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Competition in the Market for Supplementary Health Insurance: The Case of Competing Nonprofit Sickness Funds

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Abstract

This paper examines the competition of nonprofit sickness funds in the market for supplementary health insurance. We investigate product quality strategies when quality is costly and the sickness funds are competing for customers. As long as the sickness funds choose the qualities for simultaneously, any equilibrium will be nondifferentiated. Only if total demand is increasing in quality, both sickness funds provide the maximum quality. For decreasing total demand the existence of an equilibrium depends on the consumers' sensitivity. If there is no equilibrium in the simultaneous competition, sequential quality competition leads to a differentiated equilibrium with a first mover advantage.

Keywords: supplementary health insurance, vertical differentiation, output maximization
JEL: I11, L22, L30

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1 Introduction

This study targets the research question of how the competition in the market for supplementary health insurance works when the products are provided by competing nonprofit sickness funds. The intention of our paper is to show the theoretical fundamentals for a fast-growing market. The answer to our research question is crucial for countries that have organized their health care system via competing nonprofit sickness funds like Germany, Japan, France, Switzerland or Romania. For instance, in Germany there are more than 200 sickness funds and people are allowed to switch between those sickness funds independent of their health care status, their income or their profession. Therefore the market is highly competitive. Due to the fact that the sickness funds are not allowed to make any profits the competition might be very different compared to the competition of profit maximizing firms. Analyzing the competition in the market for supplementary health insurance is the intention of our paper.

While the core business of nonprofit sickness funds is the provision of basic health care, the market for supplementary health insurance is getting more attention for two reasons. First, the market size of supplementary health insurance is increasing due to demographic change, epidemiologic transition and the rapid growth of medical technologies. The countries therefore face the challenge of rapidly increasing health care expenditures. One way to cope with this problem is rationing such that compulsory health insurance provides a basic coverage only. This of course makes supplementary health insurance more important.[1] Special kinds of products in the market for supplementary health insurance might be the access to the best physicians' network or to high cost technologies.

The second reason why the market for supplementary health insurance is getting more attention follows from the first reason and is only applicable if the market for basic health care coverage is organized via competing nonprofit sickness funds. If people are allowed to switch between the sickness funds, a sickness fund only gets new customers, if it provides products with a high quality-cost ratio. One way to enhance the quality-cost ratio is the provision of high quality supplementary health insurance. The market for supplementary health insurance therefore has a high cross-selling potential. To understand the second reason we need to explain the market for basic health care coverage a bit more detailed: In counties that have organized the basic health care coverage via competing nonprofit sickness funds we often have community rating insurers. Since these community rating insurers must charge a uniform premium from all individuals, one could argue that there is a high incentive to get the low risk people only.

[1] Already today some medical treatments are not covered by compulsory health insurance and the legal foundations of many countries states that compulsory health insurance has to provide a basic coverage only. For instance in Germany legislation directs that compulsory health care coverage must not exceed the necessary health care (§12 German Social Security Code). Either a medical area is completely excluded from basic coverage, such as alternative medicine or some dental health services, or the method of treatment covered by the compulsory health insurance is not the best possible. For instance, in Germany magnetic resonance imaging for diagnosing breast cancer is only covered by compulsory health insurance if a lump was discovered via mammography or breast ultrasound before. Medical research shows, that MRI can discover lumps at an earlier stage and is therefore the better medical treatment (Kuhl et al., 2005). Another example is the dual energy X-ray absorptiometry. It is not covered by compulsory health insurance if it is used as preventive medical examination.

But this argument is only valid, as long as there is no risk adjustment scheme that is sufficient to remove the cause of risk selection by closing the gap between expected cost and premium income. Since this problem is well known, governments have developed very comprehensive risk adjustment schemes. For instance, in Germany the risk adjustment scheme relies on age, gender and 80 costly diseases. It is therefore very difficult for a sickness fund to discriminate between good and bad risks. Hence, if the risk adjustment scheme is sufficient to close the gap a sickness fund is a priori indifferent between high and low risk people.

We now can return to the second reason and explain why the market for supplementary health insurance has a very high cross-selling potential. One reason is that the possibility of purchasing the supplementary health insurance can be conditional on being primary insured by the same sickness fund as well. Another reason is that the insured prefers to deal with only one sickness fund instead of two. Due to the fact that people buying those high quality services might switch to the same sickness fund for their primary health care we assume that the sickness funds are trying to sell as many supplementary health insurance policies as possible which means they are output maximizers.[2] The competition of output maximizing firms works very different compared to the competition of profit maximizing firms. In the market for supplementary health insurance the firms can provide products for the different needs of the consumers.[3] It is very well known that profit maximizing firms use product differentiation in order to relax price competition. But output maximizing firms do not fear price competition. In our study we therefore analyze whether product differentiation is a useful tool for output maximizing sickness funds as well.

To keep our model as simple as possible we assume that there are only two firms in the market. Of course, this is a simplification but it still captures a very important fact: We can model competition. These two competing sickness funds need to position themselves in a market segment for supplementary health insurance. This means that if a sickness fund wants to be a high quality provider it cannot provide a product that is below the quality of its competitor. To capture that point we assume that the firms provide only one quality. We further assume that the provision of high quality supplementary health insurance is costly. This assumption is very intuitive. Otherwise there would be no trade off between price and quality and the product could belong to the basic health care coverage as well. Due to our assumption that the provision of high quality supplementary health insurance is costly, there is a trade-off between price and quality, since the consumers receive a higher quality only at a higher price.[4] Depending on the consumers' sensitivity this trade-off determines whether an equilibrium exists or not.

[2]Assuming output maximization as the goal of nonprofit organizations is not uncommon. For instance, Xu & Birch (1999) show that almost two out of three nonprofit firms aim for output maximization facing a maximum loss constraint.

[3]For instance, the access to a physicians' network specialized on diabetes is very valuable to people suffering from diabetes while it is of no use to others.

[4]For instance, in Germany legislation directs that compulsory health care coverage must not exceed the necessary health care (§ 12 German Social Security Code). This means that every treatment that exceed the necessary health care must belong to supplementary health insurance. Furthermore, the German Social Security Code states that expenditures have to be compensated by earnings. Otherwise premiums have to be adjusted. Therefore, cross-subsidization is not allowed.

Our results are the following. As long as the sickness funds choose the qualities for their supplementary health insurance policies simultaneously, any equilibrium will be nondifferentiated. Only if total demand is increasing in quality, both sickness funds provide the maximum possible quality. For decreasing total demand the existence of an equilibrium depends on the consumers' sensitivity. If there is no equilibrium in the case of simultaneous quality choice, sequential quality competition leads to a differentiated equilibrium with a first mover advantage.

The rest of this article proceeds as follows. Section 2 gives a literature review. Section 3 introduces our model framework. Section 4 examines the reactions of the market participants. We focus on two different market settings. First, we derive market equilibria of our game in section 5. Then, section 6 looks at equilibria in a sequential setting. The concluding section, section 7, summarizes our main results and briefly discusses future research.

2 Literature review

This section gives a literature review and states the main distinctions to our article. Related literature can be found in different directions. As a starting point we have a look at standard vertical differentiation models and models that focus on nonprofit firms. After that we review models that focus on supplementary health insurance. Differentiation by quality was first analyzed by Gabszewicz & Thisse (1979), Shaked & Sutton (1982) and Tirole (1988) for profit maximizing firms. They show that differentiation takes place in order to relax price competition even if quality improvement is costless. If quality improvement turns out to be costly, differentiation is still a valuable tool for profit maximizing firms (Ronnen, 1991; Motta, 1993; Boom, 1995; Aoki & Prusa, 1997; Lehmann-Grube, 1997, among others). But if profit maximization is not the goal of a company as in our analysis, there is no reason to fear price competition. Therefore the results of our analysis are different.[5]

Related literature concerning the competition of nonprofit firms can be found in the hospital market, since there we observe heterogeneous products and nonprofit firms as well. Research was done on horizontal product differentiation (Cremer et al., 1991; Matsushima & Matsumura, 2003; Matsumura & Matsushima, 2004; Sanjo, 2009) as well as vertical product differentiation (Grilo, 1994; Herr, 2011; Beitia, 2003; Brekke et al., 2010). But those papers are only helpful as guidance, since hospitals are not solely competing for costumers.[6] There are also interesting papers dealing with supplementary health insurance. For instance, Kifmann (2002) presents a model of a competitive health insurance market with two risk types and two exogenously given health benefits where individuals have to buy a basic benefit package from a community rating insurer. The aim of his paper is to show the incentive of cream skimming.[7] Due to the

[5]While it is intuitive that output maximizing sickness funds will not differentiate in quality if a quality improvement is costless, it is not obvious if sickness funds can use quality differentiation as a strategic tool in order to gain customers if quality improvement is costly.

[6]Studies dealing with hospital competition often assume a mixed duopoly competition where one hospital maximizes its profits while the other hospital maximizes either social surplus (Matsushima & Matsumura, 2003; Cremer et al., 1991; De Fraja & Delbono, 1989; Grilo, 1994) or its output facing a budget constraint (Newhouse, 1970; Merrill & Schneider, 1966, among others).

[7]In 2006, Kifmann compares the integration approach to the separation approach in the market for supple-

fact that community rating insurers must charge a uniform premium for all individuals there is a high incentive to get the low risk people only.[8] One way to avoid cream skimming is to regulate the benefit package such that community rating insurers are not allowed to provide any additional benefits. Therefore, in a benchmark situation, Kifmann assumes that community rating insurers offer the basic benefit only and risk rating insurers provide supplementary health insurance. It is shown that low risk types can only be better off at the expense of high risk types if community rating insurers are allowed to offer the additional benefit and no additional regulations are taken. Both risk types can only be made better off at the same time if community rating health insurers offering the additional benefit are subsidized while those selling only the basic benefit are taxed. A closely related paper that is concerned with asymmetric information has been written by Hansen & Keiding (2002). Even though the question is similar to the question of Kifmann (2002) the conclusion of this paper is very different. They conclude that the compulsory scheme with voluntary supplementation is likely to be welfare superior to the pure compulsory scheme. These contradictory findings are possible because the two papers differ in their basic assumptions. For a thorough comparison see Danzon (2002).

Kifmann (2002) and Hansen & Keiding (2002) concentrate on cream skimming due to asymmetric information. Focussing on cream skimming is reasonable if the health insurance companies must charge a uniform premium for all individuals and risk adjustment schemes are not sufficient to remove the cause of risk-selection by closing the gap between expected costs and premium income. Our focus is different. We concentrate on a homogeneous group with a high preference for quality. In our special case, concentration on a homogeneous group is reasonable for two reasons. First, risk adjustment schemes are getting more sophisticated, making it very difficult for the firms to discriminate between good and bad risks.[9] Second, people with a high preference for costly supplementary health insurance are most likely those people who might need a treatment.[10] Pauly (2004) reviews the concept of optimal quality in medical care from an economic viewpoint. This paper coincides with our assumption that there might be a trade-off between price and quality and that people have different needs.[11] In our study we continue to analyze this trade-off. Since this trade-off is solely between price and quality we will not allow for the possibility of horizontal differentiation. A model that is concerned about horizontal differentiation of market share maximizing nonprofit firms has been

mentary health insurance in order to show the incentives to cream skimming (Kifmann, 2006). It is shown that under the integration approach insurers cream skim by selling supplementary health insurance to low risks at a discount. The integration approach still can be Pareto-superior if the cost savings due to the integration of basic and supplementary health insurance are sufficiently large.

[8]Kifmann (2006) assumes that there is no sufficient risk adjustment scheme.

[9]If the risk adjustment schemes are sufficient to remove the cause of risk-selection by closing the gap between expected costs and premium income the sickness funds are a priori indifferent between high and low risk people. Hence, even though high quality supplementary health insurance might attract high risk people only, this does not mean that those high risk people are not attractive for the sickness funds for the basic health care coverage.

[10]Self-selection leads to a homogeneous group. Then a difference in preferences can be interpreted as a difference in income (Tirole, 1988).

[11]Pauly (2004) gives the example that the best hospital in town does not have to be the cheapest or vice versa and he claims that it is certain that the optimal level of quality, given quantity, will be different for different people, depending on the value they attach to quality.

written by Gannon (1973).[12] He shows that in a duopolistic market the nonprofit firms always choose the geographical center independent of the consumers' individual demand. So market share maximizing firms do not differentiate themselves in taste.[13]

3 Model

Our model framework builds on the following basic assumptions. Two output maximizing non-profit sickness funds are competing in a duopolistic market for supplementary health insurance. At the first stage of the game the sickness funds choose their respective quality S_1 and S_2 either simultaneously or in sequential order. With common knowledge about the chosen qualities the sickness funds choose their prices P_1 and P_2 simultaneously at the second stage of the game under the constraint of nonnegative profits. This constraint means that the firms run a self-financing business in this market.[14] The interval $[\underline{S}, \overline{S}]$, with $\underline{S} = 0$, gives the possible qualities the sickness funds can choose for their products.[15] If the two sickness funds provide the same quality at the same price, the total demand is split between the two firms in equal parts. Since the main part of the product costs in the market for supplementary health insurance accrues at the moment of purchase by consumers, we focus on variable costs of quality improvement.[16] The unit costs for supplementary health insurance with quality S are therefore independent of output and described by the twice continuously differentiable function C with $C'(S) > 0$ for all $S > \underline{S}$. The cost function is exogenous and identical for both sickness funds.

The consumers are described via their valuation of quality $\theta \in [\underline{\theta}, \overline{\theta}]$, with $\underline{\theta} = 0$. The net utility of a consumer with preference θ from buying a supplementary health insurance with quality S at a price $P \geq C(S)$ is given by the Mussa-Rosen utility function $u_\theta(S, P) = \theta \cdot S - P$ (Mussa & Rosen, 1978). Consumers maximize their individual utility and buy at most one supplementary health insurance.[17] Only if the utility is nonnegative the consumer buys the product, meaning we might face an uncovered market. If he is indifferent between two products he buys the one with the higher quality. The marginal consumer who has utility zero from buying supplementary health insurance with quality S at price P is given by

$$\theta_0(S, P) = \frac{P}{S}. \tag{1}$$

[12]First research in this field stems from Devletoglou & Demetriou (1967). Following Devletoglou (1965) they assumed that there exists a threshold for the consumers reaction.

[13]For profit maximizing firms this only holds in a very special case (Hotelling, 1929).

[14]For instance, in Germany the Social Security Code prohibits cross-subsidization.

[15]The term product is to be seen in a broad sense. It especially includes all kinds of services. E.g. one firm provides access to a small physicians' network while the competitor provides access to a large physicians network with lots of specialist doctors.

[16]In the health market there are obviously high fixed costs due to R & D, but the sickness fund only has to pay for each application. For instance, if supplementary health insurance includes the access to high cost technologies, the sickness fund pays a given price for each high quality treatment. A higher quality therefore leads to a higher price.

[17]Of course, consumers can buy more than one supplementary health insurance for different segments. Buying more than one supplementary health insurance for the same segment obviously does not make any sense and the competition has to be analyzed for each segment individually.

The consumer with preference θ_{ind}, who is indifferent between the two products, is determined by solving $u_{\theta_{ind}}(S_1, P_1) = u_{\theta_{ind}}(S_2, P_2)$. This leads to

$$\theta_{ind}(S_1, S_2, P_1, P_2) = \frac{P_2 - P_1}{S_2 - S_1}. \tag{2}$$

Let D_1 denote the demand for the supplementary health insurance provided by sickness fund 1 and D_2 the demand of sickness fund 2. Then the maximization problem is given by

$$\begin{array}{lcl} D_1 \overset{S_1,P_1}{\longrightarrow} \max & \multirow{2}{*}{$s.t.$} & P_1 \geq C(S_1), \\ D_2 \overset{S_2,P_2}{\longrightarrow} \max & & P_2 \geq C(S_2). \end{array} \tag{3}$$

Total demand is $TD = D_1 + D_2$.

4 The sickness funds' reactions

We solve the game via backward induction. On the second stage the sickness funds simultaneously choose their prices for given and known qualities of their supplementary health insurance products in order to maximize their respective output. If the sickness funds choose the same quality $S = S_1 = S_2$, the only stable price equilibrium will be at $P = C(S)$, otherwise the sickness funds have the incentive to underbid each other. So we only have to focus on the situation $S_1 \neq S_2$ and without loss of generality we assume $S_1 > S_2$ from which follows $P_1 > P_2$. We then have

$$D_1 = \overline{\theta} - \theta_{ind}(S_1, S_2, P_1, P_2) \tag{4}$$

$$D_2 = \theta_{ind}(S_1, S_2, P_1, P_2) - \theta_0(S_2, P_2), \tag{5}$$

as long as $0 \leq \theta_0 \leq \theta_{ind} \leq \overline{\theta}$ holds. In this case total demand is $TD(S_2, P_2) = \overline{\theta} - \theta_0(S_2, P_2)$. As one can easily see, the demand is decreasing if the firm increases its price. So in this case we also have $P_i = C(S_i)$ for $i = 1, 2$. Hence, as the solution of the second stage game we always have price equal to the unit costs. This result is very intuitive, since the sickness funds try to sell as many supplementary health insurance policies as possible and a higher price c.p. decreases the consumer's utility. In order to simplify notation we suppress prices as arguments from now on.

On the first stage the sickness funds choose their qualities for their supplementary health insurance products. To choose their qualities optimally the firms need to know how the consumers react on changes in quality. Note that total demand is now $TD(S_2) = TD(S_2, C(S_2)) = \overline{\theta} - \frac{C(S_2)}{S_2}$. Depending on the slope of the cost function, total demand is either increasing or decreasing in quality.[18]

[18]If the cost function C is strictly convex, the price for supplementary health insurance increases disproportionately high when quality is increased. Thus, less people are willing to buy supplementary health insurance an total demand is strictly decreasing.

Proposition 1. *If total demand is increasing in quality, there exists a unique subgame perfect Nash equilibrium in pure strategies with no quality differentiation. Both sickness funds provide supplementary health insurance with the highest quality.*

Proof. Since the total demand $TD = \overline{\theta} - \theta_0$ is increasing in quality, we have $\frac{d\theta_0(S)}{dS} \leq 0$. Thus an increase in quality leads to more consumers buying the product as long as $\theta_0(S) \leq \overline{\theta}$. So no consumers buy the low quality product, which is why both firms provide a product with the maximal possible quality $\overline{S}$. □

As we can see in Proposition 1 both firms have an incentive to provide the maximal quality, if total demand is increasing in quality. Let us now consider a strictly decreasing total demand. We assume $TD(\underline{S}) = \overline{\theta}$ and $TD(\overline{S}) = 0$.[19] Analogously to the proof of Proposition 1 we now have $\frac{d\theta_0(S)}{dS} > 0$, such that a quality improvement leads to less consumers buying the product due to the disproportional high increase of the price.

To derive the optimal strategies, the sickness funds need further information about the consumers' reaction on variations of the quality. Not only the direction of the consumers' reaction is important, i.e. decreasing total demand, but also consumers' sensitivity measured by θ_0'. The relationship between total demand and consumers' sensitivity is shown in figure 1. The figure shows the slope of two different cost functions. From the linear price-demand function

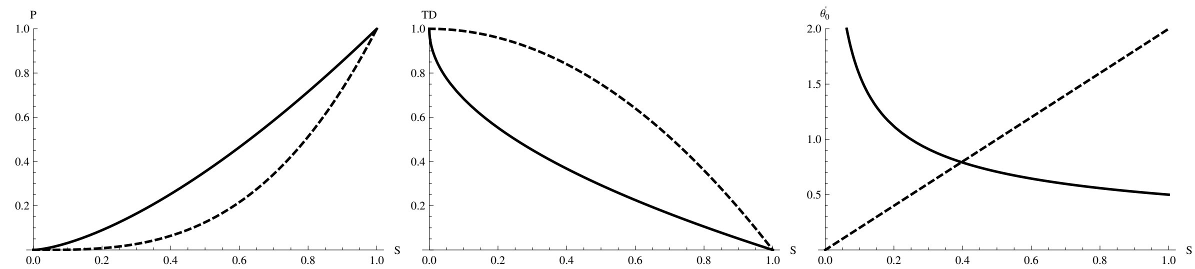

Figure 1: Price-quality function (left), demand-quality function (center) and consumers' sensitivity (right). $C(S) = S^\alpha$ with $\alpha = 1.5$ (solid) and $\alpha = 3$ (dashed).

and the slope of the cost function the demand-quality function can be directly calculated due to the results from the second stage price competition. From this we further see that consumers' sensitivity can be either increasing or decreasing in quality.

To analyze the strategies of the firms we now show how sickness fund 2 can react to the quality S_1 chosen by sickness fund 1. Basically sickness fund 2 has three options to react. It can either choose to provide supplementary health insurance with a higher quality ($S_2 > S_1$) which we will call "overbidding", choose the same quality ($S_2 = S_1$) which we will call "equalizing" or choose a lower quality ($S_2 < S_1$) which we will call "underbidding". The resulting demand

[19]The latter equality is intuitive, since even if a higher quality was possible, there would be no consumers willing to buy the product. The former equality is for ease of calculation. Although we have $\underline{S} = 0$, according to l'Hospital's rule the equality $TD(\underline{S}) = \overline{\theta}$ holds, as long as we also have $C(\underline{S}) = 0$ and $C'(S) \to 0$ for $S \to \underline{S}$.

of sickness fund 2 is given by

$$D_2(S_1,S_2)=\begin{cases}\overline{\theta}-\min\left(\overline{\theta},\ \theta_{ind}(S_1,S_2)\right), & S_1<S_2\\ \frac{\overline{\theta}-\theta_0(S_2)}{2}, & S_1=S_2\\ \min\left(\overline{\theta},\ \theta_{ind}(S_1,S_2)\right)-\theta_0(S_2), & S_1>S_2.\end{cases} \tag{6}$$

Obviously, if sickness fund 2 equalizes, the two firms share the market equally according to the assumption on the consumers' behavior. So now we need to take a closer look at the strategies "overbidding" and "underbidding".

Overbidding

If sickness fund 1 chooses the quality S_1 for its supplementary health insurance, sickness fund 2 can overbid with every quality $S_2 \in (S_1, \overline{S}]$. In this case it is not possible to derive an optimal overbidding strategy. For every $S_2 > S_1$ there exists $\tilde{S}_2 \in (S_1, S_2)$ with $D_2(S_1, \tilde{S}_2) > D_2(S_1, S_2)$.[20] Thus, the closer the overbidding quality is to S_1 the higher is the output of sickness fund 2. The limiting overbidding strategy leads to $\lim_{S_2 \searrow S_1} \theta_{ind}(S_1, S_2) = C'(S_1)$. We will denote this limiting strategy by S_1+ and call it "marginal overbidding".[21] This strategy is only reasonable, as long as $C'(S_1) < \overline{\theta}$, otherwise there will be no demand for the supplementary health insurance of the overbidding sickness fund.

Underbidding

If sickness fund 1 chooses to provide supplementary health insurance with quality S_1, sickness fund 2 can underbid with every quality S_2 from the set $[\underline{S}, S_1)$. The first order condition $\frac{\partial D_2(S_1,S_2)}{\partial S_2} = 0$ again does not need to have an interior solution on $(\underline{S}, S_1)$. Then either underbidding with $S_2 = \underline{S}$ is optimal, which we call minimal underbidding, or underbidding with a slightly lower quality than S_1 is the best underbidding strategy. Analogously to the case of overbidding this will be called "marginal underbidding", denoted by S_1-.[22] In general we define the optimal underbidding quality by

$$r_u(S_1) := \arg\max_{S_2<S_1} D_2(S_1, S_2).$$

We always have $\theta_{ind}(S_1, r_u(S_1)) \leq \overline{\theta}$, because for S_2 with $\theta_{ind}(S_1, S_2) > \overline{\theta}$ it is

$$D_2(S_1, S_2) = \overline{\theta} - \theta_0(S_2),$$

[20] In the case of decreasing total demand for $\tilde{S}_2 \in (S_1, S_2)$ we have $\theta_{ind}(S_1, \tilde{S}_2) < \theta_{ind}(S_1, S_2)$.

[21] Technically no $S_2 \in (S_1, \overline{S}]$ satisfies the first order condition $\frac{\partial D_2(S_1,S_2)}{\partial S_2} = 0$. If the overbidding quality had to be chosen from $[S_1 + \delta, \overline{S}]$ for $\delta > 0$, $S_2 = S_1 + \delta$ would be the optimal overbidding strategy. δ can be interpreted as a threshold required for quality differentiation being recognized by the consumers. For sufficiently small δ the results remain valid while the formulas would become more complicated and less intuitive. In the further analysis we therefore assume that the overbidding firm will choose marginal overbidding.

[22] Again an optimal underbidding strategy technically does not exist in this case, but we adopt our concept of the limiting strategy to keep the calculations simple.

which is decreasing in S_2. It is also intuitively clear, that once $\theta_{ind}(S_1, S_2) = \overline{\theta}$ a further increase in the underbidding quality S_2 will lead to a smaller output of sickness fund 2, since the demand for the supplementary health insurance of sickness fund 1 is already zero. As long as the inequality $\frac{\partial D_2(S_1,S_2)}{\partial S_2} < 0$ holds for $S_2 < S_1$, which is equivalent to

$$\frac{\theta_0(S_1) - \theta_0(S_2)}{S_1 - S_2} < \theta_0'(S_2), \tag{7}$$

sickness fund 2 has the incentive to decrease its quality. Due to $TD = \overline{\theta} - \theta_0$ this especially is the case for all combinations of $S_2 < S_1$ if consumers' sensitivity is decreasing (see figure 1). Then for all S_1 the optimal underbidding strategy is $S_2 = \underline{S}$. If consumers' sensitivity is increasing, choosing a higher underbidding quality S_2 always leads to an increase in demand for sickness fund 2. Thus, marginal underbidding is the optimal underbidding strategy. If consumers' sensitivity is constant, the resulting demand for sickness fund 2 is independent of the chosen underbidding quality. We then assume that sickness fund 2 chooses the marginal underbidding quality for its supplementary health insurance.

Optimal reaction

To decide which reaction is optimal, we have to compare the resulting outputs of the two sickness funds. Special attention has to be paid on those qualities which leave the competitor indifferent between two or more strategies. First we will compare overbidding and equalizing. Let the quality at which the competitor is indifferent between those two strategies be called S_{OE}.[23] Comparing the respective outputs of sickness fund 2 and solving the equation $D_2(S_{OE}, S_{OE}+) = D_2(S_{OE}, S_{OE})$ yields

$$\frac{\overline{\theta} + \theta_0(S_{OE})}{2} = C'(S_{OE}). \tag{8}$$

If the left hand side of (8) is greater, overbidding dominates equalizing and vice versa. Now we examine at which quality sickness fund 2 is indifferent between underbidding and equalizing. This quality is called S_{UE}. Comparing the respective outputs leads to

$$\theta_{ind}(S_{UE}, r_u(S_{UE})) - \theta_0(r_u(S_{UE})) = \frac{\overline{\theta} - \theta_0(S_{UE})}{2}. \tag{9}$$

Underbidding dominates equalizing, if in (9) the left hand side is greater. Finally, we derive the quality that leaves sickness fund 2 indifferent between overbidding and underbidding. This quality is called S_{OU}. The comparison of the outputs leads to

$$\overline{\theta} - C'(S_{OU}) = \theta_{ind}(S_{OU}, r_u(S_{OU})) - \theta_0(r_u(S_{OU})). \tag{10}$$

[23] S_{OE} is without loss of generality the chosen quality of sickness fund 1, leaving sickness fund 2 indifferent between overbidding and equalizing. Furthermore we assume that in the case of indifference the sickness funds choose the same quality for their supplementary health insurance.

Here overbidding dominates underbidding, if the left hand side of (10) is greater.

Having analyzed the possible reactions and identified the qualities that leave the competitor indifferent, we are now able to derive the reaction functions of the sickness funds. Based on those reaction functions we can examine the interaction between the quality choices of the two sickness funds. Here we have to distinguish between simultaneous and sequential competition at the first stage.

5 Simultaneous first stage quality competition

In this section we consider a simultaneous first stage quality competition, which means the sickness funds are able to adjust the quality of their supplementary health insurance. While marginal overbidding is the only relevant overbidding strategy, the optimal underbidding strategy r_u depends on the consumers' sensitivity. From (7) we know that in the case of increasing consumers' sensitivity it is $r_u(S) = S-$ for all S with $\theta_{ind}(S, S-) \leq \overline{\theta}$ and $r_u(S)$ according to $\theta_{ind}(S, r_u(S)) = \overline{\theta}$ otherwise, while in the case of strictly decreasing consumers' sensitivity we have $r_u(S) = \underline{S}$ for all S.

Increasing consumers' sensitivity

For the marginal underbidding strategy (10) yields[24]

$$C'(S_{OU}) = \frac{\overline{\theta} + \theta_0(S_{OU})}{2}.$$

According to (8) we then have $S_{OU} = S_{OE}$. Obviously this leads to $S_{OU} = S_{OE} = S_{UE}$. To analyze the sickness funds' behavior, we need to derive the reaction functions.

Lemma 2. *If consumers' sensitivity is increasing, the reaction functions of the sickness funds are identical and given by*

$$r(S) = \begin{cases} S+, & S < S_{OE} \\ S, & S = S_{OE} \\ r_u(S), & S > S_{OE}. \end{cases} \tag{11}$$

Proof. According to (7) the only relevant underbidding strategy is given by marginal underbidding $r_u(S_1) = S_1-$ on $\{S_1 \mid \theta_{ind}(S_1, S_1-) \leq \overline{\theta}\}$ and choosing the quality $r_u(S_1) = \inf\{S_2 \mid S_2 < S_1,\ \theta_{ind}(S_1, S_2) \geq \overline{\theta}\}$ on the set $\{S_1 \mid \theta_{ind}(S_1, S_1-) > \overline{\theta}\}$. We further have $S_{OE} \in \{S_1 \mid \theta_{ind}(S_1, S_1-) \leq \overline{\theta}\}$, since otherwise there would be no demand in case of overbidding. Therefore on $\{S_1 \mid \theta_{ind}(S_1, S_1-) > \overline{\theta}\}$ sickness fund 2 will never be indifferent between overbidding and equalizing. So on $[\underline{S}, S_{OE})$ overbidding dominates underbidding and equalizing, while on $(S_{OE}, \overline{S}]$ underbidding dominates overbidding and equalizing. In S_{OE} all three

[24] Note that $\lim_{S \nearrow S_{OU}} \theta_0(S) = \theta_0(S_{OU})$.

strategies yield the same output and the sickness funds equalize. Thus, we yield the reaction function (11). □

To improve readability, we denote the reaction function of sickness fund 1 and sickness fund 2 by r_1 and r_2 respectively, with $r_1 = r_2 = r$. Now that we have derived the reaction function, we are able to examine whether equilibrium strategies exist.

Proposition 3. *If consumers' sensitivity is increasing, there exists a unique subgame perfect Nash equilibrium in pure strategies with no quality differentiation.*

Proof. The two sickness funds have the same reaction function given by (11). Therefore $r_1(r_2(S)) = r_2(r_1(S)) = S$ holds if and only if $S = S_{OE}$. Thus (S_{OE}, S_{OE}) is the unique Nash equilibrium in pure strategies. □

As an example let the unit cost function be given by $C(S) = S^\alpha$, with $\alpha > 1$, so the total demand is decreasing. Let further $\overline{\theta} = 1$ and $\overline{S} = 1$, so that we have $\theta_0(\overline{S}) = \overline{\theta}$. Consumers' sensitivity then is $\theta_0'(S) = (\alpha - 1)S^{\alpha-2}$ and $S_{OE} = (1/(2\alpha - 1))^{1/(\alpha-1)}$ is the equilibrium quality for $\alpha \geq 2$.[25]

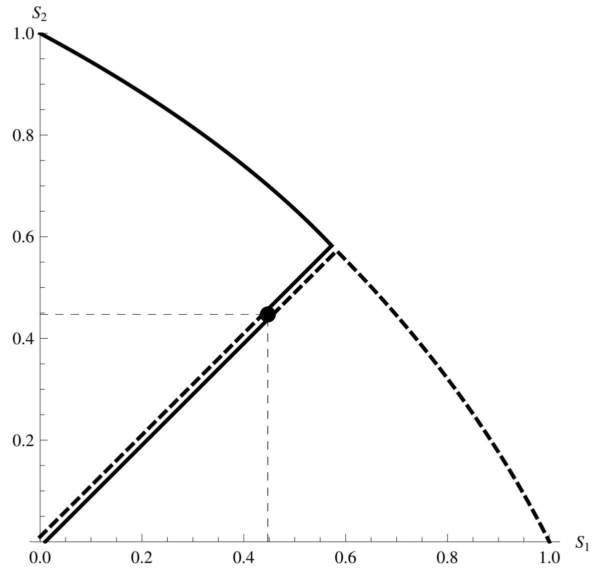

Figure 2: Reaction functions of sickness fund 1 (solid) and sickness fund 2 (dashed) with $\alpha = 3$.

Let us take a look at the reaction function of sickness fund 2 in figure 2: As we have seen before, if sickness fund 1 chooses a quality $S_1 \in [\underline{S}, S_{OE}) = [0, \frac{1}{\sqrt{5}})$ for its supplementary health insurance, marginal overbidding is the optimal reaction. If $S_1 = S_{OE} = \frac{1}{\sqrt{5}}$, sickness fund 2 is indifferent between overbidding, underbidding and equalizing and according to (11) reacts with equalizing. In the case of $S_1 \in (S_{OE}, \overline{S}] = (\frac{1}{\sqrt{5}}, 1]$, sickness fund 2 reacts with underbidding. On $(\frac{1}{\sqrt{5}}, \frac{1}{\sqrt{3}}]$ marginal underbidding is the optimal strategy. If we have $S_1 \in (\frac{1}{\sqrt{3}}, 1]$, marginal underbidding is not optimal anymore, since it is $C'(S_1) > C'(\frac{1}{\sqrt{3}}) = 1 = \overline{\theta}$. Here we have $r_2(S_1) = \frac{1}{2}\left(\sqrt{4 - 3S_1^2} - S_1\right)$, which leads to $\theta_{ind}(S_1, r_2(S_1)) = \overline{\theta}$ for all $S_1 \in (\frac{1}{\sqrt{3}}, 1]$. Since

[25] $\alpha > 2$ leads to a strictly increasing consumers' sensitivity, $\alpha < 2$ leads to strictly decreasing consumers' sensitivity and $\alpha = 2$ is the case of constant consumers' sensitivity.

sickness fund 1 has the same reaction function as sickness fund 2, the two reaction functions intersect only in $(S_{OE}, S_{OE}) = (\frac{1}{\sqrt{5}}, \frac{1}{\sqrt{5}})$, which is the unique Nash equilibrium in pure strategies for the special cost function.

Strictly decreasing consumers' sensitivity

According to (7), in the case of strictly decreasing consumers' sensitivity we have $r_u(S) = \underline{S}$ for all $S \in (\underline{S}, \overline{S}]$. From (10) we get

$$\overline{\theta} - \theta_0(S_{OU}) = C'(S_{OU}). \tag{12}$$

Lemma 4. *If consumers' sensitivity is strictly decreasing, we have $S_{UE} < S_{OU} < S_{OE}$ and the sickness funds' reaction function is given by*

$$r(S) : [\underline{S}, \overline{S}] \to [\underline{S}, \overline{S}], \tag{13}$$
$$S \mapsto r(S) := \begin{cases} S+, & S < S_{OU}, \\ \underline{S}, & S \geq S_{OU}. \end{cases}$$

Proof. Since consumers' sensitivity is strictly decreasing

$$\theta_0'(S_1) < \frac{\theta_0(S_1) - \theta_0(S_2)}{S_1 - S_2}$$

holds for all $S_2 < S_1$. Especially for $S_1 = S_{OU}$ and $S_2 = \underline{S}$ we have

$$\begin{aligned} & & \theta_0'(S_{OU}) &< \frac{\theta_0(S_{OU})}{S_{OU}} \\ \iff & & C'(S_{OU}) - \theta_0(S_{OU}) &< \theta_0(S_{OU}) \\ \iff & & C'(S_{OU}) &< 2\theta_0(S_{OU}). \end{aligned}$$

If we now had $S_{OU} < S_{OE}$, we would get

$$\begin{aligned} S_{OU} < S_{UE} &\overset{(9)}{\iff} \theta(S_{OU}) < \frac{\overline{\theta}}{3} \\ &\overset{(12)}{\iff} C'(S_{OU}) > \frac{2}{3}\overline{\theta} > 2\theta_0(S_{OU}), \end{aligned}$$

which is contradictory to a decreasing consumers' sensitivity. Therefore we have

$$
\begin{aligned}
& & S_{UE} &< S_{OU} \\
&\Longrightarrow & \theta_0(S_{UE}) &< \theta_0(S_{OU}) \\
&\overset{(9),(12)}{\Longrightarrow} & \frac{\overline{\theta} - \theta_0(S_{UE})}{2} &< \overline{\theta} - C'(S_{OU}) \\
&\Longrightarrow & \frac{\overline{\theta} - \theta_0(S_{OU})}{2} &< \overline{\theta} - C'(S_{OU}) \\
&\Longrightarrow & C'(S_{OU}) &< \frac{\overline{\theta} + \theta_0(S_{OU})}{2} \\
&\overset{(8)}{\Longrightarrow} & S_{OU} &< S_{OE}.
\end{aligned}
$$

So, for the optimal reactions of the sickness funds we now have the following rules for behavior: On $[\underline{S}, S_{UE}]$ overbidding dominates equalizing and equalizing dominates underbidding. On $(S_{UE}, S_{OU}]$ overbidding dominates underbidding and underbidding dominates equalizing. On $(S_{OU}, S_{OE}]$ underbidding dominates overbidding and overbidding dominates equalizing. On $(S_{OE}, \overline{S}]$ underbidding dominates equalizing and equalizing dominates overbidding. Thus, we yield the reaction function (13). $\square$

For the special cost function $C(S) = S^\alpha$ with $\alpha < 2$ we have $S_{UE} = (1/3)^{1/(\alpha-1)} < S_{OU} = (1/(\alpha+1))^{1/(\alpha-1)} < S_{OE} = (1/(2\alpha-1))^{1/(\alpha-1)}$. The shape of the reaction functions is shown in

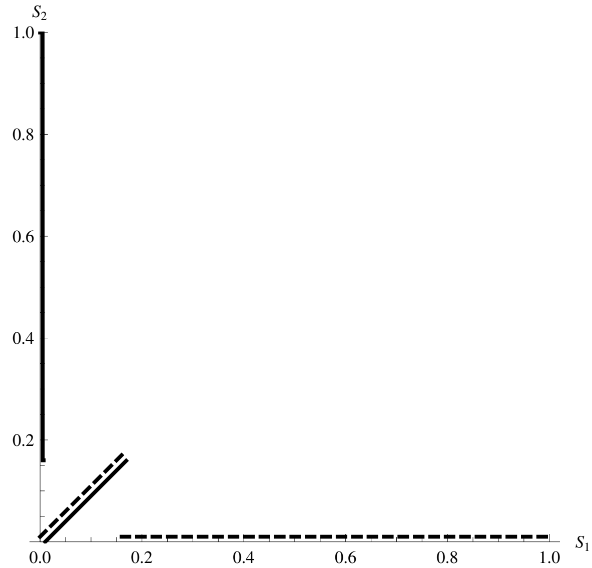

Figure 3: Reaction functions of sickness fund 1 (solid) and sickness fund 2 (dashed) with $\alpha = \frac{3}{2}$.

figure 3. One can see that in this special case of $C(S) = S^{3/2}$ no equilibrium exists, since the reaction functions do not intersect. In general the following result holds.

Proposition 5. *If consumers' sensitivity is strictly decreasing, there is no Nash equilibrium in pure strategies.*

Proof. If sickness fund 1 chooses $S_1 \in [\underline{S}, S_{OU}]$, overbidding is the dominant strategy. Thus, if (S_1^*, S_2^*) was an equilibrium, it has to be $(S_1^*, S_2^*) \in (S_{OU}, \overline{S}]^2$. For $S_1^* \in (S_{OU}, \overline{S}]$, according to

(13) we have $r_2(S_1^*) = \underline{S} \notin (S_{OU}, \overline{S}]$. Then again we have $r_1(r_2(S_1^*)) = r_1(\underline{S}) = \underline{S}+ \notin (S_{OU}, \overline{S}]$. Hence, S_1^* is no equilibrium strategy for sickness fund 1. Since this also holds for sickness fund 2, there exists no Nash equilibrium in pure strategies. □

In this section we have derived sufficient conditions for the existence of a unique Nash equilibrium in pure strategies in the case of simultaneous first stage quality competition. So in this section the sickness funds were able to adjust the quality of their supplementary health insurance policies, while in the next section the sickness funds have to commit themselves to a certain quality for their supplementary health insurace policies.

6 Sequential first stage quality competition

In this section we consider a sequential first stage quality competition, while we still assume a simultaneous second stage price competition, meaning the sickness funds enter the market simultaneously. We further assume that the sickness funds commit themselves to the chosen quality. This means the quality leader cannot adjust its quality after observing the quality chosen by the follower. We will again solve the problem via backward induction. The price competition on the second stage remains the same, while on the first stage we now have a subgame of sequential quality choices. The leader will anticipate the follower's reaction and therefore choose the quality that maximizes his output given the optimal reaction by the follower. Therefore, the leader's output might differ from the follower's. Without loss of generality let sickness fund 1 be the leader and sickness fund 2 be the follower. Let the reaction function of sickness fund 2 be denoted by r_2 as before, then for any given quality choice S_1 of sickness fund 1 the optimal answer of sickness fund 2 is choosing the quality $S_2 = r_2(S_1)$ for its supplementary health insurance. Knowing this, sickness fund 1 faces the maximization problem

$$D_1(S_1, r_2(S_1)) \xrightarrow{S_1} \max\,. \tag{14}$$

In this section we will focus on a decreasing total demand.[26]

Increasing consumers' sensitivity

The reaction function of the follower corresponds to the reaction function derived in Lemma 2 in the preceding section.

Proposition 6. *If consumers' sensitivity is increasing, there exists a unique subgame perfect Nash equilibrium in pure strategies with no quality differentiation. There is neither a first nor a second mover advantage.*

Proof. If sickness fund 1 decides to be the high quality provider, it has to choose a quality $S_1 > S_{OE}$ for its supplementary health insurance. Of course the range of possible qualities in this

[26] If the total demand is increasing, the result from Proposition 1 remains valid.

case is limited by the condition $\theta_{ind}(S_1, r_2(S_1)) < \overline{\theta}$. For those qualities we have $r_2(S_1) = S_1-$ such that the resulting output is given by

$$D_1(S_1, r_2(S_1)) = \overline{\theta} - \theta_{ind}(S_1, S_1-) = \overline{\theta} - C'(S_1),$$

which is obviously decreasing in S_1. If on the other hand sickness fund 1 decides to provide supplementary health insurance with a low quality, it has to choose $S_1 < S_{OE}$. Then of course it is $r_2(S_1) = S_1+$ and we have

$$D_1(S_1, r_2(S_1)) = \theta_{ind}(S_1, S_1+) - \theta_0(S_1) = C'(S_1) - \frac{C(S_1)}{S_1} = S_1\theta_0'(S_1).$$

Since consumers' sensitivity is increasing, derivation of this term shows that the output is increasing in S_1. Hence, sickness fund 1 will provide supplementary health insurance with the quality $S_1 = S_{OE}$. According to (11) sickness fund 2 also chooses the quality $S_2 = S_{OE}$. Thus, there is no quality differentiation and both sickness funds gain the same demand since they share the market equally. □

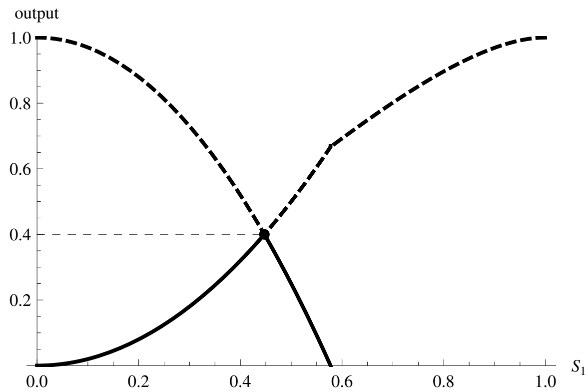

Figure 4: Output of sickness fund 1 (solid) and sickness fund 2 (dashed) with optimal reaction of sickness fund 2 with $\alpha = 3$.

In figure 4 we see the resulting outputs of the two sickness funds plotted against the quality choice of sickenss fund 1. As we can see, sickness fund 1 maximizes its output by choosing the quality $S_1 = S_{OE} = \frac{1}{\sqrt{5}}$ for its supplementary health insurance, resulting in an output of $\frac{2}{5}$. If sickness fund 1 chooses a different quality, the resulting output would be less than $\frac{2}{5}$. A quality $S_1 > \frac{1}{\sqrt{3}}$ would leave sickness fund 1 with no output, because sickness fund 2 will provide the quality S_2 such that $\theta_{ind}(S_1, S_2) = \overline{\theta}$. Since sickness fund 2 provides the same quality as sickness fund 1, the resulting output is also $\frac{2}{5}$ which leaves the market uncovered.

Strictly decreasing consumers' senstivity

Proposition 5 states that there is no equilibrium in pure strategies, if the sickness funds choose their qualities simultaneously. In the sequential quality competition the leader chooses his quality and commits himself. The follower reacts with his best response, so there will be an equilibrium. Now the reaction function of the follower corresponds to the reaction function given in Lemma 4.

Proposition 7. *If consumers' sensitivity is strictly decreasing, there exists a unique subgame perfect Nash equilibrium in pure strategies with quality differentiation and a first mover advantage.*

Proof. First we will show, that sickness fund 1 chooses $S_1 = S_{OU}$. If sickness fund 1 decides to provide the high quality supplementary health insurance, the output is obviously decreasing in S_1, since we have

$$D_1(S_1, r_2(S_1)) = D_1(S_1, \underline{S}) = \overline{\theta} - \theta_0(S_1)$$

for $S_1 \geq S_{OU}$. So sickness fund 1 will provide supplementary health insurance with a quality not higher than S_{OU}. It will also at least provide S_{OU}, since for $S_1 < S_{OU}$ and strictly convex C we have

$$\begin{aligned} D_1(S_1, r_2(S_1)) &= C'(S_1) - \theta_0(S_1) < C'(S_1) \\ &< C'(S_{OU}) \overset{(12)}{=} \overline{\theta} - \theta_0(S_{OU}) \\ &= D_1(S_{OU}, r_2(S_{OU})). \end{aligned}$$

Thus, sickenss fund 1 chooses $S_1 = S_{OU}$ and according to Lemma 4 sickness fund 2 responds with $S_2 = \underline{S}$. The resulting outputs in the equilibrium $(S_{OU}, \underline{S})$ are $D_2(S_{OU}, \underline{S}) = \theta_0(S_{OU})$ and $D_1(S_{OU}, \underline{S}) = \overline{\theta} - \theta_0(S_{OU})$. We have

$$\begin{aligned} & D_1(S_{OU}, \underline{S}) > D_2(S_{OU}, \underline{S}) \\ \Longleftrightarrow \quad & \overline{\theta} - \theta_0(S_{OU}) > \theta_0(S_{OU}) \\ \overset{(12)}{\Longleftrightarrow} \quad & \overline{\theta} - \theta_0(S_{OU}) > \overline{\theta} - C'(S_{OU}) \\ \Longleftrightarrow \quad & C'(S_{OU}) - \theta_0(S_{OU}) > 0. \end{aligned}$$

Since C is strictly convex, this shows the first mover advantage. □

Figure 5 shows the resulting outputs of the two sickness funds against the quality choice of sickness fund 1. As we can see, sickness fund 1 maximizes its output by choosing the quality $S_1 = S_{OU} = \frac{4}{25}$ for its supplementary health insurance, resulting in an output of $D_1(S_{OU}, \underline{S}) = \frac{3}{5}$. At $S_1 = S_{OU}$ the output of sickness fund 1 is noncontinuous, because at this quality the optimal reaction of sickness fund 2 changes from marginal overbidding to underbidding with $S_2 = \underline{S}$. In equilibrium we can clearly see the first mover advantage of sickness fund 1. Furthermore, the market is fully covered.

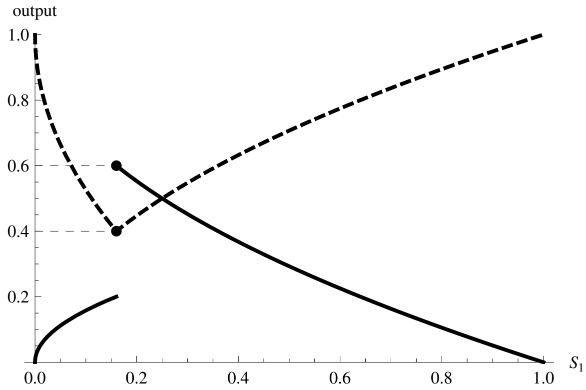

Figure 5: Output of sickness fund 1 (solid) and sickness fund 2 (dashed) with optimal reaction of sickness fund 2 with $\alpha = \frac{3}{2}$.

7 Conclusion and Outlook

In this paper we have analyzed a duopolistic competition of output maximizing nonprofit sickness funds in the market for supplementary health insurance. The solution of the second stage price competition has shown, that the sickness funds choose their prices according to their unit costs. So, in the case of output maximization, quality differentiation is not used to relax price competition as it is in the case of profit maximization. We have shown that the equilibrium in the first stage quality competition highly depends on the slope of the cost function and therefore on the consumers' sensitivity. The equilibrium quality for supplementary health insurance is the maximum quality, if and only if the sickness funds face concave unit costs, which leads to a total demand increasing in quality. This holds for the simultaneous as well as for the sequential first stage quality competition.

If the unit cost function is convex, the sickness funds will never choose the highest quality for their supplementary health insurance. This is because an increase in quality leads to a disproportional higher price and therefore to a decrease in market coverage. We have taken a look at the sickness funds' reactions overbidding, underbidding and equalizing. Since the output maximizing sickness funds do not fear price competition, equalizing might be optimal. The analysis has shown that there exists a unique subgame perfect Nash equilibrium in pure strategies, if the sickness funds face an increasing consumers' sensitivity. This is independent of the quality competition being either simultaneous or sequential. There is no quality differentiation and no sickness fund has the opportunity to achieve quality leadership. Hence, there is neither a first nor a second mover advantage and both sickness funds gain the same demand independent of the game's structure. If the sickness funds face a strictly decreasing consumers' sensitivity, there exists no Nash equilibrium in pure strategies in the simultaneous first stage quality competition. A possible way to cope with this fact is to act first and commit oneself to a certain quality, since there exists a first mover advantage if the quality competition is sequential. The quicker moving sickness fund then receives a higher demand than the competitor. Therefore, the quality competition might tend to be sequential in the case of strictly decreasing consumers' sensitivity.

Important for the existence of an equilibrium is the underbidding behavior. For increasing total demand there is no incentive to underbid at all. Therefore the existence of an equilibrium with both sickness funds providing supplementary health insurance with the highest quality is intuitive. For decreasing total demand the existence depends on the consumers' sensitivity. If the consumers' sensitivity is increasing, enforcing quality competition leads to a higher demand, since the consumers with a low preference for quality react insensitive. So the sickness fund has no incentive to deviate substantially from the competitor's quality choice which results in a stable market outcome. If the consumers' sensitivity is decreasing, the low preference people react highly sensitive. Thus, there is an incentive to deviate much from the competitors quality choice, since the gain in demand of consumers with low preference for quality outweights the loss of demand due to the relaxed competition. This substantial deviation leads to an adjustment of the competitor's quality choice and therefore no stable market outcome is achieved.

This paper shows the theoretical fundamentals of the competition of nonprofit sickness funds in the market for supplementary health insurance. Based on our results further research can be done in several directions. In our paper the sickness funds choose the lowest possible price for any given quality, since the only objective is output maximization. If we relax this assumption the sickness funds might have mixed objective functions. Firms that aim for profit and output at the same time face a trade-off between those two objectives, since a change in the price for a given quality influences the two objectives in different directions. As a special case the competition of a purely output maximizing firm and a purely profit maximizing firm is of interest as well. This kind of competition is appropriate to describe health care markets where statutory and private health insurance firms compete (e.g. Germany). To help to decide how competition in markets with firms that focus on various objectives should be organized, further research on the welfare implications of those objectives needs to be taken. Furthermore, it needs to be analyzed whether the government can improve the market outcome by further regulation.

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