Quality Competition, Insurance, and Consumer Choice in Health Care Markets

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In this model, insurance offering a choice of hospitals is valued because consumers are uncertain which hospital they will prefer ex post. A competitive insurance market facilitates tacit price collusion between hospitals; high margins induce hospitals to compete for customers through overinvestment in quality. Incentives may exist to lock in market share via managed-care plans with less choice and lower prices. As technology becomes more expensive, the market increasingly offers too little choice. A pure managed care market may emerge, with underinvestment in quality. Relative to a pure insurance regime, however, all consumers are better off under managed care.

1. Introduction

Health economists largely agree that the key driver of health care costs is the adoption of expensive quality-enhancing technologies and procedures.[1] They also recognize that the incentives for quality improvement are created in large part by the structure of insurance and other health care payment plans. The interplay of technology, insurance, quality of care, and cost containment has been eloquently described and dubbed the health care "quadrilemma" by Weisbrod (1991). Despite the familiarity of these concerns, however, they have not been the subject of much formal modeling.

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[1] See, for example, Newhouse (1992).

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I develop a simple model that highlights an aspect of the problem that has been relatively neglected: consumers' *freedom of choice* among alternative providers of health care. Specifically, I focus on the value to consumers of having a choice of hospital when they are uncertain *ex ante* which hospital will offer the highest quality care *ex post*. While there is a sizable literature on quality competition in hospital markets, as surveyed by Dranove and White (1994), little of it has recognized the role of consumer choice.[2] Olson (1981, pp. 1–28) referred to choice as the "subtle subsidy" in the health care system, arguing that it softens price competition between care providers and thereby encourages excessive adoption of new technology. In this paper I provide a formal analysis of these issues.

My model examines the role of consumer choice formally in a setting where hospitals are differentiated both with respect to geographical location and with respect to quality of care. Hospitals can invest in quality improvement, e.g., by hiring well-known specialists, but they are unsure how much quality enhancement will actually result. Consumers, at the time they choose a health care plan, are likewise uncertain whether a hospital's innovative efforts will succeed.[3] Those consumers who sign an insurance contract with choice can select their hospital *ex post*, while those who sign an exclusive contract with a particular hospital ("managed care") cannot. In order to highlight the interplay between quality rivalry and contracts with freedom of choice, I assume consumers are risk-neutral, and abstract from their uncertainty about future health status. The role of insurance, then, becomes simply that of ensuring consumers access to the highest-quality care provider.[4] I leave for future work the interesting task of integrating into the analysis the more traditional issues of health status uncertainty, adverse selection, and moral hazard. The emphasis here is on the performance of alternative payment systems as measured by prices, the extent of choice available to consumers, and the amount of quality enhancement.

I show that traditional insurance plans with choice indeed facilitate excessive prices, compared to either the welfare benchmark

[2] Dranove and White do note, however, (p. 175) that "patients may select insurance plans . . . in order to avail themselves of the option of being admitted to their most preferred hospital. . . ."

[3] Hospitals increasingly compete with one another to hire specialists with strong track records, often luring big names away from other hospitals in the same region. An excellent account of the volatile market for cancer care in New York City appeared in the *New York Times* (Steinhauer, 1999).

[4] Nyman (1999) makes a strong case that the access motive is in fact the dominant reason people buy health insurance.

or managed care plans, by relaxing price competition between hospitals; the high resulting margins induce hospitals to compete for market share through excessive investment in costly quality enhancement. When quality is sufficiently expensive, hospitals have incentives to lock in market share via plans that offer consumers less choice and lower prices. The use of exclusive contracts to defend market share against a rival's successful quality increase results in less consumer choice than is socially optimal. In fact, when quality is costly enough, hospitals have incentives to price traditional insurance out of the market altogether by demanding exorbitant reimbursement rates. The resulting market, offering only managed care, exhibits a level of innovation below the social optimum. Nevertheless, all consumers are better off under managed care than under the high-priced traditional insurance regime. These findings mirror many familiar trends in health care markets, yet emerge from a highly parsimonious model that emphasizes the twin features of quality rivalry and consumer choice.

The literature contains a few papers that examine how payment schemes affect incentives for innovation,[5] and a few papers that examine competition between contracts offering choice and exclusive contracts.[6] To my knowledge, however, this paper is the first to incorporate both features in a single model. In the paper closest to this one, Gal-Or (1997) considers a model with two differentiated hospitals and two differentiated payers who may or may not offer consumers a choice of hospital. She shows that when hospitals are much more differentiated than payers, all contracts will offer choice, while if payers are much more differentiated, no contracts will offer choice and one hospital will monopolize the market. Her model differs from mine in two important respects. First, her hospitals

[5]Goddeeris (1984) and Baumgardner (1991) study innovation using models that emphasize the role of insurance in protecting consumers against health shocks. Both papers show that moral-hazard problems due to low coinsurance levels can induce excessive adoption of quality-enhancing technology. Neither paper allows for competition, however, either between hospitals or between payment plans. Ma and Burgess (1993) study competition between managed-care plans when the firms choose both quality and price. They find underinvestment in quality when firms commit to a quality level before setting prices, as is likely to be the case in a technology adoption game. Their model contains no uncertainty, however, so it does not allow for the examination of insurance contracts with choice.

[6]Ma (1997) examines competition between "option contracts," which resemble my insurance contracts, and simple contracts, which commit a purchaser to a particular seller. In his model, option contracts always drive out simple contracts. His structure is quite different from mine, however, in that his consumers are identical *ex ante*, and his firms do not make investments that can improve quality. Gal-Or (1997), discussed further in the text, also belongs to this category of papers.

cannot choose their quality levels; in her model quality is fixed, and the value of choice derives from consumers' uncertainty about their own future health status, while in the present paper the value of choice derives from uncertainty about the future quality characteristics of the hospitals. Second, while my insurance industry is perfectly competitive, her insurers are duopolistic and are assumed to be differentiated even when they offer identical contractual terms. These two differences lead to very different analyses: my hospitals are always more differentiated than payers, yet choice may still be eliminated, as hospitals use exclusionary managed-care contracts to lock in market share that might otherwise migrate to a rival that successfully raises its quality of care. In addition, I am able to characterize quality choices under alternative payment regimes, and to show how payment regimes change as the cost of quality rises.

The paper is organized as follows. The following section sets out the basic structure of the model, and characterizes the welfare-maximizing benchmark. Section 3 characterizes prices and investments in quality enhancement when all consumers are covered by managed care plans, Section 4 does the same when all consumers are covered by insurance contracts offering freedom to choose one's hospital, and Section 5 examines the case where managed care plans compete with traditional insurance plans. Section 6 discusses how the observed payment regime changes when the cost of quality increases. The final section summarizes my results, discusses policy implications, and concludes.

2. The Model and the Welfare Benchmark

This section describes the basic elements of the model and the choices that would be made by a welfare-maximizing social planner.

2.1 The Model

There are two competing health-care providers (*hospitals*), which are differentiated both horizontally and vertically. Consumers are distributed uniformly on the unit line, with total mass normalized to one, and with one hospital at each end of the line. Consumers are identical except for their location; I abstract from issues of adverse selection and uncertain health status in order to focus on the relationship between quality enhancement and consumer choice of care provider. A consumer located at position x must incur transportation costs of t per unit distance to reach a hospital. Thus the cost of reaching hospital 0 is tx, while the cost of reaching hospital 1 is

$t(1 - x)$. For simplicity, I assume that the two firms possess equivalent levels of specialists and of current technology, which generate for consumers a base level of utility V.[7] I also assume that through its investment, hospital i can further raise the expected quality of its care to q_i. Let p_i be the price paid by a consumer for care from hospital i. (If the consumer purchases insurance with choice of hospital, then $p_0 = p_1$, but this equality does not necessarily hold under managed care.) Abstracting from issues of risk aversion, the consumer's net expected utility from health care is thus $U_0(x) = q_0 - tx - p_0$ if he obtains care from hospital 0 and $U_1(x) = q_1 - t(1 - x) - p_1$ if he obtains care from hospital 1. This basic structure is illustrated in Figure 1.

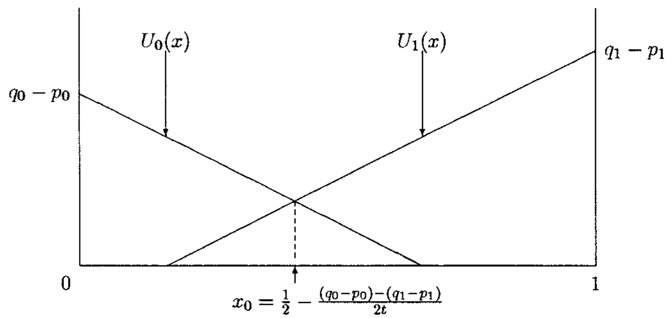

FIGURE 1. BASIC SETUP OF THE MODEL ON THE UNIT LINE

The timing in the model is shown in Figure 2. At time 1, hospitals choose investments in quality enhancement that may in-

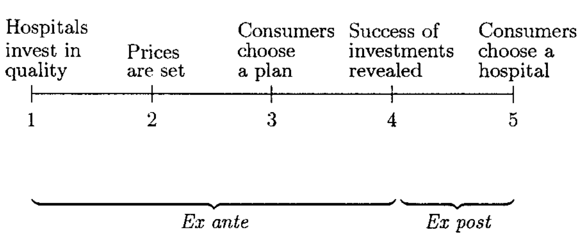

FIGURE 2. SEQUENCE OF EVENTS IN QUALITY IMPROVEMENT GAME

[7] It is possible to allow the hospitals to have different levels of quality *ex ante*, but the assumption of symmetry simplifies and tightens the analysis and exposition.

crease the quality of care by an amount Δ. At the time the investment is made, there is some uncertainty regarding the quality enhancement it will provide. Hospital H_i chooses a probability ρ_i with which the quality it offers will improve; if it succeeds, its consumers receive utility $V + \Delta$. The (fixed) cost of improvement is represented by $F(\rho, \Delta, \gamma)$, where γ is a cost parameter and $F(\cdot)$ is increasing and convex in all arguments. This cost may represent the cost of new technology, the cost of searching for and hiring the best specialists, or any other costly form of quality improvement whose value to consumers is uncertain. I will assume $F(\cdot)$ has nonnegative cross partial derivatives and that $\lim_{\Delta \to 0} F_{\rho\Delta} = 0$, $F_{\rho\rho} > 0$, and $\lim_{\gamma \to \infty} F_{\rho} = \infty$. To simplify notation, I will sometimes write $F(\rho)$, suppressing the other arguments of the cost function. At time 2, before the success of the investment is known, each hospital must set the price(s) it charges to health care plans. Depending on the case under consideration, consumers have available to them either an insurance plan with choice of hospital, a managed care plan without choice (a *health maintenance organization*, or HMO), or both. The insurance market, if it exists, is assumed to be competitive, so insurance plans are priced to maximize consumer surplus taking the cost of care as given. Managed care plans purchase hospital services at marginal cost and then set prices optimally. Alternatively, one can think of managed care plans as taking the price set by the hospital as given and simply passing it through to consumers. At time 3, after the plan prices are set, consumers choose a plan. At this point, the expected quality offered by hospital H_i is $q_i = V + \rho_i \Delta$. I am thus assuming that consumers can observe and compare the commitments to quality enhancement made by the two hospitals, even though the ultimate quality of service that will be delivered *ex post* by each hospital has not yet been realized. At time 4, all participants in the market learn whether the hospitals' investments have succeeded in raising quality or not. Based on that information, at time 5 consumers whose plan allows choice select the hospital that offers them the greatest utility net of transportation costs. I assume for simplicity that insurance pays all of the *ex post* costs of going to a hospital.[8]

[8]The basic model here is very similar to that of Ma and Burgess (1993) and Wolinsky (1997). Note that my formulation differs importantly from that of Wolinsky (1997), who assumes prices and qualities are determined simultaneously. Ma and Burgess consider both simultaneous choice and sequential choice.

Throughout the remainder of the paper I will maintain the following assumptions:

Assumptions:

(a) $V > 3t/2$,
(b) $\Delta < t$.

Assumption (a) ensures that all consumers receive health care in each of the models I examine. This avoids the complications of analyzing the size of the "gap" of unserved consumers on the unit line for each case, and keeps the exposition more focused. Assumption (b) ensures that there is a natural market for managed care when HMOs compete with insurance, since under this assumption some consumers do not find it worthwhile to travel to the more distant hospital, even if that hospital offers higher-quality service. I will also assume, without loss of generality, that marginal costs are zero.

2.2 Welfare-Maximizing Quality Choice

In this section I characterize the welfare-maximizing level of investment in quality improvement as a benchmark against which to compare the performance of alternative health care plans. I suppose that all consumers receive insurance that fully reimburses their costs at the hospital of their choice. (If consumer valuation of health care is large, then it is not optimal to exclude any consumers from the market.) Consumers can be divided into three groups based on their location. Define $\hat{x}_0 = \frac{1}{2} - \Delta/2t$ such that customers $x \le \hat{x}_0$ always go to firm 0 (their travel costs are so high that traveling to hospital 1 is not justified, even for an increase of Δ in the value of care), and $\hat{x}_1 = \frac{1}{2} + \Delta/2t$ such that customers at $x \ge \hat{x}_1$ always go to firm 1. Customers who are potential switchers, $x \in (\hat{x}_0, \hat{x}_1)$, will go to the provider with higher quality, but if the providers offer the same quality, then customers in this region will go to the closer provider. Thus these customers must be subdivided according to whether they reside to the left or the right of $x = \frac{1}{2}$. These various positions on the unit line are illustrated in Figure 3.

Let welfare be given by $W = S^{\mathrm{NC}} + S^{\mathrm{O}} - F(\rho_0) - F(\rho_1)$, where S^{NC} is gross consumer surplus if consumers have no choice of hospital and S^{O} is the additional surplus (*option value*) to consumers if they have a choice of hospital. The no-choice optimum would require all customers at $x \in [0, \frac{1}{2}]$ to go to hospital 0 and all cus-

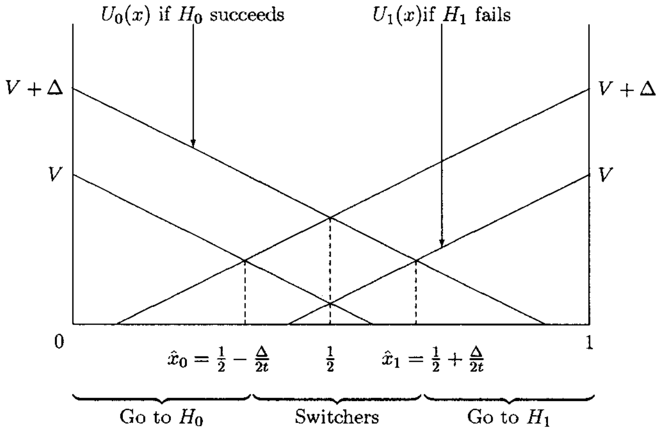

FIGURE 3. LOCATION OF CUSTOMERS WILLING TO SWITCH PROVIDERS

tomers at $x \in (\frac{1}{2}, 1]$ to go to hospital 1. S^{NC} can be written as

$$S^{\mathrm{NC}} = \int_0^{1/2} [V + \rho_0 \Delta - tx]\, dx + \int_{1/2}^{1} [V + \rho_1 \Delta - t(1-x)]\, dx$$
$$= V + \frac{\Delta(\rho_0 + \rho_1)}{2} - \frac{t}{4}.$$

Consider now the option value S^{O}. Clearly, option value accrues only to consumers residing in $[\hat{x}_0, \hat{x}_1]$, since the other consumers are never willing to incur the travel costs required to switch hospitals. A consumer located at $x \in [\hat{x}_0, \frac{1}{2}]$ will travel to hospital 1 if and only if hospital 0 fails to improve quality but hospital 1 succeeds, which occurs with probability $(1-\rho_0)\rho_1$. The extra value from traveling to hospital 1 consists of the quality enhancement Δ less the increase in travel costs $t(1-x) - tx = t(1-2x)$. Similar reasoning applies for consumers located at $x \in [\frac{1}{2}, \hat{x}_1]$. Thus, the option value of consumer choice can be written as

$$S^{\mathrm{O}} = (1-\rho_0)\rho_1 \int_{\hat{x}_0}^{1/2} [\Delta - t(1-2x)]\, dx$$
$$+ (1-\rho_1)\rho_0 \int_{1/2}^{\hat{x}_1} [\Delta - t(2x-1)]\, dx$$
$$= \frac{\Delta^2}{4t}(\rho_0 + \rho_1 - 2\rho_0\rho_1).$$

In the symmetric case where $\rho_0 = \rho_1 = \rho$, we have $S^{NC} = V + \rho\Delta - t/4$ and $S^{O} = \Delta^2\rho(1 - \rho)2t$. Note that option value is maximized when $\rho = \frac{1}{2}$. This is intuitive, since if both hospitals are sure to succeed (or sure to fail), then the customer may as well just go to the closer one. The implication is that the social planner tolerates more uncertainty about quality improvement at each hospital than would be acceptable if consumers had no choice of hospital. More formally, let the optimal value of ρ in the no-choice environment be ρ^{NC}. If $\rho^{NC} < \frac{1}{2}$, then the presence of choice increases the optimal quality investment, but if $\rho^{NC} > \frac{1}{2}$, then choice reduces the welfare-maximizing quality investment. In either case, the presence of consumer choice pushes the optimal probability of success closer to one-half.

Combining terms yields the following expression for social welfare:

$$W = V + \frac{\Delta(\rho_0 + \rho_1)}{2} - \frac{t}{4}$$

$$+ \frac{\Delta^2}{4t}(\rho_0 + \rho_1 - 2\rho_0\rho_1) - F(\rho_0) - F(\rho_1). \tag{1}$$

Note that issues of pricing are suppressed in this formulation. This is because all sets of prices are equivalent, from a welfare perspective, as long as they cover total costs and induce no customers to quit the market. Let ρ^{W} be the socially optimal probability of quality improvement. The welfare-maximizing nondiscriminatory pricing scheme is to charge each customer $2F(\rho^{W})$, which just allows both hospitals to cover their costs of investing in the optimal level of quality.

A more challenging issue than pricing, for a social planner, is to determine the welfare-maximizing level of quality. Using subscripts to indicate partial derivatives of $F(\cdot)$, the first-order conditions for welfare-maximizing investment in quality enhancement are

$$\frac{\Delta}{2t}\left(t + \frac{\Delta}{2} - \rho_j\Delta\right) = F_\rho(\rho_i^{W}), \tag{2}$$

For example, if $F(\gamma, \rho, \Delta) = \gamma(\rho\Delta)^2/2$, then one obtains the symmetric closed-form solution $\rho^{W} = (2t + \Delta)/[2\Delta(2t\gamma + 1)]$. The welfare-maximizing probability of success is decreasing in the cost of quality, γ. One can also readily find that $\partial\rho^{W}/\partial\Delta = -t/[\Delta^2(2t\gamma + 1)] < 0$, so the probability of success also falls as the potential quality increase Δ rises. This second effect is due to the rapid increase in costs as quality rises.

I summarize the characteristics of the welfare-maximizing solution in the following proposition.

Proposition 1: *The welfare-maximizing solution has the following characteristics*: (a) *for V large enough, all consumers receive health care;* (b) *consumers located at any $x \in \left[\frac{1}{2} - \Delta/2t, \frac{1}{2} + \Delta/2t\right]$ have a choice of hospital* ex post; (c) *the nondiscriminatory fee collected from each consumer is $2F(\rho^{W})$.*

Note that (b) implies that the fraction of the population with choice increases as the potential quality improvement Δ grows larger, and decreases as transportation costs t rise.

With this welfare benchmark in mind, I turn now to characterizing the performance of alternative health care payment schemes. I begin with the simplest of these, pure managed care competition, and then in Section 4 consider the pure insurance case. After analyzing these two pure cases, I examine the mixed case with both types of payment plan in Section 5.

3. Pure Managed Care Competition

In pure managed care competition, consumers are locked into their choice of care provider once they select their health plan. They thus choose between hospitals *ex ante* on the basis of expected quality $q_i = V + \rho_i \Delta$ and price p_i. The consumer who is just indifferent between the two HMOs is located at position

$$x_0 = \frac{1}{2} + \frac{(q_0 - p_0) - (q_1 - p_1)}{2t}, \tag{3}$$

where $U_0(x) = U_1(x)$.[9] Expected profits are $\pi_0 = p_0 x_0 - F(\rho_0)$ and $\pi_1 = p_1(1 - x_0) - F(\rho_1)$.

3.1 The Pricing Subgame

Given investments in quality enhancement, the firms set prices to maximize profits. The price reaction curve of firm i is $p_i = t/2 + (q_i - q_j + p_j)/2$, from which it can be seen immediately that prices are strategic complements in this game. Solving for the equilibrium

[9]Assumption (a) ensures that local monopolies will not exist.

prices yields

$$\rho_i^{\mathrm{HMO}} = t + \frac{(\rho_i - \rho_j)\Delta}{3}. \tag{4}$$

The firm that invests more heavily in quality improvement can charge a higher price. In symmetric equilibrium, however, $p_0^{\mathrm{HMO}} = p_1^{\mathrm{HMO}} = t$. With symmetric investments in quality, price is not a function of expected quality. Symmetric investments in quality exactly cancel each other and fail to raise equilibrium prices. This characteristic of the equilibrium is discussed further below. Recall, however, that in this model improving quality increases fixed but not variable costs; if variable costs were to increase as well, then equilibrium prices might be expected to depend on quality.

3.2 Quality Choice

To obtain a reduced-form expression for profits, substitute (4) into (3) to obtain

$$x_0 = \frac{1}{2} + \frac{(\rho_0 - \rho_1)\Delta}{6t}. \tag{5}$$

Then the profit functions are

$$\pi_i = \frac{t}{2} + \frac{(\rho_i - \rho_j)\Delta}{3} + \frac{(\rho_i - \rho_j)^2\Delta^2}{18t} - F(\rho_i). \tag{6}$$

Firm i's optimal investment in quality improvement is then given by the following first-order condition:

$$\frac{\Delta}{9t}\left(3t + \rho_i^{\mathrm{HMO}} - \rho_j^{\mathrm{HMO}}\right) = F_\rho(\rho_i). \tag{7}$$

Quality choices, as well as prices, are strategic complements in this game. In symmetric equilibrium, the first-order condition reduces to

$$\frac{\Delta}{3} = F_\rho(\rho^{\mathrm{HMO}}). \tag{8}$$

Totally differentiating equation (8) shows that $\partial\rho^{\mathrm{HMO}}/\partial\gamma = -F_{\rho\gamma}/F_{\rho\rho} < 0$. Thus, the probability of improvement falls as the cost of quality rises. Note that by the envelope theorem,

$$\frac{d\pi^{\mathrm{HMO}}}{d\gamma} = -F_\gamma - F_\rho \frac{\partial \rho^{\mathrm{HMO}}}{\partial \gamma} = -F_\gamma + F_\rho \frac{F_{\rho\gamma}}{F_{\rho\rho}}. \tag{9}$$

Profits are not necessarily decreasing in γ; it is quite possible for HMO profits to increase as the cost of quality rises. For example, if $F(\gamma, \rho, \Delta) = \gamma(\rho\Delta)^2/2$, then the symmetric equilibrium has $\rho^{\mathrm{HMO}} = 1/(3\gamma\Delta)$, and profit per firm is $\pi^{\mathrm{HMO}} = t/2 - 1/(18\gamma)$. Clearly, profits are rising in γ. This may seem puzzling at first glance, but has a simple intuition. Quality improvements, much like advertising, serve to attract customers from one's rival, but unless total market demand expands, they merely serve to shift market share. As mentioned above, symmetric investments in quality exactly cancel each other and fail to raise equilibrium prices.[10] Quality competition thus has the flavor of a prisoner's dilemma. In this situation, firms may well spend less on quality as the cost of quality rises, thereby dissipating less of the available total profits. As a result, profits can rise along with the cost of quality. Whenever profits are positive, of course, prices are higher than is necessary to achieve the (socially nonoptimal) probability of improvement ρ^{HMO}.

How does quality in the managed care regime compare to the welfare benchmark? To answer this question, I compare the respective first-order conditions for choice of ρ. The following proposition provides the results of the comparison.

Proposition 2: *The pure managed care regime exhibits underinvestment in quality for sufficiently costly improvements, but overinvestment for inexpensive improvements.*

Proof. Let θ^{W} be the left-hand side of equation (2) and $\theta^{\mathrm{HMO}} = \Delta/3$ be the left-hand side of equation (8). Note that $\theta^{\mathrm{W}} - \theta^{\mathrm{HMO}} = \Delta/6 + (\Delta^2/2t)(\frac{1}{2} - \rho^{\mathrm{W}})$. Then $\theta^{\mathrm{W}} - \theta^{\mathrm{HMO}} > 0$ if and only if $\rho^{\mathrm{W}} < \frac{1}{2} + t/(3\Delta)$. Since assumption (b) gives $\Delta < t$, the inequality $\rho^{\mathrm{W}} < \frac{5}{6}$ is sufficient to ensure that $\theta^{\mathrm{W}} - \theta^{\mathrm{HMO}} > 0$. Finally, $\rho^{\mathrm{W}} < \frac{5}{6}$ for γ large enough. This last point follows because $\lim_{\gamma\to\infty} F_\rho = \infty$ and $F_{\rho\rho} > 0$. Thus, as $\gamma \to \infty$, $\rho^{\mathrm{W}} \to 0$. □

An oft-expressed concern is that HMOs lack incentives to provide high-quality care. My analysis provides some grounds for this

[10] A more general model might allow quality improvements to increase the density of customers on the unit line, in which case the market would expand and price would rise with symmetric quality improvements.

concern, but only for sufficiently costly technologies. The reason for the qualified nature of the underinvestment result is that in the welfare maximum, the presence of consumer choice pushes the welfare-maximizing quality investment toward $\frac{1}{2}$. (Choice is more valuable when there is greater uncertainty about which hospital will offer the best care *ex post*.) Interestingly, pure HMO competition always produces underinvestment relative to a no-choice welfare maximum where consumers cannot choose their hospital. Suppose that $F(\gamma, \rho, \Delta) = \gamma(\rho\Delta)^2/2$. Then $\rho^{\mathrm{HMO}} = 1/(3\gamma\Delta)$, as shown above, and $\rho^{\mathrm{NC}} = 1/(2\gamma\Delta)$, so that $\rho^{\mathrm{NC}} > \rho^{\mathrm{HMO}}$ regardless of cost. This is intuitive, since competition on both the price and quality dimensions means that a hospital cannot appropriate the full benefits of its quality enhancement. However, when the welfare maximum allows for consumer choice, the social planner must also consider the option value S^{O} when determining optimal investments in quality improvement. As discussed in Section 2.2, including the option value in the objective function causes the planner's choice of ρ to move closer to $\frac{1}{2}$. Indeed, if quality enhancement is inexpensive (i.e., γ is small), then both ρ^{HMO} and ρ^{NC} may be greater than $\frac{1}{2}$, and the inclusion of option value in the planner's objective could cause $\rho^{\mathrm{W}} < \rho^{\mathrm{HMO}}$. For the cost function $F(\gamma, \rho, \Delta) = \gamma(\rho\Delta)^2/2$, the social planner chooses $\rho^{\mathrm{W}} = (2t + \Delta)/[2\Delta(2t\gamma + 1)]$. A bit of algebra shows that $\rho^{\mathrm{W}} > \rho^{\mathrm{HMO}}$ if and only if $\gamma > 1/(t + 3\Delta/2)$. Thus, for inexpensive technologies, managed care competition could result in an excessively high probability of success from a social perspective. It would be more efficient to invest less in quality enhancement and compensate by allowing consumers to shift demand *ex post* to the hospital that succeeds in improving quality.

4. The Pure Insurance Case

I turn now to the institutional structure that dominated the US health care market into the 1980s: traditional fee-for-service insurance contracts offering choice of provider. Following Baumgardner (1991) and other authors, I assume a competitive insurance market, with insurance plans priced to maximize consumer surplus taking the cost of care as given. Thus, all consumers who purchase insurance pay the same premium, which is just the expected reimbursement paid to the hospitals. Let r_i be the reimbursement demanded by hospital i, and $\overline{D}_i(\rho_i, \rho_j)$ be hospital i's expected sales. I will generally suppress the dependence of expected sales on investments to keep my notation uncluttered. Then the equilibrium premium in the insurance market is

$$r = \frac{r_0 \overline{D}_0 + r_1 \overline{D}_1}{\overline{D}_0 + \overline{D}_1}. \tag{10}$$

4.1 The Pricing Subgame

The pricing subgame in the pure insurance regime is rendered complex by the average-cost pricing created by a competitive insurance market, as represented in equation (10). The key intuition for the pricing subgame is that hospitals have an incentive to raise prices aggressively because their individual reimbursement demands are not fully reflected in the equilibrium insurance premium. Thus, if hospital 0 has a 50% market share, a one-dollar increase in its reimbursement demand only raises the equilibrium insurance premium by fifty cents. It is easy to see that this aspect of the insurance market might facilitate tacit collusion between the hospitals.

Since hospitals have little incentive to hold down prices, it is conceivable that some consumers might be excluded from the health care market entirely if insurance is priced too high. There are three potential gaps in the market: at $\hat{x}_0 \equiv \frac{1}{2} - \Delta/2t$, $x = \frac{1}{2}$, and $\hat{x}_1 \equiv \frac{1}{2} + \Delta/2t$. For customers in the region defined by $x \in [0, \hat{x}_0]$, utility clearly declines with increasing x, since these customers always go to hospital 0 and their travel costs increase with x; the opposite applies to customers at the other end of the line. For potential switchers in the region $x \in [\hat{x}_0, \hat{x}_1]$, being close to the outer edges of the region is desirable, since then travel costs are low except for the case when only the further hospital succeeds in enhancing its quality, which occurs with probability $\rho_i(1 - \rho_j)$. Where a gap will show up first depends on the pair of investment levels (ρ_0, ρ_1) chosen by the hospitals in the first stage of the game. The following proposition identifies pricing equilibria for all possible combinations of first-stage investment levels.

Proposition 3: *In the pure insurance regime, for all pairs of* ex ante *investments (ρ_0, ρ_1) there exists a Nash equilibrium in prices in which both hospitals charge the same price, all customers receive nonnegative expected utility, and all customers purchase insurance. The prices are*:

1. $r_0 = r_1 = V + \rho_0\Delta + (\Delta - t)/2$ *if* $\rho_1(1 - \rho_0) > \frac{1}{2}$,
2. $r_0 = r_1 = V + \rho_1\Delta + (\Delta - t)/2$ *if* $\rho_0(1 - \rho_1) > \frac{1}{2}$,
3. $r_0 = r_1 = V + \Delta(\rho_0 + \rho_1 - \rho_0\rho_1) - t/2$ *if* $\rho_1(1 - \rho_0) \leq \frac{1}{2}$ *and* $\rho_0(1 - \rho_1) \leq \frac{1}{2}$.

Proof. See the Appendix. □

The pricing equilibria exhibited in the proposition have the property that neither hospital wants to create a gap of uninsured customers. Instead, each hospital prefers to raise its reimbursement demand to the point where the worst-off customer is just indifferent between purchasing insurance and not receiving health care.[11]

4.2 Quality Choice

The firms will split the market *ex post* whenever they end up with the same quality levels, and if the quality levels are asymmetrical, then the firm with the higher quality captures all the potential switchers. The resulting expected demands are then $\overline{D}_i = \frac{1}{2} + (\Delta/2t)(\rho_i - \rho_j)$. Proposition 3 establishes three possible outcomes for the pricing subgame, suggesting that there may be a multitude of possible cases in the quality-choice subgame as well. The following proposition, however, shows that the first two cases in Proposition 3 are not subgame perfect: hospitals expecting these outcomes in the pricing subgame will not choose quality investments that lead to cases 1 and 2.

Proposition 4: *Only case 3 of Proposition 3 is subgame perfect.*

Proof. See the Appendix. □

In the subgame perfect case 3, expected profits are

$$\overline{\pi}_i = \left(V + \Delta\left[1 - (1-\rho_i)(1-\rho_j)\right] - \frac{t}{2}\right)\left(\frac{1}{2} + \frac{\Delta}{2t}(\rho_i - \rho_j)\right) - F(\rho_i), \tag{11}$$

and the first-order condition for optimal choice of ρ_i is

$$\frac{\Delta}{2t}\left[V + t\left(\tfrac{1}{2} - \rho_j\right)\right] + \frac{\Delta^2}{2t}\left[(1-\rho_j)(2\rho_i - \rho_j - 1) + 1\right] = F_\rho(\rho_i). \tag{12}$$

[11] There are some interesting parallels between this pricing game and the "split-award" auctions analyzed by Anton and Yao (1992). Most importantly, both the insurance pricing game and the split-award bidding game induce a form of collusive pricing. In addition, sellers in both games can effectively veto an outcome they dislike by setting a very high price.

In a symmetric equilibrium, this reduces to

$$\frac{\Delta^2}{2t}\left(\rho^{\mathrm{I}}(2-\rho^{\mathrm{I}}) - \frac{t}{\Delta}\rho^{\mathrm{I}}\right) + \frac{\Delta}{2t}\left(V + \frac{t}{2}\right) = F_\rho(\rho^{\mathrm{I}}). \tag{13}$$

For simplicity, the remainder of this section focuses solely on the symmetric equilibrium. Let ρ^{I} and r^{I} be the probability of quality improvement and the equilibrium insurance premium, respectively, for this case. The next two propositions compare the pure insurance equilibrium with the pure managed care equilibrium, and then with the welfare maximum.

Proposition 5: *The pure insurance regime features higher prices and higher quality than the pure managed care regime.*

Proof. The equilibrium insurance premium is $r^{\mathrm{I}} \equiv V + \Delta\rho(2-\rho) - t/2$. Clearly $r^{\mathrm{I}} > p^{\mathrm{HMO}} = t$ if and only if $V + \Delta\rho(2-\rho) > 3t/2$, which holds by assumption (a).

Incentives for quality improvement can be assessed by examining the first-order conditions determining quality choice under the two regimes. Specifically, I compare the left-hand side of equation (8), which I denote by θ^{HMO}, and the left-hand side of equation (13), denoted by θ^{I}. Straightforward calculations show that

$$\theta^{\mathrm{I}} - \theta^{\mathrm{HMO}} = \frac{\Delta^2}{2t}\left[\rho\left(2 - \frac{t}{\Delta}\right) - \rho^2\right] + \frac{\Delta}{2}\left(\frac{V}{t} - \frac{1}{6}\right).$$

The first term reaches its minimum at $\rho = 1$, where it takes on the value $(\Delta^2/2t)(1 - t/\Delta)$. The second term is always greater than or equal to $2\Delta/3$ by assumption (a). Combining terms, it is clear that $\theta^{\mathrm{I}} - \theta^{\mathrm{HMO}} > 0$, so $\rho^{\mathrm{I}} > \rho^{\mathrm{HMO}}$. □

As suggested by Olson (1981), the insurance market serves to soften price competition between the two health care providers. Under insurance, an increase in r_0 is not fully passed through into the insurance premium r^{I}; in fact, in symmetric equilibrium it raises r^{I} by only $\frac{1}{2}$. As a result, hospital 0 has incentives to raise its reimbursement charge. These spillover effects are absent under managed care competition, which generates more aggressive price competition. The presence of a price-taking competitive insurance sector thus serves as a facilitating institution allowing hospitals to increase their prices.

Proposition 5 further shows that reduced price competition has implications for the hospitals' investments in quality. The resulting high margins and the lack of *ex post* price competition induce firms to compete for market share through quality enhancement. Thus a regime of insurance with choice spurs quality competition between hospitals. This result is consistent with the notion of a ''medical arms race,'' often discussed in the health economics literature, which suggested that competition in health care resulted in excessive investment in quality of care. Indeed, the pure insurance regime generates socially excessive investment in quality, as shown in the next proposition.

Proposition 6: *The symmetric insurance equilibrium exhibits excessive investment in quality enhancement, relative to the welfare optimum.*

Proof. Denote the left-hand side of (2) by $\theta^{W}(\rho)$ and the left-hand side of (13) by $\theta^{I}(\rho)$; in addition, let $\theta(\rho) \equiv \theta^{I}(\rho) - \theta^{W}(\rho)$. Then

$$\theta(\rho) \equiv \theta^{I}(\rho) - \theta^{W}(\rho) = \frac{\Delta}{2t}\left(V - \frac{t+\Delta}{2} - \rho t + \Delta\rho(3-\rho)\right).$$

Note that $\theta(\rho)$ is concave, and thus over the feasible range of $\rho \in [0,1]$ attains its minimum at either $\rho = 0$ or $\rho = 1$. Direct calculation shows that $\theta(0) = V - (t+\Delta)/2$ and $\theta(1) = V - 3(t-\Delta)/2$. Assumption (a) is sufficient to ensure that both of these are positive. Hence the symmetric insurance equilibrium always involves socially excessive levels of investment in quality. □

While the comparison with the welfare maximum is interesting, it is also useful to directly compare the performance of the pure insurance regime with the performance of the pure managed care regime. This is illustrated in Figure 4, which shows the utility of consumers located at each point on the unit line under the managed care and pure insurance regimes. The rate at which utility changes with location is simply the slope of the utility graphs. Under managed care, the slope is either $+t$ or $-t$, with the customer at $x = \frac{1}{2}$ receiving the lowest net benefits, since he has to travel the farthest on average. Under insurance, the slope is $-t$ for $x \in [0, \hat{x}_0)$ and $+t$ for $x \in (\hat{x}_1, 1]$; for $x \in (\hat{x}_0, \hat{x}_1)$, however, the slopes are lower in absolute value. Furthermore, the tacit price collusion facilitated by insurance means that the consumer located at $x = \frac{1}{2}$ receives a net utility of zero, as is demonstrated in the proof of Proposition 3. Hence, to show that all consumers are better off under managed care than pure insurance, it is sufficient to show that the consumer at $x = \frac{1}{2}$ receives strictly positive utility under managed care. It is easy to see from Figure 4 that if this consumer does better under managed care, so do

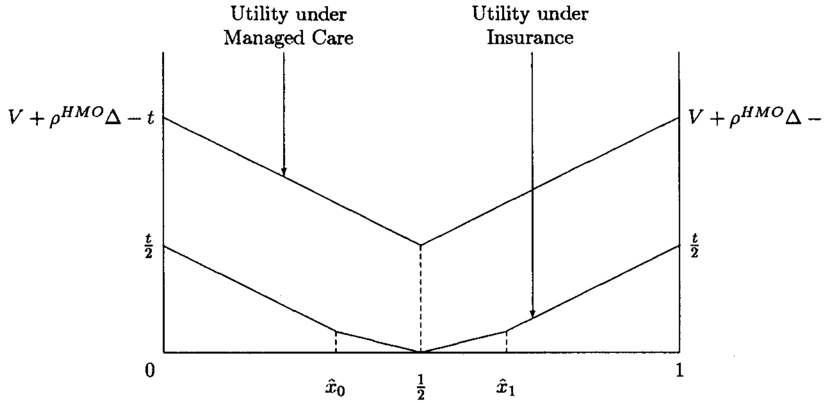

FIGURE 4. UTILITY RECEIVED BY CONSUMERS UNDER MANAGED CARE AND PURE INSURANCE

all other consumers. Since the consumer at $x = \frac{1}{2}$ always travels a distance $\frac{1}{2}$ and since $p^{\text{HMO}} = t$, it is straightforward to calculate that under managed care the consumer at $x = \frac{1}{2}$ receives net utility $U^{\text{HMO}} = V + \rho^{\text{HMO}}\Delta - 3t/2$, which is strictly greater than zero by assumption (a). The foregoing argument has proven the following proposition.

Proposition 7: *All consumers are better off under the pure managed care regime than under the pure insurance regime.*

Proposition 7 is a strong and quite striking result, since it does not depend upon the values of the parameters Δ, γ, and t. It is driven by the fact that fee-for-service insurance facilitates tacit collusion on prices, which extracts a large portion of surplus from consumers. From this perspective, socially excessive spending on the quality dimension is simply an undesired and unavoidable by-product of high insurance prices. The analysis thus supports the view that insurance plans like Blue Cross/Blue Shield have served to facilitate physician control of the health care market.[12] While Proposition 2 showed that managed care may induce hospitals to underinvest in high-cost quality improvement, this deficiency is more than compensated for (relative to insurance) by the price competition created by

[12] For a discussion of this point, and references to papers further exploring the idea, see Phelps (1992, p. 311).

managed care. The next section examines the more complex setting in which the two forms of payment scheme compete with one another.

5. A Mixed Regime: Managed Care and Insurance with Choice

I turn next to characterizing the market when managed care competes against insurance. This broader perspective allows me to investigate whether the market will offer the correct amount of choice, as well as to characterize the price and quality performance of the mixed regime.

A managed care plan may be thought of as vertical integration between a hospital and a particular insurer, so that the hospital charges the managed care plan at marginal cost and the plan then sets a price to consumers. Equivalently, one can think of a managed care plan as a contractual arrangement between a particular insurer and a particular hospital. In either case, the hospital may still choose to provide services via insurance, as well as through the managed care plan, so each hospital will now have a pair of prices (p_i, r_i), where p_i is the price paid by consumers who elect to join HMO$_i$ *ex ante* and r_i is the reimbursement demanded from nonintegrated insurers for each consumer who elects to use hospital i's services *ex post*. As in Section 4, I assume there is a competitive insurance market, so the price consumers pay for the insurance contract is simply equal to the insurer's expected costs, which I will denote by $\bar{r}$. I continue to assume for simplicity that consumers who buy insurance pay no copayment when they select a provider *ex post*.

I begin by noting that not all consumers are interested in purchasing insurance. Assumption (b) says that $\Delta < t$, so there are some consumers who live close to one hospital or the other, and never find it worthwhile to travel to the more distant hospital, because the quality differential is not great enough to justify the travel costs. Thus, as in the preceding sections, the unit line will be divided into three segments, this time defined by x_0^{MIX} and x_1^{MIX}. Consumers located at $x \in [0, x_0^{\mathrm{MIX}}]$ choose HMO$_0$, consumers located at $x \in (x_0, x_1^{\mathrm{MIX}})$ choose between the HMOs and the insurance contract, and consumers located at $x \in [x_1^{\mathrm{MIX}}, 1]$ choose HMO$_1$. As in earlier sections of the paper, x_0^{MIX} and x_1^{MIX} are determined endogenously as functions of prices and expected qualities.

5.1 The Pricing Subgame

Because the insurance market is competitive, insurers obtain zero profits, and the equilibrium price is just equal to the expected reimbursement paid to hospitals. Note that if only one of the hospitals succeeds in raising quality to $V + \Delta$, then all of the consumers who purchase insurance will go to the same service provider *ex post*, since for these consumers the increase in quality more than justifies the transportation cost to either provider. However, if both succeed or both fail, then insurance consumers will simply go to the provider closer to them. Given this situation, the actuarily fair insurance premium can be expressed as

$$r^{\mathrm{MIX}} = r_0 \rho_0 (1 - \rho_1) + r_1 \rho_1 (1 - \rho_0) + \frac{\left(\frac{1}{2} - x_0^{\mathrm{MIX}}\right) r_0 + \left(x_1^{\mathrm{MIX}} - \frac{1}{2}\right) r_1}{\left(x_1^{\mathrm{MIX}} - x_0^{\mathrm{MIX}}\right)\left[\rho_0 \rho_1 + (1 - \rho_0)(1 - \rho_1)\right]}. \tag{14}$$

It is now possible to solve for x_0^{MIX} and x_1^{MIX}. I discuss only x_0^{MIX}, since x_1^{MIX} is entirely symmetric. Consider a consumer who lives closer to hospital 0 but is willing to travel to hospital 1 for higher-quality service; he is thus located at some $x \in \left[\frac{1}{2} - \Delta/2t, \frac{1}{2}\right]$. If he purchases from HMO_0, he obtains high-quality service with probability ρ_0 and always travels to hospital 0. He thus obtains expected utility

$$\overline{U}_0 = V + \rho_0 \Delta - tx - p_0. \tag{15}$$

If he purchases insurance, however, he will obtain high-quality service unless both hospitals fail to improve their quality, which occurs with probability $(1 - \rho_0)(1 - \rho_1)$, and will travel to hospital 0 unless hospital 1 is the only one to succeed, which occurs with probability $\rho_1(1 - \rho_0)$. His expected utility is thus

$$\overline{U}_r = V + \Delta\left[1 - (1 - \rho_0)(1 - \rho_1)\right] - tx\left[1 - \rho_1(1 - \rho_0)\right] - t(1 - x)\rho_1(1 - \rho_0) - r^{\mathrm{MIX}}. \tag{16}$$

Equating $\overline{U}_0$ and $\overline{U}_r$ identifies the marginal consumer, located at x_0^{MIX}. Some algebraic calculations show that

$$x_0^{\mathrm{MIX}} = \frac{1}{2} - \frac{1}{2t}\left(\Delta - \frac{r^{\mathrm{MIX}} - p_0}{\rho_1(1 - \rho_0)}\right). \tag{17}$$

Similarly,

$$x_1^{\mathrm{MIX}} = \frac{1}{2} + \frac{1}{2t}\left(\Delta - \frac{r^{\mathrm{MIX}} - p_1}{\rho_0(1-\rho_1)}\right). \tag{18}$$

Note that consumers are never willing to pay a higher price for managed care than for insurance, so it must be the case that $p_0 \le r^{\mathrm{MIX}}$ and $p_1 \le r^{\mathrm{MIX}}$. Now hospital 0's expected profits are

$$\begin{aligned}\overline{\pi}_0 &= p_0 x_0 + r_0(x_1 - x_0)\rho_0(1-\rho_1)\\ &\quad + r_0(\tfrac{1}{2} - x_0)[\rho_0\rho_1 + (1-\rho_0)(1-\rho_1)] - F(\rho_0).\end{aligned} \tag{19}$$

Differentiating with respect to p_0 yields

$$\frac{\partial\overline{\pi}_0}{\partial p_0} = x_0 + \{p_0 - r_0[1 - \rho_1(1-\rho_0)]\}\frac{\partial x_0}{\partial p_0}. \tag{20}$$

The first term, x_0, shows the increased revenue from those HMO customers who continue to purchase managed care even after the price increases. The second term gives the incremental revenue lost from each HMO customer who switches to insurance, $p_0 - r_0[1 - \rho_1(1-\rho_0)]$, multiplied by the number of HMO customers lost to insurance. Note that the value to the hospital of an HMO customer is that the customer is locked in and yields revenue p_0 with certainty. When that customer is an insurance customer, hospital 0 loses the business of that customer in the event that hospital 1 is the only one to successfully increase quality, which occurs with probability $\rho_1(1-\rho_0)$. Thus, managed care is a potentially powerful tool for expanding a hospital's market share and protecting against a rival's successful innovation. At the same time, a hospital faces a trade-off when deciding whether to participate in a managed care plan: managed care increases the hospital's market share by locking in customers, but a price discount must be offered to attract customers who value having a choice of hospital. The ultimate effects of offering a managed care plan can only be determined by analyzing the equilibrium of the mixed regime.

Solving the first-order conditions for the pricing of hospital services, hospital 0's optimal price for HMO service is seen to be

$$p_0 = \frac{\rho_1(1-\rho_0)}{2}(t-\Delta) + \frac{r_0(1+\rho_0-\rho_1)}{2} + \frac{r_1(1-\rho_0+\rho_1)}{4}, \tag{21}$$

while its optimal price to charge for insurance reimbursement is

$$r_0 = \frac{2p_0\rho_0(1-\rho_1) + p_1\rho_1(1-\rho_0) + 2\Delta\rho_0\rho_1(1-\rho_0)(1-\rho_1)}{(1+\rho_0-\rho_1)[\rho_0(1-\rho_1)+\rho_1(1-\rho_0)]} - \frac{r_1(1-\rho_0+\rho_1)}{2(1+\rho_0-\rho_1)}. \tag{22}$$

Combining these expressions with the similar ones for firm 1 and solving all four equations simultaneously yields equilibrium prices for managed care and insurance:

$$p_i^{\mathrm{MIX}} = t(\rho_i+\rho_j-\rho_i\rho_j) + \frac{\Delta}{3}(\rho_i-\rho_j), \tag{23}$$

$$r_i^{\mathrm{MIX}} = \left(t+\frac{\Delta}{3}\right)\frac{2\rho_i(1-\rho_j)}{1+\rho_i-\rho_j}. \tag{24}$$

In a symmetric equilibrium, these expressions simplify further to

$$p^{\mathrm{MIX}} = \rho(2-\rho)t, \tag{25}$$

$$r^{\mathrm{MIX}} = 2\rho(1-\rho)\left(t+\frac{\Delta}{3}\right). \tag{26}$$

The price differential is thus $r^{\mathrm{MIX}} - p^{\mathrm{MIX}} = 2\Delta\rho(1-\rho)/3 - t\rho^2$. In the mixed equilibrium, managed care customers pay lower prices than insurance customers. In exchange for lower prices, managed care customers give up the right to switch hospitals if the other hospital has higher quality *ex post*, so managed care customers receive lower-quality care on average.[13] It is also of interest to

[13]Since HMOs must offer lower prices than insurance in order to attract any business, the interior equilibrium only holds for $\rho < 2\Delta/(2\Delta + 3t)$. I defer a discussion of switches between payment regimes until the following section of the paper.

compare prices in the mixed regime with those in either of the pure regimes, which is done in the following proposition.

Proposition 8: *For any given level of investment in innovation, prices in a pure insurance regime are higher than those in a pure managed care regime, which are in turn higher than those in a regime where HMOs compete with insurance plans offering choice of providers; that is,* $r^{\mathrm{I}} > p^{\mathrm{HMO}} > r^{\mathrm{MIX}} > p^{\mathrm{MIX}}$.

Proof. Recall that the two pure regimes features prices $p^{\mathrm{HMO}} = t$ and $r^{\mathrm{I}} = V + \Delta\rho(2-\rho) - t/2$. I have established already that $p^{\mathrm{MIX}} \leq r^{\mathrm{MIX}}$ and that $r^{\mathrm{I}} > p^{\mathrm{HMO}}$. It is easy to see by inspection that $p^{\mathrm{MIX}} \leq p^{\mathrm{HMO}}$, with the equality occurring when $\rho = 1$. I next compare r^{MIX} and r^{I}. Some calculations reveal that $r^{\mathrm{I}} - r^{\mathrm{MIX}} = V - t/2 + \rho\Delta - \rho(1-\rho)(2t - \Delta/3)$, which reaches a minimum at $\rho' = (3t - 2\Delta)/(6t - \Delta)$, at which point $r^{\mathrm{I}} - r^{\mathrm{MIX}} = V - t/2 - (3t - 2\Delta)^2/(18t - 3\Delta)$; this expression is positive for all $\Delta < t$. I have thus established that $r^{\mathrm{I}} > r^{\mathrm{MIX}} > p^{\mathrm{MIX}}$. Finally, note that $r^{\mathrm{MIX}} = 2\rho(1-\rho)(t + \Delta/3)$ is maximized when $\rho = \frac{1}{2}$, and recall that I assume $\Delta < t$. Then $r^{\mathrm{MIX}} < 2t/3 < t = p^{\mathrm{HMO}}$. □

Competition between managed care and insurance with choice produces lower prices than do either of the two pure regimes. The opportunity to offer managed care creates a dilemma for the hospitals. Each firm's individual incentive is to participate in a managed care plan, in order to increase its market share beyond what it could obtain through insurance customers alone. If both hospitals have managed care plans, however, the aggregate effect is to increase competition and reduce prices; it is impossible for both hospitals to increase market share simultaneously. The hospitals thus may have incentives to collusively eschew managed care. Unfortunately for them, however, they cannot achieve this outcome through unilateral action, since each hospital individually wants to offer a managed care plan. The emergence of managed care thus undermines the ability of competitive insurance markets to facilitate tacit collusion between hospitals. I discuss in Section 6 the important issue of how equilibrium payment regimes change as the cost of quality increases.

5.2 Quality Choice

Consider now the equilibrium investments in quality in a mixed regime that offers both insurance and managed care. Using the foregoing results for equilibrium prices, it is possible to rewrite (19), the expression for expected profits, solely in terms of ρ_0 and ρ_1:

$$\begin{aligned}\overline{\pi}_0 &= p_0 x_0 + \frac{r_0(x_1 - x_0)}{2}(1 + \rho_0 - \rho_1) - F(\rho_0)\\ &= \left(t(\rho_0 + \rho_1 - \rho_0\rho_1) + \frac{\Delta(\rho_0 - \rho_1)}{3}\right)\left(\frac{1}{2} - \frac{\Delta}{6t} - \frac{\rho_0}{2(1-\rho_0)}\right)\\ &\quad + \left(t + \frac{\Delta}{3}\right)\rho_0(1-\rho_1)\left(\frac{\Delta}{3t} + \frac{\rho_1}{2(1-\rho_1)} + \frac{\rho_0}{2(1-\rho_0)}\right)\\ &\quad - F(\rho_0). \end{aligned} \tag{27}$$

The first-order conditions corresponding to this profit expression are complex, but in symmetric equilibrium they simplify somewhat to

$$\begin{aligned}&\frac{t}{2} + \frac{\Delta}{9} + \frac{\Delta^2}{18t} + \rho^{\mathrm{MIX}}\left(\frac{7\Delta}{18} - \frac{2t}{3} - \frac{\Delta^2}{9t}\right)\\ &\quad + \frac{t\rho^{\mathrm{MIX}}}{1-\rho^{\mathrm{MIX}}}\left(\frac{1}{6} - \frac{2-\rho^{\mathrm{MIX}}}{2(1-\rho^{\mathrm{MIX}})}\right) = F_\rho(\rho^{\mathrm{MIX}}). \end{aligned} \tag{28}$$

Totally differentiating this condition shows that

$$\frac{\partial\rho^{\mathrm{MIX}}}{\partial\gamma} = \frac{-F_{\rho\gamma}}{F_{\rho\rho} + E} < 0, \tag{29}$$

where the inequality follows because

$$E \equiv \frac{\Delta^2}{9t} + \frac{2t}{3} - \frac{7\Delta}{18} + \frac{5t}{6}\frac{1 + 2\rho^{\mathrm{MIX}}}{(1-\rho^{\mathrm{MIX}})^3} > 0.$$

Again, the probability of quality improvement falls as the cost of quality rises. It is worth noting that it falls less rapidly in the mixed regime than in the pure managed care regime, where $\partial\rho^{\mathrm{HMO}}/\partial\gamma = -F_{\rho\gamma}/F_{\rho\rho}$. Thus, for large γ, the mixed regime produces a higher probability of quality improvement, while for low values of γ either regime may in principle produce higher-quality care. It is thus impossible to determine in general whether the mixed regime produces more socially desirable performance than does pure managed care. Since the mixed regime generates lower prices, it will certainly outperform managed care whenever $\rho^{\mathrm{MIX}} > \rho^{\mathrm{HMO}}$; this is most likely to occur when the cost of quality improvement is high, i.e., for large values of γ. Note that if $\rho^{\mathrm{MIX}} > \rho^{\mathrm{HMO}}$, then all consumers are better off under the mixed regime, since they all pay lower prices and receive a higher expected quality of care. I turn next to the important question of whether the market provides the correct amount of consumer choice.

5.3 Does the Market Offer Enough Choice?

Using the equilibrium results from the preceding section, it is now possible to characterize the amount of choice offered by the market. The marginal purchaser of insurance can be found by substituting equilibrium prices from (25) and (26) into equation (17); he is located at

$$x_0^{\mathrm{MIX}} = \frac{1}{2} - \frac{\Delta}{6t} - \frac{\rho^{\mathrm{MIX}}}{2(1-\rho^{\mathrm{MIX}})}. \tag{30}$$

Recall that welfare maximization requires that all customers located at $x \in (\frac{1}{2} - \Delta/2t, \frac{1}{2} + \Delta/2t)$ have a choice of hospital *ex post*. As mentioned earlier, however, at any mixed equilibrium it must be that $\rho < 2\Delta/(2\Delta + 3t)$, so it is clear that $x_0^{\mathrm{MIX}} > \frac{1}{2} - \Delta/2t$. Thus, in their attempts to lock in extra market share via managed care contracts, hospitals restrict the scope of the insurance market, with detrimental effects on welfare.

Inspection of equation (30) shows that x_0^{MIX} is decreasing in ρ, so the number of customers who inefficiently are deprived of choice increases as the probability of quality improvement falls. Intuitively, as ρ falls, the value of choice falls also, since there is less of a chance that the more distant hospital will be the sole successful innovator.[14] As a result, consumers are less willing to pay a premium for insurance, and switching customers to managed care plans becomes more profitable. Equation (29) shows that the probability of quality improvement falls as the cost of quality rises. Combining these observations yields the following proposition.

Proposition 9: *In an equilibrium with both managed care and insurance, fewer customers than is socially optimal purchase insurance: the market provides too little choice of provider. The share of customers who are inefficiently deprived of choice increases with the cost of quality.*

[14] Technically, this result only holds when $\rho \leq \frac{1}{2}$, but the mixed equilibrium only exists for $\rho < 2\Delta/(2\Delta + 3t) < \frac{1}{2}$, so the intuition is applicable generally for the mixed case.

As discussed above, firms' use of managed care to purchase market share typically means that some potential "switchers" will choose HMO service without choice. The measure of this group on the unit line is shrinking in ρ, the probability of quality improvement, which in turn decreases as the cost of quality rises. The share of customers who are deprived of choice thus increases as the cost of quality enhancement rises.

The story implied by Proposition 9 seems broadly consistent with the experience of recent years in the US, as summarized, for example, by Weisbrod (1991) or Newhouse (1992). Since the 1970s, the cost of health care has risen rapidly, driven largely by the cost of new medical techniques. Health maintenance organizations and other managed care plans emerged in the wake of these changes, in an attempt to contain costs. One important component of these efforts has been reducing the extent of choice available to consumers. To be sure, there have been other tools in the cost containment kit.[15] Nevertheless, the ability of my simple model to capture the broad outlines of recent developments in the health care market suggests the role of insurance with choice is an important one.

6. Equilibrium Payment Regimes and the Cost of Quality

While there has been some previous research on how the form of insurance affects incentives for the adoption of new technology, there has been virtually no work on how the structure of payment regimes shifts in response to changes in the cost of quality improvements. In this section, I bring together the foregoing analyses of different payment regimes to examine how the market adapts to changes in the cost of quality enhancement. As pointed out by Weisbrod (1991), this issue has become increasingly urgent with the emergence of such costly and specialized techniques as organ transplantation, magnetic resonance imaging (MRI), positron emission tomography (PET), and sophisticated but expensive new pharmaceuticals such as AZT.

My approach in this section is to examine the circumstances under which the market will shift between the mixed regime and one of the two pure regimes. Consistent with the changes that have taken

[15] Perhaps most importantly, Medicare has shifted from cost-plus reimbursement of health-care providers to a system of fixed payments for the treatment of illness episodes that fall into specific *diagnostic-related groups* (DRGs). The incentives created by the use of DRGs have been studied by a number of authors; for an excellent overview of these issues see Ellis and McGuire (1993).

place historically, I begin with the boundary between pure insurance and the mixed regime, and then turn to that between the mixed regime and pure managed care.

6.1 From Pure Insurance to the Mixed Regime

As shown earlier, the mixed regime only exists for $\rho^{\mathrm{MIX}} < 2\Delta/(2\Delta + 3t)$. Otherwise the equilibrium price for managed care would exceed that for insurance, with consumers abandoning managed care for insurance offering higher average quality. It was also shown earlier that $\partial\rho^{\mathrm{MIX}}/\partial\gamma < 0$. Let $\underline{\gamma}$ be defined as the cost, for a given Δ and t, at which $\rho^{\mathrm{MIX}} = 2\Delta/(2\overline{\Delta} + 3t)$. The transition from a pure insurance regime to the mixed regime occurs at $\gamma = \underline{\gamma}$.

The transition to the mixed regime may seem puzzling, since section 5 showed that prices, and hence revenues, are lower in the mixed regime than in the pure insurance regime. Nevertheless, if $\rho^{\mathrm{MIX}} < 2\Delta/(2\Delta + 3t)$, then hospitals cannot unilaterally prevent the shift to the mixed regime. The incentive to invade the pure insurance market with a managed care plan can be understood as follows. The pure insurance market can be characterized as having $p_0 \geq r^{\mathrm{MIX}}$, because in this case all consumers select the insurance plan, since it offers quality of care at least as great as that of the managed care plan at a lower price. Now consider reducing p_0 slightly below the symmetric equilibrium pure insurance price, i.e., evaluate (20) at $p_0 = r_0 = r_1 = r^{\mathrm{I}} \equiv V + \Delta\rho(2-\rho) - t/2$ and $x_0^{\mathrm{MIX}} = \frac{1}{2} - \Delta/(2t)$, which yields

$$\left.\frac{\partial\overline{\pi}_0}{\partial p_0}\right|_{p_0=r^{\mathrm{I}}} = \frac{1}{2} - \frac{\Delta}{2t} + \{r^{\mathrm{I}} - r_0[1-\rho(1-\rho)]\}\frac{-1}{2t\rho(1-\rho)}$$

$$= \frac{1}{2} - \frac{\Delta}{2t} - \frac{V + \Delta\rho(2-\rho) - t/2}{2t}$$

$$= \frac{-1}{2t}\left(V - \frac{3t}{2} + \Delta(1 + 2\rho - \rho^2)\right) < 0. \tag{31}$$

The final inequality is guaranteed by assumption (a), which ensures $V > 3t/2$. Thus, a reduction in the managed care price by one hospital acting unilaterally would increase profits. If $\rho^{\mathrm{MIX}} > 2\Delta/(2\Delta + 3t)$, then it is impossible for *equilibrium* managed care prices to fall far enough to attract any customers, but if $\rho^{\mathrm{MIX}} < 2\Delta/(2\Delta + 3t)$, then entry by managed care plans is feasible and each hospital has unilateral incentives to do so.

To put matters differently, there exists a managed care price such that the increase in market share for a hospital making a unilateral reduction in its managed care price outweighs the lost revenues on ''captive'' insurance customers (located close to the hospital) who switch to the cheaper managed care plan. Of course, the unfortunate fact for firms creating managed care plans is that when *both* hospitals participate in such plans, they both end up worse off. The firms face a prisoner's dilemma with regard to the introduction of managed care. This is reflected in declining profitability among HMOs and other managed care plans in the US. According to *Business Week* (Anon., 1997, p. 42), ''Managed care is turning into a commodity business. The easy money—made when insurers first converted employees from fee-for-service plans—is gone. . . . The gutting of managed care began as a battle for market share. For three years, insurers have low-balled bids to snap up big accounts as quickly as possible, savaging margins in many markets.'' For example, United Healthcare and Wellpoint, two large HMOs, saw pretax profit margins fall from over 13% in 1994 to less than 8% in 1997.

6.2 From the Mixed Regime to Pure Managed Care

I turn next to the boundary between the mixed regime and the pure managed care regime. As discussed above, hospitals cannot unilaterally shut down the managed care market. In contrast, an important feature of the insurance market is that it can be effectively eliminated by either firm acting unilaterally. Consumer choice of hospital *ex post* is perfectly inelastic, and based solely on hospital quality. Thus, by raising its reimbursement charge high enough, either hospital can raise r^{MIX} to the point where all consumers desert insurance altogether and select a managed care plan instead. If hospitals determine that a pure managed care market would be more profitable than a mixed market that also includes insurance, the mixed market can easily be vetoed by either hospital. This feature of the insurance market parallels the work of Anton and Yao (1992) on split-award auctions, which shows that when companies bid on alternative splits of a procurement market, either firm can veto any undesirable split by raising its price arbitrarily high. As a result, split-award auctions have a strongly collusive flavor. As shown in Section 3, strong pricing coordination also emerges in insurance markets with choice of provider. The point I emphasize here, however, is that either provider can unilaterally veto the mixed market in favor of a pure managed care regime.

Since the mixed regime produces lower revenues than the pure managed care regime, it will only be observed if it allows the hospitals to reduce their expenditures on quality rivalry below what can be achieved under pure managed care.[16] As shown in Section 5, $0 > \partial\rho^{\mathrm{MIX}}/\partial\gamma > \partial\rho^{\mathrm{HMO}}/\partial\gamma$. Thus, as the cost of quality rises, there will eventually come a point beyond which $\rho^{\mathrm{MIX}} > \rho^{\mathrm{HMO}}$. Since this is a sufficient, not a necessary, condition for $\pi^{\mathrm{HMO}} > \overline{\pi}^{\mathrm{MIX}}$, there exists a smaller value of γ, which I will denote by $\overline{\gamma}$, such that for all $\gamma \geq \overline{\gamma}$ one has $\pi^{\mathrm{HMO}} > \overline{\pi}^{\mathrm{MIX}}$. Since either hospital can unilaterally veto the mixed regime at any time, there will be a shift to pure managed care for all $\gamma \geq \overline{\gamma}$.

Interestingly, the shift to pure managed care occurs as a discontinuous jump rather than as the culmination of a shifting balance within the mixed regime. By referring back to equation (30), it is easy to see that as $\rho^{\mathrm{MIX}} \to 0$ (due to increases in γ), $x_0^{\mathrm{MIX}} \to \frac{1}{2} - \Delta/6t$. The market for choice is not shut down altogether until $x_0^{\mathrm{MIX}} = \frac{1}{2}$. Thus choice is never eliminated entirely in the mixed regime. Instead, it disappears suddenly at $\gamma = \overline{\gamma}$ when the hospitals veto the insurance market.

It is possible that the mixed regime never emerges, and there is a direct shift from pure insurance (at low values of γ) to pure managed care (at high values of γ). Whether this is the case can be determined by comparing ρ^{MIX} and ρ^{HMO} at $\gamma = \underline{\gamma}$. Recall that $\underline{\gamma}$ is defined so that $\rho^{\mathrm{MIX}} = 2\Delta/(2\Delta + 3t)$. If $\rho^{\mathrm{MIX}} > \rho^{\mathrm{HMO}}$ at $\underline{\gamma}$, then the mixed regime never emerges. For all $\gamma < \underline{\gamma}$, the mixed regime cannot exist because equilibrium managed care prices are too high to attract any customers. For all $\gamma > \underline{\gamma}$, $\partial\rho^{\mathrm{MIX}}/\partial\gamma > \partial\rho^{\mathrm{HMO}}/\partial\gamma$, so $\rho^{\mathrm{MIX}} > \rho^{\mathrm{HMO}}$ and the mixed regime is vetoed. Some fairly tedious calculations reveal that $\theta^{\mathrm{MIX}} - \theta^{\mathrm{HMO}} > 0$ at $\underline{\gamma}$ if $\Delta = 0$, that $\theta^{\mathrm{MIX}} - \theta^{\mathrm{HMO}} < 0$ at $\underline{\gamma}$ if $\Delta = t$, and that $\partial(\theta^{\mathrm{MIX}} - \theta^{\mathrm{HMO}})/\partial\Delta < 0$. Thus, there exists a $\overline{\Delta}$ such that for $\Delta < \overline{\Delta}$ the mixed regime never emerges, regardless of the value of γ.

I summarize the foregoing discussion in the final proposition.

Proposition 10: *The nature of the equilibrium payment regime depends on both the potential quality improvement available and its cost. Two cases can be identified:*

(a) *When the potential quality improvement is modest, i.e., $\Delta < \overline{\Delta}$, the mixed regime never exists. In this case, if the cost of quality enhancement is low, then the pure insurance regime is observed, and if the cost is high, the pure managed care regime is observed.*

[16] I thank Bill Encinosa for this observation.

(b) *When the potential quality improvement is substantial, i.e.,* $\Delta > \overline{\Delta}$, *then the pure insurance regime is observed for* $\gamma < \underline{\gamma}$, *the mixed regime is observed for* $\gamma \in (\underline{\gamma}, \overline{\gamma})$, *and pure managed care is observed for* $\gamma \geq \overline{\gamma}$.

As suggested by Weisbrod (1991), health care markets exhibit a coevolution between technology and payment institutions. Both aspects of market structure are ultimately endogenous, posing challenging but fascinating problems for theorists and empiricists alike.

7. Conclusions

This paper has presented what I believe to be the first attempt to formally model the nature of quality competition when there is competition between payment plans with and without choice. I focused on the contrasting roles of managed care and insurance with choice of hospital, and embedded my analysis in the context of rivalry with uncertain quality improvement. Although my model is quite simple, it generates a surprising number of the stylized facts about the role of alternative payment regimes in health care.

Pure insurance competition softens price competition between hospitals, leading to high prices; the resulting high margins induce hospitals to invest excessively in innovation as a way to attract consumers away from rivals. As the cost of quality enhancement rises, the insurance equilibrium is vulnerable to entry by managed care plans that lock up market share by eliminating *ex post* choice of hospital. Entry by managed care plans has a prisoner's dilemma character, however, and hospital prices and revenues fall as a result. Nevertheless, the mixed regime can be an equilibrium if it allows hospitals to control costs by reducing investments in quality of care. When the cost of quality is high, hospitals can further reduce costs by switching to a pure managed care regime. Either hospital can achieve this unilaterally by raising the price demanded for insurance reimbursement to the point where the insurance market is shut down altogether. For expensive quality improvements, the resulting pure managed care regime produces underinvestment in quality and, conditional on this level of quality, prices that are higher than socially optimal. Still, managed care strictly outperforms the pure insurance regime: all consumers are better off under the former than under the latter.

A number of extensions of the above results remain to be examined. I have left unmodeled traditional health care issues such as moral hazard and adverse selection, and their inclusion, if it can be done in a tractable fashion, would certainly enrich the model. Adding uncertain health status to the model would be another worthwhile extension. Even within my simple demand structure, I have assumed that if hospitals successfully improve quality, HMO patients are not excluded from taking advantage of the advance; this assumption could be relaxed. One could also explore the use of more complex reimbursement arrangements between insurers and hospitals, or an oligopolistic structure for the insurance market. It may also be interesting to study how the possibility of imitation across hospitals, as in Lyon and Huang (1997), would affect the results. Finally, empirical analysis of the relationship between quality improvement and the form of payment regimes would be a valuable contribution.

Appendix

This appendix provides proofs for two key propositions regarding the pure insurance case.

Proposition 3: *In the pure insurance regime, for all pairs of* ex ante *investments* (ρ_0, ρ_1) *there exists a Nash equilibrium in prices in which both hospitals charge the same price, all customers receive nonnegative expected utility, and all customers purchase insurance. The prices are*:

1. $r_0 = r_1 = V + \rho_0\Delta + (\Delta - t)/2$ *if* $\rho_1(1 - \rho_0) > \frac{1}{2}$,
2. $r_0 = r_1 = V + \rho_1\Delta + (\Delta - t)/2$ *if* $\rho_0(1 - \rho_1) > \frac{1}{2}$,
3. $r_0 = r_1 = V + \Delta(\rho_0 + \rho_1 - \rho_0\rho_1) - t/2$ *if* $\rho_1(1 - \rho_0) \le \frac{1}{2}$ *and* $\rho_0(1 - \rho_1) \le \frac{1}{2}$.

Proof. For any pair (ρ_0, ρ_1), the trade-off between obtaining high-quality hospital care and minimizing transportation costs uniquely identifies one customer on the unit line who obtains lower utility than any other customer. There are three cases to analyze, each with a corresponding worst-off customer:

1. $\rho_1(1 - \rho_0) > \frac{1}{2}$, with worst-off customer at $\hat{x}_0 = \frac{1}{2} - \Delta/2t$.
2. $\rho_0(1 - \rho_1) > \frac{1}{2}$, with worst-off customer at $\hat{x}_1 = \frac{1}{2} + \Delta/2t$
3. $\rho_1(1 - \rho_0) \le \frac{1}{2}$ and $\rho_0(1 - \rho_1) \le \frac{1}{2}$, with worst-off customer at $x = \frac{1}{2}$.

Case 1: $\rho_1(1 - \rho_0) > \frac{1}{2}$. Consider the candidate pricing equilibrium $r_0 = r_1 = V + \rho_0\Delta + (\Delta - t)/2$. It is clear that neither hospital wants to cut its price, for doing so would neither expand the total number of insured customers *ex ante* (at the specified price, all customers already buy insurance) nor increase the hospital's market share *ex post* (under insurance, share is driven solely by quality *ex post*). It is not immediately obvious, however, whether either hospital has incentives to raise price. Hospital 0 prefers to raise price if and only if

$$\frac{\partial \bar{\pi}_0}{\partial r_0} = \bar{D}_0 + r_0 \frac{\partial \bar{D}_0}{\partial r} \frac{\partial r}{\partial r_0} > 0. \tag{32}$$

At the candidate price, $\bar{D}_0 = \frac{1}{2} + (\Delta/2t)(\rho_0 - \rho_1)$. Let $s_0 = \bar{D}_0/(\bar{D}_0 + \bar{D}_1)$ be hospital 0's share of expected demand. Then

$$\frac{\partial r}{\partial r_0} = \frac{s_0}{1 - (r_0 - r_1)\, \partial s_0/\partial r}, \tag{33}$$

and for $r_0 = r_1$, $\partial r/\partial r_0 = s_0$. Furthermore, at the candidate price, all customers purchase insurance, so $\bar{D}_0 + \bar{D}_1 = 1$ and $s_0 = \bar{D}_0$. Differentiating demand with respect to r yields

$$\frac{\partial \bar{D}_0}{\partial r} = -\frac{1}{t} + \frac{1 - \rho_1 + \rho_0 \rho_1}{t[1 - 2\rho_1(1 - \rho_0)]} < -\frac{1}{t}. \tag{34}$$

Substituting into equation (32), one obtains the following sufficient condition for hospital 0 to prefer not to raise price:

$$\bar{D}_0 - \frac{r_0}{t}\bar{D}_0 = \bar{D}_0\left(1 - \frac{r_0}{t}\right) < 0. \tag{35}$$

This condition reduces to $r_0 > t$. Since the candidate price is $r_0 = V + \rho_0 \Delta + (\Delta - t)/2$, it is clear that $V > 3t/2$ ensures that the sufficient condition holds. Thus, given assumption (a), hospital 0 has no incentive to deviate from the candidate equilibrium.

Does hospital 1 prefer to raise price above the candidate pricing equilibrium? Just as for hospital 0, hospital 1 has no incentive to cut price below the candidate equilibrium. It will prefer *not* to raise price above the candidate equilibrium price if

$$\frac{\partial \bar{\pi}_1}{\partial r_1} = \bar{D}_1 + r_1 \frac{\partial \bar{D}_1}{\partial r} \frac{\partial r}{\partial r_1} < 0. \tag{36}$$

Hence, if this condition holds, the candidate equilibrium is indeed a Nash equilibrium. Just as for hospital 0, at the candidate equilibrium $\partial r/\partial r_1 = \bar{D}_1$, so hospital 1 prefers not to raise price if

$$\frac{\partial \bar{\pi}_1}{\partial r_1} = \bar{D}_1\left(1 + r_1 \frac{\partial \bar{D}_1}{\partial r}\right) < 0. \tag{37}$$

Divide through by $\overline{D}_1$, and note that calculations show

$$\frac{\partial \overline{D}_1}{\partial r} = \frac{\rho_1(1-\rho_0)}{t[1-2\rho_1(1-\rho_0)]} < 0,$$

where the sign is determined because case 1 is defined by the condition $\rho_1(1-\rho_0) > \frac{1}{2}$. After dividing through (37) by $\overline{D}_1$ and plugging in the candidate price $r_1 = V + \rho_0\Delta + (\Delta - t)/2$, the sufficient condition for a Nash equilibrium becomes

$$1 + \left(V + \rho_0\Delta + \frac{\Delta - t}{2}\right)\frac{\rho_1(1-\rho_0)}{t[1-2\rho_1(1-\rho_0)]} < 0. \tag{38}$$

Some algebra reduces this to

$$V + \rho_0\Delta + \frac{\Delta}{2} > \frac{5t}{2} - \frac{t}{\rho_1(1-\rho_0)}.$$

Note that $\rho_1(1-\rho_0) < 1$, so $t/[\rho_1(1-\rho_0)] > t$ and thus $5t/2 - t/[\rho_1(1-\rho_0)] > 3t/2$. Hence, $V > 3t/2$ is sufficient to ensure that hospital 1 does not wish to raise price above the candidate equilibrium price. Therefore, in case 1, $r_0 = r_1 = V + \rho_0\Delta + (\Delta - t)/2$ is a Nash equilibrium.

Case 2: $\rho_0(1-\rho_1) > \frac{1}{2}$. This case is simply the mirror image of case 1, and hence the proof is omitted.

Case 3: $\rho_1(1-\rho_0) \leq \frac{1}{2}$ *and* $\rho_0(1-\rho_1) \leq \frac{1}{2}$. In this case, the worst-off customer resides at $x = \frac{1}{2}$. If a price increase were to drive some customers to forgo insurance, the gap would be on some range $[\tilde{x}_0, \tilde{x}_1]$, with endpoints where consumer utility goes to zero. It is straightforward to calculate that

$$\tilde{x}_0 = \frac{V + \Delta(\rho_0 + \rho_1 - \rho_0\rho_1) - t\rho_1(1-\rho_0) - r}{t[1-2\rho_1(1-\rho_0)]},$$

$$\tilde{x}_1 = 1 - \frac{V + \Delta(\rho_0 + \rho_1 - \rho_0\rho_1) - t\rho_0(1-\rho_1) - r}{t[1-2\rho_0(1-\rho_1)]}.$$

As mentioned above, those customers at $x < \hat{x}_0$ always go to provider 0 and $x > \hat{x}_1$ always go to provider 1. Thus one can write

$$\overline{D}_0 = \tilde{x}_0[\rho_0\rho_1 + (1-\rho_1)(1-\rho_0)] + \hat{x}_0\rho_1(1-\rho_0)$$
$$+(\tilde{x}_0 - \tilde{x}_1 + \hat{x}_1)\rho_0(1-\rho_1). \tag{39}$$

After some algebra, one obtains

$$\frac{\partial\overline{D}_0}{\partial r} = -\frac{1}{t} - \frac{\rho_1(1-\rho_0)}{t[1-2\rho_1(1-\rho_0)]} - \frac{\rho_0(1-\rho_1)}{t[1-2\rho_0(1-\rho_1)]} < -\frac{1}{t}. \tag{40}$$

Hospital 0's expected profits are

$$\overline{\pi}_0^I = r_0\overline{D}_0 - F(\rho_0).$$

Differentiating with respect to r_0, hospital 0 will not deviate from the candidate equilibrium if

$$\overline{D}_0 + r_0\frac{\partial\overline{D}_0}{\partial r}\frac{\partial r}{\partial r_0} < 0.$$

At the candidate equilibrium, $\partial r/\partial r_0 = \overline{D}_0$, and the sufficient condition for hospital 0 not to deviate simplifies to

$$1 + r_0\frac{\partial\overline{D}_0}{\partial r} < 0.$$

However, since $\partial\overline{D}_0/\partial r < -1/t$, the sufficient condition can be further simplified to

$$1 + r_0\frac{-1}{t} < 0.$$

Substituting in for r_0 and rearranging terms yields

$$t < V + \Delta(\rho_0 + \rho_1 - \rho_0\rho_1) - t/2.$$

If $V > 3t/2$, as specified by assumption (a), then the sufficient condition is met. □

Proposition 4: *Only case 3 of Proposition 3 is subgame perfect.*

Proof. The pricing equilibria in all three cases involve symmetric pricing, so $r_0 = r_1 = r$; they also involve all customers purchasing insurance, so $\overline{D}_i = \frac{1}{2} + (\Delta/2t)(\rho_i - \rho_j)$. Hence one can write

$$\overline{\pi}_i = r\overline{D}_i + \frac{\partial r}{\partial \rho_i}\overline{D}_i - F'(\rho_i).$$

Suppose case 1 obtains, which means that $\rho_1(1 - \rho_0) > \frac{1}{2}$. This condition implies that $\rho_1 > \frac{1}{2}/(1 - \rho_0) > \frac{1}{2}$. Similarly, $1 - \rho_0 > \frac{1}{2}/\rho_1 > \frac{1}{2}$, which implies $\rho_0 < \frac{1}{2}$. Thus, $\rho_1 > \frac{1}{2} > \rho_0$ in case 1.

Note that in case 1 the equilibrium insurance price is independent of ρ_1, while in case 2 the price is independent of ρ_0. In case 1, then, $\partial r/\partial\rho_0 = \Delta$ while $\partial r/\partial\rho_1 = 0$. Thus,

$$\frac{\partial\overline{\pi}_0}{\partial\rho_0} = \frac{r\Delta}{2t} + \Delta\,\overline{D}_0 - F'(\rho_0),$$

$$\frac{\partial\overline{\pi}_1}{\partial\rho_1} = \frac{r\Delta}{2t} - F'(\rho_1).$$

Clearly, $\partial\overline{\pi}_0/\partial\rho_0 > \partial\overline{\pi}_1/\partial\rho_1$. Hence, $\rho_0 > \rho_1$. However, this contradicts the supposition that case 1 obtains, with its implication that $\rho_1 > \rho_0$. Thus case 1 is not a subgame perfect equilibrium. A symmetric argument establishes that case 2 is not subgame perfect.

Suppose now that case 3 obtains. Now $\partial r/\partial\rho_0 = \Delta(1 - \rho_1)$ and $\partial r/\partial\rho_1 = \Delta(1 - \rho_0)$. Differentiating the profit expression for hospital i yields

$$\frac{\partial\overline{\pi}_i}{\partial\rho_i} = \frac{r\Delta}{2t} + \Delta(1 - \rho_j)\left(\frac{1}{2} + \frac{\Delta}{2t}(\rho_i - \rho_j)\right) - F'(\rho_i).$$

A little algebra yields

$$\frac{\partial\overline{\pi}_i}{\partial\rho_i} - \frac{\partial\overline{\pi}_j}{\partial\rho_j} = \frac{\Delta}{2}(\rho_i - \rho_j)\left(1 + \frac{\Delta}{t}(2 - \rho_i - \rho_j)\right)$$
$$- \left[F'(\rho_i) - F'(\rho_j)\right].$$

If the above expression is positive, then in equilibrium $\rho_i > \rho_j$; if it is negative, then $\rho_i < \rho_j$. It is clear from inspection that the above expression is positive when $\rho_i > \rho_j$ and conversely. Thus, case 3 is internally consistent and is the only case that is subgame perfect. Furthermore, it is easy to see that the symmetric equilibrium with $\rho_0 = \rho_1$ is subgame perfect. It is also easy to check that in the symmetric case, $\rho(1 - \rho)$ is maximized at $\rho = \frac{1}{2}$, which yields $\rho(1 - \rho) = \frac{1}{4}$. Thus, the symmetric case satisfies the conditions that $\rho_1(1 - \rho_0) \leq \frac{1}{2}$ and $\rho_0(1 - \rho_1) \leq \frac{1}{2}$. $\square$

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