Yardstick Competition when Quality is Endogenous: The Case of Hospital Regulation

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Abstract

In many countries hospital regulation undergoes fundamental change. In reaction to steadily increasing costs, authorities switch from cost of service regulation to prospective payment systems (PPS). While it seems clear that this new scheme sets strong cost saving incentives, this is not so clear for quality provision. As a matter of fact, everything hinges on the prices the regulator sets. Figuring out optimal prices is, however, a difficult task, because the regulator faces serious informational limitations. The literature largely ignores this problem and points to Shleifer's (1985) yardstick competition for a solution. Yardstick competition, however, ignores quality issues. This paper fills this gap in the literature and shows that endogenizing quality changes the results of yardstick competition substantially. Quality will

be zero and cost reduction efforts can be heavily distorted. In general, a simpler version of yardstick competition average cost pricing turns out to be more favorable, though not perfect.

1 Introduction

Until recently, hospitals in most countries have been financed by a cost-of-service regulation (CoSR[1]) scheme, i.e. they were simply reimbursed all their costs. The problem with this type of regulatory policy is that it lacks incentives to control expenditures. In reaction to rising health care costs an increasing number of countries therefore changes the regulation of their hospital markets. The main component of this change is typically a switch from CoSR to a prospective payment system (PPS). In a PPS illnesses are categorized according to their diagnosis into about 500 different groups (diagnosis related group = DRG). A hospital gets the same pre-determined price per patient in a specific group. The basic logic of this system is simple: Giving it a fixed price for a patient, it is then the hospital who bears the costs of treatment. This will motivate the hospital to minimize costs.

Experience in practice, however, renders the view of PPS less positive than had been hoped. In Germany, for example, already the partial introduction of PPS has had a number of undesired or at least questionable effects. The most prominent of those are overworked doctors and nurses, nation wide strikes, emigration of qualified personal to other European countries, decreased care intensity, rejection of patients, and bankruptcies of rural area hospitals.[2]

This emphasizes that costs are only one dimension of a hospital's activity. The second dimension is quality of care. As a matter of fact, there is hardly any

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[1] We use the abbreviation CoSR instead of the commonly used FFS (fee for service), because we experienced some confusion in discussions when using FFS. The reason seems to be that "fee" sounds more like a pricing mechanism than like cost reimbursement.

[2] Especially the last two points cause increasing grief, because they imply that patients have to travel longer distances for treatment. Since these transport costs do not only consist of fuel and time consumption but also of risk of accidents and worsening of health condition due to delayed treatment, they are estimated to have a significant negative effect on a patient's utility. See e.g. Ho (2005) for details.

other product in which quality is so important for the customer as in health care. Consequently, there has been a lot of concern whether a PPS may not also have negative effects on the quality provision. Ever since a PPS was first introduced in the U.S. in the early eighties this issue has received considerable attention in the literature. Ellis and McGuire (1986) were the first to point out the basic problem of a PPS: If quality is costly, a fixed price gives incentives to reduce quality. The major counterargument is brought up by Pope (1989). He argues that since patients do not pay for treatment directly, hospital demand depends mostly on quality. Consequently, hospitals have an interest in retaining high reputation in order to attract patients. This could set incentives strong enough to provide high quality. As a matter of fact, in his seminal paper Ma (1994) demonstrates in a multitask agent model that PPS may even achieve the first best allocation in cost as well as in quality effort - if prices are set correctly.

This last "if" is, however, crucial. None of the relevant papers discusses the regulator's ability to set prices correctly. In particular, Ma states conditions that prices must fulfill, but implicitly he assumes the regulator to have perfect information. As will be demonstrated in this paper, setting the first best inducing prices requires the regulator to have extensive knowledge of each hospital and its market environment. Most critically, he needs to know the hospital's cost function.

This, however, is far from reality and causes serious problems for regulators in practice. They usually do not know hospitals' cost functions. Consequently they are unable to determine first best inducing prices. Instead, they have to rely on other price mechanisms. Unfortunately, the literature of health economics is of little use in this quest and points to regulatory economics, namely Shleifer's (1985) yardstick competition. This is a method for regulating firms whose costs functions

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are unknown to the regulator, but whose cost levels are observable. The main goal of this regulation is to make it impossible for the regulated firm to influence its own price. This is done by reimbursing the regulated firm with a price that reflects the costs of an identical twin of this firm. Thereby the regulator can induce an indirect competition between the regulated company and it's yardstick. The Nash equilibrium can result in first best outcomes.

In the light of the discussion on hospital regulation, Shleifer's (1985) paper has some important shortcomings, though, because it neglects some key features of the hospital market. First, Shleifer does not incorporate endogenous quality of care. Second, unlike the customers in Shleifer's model patients do not pay prices for medical treatment.

This is where my paper picks up. I link together the two strands of literature, the health economics side and the regulatory economics side, by merging the two decisive papers in the respective fields, namely Ma's (1994) multitask agent model and Shleifer's (1985) yardstick competition. Specifically, I take Ma's multitask agent model, specify the regulator's information set the way this is typically done in the discussion among practitioners, and then apply the yardstick competition regulation rule. The aim is to see whether yardstick competition is really applicable in the specific hospital sector. I find that Shleifer's results do not persist in this environment. In particular, hospitals will set quality equal to zero in response to pricing a la Shleifer. The intuition for this result is the following. Since the demand response to quality is the only incentive for hospitals to provide high quality, hospitals need to receive positive mark-ups per patient. In the Nash equilibrium of the indirect competition induced by a yardstick regulation the mark-ups are, however, zero. It turns out that a simpler version of yardstick competition performs

better, though not perfectly.[3]

The paper is organized as follows. Section 2 summarizes the related literature other than Ma (1994) and Shleifer (1985). Section 3 introduces the model's basics. Section 4 briefly summarizes Ma's model, but draws a different conclusion than Ma, namely that under the restrictions of the regulator's information set it is a very difficult task to determine optimal prices. Section 5 reviews Shleifer's model in its original form. Section 6 is the main part of this paper. It introduces quality into yardstick competition. In response to the results, section 7 proposes a simpler and more favorable pricing rule. The paper then concludes with section 8.

2 Related Literature

2.1 Theoretical Literature

In the health economics literature most papers ignore the restrictions of the regulator's information set and his difficulties to determine prices. Instead authors concentrate more on the question whether a fixed price per patient generally leads to too low quality provision within a DRG. In addition to Ma and Shleifer the following authors have contributed especially valuable insights to the discussion on PPS:

The quality issue was first considered by Ellis and McGuire (1986). They argue

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[3]To the best of my knowledge there exists only one other paper, Tangeras (2002), that discusses yardstick competiton when quality matters. This sentence, however, already exhausts the similiarties to my paper. The reason is that Tangeras defines yardstick competition in a much broader sense and asks a more general question, namely whether it is useful to use other firms' reports on cost functions to evaluate whether the cost function that the regulated firm i reports is reasonable. Since this is also done under CoSR, Tangeras' results do not help in answering the more specific question we are dealing with in this paper.

that as prices in the PPS are fix, it is profitable for hospitals to reduce quality of treatment if quality is costly. This result is formally derived in a model where each patient is locked-in to his physician. They suggest that a mixed reimbursement system (fixed price component and a cost based variable component) is superior to pure PPS. Ellis and McGuire assume efficient production as well as patient homogeneity, and do not model competition, or hospital heterogeneity.

In contrast to this, Pope (1989) offers a model of competition under a PPS, where identical hospitals choose quality and degree of managerial slack. In the symmetric Cournot equilibrium, competition (in quantity, by setting quality) does not only reduce managerial slack (i.e. increases efficiency), but also increases quality. The intuition is that expanding quantity by increasing quality is profitable. Pope concludes that a mixed reimbursement system may be better in situations where there is little competition. When competition is very strong, quality may be excessive. This can, however, be mitigated by reducing the price. His equilibrium concept requires complete symmetry of the firms. He does not analyze the price setting.

Dranove (1987) is the first to distinguish severity of cases within a DRG. He points out that there may be efficiency effects due to specialization. These effects may be positive as well as negative. He considers two types of hospitals in a given DRG - an efficient type and an inefficient type. Furthermore, he assumes that patients within a DRG vary in the costs they cause. At given price inefficient hospitals may stop treating patients, while efficient ones continue to treat - an efficiency enhancing specialization. If hospitals can forecast the costs a specific patient will cause, they may engage in dumping (treat the relatively cheap patients and turn down the costly ones) - an efficiency decreasing specialization. Dranove

does not take into account quality of treatment and competition among hospitals.

Ellis (1998) points out that the degree of competition for patients within one DRG may be ambiguous when travel costs are present (horizontal differentiation) and patients' severity of illness varies (vertical differentiation). In this case, low severity patients are those who are (relatively) unwilling to travel great distances. Each hospital is then a local monopolist for low severity patients. Since under PPS hospitals receive a fixed price for this DRG and since low severity patients offer a greater margin, hospitals will generally oversupply services (creaming) in order to extend demand. High severity patients on the other side are willing to travel great distances. Hospitals are therefore automatically competitors for those. Since high severity patients are, however, less profitable, hospitals will try to not treat ("dump") or at least underprovide services for them ("skimp"). Since no reimbursement system is able to take travel costs and differences in severity of illness for each single patient into account (due too informational and complexity problems), no regulation scheme can hope to achieve neither first nor second best outcomes. Ellis argues that a mixed reimbursement system may nevertheless be superior to both a pure cost-of-service system and a pure PPS for the same reasons as stated in Ellis and McGuire (1986). Ellis assumes efficient production and complete symmetry of hospitals.

2.2 Empirical Literature

The empirical literature is vast, has to fight with serious structural problems, and delivers mixed results. The biggest obstacle for empirical researchers is that the key variables (cost reduction efforts, quality of care, and hospital cost functions) in

hospital markets are unobservable. The lack of observations and the corresponding reliance on imperfect proxies of the important factors make econometric research in this field a very difficult task and vulnerable to an infinity of objections. The incomplete list of contributions reported here is mainly drawn from Chalkley and Malcomson (2000).

Among the pioneers in assessing the cost saving effects of a switch from CoSR to PPS are Freiman et al. (1989), Frank and Lave (1989), Newhouse and Byrne (1988), and Ellis and McGuire (1996). They report that the length of stay in hospitals (the most commonly used proxy for resource usage) declines in response to a change to PPS. Among the many criticisms of this proxy, the most severe one is that length of stay is influenced by large number of factors. This is demonstrated by e.g. DesHarnais et al. (1987) and Miller and Sulvetta (1995), the latter attributing 69 % of costs to exogenous factors.

The quality effects of a switch in regulation has received increasing attention, recently, but suffers a lot from the lack of reliable, objective quality measurements. The most frequently used variable is mortality rates. Although this is a very crude and relatively inelastic measure of quality (only a small number of patients are that severely ill), even here the results are mixed. DesHarnais et al. (1987, 1990) find no change. Cutler (1995) observes no change in the overall rate, but in the timing of mortality. Another measure is treatment numbers. The results by Hodgkin and McGuire (1994) indicate a decline in treatment numbers. This could be due to dumping of costly patients, transfer of patients to non-PPS institutions, or reduced quality. Another study by Ellis and McGuire (1996) provides evidence that 40% of reduction in length of stay is due to reduced care intensity, while 60% is due to other aspects of quality or effort.

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3 The Model Primitives

To simplify matters, we will consider hospitals that produce only one DRG (one-product firm). Furthermore, we assume patients to be homogenous.

3.1 Costs

Since the regulator is interested in a long-term regulation scheme, we will proceed in our analysis considering the long-run cost curves of hospitals. In the long-run all costs are variable costs that depend on the quality of treatment q and on cost reducing efforts e. Additionally, there will be some costs of quality-increasing and cost-reducing efforts, $E(e,q)$. The interpretation of the variables is the following: The quality of treatment q consists of intensity of care, qualification of the doctors and nurses, available technical equipment, effectiveness of medication, etc. Cost reducing effort e is mainly organizational effort that incorporates effort to optimize the length of a patient's stay in hospital, setting incentives to use the cheapest medication for given quality, design of efficient wages for employees, monitoring of employees, organization of work flows, etc. Marginal costs $c(q,e)$ are all observable long-run marginal costs of running a hospital, i.e. mainly wages, expenditures for technical equipment, maintenance costs of buildings, payments for electricity and water, etc. $E(e,q)$ are those costs of the residual claimant of profits (chief doctor, administration, local municipality, management, shareholders of private hospital) that he bears for e.g. designing incentive compatible wage contracts for the employees, monitoring the employees, organization (duration of stay of patients, ...), optimizing the work flow in the hospital, etc. We will make the

following assumptions on the cost function of hospital i:

$$C^i(q^i, e^i) = c(q^i, e^i)D^i(q^i) + E(q^i, e^i) \tag{1}$$

where:

1. Structural Assumptions:

   - The functional forms of $c(\bullet)$ and $E(\bullet)$ are the same for all hospitals $i = 1, ..., n$. This is a simplification which is based upon the hypothesis that in the long run all hospitals have access to the same production technology.

   - The demand function $D^i(q^i)$ is different for each hospital and increasing in quality. This assumption captures the heterogeneity of hospitals, as for example the differences in market environments and sizes between metropolitan and rural area hospitals. See next section for a detailed discussion.

   - $c_{q^i}(\cdot) > 0$, $c_{q^i q^i}(\cdot) > 0$, $c_{e^i}(\cdot) < 0$, $c_{e^i e^i} > 0$, $c_{q^i e^i} \geq 0$

   - For all markets i, $D^i_{q^i}(q^i) > 0$ and $D^i_{q^i q^i}(q^i) < 0$ is assumed.

   - $c(q^i, e^i)D^i(q^i)$ is assumed to be a convex function

   - $E_{q^i}(\cdot) > 0$, $E_{q^i q^i}(\cdot) > 0$, $E_{e^i}(\cdot) > 0$, $E_{e^i e^i}(\cdot) > 0$, $E_{q^i e^i}(\cdot) \geq 0$

2. Informational Assumptions:

   - e^i is unobservable[4]

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[4]For a discussion of the empirical observability of e and q see e.g. Chalkley and Malcomson (2000).

- q^i is unverifiable for the regulator, but observable by local doctors such that it influences demand (see next section for a detailed discussion)

- The total levels $c(q^i, e^i)$, $E(q^i, e^i)$, and $D^i(q^i)$ are verifiable by the regulator.

- The functional forms of $D^i(q^i)$ are known to the regulator, but not the ones of $c(q^i, e^i)$ or $E(q^i, e^i)$.[5]

3.2 Demand

Due to the insurance principle in health care, patients do not bear any direct costs of treatment. This creates a moral hazard problem on the demand side: Patients will seek the best treatment quality and intensity possible, without taking into account the costs they cause.[6] Therefore demand depends mostly on quality of care.

Typically, ordinary people are, however, unable to judge quality of treatment, because medical care is a highly sophisticated product. In order to decide what hospital to visit, prospective patients have to rely upon sources of information and advice other than their own judgement.

It is therefore a reasonable working hypothesis to assume that a patient chooses the hospital for treatment that is recommended to him by his physician ("Hausarzt").[7]

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[5]Estimating hospital cost functions is a very difficult task. Some of the most evident problems are unobservable case mix variations, output measurement in aggregates, uncertainty of demand, difficulties in modelling hospital competition, etc. For a discussion of these matters see e.g. Gaynor and Vogt (2000).

[6]The use of the term "moral hazard" in this context may be irritating for some reader. It is, however, the typical expression for the observed behavior of fully insured patients, who do not take the costs they cause into account. For a more detailed discussion see e.g. Newhouse (2002), pp. 80-81.

[7]Quoting a German chief doctor: "Our customers are, in fact, not the patients, but their physicians."

What does a physician base his recommendation upon? Considering him a reasonably good agent of his patient, he will probably suggest the hospital that he thinks will deliver the best care. In how far is a physician able to judge the quality of care in a given hospital? Like the regulator, a physician will have significant difficulties to evaluate the quality of care in all hospitals in Germany. It seems sensible, though, to assume that he has superior (to the regulator) knowledge about local hospitals with which he has been dealing for quite a while. Therefore, as long as a patient chooses among local hospitals, only, he will be able to assess a hospital's quality fairly well and select the one that yields him the highest utility[8] For this reason it is a fair assumption that demand of hospital i depends roughly on the quality of treatment in this hospital, i.e. $D^i = D^i(q^i)$.

Own quality of care, however, is not the only determinant of own demand. Usually, there is at least some degree of competition among hospitals - weakened by transport costs, d, and individual preferences (which may be independent of quality of care, such as e.g. design of the rooms, relatives working or having been treated there, etc.). A more elaborate model of competition would therefore be advisable, specifying the individual hospital's competitive environment and demand: $D^i = D(q^i, q^j, d)$. The methodological problem with such a model is, however, that it implies the solution of reaction functions, which is generally impossible without specifying functional forms of cost functions - something that we want to avoid, since the nescience of the cost functions is the origin of our quest.

We will therefore base our analysis on a model of monopolistic competition

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[8] A number of econometric studies have established the close relationship between distance and patient's hospital choice. In a recent study by Ho (2005) the author estimates that if a hospital moves one additional mile away from a patient's home this reduces the probability that the patient chooses it by 21%.

in which $D^i = D^i(q^i)$, $\frac{dD^i(q^i)}{dq^i} > 0$, but varying in its functional forms over the different hospitals $i = 1, ..., n$. Wherever necessary we will additionally provide a model of competition to show that the results carry over.

4 Achievability of First Best

This section shows that a PPS can in principle achieve the first best allocation of quality and cost reduction efforts. In essence, it is simply a summary of the key results of Albert Ma's seminal (1994) paper. Going beyond Ma, however, we want to analyze here what the regulator can achieve under the restrictions we impose on his information set in the previous section. It turns out that under these assumptions the authorities are incapable of determining the first best inducing prices.

4.1 Benchmark: First Best

The regulator seeks to maximize social welfare which is defined as

$$SW = W(q^i) - c(q^i, e^i)D^i(q^i) - E(q^i, e^i) \tag{2}$$

where $W(q^i)$ is some function that measures consumer benefits from quality, $W_{q^i}(q^i) > 0$. The first order conditions are then given by:

$$q^{i,SO} \quad : \quad W_{q^i}(q^i) - c_{q^i}(q^i, e^i)D^i(q^i) - c(q^i, e^i)D_{q^i}^i(q^i) = E_{q^i}(q^i, e^i) \tag{3}$$

$$e^{i,SO} \quad : \quad -c_{e^i}(q^i, e^i)D^i(q^i) = E_{e^i}(q^i, e^i) \tag{4}$$

These equations are the benchmark for the performance of PPS.

4.2 Prospective Payment System

Under the prospective payment system a fixed price, p^i, is paid per patient, that is independent of the hospital's own costs. Profits are therefore:

$$\pi^i(q^i, e^i) = p^i D^i(q^i) - c(q^i, e^i) D^i(q^i) - E(q^i, e^i) \tag{5}$$

and the first order conditions for the private optimum:

$$q^{i,*} \quad : \quad p^i D_{q^i}^i(q_i) - c_{q^i}(q^i, e^i) D^i(q^i) - c(q^i, e^i) D_{q^i}^i(q^i) = E_{q^i}(q^i, e^i) \tag{6}$$

$$e^{i,*} \quad : \quad -c_{e^i}(q^i, e^i) D^i(q^i) = E_{e^i}(q^i, e^i) \tag{7}$$

Clearly the hospital exerts some cost-reducing effort. What is more, this is even the first best effort level, if $q^{i,*} = q^{i,SO}$. The quality provision depends among other things on the price the hospital receives. Proposition 1 summarizes the results.

Proposition 1 *Under a prospective payment system the first best effort level is induced if $q^{i,*} = q^{i,SO}$. The quality level depends on the functions $c(q^i, e^i)$, $c_{q^i}(\cdot)$, $E_{q^i}(\cdot)$, $D_{q^i}^i(q^i)$ and price p^i. Therefore, the first best level is induced if and only if $p^i = \frac{W_{q^i}(q^i)}{D_{q^i}^i(q^i)}\Big|_{q^i=q^{i,SO}}$. Profits may or may not be positive - depending on the price.*

Thus, in principle, PPS can achieve the first best allocation. This is Ma's (1994) conclusion. This is, however, an incomplete reading of proposition 1, because it says that the first best allocation is achieved **if and only if** $p^i = \frac{W_{q^i}(q^i)}{D_{q^i}^i(q^i)}\Big|_{q^i=q^{i,SO}}$. This is an important detail, because $q^{i,SO}$ depends on the functions $c(q^i, e^i)$ and

$E(q^i, e^i)$, which are unknown to the regulator. He will therefore be unable to evaluate the first best inducing prices.[9] If he sets the wrong price, distortions may be great, even greater than under CoSR.

If a regulator wants to change to a PPS, he therefore has to find a method to compute welfare maximizing prices that does not require knowledge of the hospitals' production function. Regulatory practice as well as the theoretic literature relies upon Shleifer's (1985) yardstick competition for a solution to this problem. Unfortunately, Shleifer's paper does not consider quality issues. The next section reviews Shleifer's original model. The section thereafter analyzes the consequences of applying Shleifer's yardstick competition in Ma's environment, i.e. when quality is endogenous and unverifiable.

5 Yardstick Competition a la Shleifer

For those readers who are not familiar with yardstick competition this section offers a brief summary of Shleifer's (1985) model in his original form. The next section will then apply yardstick competition in the previously described environment of Ma (1994).

5.1 Overview

In a general framework of local monopolists, Shleifer (1985) suggests to use the costs of a (or several) comparable firm, a yardstick, to set the price for the regulated firm. The three properties of his approach that make it appealing for the regulation of hospitals are: (i) It does not matter whether the market environ-

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[9]Not to mention the problems that the regulator usually has in computing $D^i(\cdot)$ and $W(q^i)$.

ments (especially the demand functions) of the regulated firms are different. (ii) Marginal cost pricing, where simply $p_i = c_j$ is set and losses are covered by a lump-sum transfer, achieves first best production. (iii) Adjusted average cost pricing, where the regulated firm is reimbursed as if it had the same marginal and fix costs as the yardstick, leads to second best production.

5.2 Marginal Cost Pricing

In our notation Shleifer's argument works as follows. Profits are given by

$$\pi^i = (p^i - c(e^i))D^i(p^i) - E(e^i) \tag{8}$$

Suppose now that there is a set of identical firms $j = 1, ..., n - 1$. Then the regulator can induce i to produce efficiently by setting the firms j as i's yardstick against which i has to compete. He does so by setting

$$p^i = \bar{c}^i := \frac{1}{n-1} \sum_{j \neq i}^{n} c(e^j)$$

and an extra transfer of

$$T^i = \frac{1}{n-1} \sum_{j \neq i}^{n} E(e^j)$$

Profit maximization then yields:

$$\max_{e^i} (\bar{c}^i - c(e^i))D^i(c(e^j)) - E(e^i) + T^i$$
$$\Rightarrow \quad -c_{e^i}(e^i))D^i(c(e^j)) = E_{e^i}(e^i)$$

Obviously, one interior symmetric Nash equilibrium is that both firms choose the socially optimal $e^{i,SO}$. It turns out that this is also unique.[10]

5.3 Average Cost Pricing

In case that the regulator is unable to use lump-sum transfers, he can still achieve second best outcomes by applying the following adjusted average pricing scheme. Under $T^i = 0$ the optimal allocation is characterized by the following two equations:

$$-c_{e^i}(e^i)D^i(p^i) = E_{e^i}(e^i) \tag{9}$$

$$\left(p^i - c(e^i)\right)D^i(p^i) - E(e^i) = 0 \tag{10}$$

The first one equates marginal gain from cost reduction effort to marginal cost. The second one is the breakeven condition. The regulator can now implement second best allocation by replacing $c(e^i)$ by $c(e^j)$ and $E(e^i)$ by $E(e^j)$ in 10 and solve for p^i. Under this price firm i's cost minimization leads to the second best optimum.

6 Yardstick Competition in Presence of Competition in Quality

Shleifer's model does not capture some important characteristics of the hospital market. First, patients do not pay prices for treatment. This implies that they go where quality is highest. At the same time, quality cannot be verified by the

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[10]For the formal proof see pp. 322/323 in Shleifer (1985).

regulator. This means that he can steer it only via the prices he pays to the hospitals. That, however, causes serious problems for yardstick competition. To see this, consider Shleifer's model under the assumptions made in section 3. The hospital's profit function is then

$$\pi^i(q^i, e^i) = p^i D^i(q^i) - c(q^i, e^i) D^i(q^i) - E(q^i, e^i)$$

6.1 Marginal Cost Pricing

Under the marginal cost pricing rule of yardstick competition, hospitals are reimbursed according to the following rule:

$$p^i = \frac{1}{n-1} \sum_{j \neq i}^{n} c(q^j, e^j) \text{ and } T^i = \frac{1}{n-1} \sum_{j \neq i}^{n} E(q^j, e^j) \tag{11}$$

Profits are then

$$\Rightarrow \pi^i(q^i, e^i) = \left(\frac{1}{n-1} \sum_{j \neq i}^{n} c(q^j, e^j) - c(q^i, e^i) \right) D^i(q^i) + \sum_{j \neq i}^{n} \frac{1}{n-1} E(q^j, e^j) - E(q^i, e^i) \tag{12}$$

which leads to the first order conditions

$$q^{i,*} \quad : \quad \frac{1}{n-1} \sum_{j \neq i}^{n} c(q^j, e^j) D^i_{q^i}(q^i) - c_{q^i}(q^i, e^i) D^i(q^i) - c(q^i, e^i) D^i_{q^i}(q^i) = E_{q^i}(q^i, e^i) \tag{13}$$

$$e^{i,*} \quad : \quad - c_{e^i}(q^i, e^i) D^i(q^i) = E_{e^i}(q^i, e^i) \tag{14}$$

The difference to the first best FOCs 3 and 4 is that here we have $\frac{1}{n-1} \sum_{j \neq i}^{n} c(q^j, e^j) D^i_{q^i}(q^i)$ instead of $W_{q^i}(q^i)$. How big this distortion is, cannot be said without some more

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structure. The next sections show that the distortions are tremendous.

6.1.1 Symmetric Hospitals

Suppose there are n hospitals. All have access to the same cost functions and face identical demand functions. For the moment we neglect competition, i.e. $D^i = D^i(q^i)$ instead of $D^i = D^i(q^i, q^j)$. This facilitates the analysis considerably and allows us to study general demand and cost functions. Later we will also specify a more elaborate model of competition. Section 6.1.3 shows that the following result also translates to more asymmetric environments.

Proposition 2 *In the case of complete symmetry, marginal cost pricing that follows yardstick competition leads to zero quality: $q^{i,*} = 0$. If furthermore $D^i(q^i = 0) = 0$, then also $e^{i,*} = 0$.*

Proof. If all hospitals are identical, all hospitals will get the same price $p^i = p^j = p$. If all hospitals get the same price, the optimization problem is the same for all hospitals, yielding the same set of first order conditions

$$q^{i,*}(p) \quad : \quad pD^i_{q^i}(q^i) - c_{q_i}(q^i, e^i)D^i(q^i) - c(q^i, e^i)D^i_{q^i}(q^i) = E_{q_i}(q^i, e^i) \quad (15)$$

$$e^{i,*}(p) \quad : \quad -c_{e^i}(q^i, e^i)D^i(q^i) = E_{e^i}(q^i, e^i) \quad (16)$$

It follows that all hospitals choose the same quality and effort levels $q^{i,*}(p) = q^{j,*}(p)$ and $e^{i,*}(p) = e^{j,*}(p)$. This implies that all of them will have the same marginal cost levels $c(q^{i,*}(p), e^{i,*}(p)) = c(q^{j,*}(p), e^{j,*}(p))$. According to the pricing rule $p^i = \frac{1}{n-1}\sum_{j \neq i}^{n} c(q^j, e^j)$ this implies $p^i = p = c(q^{i,*}, e^{i,*})$. Inserting this into 15 yields $-c_{q^i}(q^{i,*}, e^{i,*})D^i(q^{i,*}) - E_{q_i}(q_i^*, e_i^*) = 0$ which yields the corner solution

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$q^{i,*} = 0$. Substituting this into 16 results in $e^{i,*} = 0$, if $D_i(q_i = 0) = 0$. ∎

The intuition for this result is that in equilibrium, hospitals will earn a zero profit margin per patient. Then, however, no hospital has an interest in sustaining high reputation and provide zero quality. For a more detailed discussion see at the end of this section.

6.1.2 Symmetric Hospitals in Competition on a Salop Circle

The result of zero cost reduction effort depends on the assumption $D^i(q^i = 0) = 0$. This may seem unrealistic, because patients may still prefer low (or even zero) quality treatment in a hospital than no treatment at all. To see how this changes the results, consider a model of quality competition among hospitals on a Salop circle. On a Salop circle, which may as usual be thought of as a city, there are n identical hospitals active, each facing marginal costs $c^i(q^i, e^i) = q^i - e^i$ and effort costs $E(q^i, e^i) = (q^i)^2 + (e^i)^2$. Consumers derive utility $u(q^i)$ from being treated at hospital i. When yielding care from a hospital a patient does not have to pay prices, but incurs transportation costs of $d * distance$. We assume $u_{q^i}(q^i) > 0$, $u_{q^i q^i}(q^i) < 0$ and $u(q = 0) > d$ to assure that market is always covered, independent of the number of hospitals. Marginal consumers $\widetilde{x}$ are then characterized by

$$u(q^i) - d\widetilde{x} \quad = \quad u(q^j) - d(\frac{1}{n} - \widetilde{x}) \tag{17}$$

$$\Leftrightarrow \quad \widetilde{x} = \frac{u(q^i) - u(q^j) + \frac{d}{n}}{2d} \tag{18}$$

which implies demand for hospital i of

$$D^i(q^i, q^j) = \frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} \tag{19}$$

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Under PPS his results in the optimization problem

$$\max_{e^i, q^i} \pi^i = (p^i - q^i + e^i) \frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} - (q^i)^2 - (e^i)^2 + T^i \qquad (20)$$

with the first order conditions

$$q^{i,*} \quad : \quad -\frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} + (p^i - q^i + e^i) \frac{u_{q^i}(q^i)}{d} - 2q^i = 0 \qquad (21)$$

$$e^{i,*} \quad : \quad \frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} - 2e^i = 0 \qquad (22)$$

which implies $e^{i,*} = \frac{u(q^i) - u(q^j) + \frac{d}{n}}{2d}$. Substituting this into 21 yields

$$-\frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} + \left(p^i - q^i + \frac{u(q^i) - u(q^j) + \frac{d}{n}}{2d}\right) \frac{u_{q^i}(q^i)}{d} - 2q^i = 0 \qquad (23)$$

Due to the symmetry, we have $p^i = p^j = p$ and $q^i = q^j$, from which follows

$$q^{i,*} \quad : \quad -\frac{1}{n} + \left(p - q^i + \frac{1}{2n}\right) \frac{u_{q^i}(q^i)}{d} - 2q^i = 0 \qquad (24)$$

$$e^{i,*} \quad : \quad e^{i,*} = \frac{1}{2n} \qquad (25)$$

The pricing rule $p^i = \frac{1}{n-1} \sum_{j \neq i}^{n} c(q^j, e^j)$ implies also here $p = c(q^{i,*}, e^{i,*}) = q^{i,*} - \frac{1}{2n}$. This leads to the corner solution $q^{i,*} = q^* = 0$.

How does this compare to the social optimum? Welfare is given by

$$W = u(q) - q + e - q^2 n - ne^2 - \frac{d}{4n} \qquad (26)$$

The first order conditions are then:

$$q^{SO} \quad : \quad u_q(q) - 1 - 2qn = 0 \tag{27}$$

$$e^{SO} \quad : \quad 1 - 2ne = 0 \tag{28}$$

In the social optimum we have therefore $e^{SO} = \frac{1}{2n}$ and $q^{SO} > 0$ **for given n**. The comparison is summarized in the following proposition

Proposition 3 *Let the number of hospitals be exogenously fixed. If $D^i(q^i = 0) > 0$, the marginal cost pricing rule of yardstick competition potentially achieves first best cost reduction effort, but leads to too low, namely zero, quality.*

The intuition for this result is the following: As before, the hospital has no incentive to increase its reputation and therefore chooses zero quality. But it has an incentive to save on costs, because in equilibrium it gets an amount of transfers that it cannot influence (due to symmetric positive equilibrium demand) - the typical yardstick competition effect.

Remark 1 *Recall that in this Salop example we had to make explicit assumptions on the cost functions. In particular, the restrictions $c_{qe} = 0$ and $E_{qe}(\cdot) = 0$ are important. It may seem more reasonable to assume $c_{qe}(\cdot) > 0$ and $E_{qe}(\cdot) > 0$. This leaves the result of zero quality provision unaffected, but implies that then the cost reduction effort level is distorted upwards, i.e. too much weight is put on reducing costs - a typical result of multitask agent models.*

6.1.3   Asymmetric Hospitals

When hospitals differ from each other in market environments, then the question is what firm(s) $j \in \{1, ..., n\}$, $j \neq i$ does the regulator take as a yardstick for firm i? The only candidates are all those firms that have the same market environments, because if other firms are taken, it is not guaranteed anymore that the regulated firm yields nonnegative profits. Then, however we are back at equations 15 and 16. which results in the same conclusion as stated in propositions 2 and 3.

What do these results mean? Let us summarize what we have done up to now to recall the context for these results. In the introduction we described that the former regulation scheme of hospitals, simple reimbursement of cost of service, does not give any incentives to save costs. As reaction a regulatory authority may want to switch to prospective payment systems to finance the hospitals. This scheme can in principle induce hospitals to produce first best efforts in quality as well as in cost control. This is possible if prices are set correctly. In reality, however, the regulator has problems to determine these optimal prices, because he does not know the hospitals' cost functions. It is commonly said that the way to bypass this problem is to use yardstick competition a la Shleifer, in particular the marginal cost pricing version discussed in this section. Unfortunately, Shleifer's mechanism does not take into account some particularities of the hospital market. In this section of the paper we do this and propositions 2 and 3 show that if a regulator uses Shleifer's marginal cost pricing rule, hospitals will provide zero quality. The reason is that they earn a zero profit margin per patient and therefore have no incentive to compete for patients by setting high quality.

Is this realistic? Will this happen? Not quite, probably, because first of all

doctors may have motives other than profit maximization. In particular, they may be driven by altruism or fear of law suits. It is therefore more likely that quality will be driven down to some minimum level. The basic logic, however, remains the same. We conclude, therefore, that a prospective payment system, where the marginal cost pricing rule of yardstick competition is used, generally leads to too low, in the extreme zero, quality of service and to a cost reduction effort level of $e^* \in [0, \infty]$, i.e. $e^* \lesseqgtr e^{SO}$ (depending on $D^i(q^i = 0)$).

Since the reason for this result lies in the marginal cost pricing, it is a natural question to ask whether the average cost pricing scheme of yardstick competition can do any better. This is subject of the next section.

6.2   Average Cost Pricing

The average cost pricing version of yardstick competition demands the regulator to take for each hospital i at least one twin j and set p^i such that the following condition is fulfilled:

$$\pi^i(q^i, e^i) = p^i D^i(q^i) - \frac{1}{n-1} \sum_{j \neq i}^{n} c(q^j, e^j) D^i(q^i) - \frac{1}{n-1} \sum_{j \neq i}^{n} E(q^j, e^j) = 0$$

$$\Leftrightarrow p^i = \frac{\frac{1}{n-1} \sum_{j \neq i}^{n} c(q^j, e^j) D^i(q^i) + \frac{1}{n-1} \sum_{j \neq i}^{n} E(q^j, e^j)}{D^i(q^i)} \tag{29}$$

We observe that price is larger than marginal costs. This suggests that the problems we have with marginal costs, as described in section 6.1, are not present here. But there is another one: Here p_i depends on the own choice of q^i, namely decreasing in q^i. This is detrimental to the idea of yardstick competition:

Proposition 4 *In presence of Cournot competition via quality, the average cost pricing scheme of yardstick competition does not make own price independent of own decisions, anymore:* $p^i = p^i(q^i)$.

This results in significant distortions as we shall demonstrate now.

The first order conditions of the hospital's maximization problem are:

$$q^{i,*} \quad : \quad p^i_{q^i}(q^i)D(q^i) + p^i D^i_{q^i}(q^i) - c_{q^i}(q^i, e^i)D^i(q^i) - c(q^i, e^i)D^i_{q^i}(q^i) = E_{q^i}(q^i, e^i) \tag{30}$$

$$e^{i,*} \quad : \quad -c_{e^i}(q^i, e^i)D^i(q^i) = E_{e^i}(q^i, e^i) \tag{31}$$

Average cost pricing a la Shleifer implies two opposing price effects. One, $p^i D^i_{q^i}(q^i)$, works quality increasing and is the desired effect of any prospective payment system. The other one, $p^i_{q^i}(q^i)D(q^i)$, stems from the adjustment of j's costs to i's demand environment. As described in proposition 4, this effect is negative. Inserting 29 for p^i yields:

$$q^{i,*} : -\frac{\frac{1}{n-1}\sum_{j\neq i}^{n} E(q^j, e^j)}{D^i(q^i)}D^i_{q^i}(q^i) + \frac{\frac{1}{n-1}\sum_{j\neq i}^{n} c(q^j, e^j)D^i(q^i) + \frac{1}{n-1}\sum_{j\neq i}^{n} E(q^j, e^j)}{D^i(q^i)}D^i_{q^i}(q^i)$$
$$- c_{q^i}(q^i, e^i)D^i(q^i) - c(q^i, e^i)D^i_{q^i}(q^i) = E_{q^i}(q^i, e^i)$$

$$e^{i,*} : -c_{e^i}(q^i, e^i)D^i(q^i) = E_{e^i}(q^i, e^i)$$

Analgously to the proof of proposition 2, under symmetry we have $c(q^{i,*}(p), e^{i,*}(p)) = c(q^{j,*}(p), e^{j,*}(p))$ and consequently $p^i = p = c(q^{i,*}, e^{i,*})$. It follows:

$$q^{i,*} \quad : \quad -c_{q^i}(q^{i,*}, e^{i,*})D^i(q^{i,*}) - E_{q^i}(q^{i,*}, e^{i,*}) = 0 \tag{32}$$

$$e^{i,*} \quad : \quad -c_{e^i}(q^i, e^i)D^i(q^i) = E_{e^i}(q^i, e^i) \tag{33}$$

The result is completely analogous to the preceding section on marginal cost pricing and is summarized in proposition 5.

Proposition 5 *In the case of complete symmetry, average cost pricing a la Shleifer (1985) leads to zero quality: $q^{i,*} = 0$. If furthermore $D^i(q^i = 0) = 0$, then also $e^{i,*} = 0$.*

The reason for this zero quality result is that the two effects of an increase in quality, namely increase in demand and decrease in price, exactly outweigh each other.

The next section shows that the zero quality result also holds in a strategic competitive environment, but that cost reduction effort may be optimal.

6.2.1 Symmetric Hospitals in Competition on a Salop Circle

We will use the same Salop model as in the section on marginal cost pricing. The only difference is that now the pricing scheme is different. Here, however, the hospital can affect its own price:

$$\max_{e^i, q^i} \pi^i = (p^i(q^i) - q^i + e^i)\frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} - \left(q^i\right)^2 - \left(e^i\right)^2$$

$$q^{i,*} \quad : \quad (p^i_{q^i}(q^i) - 1)\frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} + (p^i(q^i) - q^i + e^i)\frac{u_{q^i}(q^i)}{d} - 2q^i = 0 \quad (34)$$

$$e^{i,*} \quad : \quad \frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} - 2e^i = 0 \quad (35)$$

Following Shleifer's pricing rule we have $p^i(q^i) = \frac{(q^j - e^j)D_i(q_i) + \left(q^i\right)^2 + \left(e^i\right)^2}{D^i(q^i)}$ and $p^i_{q^i}(q_i) = \frac{-\left(\left(q^i\right)^2 + \left(e^i\right)^2\right)D'_i(q_i)}{(D^i(q^i))^2}$. Additionally, $D^i(q^i) = \frac{u(q^i) - u(q^j) + \frac{d}{n}}{d}$. Inserting this yields:

$$q^{i,*} : \frac{-((q^i)^2 + (e^i)^2)\frac{u_{q^i}(q^i)}{d}}{\frac{u(q^i) - u(q^j) + \frac{d}{n}}{d}} - \frac{u(q^i) - u(q^j) + \frac{d}{n}}{d}$$
$$+ \left(\frac{(q^j - e^j)\frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} + (q^i)^2 + (e^i)^2}{\frac{u(q^i) - u(q^j) + \frac{d}{n}}{d}} - q^i + e^i \right) \frac{u_{q^i}(q^i)}{d} - 2q^i = 0$$

$$e^{i,*} : \frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} - 2e^i = 0$$

This simplifies to:

$$q^{i,*} \quad : \quad -\frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} + (q^j - e^j)\frac{u^i_{q^i}(q^i)}{d}\left(-q^i + e^i\right)\frac{u_{q^i}(q^i)}{d} - 2q^i = 0$$

$$e^{i,*} \quad : \quad \frac{u(q^i) - u(q^j) + \frac{d}{n}}{d} - 2e^i = 0$$

Due to the symmetry we have $p^i = p^j = p$, $e^i = e^j$ and $q^i = q^j$, from which follows

$$q^{i,*} \quad : \quad -\frac{1}{n} - 2q^i = 0 \Rightarrow q^{i,*} = 0$$
$$e^{i,*} \quad : \quad \frac{1}{n} - 2e^i = 0 \Leftrightarrow e^{i,*} = \frac{1}{2n}$$

Recall that the social optimum is determined by

$$q^{SO} \quad : \quad u_q(q) - 1 - 2qn = 0 \tag{36}$$
$$e^{SO} \quad : \quad e^{SO} = \frac{1}{2n} \tag{37}$$

Obviously, cost reduction effort is provided in the socially optimal amount, but quality is zero and therewith suboptimal:

Proposition 6 *If $D(q^i = 0) > 0$ and additionally $c_{qe}(\cdot) = 0$ and $E_{qe}(\cdot) = 0$, then the average cost pricing rule of yardstick competition achieves first best cost reduction effort, but leads to too low, namely zero, quality.*

6.3 Summary

In this section we analyzed what happens if yardstick competition a la Shleifer (1985) is applied in the specific market environment of the hospital sector. We showed that it always leads to zero quality provision. For the practice of regulation this means that a regulator who changes to a prospective payment system and uses yardstick competition as his method to compute prices cannot be sure that he improves his health care system at all. Instead he may even worsen it.

7 A Simple Refinement of Yardstick Competition

We have seen that yardstick competition à la Shleifer leads to zero quality provision. The question is whether yardstick competition can be refined and improved in some way. Indeed this is the case, but only to a certain extend. Recall that a regulator has to choose completely identical hospitals as yardsticks to ensure nonnegative profits. Then, however, he can use simple average cost pricing $p^i = AC^j$ instead of the adjusted average cost pricing rule that Shleifer proposes. The advantage is that then price is independent of own action and larger than marginal costs. This results in strictly positive quality provision:

$$q^{i,*} \quad : \quad p^i D^i_{q^i}(q^i) - c_{q^i}(q^i, e^i)D^i(q^i) - c(q^i, e^i)D^i_{q^i}(q^i) = E_{q^i}(q^i, e^i) \qquad (38)$$

$$e^{i,*} \quad : \quad -c_{e^i}(q^i, e^i)D^i(q^i) = E_{e^i}(q^i, e^i) \qquad (39)$$

Inserting $p^i = AC^j$ and using the symmetry argument, i.e. $c(q^{i,*}(p), e^{i,*}(p)) = c(q^{j,*}(p), e^{j,*}(p))$ and consequently $p^i = p = c(q^{i,*}, e^{i,*})$, yields:

$$q^{i,*} \quad : \quad \frac{E(q^j, e^j)}{D^j(q^j)} D^i_{q^i}(q^i) - c_{q^i}(q^i, e^i)D^i(q^i) = E_{q^i}(q^i, e^i)$$

$$e^{i,*} \quad : \quad -c_{e^i}(q^i, e^i)D^i(q^i) = E_{e^i}(q^i, e^i)$$

which has, in principle, an interior solution.

Proposition 7 *Simple average cost pricing, $p^i = AC^j$, where hospital j is an*

identical twin to hospital i, leads to positive quality provision.[11]

We can, however, not say much more about the level of quality provided. It can be everything: just right, too low, or even too high. If furthermore, the cross-derivative of $c(q^i, e^i)$ is non-zero, also cost reduction effort is distorted. Summing up, even under this refined version of yardstick competition, a prospective payment system may harm a health system more than it helps.

8   Conclusion

The dominating opinion in the literature is that as regulatory scheme for the hospital market a prospective payment system is superior to cost of service regulation. The arguments put forward are that, first, PPS gives higher incentives for cost savings. Second, reputation effects will force the hospitals to provide high levels of quality.

This paper argues that this judgement is incomplete, because it ignores informational limitations of the regulator. The level of quality provided depends crucially on the prices set. In practice, however, the regulator proves unable to determine optimal prices. Therefore, unless a suitable second best pricing mechanism is found, PPS may even worsen the performance of the health care sector.

The pricing mechanism suggested in the literature is Shleifer's yardstick competition. Shleifer does not consider quality, though. It was the aim of this paper to understand, whether yardstick competition really is applicable to the hospital

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[11]As a matter of fact, in practice regulators use simple average cost pricing. In Germany, one price is set per DRG. This price is the same for all hospitals and calculated as some average of all hospitals average costs. (Note that lemma **??** is ignored. This helps explaining the bankruptcies of many hospitals in Germany.)

market. The analysis yields the following objections:

First, yardstick competition in this environment requires the regulator to use only firms as yardsticks that are identical to the regulated firm even in demand. Second, it is shown that even if all necessary information can be inferred and an identical twin can be found for each firm, yardstick competition à la Shleifer will lead to zero quality provision. Third, a simpler version of yardstick competition average cost pricing can lead to positive quality and cost reduction effort. Even then, however, quality can be too low or even excessive depending on the individual market environments. Furthermore, if cost functions exhibit non-negative cross elasticities, the distortions in quality will also lead to too low or too strong cost reduction effort.

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