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Working Paper

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Diskussionspapier Nr. 66

Spatial Competition between Health Care Providers:
Effects of Standardization

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Oktober 2009

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Abstract

In the international health care literature there is a broad discussion on impacts of competition in health care markets. But aspects of standardization in regional health care markets with no price competition received comparatively little attention. We use a typical Hotelling-framework (reference case) to analyze a regional health care market with two health care providers competing in (vertical) quality after the scope of medical treatment is set (horizontal quality). We conclude, that in the reference case both health care provider will use vertical quality to separate from each other. In the next step (standardization case) we introduce one health care provider to be the standard leader in vertical quality. In the standardization case a more homogeneous supply can be expected. But, there is a higher possibility that the standard follower has to leave the regional health care market.

Contents

1 Introduction

The international literature has devoted much attention to the analysis of competition in health care markets (see for example Dranove and Satterthwaite (2000); Gaynor and Vogt (2000)). In this context, most authors focus on horizontal competition (cf. Dranove and Satterthwaite (2000); Gaynor and Haas-Wilson (1998); Pauly (1998)). Limited attention has been paid to standardization effects and horizontal competition within a regional health care market. Nevertheless, in many health care systems there is a tendency to enforce standardization in inpatient as well as outpatient care. As this has direct impacts on the competition environment within a regional health care market these effects are modeled in this paper.

In this paper we analyse spatial competition between two health care providers. We elaborate the relationship between two health care providers and the market performance with and without standardization. For this, we will develop an expanded Hotelling-model in two steps:

In the first step we analyse quality choice. We allow the suppliers to choose their location, their scope of treatments and the quality of treatments being offered. In the following we use the term *horizontal quality* when we focus on the choice of location and scope of treatments.[1] We use the term *vertical quality* when we analyse the quality of treatments being offered. We call this first step the reference case.

In the second step we introduce standardization, e. g. a standard of vertical quality for treatments in the regional health care market. We call this case the standardization case. The standard could be the result of a benchmark process initiated by the regulator or a cost payer (insurance company). This means, we assume that a third party is able to observe the vertical qualities and to prescribe the higher quality as a standard. This standard is binding for all health care suppliers, even those whose optimal quality is lower. A typical backwards induction model will be employed. We show that the health care provider with lower costs for producing vertical quality is the standard leader. The other one is the standard follower. In this scenario we focus on the effects of vertical quality standardization.

The paper is organized as follows: Section 2 describes the typical characteristics of a regional health care market. Section 3.1 introduces the basic model of spatial competition. The model is expanded in section 3.2 to include a standardization process in the regional health care market. Section 4 summarizes our findings and outlines their implications for further research.

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[1]This means we have two possible interpretations for horizontal quality.

2 Regional Health Care Markets

For the discussion it is necessary to define the conditions and restrictions outpatient (physicians) and inpatient (hospitals) health care providers face within the regional market. In a typical patient-physician-situation, patient's primary demand is directed to a physician who diagnoses the patient and makes the first treatment decisions. For more severe illnesses the patient will be referred to a higher equipped health care provider for appropriate care. This can be an outpatient specialist or a hospital. For the sake of simplicity we assume that the patient is free to choose between health care providers, i.e. we do not differentiate between inpatient and outpatient care. In contrast to other markets, prices in health care markets are regularly set by a regulator or the third payer (insurance).[2] This strengthens the relevance of competition in quality.

In the tradition of industrial economics, we distinguish between vertical quality and horizontal quality. Patient's preferences for vertical quality are uniformly ranked, i.e. all patients prefer a higher vertical quality. Consequently, all patients are better off when the level of medical quality health care provider 1 offers rises.[3]

Horizontal quality on the other hand refers to characteristics, where the optimal choice depends on the characteristics of the consumer. In the case of health care providers location or the range of treatments offered can be considered as horizontal quality variables. Patients which are closer to health care provider 1 have less opportunity costs than those located closer to the other one. In contrast to a rise in vertical quality a rise in horizontal quality does not necessarily constitute a pareto improvement. Consumers, whose optimal horizontal quality was close to the offered horizontal quality before the change, may face a pronounced decline in utility as the deviation between their desired quality and the quality offered increases. Consumers, whose preferences are now better aligned with market quality, on the other hand, gain in utility (cf. Shy (1995)).

For the purpose of this paper we regard it as impractical to treat horizontal differentiation only as the choice of location, like the Hotelling-model does. Once chosen horizontal quality is necessarily fixed for the time being. Therefore, the only remaining choice concernes vertical quality. We propose to look at the range of treatments offered instead and interpret increased horizontal quality as a larger (and therefore less specialized) scope of treatments offered by a particular health care provider.

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[2]We will therefore treat prices as fixed in this paper.

[3]The same argument applies to health care provider 2.

3 Model of Quality Competition

3.1 Basic Model

A simple model of a regional health care market can be derived from the papers of Glazer and McGuire (1993) or Montefiori (2005). Considering the results of Gravelle (1999) and Calem and Rizzo (1995) we use the approach of the spatial competition literature to model the effects of standardization. This should provide a good intuition for the probable consequences of the implementation of a new form of standardized care.

Brekke, Nutscheler, and Staume (2006) develop a specific model that combines ideas of spatial competition in the tradition of Hotelling (1929) with quality competition. This is our point of reference in this paper.[4] Like them we employ a two-stage model of health care provision with fixed prices. In the first stage, each health care provider decides on horizontal quality. He selects his range of treatments offered.[5] After the decision on horizontal differentiation at the first stage, the health care providers compete by choosing the quality of care they provide in the second stage, i.e. by choosing a level of vertical quality.

3.1.1 Demand for Health Care

As a first step we model patient's demand for health care. We follow Hotelling's idea of a linear city[6] and assume rational consumers with perfect and complete information about all relevant parameters.

The term a_i denotes the absolute position of the health care provider i on the $[0, 1]$ interval.[7] We assume health care provider 1 is located left within the spectrum and health care provider 2 is located right ($a_1 \in [0; 0.5-\epsilon]$ and $a_2 \in [0.5+\epsilon; 1]$). Hence, we assume there is a perceivable horizontal quality difference so that patient's location or need for a specific treatment will generally direct them to one of the providers, i.e. the average patient is not indifferent between health care providers but has a decided preference for one.

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[4]In contrast to Brekke, Nutscheler, and Staume (2006) we do not attempt to find an optimal reimbursement scheme or the reimbursement level that will maximize welfare.

[5]Interested readers are referred to Robinson and Casalino (1996) and Gal-Or (1999) for an in depth discussion of this topic.

[6]The presentation of the basic model follows Tirole (1988): 96 ff.

[7]a_i stands for the chosen location in the spatial interpretation. In the service differentiation case it denotes the range of treatments offered.

Demand for a (specific) unit of health care h_l is assumed to be independently identically distributed on the $[0; 1]$ interval.[8] In addition to horizontal quality we consider vertical quality in the standard of care for any given treatment, which is described by the parameter q_k.

The variable costs for crossing the distance to a regional provider are borne by the patient. They are assumed to be constant and denoted by t. As we have noted before, within the model p_m, the price for medical treatment, is independent of the scope of medical treatment and the vertical quality offered. Now, we additionally assume p_m is regulated and fix for all health care providers.[9]

Similar to Brekke, Nutscheler, and Staume (2006) each patient faces the following objective:

$$L^A(h, q_k, p_m) = \bar{u} + q_k - t \cdot (h_l - a_i)^2 - p_m \tag{3.1}$$

To maximize his utility, the patient has to decide whether health care provider 1 or health care provider 2 are entitled to treat him.[10] We assume, that net utility is always positive, even for the lowest vertical quality possible. The whole market is always covered and for a regulated price p_m which is equal for all patients. Each consumer demands one unit of the good as we assume that a second unit does not offer additional utility. The indifferent patient between the both health care providers has the location $\bar{h}$ which is the solution to:

$$q_1 - t(\bar{h} - a_1)^2 = q_2 - t(a_2 - \bar{h})^2 \tag{3.2}$$

The result allows us to denote the position h in the linear city. Both health care providers face the same indifferent patient. Consequently, health care provider one's demand y_1 is the fraction of the market just up to the marginal consumer $\bar{h}$.

$$\bar{h} = \frac{q_2 - q_1}{2t(a_1 - a_2)} + \frac{a_1 + a_2}{2} \tag{3.3}$$

For the other health care provider $y_2 = 1 - \bar{h}$ holds.

For the non-spatial case there is an intuitive interpretation of this variable. If $\bar{h}$ is high, a substantial part of patients choose health care providers offering a wide

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[8] Differences between h_l and a_i represent a quality mismatch. Opportunity costs are the costs consumers face because the range of treatments offered by a given medical care provider does not exactly match their preferences (cf. Shy (1995) and can be computed by multiplying the actual mismatch with a cost parameter t).

[9] As we assume all patients are insured, they do not face variable costs of treatment. Effects on insurance premia are either non existent or not perceptible for patients. It is important to note that this price for treatment is not identical with hospital remuneration which we will denote later by $\bar{p}$.

[10] The model is limited to selective medical treatments a patient can anticipate and plan.

range of treatments. If $\bar{h}$ is low, the majority prefers treatment by providers with a lower degree of horizontal quality a_i, i.e. by providers who specialize in a small number of treatments.

We split expression (3.3) into three parts:[11]

$$\bar{h} = \underbrace{(q_2 - q_1)}_{\text{vertical quality difference}} \cdot \underbrace{\frac{1}{2t(a_1 - a_2)}}_{\text{degree of competition}} + \underbrace{\frac{a_1 + a_2}{2}}_{\text{average horizontal quality}} \tag{3.4}$$

The position of $\bar{h}$, the marginal consumer, depends on vertical quality difference, the degree of competition and average horizontal quality. We are particularly interested in the degree of competition. From the second term over braces we infer that the degree of competition rises when t low and/or the gap between a_1 and a_2 is small, i.e. there is little differentiation in horizontal quality.

3.1.2 Supply of Health Care

Taking health care provider 1 as our representative producer in a world with two health care providers, we get the following profit function:

$$\Pi_1 = (\bar{p} - c_1) \cdot y_1 - \left(\varphi_1 \cdot \frac{q_1^2}{2} \right) - C_1^F \tag{3.5}$$

We set $\bar{p}$ for the regulated price all health care suppliers face. We suppose that reimbursements cover costs, i.e. that $c_n \leqslant \bar{p}$ is valid. If reimbursements do not cover costs there will be no voluntary supply, consequently, this case is irrelevant in a market economy.[12] The parameter c_n signifies the variable cost of a treatment while C_n^F denotes fixed cost. The variable costs occur if the the minimum level of quality ($\varphi_0 = 0$) is provided. The costs φ_0 for producing higher vertical quality q_k are supposed to be convex.[13] Costs for a given level of vertical quality are therefore a combination of the variable costs for the provision of basic quality and a higher vertical quality cost increment.

There are already a few very straightforward results to be derived from this profit function. Profit can only be positive, if reimbursements exceed variable costs ($\bar{p} > c_1$) and rises with the difference between these two variables. Variable cost

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[11]Cf. Pfähler and Wiese (2006): 244.

[12]The case where this condition is not met presents us with an argument against insufficiently high reimbursements, as these could lead to low levels of quality and a sub-optimally narrow range of treatments. Interested readers are referred to Newhouse (1996) and Pope (1989).

[13]$K(q_k) = \varphi \frac{q^2}{2}$. See Brekke, Nutscheler, and Staume (2006): 212.

for vertical quality φ_1 and fixed costs C_1^F have a negative impact on profits. These results are general and do not depend on the specifications of the model.

Substituting the results derived in (3.3) into the profit function we get:

$$\Pi_1 = (\bar{p} - c_1) \cdot \left(\frac{q_2 - q_1}{2t(a_1 - a_2)} + \frac{a_1 + a_2}{2} \right) - \left(\varphi_1 \cdot \frac{q_1^2}{2} \right) - C_1^F \tag{3.6}$$

Now we analyze the effects of decisions on vertical and horizontal quality. We know, that provider 1 has a smaller a_i than provider 2, therefore the first term within the brackets can only be positive if $q_1 > q_2$. Provider 1, the provider with the smaller range of treatments offered in the non-spatial interpretation, has an incentive to offer higher vertical quality, because this increases his profits. If he offers a lower vertical quality, the difference in horizontal quality between providers will lower his profits in comparison to the case where both providers offer homogenous goods. For this vertical quality distribution, profits for a provider with the higher vertical quality rise, the smaller the difference in horizontal quality $(a_1 - a_2)$ and the smaller transport costs t are. Consequently, there is an incentive to diversify horizontally for this provider.

3.1.3 Optimal Vertical Quality

In the standard case we assume that both health care providers offer different levels of vertical quality. The first order condition for the profit-maximizing quality q_1 is:

$$\frac{\partial \Pi_1}{\partial q_1} = -\frac{\bar{p} - c_1}{2t(a_1 - a_2)} - q_1 \cdot \varphi_1 = 0 \tag{3.7}$$

As we have assumed that $a_1 < a_2$ the above equation only holds if $\bar{p} \geq c_1$. Otherwise the first order condition for a profit-maximum would not be satisfied, as $\Pi_1 < 0$. Profit-maximizing vertical quality[14] can be written as:

$$q_1^* = \frac{-\bar{p} + c_1}{2t(a_1 - a_2)\varphi_1} \tag{3.8}$$

Comparative static for optimal quality yield for $a_1 < a_2$:[15]

$$\frac{dq_1^*}{da_1} = \frac{\bar{p} - c_1}{2t(a_1 - a_2)^2 \cdot \varphi_1} \tag{3.9}$$

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[14]The second-order condition is negative ($\frac{\partial^2 \Pi_1}{\partial q_1^2} = -\varphi_0$).

[15]For the discussion of health care provider 2 cf. Appendix A.1.

This equation tells us, that there is an inverse relation between horizontal and vertical quality for health care provider 1. If a_1 rises and therefore c.p. approaches a_2 q_1 rises. The closer the offers of the health care providers are, the higher the incentive of the provider with the smaller range of treatments to offer a high vertical quality. The implication of this relationship can be expressed in everyday words: The further apart the health care providers are, the lower the quality they will probably offer.

Comparing this result with the impact of a_2 gives:

$$\frac{dq_1^*}{da_2} = -\frac{\bar{p} - c_1}{2t(a_1 - a_2)^2 \cdot \varphi_1} \tag{3.10}$$

An increase in the (horizontal quality) distance between the two health care providers increases provider 1's incentive to offer a high level of vertical quality.

$$\frac{dq_1^*}{dt} = \frac{\bar{p} - c_1}{2t^2 \cdot (a_1 - a_2) \cdot \varphi_1} \tag{3.11}$$

The incentive to provide quality is negatively related to t, the parameter denoting transport cost or the cost of quality mismatch for patients. This is plausible, as competition from other health care providers is lower when opportunity costs (the product of the actual distance/quality mismatch and the cost parameter) are high. If travelling has a higher negative impact on utility than putting up with lower vertical quality, people will stay with their local health care provider and the provider chooses his quality accordingly.

$$\frac{dq_1^*}{dc_1} = \frac{1}{2t(a_1 - a_2) \cdot \varphi_1} < 0 \tag{3.12}$$

As $a_1 < a_2$ is true per definition, the impact of an increase in c_1 is to lower the level of vertical quality. Costs directly reduce profit and consequently reduce the incentive to compete via higher quality.

$$\frac{dq_1^*}{d\varphi_1} = -\frac{q_1}{\varphi_1} < 0 \tag{3.13}$$

The above equation shows that the negative relationship between costs and quality is not only true for the cost of treatment, but also for the costs of quality improvements φ_o. Again, a reduction of profits lowers the incentive to compete for them via higher vertical quality.

3.1.4 Optimal Horizontal Quality

When determining optimal horizontal quality a_i for each health care provider we have to keep in mind that $a_1 < a_2$ is true per definition. In other words, for provider

1 an increase in a_1 would reduce differentiation between providers, whereas an increase in a_2 would c.p. induce a greater distance. Backwards induction stipulates both health care providers to choose an optimal level of q_k^* when determining optimal horizontal quality a_1. Inserting q_k^* into equation (3.6) gives us the new profit function:

$$\Pi_1 = (\bar{p} - c_1) \cdot \left(\frac{q_2^* - q_1^*}{2t(a_1 - a_2)} + \frac{(a_1 + a_2)}{2} \right) - \left(\varphi_1 \cdot \frac{q_1^{*\,2}}{2} \right) - C_F \qquad (3.14)$$

The implicit optimal value of a_1 considering the first order condition is:

$$\frac{\partial \Pi_1}{\partial a_1} = (\bar{p} - c_1) \cdot \left[\frac{1}{2} - \frac{q_2^* - q_1^*}{2t(a_1 - a_2)^2} - \frac{1}{2t(a_1 - a_2)} \cdot \left(\frac{\partial q_2^*}{\partial a_1} - \frac{\partial q_1^*}{\partial a_1} \right) - \varphi_1 \cdot q_1^* \cdot \frac{\partial q_1^*}{\partial a_1} \right] = 0$$
$$(3.15)$$

We expect that the optimal level of a_1 and a_2 will equal the extreme values within the range $a_i \in [0, 1]$ resulting in maximum differentiation in horizontal quality. But we can directly infer from the implicit function used beyond that this assumption only holds for no difference in vertical quality. As soon as there is a difference in vertical quality, the health care provider, which is in a quality leading position may be able to reduce his horizontal differentiation.

Looking at the marginal differentiation of both profit functions we can infer that $\frac{\partial \Pi_1}{\partial a_1} < 0$ and $\frac{\partial \Pi_2}{\partial a_2} > 0$ holds.[16] Considering health care provider 1 we observe that the second derivative is also negative which means that there is a local profit maximum at the left side of the range $a_1 \in [0, 1]$.[17] We can can assume a reaction function for the optimal values a_i^*:[18]

$$a_1^* = f(a_2) \, \text{and} \, a_2^* = f(a_1) \qquad (3.16)$$

Looking at the sign of the reaction functions we argue that $\frac{\partial a_1^*(a_2)}{\partial a_2} > 0$ and vice versa. Hence, considering the constraint $a_1 < a_2$ and with respect to the equation we formulate the following: Given one health care provider has set his horizontal quality, the other health care provider will set his horizontal quality contingent on the given level of a_i. From what we have seen above we conclude, that horizontal quality a_i is an important parameter for the competitors.

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[16]Cf. Appendix (A.10).

[17]Cf. Appendix (A.2) Although it might be interesting to consider quality choice by a provider, who is not able to choose his location freely in view of existing regulations. The scope of this paper is limited and we have to refrain from discussing that particular topic.

[18]For the explicit solution cf. Appendix (A.10).

3.2 Quality Competition in the Regional Health Care Market

3.2.1 Reference Case

In the reference case we employ the assumption of the basic case where each health care provider sets its own vertical quality q_k. Now we want to discuss the values for a_i via backwards induction. We concentrate on horizontal quality and the impact on competition if both health care providers assume that the other health care provider acts simultaneously. The profit function of health care provider 1 is:

$$\Pi_1 = (\bar{p} - c_1) \cdot \left(\frac{(a_1 + a_2)}{2} + \frac{q_2^* - q_1^*}{2t(a_1 - a_2)} \right) - \left(\varphi_1 \cdot \frac{q_1^{*2}}{2} \right) - C_F \tag{3.17}$$

Considering the first order condition, the following holds:

$$\frac{\partial \Pi_1}{\partial a_1} = (\bar{p} - c_1) \cdot \left[\frac{1}{2} - \frac{q_2^* - q_1^*}{2t(a_1 - a_2)^2} - \frac{1}{2t(a_1 - a_2)} \cdot \left(\frac{\partial q_2^*}{\partial a_1} - \frac{\partial q_1^*}{\partial a_1} \right) - \varphi_1 \cdot q_1^* \cdot \frac{\partial q_1^*}{\partial a_1} \right] = 0 \tag{3.18}$$

Now we discuss the impact of a change of a_2 on a_1 from the perspective of health care provider 1. The analysis encompasses comparative static for the optimal level for a_1 (stage one). As we cannot directly infer the marginal effects for the first stage, we use the optimal level of q_k and the marginal effects (stage two).[19] Following the first-order condition for vertical quality, we compare the results for both health care providers at the second stage:

$$q_1^* = \frac{-\bar{p} + c_1}{2t(a_1 - a_2)\varphi_1} \text{ for health care provider 1} \tag{3.19}$$

$$q_2^* = \frac{-\bar{p} + c_2}{2t(a_1 - a_2)\varphi_2} \text{ for health care provider 2}$$

For $q_1^* > q_2^*$ the following must be true:

$$q_1^* \equiv \frac{-\bar{p} + c_1}{2t(a_1 - a_2)\varphi_1} > q_2^* \equiv \frac{-\bar{p} + c_2}{2t(a_1 - a_2)\varphi_2} \tag{3.20}$$

- if $\varphi_2 > \varphi_1$ and $c_1 = c_2$ is valid or

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[19] In the following we concentrate on health care provider 1. The results for the other health care provider are to be found in Appendix A.3.

- if $\varphi_2 = \varphi_1$ and $c_1 < c_2$ is valid or

- if $\varphi_1 > \varphi_2$ and $c_2 >> c_1$ can be assumed

Under the described circumstances competition will always result in a higher vertical quality for the health care provider with the lower a_i.

A change of horizontal quality of health care provider 2 leads to:

$$\frac{da_1^*}{da_2} = \frac{6c_2\varphi_1 - 3c_1\varphi_2 + \bar{p}\cdot(-6\varphi_1 + 3\varphi_2)}{4c_2\varphi_1 - c_1\varphi_2 + \bar{p}\cdot(-4\varphi_1 + \varphi_2)} \tag{3.21}$$

Looking at the fraction, we argue that the sign depends on the relationship between c_i and φ_i. For symmetric variable cost the sign of the numerator and the denominator will be dominated by $\bar{p}$, therefore $\frac{da_1^*}{da_2} > 0$.[20] We therefore conclude that a negative change in horizontal quality of health care provider 2 incites health care provider 1 to reduce his horizontal quality given one of the cost parameters (φ_0 or c_n) are equal.

This sheds light on the conditions that could be relevant for different qualities q_k if horizontal quality is set. Therefore, the decision for the horizontal quality at stage one is taken in view of the capabilities for producing vertical quality.

The influence of the variable costs c_1 can be described as follows:

$$\frac{da_1^*}{dc_1} = \frac{(a_1 - a_2)\cdot(a_2\varphi_0 + c_2\varphi_1 - \bar{p}\cdot(\varphi_1 - 2\varphi_2) - 2c_1\varphi_2)}{((\bar{p} - c_1)\cdot(-4c_2\varphi_1 + \bar{p}\cdot(4\varphi_1 - \varphi_2) + c_1\varphi_2))}$$
$$+ \frac{(a_1 - a_2)\cdot(-2t^2a_1^3\varphi_1\varphi_2 + 6t^2a_2\varphi_1\varphi_2)}{((\bar{p} - c_1)\cdot(-4c_2\varphi_1 + \bar{p}\cdot(4\varphi_1 - \varphi_2) + c_1\varphi_2))} \tag{3.22}$$
$$+ \frac{(a_1 - a_2)\cdot(2t^2a_2^3\varphi_1\varphi_2 - a_1\varphi_1\cdot(1 + 6t^2a_2^2\varphi^2))}{(\bar{p} - c_1)\cdot(-4c_2\varphi_1 + \bar{p}\cdot(4\varphi_1 - \varphi_2) + c_1\varphi_2)}$$

The sign of the fraction is not directly clear. Hence, we use the following assumption to get an idea of the relationship between horizontal and vertical quality.

The denominator will be positive

- if: $\varphi_2 = 4\cdot\varphi_1$

- or: $\varphi_2 > 4\cdot\varphi_1 \wedge \bar{p} \leq \frac{-c_1\varphi_1 + 4c_2\varphi_1}{4\varphi - \varphi_2}$

- or: $\varphi_2 < 4\cdot\varphi_1 \wedge \bar{p} \geq \frac{-c_1\varphi_1 + 4c_2\varphi_1}{4\varphi - \varphi_2}$ or

- or: $c_2 = \frac{c_1}{4} \wedge \varphi_2 < 4\cdot\varphi_1 \wedge \bar{p} \geq \frac{-c_1\varphi_1 + 4c_2\varphi_1}{4\varphi - \varphi_2}$

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[20]For the other cases it is impossible to infer results without further math.

In this case a high level of a reimbursement $\bar{p}$ makes the second, fourth and sixth term of the numerator negative. Nevertheless, the whole numerator is positive as long as $a_1 - a_2 < 0$. In consequence $\frac{da_1^*}{dc_1} > 0$ could be assumed.

An increase of the marginal costs c_1 will induce health care provider 1 to reduce his horizontal quality. Additionally, both health care providers will be incited to reduce their vertical quality ((3.12)).

For a change in quality costs φ_1 the following holds:

$$\frac{da_1^*}{d\varphi_1} = \frac{(a_1 - a_2) \cdot (\bar{p} - c_1)\varphi_2}{\varphi_1 \cdot (-4c_2\varphi_1 + \bar{p} \cdot (4\varphi_1 - \varphi_2) + c_1\varphi_2)} \tag{3.23}$$

The sign of the denominator is still assumed to be positive, as we have outlined above. Hence, following the basic assumption $a_1 - a_2 < 0$ the whole fraction gets negative and $\frac{da_1^*}{d\varphi_1} < 0$ holds.

Higher costs φ_1 will incite health care provider 1 to expand his horizontal quality. Only when health care provider 1 has a large cost advantage in c_i he would accept to converge to the other health care provider. Refering to the optimal value of q^* higher costs φ_0 will directly reduce the health care providers' incentive to increase vertical quality.

When we look at the parameter t we get:

$$\frac{da_1^*}{dt} = \frac{2 \cdot (a_1 - a_2) \cdot (2c_2\varphi_1 - c_1\varphi_2 + \bar{p} \cdot (-2\varphi_1 + \varphi_2))}{t \cdot (-4c_2\varphi_1 + \bar{p} \cdot (4\varphi_1 - \varphi_2) + c_1\varphi_2)} \tag{3.24}$$

For the denominator the impact of the assumption concerning quality cost will be helpful, too. The numerator will be negative for the range $\frac{\varphi_2}{4} < \varphi_1 < \frac{\varphi_2}{2}$. Hence, the result could be $\frac{da_1^*}{dt} > 0$. The more φ_1 converges to φ_2 the more probable the expected result $\frac{da_1^*}{dt} < 0$ gets. An increase in opportunity costs t will regularly incite health care provider 1 to reduce his horizontal quality, i.e. to increase the differentiation. Only if health care provider 1 has an advantage in the costs for vertical quality $\varphi_1 < \varphi_2$ it could be optimal to expand horizontal quality and reduce differentiation.

3.2.2 Standardization and the Impact on Competition

Up to now we have discussed the case where both health care providers could differentiate horizontal and vertical quality. Now we introduce the idea of a standard for vertical quality. We assume that both health care providers are not able to

anticipate this step by the regulator. They are not able to form expectations about the timing, process or nature of the actual regulation and are therefore not able to choose their competition parameters strategically. This is not entirely implausible as things can change quickly in health care systems. For the purpose of this model we assume that the regulator chooses the highest observable level of vertical quality as standard.

The regulator perfectly sees the level of q_1^* and q_2^* and chooses the health care provider with the higher quality. As the UK, Germany and Switzerland require their independent health care providers to document their quality levels, the assumption of an informed regulator is plausible. In the following we assume that health care provider 1 has a higher q_k than health care provider 2.[21] In addition, we assume that health care provider 1 has lower costs φ_1 than health care provider 2. As a consequence of regulation, health care provider 2 has to accept the level $q_1^* \equiv q_2$ and provide a sub-optimal level of quality from his point of view.

The position of the indifferent patient changes to $h_{Standard}$:

$$h_{Standard} = \frac{a_1 - a_2}{2} \tag{3.25}$$

Both health care providers choose the levels of a_1 and a_2 within the model. The new profit function for the standard leader can be written as:

$$\Pi_1 = (\bar{p} - c_1) \cdot \frac{a_1 + a_2}{2} - \left(\varphi_1 \cdot \frac{q_1^{*2}}{2} \right) - C_1^F \tag{3.26}$$

Considering the first order condition the following holds:

$$\frac{\partial \Pi_1}{\partial a_1} = \frac{1}{2} \cdot (\bar{p} - c_1) - \varphi_1 \cdot q_1^* \cdot \frac{dq_1^*}{da_1} \tag{3.27}$$

3.2.3 Impact of Regulation on Health Care Provider 1

For the discussion of the effects on the optimal horizontal quality a_1^* we apply the total differentiation of the first order condition and insert the marginal effects from the second stage. With other words, we assume the optimal level of vertical quality for the quality leader and then look on standardization. As a fist step we analyze the impact of a_2 on a_1:

$$\frac{da_{1Stand}^*}{d\,a_2} = -\frac{\frac{3 \cdot (\bar{p} - c_1)^2}{4t^2 \cdot (a_1 - a_2) 4\varphi_1}}{-\frac{3 \cdot (\bar{p} - c_1)^2}{4t^2 \cdot (a_1 - a_2) 4\varphi_1}} = 1 \tag{3.28}$$

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[21]We do not analyze the welfare maximizing level of q_k.

The result holds for every level of c_1 and φ_1. The quality leader has an incentive to reduce the differentiation, provider 1 increases his horizontal quality.

For the impact of c_1 on a_1 the following holds:

$$\frac{da^*_{1Stand}}{dc_1} = -\frac{2 \cdot (a_1 - a_2) \cdot (\bar{p} - c_1 + t^2(a_1 - a_2)^3 \varphi_1)}{3 \cdot (\bar{p} - c_1)^2} \tag{3.29}$$

For $\bar{p} < c_1 - t^2 \cdot (a_1 - a_2)^3 \varphi_1$ the third term of the numerator is negative, as the second term is negative per definition we can conclude that $\frac{da^*_1}{dc_1} < 0$. Consequently, a relatively small renumeration reduces the quality leader's incentive to attract more patients through an increase in horizontal quality. In this case an increase in costs induces the quality leader to increase vertical differentiation in order to drive away patients, reduce costs and increase profits.

For $\bar{p} > c_1 + t^2 \cdot (a_1 - a_2)^3 \varphi_1$ a positive impact of c_1 on a_1 increases the incentive to expand the horizontal quality ($\frac{da^*_1}{dc_1} < 0$). If the profit margin is high enough, higher costs for basic quality provision encourage greater homogeneity from the standard leader's point of view.

Considering the parameter φ_i we get:

$$\frac{da^*_{1Stand}}{d\varphi_1} = \frac{a_1 - a_2}{3\varphi_1} < 0 \tag{3.30}$$

The expression will always be negative if the basic assumption $a_1 - a_2 < 0$ is still valid. A higher cost for the provision of vertical quality reduces the incentive to diminish horizontal differentiation.[22]

For the parameter t we get:

$$\frac{da^*_{1Stand}}{dt} = -\frac{2 \cdot (a_1 - a_2)}{3t} > 0 \tag{3.31}$$

The expression will be always positive, if the basic assumptions are still valid. Higher travelling or quality mismatch costs reduce the standard leader's incentive to differentiate horizontally.

3.2.4 Impact of Regulation on Health Care Provider 2

The next equations show the impact of vertical quality regulation on health care provider 2's decision for horizontal quality. He cannot implement his own optimal

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[22]The following only holds as long as $\varphi_1 \leq \varphi_2$.

vertical quality and therefore we want to elaborate $\tilde{a}_2$ when $\tilde{q}_2$ holds. A change in horizontal quality a_1 has the following consequence for the standard follower:

$$\frac{d\tilde{a}_{2Stand}}{d\,a_{1Stand}} = -\frac{\frac{3\cdot(\bar{p}-c_1)2\varphi_2}{4t^2\cdot(a_1-a_2)4\varphi_1^2}}{-\frac{3\cdot(\bar{p}-c_1)2\varphi_2}{4t^2\cdot(a_1-a_2)4\varphi_1^2}} = 1 \tag{3.32}$$

The relationship between an alteration in a_2 is mathematically identical to the one scrutinized before. But we have to keep in mind that the original values for a_1 and a_2 are fundamentally different. In particular, in the non-standardized case a_1 approached zero while a_2 approached one. An increase in the level of a_1 consequently diminishes horizontal differentiation while an increase in the level of a_2 increases it. This leads to the following interpretation of the above equation. In contrast to the quality leader the follower has no incentive to reduce horizontal quality variation, instead, he will try to keep the distance constant by increasing his own horizontal quality when a_1 increases.

Due to regulated vertical quality, competition can only take place through a choice of locations or differences in the scope of treatments. For the standard follower there is c. p. a high incentive to hold the distance in horizontal quality. For the standard leader the opposite is true.

For the production costs c_2 we get:

$$\frac{d\tilde{a}_{2Stand}}{dc_2} = \frac{2t^2(a_1-a_2)4\varphi_1^2}{3\cdot(\bar{p}-c_1)^2\varphi_2} \tag{3.33}$$

The sign is definitely negative as long as the basic assumption $a_1 - a_2 < 0$ holds. The impact of c_2 on a_2^* is unambiguous. As we assumed, the standard follower has to bear higher vertical quality costs φ_2. If there is a rise in the cost for basic health services c_2, the follower has an incentive to reduce the distance to the standard follower.

For a change in φ_2 the following is valid:

$$\frac{d\tilde{a}_{2Stand}}{d\varphi_2} = \frac{-a_1+a_2}{3\varphi_2} \tag{3.34}$$

The sign of the numerator is positive due to the basic assumption $(a_1 < a_2)$.

Higher costs for producing vertical quality additionally diminish health care provider 2's profits, and therefore his incentive to attract patients. Instead of increasing the level of competition, he chooses a greater horizontal differentiation from the quality leader to reach the point where his marginal quality costs equal marginal returns.

When we look at t we get:

$$\frac{d\tilde{a}_{2Stand}}{dt} = \frac{2(a_1 - a_2)}{3t} \tag{3.35}$$

The impact seems to be clear. The numerator is definitely negative, whereas the denominator is always positive. A higher cost parameter t also encourages the standard follower to reduce his horizontal quality.

4   Conclusion and Outlook

We use an extension of a Hotelling-model to analyse the impact of a standardization on horizontal and vertical quality in a regional health care market. In the reference case both health care providers compete in horizontal and vertical quality. Our reference case tells us that the choice of horizontal quality a_i will be made conditionally on optimal vertical quality q_K of the competitor. The success of competing in vertical quality is directly dependent on the comparison of the cost parameters φ_i of both competitors. As sequential profit maximization demands that optimal vertical quality is chosen after horizontal quality is set, an exact determination of the absolute height of the chosen vertical quality is impossible.

In the standardization case, all results hold for the standard leader. But, the standard follower loses control over horizontal and vertical quality as these become dependent on the choices of the standard leader in the horizontal quality case and on the regulator observing the quality leader in the vertical quality case. This leads to a non-optimal level of vertical quality for the standard follower. The follower is either driven out of the market, because he is not able to offer the standard quality as the cost of doing so are prohibitively high for him or he has to accept the quality chosen by the standard leader and make do with probably sub-optimal profits.

Our results are directly related to the assumptions we make for the regional health care market. Especially, we focus on a restricted area of horizontal quality both health care providers are free to choose. For further research it would be interesting to widen our approach by incorporating a more detailed discussion on the scope and level of standardization. Moreover, it could be beneficial to widen the analysis to the demand side where we can discuss some impacts of managed care within a regional health care market.

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A   Appendix

A.1   Vertical Quality

The second health care provider has to optimize the following profit function:

$$\Pi_2 = (\bar{p} - c_2) \cdot \left(1 - \left(\frac{q_2 - q_1}{2t(a_1 - a_2)} + \bar{a}\right)\right) - \left(\varphi_2 \cdot \frac{q_2^2}{2}\right) - C_F \tag{A.1}$$

The first order condition for the profit maximizing quality q_2 is:

$$\frac{\partial \Pi_2}{\partial q_2} = -\frac{\bar{p} - c_2}{2t(a_1 - a_2)} - q_1 \cdot \varphi_2 = 0 \tag{A.2}$$

The optimal level of q_2^* is:

$$q_2^* = \frac{-\bar{p} + c_2}{2t(a_1 - a_2)\varphi_2} \tag{A.3}$$

Using comparative statics we get:

$$\frac{dq_2^*}{da_2} = -\frac{\bar{p} - c_2}{2t(a_1 - a_2)^2 \cdot \varphi_2} \Rightarrow \begin{cases} < 0, if & \bar{p} \geq c_2 \\ > 0, \ if & \bar{p} < c_2 \end{cases} \tag{A.4}$$

$$\frac{dq_2^*}{da_1} = \frac{\bar{p} - c_2}{2t(a_1 - a_2)^2 \cdot \varphi_1} \Rightarrow \begin{cases} > 0, if & \bar{p} \geq c_2 \\ < 0, \ if & \bar{p} < c_2 \end{cases} \tag{A.5}$$

$$\frac{dq_2^*}{dt} = \frac{\bar{p} - c_2}{2t^2 \cdot (a_1 - a_2) \cdot \varphi_2} \Rightarrow \begin{cases} < 0, if & \bar{p} \geq c_2 \text{ and } a_1 < a_2 \\ > 0, if & \bar{p} < c_2 \text{ and } a_1 < a_2 \end{cases} \tag{A.6}$$

$$\frac{dq_2^*}{d\bar{p}} = -\frac{1}{2t(a_1 - a_2) \cdot \varphi_2} > 0 \text{ if } a_1 < a_2 \tag{A.7}$$

$$\frac{dq_2^*}{dc_2} = \frac{1}{2t(a_1 - a_2) \cdot \varphi_2} < 0 \tag{A.8}$$

$$\frac{dq_2^*}{d\varphi_2} = -\frac{q_2}{\varphi_1} < 0 \tag{A.9}$$

A.2 Horizontal Quality

For the optimal horizontal quality we insert the optimal values q_1^* and q_2 into the profit function (3.14) und compute in an explicit manner. Because we are looking at a corner solution we get:

$$\frac{\partial \Pi_1}{\partial a_1} = \frac{(-\bar{p} + c_1)^2}{4t^2 \varphi_1 \cdot (a_1 - a_2)^3} + (\bar{p} - c_1) \cdot$$
$$\left(\frac{1}{2} + \frac{\frac{-\bar{p}+c_1}{2t\varphi_1(a_1-a_2)^2} - \frac{-\bar{p}+c_2}{2t\varphi_1(a_1-a_2)^2}}{2t(a_1-a_2)} - \frac{-\frac{-\bar{p}+c_1}{2t\varphi_1(a_1-a_2)} + \frac{-\bar{p}+c_2}{2t\varphi_1(a_1-a_2)}}{2t(a_1-a_2)^2} \right) \tag{A.10}$$

The whole expression will be negative the less the second addend can compensate the negative impact of the first addend. If there is no difference in vertical quality the second addend will be zero. Hence, the whole expression gets negative. Considering the second derivation we get:

$$\frac{\partial^2 \Pi_1}{\partial a_1^2} = -\frac{3(-\bar{p} + c_1)^2}{4t^2 \varphi_1 \cdot (a_1 - a_2)^4} + (\bar{p} - c_1) \cdot$$
$$\left(\frac{-\frac{-\bar{p}+c_1}{2t\varphi_1(a_1-a_2)^3} + \frac{-\bar{p}+c_2}{2t\varphi_1(a_1-a_2)^3}}{2t(a_1-a_2)} - \frac{\frac{-\bar{p}+c_1}{2t\varphi_1(a_1-a_2)^2} - \frac{-\bar{p}+c_2}{2t\varphi_1(a_1-a_2)^2}}{t \cdot (a_1-a_2)^2} + \frac{-\frac{-\bar{p}+c_1}{2t\varphi_1 \cdot (a_1-a_2)} + \frac{-\bar{p}+c_2}{2t\varphi_1 \cdot (a_1-a_2)}}{t(a_1-a_2)^3} \right) \tag{A.11}$$

As the first addend will be always negative and the expression within the brackets encompasses positive as well as negative parts we can assume that the whole formula gets negative considering the assumption done in the first derivative. The result for the optimal choice of a_1 given a_2 can be computed by inserting the optimal values q_1^* and q_2^* into the profit function (3.14) (cf. (A.10)):

$$a_1^* = a_2 + \frac{(-2t^4 \bar{p} \varphi_1^3 \varphi_2^2 + 2t^4 c_2 \varphi_1^3 \varphi_2^2 + t^4 \bar{p} \varphi_1^2 \varphi_2^3 - t^4 c_1 \varphi_1^2 \varphi_2^3)^{\frac{1}{3}}}{2^{\frac{1}{3}} t^2 \varphi_1 \varphi_2} \tag{A.12}$$

As we can see from (A.12) the optimal level of a_1^* depends on a_2, the other provider's horizontal quality. We are looking at a reaction function $a_1(a_2)$. The corresponding reaction function for health care provider 2 is:

$$a_2^* = a_1 + \frac{(-t^4 \bar{p}^2 \varphi_1^3 \varphi_2^2 + 2t^4 \bar{p} c_2 \varphi_1^3 \varphi_2^2 - t^4 c_2^2 \varphi_1^3 \varphi_2^2 + 2t_4 \bar{p}^2 \varphi_1^2 \varphi_2^3}{2^{\frac{2}{3}} t^2 \varphi_1 \varphi_2}$$
$$\frac{-2t^4 \bar{p} c_1 \varphi_1^2 \varphi_2^3 - 2t^4 \bar{p} c_2 \varphi_1^2 \varphi_2^3 + 2t^4 c_1 c_2 \varphi_1^2 \varphi_2^3)^{\frac{1}{3}}}{2^{\frac{2}{3}} t^2 \varphi_1 \varphi_2} \tag{A.13}$$

For the second provider holds:

$$\frac{\partial \Pi_2}{\partial a_2} = -\frac{(-\bar{p} + c_2)^2}{4t^2 \varphi_1 \cdot (a_1 - a_2)^3} + (\bar{p} - c_2) \cdot$$

$$\left(-\frac{\frac{-\bar{p}+c_1}{2t\varphi_2(a_1-a_2)^2} + \frac{-\bar{p}+c_2}{2t\varphi_2(a_1-a_2)^2}}{2t(a_1 - a_2)} - \frac{-\frac{-\bar{p}+c_1}{2t\varphi_2(a_1-a_2)} + \frac{-\bar{p}+c_2}{2t\varphi_2(a_1-a_2)}}{2t(a_1 - a_2)^2} \right)$$

Referring to the result for the first health care provider we can assume that the first derivation will be positive. Using some mathematics we can compute one solution for a_1^* [23]:

$$a_1^* = a_2 + \frac{(-t^4 \varphi^2 \bar{p} - t^4 \varphi^2 c_1 + 2t^4 \varphi^2 c_2)^{\frac{1}{3}}}{2^{\frac{1}{3}} t^2 \varphi} \tag{A.14}$$

A.3   The Reference Case: Provider 2

For the impact of a_1 on a_2^* holds:

$$\frac{da_2^*}{da_1} = -\frac{-\frac{3 \cdot (\bar{p}-c_2)(-c_2\varphi_1 + \bar{p}(\varphi_1 - 2\varphi_2) + 2c_1\varphi_2)}{4t^2(a_1-a_2)^4 \varphi_1 \varphi_2}}{\frac{3 \cdot (\bar{p}-c_2)(-c_2\varphi_1 + \bar{p}(\varphi_1 - 2\varphi_2) + 2c_1\varphi_2)}{4t^2(a_1-a_2)^4 \varphi_1 \varphi_2}} = 1 \tag{A.15}$$

As we can see a variation of the level of $a1$ will be perfectly equalized by a change in the optimal level of a_2^*.

$$\frac{da_2^*}{d\bar{p}} = \frac{-(2(a_1 - a_2) \cdot (\bar{p}(\varphi_1 - 2\varphi_2) + (c_1 - t^2 \cdot (a_1 - a_2)^3 \varphi_1)\varphi_2 + c_2(-\varphi_1 + \varphi_2)))}{(3(\bar{p} - c_2) \cdot (-c_2\varphi_1 + \bar{p}(\varphi_1 - 2\varphi_2) + 2c_1\varphi_2))} \tag{A.16}$$

The impact of the regulated price $\bar{p}$ depends on the value of c_i and φ:

- If $c_1 = c_2$ an increase in $\bar{p}$ will expand the horizontal differentiation if $\varphi_1 > 2\varphi_2$. For $\varphi_2 > \frac{1}{2}\varphi_1$ an increase could probably reduce the incentive for more horizontal differentiation.

- If $\varphi_1 = \varphi_2$ and given a low starting level of $\bar{p}$ an increase in $\bar{p}$ would incite Health Provider 2 to reduce horizontal differentiation. Only for high levels of $\bar{p}$ the incentive could be reverse.

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[23]There exist two other values which encompasses complex numbers.

- If all cost parameters are different no definite result can be inferred.

$$\frac{da_2^*}{dc_2} = -\frac{2 \cdot (a_1 - a_2) \cdot (c_2\varphi_1 - (c_1 - t^2(a_1 - a_2)^3\varphi_2)\varphi_2 + \bar{p}(-\varphi_1 + \varphi_2))}{3 \cdot (\bar{p} - c_2) \cdot)(-c_2\varphi_1 + \bar{p} \cdot (\varphi_1 - 2\varphi_2) + 2c_1\varphi_2)} \quad \text{(A.17)}$$

- If $\varphi_1 = \varphi_2$ holds and the starting level of $\bar{p}$ is low an increase in costs c_2 will induce the Health Care Provider 2 to reduce horizontal differentiation. Only with a high starting level the opposite case can be true.

- If the costs parameters are different no direct result can be inferred.

$$\frac{da_2^*}{d\varphi_2} = \frac{(a_1 - a_2) \cdot (\bar{p} - c_2)\varphi_1}{3\varphi_2 \cdot (-c_2\varphi_1 + \bar{p}(\varphi_1 - 2\varphi_2) + 2c_1\varphi_2)} \quad \text{(A.18)}$$

As the numerator is always negative the sign of the fraction depends on the denominator. If $\bar{p} > \frac{c_2\varphi_1 - 2c_1\varphi_2}{\varphi_1 - 2\varphi_2}$ holds the denominator is positive and higher cost of producing vertical quality would result in smaller scope of horizontal differentiation. The lower the regulated price is the more the Health Care Provider would substitute higher costs for vertical quality with an expansion of horizontal quality.

$$\frac{da_2^*}{dt} = \frac{2 \cdot (a_1 - a_2)}{3t} \quad \text{(A.19)}$$

The is result is unambiguous. The more the patient face higher opportunity costs the more the health care provider would reduce his difference to the competitor.

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