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# OPTIMAL CO-PAYMENT POLICY IN HEALTH CARE: COMPETITION, OWNERSHIP STRUCTURE AND QUALITY PROVISION?

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# Optimal Co-Payment Policy In Health Care: Competition, Ownership Structure And Quality Provision[1]

**Abstract**

We analytically characterize the effects of ownership and competition in the health care industry on quality provision, market coverage and optimal co-payment policy. A private monopoly selects a lower quality than a public supplier, and the socially optimal co-payment rate with a private monopoly exceeds that with a public monopoly. We establish that the optimal co-payment policy is invariant to the introduction of private competition. Thus, market coverage is invariant to the introduction of competition, whereas all consumers with a higher willingness to pay for quality are better off with competition.

JEL Classification: I11, I18, L10

Key words: public vs private health care provision, competition in health care, health care quality, quality differentiation, mixed duopoly

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# 1 Introduction

A characteristic feature of health care services in many countries is that at the time the service is offered to citizens it is for free or offered at a price well below the costs of producing the service in question. This holds true not only for public health care services, but in many circumstances it holds also for private service providers as these are reimbursed either from the government or from insurance companies/organizations, which cover the treated individual. For example, in a wide range of countries hospitals are reimbursed from the government for every patient they treat, and these patients face a free choice of service provider. In such systems the hospitals compete for patients with quality as the main instrument. As information economics emphasizes, in systems like these patients have incentives to acquire the service also under circumstances where their willingness to pay for the service is lower than the true cost of supplying this service. In other words, such a system leads to a structural moral hazard problem. A number of policy proposals to reform health care have been formulated to address this problem. Inspired by how the insurance business has addressed the moral hazard problem the common denominator in those proposals has been to make individuals pay for a share of the expenditures associated with the health care service, typically in the form of deductibles or co-payment.[2]

In this study we will characterize optimal co-payment policy from a new perspective, which emphasizes that the co-payment policy will affect the quality decisions by the health care providers, and thereby also the decisions of individuals. Internationally, and within the United States alike, the health care sector exhibits a diversity of market structures ranging from public sector monopolies via private for-profit monopolies to mixed oligopolies. The nature of the optimal co-payment policy may very well depend on the market structure. In this study we design a two-stage model of a

[2]For example, Medicare Part B (outpatient medical care) requires coinsurance, after monthly premiums and deductibles the patient (or their Medigap insurance policy) is responsible for 20% of the cost of most Part B services.

health care industry, where the policy maker commits to a reimbursement rate and a co-payment share in the long run. Contingent on this policy the suppliers of health care subsequently decide on quality within the framework of a model of vertical product differentiation. We address the following questions: What are the effects of the applied co-payment policy on quality provision and how do these effects depend on ownership structure and market structure? How does optimal co-payment policy with a public monopoly supplier differ from that with a private monopoly supplier? What is the effect on optimal co-payment policy of introducing competition from a private supplier into a health care industry with an incumbent public supplier? Also, what is the associated effect on consumers of introducing private competition?

Our study focuses on how to design health care policy, in the form co-payment, with particular emphasis on the mechanism for how this policy affects the quality of health care services and thereby welfare of the citizens. This is a highly topical policy issue of key importance. For example, in the US the controversial Affordable Care Act - also known as Obamacare - is ultimately about making it mandatory for all Americans to acquire health care insurance, thereby placing all citizens in a situation that they individually face prices for health care well below the true costs of producing the service in question. The absence of the Affordable Care Act means that a significant proportion of the population continues to be billed a price for health care treatments at the time of the procedure ? a feature implying that a significant proportion of the population is in effect excluded from many types of health care services. Of course, the Obamacare reform addresses the health care policy issues in a more comprehensive way, but independently of the institutional details the determination of the co-payment policy is one of the key features of this reform from an economic point of view.

Our model enables for us to characterize the effects of ownership in the health care industry on quality provision, market coverage and optimal co-payment policy. For this purpose we compare the

quality decision of public welfare-maximizing supplier operating with a binding budget constraint with that of a private profit-maximizing supplier. In this respect we find that the private monopoly selects a lower quality, thereby also implying lower market coverage, than the public supplier. Furthermore, the socially optimal co-payment rate with a private monopoly exceeds that with a public monopoly. Subsequently, we explore the effects of introducing private competition into a health care industry with an incumbent public supplier. We show analytically that the quality equilibrium is characterized by a configuration of differentiated services such that the quality offered by the public supplier is invariant to the introduction of competition. Further, we establish that the optimal co-payment policy is invariant to the introduction of private competition directed towards consumers with higher preference for the health care service. This implies that market coverage is invariant to the introduction of competition, meaning that the introduction of competition from a private high-quality supplier is not a mechanism to eliminate potential problems associated with exclusion of consumers with a low valuation of quality. However, this does not by any means imply the absence of welfare gains from competition. On the contrary, all consumers with preference for the high-quality service are better off with competition and this is an important social benefit from a shift in market structure from a public monopoly to a mixed duopoly.

A number of studies, for example Zeckhauser (1970), Ma and Riordan (2002) and Hoel (2005), have theoretically characterized socially optimal co-payment policies in ways which are highly relevant for health care[3]. In line with the approach to the design of insurance contacts these studies emphasize the moral hazard aspects induced by the decisions taken by risk averse individuals and these studies explore how to design combinations of deductibles or co-payment so as to limit the damage caused by moral hazard. Other studies have explored policy measures to deal with this

[3]Weisbrod (1991) has more generally explored the effects of health care insurance on technological progress and quality and discussed how these effects might exhibit systematic differences across different institutional forms.

moral hazard problem from an empirical perspective, for example, Westerhout and Folmer (2007) and Trottman et al (2012). We contribute to this literature by characterizing optimal co-payment policy within the framework of an approach which emphasizes that the co-payment policy will affect the discretionary quality decisions by the health care providers, and thereby also the decisions of individuals.

We also contribute to the literature exploring the effects of competition on quality in health care. This literature has in different ways clarified under which conditions we can expect competition to promote (harm) quality in health care. This literature is surveyed in Gaynor 2006). Many of the studies analyzing this issue, for example Brekke et al (2011) and Halonen and Propper (2012), have applied Hotelling models, which are really designed to capture horizontal product differentiation rather than vertical product differentiation. The empirical health economics literature focusing on quality issues makes use of measures such as, for example, survival rates from acute myocardial infarction to capture quality (Bloom et al (2012); Chandra et al. (2012); Gaynor et al. (2010); Gowrisankaran and Towne (2003); Volpp, et al (2003)). These empirical measures are more consistent the application of models of vertical product differentiation rather than horizontal product differentiation as theoretical representation of quality in health care. Overall we contribute to the analysis evaluating the effects of competition in health care by designing a vertical differentiation model able to characterize explicitly how the introduction of competition affects the quality equilibrium, market coverage and welfare in a mixed duopoly model.

Our study proceeds as follows. In Section 2 we introduce the model. Section 3 analyzes quality provision with the particular goal of delineating the effects of ownership and market structure. In Section 4 we characterize optimal co-payment policy and its consequences for quality provision and market coverage. Finally, we present concluding comments in Section 5.

## 2 The Model

In this study we design a model for the health care sector with the feature that the government maintains a system whereby it compensates the supplier of the health care service with a reimbursement R. We consider this reimbursement to be fixed and invariant to the particular ownership structure or market structure prevailing in the health care industry. The feature with a fixed reimbursement reflects an underlying assumption according to which the government is unable to observe the quality of the service provided to individual consumers. The reimbursement policy is one important component of health care policy. In this study we will consider reimbursement policy as given, and instead we focus on another important instrument, namely the co-payment. We design a two-stage model, where the policy maker (the government) commits itself to a co-payment policy in the long run. This co-payment policy specifies which proportion of the citizen?s health care expenses should be carried by the citizen herself/himself, and, correspondingly, which proportion should be funded by the public purse. Conditional on the co-payment policy the supplier of the health care service subsequently decides on the quality of this service. In this study we focus particularly on characterizing the effects of ownership and market structure on the optimal co-payment policy.

For the determination of quality we adopt a model of vertical product differentiation developed by Mussa and Rosen (1978) and Shaked and Sutton (1982) in order to analyse the determination of quality[4]. We assume consumers (citizens) to be differentiated with respect to their valuation of the quality associated with the health care service. More precisely, the consumption of a health care service of quality $q$ yields a utility given by $u(q, p|\lambda) = \lambda q - p$ for a consumer of type $\lambda$ if

[4]In the health economics literature it is common to apply models of horizontal product differentiation to capture quality decisions, for example Brekke et al (2008), (2011) or Sanjo (2009). However, the extensive literature in industrial economics has clarified important qualitative differences between models of horizontal and vertical product differentiation, and forcefully argued for why models of vertical product differentiation should be applied to analyze quality competition.

this consumer is charged a price $p$ (for example, in the form of co-payment). For all the explicit calculations to come we will assume that the differentiation regarding the valuation for quality across consumers is captured by a uniform distribution $f(\lambda) = \frac{1}{\bar{\lambda}}$ on a bounded support with $\lambda \in [0,\ \bar{\lambda}]$. In line with the tradition established in the literature focusing on vertical product differentiation we can make the interpretation whereby $\lambda$ captures income. Thus, in line with such an interpretation $\bar{\lambda}$ is a measure of the variance in income. With a more general interpretation we can view $\bar{\lambda}$ as a measure of the variance of the distribution of the willingness among consumers to pay for quality. Also, following the established approach in the literature we assume that each citizen consumes at most one unit of the health care service.

The consumer indifferent between acquiring the service or not, denoted $\tilde{\lambda}$ , is determined by the condition $\tilde{\lambda}q - p = 0$. We can directly see that the segment of consumers served is determined by the quality of the service as well as by the price faced by the consumer. In particular, consumers with $\lambda < \tilde{\lambda}$ are excluded from this health care service.

With N denoting the measure of total number of potential consumers, and with D denoting the demand function, the costs associated with the health care service is assumed to be given by

$$C(q, D(q)) = cqD(q) = cq \int_{\tilde{\lambda}}^{\bar{\lambda}} Nf(\lambda)d\lambda$$

where $c$ is the constant marginal costs of quality. This cost function exhibits a twofold dependence on quality. Firstly, there is a direct effect according to which quality improvements increase costs. In addition, there is an indirect effect associated with market coverage. More precisely, the indirect effect captures the feature that a quality improvement increases market coverage and thereby increases costs. This could be seen as a congestion effect, whereby it is increasingly costly to provide

high-quality service to a higher volume of consumers[5].

Formally, by applying the Leibniz integral rule we find that the effect of a quality improvement is given by

$$\frac{\partial C(q, D(q))}{\partial q} = c\int_{\tilde{\lambda}}^{\bar{\lambda}} Nf(\lambda)d\lambda - cqNf(\tilde{\lambda})\frac{\partial \tilde{\lambda}}{\partial q} = \frac{cN}{\bar{\lambda}}\int_{\tilde{\lambda}}^{\bar{\lambda}} d\lambda + \frac{cNp}{\bar{\lambda}q},$$

where the uniform distribution has been imposed on f(x) in order to get the latter equality. In order to make sure that the considered health care service is valuable for at least some consumers we impose the assumption that $\bar{\lambda} >$ c. Otherwise, the health care service would not be valuable for any consumers, and the model would be very uninteresting.

# 3 Quality Provision: Effects of Ownership and Market Structure

In this section we assume that the policy maker (the government) has committed itself to a co-payment policy with the property that the citizen covers the share s of the public expenses for the health care service. In light of the assumption that the service provider gets a reimbursement R this means that the cost covered by the consumer is sR. We initially contrast the quality selected by a welfare-maximizing public monopoly from that of a private monopoly in order to explore the effects of ownership on quality provision. Subsequently, we explore the effects of introducing private competition by comparing the quality provision in a mixed duopoly with that in a public monopoly.

[5]Service speed is one important dimension of quality which such congestion effects are important. Stenbacka and Tombak (1995)) present an analysis of time-based competition emphasizing congestion effects.

### 3.1 Welfare-Maximizing Public Monopoly with a Binding Budget Constraint

In this subsection we direct our attention to the supply of quality by a welfare-maximizing public monopoly equipped with a binding budget constraint[6]. The quality is determined as the outcome of the following optimization problem[7].

$$max_q \quad N \int_{\tilde{\lambda}}^{\bar{\lambda}} \lambda q f(\lambda) d\lambda - C(q, D(q)) \tag{1}$$

subject to

$$N \int_{\tilde{\lambda}}^{\bar{\lambda}} R f(\lambda) d\lambda \geq C(q, D(q)), \tag{2}$$

where $D(q) = N \int_{\tilde{\lambda}}^{\bar{\lambda}} q f(\lambda) d\lambda$ and $\tilde{\lambda} = \tilde{\lambda}(q) = \dfrac{sR}{q}$

By application of Leibniz integral rule with variable limits we find that the necessary first-order condition associated with this constrained optimization problem is

$$N \int_{\tilde{\lambda}}^{\bar{\lambda}} \lambda f(\lambda) d\lambda - N\tilde{\lambda} f(\tilde{\lambda}) q \frac{\partial \tilde{\lambda}}{\partial q} + NRf(\tilde{\lambda}) \frac{\partial \tilde{\lambda}}{\partial q} = 0, \tag{3}$$

where the first two terms define the marginal returns of quality supply, whereas the last term denotes the marginal costs of quality supply. Furthermore, observe that $\dfrac{\partial \tilde{\lambda}}{\partial q} = -\dfrac{sR}{q^2} < 0$. From (3)

[6]There seems to be no consensus on the precise objective function of non-profit health care suppliers, in particular public suppliers (see, for example, the discussion in Kesteloot and Voet (1998)). In this study we specify welfare maximization as the objective of the public supplier, and we assume that the government is able impose a binding budget constraint on the public supplier - a constraint which seems empirically plausible.

[7]This optimization problem captures the idea that quality is determined by the service provider, who faces the reimbursement rate R. An essential feature of this formalization is that the policy maker delegates the service provision to the public institution, for example a hospital. It should be emphasized that this formalization makes the optimization problem different from a configuration where quality would be determined directly by the policy maker facing the costs of quality provision. Our formalization seems to accurately account for the realistic feature that policy makers (governments) themselves are seldom able to determine quality, but that they have to rely on delegation to specialized institutions.

we can derive that the second-order derivative of the objective function with respect to the quality is given by

$$-N\tilde{\lambda}f(\tilde{\lambda})\frac{\partial\tilde{\lambda}}{\partial q}+N(1-s)R\left[f(\tilde{\lambda})\frac{\partial^2\tilde{\lambda}}{\partial q^2}+f'(\tilde{\lambda})\frac{\partial\tilde{\lambda}}{\partial q}\right],$$

where $\frac{\partial^2\tilde{\lambda}}{\partial q^2}=\frac{2\tilde{\lambda}}{q^2}>0$. By substitution of the uniform distribution $f(\lambda)=\frac{1}{\bar{\lambda}},\lambda\in[0,\bar{\lambda}]$, we find this second-order derivative to satisfy

$$\frac{NR\tilde{\lambda}}{\bar{\lambda q^2}}(2-s)>0,$$

from which we can conclude that the objective function is strictly convex. This means that the solution to (3) yields a local minimum, not a local maximum. Taken together our findings above imply that there are two candidates for a solution of optimization problem (1) subject to (2). The first candidate, q = 0 , yields an empty model and cannot be a maximum. The second candidate is the quality determined by the binding budget constraint

$$N\int_{\tilde{\lambda}}^{\bar{\lambda}}Rf(\lambda)d(\lambda)=c(q,D(q)),$$

The quality satisfying this budget constraint is the welfare-maximizing quality solving optimization problem (1) subject to (2). By substitution of the uniform distribution $f(\lambda)=\frac{1}{\bar{\lambda}},\lambda\in[0,\bar{\lambda}]$, as well as the cost function C(q,D(q)) = c q $\int_{\tilde{\lambda}}^{\bar{\lambda}}Nf(\lambda)d\lambda$ we find the welfare-maximizing quality to be given by $q^{BW}=\frac{R}{c}$. Likewise, with a welfare-maximizing public monopoly equipped with a binding budget constraint market coverage is determined by $\tilde{\lambda}^{BW}=\frac{sR}{q^{BW}}=$ sc. Note, that the assumption

$\bar{\lambda} >$ c guarantees that the market coverage is non-empty, i.e. that $\bar{\lambda}$ - $\tilde{\lambda}^{BW} > 0$.

It can immediately be seen that $q^{BW}$ is directly proportional to the reimbursement (R), whereas it is inversely proportional to the direct costs of quality provision. However, $q^{BW}$ is independent of the co-payment rate s. Furthermore, an increased co-payment rate leads to lower market coverage because $\frac{\partial(\bar{\lambda} - \tilde{\lambda}^{BW})}{\partial s}$ = - c $< 0$.

We summarize our findings regarding the welfare-maximizing quality subject to the balanced budget according to the following

**Result 1** *The welfare-maximizing quality subject to the balanced budget is given by* $q^{BW} = \frac{R}{c}$. *In particular, this quality is independent of the co-payment rate, whereas market coverage is strictly decreasing as a function of the co-payment rate.*

## 3.2 Private Monopoly

In order to highlight the effect of ownership on quality provision we next shift our attention to a private, profit-maximizing monopoly. The private profit-maximizing supplier determines quality in order to maximize profits

$$max_q \quad N \int_{\tilde{\lambda}}^{\bar{\lambda}} Rf(\lambda)d(\lambda) - C(q, D(q)), \tag{4}$$

where, as before, C(q, D(q)) = cq N $\int_{\tilde{\lambda}}^{\bar{\lambda}} f(\lambda)d(\lambda)$ and $\tilde{\lambda} = \tilde{\lambda}(q) = \frac{sR}{q}$. By application of Leibniz integral rule with variable limits we find that the necessary first-order condition is given by

$$-cN \int_{\tilde{\lambda}}^{\bar{\lambda}} f(\lambda)d\lambda - N(R - cq)f(\tilde{\lambda})\frac{\partial\tilde{\lambda}}{\partial q} = 0.$$

Imposing the uniform distribution and utilizing the feature that $\frac{\partial\tilde{\lambda}}{\partial q} = -\frac{\tilde{\lambda}}{q}$ this first-order condition

can be rewritten according to

$$\frac{N}{\bar{\lambda}}\left[-cN(\bar{\lambda}-\tilde{\lambda})+N(R-cq)\frac{\tilde{\lambda}}{q}\right]=0^{8}.$$

Straightforward explicit solution of (5) yields the profit-maximizing quality

$$q^{M}=R\sqrt{\frac{s}{c\bar{\lambda}}} \tag{5}$$

From (6) we can directly conclude that $\frac{\partial q^{M}}{\partial s}=\frac{1}{2}R\sqrt{\frac{1}{c\bar{\lambda}s}}$, meaning that an increased co-payment rate induces a private monopoly to raise its service quality. This feature seems consistent with intuition, because ceteris paribus with increased co-payment more consumers decide not subscribe to the service and faced with a more severe threat of that type the monopolist has incentives to raise its service quality. As a matter of fact, (6) exhibits precisely that the co-payment rate plays a crucial role as a source of incentives in a world, like that of the present model, where the policy makes is unable to make the reimbursement contingent on quality.

Formally, with a private monopoly the threshold determining market coverage is given by $\tilde{\lambda}^{M}=\frac{sR}{q^{M}}=\sqrt{c\bar{\lambda}s}$. Thus, with optimal quality provision we see that market coverage actually decreases with an increased co-payment rate, because $\frac{\partial(\bar{\lambda}-\tilde{\lambda}^{M})}{\partial s}=-\frac{1}{2}\sqrt{\frac{c\bar{\lambda}}{s}}<0$. We summarize our findings regarding private monopoly provision of the health care service according to

**Result 2** *The optimal quality provided by a private monopoly supplier is given by* $q^{M}=R\sqrt{\frac{s}{c\bar{\lambda}}}$. *In particular, the quality is strictly increasing whereas market coverage is strictly decreasing as a function of the copayment rate.*

By comparing the welfare-maximizing quality subject to the balanced budget with (6) we find

[8] For the maximization problem (4) the sufficient second-order condition is satisfied, because by differentiating the first-order condition (5) with respect we find that $\frac{N}{\bar{\lambda}}\left[-2c\frac{\tilde{\lambda}}{q}-(R-cq)\frac{2\tilde{\lambda}}{q^{2}}\right]<0$

that $q^{BW} > q^M$ if and only if $\sqrt{s} < \sqrt{\frac{\overline{\lambda}}{c}}$ . But, the latter inequality always holds true. Therefore we can draw the general conclusion that the private monopoly selects a lower quality than the welfare-maximizing public supplier which operates subject to the budget constraint. This result, in its turn, implies that more consumers are excluded from the health care service with a private monopoly supplier than with a welfare-maximizing public supplier operating subject to the budget constraint. Comparing Result 1 and 2 we can conclude

**Result 3** *The private monopoly selects a lower quality, thereby also implying lower market coverage, than the welfare-maximizing public supplier operating subject to the budget constraint.*

### 3.3 Mixed Duopoly: Effects of Introducing Private Competition

In this subsection we will explore the effects on service quality of introducing competition from a high-quality private supplier into a health care industry originally served by a public welfare-maximizing monopoly operating with a budget constraint. This amounts to an analysis of the equilibrium with respect to the service qualities in a mixed duopoly where a private supplier competes with a public supplier[9]. Such a market structure seems to be a good representation of the health care system in countries where private for-profit services compete with those offered by an extensive public service sector, which focuses on supplying standardized health care services. As a representation of such a configuration we focus on a mixed duopoly with a distribution of roles such that a private high-quality supplier competes with a public low-quality supplier.

We assume that the public supplier offers a standardized service of quality $q_1$ , whereas the

[9] Herr (2011) and Stenbacka and Tombak (1995) have focused on models of mixed duopolies relevant for health care in order to explore the effects of introducing competition regarding qualities (or service speeds). Also Brekke and Sorgard (2007) have studied the interaction between free public and costly private health care. They focused on how physicians optimally allocate their time between the public and private sectors, and they demonstrated that private practice for physicians may crowd out public health care provision, thereby reducing the aggregate supply of health care.

private supplier offers a service of quality $q_2$ with $q_2 > q_1$. We assume that the policy maker implements a competition-neutral health care policy in the sense that it adopts a uniform co-payment rate across the two types of services. However, the private supplier is allowed charge a regulated premium, denoted p. As earlier, the uniform distribution $f(\lambda) = \frac{1}{\bar{\lambda}}$, with $\lambda \in [0,\ \bar{\lambda}]$, captures the differentiation across the consumers regarding their valuation of quality.

In the mixed duopoly the market coverage is determined by the condition $\tilde{\lambda}\ q_1$ - sR = 0, implying that $\tilde{\lambda} = \tilde{\lambda}(q_1) = \frac{sR}{q_1}$. The consumer, denoted $\hat{\lambda}$, indifferent between the private high-quality service $q_2$ and the public low-quality service $q_1$ is given by the condition $\hat{\lambda}q_1$ - sR = $\hat{\lambda}q_2 - sR - p$, implying that $\hat{\lambda} = \hat{\lambda}(q_2, q_1) = \frac{p}{q_2 - q_1}$. Consumers with $\lambda \in [\hat{\lambda}, \bar{\lambda}]$ prefer the private high-quality service, whereas consumers with $\lambda \in [\tilde{\lambda}, \hat{\lambda}]$ subscribe to the low-quality service. Furthermore, consumers with $\lambda \in [0, \tilde{\lambda}]$ are excluded from the service. In order for our mixed duopoly model to be defined and logically consistent it has to hold true that $\hat{\lambda} > \tilde{\lambda}$. For this reason we will assume that p is sufficiently large compared with R[10].

The public welfare-maximizing service provider decides on in order to solve the following optimization problem:

$$max_{q_1} \quad N \int_{\tilde{\lambda}}^{\hat{\lambda}} \lambda q_1 f(\lambda) d\lambda - C(q_1, D_1(q_1, q_2)) \tag{6}$$

subject to

$$N \int_{\tilde{\lambda}}^{\hat{\lambda}} R f(\lambda) d\lambda \geq C(q_1, D_1(q_1, q_2)), \tag{7}$$

where $D_1(q_1, q_2) =$ N $\int_{\tilde{\lambda}}^{\hat{\lambda}} f(\lambda) d\lambda$ and $C(q_1, D_1(q_1, q_2)) = cq_1 D_1(q_1, q_2)$.

The private service provider determines $q_2$ as the solution to the profit-maximization problem

[10]In Appendix A we will verify that the quality equilibrium of our mixed duopoly model satisfies this constraint.

$$max_{q_2} \quad N \int_{\hat{\lambda}}^{\bar{\lambda}} (R+p) f(\lambda) d\lambda - C(q_2, D_2(q_2, q_1)), \tag{8}$$

where $D_2(q_2, q_1) = \mathrm{N} \int_{\hat{\lambda}}^{\bar{\lambda}} f(\lambda) d\lambda$ and $C(q_2, D_2(q_2, q_1)) = \mathrm{c} q_2 D_2(q_2, q_1)$.

In Appendix A we derive the Nash equilibrium with respect to the quality decisions solving the optimization problems (7) subject to (8) and (9). Based on these calculations we characterize the quality equilibrium in the following way.

**Result 4** *In the mixed duopoly the equilibrium is characterized by differentiated services. The public supplier offers the quality* $q_1^* = \frac{R}{c}$*, whereas the private supplier offers the quality* $q_2^* = \frac{R}{c} + p\sqrt{\frac{1}{c\bar{\lambda}}}$.

From Result 4 we can directly conclude that the degree of quality differentiation, $q_2^* - q_1^* = p\sqrt{\frac{1}{c\bar{\lambda}}}$, is proportional to the price premium the high-quality supplier is able to charge. Furthermore, higher costs (c) or higher variance in the consumer valuations for quality ($\bar{\lambda}$) reduce the quality differentiation in equilibrium. The nonlinear relationship between the quality differentiation and the product of costs and variance in consumer valuations is a reflection of the quality-related congestion effects. In particular, with an exogenously given price premium we see that the equilibrium qualities are independent of the co-payment rate s. For the public low-quality supplier this property carries over from the market structure with a public monopoly. And the equilibrium configuration with a market segmentation according to which the private high-quality supplier captures the segment of consumers with $\lambda \in [\hat{\lambda}, \bar{\lambda}]$ explains why the high quality is independent of the co-payment rate.

From the perspective of evaluating the effects of introducing private competition into the health care industry Result 4 is very interesting. Based on a comparison of Result 4 with Result 1 we can conclude that the quality provided by the public supplier is invariant to the introduction of competition. This implies that market coverage is invariant to the introduction of competition. Formally, ($\tilde{\lambda}$) is invariant to a shift from a public monopoly to a mixed duopoly. In other words,

the introduction of competition from a private high-quality supplier is not a mechanism to eliminate potential problems associated with exclusion of consumers with a low valuation of quality. However, this does not by any means imply that consumers do not benefit from competition. Actually, all consumers with $\lambda > \hat{\lambda}$ engage in self-selection to the private supplier as these consumers benefit from the high-quality service offered by the private competitor compared with a public monopoly.

In the mixed duopoly equilibrium $\hat{\lambda} = \sqrt{c\bar{\lambda}}$. In light of the uniform distribution of consumers this means that in equilibrium the proportion 1 - $\sqrt{\frac{c}{\bar{\lambda}}}$ of consumers prefers the service offered by the private supplier, and this proportion of consumers benefits from the shift from a public monopoly to the mixed duopoly. The public service offered to consumers with valuation $\lambda \in [\tilde{\lambda}, \hat{\lambda}]$ could also plausibly improve, because the private service relaxes congestion associated with the public service. Namely, the private service relaxes the pressure on the reimbursement program supporting the public service. In the presence of distortions associated with raising funds to support such a reimbursement program this relaxation could potentially also be allocated to benefit the market segment consuming the public service. However, since we formally consider the reimbursement R to be an exogenous feature of our model, this mechanism is strictly speaking outside our formal analysis.

An important research approach in health economics has operated with the ambition to clarify those conditions under which the introduction of competition promotes quality in health care (see, for example, the surveys by Gaynor (2006) or Katz (2013)). Our study highlights that the introduction of competition from a differentiated high-quality service induces some consumers to switch to this high-quality service, whereas it does not change the quality selected by others. Furthermore, independently of which of the two market structures prevail, an important segment of consumers ($\lambda \in [0, \tilde{\lambda}]$) are excluded from the service. Overall, our study implies that with heterogeneous con-

sumers there need not be any universal effects for quality of the introduction of competition with respect to health care, but that these effects may very well be segment-specific among a spectrum of heterogeneous consumers.

# 4 Optimal Co-Payment Policy

In this section we will characterize optimal co-payment policy. We focus on a health care industry where the policy maker is unable to make policy decisions contingent on quality determined in a discretionary way by public or private health care suppliers. We initially characterize optimal co-payment policy with a monopoly supplier and subsequently we shift our attention to a market structure with duopoly.

## 4.1 Optimal Co-Payment Policy with a Monopoly Supplier

Suppose, as a general feature, that the monopoly supplier finds it optimal to provide quality q(s), which could in principle depend on the co-payment rate determined by the policy maker. The policy maker determines the co-payment policy in order to solve the optimization problem

$$max_s \quad W(s) = N\int_{\tilde{\lambda}}^{\bar{\lambda}} \lambda q(s) f(\lambda) d\lambda - N\int_{\tilde{\lambda}}^{\bar{\lambda}} Rf(\lambda) d\lambda - N\int_{0}^{\tilde{\lambda}} \mu f(\lambda) d\lambda, \tag{9}$$

where the parameter $\mu$ denotes the social cost for each consumer excluded from the health care service. The objective function W(s) has three components. The first term measures the total social benefits to all those consumers who are served. The second term is a representation of the costs to the government of funding the service by reimbursing the health care supplier at the rate R for each served consumer. Finally, the third term captures the total social costs associated with all the

excluded consumers. As earlier, the size of the consumer segment served (excluded) is determined by $\tilde{\lambda} = \frac{sR}{q(S)}$. Thus, the policy instrument, s, has a direct as well as an indirect effect, through the quality supplied, on the size of the consumer segment served (excluded).

Imposing the uniform distribution we find that the necessary first-order condition for a socially optimal co-payment rate is given by

$$W'(s) = \int_{\tilde{\lambda}}^{\bar{\lambda}} \lambda q_s(s) d\lambda - (\tilde{\lambda} q(s) - R) \frac{\partial \tilde{\lambda}}{\partial s} - \mu \frac{\partial \tilde{\lambda}}{\partial s} = 0, \tag{10}$$

where $q_s(s)$ denotes the derivative of the quality with respect to the co-payment rate. The first term in (11) captures the consumer benefits associated with the fact that an increase in the co-payment rate promotes quality provision. The second term measures the cost savings to society associated with a lower number of consumers served in response to an increased co-payment rate. Finally, the third term denotes the welfare costs associated with an increased number of excluded consumers.

Based on a straightforward calculation we find that $\frac{\partial \tilde{\lambda}}{\partial s} = \frac{1 - \eta(s)}{s} \tilde{\lambda}$, where $\eta(s) = \frac{s q_s(s)}{q(s)}$ is the elasticity of quality provision with respect to the co-payment rate. Taking this feature into account the first-order condition (11) can be simplified to

$$W'(s) = \frac{q_s(s)}{2} (\bar{\lambda}^2 - \tilde{\lambda}^2) + (R(1 - s) - \mu) \frac{1 - \eta(s)}{s} \tilde{\lambda} = 0. \tag{11}$$

We next apply (12) in order to characterize the optimal co-payment policy with the two types of monopoly suppliers we analyzed in subsections 3.1 and 3.2.

#### 4.1.1 Welfare-Maximizing Public Monopoly with a Binding Budget Constraint

With a public monopoly operating subject to a binding budget constraint the welfare-maximizing quality is given by $q^{BW} = \frac{R}{c}$ according to Result 1 and the associated market coverage is determined

by $\tilde{\lambda}^{BW} = \text{sc}$. Substitution of this combination of $q^{BW}$ and $\tilde{\lambda}^{BW}$ into (12) yields the following condition for the socially optimal co-payment rate:

$$W'(s) = (R(1-s) - \mu)c = 0.$$

Consequently we can conclude that the socially optimal co-payment rate is given by

$$s^{BW} = 1 - \frac{\mu}{R}. \tag{12}$$

In this market configuration the quality-promoting effect of the co-payment rate is absent, and the ratio between the social cost for each consumer excluded from the health care service ($\mu$) and the reimbursement per served consumer (R) is a very important component of the socially optimal co-payment rate. In particular, in the absence of any social costs associated with excluded consumers it would be socially optimal to make consumers bear the full costs of the service.

### 4.1.2 Private Monopoly

With a monopoly the profit-maximizing quality depends on the co-payment rate according to $q^M = \text{R}\sqrt{\frac{s}{c\bar{\lambda}}}$ (see, Result 2) and the associated market coverage is determined by $\tilde{\lambda}^M = \sqrt{c\bar{\lambda}s}$. With private ownership of the monopoly supplier, quality is strictly increasing as a function of the co-payment rate, $q_s^M(s) = \frac{1}{2}R\sqrt{\frac{1}{c\bar{\lambda}s}} > 0$. Substitution of this combination of $q^M$ and $\tilde{\lambda}^M$ into (12) yields the following condition for the socially optimal co-payment rate:

$$W'(s) = \frac{R}{4}\sqrt{\frac{1}{c\bar{\lambda}s}}(\bar{\lambda}^2 - c\bar{\lambda}s) + (R(1-s)-\mu)\frac{1}{2}\sqrt{\frac{c\bar{\lambda}}{s}} = 0.$$

By solution of this first-order condition we find that the socially optimal co-payment policy is given by[11]

$$s^M = \frac{1}{3}\left(\frac{\bar{\lambda}}{c} + 2(1 - \frac{\mu}{R})\right) > s^{BW}, \tag{13}$$

where the inequality follows from the assumption that $\bar{\lambda} >$ c. Thus, given the market structure with monopoly the ownership structure matters for optimal the optimal co-payment policy. We can draw the following general conclusion:

**Result 5** The socially optimal co-payment rate with a private monopoly, $s^M = \frac{1}{3}\left(\frac{\bar{\lambda}}{c} + 2(1 - \frac{\mu}{R})\right)$, exceeds that with a public monopoly operating with a balanced budget constraint, $s^{BW}$ = 1 - $\frac{\mu}{R}$.

The private monopoly does not pay attention to consumer surplus, and for that reason it induces a distortion. This distortion calls for a stronger financial inducement with a private monopoly supplier than with a public one. This is aggravated by that fact that higher qualities are more costly to produce.

## 4.2 Optimal Co-Payment Policy with a Mixed Duopoly

We next characterize the optimal uniform co-payment policy in a mixed duopoly, where, as in subsection 3.3, public supplier offers a standardized service of quality $q_1$(s) , whereas the private supplier offers a service of quality $q_2$(s) with $q_2$(s) > $q_1$(s).

With qualities characterized in Result 4, the policy maker determines the co-payment policy in order to solve the optimization problem

$$max_s W(s) = N\int_{\tilde{\lambda}}^{\hat{\lambda}} \lambda q_1(s) f(\lambda) d\lambda + N\int_{\hat{\lambda}}^{\bar{\lambda}} \lambda q_2(s) f(\lambda) d\lambda - N\int_{\tilde{\lambda}}^{\bar{\lambda}} R f(\lambda) d\lambda - N\int_0^{\tilde{\lambda}} \mu f(\lambda) d\lambda, \tag{14}$$

[11]It can be verified in a straightforward way that W(s) is a strictly concave function of s, implying that the first-order condition is also a sufficient condition for a maximum.

where $\tilde{\lambda}(s) = \dfrac{sR}{q_1(s)}$ and $\hat{\lambda}(s) = \dfrac{p}{q_2(s) - q_1(s)}$. In (14), the first two terms measure the total social benefits to all those consumers who are served the public and the private supplier, respectively. The third term is a representation of the costs to the government of funding the service by reimbursing the health care suppliers at the rate R for each served consumer, whereas the fourth term captures the total social costs associated with all the excluded consumers.

Imposing the uniform distribution we see that the optimal co-payment rate has to satisfy

$$W'(s) = \hat{\lambda} q_1 \frac{\partial \hat{\lambda}}{\partial s} - \tilde{\lambda} q_1 \frac{\partial \tilde{\lambda}}{\partial s} + \int_{\tilde{\lambda}}^{\hat{\lambda}} \lambda \frac{\partial q_1}{\partial s} d\lambda + \int_{\hat{\lambda}}^{\bar{\lambda}} \lambda \frac{\partial q_2}{\partial s} d\lambda - \hat{\lambda} q_2 \frac{\partial \hat{\lambda}}{\partial s} + R \frac{\partial \tilde{\lambda}}{\partial s} - \mu \frac{\partial \tilde{\lambda}}{\partial s} = 0. \tag{15}$$

Substitution of the qualities characterized in Result 4 immediately implies that $\hat{\lambda}$(s) = $\sqrt{c\bar{\lambda}}$, , which is independent of the co-payment rate. This feature simplifies the characterization of the optimal co-payment policy considerably. Taking this feature into account we can conclude that the necessary first-order condition associated with (14) can be simplified to

$$W'(s) = (R(1-s) - \mu) \frac{\partial \tilde{\lambda}}{\partial s} = 0, \tag{16}$$

where $\dfrac{\partial \tilde{\lambda}}{\partial s}$ = c. Consequently, we have shown the following result[12]

**Result 6** *With a mixed duopoly the socially optimal co-payment policy is characterized by* $s^*$ = *1* - $\dfrac{\mu}{R}$.

Comparing Result 6 with (13) we can conclude that the optimal co-payment policy is invariant to the introduction of private competition directed towards consumers with higher preference for the health care service. This property implies that the proportion of excluded consumers is invariant to market structure. This means that introduction of private competition targeting consumers with

[12]It can be verified in a straightforward way that the objective function (14) is strictly concave, i.e. that the sufficient second-order condition is satisfied.

a stronger preference for the service does not expand the number of consumers served when the optimal co-payment policy is implemented. Again, this does not preclude segment-specific gains to consumers from the introduction of competition. Actually, when the optimal co-payment policy is implemented, all consumers with $\lambda > \hat{\lambda} = \sqrt{c\bar{\lambda}}$ benefit from the introduction of competition shifting the market structure from a public monopoly into a mixed duopoly.

# 5 Concluding Discussion

In this study we have characterized the effects of ownership in the health care industry on quality provision, market coverage and optimal co-payment policy. We demonstrated that a private monopoly selects a lower quality, leading to lower market coverage, compared with a public supplier. We also showed that the optimal co-payment rate with a private monopoly exceeds that with a public monopoly. Also, we explored the effects of the introduction of private high-quality competition into a health care industry with a public incumbent. In such a configuration we established analytically that the quality equilibrium is characterized by differentiated services with the property that the quality offered by the public supplier is invariant to the introduction of competition. We demonstrated that this feature leads the optimal co-payment policy to be invariant to the introduction of private competition. Thus, we concluded that market coverage is invariant to the introduction of competition, meaning that the introduction of competition from a private high-quality supplier is not a mechanism to eliminate potential problems associated with exclusion of consumers with a low valuation of quality. Consequently, according to our model the optimal co-payment rate depends on the type of ownership of the service provider (private or public), but not on the market structure (public monopoly or mixed duopoly). However, as we emphasized, our model does not by any means rule out welfare gains from competition. In fact, we argued that all

consumers with preference for the high-quality service are better off with competition and this is an important social benefit from a shift in market structure from a public monopoly to a mixed duopoly.

Our results have strong implications for a spectrum of highly topical policy issues relevant for the health care sector. Here we highlight a few of those. Our characterization of how optimal co-payment policy depends on ownership and market structure has direct links to evaluations of Obamacare, because co-payment policy is a crucial determinant of the proportion of consumers excluded from health care services. For countries with public care monopolies, such as Canada, our analysis of the consequences of the introduction of competition suggests that private for-profit entry should be promoted. For countries with competing service providers of different types (e.g., the U.S.) there is reason to believe that antitrust concerns are legitimate in areas where those service providers are being consolidated.

Our results are suggestive regarding the controversial distributional effects of co-payments on the provision of healthcare service, in particular the effects on the lower end of the income distribution. There are reasons to expect a strong correlation between the income distribution and the distribution regarding the willingness to pay for quality, which has formally been the dimension along which consumers are differentiated in our analysis. If there is such a correlation, our analysis characterizes the effects of ownership structure and the introduction of competition on exclusion of consumers with lower income from health care services. Our study also characterizes the exclusion implied by socially optimal co-payments. To avoid such income effects some governments have provisions for income adjusted co-payments.

Our study abstracts from a number of significant features. Throughout our study the reimbursement rate was considered to be exogenous for reasons related to the transparency of the economic

mechanisms involved. From the perspective of a structural, long-term welfare analysis of the health care system with an ambition to explain public resource allocation between different sectors (health care versus education and so on) it would be important that the reimbursement is endogenously determined in combination with the co-payment policy. This is a particularly serious concern if there are significant distortions caused by raising the public funds needed to facilitate a public reimbursement policy. Under such circumstances there would be an important tradeoff between those distortions and the quality-promoting effects of the reimbursements. Our present analysis does not focus on the public resource allocation between sectors and we have therefore not incorporated any distortions associated with the public financing of the health care service. Our study focuses instead on co-payment policy as a mechanism to promote efficiency within the health care sector.

Our model has focused on a restricted class of co-payment policies, namely policies whereby consumers themselves cover a certain proportion of the health care expenses. However, many real-world health care insurance programs, public as well as private ones, specify that the patient is responsible for fixed sum of money per unit of provided health care service. Our model could be extended to explore the robustness of our findings to alternative, empirically relevant forms of co-payment policies[13]

Throughout our study we have also assumed that consumers are perfectly informed about the quality of the available services. This is hardly a particularly accurate description of health care services where consumers are typically poorly informed[14] and often heavily insured with weak incentives to acquire information. In addition, as emphasized by Katz (2013), it may be difficult for consumers to assess quality even after consumption. It remains for future research to evaluate the robustness of our conclusions to health care markets where the consumers have imperfect

[13]Barros and Martinez-Giralt (2002) present a valuable approach in this direction.

[14]Gravelle and Sibley (2010) and Brekke et al (2012) have developed models to analyze health care markets where consumers have imperfect quality information.

information regarding quality.

Finally, still another avenue for fruitful future research would be the inclusion of service providers with different productivities in light of the empirical results of Chandra, et. al. (2012). In our model this feature could be implemented in the form of supplier-specific marginal costs of quality. If such differences in productivity were related to ownership it would affect the market shares of the public and private services providers, thereby having welfare implications relevant for evaluations of the introduction of private competition.

# 6 Appendix A The Nash equilibrium with respect to the quality decisions in the mixed duopoly

The optimization problem (7) combined with the constraint (8) means that the public service provider decides in quality $q_1$ in order to solve

$$max_{q_1} \quad \Gamma(q_1, q_2) = N \int_{\tilde{\lambda}}^{\hat{\lambda}} (\lambda q_1 - R) f(\lambda) d\lambda \tag{A1}$$

The optimization problem facing the private firm can be written as

$$max_{q_2} \quad \pi_2(q_2, q_1) = N \int_{\hat{\lambda}}^{\bar{\lambda}} (R + p - cq_2) f(\lambda) d\lambda \tag{A2}$$

Based on straightforward differentiation of the objective function in (A1) we find that

$$\frac{\partial \Gamma_1}{\partial q_1} = \frac{N}{\bar{\lambda}} \left[ \int_{\tilde{\lambda}}^{\hat{\lambda}} \lambda d\lambda + (\hat{\lambda} q_1 - R) \frac{\partial \hat{\lambda}}{\partial q_1} + (1 - s) R \frac{\partial \tilde{\lambda}}{\partial q_1} \right], \tag{A3}$$

where $\frac{\partial \hat{\lambda}}{\partial q_1} = \frac{\hat{\lambda}}{(q_2 - q_1)}$ and $\frac{\tilde{\lambda}}{\partial q_1} = -\frac{\tilde{\lambda}}{q_1}$. Further, by differentiation of (A3) again with respect to $q_1$

we find that the second-order derivative of the objective function in (A1) can be written according to

$$\frac{\partial^2 \Gamma_1}{\partial q_1^2} = \frac{N}{\bar{\lambda}} \left[ \frac{2\hat{\lambda}^2}{(q_2 - q_1)} + \frac{\tilde{\lambda}^2}{q_1} + (\hat{\lambda} q_1 - R) \frac{2\hat{\lambda}}{(q_2 - q_1)^2} + R(1-s) \frac{2\tilde{\lambda}}{q_1^2} \right] \tag{17}$$

It can directly be seen that all the terms in (A4) are positive with the potential exception of the third term. As for the third term we observe that the constraint $\hat{\lambda} > \tilde{\lambda}$ is equivalent to the inequality p $> \frac{sR}{q_1}(q_2 - q_1)$, which has to hold true for all feasible values of s. This requirement implies that $\hat{\lambda}\ q_1$ - R $> 0$, guaranteeing that also the third term in (A4) is positive. Consequently, we have shown that the constraint $\hat{\lambda} > \tilde{\lambda}$ implies that second-order derivative in (A4) is strictly positive, i.e. that the objective function (A1) is strictly convex.

Therefore, the necessary first-order condition does not yield a maximum, but the maximum is located at the highest feasible level $q_1^* = \frac{R}{c}$ . In order to make sure that $q_1^* = \frac{R}{c}$ defines the equilibrium quality for the public service provider we still have to check the proposed equilibrium qualities do not violate the constraint $\hat{\lambda} > \tilde{\lambda}$.

We next shift our attention to the quality decision of the private high-quality supplier. The first-order condition associated with the optimization problem (A2) is given by

$$\frac{\partial \pi_2}{\partial q_2} = \frac{N}{\bar{\lambda}} \left[ -c \int_{\hat{\lambda}}^{\bar{\lambda}} d\lambda - (R + p - cq_2) \frac{\partial \hat{\lambda}}{\partial q_2} \right] = 0, \tag{18}$$

where $\frac{\partial \hat{\lambda}}{\partial q_2}$ = - $\frac{\hat{\lambda}}{(q_2 - q_1)}$. Substituting $q_1^* = \frac{R}{c}$ and solving the first-order condition (A5) demonstrates that equilibrium quality for the private supplies is given by $q_2^* = \frac{R}{c} + p\sqrt{\frac{1}{c\bar{\lambda}}}$. It can directly be verified that the objective function in (A2) is strictly concave, meaning that the solution to (A5) yields the equilibrium quality.

It remains to verify that the equilibrium configuration $q_1^* = \frac{R}{c}$ and $q_2^* = \frac{R}{c} + p\sqrt{\frac{1}{c\bar{\lambda}}}$ is consistent with the constraint $\hat{\lambda} = \tilde{\lambda}$. This actually holds true, because with this equilibrium configuration $\hat{\lambda} = \tilde{\lambda}$ is equivalent with the inequality p > p $\sqrt{\frac{1}{c\bar{\lambda}}}$ which holds true as a consequence of our assumption according to which $\bar{\lambda} >$ c.

**QED**

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