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A theory of yardstick competition

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In the typical regulatory scheme a franchised monopoly has little incentive to reduce costs. This article proposes a mechanism in which the price the regulated firm receives depends on the costs of identical firms. In equilibrium each firm chooses a socially efficient level of cost reduction. The mechanism generalizes to cover heterogeneous firms with observable differences. Medicare's prospective reimbursement of hospitals by using diagnostically related groups is a scheme very similar to the one outlined here.

1. Introduction

■ Franchised monopolies in the United States are typically subject to "cost-of-service" regulation. Under this scheme, the regulator adjusts the firm's prices to equal the costs it incurs in providing service to consumers at each point of time. Such regulation avoids welfare losses from monopoly pricing, but also permits high enough prices to induce the firm to supply. Unfortunately, this scheme does not adequately address the problem of efficient cost reduction by the regulated firm. For if prices track costs, the firm has no profit incentive to minimize costs. And since the regulator is unlikely to know what the appropriate cost level should be, he can rarely argue that the firm is run inefficiently. To assure cost control, prevent waste, and promote cost-reducing innovation, cost-of-service regulation must be modified.

One approach to this problem is lagged price adjustment (Baumol, 1970; Bailey, 1974), which allows firms to reap the benefits from reducing their costs for some time until the price is brought down. Though this modification is both simple and at least in part effective, it does not resolve the problem completely. First, there is the welfare loss from divergence of marginal cost from price, which accumulates between cost reviews. Second, if firms recognize that prices ultimately follow costs, they may well not reduce costs to efficient levels (Vogelsang, 1983). What the regulator needs is some relatively simple benchmark, other than the firm's present or past performance, against which to evaluate the firm's potential. With such a benchmark, he can decide what the firm's costs ought to be, and set the price accordingly.

One obvious available benchmark is a state-owned firm engaged in the same line of business as the regulated firm. Unfortunately, state-run utilities are often too different from private firms to serve as useful benchmarks, and they are not necessarily efficient (Schmalensee, 1979). As an alternative, this article suggests comparing similar regulated firms with

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each other. For any given firm, the regulator uses the costs of comparable firms to infer a firm's attainable cost level. Borrowing the term that describes comparison of private and state-controlled firms, we call this regulatory scheme "yardstick competition."

Cost comparisons across similar firms are not new to regulatory practice. Medicare's prospective reimbursement system compensates hospitals on the basis of average costs incurred by comparable hospitals in treating patients in the same diagnostically related group. Utility regulators are starting to estimate cost functions to infer "allowable" construction expenditures for nuclear power plants on the basis of observations on other utilities (Johnson, 1985). The Defense Department has employed dual-sourcing to procure the cruise missile and engines for the F-15 plane, in hopes to save enough from cost control to offset foregone gains from economies of scale. This article can be seen as a theoretical justification for rewarding similar firms on the basis of relative performance.[1]

The efficacy of using costs of comparable firms as indicators of a firm's potential is best illustrated for "identical" firms, which the regulator can expect to be able to reduce costs at the same rate. By relating the utility's price to the costs of firms identical to it, the regulator can force firms serving different markets effectively to compete. If a firm reduces costs when its twin firms do not, it profits; if it fails to reduce costs when other firms do, it incurs a loss. To use this scheme, the regulator does not need to know the cost reduction technology; the accounting data suffice to achieve efficiency. Even in the case of heterogeneous firms, yardstick competition is likely to compare favorably with cost-of-service regulation, and it actually attains the social optimum if heterogeneity is accounted for correctly.

A model designed to illustrate the workings of yardstick competition is set out in the next section, which also presents the social optimum and shows that cost-of-service regulation fails to achieve the optimum. Yardstick competition between identical regulated firms is formulated and discussed in Section 3, while Section 4 examines the robustness of such competition with respect to changes in the regulator's set of instruments and to permitting diversity of firms. Yardstick competition is shown to generalize easily, at least for the range of perturbations I explore. Section 5 discusses prospective reimbursement as an example of yardstick competition in some detail.

2. The model

■ We consider a one-period model, with N identical risk-neutral firms operating in an environment without uncertainty. Each firm faces a downward-sloping demand curve $q(p)$ in a separate market. Market-specific demand curves can be handled without much complication, if we assume that they are known to the regulator; the advantage of identical demand curves is that the regulator will not need to know them to implement yardstick competition. Each firm has an initial constant marginal cost c_0, and can reduce c_0 to a constant marginal cost c by spending $R(c)$. We assume that $R(c_0) = 0$, $R'(c) < 0$, and $R''(c) > 0$. Thus, the higher is the investment in cost reduction, the lower is the final unit cost. Note that because of fixed cost reduction expenditures, the firm has decreasing average costs. Firms with heterogeneous cost reduction technologies will be considered in Section 4.

Profits of a firm are given by:

$$V = (p - c)q(p) + T - R(c), \tag{1}$$

where T is a lump-sum transfer to the firm. We assume that lump-sum taxes can be collected, and that the regulator does not care about the distribution of income between the firm and

[1] The model here is closely related to those of Nalebuff and Stiglitz (1983b), although they focus on risk sharing. Also related are articles on tournaments, e.g. Lazear and Rosen (1981) and Nalebuff and Stiglitz (1983a).

consumers. In that case, lump-sum transfers do not affect welfare. In the command optimum the regulator picks c, p, and T to maximize

$$\left\{\int_p^\infty q(x)dx\right\} + (p - c)q(p) - R(c) \tag{2}$$

subject to the breakeven constraint:

$$V \geqslant 0. \tag{3}$$

The integral in (2) is the consumers' surplus, and (3) specifies that T covers losses.

The solution to this problem is the social optimum, given by:

$$R(c^*) = T^* \tag{4}$$

$$p^* = c^* \tag{5}$$

$$-R'(c^*) = q(p^*). \tag{6}$$

Because lump-sum transfers are available, the shadow price of (3) is zero. Equation (5) sets the price equal to the marginal cost, and (4) says that the transfer just covers the expenditures on cost reduction. Equation (6) is the condition for total cost minimization to produce output q. Note that $-R'(c)$ is the marginal cost of cost reduction, which (6) equates to output. Intuitively, lowering unit costs by Δc requires $-R'(c)\Delta c$ investment in cost reduction, but reduces production costs by $q(p)\Delta c$. At the optimum, the costs and benefits of a marginal change in c must be equal.

Assume that $-R'(c_0) < q(c_0)$, that $-R'(0) > q(0)$, and that $-q'(c) - R''(c) < 0$ (the second-order condition for (2)). These assumptions imply that cost reduction is cheap at the start but gets progressively costlier. When they hold, the optimum exists and is unique.

To order firms to achieve c^*, the regulator must know $R(c)$. In the subsequent discussion, we assume that he does not have this information, and investigate his options in that case. Specifically, suppose that the firm is run by managers, and the regulator tries to get them to run it efficiently. He does not know, however, what the cost-reduction technology is, and hence cannot decide what cost level should be attained. We assume that the firm's managers maximize profits, but as long as profits are not at stake, they exert as little effort as possible. We suppress effort from the discussion as it only enters to break ties in favor of "doing nothing." The regulator must use the profit motive of the firm's managers to encourage them to reduce costs.

The regulator maximizes the sum of consumers' and producers' surpluses. His instruments, for now, are prices and lump-sum transfers to the firm. At any given regulator-set price, the firm always has to produce to meet the demand. It does not have the option to refuse to produce and to exit if it does not like the price the regulator has set.[2] We assume that first the regulator announces his pricing *rule,* which describes how he will set prices and transfers on the basis of what he will observe. After that, firms invest in cost reduction, and the regulator observes their cost levels c and cost-reduction expenditures $R(c)$. Equipped with this knowledge, he sets prices and transfers according to the rule he announced. Finally, firms produce their output, sell it at the prices the regulator has set, and receive their transfers.

Cost-of-service regulation cannot implement the social optimum. Under this pricing rule, the regulator sets $p = c$ and $T = R(c)$, whatever the costs are. Faced with this policy, managers recognize that their profits are going to be zero regardless of costs, and, since they prefer not to reduce costs, they keep $c = c_0$. In this model, cost-of-service regulation fails to deliver any cost reduction at all.

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[2] In equilibrium shareholders of the firm will be willing to participate in the regulatory arrangement I discuss below.

3. Yardstick competition among identical firms

■ Since cost-of-service regulation leads to inefficient performance, the regulator should like to eliminate the dependence of the firm's price on its own chosen cost level. To do that, he can use cost levels of identical firms to determine the price. Recall that the regulator has $N \geqslant 2$ identical firms under his jurisdiction.[3] For each firm i define

$$\bar{c}_i = \frac{1}{N-1} \sum_{j \neq i} c_j \tag{7}$$

$$\bar{R}_i = \frac{1}{N-1} \sum_{j \neq i} R(c_j). \tag{8}$$

Each firm i is assigned its own "shadow firm," with cost level $\bar{c}_i$ equal to the mean marginal cost of all other firms, and with a similarly defined cost-reduction expenditure $\bar{R}_i$. This fictitious shadow firm serves as the benchmark in yardstick competition.

Specifically, suppose the regulator commits himself to the price and transfer rule given by

$$T_i = \bar{R}_i \tag{9}$$

$$p_i = \bar{c}_i \tag{10}$$

for each i. Proposition 1 shows that if firms believe this commitment, and choose costs accordingly, then the regulator can achieve the social optimum as the unique equilibrium of the game in which firms simultaneously pick their unit cost levels.

Proposition 1. If the regulator sets the price and the transfer by using the shadow firm (i.e., (9) and (10)), the unique Nash equilibrium is for each firm i to pick $c_i = c^*$.

Proof. Using (9) and (10), observe that firm i maximizes

$$q(\bar{c}_i)(\bar{c}_i - c_i) - R(c_i) + \bar{R}_i, \tag{11}$$

where $\bar{c}_i$ and $\bar{R}_i$ are defined by (7) and (8). As equation (11) shows, a firm's choice of c_i has no effect on the price it gets. Profit maximization then implies

$$-R'(c_i) = q(\bar{c}_i). \tag{12}$$

We must find all cost choices by firms that will satisfy (12). Clearly, if each firm picks $c_i = c^*$, we obtain an interior symmetric Nash equilibrium, with $p_i = c_i = c^*$ for each i. We must now show that there does not exist, in addition, an asymmetric equilibrium.

Recall that the second-order condition for the social optimum problem implies that

$$q(c) \gtrless -R'(c) \qquad \text{according as} \qquad c \gtrless c^*. \tag{13}$$

Suppose there is an equilibrium in which not all firms choose c^*. Then, either the firm with the highest chosen unit cost has $c_i > c^*$ or the firm with the lowest unit cost has $c_i < c^*$ (or both). In the former case $c_i \geqslant p_i$, since p_i is the average of unit costs lower than c_i. Suppose now that firm i lowers c_i by Δc_i. It gains $q(p_i)\Delta c_i$ at the cost of $-R'(c_i)\Delta c_i$. But $-R'(c_i) < q(c_i) \leqslant q(p_i)$, where the first inequality follows from (13) and the second obtains since $c_i \geqslant p_i$ and the demand curves slope down. But then the firm clearly prefers to lower its cost, since $q(p_i)\Delta c_i > -R'(c_i)\Delta c_i$. This shows that there is no equilibrium with

[3] Alternatively, if the regulator has heterogeneous firms under his jurisdiction, assume that he has sorted them into groups of identical firms, and focus on one such group with $N \geqslant 2$ members.

$c_i > c^*$. Likewise, if $c_i < c^*$, firm i can be shown to want to raise its unit cost, and again there can be no equilibrium. This contradiction establishes that firms' maximizing strategies are unique. *Q.E.D.*

Remark. Price rules other than (10) can work just as well. Any price rule

$$p_i = f(c_1, \ldots, c_{i-1}, c_{i+1}, \ldots, c_N)$$

satisfying the two conditions:

$$f(a, a, \ldots, a) = a \tag{14a}$$

$$\partial f/\partial c_j \geqslant 0 \qquad \text{for any } j, \tag{14b}$$

will deliver the first best as the unique equilibrium.[4] The reason is as follows. The price rule (10) was used in the uniqueness proof only to show that the highest unit cost c_i is at least as high as the price p_i that the firm incurring c_i faces. Conditions (14a) and (14b) ensure this for the price rule f. For, since $f(c_i, \ldots, c_i) = c_i$ by (14a) and each c_j for $j \neq i$ is lower than c_i, we have $p_i = f(c_1, \ldots, c_{i-1}, c_{i+1}, \ldots, c_N) \leqslant c_i$ by (14b). Another example of a price rule that satisfies (14a) and (14b) is $p_i = c_j$: a firm's price is any other firm's unit cost. In the sequel, I prefer to use (9) and (10), in part because their analogs show up naturally in the heterogeneous firms' case.

Yardstick competition works because it does not let an inefficient cost choice by a firm influence the price and transfer payment that that firm receives. It is essential for the regulator to commit himself not to pay attention to the firms' complaints and to be prepared to let the firms go bankrupt if they choose inefficient cost levels. Unless the regulator can credibly threaten to make inefficient firms lose money (or, alternatively, can prove in court that firms chose to be inefficient and that their practices were imprudent), cost reduction cannot be enforced.[5]

But if the regulator can make such a commitment, yardstick competition actually delivers the first best. The reason is that, as long as the regulator can get the price to be c^*, his and the firms' preferences for cost reduction coincide ((6) is the same as (12)). Since with (10) the price tracks the marginal cost exactly, the regulator can actually get the firms to pick c^*. In a symmetric equilibrium the social optimum is revealed to the regulator, and is attained as the outcome.

4. Yardstick competition in alternative environments

■ In this section I discuss yardstick competition under alternative assumptions. First, I consider the case in which the regulator can only use prices, and not lump-sum transfers, to compensate the firm. Yardstick competition works in this case as well. Second, I show that if the regulator observes the characteristics that make firms heterogeneous, yardstick competition is not the best way he can regulate. Instead, a multivariate regression defines a price rule that can bring us back to the first best.

□ **Average cost pricing.** If lump-sum transfers are not available to the regulator, he must compensate the firm for cost-reducing expenditures by allowing higher prices. In the present case of one good, this amounts to average cost pricing.

The equations characterizing the social optimum when $T \equiv 0$ are:

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[4] I am grateful to Stephen Salant for suggesting this generalization.

[5] In practice, if the regulator can prove in court that the firm's expenditures were imprudent, he can refuse to adjust the firm's rate to cover these expenditures. Superior performance by comparable firms clearly improves his odds of establishing imprudence.

$$-R'(c_i) = q(p_i) \tag{15}$$

$$(p_i - c_i)q(p_i) - R(c_i) = 0. \tag{16}$$

Equation (15) continues to equate the marginal gain in producer's surplus to the marginal cost of cost reduction, whereas (16) is the breakeven condition.

To implement the average cost pricing version of yardstick competition, the regulator replaces c_i by $\bar{c}_i$ and $R(c_i)$ by $\bar{R}_i$ in (16), and solves it to set the price for firm i. Firm i will choose c_i to minimize its total costs, given by $q(p_i)(p_i - c_i) - R(c_i)$. This minimization gives the first-order condition (15), just as in the command optimum. When p_i is given by (16) with c_i replaced by $\bar{c}_i$, the symmetric equilibrium yields unit costs and prices satisfying both (15) and (16). Thus, the average cost pricing version of yardstick competition gives rise to a symmetric equilibrium in which all firms pick the second-best unit cost levels.[6]

□ **"Reduced-form" regulation.** Sorting firms into identical or even similar groups to apply yardstick competition is a very inefficient use of information. Even though implementing yardstick competition requires only two identical firms, there may be firms with no identical twins. The regulator can avoid this problem if he observes the characteristics that make firms differ, and corrects for this heterogeneity. This correction amounts to a regression of costs on characteristics that determine diversity, as I shall show for the case of marginal cost pricing.

If firms have observable exogenous characteristics θ, the first best is given by costs $c(\theta)$, prices $p(\theta)$, and transfers $T(\theta)$ for each type θ, satisfying:

$$-R_1(c, \theta) = q(p) \tag{21}$$

$$c(\theta) = p(\theta) \tag{22}$$

$$T(\theta) = R(c, \theta). \tag{23}$$

Substituting (22) into (21), we obtain

$$-R_1(c, \theta) = q(c(\theta)), \tag{24}$$

which can be approximated by a Taylor series around some $(\theta_m, c_m(\theta_m))$ and then solved for c in terms of θ to obtain:

$$c \approx a + b\theta, \tag{25}$$

where

$$a = \frac{c_m(R_{11} + q_1) + \theta_m R_{12}}{q_1 + R_{11}}, \tag{26}$$

$$b = \frac{R_{12}}{q_1 + R_{11}}, \tag{27}$$

and all the derivatives are evaluated at (θ_m, c_m). If θ is a vector, these expressions can be generalized; however, θ must consist of observable characteristics that cannot be altered by the firm (e.g., the regional cost-of-labor index). Also, higher-order Taylor expansions can be used for greater precision. To the extent that firms are not very different, (25) is a good local approximation for (24), and thus is not very far from the true condition for the social optimum.

The regulator can now estimate (25) by using the data on costs and firm-specific characteristics. (By analogy with Section 3, he can exclude observations on firm i from the regression for firm i, but this is unlikely to make much difference for parameter estimates.)

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[6] Uniqueness of equilibrium under average cost pricing remains to be established.

He then obtains the predicted unit cost level for firm i by using the estimated coefficients $\hat{a}$ and $\hat{b}$, via

$$\hat{c}_i = \hat{a} + \hat{b}\theta_i. \tag{28}$$

The regulator thus commits himself to the following price rule: whatever costs the firms incur, he will run the regression (25), get the predicted cost level from (28), and set $p_i = \hat{c}_i$. Note that when there is no variation in θ, $\hat{a} = \bar{c}_i$, and we are back to yardstick competition!

In addition to the price rule, the regulator must specify the transfer $T_i(\theta)$ which in equilibrium satisfies (23) and is independent of firm i's own choice of unit cost. To do this the regulator again runs a regression, which is now based on a Taylor expansion of $R(c, \theta)$, with c implicitly defined from (24):

$$R_i = \alpha + \beta\theta_i. \tag{29}$$

From this regression he obtains the predicted cost-reduction expenditure for a firm with characteristics θ_i, and sets the transfer $T_i(\theta_i)$ to firm i equal to $\hat{R}_i$.

Under the assumption that firm i knows the distribution $F(\theta)$ as well as the function $R(c, \theta)$, it will pick c_i with knowledge of the price it will get, according to (21). This mechanism has several properties. First, if (25) is the exact version of (24), and if θ is the complete list of characteristics accounting for diversity (i.e., the R^2 of regression (25) equals one), then this regulatory scheme yields first-best unit cost levels as its outcome, just as the simplest version of yardstick competition did.[7] If, in addition, (29) is the exact version of (23), then each firm breaks even in equilibrium.

If (25) is an approximation, or if some heterogeneity is not accounted for, then the outcome diverges from the optimum. Furthermore, these problems may render the transfer insufficient to cover cost-reduction expenditures, thereby requiring a subsidy to run the scheme without bankruptcies. Since there is continuity throughout, however, if the R^2 of (25) and of (29) is high, this divergence is not very large, and significant subsidies may not be necessary.

Reduced-form regulation may run into several difficulties. First, in running the regression, we have assumed that whatever exogenous characteristics have been omitted are uncorrelated with θ. If that assumption is false, we have an omitted variable bias on estimated coefficients. As long as the covariance between excluded and included characteristics is the same for all firms, however, we do not need unbiased parameter estimates, and can predict costs consistently with whatever variables we have. Second, we have assumed that elements of θ are exogenous, whereas the firms may actually have control over some of their characteristics. But again, we can estimate the reduced form, and obtain consistent predictions of costs, even if the coefficients of the regression are biased. Joskow and Schmalensee (1985) discuss ways to improve the explanatory power of such regressions by using panel data.

5. Prospective reimbursement using diagnostically related groups

■ The experience with diagnostically related group reimbursement by Medicare nicely illustrates both strengths and pitfalls of yardstick competition. Under this system, Medicare divides all possible patient types into 500 diagnostically related groups. Each patient is assigned to a group on the basis of his physician's diagnosis, and Medicare pays hospitals a fixed fee for treating a patient, given his diagnostically related group. The size of this fee is the average of costs of treating patients who fall into a particular group taken across comparable hospitals over the previous year, plus certain adjustments for inflation.

This system is remarkably close to yardstick competition. If a hospital can treat its

[7] Uniqueness of equilibrium for reduced-form regulation remains to be established.

patients for below what it costs others to treat similar patients, it pockets the excess of its fee over its cost; if it cannot keep costs below fees, it suffers a loss. With 40% of an average hospital's revenue coming from Medicare payments (*Wall Street Journal,* 1984), one expects hospitals to try to minimize costs.

In fact, evidence from early nationwide Medicare results points to progress in cost control. In the half-year after the beginning of Medicare's program, the average stay per Medicare patient has dropped (*Wall Street Journal,* 1984), arguably because payments, unlike costs, do not rise with the length of the stay. In contrast, in states that introduced incentive payments based on *per diem* rates, lengths of stay seem to rise (Worthington and Piro, 1982).

Although this evidence points to effectiveness of diagnostically related group reimbursement, the problems of diversity and strategic behavior considered in Section 4 keep the system far from being perfect. Though Medicare currently adjusts its payments by a geographic cost-of-labor index, and gives extra money to teaching hospitals, it disregards other sources of variation. Most conspicuously, it does not adjust the payment for the severity of illness (or, more or less equivalently, for the duration of hospital stay). The reasons for this policy are obvious: the moral hazard associated with reporting severity is great, and also, *on average,* different hospitals are probably getting equally sick patients. If, however, some hospitals get a disproportionate share of very sick patients, they will suffer. In the worst case they may even turn down patients (Joskow, 1983). This issue seems to be perceived as a serious flaw in the current system, and cheat-proof corrections for severity are a large research topic in this area.[8]

Difficulties of devising a perfect reimbursement program point to the importance of moral hazard. To beat the system, doctors can do several things. They can injudiciously reduce patients' length of stay in the hospital to contain costs (*Wall Street Journal,* 1984), they can discharge patients and then readmit them "with complications" or under a different diagnostically related group, or they can forego implementation of new and better procedures because Medicare does not adequately pay for them (Cromwell and Kanak, 1982). The results in Section 4 suggest that Medicare should consider applying the same approach it applies to costs to other endogenous variables. Thus, hospitals that have more than the average number of readmissions might not be compensated for them; hospitals that discharge patients within a diagnostically related group much faster than do other hospitals should perhaps be penalized, etc. Though such modifications are feasible in principle, they may add in complexity more than what they will save in cost. The system seems to be working reasonably well as it is.

6. Conclusion

■ Yardstick competition describes the simultaneous regulation of identical or similar firms. Under this scheme the rewards of a given firm depend on its standing *vis-à-vis* a shadow firm, constructed from suitably averaging the choices of other firms in the group. Each firm is thus forced to compete with its shadow firm. If firms are identical, or if heterogeneity is accounted for correctly and completely, the equilibrium outcome is efficient.

Even if diversity is not adequately incorporated into the price formula, yardstick competition is likely to outperform cost-of-service regulation. The reason is that welfare losses from unobservable firm differences are small under yardstick competition as long as these differences are small. In contrast, welfare under cost-of-service regulation can fall far short of the optimum. The encouraging performance of yardstick competition in Medicare's

[8] The vast majority of articles in the November, 1984, supplementary issue of *Health Care Financing Review,* dedicated entirely to prospective reimbursement, were devoted to improvements of prospective reimbursement's treatment of severity.

diagnostically related group reimbursement system, despite the problems of diversity of firms, suggests that these problems are not overwhelming.

An important potential limitation of yardstick competition is its susceptibility to collusive manipulation by participating firms. At issue is whether firms can slow down cost reduction without losing money or even make money over time as yardstick competition price and transfer rules are used repeatedly. Although some scope for collusion is probably present, it is somewhat limited by two considerations.

First, if the regulator observes firm behavior which he can prove (e.g., in court) to be collusive, he can punish firms for engaging in such conduct. An example would be disallowing a firm to choose unit costs that are vastly higher than those of a very similar firm. The presence of a third party—in this case the regulator—that can disallow certain strategies[9] sets the case of yardstick competition apart from that of oligopoly. The limits the regulator can impose on permissible choices of firms can narrow the scope for collusion.

Second, with a very large number of firms, as in the case of hospitals discussed in Section 5, complicated collusive strategies may not be sustainable. A large number of firms may simply fail to coordinate on a punishment strategy for one firm that deviates from a collusive equilibrium. In addition, firms might not know which one of them has violated the collusive agreement. These considerations notwithstanding, an analysis of collusive response to yardstick competition remains an important part of evaluation of this policy rule, which must be addressed in the future.

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[9] In particular, punishment strategies off the equilibrium path may require that all firms lower costs dramatically to punish a deviator. If the regulator notes these dramatic cost reductions, and holds the firms to them in the future, firms may be less likely to try reducing costs. In so far as such response by the regulator limits the scope for punishment, it also limits the scope for collusion.