geqslant \left(\frac{1-\delta}{\delta}\right)\left(\frac{\tilde{\sigma}_i'}{\bar{\sigma}_i'}\right)(c_H - c_L) + c_H,$$

where $\tilde{\sigma}_i'$ and $\bar{\sigma}_i'$ are firm $i$'s new upper bound and new mean market shares, respectively. Notice that the current price $p'$ plays no direct role in this condition. It affects the incentive to produce high quality only through its effect on the distribution of market shares. By the formula for $p^*$, if and only if

$$\text{(B)} \qquad \frac{\tilde{\sigma}_i'}{\bar{\sigma}_i'} \leqslant \frac{\tilde{\sigma}_i}{\bar{\sigma}_i},$$

the incentive condition is satisfied, and the firm's offer of high-quality goods is credible.

Suppose condition (B) holds. A firm then has an incentive to cut its price if and only if by doing so it can increase its overall profits from producing high quality, i.e. if $\prod_i^H(p', \mathbf{p}^*, \sigma^{t-1}) > \prod_i^H(p^*, \mathbf{p}^*, \sigma^{t-1})$. Note that, at the point where a firm sets its price, it does not know what its market share, $\sigma_i^t(p', \mathbf{p}^*, \sigma^{t-1})$, will be in that period; hence $\sigma^{t-1}$ is an argument. We can write this inequality as follows:

$$(p' - c_H) \cdot \bar{\sigma}_i^t(p', \mathbf{p}^*, \sigma^{t-1}) + \frac{\delta}{1-\delta}(p^* - c_H) \cdot \bar{\sigma}_i^\tau(p')$$

$$> (p^* - c_H) \cdot \bar{\sigma}_i^t(p^*, \mathbf{p}^*, \sigma^{t-1}) + \frac{\delta}{1-\delta}(p^* - c_H) \cdot \bar{\sigma}_i^\tau(p^*),$$

where $\bar{\sigma}_i^\tau(p')$ is firm $i$'s expected market share in future periods when it cuts its price, and $\bar{\sigma}_i^\tau(p^*)$ is firm $i$'s expected market share in future periods when it does not. Since $p^* > c_H$, there is price $p'$ such that $c_H < p' < p^*$. We can rewrite this condition as

$$\text{(A)} \qquad \bar{\sigma}_i^\tau(p') - \bar{\sigma}_i^\tau(p^*) > \left(\frac{1-\delta}{\delta}\right)\left(\bar{\sigma}_i^t(p^*) - \frac{(p' - c_H)}{(p^* - c_H)}\bar{\sigma}_i^t(p')\right).$$

If, and only if, the firm's current and mean market share increases sufficiently following the price cut, the firm will have an incentive to cut price. □

The proof of this result can be illustrated using Figure 1, which shows the sequence of moves of firms and consumers in a single period, along with

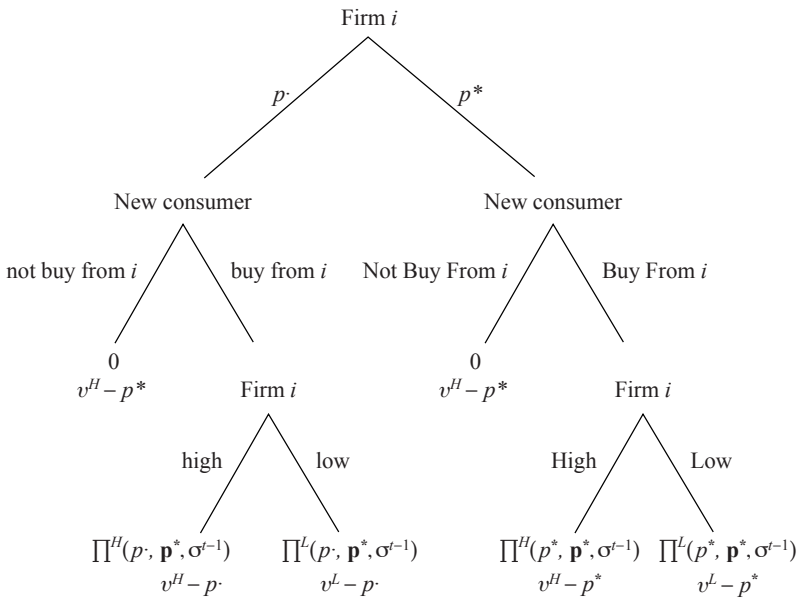


FIGURE 1

continuation payoffs. First, a firm $i$ can either set $p_i^t = p^*$ or deviate and set $p_i^t = p' < p^*$. Consumers observe these prices and decide whether or not to purchase from firm $i$. If a consumer purchases, firm $i$ then decides whether to produce a high-quality good or low-quality good, which yields profits $\prod_i^H(p_i^t, \mathbf{p}^*, \sigma^t)$ and $\prod_i^L(p_i^t, \mathbf{p}^*, \sigma^t)$, respectively for price $p_i^t$. Solving backwards, since $\prod_i^H(p^*, \mathbf{p}^*, \sigma^t) \geqslant \prod_i^L(p^*, \mathbf{p}^*, \sigma^t)$, firm $i$ plays 'High' when its sets $p_i^t = p^*$. If and only if condition (B) holds, $\prod_i^H(p', \mathbf{p}^*, \sigma^t) \geqslant \prod_i^L(p', \mathbf{p}^*, \sigma^t)$, and firm $i$ plays 'high' when it deviates and sets $p_i^t = p'$. Given that condition (B) holds, the offer of high-quality goods at a low price is credible; new consumers buy from firm $i$ no matter the current price: they play 'Buy From $i$' and 'buy from $i$'. Finally, if and only if condition (A) holds, that is if $\prod_i^H(p', p^*, \sigma^{t-1}) > \prod_i^H(p^*, \mathbf{p}^*, \sigma^{t-1})$ and a firm increases its market share from lowering its price, firm $i$ will set $p_i^t = p'$.

There is a Nash equilibrium where, on the equilibrium path, firm $i$ charges $p^*$ and plays 'High'. This equilibrium is supported by the off-equilibrium path strategies: new consumers play 'not buy from $i$' and firm $i$ plays 'low'. This equilibrium, however, is not subgame-perfect when condition (B) holds. At the point where firm $i$, setting $p_i^t = p'$, chooses quality, playing 'low' is not optimal. If consumers were to buy from $i$ in period $t$, firm $i$ would produce high-quality goods, because, by producing high quality, it could increase its market share and earn higher future profits.

The following specific model of competition for market share provides an example to illustrate this result. Suppose that a proportion $\alpha_i$ of consumers is initially 'loyal' to firm $i$. They buy from $i$ unless, or until, another firm offers high quality at a strictly lower price. The total number of consumers loyal to firms is $\sum_i(\alpha_i)$, with the remainder $1 - \sum_i(\alpha_i)$ having no loyalty to any firm.

Suppose further that the each firm $i$ receives a random share $\rho_i^t \in [0, 1]$ of the non-loyal consumers in period $t$ (where $\sum_i(\rho_i^t) = 1$). This proportion is i.i.d. across firms and time periods. The existence of loyal and non-loyal consumers could be the result of different levels of switch costs, for example. Loyalty is unchanged as long as all firms charge the same price. If however a firm makes a credible offer of high quality at a lower price than a consumer's usual firm, it attracts some of those consumers in that period. And some of these consumers become firm $i$'s loyal consumers in future periods.

To find the quality-assuring price for this situation, suppose all firms charge the same price $p$ every period. The upper bound of firm $i$'s market share in any period is $\tilde{\sigma}(p, \mathbf{p}, \sigma^{t-1}) = 1$, and firm $i$'s expected market share in period $t$ is $\bar{\sigma}_i^t(p, \mathbf{p}, \sigma^{t-1}) = \alpha_i + E(\rho_i^t)[1 - \sum_i(\alpha_i)]$. The quality-assuring price $p^*$ is then

$$p^* - \left(\frac{1-\delta}{\delta}\right)\left(\frac{1}{\bar{\sigma}_j}\right)(c_H - c_L) + c_H,$$

where firm $j$ has the lowest number of loyal consumers.

Now consider whether setting price a price of $p^*$ every period is an equilibrium outcome without collusive strategies. That is, let us check when conditions (A) and (B) are satisfied. Recall that condition (B) ensures that a deviating firm $i$'s offer of high-quality goods is credible: the dispersion in firm $i$'s market share is weakly smaller than before the price cut. Here, the firm's upper bound on market share, $\tilde{\sigma}$, cannot increase, since it is already equal to 1. Hence the dispersion can only weakly decrease, and condition (B) is satisfied. Let us now check condition (A). Since $\rho_i^t$ is i.i.d. across time periods, condition (A) would be satisfied when a small price cut increases the number of firm $i$'s loyal consumers, $\alpha_i$, by a sufficiently high amount.

The preceding proposition shows that all firms pricing $p^*$ in every period on the equilibrium path is not a perfect high-quality equilibrium. It is also that case that when conditions equivalent to (A) and (B) above hold, the only possible price on the equilibrium path in a perfect high-quality equilibrium is $p^*$.

*Lemma 2*. Without collusive pricing strategies, if there exists a perfect high-quality equilibrium, the price on the equilibrium path is $p^*$ for all firms in every period, given that if a firm $i$ cuts its price, (A) its expected market share, $\bar{\sigma}$, increases by enough, and (B) the dispersion, $\tilde{\sigma}/\bar{\sigma}$, weakly decreases.

*Proof*. Notice, first, that the price on the equilibrium path cannot be above $p^*$ in any period. To see this, suppose that in some period $t$ all firms are charging a price above $p^*$: $p_i^t = p_j^t = p > p^*$ for all firms $j \neq i$. By the same argument as in Proposition 1, if and only if conditions (A) and (B) hold, firm $i$ could gain by deviating and setting a lower price. Furthermore, in a perfect high-quality equilibrium, since firms cannot charge a price strictly above $p^*$ in any period, firms cannot charge a price below $p^*$ in any one period. This is by the definition of $p^*$. Therefore, on the equilibrium path in a perfect high-quality equilibrium, all firms must charge $p^*$ in every period. □

Lemmas 1 and 2, Proposition 1, and Propositions 4 and 5 in Abreu (1988) give the result that high-quality production cannot be sustained in equilibrium when firms compete for market share.

*Proposition 2*. Without collusive pricing strategies, if and only if conditions (A) and (B) are satisfied, there does not exist a perfect high-quality equilibrium.

## III. Guilds, Professional Associations and Empirical Studies

The above analysis shows why there may be a role for regulation and industry associations to guarantee product quality. Competition for consumers can destroy firms' incentives to produce high-quality goods. In this section I review the empirical economic literature concerning competition and product quality. I also discuss how guilds and professional associations have historically regulated industries to ensure high-quality production.

Historically, professional associations and guilds have regulated industries to protect their profits from competition and improve product quality. I discuss here a variety of associations, all of which performed similar tasks in their attempts to regulate their industries. They (i) set quality standards and monitored and enforced these standards, and (ii) restricted competition and entry. The first of these activities could guarantee that consumers are informed of firms' fraudulent behaviour. However, the analysis in this paper shows that, when firms compete for consumers, consumers' refusal to buy from firms that produce low quality is not sufficient to maintain the incentive to produce high quality.[18] There must also be a mechanism to prevent competition that erodes the quality-assuring price.

### *Empirical literature*

The empirical literature examining the effect of competition on firms' incentives to provide quality is sparse. There is some evidence, however, that a consumer-based reputation mechanism is insufficient to guarantee high-quality production.[19] Studying a geographic cross-section, Kwoka (1984) shows that advertising decreased both the price and the quality of optometrist services. Advertising, of course, helps firms to compete for consumers and was typically forbidden by professional associations. Rose's (1990) study of US airlines shows that profitability is directly correlated with airline safety. The effect is strongest for small carriers and is particularly pronounced in recent (1981–6, post-deregulation) airline incident data. These results indicate that eroding profits are indeed correlated with declines in safety and quality. McMaster (1995) finds that quality suffered when competitive bidding was introduced for some health services in the United Kingdom.[20]

### *Guilds in medieval Europe, the Middle East and North Africa*

In cities and towns throughout medieval Europe, markets for goods and services were governed by guilds.[21] All individuals who practised a trade belonged to a guild,[22] which set rules for market transactions, production and employment. Statutes specified training requirements for apprentices, established quality standards, and limited competition among guild members.

Fraud and unobservable product quality were clearly possible problems in the craft and service markets of medieval Europe. Guilds set quality standards, ensured that individuals who had produced substandard goods were punished and, in extreme cases, informed the public of transgressions by banning the errant member from the guild.[23] The fraudulent practices these statutes forbade were precisely reductions in quality designed to fool consumers. German butcher guilds, for example, prohibited their members from mixing worm-eaten meat into sausages, adding flour to lard, and pumping water into lungs and bellies to increased slaughtered weight (Gustaffson 1987, pp. 13–15). In Florence, craftsmen in textile guilds were prohibited from mixing linen thread with woollen thread, or blending various shades of dyes that could fool the consumer. Similarly, shoemakers were required to label shoes that combined goat and horse leathers (Staley 1906, p. 144). The guilds also prohibited practices that could not be detected except after much use; for example, German pewtersmiths were forbidden from using too much lead in pewterware. The guilds monitored product quality by spot inspections and providing a forum for consumer complaints. By enforcing guild statutes, they ensured that there was a punishment for producing low-quality goods.

Beyond these measures to ensure high-quality production, guilds limited competition. They strictly regulated entrance to their industries and restricted output. Entrance to a guild required an apprenticeship with a current guild member. Guilds restrained output by strictly limiting the production. Members were forbidden from working after nightfall or other designated stopping times, such as afternoon prayers (Staley 1906, p. 154; Brentano 1870, p. 66) Guild members were also required to take long holidays from work (Brentano 1870, pp. 66–7; de Vigne 1857, pp. 37–40). Guild statutes also restricted the number of apprentices and servants who could work in any one shop (Brentano 1870, p. 67).

In the case of competition between members of different guilds, there were quality problems. Kramer (1927) relates details of the disputes among guilds over the right to manufacture specific products. These battles were often accompanied by charges, from the guilds and the consuming public, that competition from members in rival guilds resulted in shoddy production and fraud. Governments often legislated these guild jurisdictions to prevent a deterioration in quality.

The information on guilds in the Middle East is less extensive than that on guilds in Europe. However, there is enough information available to know that guilds in the Middle East, like those in medieval Europe, set and maintained quality standards and limited entry into an industry by requiring apprenticeships. Guilds were quite pervasive in Middle Eastern cities until the late nineteenth century.[24] Moreover, vestiges of the guild structure have been found in cities in the modern Arab world.[25]

Guilds in the Middle East punished members who sold inferior products with fines or banishment. Le Tourneau (1961) writes how guilds in fourteenth century Fez policed their members and used the pillory to alert consumers to violations in the 'honor of the trade'.

> If by chance one of them failed in this respect, everyone rose in protest against him, beginning with his peers, for the dishonor he incurred might affect them. ... There existed for many of the guilds a pillory where defective articles were exposed with

> the name of the inferior worker; thus the whole city quickly knew that so-and-so was a dishonest artisan and he had no other expedient but to leave the city. (p. 105)

Baer (1964, pp. 93–100), writing on Egypt, does not mention pillories, but describes how the *shaykh*, the leader of the guild, would guarantee the honesty of a guild member or the quality of members' services.[26] While the *shaykh* had this responsibility, he also was able to punish errant guild members by imposing fines or expelling them from the guild.

Guilds in the Middle East also limited the number of people exercising a trade. They limited entry by requiring that new members serve as apprentices or register with the *shaykh* of the guild. A manuscript written in the seventeenth century by a member of the guild of physicians and barbers describes a formal guild structure with ranks and offices. A boy entering the guild had to pass through four 'gates' (*abwab*) before becoming a master. Passage from one level to another was accompanied by elaborate ceremonies (Baer 1964, pp. 49–62). Guilds in Syria had similar ranks and rituals (Baer 1964, pp. 60–1).

As in medieval Europe, in Egypt guilds fought over jurisdictions and amalgamated to prevent rivalries (Cole 1993, pp. 179–83).

### *Professional associations in the United States*

Modern professional associations in the United States often have remarkably similar functions to those of medieval guilds. They limit entry into a profession by stipulating education requirements and administering licence examinations, albeit with government authorization.[27] The Federal Trade Commission reports that 'over 800 occupations are licensed by at least one of the fifty states' (Cox and Foster 1990). Often state licensing boards are controlled by professional associations. Professional associations assert that these licensing and entry requirements are necessary to assure that professionals provide high-quality services. I discuss here the organization and function of two professional associations: the American Medical Association, and the US Hotel Employees and Restaurant Employees International Union.

The American Medical Association is a canonical professional association. Effectively, the AMA decides on the number of physicians, since it sets the licensing exams and certification criteria for medical schools. Starr's (1982) history of the US medical profession records this consolidation of the profession by the AMA. Until the 1870s there was free entry into medical practice in the United States. Independent (private) medical societies that attempted to regulate the profession were unable to delineate the boundaries of the 'legitimate' medical profession. The, eventually successful, movement to restrict the profession began in the mid-1800s. The main impetus came from practitioners who could not distinguish themselves from 'quacks'. The original goal of the AMA, embodied in a code of professional ethics, was to regularize the profession and thereby to eliminate competition from untrained practitioners. State licensing, medical boards and school certification were all eventually controlled by the AMA.

The effect of these entry requirements was, not surprisingly, a dramatic fall in the number of physicians and an accompanying increase in their salaries.

Physicians' average real incomes more than doubled in the early twentieth century (Starr 1982, pp. 125–6, 142). With the elimination of 'quacks', the average quality of medical practice also dramatically improved.

Craft unions are another example of members of the same profession joining together to limit entry and monitor performance. Cobble (1991) relates the history of the US Hotel Employees and Restaurant Employees International Union from the 1900s to the 1960s. To ensure the quality of its members' services, the union set strict standards whose breach could be grounds for fines or blacklisting. Local branches of unions held trials to prosecute members who had been accused by employers of inadequate performance. Moreover, the union set entry requirements. The union's locals won closed-shop agreements or preferential hiring agreements with area employers. Employers accepted the union's control of the workforce, according to Cobble (1991, p. 429), because the union provided 'trained, competent labor and [oversaw] employee job performance'.[28]

All of the institutions discussed above set and enforced quality standards and restricted entry into their industries. In all cases the stated objectives of the organizations were to improve quality. The analysis in this paper provides theoretical grounds for the argument that entry barriers can enhance quality. There are also historical indications that these organizations' entry barriers did indeed prevent competition from eroding quality. In the case of the European craft guilds, there is evidence that quality suffered when members of different guilds competed in intersecting markets. In case of the AMA, the entry requirement allowed legitimate physicians to separate themselves from fraudulent physicians. Finally, employers essentially granted the waitresses' union a monopoly, indicating that the union's members did, indeed, provide high-quality services.

## IV. Conclusion

This paper shows formally that, when quality is unobservable to consumers prior to purchase, price competition can eliminate the profits necessary to induce firms to produce high-quality goods. In this case, industry associations may play a role in guaranteeing product quality.

The formal results in this paper counter the conventional wisdom in the United States that competition motivates firms to provide the highest quality at the lowest price. This reasoning is exemplified by the US 1978 Supreme Court decision *National Society of Professional Engineers* v. *U.S.*[29] The Society's canon of ethics prohibited its members from submitting competitive bids for engineering services, and the United States sued the Society for violating the Sherman Act. The Society defended its ban on competitive bidding, arguing that competition would result in unsafe construction: '[t]he Society [argues] that its restraint on price competition ultimately inures to the public benefit by preventing the production of inferior work and ensuring ethical behavior'.

While the Court analysed this case under the Rule of Reason, it specifically rejected any defense based on reasons pertaining to quality, safety or public welfare. It held that only 'reasons' pertaining to competitive conditions were relevant, and confirmed that '[t]he Rule of Reason does not support a defense

based on the assumption that competition is itself unreasonable'. Thus, the Court found that the Society's ban on competitive bidding violated the Sherman Act.

Moreover, the Court reaffirmed the proposition embodied in the Sherman Act that 'ultimately competition will produce not only lower prices, but also better goods and services'. In commenting on the decision, Posner and Easterbrook (1981, p. 161) argue that, since consumers are willing to pay high prices for high-quality goods, 'only a lack of information would lead to improperly low-quality, [and there is no reason] why competition would produce too little product information for consumers'. They further suggest that, when there is a lack of information, tort law and direct regulation of product safety are adequate to ensure that firms meet minimum 'economic' or 'political' demands for quality.

If we interpret the low-quality level in this model, as in Shapiro (1983), as the maximum quality enforceable by warranties or by law, the analysis here demonstrates that consumers' willingness to pay for higher-quality goods, reinforced by their refusal to buy from firms that sell low quality, might be insufficient to maintain prices at or above the quality-assuring price. Collusive arrangements, perhaps facilitated by trade associations or other market institutions, or regulations that protect firms' profits, could be necessary for the production of goods of higher quality. Efforts by firms in an industry to limit price competition, such as bans on competitive bidding or price advertising, could, indeed, ensure that firms have the incentive to produce high quality goods.[30]

Nonetheless, I do not claim that allowing firms to collude or protecting firms' profits by regulation is without losses to economic efficiency. In the model in this paper, the price for high-quality goods affects only the distribution of surplus between firms and consumers—not economic efficiency. If consumers were heterogeneous and the demand for high-quality goods inversely related to price, allowing firms to collude or to inhibit price competition without regulatory oversight, could, of course, lead to the well-known welfare losses from pricing above marginal cost.[31] This paper, however, shows that there could exist a trade-off between these familiar welfare losses and welfare gains from high-quality production.

## APPENDIX: FIRMS' STRATEGY SPACES

For $I \geqslant 2$ firms, let $P_i$ be the pricing action space for firm $i$: $P_i = [0, v^H]$. Let $Q_i$ be the quality action space for firm $i$: $Q_i = \{(\text{L})\text{ow}, (\text{H})\text{igh}\} \cup \varnothing$. Let $P = \times_{i \in I} P_i$; $Q = \times_{i \in I} Q_i$; Let $A = P \times Q$ (set of all possible actions). Let $p^t \equiv (p_1^t, p_2^t, ..., p_I^t)$ and $q^t \equiv (q_1^t, q_2^t, ..., q_I^t)$.

Let $h^t$ be the history of actions at the beginning of period $t$. Furthermore, in period $t$ define $h1^t$ to be the history of actions at the point that firms set prices. Let $h2^t$ be the history at the point that consumers choose firms, and let $h3^t$ be the history at the point that firms choose quality. So $h1^t = h^t$, $h2^t = (h1^t, p^t)$, $h3^t = (h2^t, \sigma^t)$. Let $H^t$ denote the set of all period $t$ histories: $H^t = (A)^t$. Analogously, define $H1^t$, $H2^t$, $H3^t$: $H1^t = (A)^t$, $H2^t = H1^t \times P$, $H3^t = H2^t \times \sigma$, where $\sigma$ is all the possible assignments of market shares. The game begins in period 0 with consumers already assigned to firms so that each firm begins with some positive market share: $\sigma_i^{-1} > 0$ for all firms $i$. For $t \geqslant 0$, $h^t = (\sigma^{-1}, p^0, \sigma^0, q^0, p^1, \sigma^1, q^1, ..., p^{t-1}, q^{t-1}, \sigma^{t-1})$.

'Restricted' histories (denoted by the subscript $r$) are the domain of 'non-collusive' strategy spaces. Let $h1^t_r = (q^0, q^1, ..., q^{t-1})$ This is the complete quality history of the game. Let $h2^t_r = (h1^t_r, p^t)$. Let $h3^t_r = (h2^t_r, \sigma^t)$. Analogously define $H1^t_r$, $H2^t_r$, $H3^t_r$. Note that I put restrictions on histories to represent behaviour, not knowledge.

A pure 'non-collusive' pricing strategy for firm $i$, $p_i$, is a sequence of maps, $p^t_i$—one for each period—from $h1^t_r \in H1^t_r \rightarrow p_i \in P_i$. A pure 'non-collusive' quality-setting strategy for firm $i$, $q_i$, is a sequence of maps, one for each period: $q^t_i$: $h3^t_r \in H3^t_r \rightarrow q_i \in Q_i$. A pure 'collusive' pricing strategy for firm $i$, $\rho_i$, is a sequence of maps: $\rho^t_i$: $h^t \in H^t \rightarrow p_i \in P_i$. A pure 'collusive' quality-setting strategy for firm $i$, $\kappa_i$, is a sequence of maps, one for each period: $\kappa^t_i$: $h3^1 \in H3^i \in H3^t \rightarrow q_i \in Q_i$.

*Proof of Lemma 1*

Consider some period $\tau \geqslant t+1$, given that firm $i$ produced low quality in $t$. Working 'backwards' in the stage game, we check firms' and consumers' incentives to deviate.

*No deviation in quality*. For firm $i$, given that $Q^\tau_i = L$, all players' strategies do not depend on firm $i$'s quality choice in period $\tau$. Consumers do not buy, and all other firms act optimally, given their new market shares. Because of consumers' behaviour, these shares are not impacted by a firm $i$'s quality choice. For any choice of quality $q^\tau_i$, all players' future play is the same. Therefore, firm $i$ should maximize its current period payoffs and produce low quality, $q^\tau_i = L$. To confirm this, examine the firm $i$'s quality choice in $\tau$. When firm $i$ produces low quality, it earns $\prod^L_i (c_L, \mathbf{p}_{-i}, \sigma^\tau)$:

$$\text{(A1)} \qquad \prod^L_i (c_L, \mathbf{p}_{-i}, \sigma^\tau) = (c_L - c_L)\sigma^\tau_i(c_L, \mathbf{p}_{-i}) + \sum_{s=\tau+1}^{\infty} \delta^{s-\tau}\pi_i(p^s(L), p^s_{-i}(L), \sigma^s(L)),$$

where $\pi_i$ indicates firm $i$'s profits in future periods, given its future prices, the prices of other firms and market shares, which all depend (among other things) on the firm $i$'s production of low quality in period $t$. If firm $i$ produces high quality in period $\tau$, it earns $\prod^H_i (c_L, \mathbf{p}^{-i}, \sigma^\tau)$:

$$\text{(A2)} \qquad \prod^H_i (c_L, \mathbf{p}_{-i}, \sigma^\tau) = (c_L - c_H)\sigma^\tau_i(c_L, \mathbf{p}_{-i}) + \sum_{s=\tau+1}^{\infty} \delta^{s-\tau}\pi_i(p^s(L), p^s_{-i}(L), \sigma^s(L)).$$

As discussed above, the strategies specify that the last term in (A1) and (A2) are the same. Therefore, since $c_H > c_L$, firm $i$ will always produce low quality after its deviation.

*No deviation in firm choice*. From (A1), firm $i$ is (credibly) promising to produce low-quality goods. Consumers would, therefore, earn negative net utility by choosing this firm at at a price above $c_L$.

*No deviation in price*. Setting a price above $c_L$, firm $i$ would be offering strictly lower consumer surplus, and therefore would not have any consumers. Setting a price below $c_L$ gives firm $i$ strictly negative profits. Therefore, since $p^\tau_i = c_L$ and $q^\tau_i = L$, firm $i$ earns zero profits in all $\tau \geqslant t+1$.

Lastly, to consider the credibility of moves at all possible subgames, consider the possibility that all firms but one have produced low quality at some point in the past. Setting the price at $\bar{p}$ maximizes this firm's profits. It will not have an incentive to deviate in quality, according to the arguments above. □

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## NOTES

1. This principle is spelled out in numerous court decisions For citations, see Heidt (1989) and Van Den Bergh and Faure (1991).
2. Price-fixing is a well-known violation of the Sherman Act. In the past decade, however, Supreme Court decisions have begun to erode the application of the *per se* rule when judging price-fixing cases. For discussion of these decisions, see Wirtz (1987) and Schmalensee (1992). *National Society of Professional Engineers* v. *US*, a 1978 US Supreme Court case that explicitly involved a pricing agreement and its effect on quality, is discussed in the Conclusion.
3. Chiang and Masson (1988) consider the relationship between industrial structure and firms' incentives to produce high quality when firms are subject to a form of statistical discrimination. Consumers cannot observe the quality of an individual firm's output, but they know the average quality of an industry's output. In this case, each firm has less incentive to raise its quality level because it does not receive the full benefit of investment.
4. Indeed, Shapiro recognizes the difficulty of sustaining a high-quality equilibrium with rational consumers. He writes that in his model 'there is no equilibrium with fully rational expectations about new products' (p. 667). Another way to understand this problem is to note that the equilibrium in his paper is a Nash equilibrium, but not a subgame-perfect equilibrium. Consumers act according to a new firm's 'threat' to produce low quality, even when this threat is not credible.
5. Restricting firms from using collusive pricing strategies eliminates tacit price collusion in oligopoly supergames. For a discussion of tacit collusion in oligopoly supergames, see Tirole (1988, chapter 6).
6. See Scherer and Ross (1990, pp. 311–15 and 347–52), for further discussion of institutions such as trade associations and social networks that can co-ordinate pricing behaviour and facilitate tacit collusion in an industry.
7. In general, the price affects the incentive to produce high quality only to the extent it affects the difference in total production costs. To see this, for a given price $p$, let $Q(p)$ be the quantity demanded. Let $C_H(q)$ and $C_L(q)$ be the total costs of producing high-quality and low-quality goods, respectively. A firm that produces high quality earns $p \cdot Q(p) - C_H(Q(p))$ and a firm that produces low quality earns $p \cdot Q(p) - C_L(Q(p))$. The gain from 'cheating' and producing low quality is then simply $C_H(Q(p)) - C_L(Q(p))$. With constant marginal production costs, this difference is independent of quantity and, therefore, of price.
8. For convenience, I simplify the notation used in body of the paper. Interested readers are referred to the Appendix for complete notation and specification of the game.
9. This timing models 'made-to-order' purchases, when consumers must pay for a good prior to production. With this timing, the game is a multi-stage game with observed actions. Consequently, a refinement 'stronger' than subgame perfection is not needed for the results obtained here.
10. That is, consumers do not base their purchasing decision on firms' past prices *per se*. With this assumption, consumers do not punish firms that have sold high-quality goods at a discounted price, and I rule out equilibria that rest on such unrealistic consumer behaviour.
11. If firms were not symmetric, the analysis below must consider the firm that has the greatest incentive to cut its price.
12. See the Appendix for full specification of firms' strategy spaces.
13. For simplicity, I restrict attention here to equilibria without price dispersion on the equilibrium path.
14. Formally, if $Q_i^t = L$ for any firm $i$, then for firm $i$, $p_i^\tau = c_L$ and $q_i^\tau = L$ in all periods $\tau \geqslant t+1$. In a switching cost model, the values of high quality, $v^H$, would be high enough that consumers would credibly switch to firms offering high quality at price $p^*$.
15. Technically, this firm strategy depends on the firms' past *quality* decisions. It says that, if a firm finds itself the only firm that consumers are willing to 'believe' will produce high quality, the firm will act as a monopolist in high quality.
16. More precisely, 'minimax' payoffs as defined in Fudenberg and Tirole (1991, p. 150) are the lowest payoffs a player $i$'s opponents can hold him to, given that player $i$ plays a best response to its opponents' strategies.
17. Firm $i$ can always set $p_i^t \geqslant c_L$. Given that it has set $p_i^t \geqslant c_L$, if $\sigma_i^t > 0$, firm $i$ can produce low quality, and, if $\sigma_i = 0$, firm $i$ earns zero profits.
18. The most extreme punishment I consider in this paper is exiting an industry. Of course, more severe penalties such as prison terms or corporal punishment would raise the punishment for a firm that cheats consumers.
19. A larger, but still small, literature considers the relationship between firm' incentives to produce high quality and the information available to consumers. This literature typically does not address competitive effects on quality. For a review of this literature and a study of restaurant quality in Los Angeles, see Jin and Leslie (2000).

20. There is also some countervailing evidence. Domberger and Sherr (1989), for example, find that competition reduced the price and increased customer satisfaction of routine legal services in the United Kingdom.
21. Craft guilds are distinct from the merchant guilds, organizations of merchants that cooperated to protect their ability to engage in long-distance trade, which are analysed in Greif *et al.* (1994).
22. On craft guilds in medieval Europe, see, e.g. Black (1984), Brentano (1870), Epstein (1991), Pirenne (1936), Renard (1918), Thompson (1928), Thrupp (1963), Unwin (1908). Guild activities also included collecting funds for members in financial emergencies, supporting chapels and religious orders, and providing personnel and goods to city governments for military operations.
23. Gustafsson (1987) argues that craft guilds in medieval Europe were founded primarily to guarantee minimum product quality and stable incomes for its members. Gustafsson's study is rich in historical detail of German guilds and I cite his work below, but he does not address why the reputation mechanism was ineffective in solving the moral hazard problem.
24. Kuran (1989) investigates the disappearance of guilds in Tunis in the late nineteenth century. He argues that guilds and their leaders, the *amins*, did not successfully adjust to the 'new' 'capitalist' economic system, but adhered to traditional forms of production and market organization. Thus, the disappearance of guilds is an example of 'institutional atrophy'.
25. Assaad (1991) found that in Cairo construction workers organize themselves into distinct neighbourhood groups. These groups provide training for 'apprentices' and control the hiring of workers. Geertz (1979) records the existence of 'guilds' (although he disputes that designation) in Sefrou, Morocco.
26. Guilds were not limited to artisans but included domestic servants, masons, porters, etc.
27. See Blair and Rubin (1980).
28. The union's efforts, however, ended in the late 1950s with the extension of the Taft–Hartley Act to the hotel and restaurant industry and the passage of the Landrum–Griffin Act. Closed shops and expulsion of members from a union for violation of its bylaws became illegal. Local branches lost the ability to set and enforce standards and control entry to the profession.
29. *National Society of Professional Engineers* v. *United States*, 435 U.S. 679, (1978).
30. Rogerson (1988) also examines the effect of price advertising on product quality. He finds that price advertising can improve economic welfare when price is a signal of quality because price advertising can reduce consumers' search costs. In his analysis, however, quality is not a choice variable; firms do not have the opportunity to 'cheat' their consumers. Quality is unknown to the consumer before she visits a firm, but is observable prior to purchase.
31. Note that when demand is inversely related to price, $p^*$ itself would be an inefficient price because $p^* > c_H$.

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