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## Physician reimbursement, time-consistency and the quality of care

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## ABSTRACT

### **Physician Reimbursement, Time-Consistency and the Quality of Care**

by Robert Nuscheler\*

We use a model of horizontal and vertical differentiation to study physicians' incentives to provide quality in the physician-patient relationship under price regulation. If the price is the only regulatory variable, the social planner cannot implement the first-best policy. Moreover, the second-best policy is time inconsistent. Excess entry and first-best efficient total quality provision is observed in the game without commitment. Allowing physicians to compete in prices does not solve the commitment problem since the competitive solution coincides with the time consistent outcome. In the median voter equilibrium the time consistency problem is more severe.

*Keywords: Economics of health care markets, time consistency, price regulation, quality competition, spatial competition*

*JEL classification: I11, I18, L51, R10*

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## ZUSAMMENFASSUNG

### **Ärztevergütung, Zeitkonsistenz und die Qualität medizinischer Leistungen**

In einem Modell der horizontalen und vertikalen Produktdifferenzierung werden die ärztlichen Anreize, medizinische Qualität bereitzustellen, in Gegenwart von Preisregulierung untersucht. In Gegenwart zweier strategischer Variablen kann ein ausschließlich preisregulierender sozialer Planer das erstbeste Wohlfahrtsoptimum nicht implementieren. Darüber hinaus ist das zweitbeste Wohlfahrtsoptimum nicht zeitkonsistent. Mit zeitkonsistenter Regulierung ergibt sich eine effiziente Qualität medizinischer Leistungen, jedoch eine zu hohe Arztdichte. Preiswettbewerb zwischen den Ärzten führt zur selben Allokation wie bei zeitkonsistenter Regulierung. Die Probleme des Gesundheitsmarktes lassen sich somit nicht durch mehr Wettbewerb lösen. Das Zeitkonsistenzproblem ist noch gravierender, wenn über den Preis durch eine Mehrheitsabstimmung entschieden wird. Wendet man das Modell auf den deutschen Gesundheitsmarkt an, so zeigt sich, dass die kassenärztliche Zulassung – trotz Bedarfsplanung – zu großzügig ist.

# 1 Introduction

In many countries the suppliers of health care services are compensated for medical treatments according to a fee schedule chosen by some regulating authority. When there is no possibility of competing in prices, suppliers of health care resort to other variables to increase market share. Consider, for instance, competition between physicians. If a patient needs medical assistance two major factors influence his decision for a private medical practice (or private clinic): the quality provided by the physicians and the distance to the medical practices. Hence, the physicians aiming at higher profits will choose quality levels and locations strategically.

There is a mutual dependency between location and quality decisions. Consider two orthopedists A and B, both with an X-ray unit. Assuming that they are closely located, quality competition will then be intensive. This can be interpreted in two ways: first, physician B, for example, may view these locations as a handicap, because they have to compete in a small market. To increase his market share, B can improve his quality (e.g. by buying a computer tomograph). Second, assume that B has the quality advantage described above. Since A cannot react with price cuts to B's advantage he will lose market share. To avoid this, A will also buy a computer tomograph. To reduce quality competition, physicians will locate as far apart as possible. However, quality levels may still remain high because of their deterrent effect on other physicians and potential entrants. The strategic importance of quality may lead to inefficiently high quality provision.

We study the incentives and consequences of price regulation in a 3-stage non-cooperative game where the providers of health care have the following successive choices: entry, location and quality. The players' decisions are simultaneous at all stages. The sequential structure reflects the different degrees of irreversibility in the strategic decisions. Quality, interpreted as medical machinery or effort spent on treatments, is variable in the short run. Quality choices are strategic given the locations. These cannot be changed in the short run because of institutional barriers and high transaction costs of relocating. For example, in Germany the licences are only valid for small districts. If a physician wants to relocate he has to apply for a new licence. Finally, the entry decision is variable

only in the long run because educational requirements are high. Alternatively, the model may be interpreted as competition among private hospitals. Quality in terms of medical machinery and size of the hospital rooms or beds per room are far more flexible than location.

The game is solved by backward induction leading to a subgame perfect Nash equilibrium. The first finding is that the regulator is not able to implement the first-best efficient allocation when price is the only regulatory variable. This is not very surprising since it is in general not possible to achieve two goals (optimal quality level and optimal number of clinics) when only one policy variable is available (price). We consider two versions of price regulation with and without commitment. If the regulator cannot commit herself to a price, the set of possible prices is reduced to time consistent policies. The symmetric non-cooperative equilibrium with price commitment is a second-best optimum with excess capacity in both quality and entry. The second-best price turns out to be not time consistent and thus cannot be an equilibrium in the game without commitment. There is a unique time consistent price policy that leads to the first-best level of total quality provision, but also to excess entry. Since welfare is lower in the game without commitment, the regulator would like to commit herself to the second-best price instead of applying the time consistent (quality-optimal) price. Of course, this problem can be solved by introducing a second regulation variable. The number of suppliers can be fixed by licences to the first-best optimal level. But, from the increases in physician density in all of the 15 EU member states from 1990 to 1999 (see EUROSTAT [2002, 68]), it would appear that entry is not very much restricted. A “natural” suggestion for overcoming the inefficiencies and the commitment problem is to allow physicians to compete in quality and prices at stage 3 of the game. Like the social planner, the physicians trade off the benefits of quality against its costs and use the price to reduce quality competition. Consequently, the (price-) competitive equilibrium coincides with the time consistent regulatory outcome. Introducing price competition has no effect. If the regulator is to be (re-)elected by patients the time consistency problem is more severe. Once physicians have entered the market, patients care only about the net gain they derive from quality provision, leading to lower welfare than in the time consistent regulatory equilibrium.

Our model is related to the wide range of quality competition (or vertical differentiation) and spatial competition (or horizontal differentiation) literature, for example, D'ASPREMONT, GABSZEWICZ, AND THISSE [1979], NOVSHAK [1980] and SALOP [1979] for horizontal differentiation, GABSZEWICZ AND THISSE [1980] for vertical differentiation and NEVEN AND THISSE [1990] for both. But, due to the peculiarities of most of the health care systems, there is a major difference between these models and ours: the absence of the price as a strategic variable. The idea of price regulation is found in MA AND BURGESS [1993]. They show, in a vertically differentiated setting, that the introduction of price regulation reduces inefficiencies in quality. Since locations are exogenous, their analysis stops where ours begins. The current paper is closely related to ECONOMIDES [1993] and GRAVELLE [1999]. Both consider the same strategic variables and the same sequential structure as those in the model presented here. In their models, location choices have no effect on quality provision thus precluding (non-price) competition in the presence of price regulation. Furthermore, GRAVELLE [1999] assumes marginal costs to be increasing in quality thereby introducing an adverse effect of quality provision. In contrast, we emphasize the public good property of the quality of medical care by considering zero marginal costs. ECONOMIDES [1993] focuses on different sequential structures and their impact on equilibria. In contrast to the current paper, ECONOMIDES [1993] does not consider price regulation. As in our paper, ECONOMIDES [1993] concentrates on competitive equilibria where firms are direct competitors. GRAVELLE [1999] follows SALOP [1979] and also analyzes monopoly and kink equilibria. Our model builds on both ECONOMIDES [1993] and GRAVELLE [1999] in order to consider the important effects of location choice on quality choice, thereby capturing non-price competition in the health care market. In addition, we explicitly consider, as these and the other papers mentioned do not, problems of time consistency. With regard to GRAVELLE [1999], who applies a similar model to the health care market, our paper contributes to the understanding of the relationship between the second-best optimum, the time consistent regulatory outcome and the equilibrium with price competition. Moreover, adding two more aspects to the GRAVELLE [1999] analysis, we explicitly derive a number of first-best efficient regulatory schemes and provide some empirical evidence.



The paper is organized as follows: in section 2 we introduce the model. The non-cooperative equilibrium is determined in section 3 followed by the welfare analysis in section 4. Regulation and time consistency is studied in section 5. Price competition is introduced in section 6. In section 7 empirical evidence found in the German health care system is presented. Section 8 concludes.

## 2 The model

Consider a population of a city which is uniformly distributed on a circle with circumference 1. Each inhabitant of this city has constant (inelastic) demand for one identical medical treatment. Location of a patient on the circle is denoted by  $x \in [0, 1]$  and the location of physician  $i$  by  $l_i \in [0, 1]$  for  $i = 1, \dots, n$ . The physicians are indexed such that  $0 \leq l_1 \leq l_2 \leq \dots \leq l_n \leq 1$ . A patient's utility from one medical treatment by physician  $i$  is

$$(1) \quad u(x, q_i, l_i, p) = q_i - p - c(x - l_i)^2,$$

where  $q_i \geq 0$  is the quality of medical practice  $i$ . Quality is the medical equipment of an institution and is assumed to be measurable and observable. Alternatively, quality may be interpreted as an index capturing different dimensions of quality. In the spirit of DONABEDIAN [1980, 79-85] these dimensions could be the structure, process, and outcome of care. The regulated fee for the treatment is denoted by  $p$  and is identical for all physicians. Notice that  $p$  may also be interpreted as the premium of a fair health insurance with full coverage. Since we have assumed that the individuals have constant demand for one medical treatment, a health insurance is redundant. The third term measures transaction costs. These costs are quadratic in the arc-length distance from  $x$  to  $l_i$  with  $c > 0$ .<sup>1</sup> The utility from not consulting a physician is assumed to be  $-\infty$ . By this assumption, physicians are never local monopolists, their neighbors will always be

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<sup>1</sup>Both ECONOMIDES [1993] and GRAVELLE [1999] consider linear transaction costs. In consequence, marginal benefits of an increase in quality are independent of locations. This precludes an important issue of physician non-price competition.

direct competitors. The monopoly and kink equilibria studied in detail by SALOP [1979] and GRAVELLE [1999] do not exist in the model presented here.<sup>2</sup> For simplicity, we do not allow physicians to compete with physicians who are not their neighbors. This is without loss of generality, because a situation of competition between non-neighboring physicians will never be an equilibrium in an entry game. In the language of SALOP [1979], there is always a competitive, but never a super-competitive, region.

The patient who is indifferent between the two neighboring medical practices  $i$  and  $i + 1$  is called the critical patient,  $x_i^{crit}$ , and is implicitly given by  $u(x_i^{crit}, q_i, l_i, p) = u(x_i^{crit}, q_{i+1}, l_{i+1}, p)$ :

$$(2) \quad x_i^{crit} = \frac{q_i - q_{i+1}}{2c(l_{i+1} - l_i)} + \frac{l_i + l_{i+1}}{2}.$$

Note that the critical patient is given by this equation if, and only if, physicians' locations do not coincide. It can be shown that identical locations cannot be an equilibrium in pure strategies of the location subgame (see proof of Lemma 1 in the appendix). Given the critical patients, the market share of physician  $i$  is  $M_i = x_i^{crit} - x_{i-1}^{crit}$ . The regulator's reimbursement policy is designed as a fee-for-service  $p \geq 0$  generating benefits of  $pM_i$ . We assume symmetry of the physicians' costs structures and that the cost function  $K(q_i)$  for the provision of quality  $q_i$  is quadratic,  $K(q_i) = kq_i^2$ ,  $k > 0$ . Notice that these costs are fixed with respect to the number of treated patients. Without loss of generality, other fixed costs are assumed to be zero. Setting marginal costs to zero stresses the local public good character of medical institutions.<sup>3</sup> Physician's  $i$  profit function is then given by

$$(3) \quad \Pi_i = pM_i - kq_i^2.$$

We do not address the problem of physician induced demand or quality elastic (total) demand in this paper. Thus, the only incentive to provide high quality is an increase

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<sup>2</sup>This seems reasonable when analyzing the health care market since, at least in the developed countries, everybody has access to medical care. This is in contrast to GRAVELLE [1999], where utility of not consulting a physician is normalized to zero. Consider, for instance, influenza or appendicitis for the hospital interpretation. In Gravelle's model the "patient" may prefer to not take pharmaceuticals or not have an appendectomy, i.e. he may prefer to die.

<sup>3</sup>ECONOMIDES [1993] assumes the same for private goods. Of course this is equivalent to the assumption of constant marginal costs  $MC > 0$ . Then  $p$  is the net-price:  $p = \tilde{p} - MC$ .

in market share. Since quality levels are only due to quality competition, they can be viewed as a lower bound for more realistic, but more complicated, elastic demand or supplier induced demand models. Regarding equations (2) and (3), the physicians' profits depend on their distance to their neighbors and their comparative quality advantages. We assume the medical practices to be for-profit institutions. Their objective is to maximize profits with respect to location and quality. This problem is analyzed in a three stage non-cooperative game of complete information consisting of:

- Stage 1: On the basis of the expected (or announced) price  $p^e \in [0, \infty)$  the potential entrants decide simultaneously whether to enter the industry, and  $n$  physicians actually enter.
- Stage 2: The  $n$  physicians simultaneously choose their locations  $l_i \in [0, 1]$ ,  $i = 1, \dots, n$ .
- Stage 3: The regulator chooses  $p \in [0, \infty)$  and the  $n$  physicians decide simultaneously on their quality levels  $q_i \in [0, \infty)$ ,  $i = 1, \dots, n$ .

Our decision for the sequential structure of the game is argued by the differences in irreversibility of the strategic decisions. The entry decision is variable only in the long run, because of demanding educational requirements. Institutional barriers and transaction costs prevent locations being variable in the short run. Assuming that the medical practices have plenty of capacity, quality, interpreted as medical machinery, is variable in the short run. This also applies to the price set by the regulator. A theoretical, rather than real life, reasoning for the sequential structure is as follows: if the physicians choose quality and location simultaneously, then, by the same argument as in GABSZEWICZ AND THISSE [1992, 291-292], no equilibrium in pure strategies exists. NOVSHEK [1980] solved this problem considering conjectural variations. With quality decision at stage 2 and location at stage 3, a symmetric equilibrium in pure strategies exists. Since the equilibrium quality provision is zero, quality competition cannot be studied in this setting.

Since the regulator's price decision is at stage three and the entry decisions on the basis of the expected price are at stage one, the question of the regulator's ability to commit herself is crucial for the outcome of the game. We consider two games, one

in which the regulator can commit on  $p$  at stage 1 and a time consistent choice of  $p$  without commitment. Before addressing the regulator's price setting problem we have to determine the non-cooperative outcome and the first-best efficient allocation of the game.

### 3 The non-cooperative equilibrium

#### 3.1 Quality

We solve the game by backward induction leading to a subgame perfect Nash equilibrium. At the third stage of the game each physician maximizes his profits with respect to quality, taking quality levels of the others and all location choices as given yielding

$$(4) \quad q_i^* = \frac{p}{4ck} \left( \frac{1}{l_{i+1} - l_i} + \frac{1}{l_i - l_{i-1}} \right), \quad i = 1, \dots, n.$$

We do not observe reaction functions connecting the quality levels of the medical practices directly.<sup>4</sup> Since symmetry of the cost functions is common knowledge and locations are observable, each physician is able to calculate his rivals' equilibrium quality levels. Thus, the direct quality reaction can be viewed as being hidden in the locations. Besides this indirect reaction to others' quality levels, physician  $i$  directly reacts with his quality choice to the location choices of the neighboring practices. Locational disadvantages can be reduced by providing high quality.<sup>5</sup> In this sense, quality and location are aggressive strategic variables. Minimum quality is chosen when physician  $i$  locates in the middle of the practices  $i - 1$  and  $i + 1$ .<sup>6</sup>

The zero slope of the reaction functions hinges on the assumption of separability of quality in the utility function. This is a standard assumption in these kinds of models to

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<sup>4</sup>This result may be surprising at a first sight. But it is theoretically appealing since the zero conjectural variation assumption of the Nash equilibrium is consistent with the slope of the reaction functions (see BRESNAHAN [1981]).

<sup>5</sup>MA AND BURGESS [1993] found a similar strategic structure. In their model disadvantages in quality can be reduced by price cuts one stage later.

<sup>6</sup>The impact of location choices on quality choices disappears when considering linear transaction costs as in ECONOMIDES [1993] and GRAVELLE [1999].

keep the analysis tractable. As long as the transaction costs are convex, the quality level depends on the own and on the neighbors' locations. That quality increases in price is fairly robust. When the utility function is given by  $f(q) - p - c(x - l)^2$  and the costs of quality provision by  $K(q)$ , then it is sufficient to assume the following plausible properties:  $f' > 0$ ,  $f'' \leq 0$ , and  $K'' \geq 0$ . More quality benefits the patient but at a decreasing rate.<sup>7</sup> Improving quality gets more expensive the higher quality is.

### 3.2 Location

To obtain the optimal location choices of the practices we have to study the relation between quality levels and locations in more detail. We have to bear in mind that, besides the own quality level, the optimal quality levels of the practices  $i - 1$  and  $i + 1$  also depend on the location choice of physician  $i$  according to equation (4). From the respective first order conditions it is straightforward to derive the following reaction coefficients

$$(5) \quad \frac{\partial q_{i-1}^*}{\partial l_i} = -\frac{p}{4ck} \frac{1}{(l_i - l_{i-1})^2},$$

$$(6) \quad \frac{\partial q_i^*}{\partial l_i} = \frac{p}{4ck} \left( \frac{1}{(l_{i+1} - l_i)^2} - \frac{1}{(l_i - l_{i-1})^2} \right),$$

$$(7) \quad \frac{\partial q_{i+1}^*}{\partial l_i} = \frac{p}{4ck} \frac{1}{(l_{i+1} - l_i)^2}.$$

Consider the situation shown in figure 1. Suppose practice  $i$  decides to locate closer to practice  $i+1$  ( $dl_i > 0$ ) starting from a symmetric situation. The competition in this market area becomes more intensive. The intensity is further increased by the enhancement of quality of practice  $i$  according to equation (6). Practice  $i$  captures some of the market of practice  $i + 1$ . Since the location choices are simultaneous, and the optimization is with respect to given locations of the others, there is no reaction in location of practice  $i + 1$ . Physician's  $i + 1$  response to the approaching (and quality improving) practice  $i$  is to increase his own practice's quality in the extent of (7). Competition between physicians  $i$  and  $i - 1$  is weakened because of the increased distance. Practice  $i - 1$  can lower its quality following (5) without losing much of the market, if any at all. We have

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<sup>7</sup>The fact that more quality may harm patients can be precluded as physicians will never invest along such dimensions. Recall that quality was supposed to be observable.

$dq_{i+1}^* > dq_i^* > 0 > dq_{i-1}^*$  for  $dl_i > 0$  and  $dq_{i+j} = 0$  for all  $j \notin \{-1, 0, 1\}$ . The relocation's impact on quality provision leaves the market share of physician  $i$  unchanged. Since the quality level has increased,  $i$ 's profit is reduced.

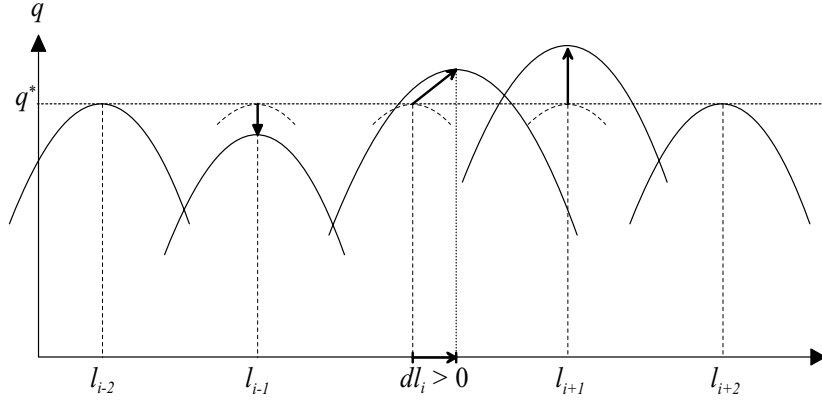


Figure 1: Starting from the perfect symmetric arrangement a relocation of physician  $i$  closer to  $i + 1$  ( $dl_i > 0$ ) alters equilibrium quality provision.

**Lemma 1** *The perfectly symmetric arrangement of the practices is a Nash equilibrium of the location subgame.*

The proof is presented in the appendix. Assume that asymmetric equilibria do exist. If the number of entrants in an asymmetric situation equals the number of physicians in the symmetric case, total quality provision will be higher and some physicians will incur a loss. Therefore we will have a (weakly) smaller number of practices in asymmetric equilibria. Since we want to study inefficiency in quality due to quality competition and not due to asymmetry, we limit ourselves to the symmetric case.

In the symmetric equilibrium the optimal quality provision of equation (4) reduces to

$$(8) \quad q_i^* = \frac{np}{2ck}, \quad i = 1, \dots, n.$$

In equilibrium the quality increases linearly in the number of entrants and also linearly in price.<sup>8</sup> Quality competition sharpens, the more physicians enter the market and the

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<sup>8</sup>When neglecting non-price competition as, for example, in ECONOMIDES [1993] and GRAVELLE [1999], quality levels are independent of the number of firms. This seems unreasonable as the number

better paid the medical treatments get. Regarding the first mentioned effect, we see that this model tends to produce strong inefficiencies in total quality. An increase in the transportation cost parameter  $c$  leads to a decrease in equilibrium quality. The reason for this is that providing a high quality is less effective than before as patients' responsiveness to quality is reduced by higher transaction costs. The marginal benefits of quality are decreasing when  $c$  increases (this is like closing the umbrellas in figure 1 a little). Increases in  $k$  directly drive the costs of quality provision up. All other things equal, the quality level has to be reduced to equalize marginal benefits and marginal costs.

### 3.3 Entry

Suppose that the profits earned outside the health care market are zero. Then the number of entrants is implicitly given by the zero profit condition  $\frac{p}{n} - k\left(\frac{np}{2ck}\right)^2 = 0$ . The only real solution is

$$(9) \quad n^* = \left(\frac{4c^2k}{p}\right)^{\frac{1}{3}}.$$

For simplicity we ignore the fact that  $n^*$  may not be integer valued. With a first brief look at equation (9), the result seems counter intuitive. Why should the equilibrium number of entrants be lowered by an increase in price? Initially, one would expect the opposite, since the benefits per patient are increasing. But we have seen in equation (8) that a higher price increases quality competition among the entrants. This higher intensity in competition is anticipated at the entry stage. Because of the quadratic quality costs, the higher price has a deterrent effect.<sup>9</sup> The argument for the parameters  $c$  and  $k$  works in the opposite direction. Quality competition becomes weaker with an increase in transportation costs or

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of firms is a measure of competition intensity. Consequently, first-best efficient quality is in terms of individual quality levels in GRAVELLE [1999] where it is in total quality in our paper. Thereby we stress the substitutability between quality and the number of practices, i.e. access to medical care.

<sup>9</sup>This reasoning holds, for instance, for cost functions of the form  $K(q) = kq^\tau$ , where  $k > 0$  and  $\tau > 1$ . For more complex cost functions the reverse may obtain. If marginal costs of quality provision are very low, then the costs incurred by the tightened competition are low, making the health care market more attractive. This also applies when marginal costs increase rapidly as the prohibitive costs prevent intensive quality competition occurring.

quality costs making the health market more attractive. The quality cost effect is weaker since the positive effect is accompanied by a negative cost effect of quality provision. Before studying welfare we summarize the results of this section.

**Proposition 1** *The symmetric non-cooperative equilibrium of the sequential 3-stage entry-location-quality game is given by:  $q_i^* = \frac{pn^*}{2ck} = \left(\frac{p^2}{2ck^2}\right)^{\frac{1}{3}}$ ,  $l_i^* - l_{i-1}^* = \frac{1}{n^*}$ , for all  $i = 1, \dots, n^*$  and  $n^* = \left(\frac{4c^2k}{p}\right)^{\frac{1}{3}}$ .*

## 4 The first-best optimum

In the presence of convex costs of quality provision and convex transportation costs, the first-best optimum is symmetric, i.e. the quality levels are equal,  $q_i = q$  for all  $i = 1, \dots, n$ , and the practices are arranged symmetrically on the circle. Then the welfare function is given by

$$(10) \quad W = q - knq^2 - \frac{c}{12n^2}.$$

The first two terms measure the net welfare gain from quality provision. This is reduced by the expected (or average) transportation costs. When equal welfare weights are considered, the price does not appear in the welfare function, i.e.  $p$  is a welfare neutral transfer from patients to physicians. Welfare is indirectly, not directly, affected by changes in  $p$ . The first-best efficient outcome is obtained by differentiation with respect to  $q$  and  $n$ .

**Proposition 2** *The welfare optimum of the sequential 3-stage entry-location-quality game is attained iff (1) the number of entrants is  $n^{fb} = \frac{2ck}{3}$ , and (2) the entrants are arranged symmetrically, i.e. with distance  $l_i^{fb} - l_{i-1}^{fb} = \frac{1}{n^{fb}}$  for all  $i = 1, \dots, n^{fb}$ , and (3) the quality provided is  $q_i^{fb} = \frac{1}{2n^{fb}k} = \frac{3}{4ck^2}$  for all  $i = 1, \dots, n^{fb}$ . The associated welfare is  $W^{fb} = \frac{3}{16ck^2}$ .*

Note that total quality provision is independent of  $n$  and  $c$  and is equal to  $\frac{1}{2k}$ . Obviously, the higher quality costs are, the lower the welfare maximizing level of total quality. Increasing transportation costs drives the welfare maximizing number of firms up without changing total quality provision, i.e. physicians' quality and physician density are substitutes.



## 5 Price regulation and time consistency

In Section 3 we solved the 3-stage game with the flat-rate  $p$  seen as exogenous or as the expected (equilibrium) fee. We now address the regulator's price setting problem. Her goal is to set the "welfare maximizing" fee such that the non-cooperative solution stated in proposition 1 approaches the first-best optimum stated in proposition 2.

### 5.1 Two benchmarks and the first-best optimum

Given that the fee influences the quality decisions of the physicians as well as the number of entries, we cannot expect to be able to implement the first-best optimum by just setting the welfare maximizing price. We have two regulation goals (the first is to fix the number of firms to  $n^{fb} = \frac{2ck}{3}$  and the second is to induce quality choice  $q_i^{fb} = \frac{3}{4ck^2}$  for all  $i = 1, \dots, n^{fb}$ ) and only one regulatory variable. To illustrate this, we study two benchmarks. The first benchmark is created by setting a fee such that the total quality provision is optimal (quality optimal price  $p_q$ ) and the second by setting a fee inducing optimal entry (entry optimal price  $p_n$ ).

**Lemma 2** *If the regulation authority chooses the fee  $p_q = \frac{c}{n_q^2} = \frac{1}{16ck^2}$  total quality is fixed to the first-best level. The number of entrants is  $n_q = 4ck > \frac{2ck}{3} = n^{fb}$  and thus identified as excess capacity. Welfare at  $p_q$  is  $W_q = \frac{11}{192ck^2} \approx \frac{0.057}{ck^2}$ .*

Individual quality levels are  $q_q = \frac{1}{8ck^2}$  and are thus not first-best efficient, while total quality provision is. The quality optimal benchmark differs from the first-best solution only by number of physicians who provide the first-best efficient amount of total quality.

**Lemma 3** *To induce the optimal number of practices, a fee of  $p_n = \frac{27}{2ck^2}$  is required. When faced with this price, physicians provide a quality level of  $q_n = \frac{9}{2ck^2} > \frac{3}{4ck^2} = q^{fb}$  which is identified as excess capacity in quality. At this price welfare is  $W_n = -\frac{147}{16ck^2}$ .*

It is worth noting that we observe excess capacity in both benchmarks. This is because the quality level varies in price linearly, and the number of entrants varies inversely. Since  $p_q < p_n$ , it is impossible to implement the first-best optimum by just choosing the correct price.

## 5.2 First-best efficient regulation

The above mentioned problem can be solved by applying a second regulatory variable or by non-constant compensation. Suppose the regulator could compensate on the basis of any non-constant reimbursement scheme. If marginal compensation increases with market share, optimal quality provision could be induced. Average compensation could be set to induce proper entry.<sup>10</sup> Let  $M$  be the market share of the physician. If, for instance, individual compensation is based on  $p_{ind}(M) = -\frac{3}{2ck^2} + \frac{5}{4k}M$ , the symmetric non-cooperative equilibrium will be first-best efficient (see appendix for a derivation). Licence fees are somewhat simpler. If the price induces the optimal quality level, the regulator has to charge an amount of  $\frac{45}{16c^2k^3}$  to implement the first-best optimum. Introducing lower bounds for quality ( $q \geq q^{fb}$ ), like the minimum standard in ECONOMIDES [1993], and controlling entry by a suitable fee ( $p = \frac{3}{8ck^2}$ ) will also be first-best efficient. Disease management programs may be seen as such a minimum standard.<sup>11</sup>

Licence fees can be seen as a tax imposed through demanding (and time consuming) educational requirements.<sup>12</sup> Looking at the increases in physician densities in the 15 EU member states from 1990 to 1999 (see EUROSTAT [2002, 68]), it would seem that the effect of the “tax” on entry is limited. Furthermore, as far as we know, neither non-constant compensation nor explicit licence fees have ever been considered in health care regulation. One reason may be that the assumption of a benevolent regulator is not always appropriate. Health care regulation may be viewed as the outcome of a bargaining game or as the outcome of a rent seeking contest where interest groups strategically interact. Another reason may be that prestige is a (major) factor in investments in health care. This especially applies to the financing of hospitals and to high-tech medicine.

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<sup>10</sup>We are indebted to Amihai Glazer for pointing this out.

<sup>11</sup>In Germany the first disease management programs started on July 1, 2002. However, there is a large political debate about whether these guidelines introduce upper or lower bounds on the quality of care.

<sup>12</sup>We thank an anonymous referee for providing this interpretation.

### 5.3 The second-best optimum

Suppose that the regulator can commit herself to price policies. Welfare is maximized with respect to the price. Substituting the non-cooperative solutions for  $q$  and  $n$  of proposition 1, (10) simplifies to

$$(11) \quad W = \frac{23}{24} \left( \frac{p^2}{2ck^2} \right)^{\frac{1}{3}} - p.$$

**Proposition 3** *The second-best optimum of the sequential 3-stage entry-location-quality game is attained iff the practices are arranged symmetrically and the price is set to  $p^{sb} = \left(\frac{23}{36}\right)^3 \frac{1}{2ck^2}$ . The resulting equilibrium values are:  $n^{sb} = \frac{72}{23}ck$ ,  $q_i^{sb} = \left(\frac{23}{36}\right)^2 \frac{1}{2ck^2}$  for all  $i = 1, \dots, n^{sb}$  and  $W^{sb} = \left(\frac{23}{36}\right)^3 \frac{1}{4ck^2} \approx \frac{0.065}{ck^2}$ .*

These values are between the values of the benchmarks given by lemma 2 and lemma 3, implying excess capacity in both entry and total quality provision. The deviation of these values from those induced by  $p_q$  is small and consequently welfare is close to  $W_q$  as well.

### 5.4 Time consistent regulation

When the social planner cannot commit herself to a certain price, the time consistency issue arises. Whether the second-best outcome can be implemented or not depends on the credibility of the announcement of  $p = p^{sb}$  at stage 1 of the game. If the regulator has an incentive to reoptimize after the entry and location decisions based on  $p^{sb}$  have been made, then  $p^{sb}$  is not credible. Differentiating (10) with respect to  $q$  we observe  $p^{reop} = \frac{c}{n^2}$  to be the welfare maximizing fee. Welfare increases from  $\frac{0.065}{ck^2}$  to  $\frac{0.071}{ck^2}$ . But, with rational physicians, it is impossible to have different fees at the different stages of the game. Physicians anticipate the regulator's incentive to reoptimize between stages two and three and base their decisions on  $p^{reop}$ . Since the functional form corresponds to the quality optimal fee, the decisions are based on  $p_q$  resulting in welfare  $\frac{0.057}{ck^2}$  as calculated above. Since  $W^{sb} > W_q$ , the regulator would like to bind herself to  $p^{sb}$ . Of course, this argument, and with it, the time inconsistency result do not rely on the second-best price.

**Proposition 4** *The only credible fee-for-service reimbursement policy of the sequential 3-stage entry-location-quality game is given by the quality optimal price  $p_q$ . Every price different from  $p_q$  (including the second-best fee) is not time consistent.*

## 5.5 The median voter equilibrium

In a democracy it may be more appropriate to consider an elected regulator. Suppose the regulator wants to be re-elected, then the price will be set in favor of the electorate. If there is majority voting, the median voter decides on  $p$ . Assuming that the share of physicians relative to the share of patients in the population is small, the fee will be chosen to maximize the patients' utility function. Utility is obtained by replacing the quality cost term in the welfare function (10) by  $p$ .

Suppose the voters take the effect of changes in  $p$  on firms profits and the equilibrium number of firms into account. If they can decide on the number of licences and the fee, they can implement the first-best optimum. The second-best optimum is the outcome if they can only decide on the fee.

But the sequential structure of the game implies myopic patients. Hence, the voting behavior described above is not time consistent. Given a certain number of practices, patients care only about their net gain from quality provision  $q - p$ . Differentiating this expression with respect to  $p$  yields a first order condition of  $n = 2ck$ . If this equation holds, the voters have no incentive to change the price after entry and location decisions have been made. The price corresponding to  $n = 2ck$  characterizes the time consistent voting equilibrium.

**Proposition 5** *The symmetric time consistent voting equilibrium of the sequential 3-stage entry-location-quality game is attained iff the price is given by  $p^v = \frac{1}{2ck^2}$ . The resulting equilibrium values are:  $q_i^v = \frac{1}{2ck^2}$  for all  $i = 1, \dots, n^v$ ,  $n^v = 2ck$ , and  $W^v = -\frac{1}{48ck^2}$ .*

Excess capacity in both entry and total quality is observed. The price exceeds the second-best price implying higher quality provision but fewer entrants than in the second-best equilibrium. Compared to the time consistent regulatory equilibrium, price and quality are higher and the number of firms is smaller. Total quality provision doubled

while costs are 8 times as high. Relative to the costs, the quality of care is poor.<sup>13</sup> The welfare derived from the values of proposition 5 is lower than in the time consistent regulatory case, i.e  $W^v < W_q$  (see lemma 2). Thus, the commitment problem is more severe.<sup>14</sup>

## 5.6 A numerical example

To illustrate the results of the welfare and time consistency analysis we provide a numerical example for  $c = 48$  and  $k = \frac{1}{8}$  (see table below). The first-best optimum is attained if the total quality of 4 quality units is provided by 4 physicians. This can be done by setting  $p = 3$  and demanding  $\frac{5}{8}$  as licence fee. In this case, expected welfare is 0.25. The benchmarks shown in the following two rows show excess entry in the quality optimal case and excess quality provision in the entry optimal case. In the commitment game (second-best) we observe excess capacity in terms of both entry and total quality. But this policy is not time consistent. The regulator's incentive to reoptimize is shown in the second last row where a price reduction after the entry decisions have been made (based on the second-best price) increases welfare from 0.09 to 0.10. The unique time consistent equilibrium is given by the quality optimal price policy. The commitment problem is more severe in the median voter equilibrium as indicated by the last row.

## 6 Price Competition

In the presence of the commitment problem discussed in the previous section, a natural suggestion would be to allow physicians to also compete in prices. Suppose that at stage

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<sup>13</sup>This is exactly what may be concluded from the World Health Report 2000 for the German health care system (WORLD HEALTH ORGANIZATION, WHO [2000, 153]).

<sup>14</sup>When precluding physician non-price competition as in GRAVELLE [1999], completely different results are obtained, since the voters no longer have the incentive to promote quality competition by increasing the fee. The voting equilibrium then has lower price, lower quality, and fewer firms. This changes implications for the movement of the health care market, especially for the quality of care, when exposing the health care market to price competition.

	$p$	$n$	$q$	$n \cdot q$	$W$
first-best	–	4	1	4	0.25
quality optimal	0.08	24	$0.1\bar{6}$	4	0.08
entry optimal	18	4	6	24	–12.25
second-best	0.17	18.78	0.27	$5.1\bar{1}$	0.09
reoptimized	0.14	18.78	0.21	4	0.10
median voter	$0.6\bar{6}$	12	$0.6\bar{6}$	8	$-0.4\bar{4}$

Table 1: A numerical example for  $c = 48$  and  $k = \frac{1}{8}$ .

3 of the game physicians decide simultaneously on quality and prices. Then the critical patient, i.e. the patient who is indifferent between the practices  $i$  and  $i + 1$ , is given by

$$(12) \quad x_i^{crit} = \frac{q_i - q_{i+1}}{2c(l_{i+1} - l_i)} - \frac{p_i - p_{i+1}}{2c(l_{i+1} - l_i)} + \frac{l_i + l_{i+1}}{2}.$$

The optimal mix of prices and quality is obtained by differentiating the profit function with respect to  $p_i$  and  $q_i$ .

**Proposition 6** *The symmetric equilibrium of the sequential 3-stage entry-location-quality and price game is given by the quality optimal benchmark, i.e. by the time consistent regulatory outcome.*

The proof is presented in the appendix. Since the competitive outcome coincides with time consistent regulatory policy, the commitment problem cannot be solved by introducing price competition into the health care market. This is not very surprising since both the regulator and the physicians trade off the benefits of quality provision against its costs, where price is used to reduce quality competition.

## 7 Reimbursement of physicians in Germany

In recent decades, we have seen many health care reforms in Germany. But reimbursement of physicians has always remained on a fee-for-service basis. In 1993 there was a switch

from cost reimbursement to sectoral budgets in the German health care market. The (regional) statutory sickness funds<sup>15</sup> bargain with the (regional) physicians' associations about a (regional) budget for panel doctors. After the budgets are agreed, the physicians' associations reimburse the physicians on a fee-for-service basis subject to the constraints given by the fixed budgets. More precisely: a relative value system is applied. Every service is scored with a certain number of points. The DM value of one point is endogenous. It is determined by dividing the budget by the total number of points submitted for reimbursement by all physicians. Consequently the budgets in Germany are always met.<sup>16</sup>

Our model can be applied to the German reimbursement system. The mass of patients was assumed to be equal to one. Then, total benefits of the market are  $p$ . This is why  $p$  can alternatively be interpreted as a fee-for-service or as a budget for physician services. The point value in our model is observed very easily. Every patient receives the same service independent of the physician he visits, and it is not possible for the physicians to treat a patient more than once. Hence, changes in  $p$  directly translate into identical changes in the point value. If one treatment is scored with one point the point value is  $p$ .

From equation (9) we know that the equilibrium number of entrants is a decreasing function of  $p$ . This counter intuitive result was explained by equation (8): the quality increases linearly in price, and, in the presence of convex costs of quality provision, this has a deterrent effect. Or, the other way round, a drop in prices makes the health care market more attractive. The reduced quality competition encourages further entries. This inverse relationship is observed in Germany (see figure 2). The point value was decreasing from 1993 to 1996. The improvement in 1997 is due to the introduction of clinic budgets in 1997 (see SACHVERSTÄNDIGENRAT FÜR DIE KONZERTIERTE AKTION IM GESUNDHEITSWESEN, SVRKAIG [1998, 369-372]). Since the clinic budgets were introduced in July 1997, the 1998 value is higher. Without these changes the point value

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<sup>15</sup>In Germany health insurance companies are called sickness funds.

<sup>16</sup>For a more detailed description of the German physician reimbursement system see ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, OECD [1992, 57-72] and more recent EUROPEAN OBSERVATORY ON HEALTH CARE SYSTEMS, EOHCS [2000, 102-106].

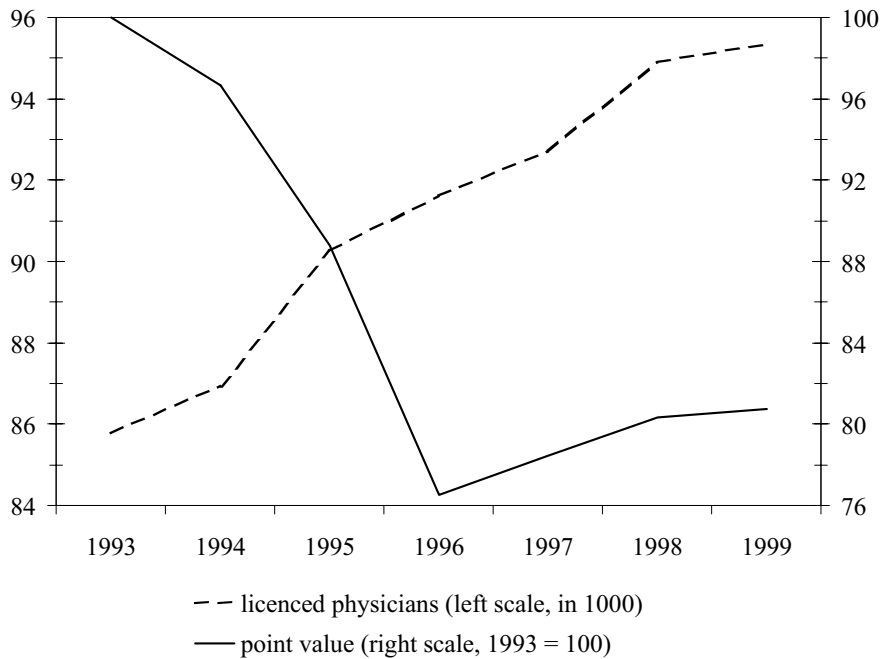


Figure 2: For the Western Länder a reciprocal relationship between the point value and licenced physicians is observed. *Source:* KASSENÄRZTLICHE BUNDESVEREINIGUNG, KBV [2001, A20] and BUNDESMINISTERIUM FÜR GESUNDHEIT, BMG [1999, 260].

would have decreased further.<sup>17</sup> In the political debate it is argued that the increasing number of physicians caused the decline in the point value. This effect is called the treadmill effect in a fixed budget system. Applying the target income hypothesis, an expected decrease in the point value implies an increase in the number of (invoiced) treatments, i.e. supplier induced demand (see BENSTETTER AND WAMBACH [2001]). This is very intuitive and is supported by figure 2. Our model shows that, due to spatial and quality competition, this relation persists in the absence of supplier induced demand.

Suppose that supplier induced demand is absent from the German health care market. Furthermore, assume that the point value in Germany is between the benchmarks studied in section 5 and that the regulator cannot commit herself. Excess capacity in total quality and entry was identified in this price range.<sup>18</sup> To attain the first-best solution price cuts

<sup>17</sup>We are indebted to Dr. Dahlhausen from the Kassenärztliche Bundesvereinigung (KBV) for providing the pointvalue data. For some of that data see KBV [2000, C6].

<sup>18</sup>The Sachverständigenrat für die Konzertierte Aktion im Gesundheitswesen, SVRKAiG, reports,



should be accompanied by a drop in physician licences. Since this is not observed in Germany, given that our model applies, the regulation of the health care market is not welfare maximizing. It seems as if the market converges to the time consistent equilibrium instead of to the first-best efficient outcome. Entry regulation is too weak.

One may argue that applying our model to this question is not appropriate since the point value was decreasing but the size of the budget was not. As a proxy for the budget's size we use the expenditure for treatments by panel doctors (see figure 3). From 1993 to 1999 the expenditure increased by roughly 9 percent in 1991 prices.<sup>19</sup> Technical progress is one of the main drivers of that growth. Making this progress available to the insureds improves the quality of the medical treatments they receive.<sup>20</sup> This can be interpreted as an increase in voter influence on health care regulation. The increase in expenditure, i.e. in price, drives quality up from the time consistent quality level to (or in direction of) the voting equilibrium value. Our model cannot explain the increase in active physicians without changing the specification of the quality cost function.<sup>21</sup> However, approaching the first-best efficient outcome starting from the time consistent outcome, price increases should be accompanied by a drop in physician licences. We again conclude that licences are allocated too generously.

## 8 Conclusion

We presented a model of physician competition in a price regulated environment. In the absence of price competition physicians resort to other variables to increase profits:

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depending on the disease, under-provision and over-provision of health care services in Germany (see SVRKAIG [2002]). Our model only explains over-provision due to quality competition.

<sup>19</sup>We deflated the numbers for expenditure on treatments found in BMG [1999] and KBV [2001] by the CPI for all households.

<sup>20</sup>Alternatively, the expenditure for outpatient care per capita can be used for the same argument. The increase from 1993 to 1998 is about 11 percent.

<sup>21</sup>As argued in section 3, if marginal costs of quality provision are low or prohibitive, then the number of practices increases in the budget. Since the quality provided in Germany is likely to be high, it may be reasonable to assume prohibitive or at least very high marginal costs.

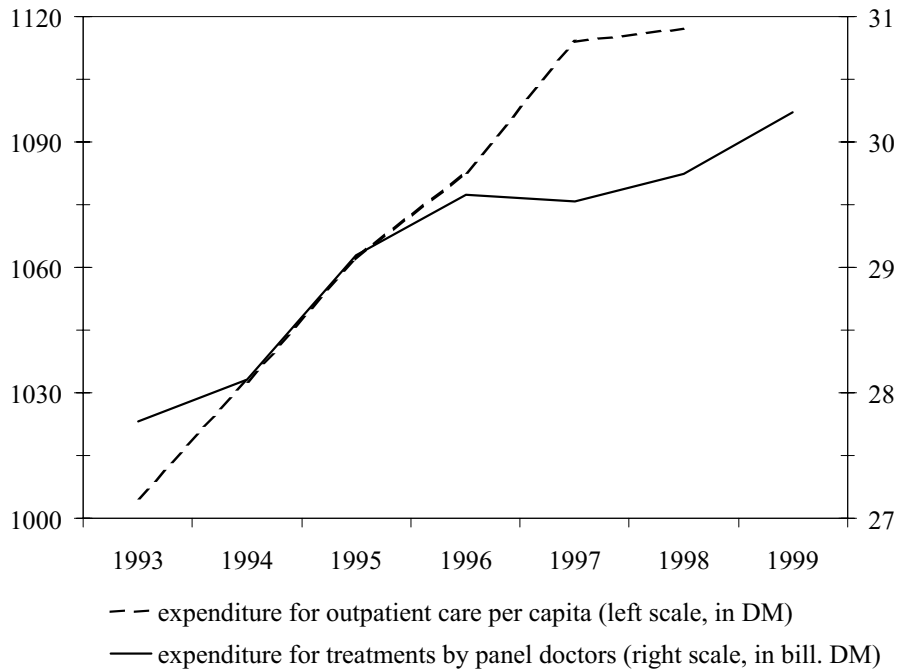


Figure 3: Expenditure for outpatient care per capita and for treatments by licenced physicians, both for the Western Länder and both in 1991 prices. *Source:* STATISTISCHES BUNDESAMT [2001, 129], BMG [1999, 402], and KBV [2001, G2].

location and quality. The problem was analyzed in a 3-stage entry-location-quality game. We restricted ourselves to inelastic demand and symmetric equilibria to obtain a lower benchmark case with respect to the level of quality provision. We found that quality is an important strategic variable used aggressively to reduce locational handicaps. The closer two physicians are located, the tighter competition, and, consequently, the higher the quality provided. An increase in the fee reduces the equilibrium number of entrants. The higher price sharpens quality competition to an extent that it has a deterrent effect. The inverse relationship of the point value and the number of licenced physicians observed in Germany is mainly attributed to the treadmill effect. This may indeed be the more reasonable explanation, but our model shows that the relation also persists in the absence of supplier induced demand due to quality competition.

The regulator's goal is to set a welfare maximizing fee. We studied two prices resulting in two benchmarks, one in which the number of firms is first-best efficient, and the other

in which total quality is. Since these two prices do not coincide, the first-best optimum cannot be implemented by just setting the correct fee. If the regulator can commit herself, she will apply the second-best fee which lies between the benchmark prices. But only the second of the two benchmarks was identified as being a credible price policy. Hence, in the game without commitment, the second-best policy is ruled out as time inconsistent. The regulator is limited to the quality optimal price. Since expected welfare is lower in the game without commitment, the regulator would like to bind herself to the second-best price. The commitment problem cannot be solved either by introducing price competition into the health care market or by letting voter patients decide on the price. The outcome of the price competition game corresponds to the time consistent regulatory outcome. In the voter equilibrium, the commitment problem is more severe.

Theoretically, the first-best efficient outcome can be implemented by simultaneously limiting entry by means of licences. Studying the relation between the price and the number of physicians makes it possible to judge whether such a policy is being applied. In both the scenarios discussed in the previous section it was indicated that, although there is entry regulation in Germany, like need-related planning in the allocation of physician licences, entry regulation seems too weak.

## Appendix

*Proof of Lemma 1:* The proof is split into two steps. First, we show that the symmetric choice of location is the best physician  $i$  can do, if the set of possible locations is restricted to the open interval  $(l_{i-1}^*, l_{i+1}^*)$ . Then, in step two, we show that the locations  $l_{i-1}^*$  and  $l_{i+1}^*$  lead to negative profits and consequently cannot be equilibrium choices in an entry game.

(i) Given the symmetric locations of all practices  $j \neq i$  and the set of possible locations  $(l_{i-1}^*, l_{i+1}^*)$ , the best response of  $i$  is to settle in the middle of the neighboring two. To show this we differentiate the objective function with respect to  $l_i$ . Substituting the expressions

following the equations (5) to (7) into the first order condition and rearranging yields

$$\begin{aligned}
(13) \quad \frac{8c^2k}{p^2} \frac{\partial \Pi_i^{\Pi}}{\partial l_i} &= \frac{1}{(l_i - l_{i-1}^*)^3} - \frac{1}{(l_{i+1}^* - l_i)^3} \\
&+ \frac{1}{(l_{i+1}^* - l_i)^2 (l_i - l_{i-1}^*)} - \frac{1}{(l_{i+1}^* - l_i)^2 (l_{i+2}^* - l_{i+1}^*)} \\
&+ \frac{1}{(l_i - l_{i-1}^*)^2 (l_{i-1}^* - l_{i-2}^*)} - \frac{1}{(l_i - l_{i-1}^*)^2 (l_{i+1}^* - l_i)}.
\end{aligned}$$

It is easy to see that, in the symmetric solution, the right-hand side of (13) is zero. To identify this decision as a global maximum on  $(l_{i-1}^*, l_{i+1}^*)$  we have to show that  $i$  is worse off when he deviates from the symmetric location or that he is better off when he moves to the center, starting from any asymmetric location. Although (13) is hard to interpret, the sign is determined for all  $l_i \in (l_{i-1}^*, l_{i+1}^*)$ . Assume that the practices have symmetric locations except  $i$  which is closer to  $i - 1$  than to  $i + 1$ , then:  $l_{i-1}^* - l_{i-2}^* = l_{i+2}^* - l_{i+1}^* = \frac{1}{n}$ ,  $l_{i+1}^* - l_i > \frac{1}{n}$  and  $l_i - l_{i-1}^* < \frac{1}{n}$ . By making a small step to the midpoint,  $i$  can increase profits since the right hand side of (13) is positive. By the same argument, this is true when  $i$  is closer to  $i + 1$ . Notice that, in this case, a movement to the center requires  $dl_i$  to be negative. Hence, given the symmetric location of the others,  $i$  cannot be better off when he deviates from the perfect symmetric solution, and he is actually worse off.

(ii) Consider that the practices are arranged symmetrically and physician  $i$  decides to relocate at exactly the same location as physician  $i - 1$ . Since both practices are at the same location patients will decide for the practice providing the higher quality. Both practices are competing with the neighboring clinics ( $i - 2$  and  $i + 1$ ) in a market of size  $\frac{3}{n}$  and actually serve a market of size  $m < \frac{3}{n}$ . Both physicians can only be sure of not being quality “over-cut” if they provide a quality level which leads to zero profits when serving  $m$  alone. But this quality level cannot be an equilibrium as both physicians will incur a loss. Thus, no equilibrium in pure strategies exists.  $\square$

*Derivation of the non-constant price scheme:* The average individual compensation is set such that the physicians exactly break even when providing the first-best quality level in a market with  $n^{fb}$  competitors:

$$(14) \quad \frac{p_{ind}(n^{fb})}{n^{fb}} = k(q^{fb})^2.$$

We obtain  $p_{ind}(n^{fb}) = \frac{3}{8ck^2}$ . Using the definition of the critical patient from equation (2), the market share of physician  $i$  is given by  $M_i = \frac{n}{2c}(2q_i - q_{i+1} - q_{i-1}) + \frac{1}{n}$ . When the individual reimbursable price depends on market share, the objective function is given by  $\Pi_i = p_{ind}(M_i)M_i - kq_i^2$ . Assuming symmetry, the first order condition for profit maximizing quality provision is  $q_i^* = \frac{1}{2ck}(p'_{ind} + p_{ind}n)$ . This equation must hold at  $n^{fb}$  yielding:

$$(15) \quad \frac{p'_{ind}(n^{fb})}{2ck} + \frac{p_{ind}(n^{fb})}{3} = q^{fb}.$$

Inserting  $q^{fb}$  and  $p_{ind}(n^{fb})$  gives the solution for  $p'$ :  $p'_{ind}(n^{fb}) = \frac{5}{4k}$ . There is an infinite number of reimbursement schemes satisfying the conditions  $p_{ind}(n^{fb}) = \frac{3}{8ck^2}$  and  $p'_{ind}(n^{fb}) = \frac{5}{4k}$ . The easiest is the one mentioned in the text, i.e.  $p(M) = -\frac{3}{2ck^2} + \frac{5}{4k}M$ , where  $M$  is physician market share.  $\square$

*Proof of proposition 6:* Substituting the expressions for the critical patients into the profit function yields the objective function for the third stage of the game:

$$(16) \quad \Pi_i = \frac{p_i}{2c} \left[ \frac{q_i - q_{i+1}}{l_{i+1} - l_i} - \frac{p_i - p_{i+1}}{l_{i+1} - l_i} - \frac{q_{i-1} - q_i}{l_i - l_{i-1}} + \frac{p_{i-1} - p_i}{l_i - l_{i-1}} \right] + \frac{p_i}{2}(l_{i+1} - l_{i-1}) - kq_i^2.$$

When solving for the symmetric equilibrium, the first order conditions are given by

$$(17) \quad q = \frac{np}{2ck} \quad \text{and} \quad p = \frac{c}{n^2}$$

proving the assertion.  $\square$

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