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The Role of Market Forces in Assuring Contractual Performance

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The conditions under which transactors can use the market (repeat-purchase) mechanism of contract enforcement are examined. Increased price is shown to be a means of assuring contractual performance. A necessary and sufficient condition for performance is the existence of price sufficiently above salvageable production costs so that the nonperforming firm loses a discounted stream of rents on future sales which is greater than the wealth increase from nonperformance. This will generally imply a market price greater than the perfectly competitive price and rationalize investments in firm-specific assets. Advertising investments thereby become a positive indicator of likely performance.

I. Introduction

An implicit assumption of the economic paradigm of market exchange is the presence of a government to define property rights and

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enforce contracts. An important element of the legal-philosophical tradition upon which the economic model is built is that without some third-party enforcer to sanction stealing and reneging, market exchange would be impossible.[1] But economists also have long considered "reputations" and brand names to be private devices which provide incentives that assure contract performance in the absence of any third-party enforcer (Hayek 1948, p. 97; Marshall 1949, vol. 4, p. xi). This private-contract enforcement mechanism relies upon the value to the firm of repeat sales to satisfied customers as a means of preventing nonperformance. However, it is possible that economic agents with well-known brand names and reputations for honoring contracts may find it wealth maximizing to break such potentially long-term exchange relationships and obtain a temporary increase in profit. In particular, the determinants of the efficacy of this market method of contract performance and therefore the conditions under which we are likely to observe its use remain unspecified.

This paper examines the nongovernmental repeat-purchase contract-enforcement mechanism. To isolate this force, we assume throughout our analysis that contracts are not enforceable by the government or any other third party. Transactors are assumed to rely solely on the threat of termination of the business relationship for enforcement of contractual promises.[2] This assumption is most realistic for contractual terms concerning difficult-to-measure product characteristics such as the "taste" of a hamburger. However, even when the aspects of a contract are less complicated and subjective and therefore performance more easily measurable by a third party such as a judge, specification, litigation, and other contract-enforcement costs may be substantial. Therefore, explicit guarantees to replace or repair defective goods (warranties) are not costless ways to assure contract performance. Market arrangements such as the value of lost repeat purchases which motivate transactors to honor their promises may be the cheapest method of guaranteeing the guarantee.

While our approach is general in the sense that the value of future exchanges can motivate fulfillment of all types of contractual prom-

[1] Hobbes ([1651] 1955, pp. 89–90) maintains that ". . . he that performeth first, has no assurance the other will perform after; because the bonds of words are too weak to bridle men's ambition, avarice, anger, and other Passions, without the fear of some coercive Power; which in the condition of here Nature, where all men are equal, and judges of the justness of their own fears cannot possibly be supposed."

[2] This assumption is consistent with the pioneering work of Macaulay (1963), where reliance on formal contracts and the threat of explicit legal sanctions was found to be an extremely rare element of interfirm relationships. Macaulay provides some sketchy evidence that business firms prevent nonfulfillment of contracts by the use of effective nonlegal sanctions consisting primarily of the loss of future business. This "relational" nature of contracts has been recently emphasized by Macneil (1974), and also by Goldberg (1976) and Williamson (1979).

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ises, we focus in this paper on contracts between producers and consumers regarding product quality. In order for a repeat-sale enforcement mechanism to operate, we assume that the identity of firms is known by consumers[3] and that the government enforces property rights to the extent that consumers voluntarily choose whom to deal with and must pay for the goods they receive.[4] In addition, managers of firms are assumed to be wealth maximizing and to place no value on honesty per se.

In Section II, the conditions are outlined under which firms will either honor their commitments to supply a high level of quality or choose to supply a quality lower than promised. In order to emphasize the ability of markets to guarantee quality in the absence of any government enforcement mechanism, a simple model is presented which assumes that consumers costlessly communicate among one another. Therefore, if a firm cheats and supplies to any individual a quality of product less than contracted for, all consumers in the market learn this and all future sales are lost. A major result of our analysis is that even such perfect interconsumer communication conditions are not sufficient to assure high quality supply. Cheating will be prevented and high quality products will be supplied only if firms are earning a continual stream of rental income that will be lost if low quality output is deceptively produced. The present discounted value of this rental stream must be greater than the one-time wealth increase obtained from low quality production.

This condition for the "notorious firm" repeat-purchase mechanism to assure high quality supply is not generally fulfilled by the usual free-entry, perfectly competitive equilibrium conditions of price equal to marginal and average cost. It becomes necessary to distinguish between production costs that are "sunk" firm-specific assets and those production costs that are salvageable (i.e., recoverable) in uses outside the firm. Our analysis implies that firms will not cheat on

[3] Nonidentification of firm output leads to quality depreciation via a standard externality argument; i.e., supply by a particular firm of lower than anticipated quality imposes a cost through the loss of future sales not solely on that firm but on all firms in the industry (see Akerlof 1970; Klein 1974).

[4] For simplicity, we assume that "theft," as opposed to nonfulfillment of contract, is not possible. While "fraud," in the sense of one party to the transaction intentionally supplying less than contracted for, is analytically similar to "theft," we draw a distinction along this continuum by assuming that the government only permits "voluntary" transactions in the sense that transactors choose whom to trade with. Therefore, while consumers cannot "steal" goods, they can, in principle, pay for the goods they receive with checks that bounce; and while firms cannot rob consumers, they can, in principle, supply goods of lower than promised quality. Although we recognize the great difficulty in practice of separating the underlying government enforcement mechanisms, e.g., property law, from the private promise-enforcing mechanisms we are attempting to analyze, this distinction between theft and fraud is analytically unambiguous.

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promises to sell high quality output only if price is sufficiently above salvageable production costs. While the perfectly competitive price may imply such a margin above salvageable costs, this will not necessarily be the case. The fundamental theoretical result of this paper is that market prices above the competitive price and the presence of nonsalvageable capital are means of enforcing quality promises.[5]

In Section III our theoretical model of quality-guaranteeing price premiums above salvageable costs is extended to examine how the capital value of these price-premium payments can be dissipated in a free-entry equilibrium. The quality-guaranteeing nature of nonsalvageable, firm-specific capital investments is developed. Alternative techniques of minimizing the cost to consumers of obtaining an assured high quality are investigated. We also explore market responses to consumer uncertainty about quality-assuring premium levels. Advertising and other production and distribution investments in "conspicuous" assets are examined as competitive responses to simultaneous quality and production-cost uncertainties. Finally, a summary of the analysis and some concluding remarks are presented in Section IV.

II. Price Premiums and Quality Assurance

Assume initially that consumers costlessly know all market prices and production technologies but not the qualities of goods offered for sale. For simplicity, the good being considered is assumed to be characterized by a single objective quality measure, q, where quality refers to the level of some desirable characteristic contained in the good. Examples are the quietness of appliance motors, the wrinkle-free or colorfast properties of clothing, or the gasoline mileage of an automobile. We also assume that the economy consists of consumers who consider buying a product x each period, where the length of a period is defined by the life (repurchase period) of product x, and who are assumed to costlessly communicate quality information among one another. Therefore, if a particular firm supplies less-

[5] The notion that an increased price can serve as a means of assuring high quality supply by giving the firm a rental stream that will be lost if future sales are not made is not new. Adam Smith ([1776] 1937, p. 105) suggested this force more than 200 years ago when he noted that "the wages of labour vary according to the small or great trust which must be reposed in the workman. The wages of goldsmiths and jewellers are everywhere superior to those of many other workmen, not only of equal, but of much superior ingenuity; on account of the precious metals with which they are intrusted. We trust our health to the physician; our fortune and sometimes our life and reputation to the lawyer and attorney. Such confidence could not safely be reposed in people of a very mean or low condition." Similar competitive mechanisms recently have been analyzed by Becker and Stigler (1974) and Klein (1974).

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than-contracted-for quality to one consumer, the next period all consumers are assumed to know. In addition, this information is assumed not to depreciate over time.[6]

Identical technology is assumed to be available to all entrepreneurs. Hence, there are many potential firms with identical total cost functions, $C = c(x,q) + F(q)$, where F is fixed (invariant to rate) costs. Higher quality and larger quantities require higher production costs, $F_q > 0$, $c_q > 0$, $c_x > 0$, and marginal cost is assumed to increase with quality, $c_{xq} > 0$. Fixed costs are assumed initially to be expenditures made explicitly each period rather than capital costs allocated to the current period. For example, they may include a payment on a short-term (one-period) rental agreement for a machine but not the current forgone interest on a purchased machine or the current period's payment on a long-term rental agreement—both of which imply long-term and hence capital commitments.

We therefore are explicitly distinguishing between "fixed" costs in the sense employed here of constant (invariant to output) current costs and "sunk" (nonsalvageable) capital costs. The usual textbook proposition that a firm will not shut down production as long as price is greater than average variable cost blurs this distinction and implicitly assumes that all fixed costs are also sunk capital costs. Our assumption of the complete absence of any long-term commitments is analytically equivalent to perfect salvageability of all capital assets. If all long-term production-factor commitments were costlessly reversible, that is, all real and financial assets such as the machine or the long-term machine rental contract could be costlessly resold and hence perfectly salvageable, there also would not be any capital costs. Only the nonsalvageable part of any long-term commitment should be considered a current sunk capital cost.

If buyers are costlessly informed about quality, the competitive price schedule, P_c, for alternative quality levels is given by the minimum average production costs for each level of quality and is designated by $P_c = P_c(q)$. This is represented in figure 1 for two alternative quality levels, q_h and $q_{\min}$, by the prices P_1 and P_0. Suppose, however, that the quality of product x cannot be determined costlessly before purchase. For simplicity, assume prepurchase inspection reveals only whether quality is below some minimum level, $q_{\min}$, and that

[6] If we modify the assumptions of our model to make interconsumer communication less than perfect and allow inflows of new ignorant consumers over time and permit individuals to forget, the potential short-run cheating gain by firms would be increased. Therefore, the quality-assuring price premium would be higher than we derive below. In this case increased firm size, by making it more likely that the individuals one is sharing product-quality information with (e.g., family and friends) have purchased from the same firm, lowers the potential short-run cheating gain by essentially reducing the repurchase period.

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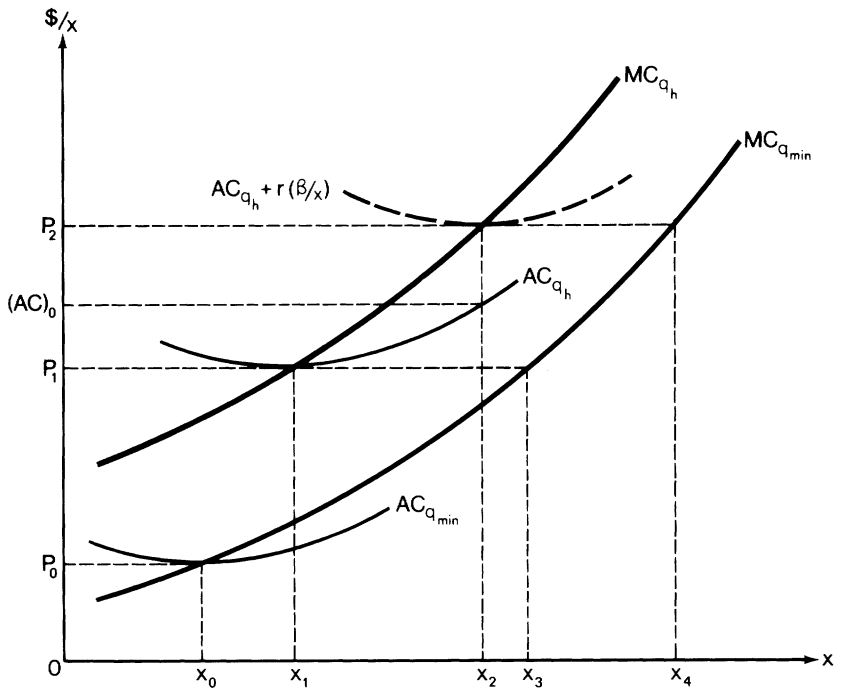

FIG 1.—Pricing and production of alternative quality levels

the costs are prohibitive of determining whether quality is above q_{min} prior to purchase.[7] Obviously, whenever the market price that consumers will pay for asserted high quality exceeds the cost of producing minimum quality output, the firm can increase its initial period profits by producing the minimum quality output and deceptively selling it as a higher quality product.

If producers are to have an incentive to produce high quality products (in the absence of governmentally enforceable contracts), consumers must somehow reward high quality production and punish low quality production. We assume in this competitive framework that consumers will purchase from particular sellers randomly chosen from the group of homogeneous sellers over which consumer information is transmitted. If a consumer receives a product of a quality at least as high as implicitly contracted for, he will continue to purchase randomly from this group of sellers. On the other hand, if quality is less than contracted for, all consumers cease to purchase from the particular sampled "cheating" firm.

[7] The quality of the good beyond the minimum level is therefore what Nelson (1970) has labeled as an "experience" characteristic. Making the minimum quality level endogenous does not substantially change the following analysis.

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Consider now an initial "competitive" equilibrium in which a single firm contemplates selling a quality below that expected by customers. Given the competitive market price for some high quality, $P_c(q_h) \equiv P_1$ in figure 1, this particular firm could increase its initial period quasi rents by producing minimum quality and selling it at the high quality price. However, since buyers are assumed to communicate fully with one another, all future customers of high quality output, that is, sales at prices greater than $P_c(q_{\min}) \equiv P_0$ in figure 1, are lost. That is, a firm that cheats will become known as a "notorious" cheater, and consumers will not purchase from the firm any product the quality of which cannot be determined prepurchase.[8]

Whether sales of high or minimum quality will maximize the firm's wealth depends on whether the capital value of future quasi rents from continued high quality production exceeds the differential initial period quasi rents from quality depreciation. In terms of figure 1, at the perfectly competitive price for high quality output, P_1, price is equal to the average costs of high quality production. Therefore, the quasi rents from continued high quality production are zero. If, alternatively, the firm were to deceptively produce minimum quality output, as a price taker it would expand its production to x_3 (where $P_1 = MC_{q_{\min}}$) and receive a one-period quasi rent, the present value of which is equal to:

$$W_1 = \frac{1}{1+r}\left\{(P_1 - P_0)x_3 - \int_{x_0}^{x_3}[MC_{q_{\min}}(x) - P_0]dx\right\}. \qquad (1)$$

Therefore, at the perfectly competitive price for any quality above $q_{\min}$ firms will always cheat consumers and supply $q_{\min}$.

Faced with this possibility, consumers would recognize that regardless of producers' promises they will not obtain the higher quality product. Therefore, consumers would be willing to pay only the costless information price of the minimum quality product whose quality they can verify prepurchase, P_0. Because of such rational consumer anticipations, firms will not be able to cheat, but desired high quality output will not be supplied.

There may, however, be a price higher than the perfectly competitive price of high quality output, P_1, that if it were the equilibrium market price would (*a*) motivate honest production of the high quality good and (*b*) not completely dissipate the consumers' surplus from purchase of higher quality. Consider a price such as P_2 in figure 1. A

[8] A terminated firm cannot begin business in this industry under a new name. However, the highest valued alternative use of the entrepreneurial skills is included in salvageable fixed production costs. The firm considered here is assumed to face the same opportunities elsewhere as the firms that are honest in production of x. Therefore, the cheating firm can elect to enter a new industry.

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firm supplying high quality output will now expand its production to x_2. The price premium $\tilde{P}$, defined as the increase in the price above minimum average cost of high quality, provides firms supplying high quality with a perpetual stream of quasi rents the present value of which (assuming unchanging cost and demand conditions over time) is equal to:

$$W_2 = \frac{1}{r}\left\{\tilde{P}x_2 - \int_{x_1}^{x_2}[MC_h(x) - P_1]dx\right\}. \tag{2}$$

The price premium also increases the gains to a firm from supplying minimum quality at the high price. A firm that chooses to cheat will now expand its output (in terms of fig. 1 to x_4) and earn the extra premium on all units sold.[9] Therefore, the capital value of the quasi rents from supplying quality less than promised is:

$$W_3 = \frac{1}{1+r}\left\{[\tilde{P} + (P_1 - P_0)]x_4 - \int_{x_0}^{x_4}[MC_{q_{\min}}(x) - P_0]dx\right\}. \tag{3}$$

A firm will honor its implicit quality contract as long as the difference between the capital values of the noncheating and cheating strategies, $W_2 - W_3$, is positive. Consider the quasi-rent flow of the cheating and noncheating alternatives, that is, the terms in braces in our expressions (2) and (3). Define QR_2 equal to rW_2 and QR_3 equal to $(1 + r)W_3$. A firm will then elect not to cheat if and only if:

$$\frac{QR_3}{QR_2} \leqslant \frac{(1+r)}{r}. \tag{4}$$

Therefore, there will be a price premium that motivates firms to honestly produce high quality as long as:

$$\lim_{\tilde{P}\to\infty}\left(\frac{QR_3}{QR_2}\right) \leqslant \frac{(1+r)}{r}. \tag{5}$$

Using L'Hospital's rule, equation (5) will be satisfied as long as

$$\frac{1}{r} > \frac{(x_4 - x_2)}{x_2} \tag{6}$$

for all $P > P_3$, where P_3 is some finite price. Intuitively, as the price increases it is only the increase in quasi rents on the additional units of minimum quality output that favors the deceptive strategy. Equation (6) insures that price increases beyond some level increase W_2 more than W_3 such that eventually W_2 is greater than W_3.

[9] Note that although x_2 may be greater or less than x_3, depending on the price premium chosen, given upward-sloping supply functions and the condition that $MC_{q_h}(q) > MC_{q_{\min}}(q)$ for all q, it must be the case that $x_4 > x_2 > x_1$.

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The condition specified in equation (6) is quite reasonable. It will be satisfied as long as a cheating firm does not accompany cheating with very large output increases. If, for example, the real interest rate were .05 we require only that the output increase by a cheating firm not be more than 20 times the total output that would be produced if the firm were not cheating. Hence, under very general cost conditions a price premium will exist that motivates competitive firms to honor high quality promises because the value of satisfied customers exceeds the cost savings of cheating them.[10]

While we cannot state broad necessary conditions for the form the cost function must take to imply the existence of a quality-assuring price, "reasonable" sufficient conditions can be stated. In particular, all cases of vertically parallel marginal cost curves, as illustrated in figure 1, where quality is produced by a fixed input not subject to decreasing returns to scale (such as the use of a better motor) and where the second derivative of marginal cost is greater than or equal to zero imply the existence of a quality-assuring price. The Appendix contains simulation results under the more unrealistic assumption of isoelastic marginal cost functions. These simulations indicate the exceptional nature of the conditions when equation (6) is not satisfied. When a quality-assuring price does not exist, the cost functions are generally such that at reasonable premiums cheating output would be expanded by very large factors (often factors of many thousands). Since marginal cost functions for most products can be expected to become quite steep if not vertical at output expansions of much less than these factors, a quality-assuring price premium can generally be expected to exist.

Throughout the remainder of the paper we assume the existence of a quality-assuring price. For given cost and demand conditions, the minimum quality-assuring price will depend upon the level of quality

[10] The potential function of price premiums as quality guarantors is also applicable to markets in which firms face downward-sloping demands. In this case, the inability of firms to increase sales without reductions in price limits the gains available from deceptive minimum quality production as price increases. The existence of a price sufficient to guarantee quality now depends on the elasticity of demand in addition to the cost savings from quality reductions at various quantities. In addition, when price-searching firms do not have stable future demands, consumer knowledge of cost and current demand conditions is not sufficient to estimate the quality-assuring price. The anticipated future demand vis-à-vis current demand is also relevant. For example, where consumers expect a growing demand for the output of a firm that continues to produce high quality output, the rate of quasi-rent flow from high quality (or future deceptive minimum quality) production increases over time. As compared to a firm with the same initial but constant demand, the growing firm will receive a larger capital value return at any price from high quality production in the initial period. Firms facing expected demand growth will therefore require smaller quality-assuring price premiums. See Klein, McLaughlin, and Murphy (1980) for an analysis of the less than perfectly elastic firm demand case.

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considered and is denoted by $P^* = P^*(q, q_{\min}, r)$. Our analysis implies that the quality-assuring price will increase as quality increases, as minimum quality decreases (for all q greater than $q_{\min}$), and as the interest rate increases. These conditions are consistent with the familiar recognition that, given a particular quality level, quality-cheating problems are less severe the higher the level of quality that can be detected prepurchase and the shorter the period of repurchase.[11]

Intuitively, the quality-assuring price treats the potential value of not producing minimum quality as an explicit opportunity cost to the firm of higher quality production. Hence the quality-assuring price must not only compensate the firm for the increased average production costs incurred when quality above that detectable prior to purchase is produced, but must also yield a normal rate of return on the forgone gains from exploiting consumer ignorance. This price "premium" stream can be thought of as "protection money" paid by consumers to induce contract performance. Although the present discounted value of this stream equals the value of the short-run gain the firm can obtain by cheating, consumers are not indifferent between paying the "premium" over time or permitting the firm to cheat. The price "premium" is a payment for high quality in the face of prepurchase quality-determination costs. The relevant consumer choice is between demanding minimum quality output at a perfectly competitive (costless information) price or paying a competitive price

[11] We can complicate our model by dropping the assumption that nondeceiving firms are anticipated to produce forever. If firms have a finite life, and the last period of production is known by both firms and consumers, there will be no premium sufficient to guarantee quality. No matter how high the premium paid by consumers for a high quality good in the last period, firms will supply "deceptive" minimum quality because there are no future sales to lose. Consumers aware of the last period will therefore demand only the minimum quality in that period. But then the next to the last period becomes the last period in the sense that, independent of the price premium, firm wealth is maximized by supplying minimum quality and going out of business. Consumers will then only pay for minimum quality output in the next to last period, and so on. High quality will never be produced. However, the necessary unraveling of the premium solution to assure high quality requires prior consumer knowledge of a date beyond which the firm will not produce. If consumers merely know that firms have finite lives but cannot with certainty specify a date beyond which a particular firm will not exist, price premiums may assure quality. While consumers are aware that some transactions will be with firms in their last period and hence cheating will occur, the expected gain from purchasing high promised quality can be positive. Our price premium–repeat business quality enforcement mechanism is analytically equivalent in form to the "super-game" solutions to the prisoner's dilemma problem developed in the game-theory literature. A general result of that analysis is that a cooperative solution can exist if one assumes either an infinitely long super game (as we have assumed in our model), or a super game of finite length but with transactors who have sufficient uncertainty regarding the period when the super game will end (see, e.g., Luce and Raiffa [1957], pp. 97–102, or, for a more recent solution to the problem that is similar in emphasis to our approach, Telser [1980]).

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"premium," which is both necessary and sufficient, for higher quality output.[12]

There is a possibility that the required quality-guaranteeing price premium may exceed the increased consumer surplus of purchasing higher quality rather than the minimum quality product. If consumers can easily substitute increased quantity of the low quality product for increased quality, then the value of guaranteed high quality will be relatively low. Therefore, although a quality-guaranteeing price exists, a higher than minimum quality product may not be produced. For those goods where the substitution possibilities between quality and quantity are lower (e.g., drugs), consumer demand for confidence will be relatively high and the high quality guarantee worth the price premium. We assume throughout that we are dealing with products where some demand exists for the high quality good in the range of prices considered.

III. Competitive Market Equilibrium: Firm-specific Capital Investments

Our analysis has focused on the case where costless information (perfectly competitive) prices do not imply sufficient firm-specific rents to motivate high quality production. A price premium was therefore necessary to induce high quality supply. Thus, if price assures quality, the firms producing quality greater than $q_{\min}$ appear to earn positive economic profits. However, this cannot describe a full market equilibrium. When the price is high enough to assure a particular high level of quality, additional firms have an incentive to enter the industry. But if additional firms enter, the summation of the individual firms' outputs will exceed the quantity demanded at the quality-assuring price. Yet this output surplus cannot result in price reductions since the quality-assuring price is, in effect, a minimum price constraint "enforced" by rational consumers. All price-taking firms supplying a particular promised quality q above the minimum face a horizontal demand curve at $P^* = P^*(q)$, which is of an unusual nature in that prices above or below P^* result in zero sales. Consumers know that any price below P^* for its associated quality results in the

[12] As opposed to the Darby and Karni (1973) analysis, this particular model implies an equilibrium quantity of "fraud" equal to zero, where fraud is the difference between anticipated and actual quality. Given the symmetrical information assumptions regarding cost functions, parties to a contract know when and by how much a contract will be broken. An unanticipated broken quality contract is therefore not possible. The implicit economic (as opposed to common usage) concept of "contract" refers to anticipated outcomes and not to verbal promises or written agreements; thus there will be no broken quality "contracts."

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supply of $q_{\min}$. They therefore will not purchase from a firm promising that quality at a price lower than P^*.

A. *Brand Name Capital Investments*

Competition to dissipate the economic profits being earned by existing firms must therefore occur in nonprice dimensions. However, the zero-profit equilibrium is consistent with only a very particular form of profit-absorbing nonprice competition. The competition involves *firm-specific capital* expenditures. This firm-specific capital competition motivates firms to purchase assets with (nonsalvageable) costs equal to the capital value of the premium rental stream earned when high quality is supplied at the quality-assuring price. That is, if $P^*(q)$ is not to increase, the investment leading to zero profits must be highly firm specific and depreciate to zero if the firm cheats and supplies $q_{\min}$ rather than the anticipated quality. Such firm-specific capital costs could, for example, take the form of sunk investments in the design of a firm logo or an expensive sign promoting the firm's name. Expenditures on these highly firm-specific assets are then said to represent brand name (or selling) capital investments.

The competitive process also forces the firm-specific capital investments to take the form of assets which provide the greatest direct service value to consumers. The consumers' "effective" price of purchasing a quality-assured good, where the effective price is defined as the purchase price of a product, P^*, less the value of the services yielded by the jointly supplied brand name assets, is thereby minimized. Competition among firms in seeking and making the most highly valued firm-specific brand name capital investments will occur until the expected wealth increase and, therefore, the incentive to enter the industry are eliminated.

If the firm decides to cheat it will experience a capital loss equal to its anticipated future profit stream. Since $P^*(q)$ is derived so that the threat of loss of this future profit stream motivates guaranteed quality, the zero-profit equilibrium "brand-name capital," β, which serves as an explicit hostage to prevent cheating, equals, in terms of figure 1, where $P^*(q_h) = P_2$,

$$\beta = \frac{[P_2 - (AC)_0]x_2}{r}. \tag{7}$$

That is, the market value of the competitive firm's brand name capital is equal to the value of total specific or "sunk" selling costs made by the firm which, in turn, equals the present value of the anticipated premium stream from high quality output. If we continue to assume that there are no capital (and therefore "sunk") costs of production, the

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zero-profit equilibrium is shown in figure 1 where average "total" cost (which includes average production costs, AC_{q_h}, plus average brand-name capital [i.e., nonsalvageable "selling"] costs, $r[\beta/x]$) just equals price, P_2.

What assures high quality supply is the capital loss due to the loss of future business if low quality is produced. Since the imputed value of the firm's brand name capital is determined by the firm's expected quasi rents on future sales, this capital loss from supplying quality lower than promised is represented by the depreciation of this firm-specific asset. The expenditures on brand name capital assets are therefore similar to collateral that the firm loses if it supplies output of less than anticipated quality and in equilibrium the premium stream provides only a normal rate of return on this collateral asset.

Note that the "effective" price paid by consumers, which equals the quality-assuring price less the value of the consumer services yielded by the brand name capital, may be minimized by the investment in specific selling assets with some positive salvage value. Even though this results in an increased quality-guaranteeing price, assets with positive salvage values may yield differentially large direct consumer service flows. All brand name capital assets must, however, satisfy a necessary condition that the salvage value per unit of output be less than the consumer service value. Firms competing to minimize the effective price will choose specific assets by trading off increased consumer service value with decreased salvage value. This may explain why stores which supply high quality products often have amenities (such as a luxurious carpet cut to fit the particular store) even though only small direct consumer services may be yielded relative to cost.[13]

B. *Nonsalvageable Productive Assets*

The market equilibrium we have developed implies an effective price for high quality output that is higher than what would exist in a zero information cost world. While the costless-information solution is meaningless as an achievable standard of "efficiency," alternative marketing arrangements may be usefully compared to this benchmark. Viable, competitive firms will adopt the arrangements which, considering all transacting and contracting costs, minimize the devia-

[13] If the "sunk" asset yields absolutely no consumer services, then the firm will not use it. Even though profits would be eliminated by purchase of such an asset, consumers would be indifferent between a firm that invested in the asset and a firm that did not. In a world where consumers do not possess full knowledge of cost conditions, however, use of obviously specific assets may be employed even if yielding no direct consumer service flow because they may efficiently inform consumers regarding the sunk capital cost to the firm. This is discussed in greater detail in Sec. III*C*.

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tions between the costless-information price and the effective price. One potentially efficient alternative or supplement to the pure price-premium method of guaranteeing quality may be the use of nonsalvageable productive assets rather than brand name (selling) assets.

In order to simplify the analysis of price premiums in guaranteeing quality, we have assumed that all production costs, including fixed costs, were noncapital costs and therefore, by definition, salvageable. More realistically, firms can control both the capital intensity of production and the salvage value of any fixed assets employed in the production process. In particular, if the firm uses a production process that has a nonsalvageable capital element, the normal rate of return (quasi-rent stream) on this element of production capital effectively serves as a quality-assuring premium. In terms of our model, the capital value of the quasi-rent stream when a firm cheats (eq. [3]) is now modified so that the net gain from cheating equals W_3 minus this nonsalvageable capital cost. Alternatively, in the zero-profit equilibrium the total level of collateral must still equal the potential gross gains from cheating, but part of the collateral is now provided by the nonsalvageable production assets rather than the brand name capital assets.

For example, if a machine is somewhat illiquid, buying it rather than renting it short term provides some of this collateral and lowers the quality-guaranteeing price. In fact, because of positive selling costs, capital assets generally have a salvage value less than cost. Thus capital inputs, especially those that have a high turnover cost, will have a value in terms of providing quality assurance in addition to their productive value. Even if the asset is not firm specific, if there is any time delay after the firm cheats and is terminated by consumers in selling the asset to another firm, the firm loses the real rate of interest for that time period on the capital. In addition to physical capital, human capital costs, especially entrepreneurial skills, are also often highly nonsalvageable in the face of consumer termination and therefore also provide significant quality assurance.

The general theoretical point is that the presence of positive quality-information costs favors an increase in the capital intensity of production, including the extent of long-term, illiquid contractual arrangements with suppliers of productive inputs. In particular, the minimum-cost production technique is no longer necessarily that which minimizes solely the average cost of production. "Sunk" production capital now accomplishes two functions—the supply of production services and the supply of quality-assuring services. Therefore, increases in average production costs accompanied by larger increases in sunk production assets may minimize the effective consumer product price. Profit maximization requires firms to trade off "inefficient"

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production technologies and the quality-assurance cost savings implied by the presence of firm-specific (sunk) capital assets in the productive process and hence the reduced necessity for the firm to make sunk selling cost (brand name capital) investments. Although the more capital intensive production technology may increase the perfectly competitive price of high quality output, P_0, it reduces the price premium, $P_2 - P_1$, necessary to assure the supply of that high quality. In fact, even a very slight modification of the minimum production cost technology, such as an alteration in some contractual terms, may imply the existence of large enough nonsalvageable assets so that the need for a quality-guaranteeing price premium is eliminated entirely.[14]

C. *Consumer Cost Uncertainty: A Role for Advertising*

The discussion to this point has assumed complete consumer knowledge of firms' costs of producing alternative quality outputs and knowledge of the extent to which any capital production costs or brand name capital selling costs are salvageable. This knowledge is necessary and sufficient to accurately calculate both the quality-guaranteeing premium and price. However, consumers are generally uncertain about cost conditions and therefore do not know the minimum quality-guaranteeing price with perfect accuracy. In fact, consumers cannot even make perfect anticipated quality rankings across firms on the basis of price. That one firm has a higher price than another may indicate a larger price premium or, alternatively, more inefficient production. In this section, we examine how the more realistic assumption of consumer cost uncertainty influences market responses to prepurchase quality uncertainty.

We have shown that increases in the price premium over average recoverable cost generally increase the relative returns from production of promised (high) quality rather than deceptive minimum (low) quality. The existence of a high price premium also makes expenditures on brand name capital investments economically feasible. The magnitude of brand name capital investments in turn indicates

[14] For example, franchisers can assure quality by requiring franchisee investment in specific production capital. A general arrangement by which this is accomplished is by not permitting the franchisee to own the land upon which its investments (e.g., capital fixtures) are made. Rather, the franchiser owns or leases the land and leases or subleases it to the franchisee, thereby creating for the franchisee a large nonsalvageable asset if he is terminated by the franchiser. This highly franchiser-specific asset can therefore serve as a form of collateral and potentially eliminate any need for a price premium. See Klein (1980) for a more complete discussion of this franchising solution, including the potential reverse cheating problem that is created by such contractual arrangements.

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the magnitude of the price premium. When a consumer is uncertain about the cost of producing a particular high quality level of output and therefore the required quality-assuring premium, information about the actual level of the price premium will provide information about the probability of receiving high quality. If consumers are risk averse, this uncertainty about receiving anticipated high or deceptively low quality output will increase the premium that will be paid. The premium will include both a (presumably unbiased) estimate of the quality-assuring premium and an extra payment to reduce the risk of being deceived.

Thus, when consumers do not know the minimum quality-guaranteeing price, the larger is a firm's brand name capital investment relative to sales, the more likely its price premium is sufficient to motivate high quality production. Competitive investment in brand name capital is now no longer constrained to assets which yield direct consumer service flows with a present discounted value greater than the salvage value of the assets. Implicit information about the sufficiency of price as a guarantee can be supplied by "conspicuous" specific asset expenditures. Luxurious storefronts and ornate displays or signs may be supplied by a firm even if yielding no direct consumer service flows. Such firm-specific assets inform consumers of the magnitude of sunk capital costs and thereby supply information about the quasi-rent price-premium stream being earned by the firm and hence the opportunity cost to the firm if it cheats. Both the informational services and the direct utility producing services of assets are now relevant considerations for a firm in deciding upon the most valuable form the brand name capital investment should take.

The value of information about the magnitude of a firm's specific or "sunk" capital cost, and therefore the magnitude of the price premium, is one return from advertising. Indeed, the role of premiums as quality guarantors provides foundation for Nelson's (1974) argument that advertising, by definition, supplies valuable information to consumers—namely, information that the firm is advertising. A sufficient investment in advertising implies that a firm will not engage in short-run quality deception since the advertising indicates a nonsalvageable cost gap between price and production costs, that is, the existence of a price premium. This argument essentially reverses Nelson's logic. It is not that it pays a firm with a "best buy" to advertise more, but rather that advertising implies the supply of "best buys," or more correctly, the supply of promised high quality products. Advertising does not directly "signal" the presence of a "best buy," but "signals" the presence of firm-specific selling costs and therefore the magnitude of the price premium. We would therefore expect, ceteris paribus, a positive correlation not between advertising intensity and

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"best buys," as Nelson claims, but between advertising intensity and the extent of quality that is costly to determine prepurchase.[15]

Conspicuous sunk costs such as advertising are, like all sunk costs, irrelevant in determining future firm behavior regarding output quality. However, consumers know that such sunk costs can be profitable only if the future quasi rents are large. In particular, if the consumer estimate of the initial sunk expenditure made by the firm is greater than the consumer estimate of the firm's possible short-run cheating gain, then a price premium on future sales sufficient to prevent cheating is estimated to exist. Our analysis therefore implies that independent of excludability or collection costs, advertising that guarantees quality will be sold at a zero price and "tied in" with the marked-up product being advertised.[16]

Our theory also suggests why endorsements by celebrities and other seemingly "noninformative" advertising such as elaborate (obviously costly to produce) commercials, sponsorships of telethons, athletic events, and charities are valuable to consumers. In addition to drawing attention to the product, such advertising indicates the presence of a large sunk "selling" cost and the existence of a price premium. And because the crucial variable is the consumers' estimate of the stock of advertising capital (and not the flow), it also explains why firms advertise that they have advertised in the past (e.g., "as seen on 'The Tonight Show'"). Rather than serving a direct certifying function (e.g., as recommended by *Good Housekeeping* magazine), information about past advertising informs consumers about the magnitude of the total brand name capital investment.[17]

Firms may also provide valuable information by publicizing the

[15] Nelson's argument is based on an assumption similar to the Spence (1973)-type screening assumption regarding the lower cost to more productive individuals of obtaining education. Nelson's argument, however, is circular since consumers react to advertising only because the best buys advertise more and the best buys advertise more only because consumers buy advertised products. Schmalensee (1978) has shown that the Nelson scenario may imply "fly-by-night" producers who advertise the most and also deceptively produce minimum quality. Like Spence's signaling model, the government could, in principle, tax this investment and thereby save real resources without reducing the effectiveness of this information if consumers were aware of the tax rate. However, advertising serves many purposes. In particular, advertising also can supply valuable consumer information about the particular characteristics and availability of products. For optimality the government would therefore have to determine the appropriate tax rate for each advertising message and consumers would have to be aware of each of these particular tax rates.

[16] Mishan (1970) has argued for legislation which would require advertising to be sold separately at a price which covers advertising costs. This would completely destroy the informational value of advertising we are emphasizing here.

[17] Note, however, that just as firms may deceive consumers about quality to be supplied, they may also attempt to deceive them about the magnitude of the advertising investments made, e.g., purchasing a local spot on "The Tonight Show" and advertising the advertising as if an expenditure on a national spot was made.

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large fees paid to celebrities for commercials. Information about large endorsement fees would be closely guarded if the purpose were to simulate an "unsolicited endorsement" of the product's particular quality characteristics rather than to indicate the existence of a price premium. Viewed in this context, it is obviously unnecessary for the celebrity to actually use the particular brand advertised. This is contrary to a recent FTC ruling (see Federal Trade Commission 1980).

This analysis of advertising implies that consumers necessarily receive something when they pay a higher price for an advertised brand. An expensive name brand aspirin, for example, is likely to be better than unadvertised aspirin because it is expensive. The advertising of the name brand product indicates the presence of a current and future price premium. This premium on future sales is the firm's brand name capital which will be lost if the firm supplies lower than anticipated quality. Therefore, firms selling more highly advertised, higher priced products will necessarily take more precautions in production.[18]

We have emphasized the informational value of advertising as a sunk cost. Other marketing activities can serve a similar informational role in indicating the presence of a price premium. For example, free samples, in addition to letting consumers try the product, provide information regarding future premiums and therefore anticipated quality. Such free or low-price samples thus provide information not solely to those consumers that receive the samples but also to anyone aware of the existence and magnitude of the free or low-price sample program. More generally, the supply by a firm of quality greater than anticipated and paid for by consumers is a similar type of brand name capital investment by the firm. By forgoing revenue, the firm provides information to consumers that it has made a nonsalvageable investment of a particular magnitude and that a particular future premium stream is anticipated to cover the initial sunk alternative cost.[19]

[18] The greater is the cost to consumers of obtaining deceptively low quality, the greater will be the demand for quality assurance. The very low market share of "generic" children's aspirin (1 percent) vis-à-vis generic's share of the regular aspirin market (7 percent) is consistent with this implication (see IMS America, Ltd. 1978). Many individuals who claim "all aspirin is alike" apparently pay the extra price for their children where the costs of lower quality are greater and therefore quality assurance is considered more important.

[19] Our analysis of advertising also illuminates the monopolistic competition debate. Chamberlin's (1965) distinction between production costs, defined as what is included in the "package" that passes from seller to buyer, and selling costs (e.g., advertising), which are not part of the package transferred, suggests that selling costs usefully may be considered as a privately supplied collective factor. For example, a firm which holds selling costs, such as expenditures on a store sign, constant as his sales increase does not appear to be decreasing the average "quality" of his product. Demsetz (1959, 1968) made the contrary assumption that average quality does fall as sales increase, holding

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Finally, even when consumers systematically underestimate the quality-assuring price because of downward-biased estimates of production or marketing costs or upward-biased estimates of anticipated demand growth, firms in a monopolistically competitive environment may not cheat. Such price-setting firms may possess specific nonsalvageable assets (such as trademarks) upon which they are earning a sufficient quasi-rent premium to induce high quality supply. However, the existence of independent competitive retailers that do not have any ownership stake in this firm-specific asset and yet can significantly influence the quality of the final product supplied to consumers creates a severe quality-cheating problem for the manufacturer. In this context, rational but imperfectly informed consumers will not demand a sufficient premium to prevent retailer cheating. Manufacturers may protect their trademarks by imposing constraints on the retailer competitive process including entry restrictions, exclusive territorial grants, minimum resale price maintenance, and advertising restrictions that will assure quality by creating a sufficiently valuable premium stream for the retailers. If this manufacturer-created premium stream is greater than the potential short-run retailer return from deceptive low quality supply, the magnitude of which is determined in part by the manufacturer by its level of direct policing expenditures, the retailer will not cheat and the consumer will receive anticipated high quality supply.[20]

IV. Conclusion

We have shown that even the existence of perfect communication among buyers so that all future sales are lost to a cheating firm is not sufficient to assure noncheating behavior. We have analyzed the

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selling costs constant, by merely ignoring Chamberlin's distinction and its possible theoretical significance and identifying quality costs with selling costs (aggregating both into the concept "demand increasing costs"). However, since in a monopolistically competitive environment the price premium that will assure quality depends upon the demand expected in the future, the quality incentive implied by an advertising investment also depends upon consumers' expectations about future demand. In particular, the relevant variable indicating an incentive to produce high quality is the level of advertising capital compared to anticipated future sales. Hence advertising is not a pure public good in a firm's production function as Chamberlin implicitly assumed, and the arbitrary contrary assumption made by Demsetz is possibly justifiable.

[20] See Klein et al. (1980) for a complete analysis of this case applied to the FTC Coors litigation. Coors appears to have employed exclusive territories on the wholesale level and resale price maintenance on the retail level to create a sufficient premium to encourage the necessary refrigeration of their nonpasteurized beer. Implications of this analysis in terms of providing a possible rationale for similar constraints on the competitive process enforced by trade associations and government regulatory agencies are also examined.

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generally unrecognized importance of increased market prices and nonsalvageable capital as possible methods of making quality promises credible. We obviously do not want to claim that consumers "know" this theory in the sense that they can verbalize it but only that they behave in such a way as if they recognize the forces at work. They may, for example, know from past experience that when a particular type of investment is present such as advertising they are much less likely to be deceived. Therefore, survivorship of crude decision rules over time may produce consumer behavior very similar to what would be predicted by this model without the existence of explicit "knowledge" of the forces we have examined.

Our analysis implies that consumers can successfully use price as an indicator of quality. We are not referring to the phenomenon of an ignorant consumer free riding on the information contained in the market price paid by other more informed buyers but rather to the fact that consumer knowledge of a gap between firm price and salvageable costs, that is, the knowledge of the existence of a price premium, supplies quality assurance. The former argument, that a naive buyer in a market dominated by knowledgeable buyers can use price as a quality signal because the relative market price of different products reflects differences in production costs and therefore differences in quality, crucially depends upon a "majority" of the buyers in the market being knowledgeable.

As Scitovsky (1945, p. 101) correctly notes, ". . . the situation becomes paradoxical when price is the index by which the average buyer judges quality. In a market where this happens price ceases to be governed by competition and becomes instead an instrument wherewith the seller can influence his customer's opinions of the quality of his wares." However, even when the "average" buyer uses price as an index of quality, we need not fear, as Scitovsky does, the havoc this supposedly wreaks on the economic theory of choice. All consumers in a market may consistently use price, given their estimates of salvageable production costs, as an indicator of the firm's price-premium stream and therefore as an indicator of the anticipated quality of the output to be supplied by the firm. Scitovsky did not consider that price not only influences buyers' expectations but also influences producers' incentives.

We do not wish to suggest that use of implicit (price premium–specific investment) contracts is always the cheapest way to assure quality supply. When quality characteristics can be specified cheaply and measured by a third party, and hence contract enforcement costs are anticipated to be low, explicit contractual solutions with governmentally enforced penalties (including warranties) may be a less

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costly solution. When explicit contract costs are high and the extent of short-run profit from deceptively low quality supply and hence the quality-assuring price premium is also high, governmental specification and enforcement of minimum quality standards may be an alternative method of reducing the costs of assuring the supply of high quality products.[21] And, finally, vertical integration, which in this consumer-product context may consist of home production or consumer cooperatives, may be a possible alternative arrangement (see Klein, Crawford, and Alchian 1978).

The three major methods in which to organize transactions can be usefully considered within this framework as (*a*) explicit contractual or regulatory specification with third-party enforcement, (*b*) direct (two-party) enforcement of implicit contracts, and (*c*) one-party organization or vertical integration. This paper has analyzed the brand name repeat-purchase mechanism represented by the second alternative. More generally, however, all market transactions, including those "within" the firm such as employer-employee agreements, consist of a combination of the two basic forms of contractual arrangements. Some elements of performance will be specified and enforced by third-party sanctions and other elements enforced without invoking the power of some outside party to the transaction but merely by the threat of termination of the transactional relationship.

Our analysis implies that, given a particular level of explicit contract costs, we are more likely to observe an increased reliance on the brand name contract-enforcement mechanism the lower the rate of interest and the lower the level of prepurchase quality-determination costs. The lower the interest rate the greater the capital cost to a firm from the loss of future sales and therefore the lower the equilibrium price premium. Hence we can expect the termination of future exchange method of enforcing contracts to be more effective. More generally, since the interest rate in our model refers to the period of product repurchase, the quality assurance will be less costly for less durable goods that have greater repurchase frequency. Franchising chains, for example, take advantage of this effect by making it possible for

[21] Such governmental regulations, however, do not avoid the contractual problems of ex ante explicitly defining in an enforceable manner all major elements of performance. Nor do they necessarily avoid the implicit contractual conditions of a price-premium stream (created by entry restrictions, an initial forfeitable bond, and/or minimum price restraints) to effectively enforce the governmental regulations (see Klein et al. 1980). In addition, by making it illegal to supply less than the regulated quality, individuals that would voluntarily demand lower quality than the regulated standard incur a loss of consumer surplus. Distribution effects are created, since while the regulation may decrease the cost of supplying high quality output it increases the cost of supplying lower quality output.

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consumers to pool information from sales of seemingly disparate sellers, thereby decreasing the period of repurchase and the quality-assuring price.

Similarly, purchase from a diversified firm increases the frequency of repeat purchase and lowers the necessary price premium. As long as consumers react to receiving unexpectedly low quality from a diversified firm by reducing purchases of the firm's entire product line, all the firm's nonsalvageable capital serves to assure the quality of each product it produces. This economy of scale in communicating quality-assurance information to consumers may be one motivation for conglomerate mergers. If a firm sells a set of products, each of which is produced by capital with salvage value less than costs, the quality-guaranteeing price premium on each product will be lower than if production were done by separate firms.

Finally, we can expect greater reliance on the non-third-party method of contract enforcement the lower the direct costs to the consumer of determining quality of the product prepurchase. The higher the costs of producing the minimum quality output that cannot be distinguished prepurchase from a given promised high quality output and the faster these minimum quality production costs rise with increased output, the lower the potential short-run cheating gain and therefore the lower the price premium. When the low quality cost function is such that a cheating firm can expand output a substantial amount with little increase in cost, use of the brand name enforcement mechanism is unlikely.

When the low quality cost function becomes so flat that the premium solution does not exist, the implicit contract-enforcement mechanism we have analyzed will not be used. When this condition is combined with an extremely high cost of quality assurance via explicit contractual guarantees, governmental supply may be the cheapest alternative. An obvious example is the good "money," where the marginal cost of production is essentially zero, the short-run cheating potential extremely large, and where the cost of a commodity money or the necessary bullion reserves to assure performance via convertibility is also extremely high. Governmental supply is the generally adopted but far from costless solution (see Klein 1974). Other products where the "hold-up" potential is very large and where explicit contract costs are high (such as police or fire protection services) are also generally supplied by non-profit-maximizing government agencies rather than by unregulated profit-maximizing firms earning large quasi rents on unsalvageable (firm-specific) capital assets. In general, minimization of the cost of assuring performance will imply an optimal combination of governmental regulation and/or supply, explicit

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contractual enforcement, vertical integration, and the implicit (brand name) contractual enforcement mechanism we have analyzed.

Appendix

Simulation of the Quality-assuring Price

If we assume that output of high and low (minimum) quality is produced by constant-elasticity cost functions of the form:

$$C_h = F_h + \beta_h x_h^{\alpha}, \tag{A1}$$

$$C_l = F_l + \beta_l x_l^{\alpha}, \tag{A2}$$

the quality-assuring price premium, $\tilde{P}$, will be given by:[22]

$$\tilde{P} = \left\{ \frac{\left[1 - \frac{(F_l/F_h)r}{1+r}\right]}{1 - \frac{r}{1+r}\left(\frac{\beta_l}{\beta_h}\right)^{1/(\alpha-1)}} \right\}^{(\alpha-1)/\alpha}. \tag{A3}$$

This expression indicates that as the ratio of low to high quality fixed costs, (F_l/F_h), decreases the quality-guaranteeing price-premium increases (because the short-run profit from cheating increases). But, as long as F_l can be assumed to be less than or equal to F_h, fixed costs cannot affect the existence of the quality-guaranteeing price premium. Similarly, as the interest rate, r, increases, the quality-guaranteeing price premium increases but will always exist. It is the marginal cost elasticity, $[1/(\alpha - 1)]$, and the ratio of the marginal cost slopes, (β_l/β_h), that determine the existence of a quality-assuring price premium. An increase in the elasticity of marginal cost or a decrease in the ratio of the low to high quality marginal cost slopes, by increasing the possible expansion of the low quality output at the high quality-guaranteeing price, increases the quality-guaranteeing price premium and the likelihood that it may not exist. Simulation results as a function of these parameters are presented in table A1 below. The ratio of the quality-assuring price to the minimum average cost of high quality production, P_2/P_1 in terms of figure 1, along with the ratio of low quality output at the quality-assuring price relative to the minimum high quality average cost output, x_4/x_1 in terms of figure 1, is presented. When the quality-assuring price does not exist, the ratio of low quality output at a P_2/P_1 ratio of 2 to the output at the minimum average cost of low quality output, x_0, is presented in brackets to indicate the shape of the low quality cost function. The results indicate that these cases of nonexistence generally occur where the low quality cost curve is so flat relative to the high quality cost curve that cheating output can be expanded dramatically relative to the noncheating output. For example, when the marginal cost elasticity is assumed to be 10.0 and the ratio of marginal cost slopes is assumed to be 0.25, it implies that low quality output can be profitably expanded by more than a billion times beyond its minimum average cost rate when the market price is double the perfectly competitive high quality price.

[22] The derivation is available to readers upon request.

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TABLE A1

SIMULATION OF QUALITY-ASSURING PRICES

Interest Rate r	Ratio of Fixed Costs (F_l/F_h)	Marginal Cost Elasticity $[1/(\alpha - 1)]$	Ratio of Marginal Cost Slopes (β_l/β_h)	Price-Premium Ratio (P_2/P_1)	Output Ratio (x_4/x_1)
.03	.5	.5	.25	1.031	2.03
.03	.5	.5	.50	1.018	1.43
.03	.5	.5	.75	1.013	1.16
.03	.5	2.0	.25	1.227	24.07
.03	.5	2.0	.50	1.037	4.30
.03	.5	2.0	.75	1.013	1.82
.03	.5	4.0	.25	Does not exist	$[4.10 \times 10^3]$
.03	.5	4.0	.50	1.130	26.12
.03	.5	4.0	.75	1.017	3.37
.03	.5	10.0	.25	Does not exist	$[1.07 \times 10^9]$
.03	.5	10.0	.50	Does not exist	$[1.05 \times 10^6]$
.03	.5	10.0	.75	1.067	33.97
.03	1.0	.5	.25	1.021	2.02
.03	1.0	.5	.50	1.008	1.42
.03	1.0	.5	.75	1.003	1.16
.03	1.0	2.0	.25	1.221	23.84
.03	1.0	2.0	.50	1.032	4.26
.03	1.0	2.0	.75	1.008	1.81
.03	1.0	4.0	.25	Does not exist	$[4.10 \times 10^3]$
.03	1.0	4.0	.50	1.127	25.81
.03	1.0	4.0	.75	1.013	3.34
.03	1.0	10.0	.25	Does not exist	$[1.07 \times 10^9]$
.03	1.0	10.0	.50	Does not exist	$[1.05 \times 10^6]$
.03	1.0	10.0	.75	1.066	1.82×10^4
.09	.5	.5	.25	1.097	2.09
.09	.5	.5	.50	1.056	1.45
.09	.5	.5	.75	1.039	1.18

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.09	.5	2.0	.25	Does not exist	[64.0]
.09	.5	2.0	.50	1.127	5.08
.09	.5	2.0	.75	1.040	1.92
.09	.5	4.0	.25	Does not exist	[4.10×10^3]
.09	.5	4.0	.50	Does not exist	[2.56×10^2]
.09	.5	4.0	.75	1.053	3.89
.09	.5	10.0	.25	Does not exist	[1.07×10^9]
.09	.5	10.0	.50	Does not exist	[1.05×10^6]
.09	.5	10.0	.75	Does not exist	[1.82×10^4]
.09	1.0	.5	.25	1.065	2.06
.09	1.0	.5	.50	1.026	1.43
.09	1.0	.5	.75	1.009	1.16
.09	1.0	2.0	.25	Does not exist	[64.0]
.09	1.0	2.0	.50	1.111	4.93
.09	1.0	2.0	.75	1.024	1.87
.09	1.0	4.0	.25	Does not exist	[4.10×10^3]
.09	1.0	4.0	.50	Does not exist	[2.56×10^2]
.09	1.0	4.0	.75	1.044	3.76
.09	1.0	10.0	.25	Does not exist	[1.07×10^9]
.09	1.0	10.0	.50	Does not exist	[1.05×10^6]
.09	1.0	10.0	.75	Does not exist	[1.82×10^4]

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