Quality Competition and Uncertainty in a Horizontally Differentiated Hospital Market

Marcello Montefiori

Abstract The chapter studies hospital competition in a spatially differentiated market in which patient demand reflects the quality/distance mix that maximizes their utility. Treatment is free at the point of use and patients freely choose the provider which best fits their expectations. Hospitals might have asymmetric objectives and costs, however they are reimbursed using a uniform prospective payment. The chapter provides different equilibrium outcomes, under perfect and asymmetric information. The results show that asymmetric costs, in the case where hospitals are profit maximizers, allow for a social welfare and quality improvement. On the other hand, the presence of a publicly managed hospital which pursues the objective of quality maximization is able to ensure a higher level of quality, patient surplus and welfare. However, the extent of this outcome might be considerably reduced when high levels of public hospital inefficiency are detectable. Finally, the negative consequences caused by the presence of asymmetric information are highlighted in the different scenarios of ownership/objectives and costs. The setting adopted in the model aims at describing the up-coming European market for secondary health care, focusing on hospital behavior and it is intended to help the policy-maker in understanding real world dynamics.

Keywords Competition · Hospitals · Information · Quality

JEL Classification I11 · I18 · L13

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1 Introduction

Patient mobility for medical care is a relatively new phenomenon that continues to grow in importance at national and international level. Patient mobility within national borders is already well established in a number of European countries, even if the organization of the health care market is quite different from country to country. In Italy, the ever greater financial autonomy and devolution enjoyed by the regions (that began in the mid-nineties) has determined the creation of very diverse and independent regional health services. However, it is the patient's right to choose the provider he prefers, both from within and outside the regional borders, from either the public or private[1] providers. Furthermore it has to be noticed that patients do not pay[2] for the health service they receive (even when it is provided by private hospitals) because the national/regional health service is publicly funded by general taxation (Montefiori 2005; Levaggi and Montefiori 2013). This setting, where patients are free to choose the hospital they prefer from public and private ones, is seen in an increasing number of European Countries with public health care systems (Gravelle and Sivey 2010; Montefiori 2005; Montefiori 2008; Appleby and Dixon 2004; Vrangbaek and Ostergren 2006).

There is a similar system in Spain. Hospitals are reimbursed by prospective payment (DRG based) and patients are free to choose the provider they prefer from either the public or accredited private institutions belonging to the "Areas de Salud" ("Health Areas"). In France, patients receive guidance from general practitioners and they choose from public and private health care providers. The hospital's activity is reimbursed by a mixed system which consists of two components: a block grant and a prospective payment.

However, the crucial point on which we want to focus attention is that nowadays, because of the process of globalization, even cross-border health mobility is growing in relevance and importance.

A recent European Directive (Directive 2011/24/EU) of the European Parliament states the right of EU patients to be financially covered in the event that they go to another country to receive healthcare services, under the condition that they were also offered it by their own health system (Brekke et al. 2012b). However there is still a lot of discretion left to member states to establish the rules and terms of reimbursement, and the problem remains indeed unsolved.

"While citizens in the EU, in principle, are free to seek health care wherever they want and from whatever provider available, in practice this freedom is limited by their ability to pay for it or by the conditions set out by public and private funding systems for health care" (Palm and Glinos 2010).

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[1] To note that a private hospital that wishes to be "accredited" has to meet specific requirements set by the national and regional government. In particular, private hospitals that want to work for the public sector are required to meet the quality standard and accept the same prospective reimbursement (DRG based) provided for public hospitals (Levaggi and Montefiori 2013).

[2] But a possible co-payment might be required from the patient in some circumstances.

The goal of patient mobility is subject to the conditions of international agreements between countries. If patients were free to choose the provider they prefer among those within the EU and the service was still free at the point of use (for example, by defining a sort of "mobility DRG tariff" to compensate for the inwards/outwards movement of patients) then a quality-competitive market would take place at EU level, with positive outcome both in terms of efficiency and quality (Chalkley and Malcomson 1998a, b; Gravelle 1999; Gravelle and Masiero 2000, 2002; Ma 1994; Montefiori 2008).

Hence we are going in the direction of an integrated international health care market[3] in which hospitals that differ from each other in terms of costs, characteristics and objectives compete for patients. However, at the same time, in this broadening market also the demand (i.e., the current patient characteristics) may differ noticeably depending on the country of origin.

In particular, the perception and expectation of the quality level provided by the hospital might be differently biased: because of the asymmetry of information that characterizes the health care market, the actual quality provided by the hospital might be incorrectly observed in a stochastic framework (Gravelle and Masiero 2000, 2002; Montefiori 2005, 2008). It is evident that uncertainty plays a crucial role in conditioning hospital behavior.

This chapter aims to investigate different scenarios in which hospitals compete for patients in a spatially differentiated market. In particular, the issues of uncertainty and asymmetric objectives will be jointly considered. The model that will be used assumes that hospitals are paid by prospective payments that consist of a fixed price per treated patient (Levaggi 2005, 2007; Montefiori 2008). The price is set as the average cost incurred by hospitals when treating a patient with a specific diagnosis. In addition, it is assumed that patients do not pay for the health services they receive since they are obtained free of charge at the point of use.

The afore-mentioned setting should create a quality-competitive hospital market, i.e., a market in which providers compete on quality in order to attract patients. In fact, since the health service is free at the point of use and the price is fixed, the only means at a hospital's disposal to increase the number of patients (and the revenue) is to invest on quality. Note that the same result is expected to be obtained in the case where all patients are assumed to be insured or when a copayment is required (both in the case of a tax financed health care system and of a private insurance) under the condition that copayments do not vary among hospitals for the same treatment/diagnosis.

In order to analyze the quality-competitive, horizontally differentiated market, the basic model presented in Montefiori (2005) is used and extended.

The model in Montefiori (2005) focuses on the effects of competition between two hospitals that are symmetric in terms of costs and objectives. Hospitals are profit maximizers and compete for patients on quality in a Hotelling type spatially

[3] In general, patient mobility within the EU is negligible, however there are exceptions of countries and regions that cope with high level of mobility flows (Palm and Glinos 2010).

differentiated market (Hotelling 1929). That paper introduced the new approach of mean–variance in order to take into account the problem of uncertainty. This biases the patient's perception of the quality level provided by hospitals for medical services.

However the study presented in this paper differs considerably from Montefiori (2005) because of a very different setting in terms of hospital (asymmetric) objectives and differentiation in terms of costs. Furthermore, a new type of uncertainty is proposed and its consequences for the market equilibrium outcome are analyzed.

The present study aims to analyze the effects of effective competition on quality among providers from the theoretical point of view and by numerical simulations. The opinion of the author is that the model used in this paper fits well the current/forthcoming scenario where hospitals compete for patients within a macro-area such as the EU. However it also applies to a "within-the-home state" competition scenario.

The chapter will be organised as follows: in Sect. 2 the model is presented. The subsequent Sect. 3 provides the analysis of the equilibrium when a simultaneous Nash–Cournot competition takes place. Section 4 presents the sequential Stackelberg quality choice equilibrium in the case when hospitals have symmetric objectives but asymmetric costs. The implications of uncertainty and the definition of "perceived quality", which might be biased with respect to the actual quality, are introduced in Sect. 5. Numerical simulations referring to all the scenarios previously studied from the theoretical point of view are reported in Sect. 6. Finally Sect. 7 summarizes the main conclusions.

2 The Model

The purpose of this paper is the study of hospital health care using a Hotelling-spatial-competition model. A simple linear Hotelling-type market is considered. A mass of patients (for simplicity normalized to 1) is uniformly distributed on a unit-length line market. Each patient demands only one medical treatment. It is assumed that the market is served by only two hospitals ($i = A, B$) whose location is exogenously set at the two extremes of the line.

In order to analyze the quality-competitive, horizontally-differentiated market, the basic model presented in Montefiori 2005 is used and extended.

2.1 Hospitals

Two distinct hospitals compete for patients and they might pursue symmetric or asymmetric objectives. When the two hospitals are both private or public, then it is assumed that they have symmetric objectives. However when a private hospital competes with a publicly owned one, then a mixed market with asymmetric objectives takes place. For private hospitals profit maximization is generally the most common assumption. Public hospitals are, in contrast, heterogeneous in their objectives. In this work it is assumed that the public hospitals may pursue alternatively two different objectives: profit maximization and quality maximization. The latter reflects, to some extent, one of the scenarios suggested in Levaggi and Montefiori (2013) under the behavior that the authors name as "excellence" but with the striking difference that in the present paper the budget constraint is hard (both for the public and the private hospital).

The hospital receives a prospective reimbursement M for each patient. The number of patients depends on the demand D which in turn depends on the quality differential between the two hospitals

The hospital cost function depends on: (i) the number of patients (i.e., the demand D); (ii) the hospital specific cost parameter c_i; (iii) the quality level provided. For simplicity and without loss of generality the fixed costs are set to zero.

Therefore the hospital profit function can be written as:

$$\pi_i = [M - c_i q_i] D_i. \tag{1}$$

The hospital participation constraint is met when the purchaser is able to set a contract that grants the hospital (at least) its reservation profit which is set equal to zero. In our model this implies: $M \geq c_i \bar{q}_i$ where $\bar{q}_i > 0$ is a given level of quality exogenously set by the regulator and that might be different from that which the hospital sets.

The only choice variable for the hospital is its own quality level.

2.2 Patients

Patients aim at utility maximization. This is positively affected by quality and negatively affected by distance. As already stated, patients receive the medical care they require free of charge at the point of use since a public health care system funded by general taxation is assumed. Nonetheless, patients face traveling costs related to the distance of the health care provider. The key elements that causes stiffness in healthcare mobility are, in fact, the monetary costs (but also the non-monetary ones) related to mobility that are not covered by the national health system. A high quality level provided by hospitals located far away, might motivate patients to meet monetary and non-monetary costs inherent in traveling for care (Levaggi and Montefiori 2013; Montefiori 2005; Sanjo 2009). The non-monetary costs are generally related to the patients' preference in receiving care close to home (and possibly in one's own country) where relatives are able to come to visit and patients themselves feel comfortable with an environment they know (Montefiori 2005).

Quality and distance affect the utility function by means of the α and the γ parameters respectively. The γ parameter synthesizes rigidity in patient mobility which is mainly due to individual preferences (Brekke et al. 2011b; Montefiori 2005). This, for example, might be determined because of cultural and language differences among countries.[4]

$$U = v + \alpha q_i - \gamma d_i; \quad i = a,\ b \tag{2}$$

where q_i is the quality level provided by hospital i: the higher the quality the higher is the patient's utility; d_i is the patient distance from hospital i: the greater the distance from the hospital the lower is the patient's utility; v is the valuation of the treatment (Brekke et al. 2006, 2011a, b; Herr 2011) and it is assumed to be high enough to meet the patient's participation constraint even when the quality level set by the hospital is set equal to zero. In this paper the minimum quality level that the hospitals are forced to provide in order to avoid malpractice is assumed to be zero (Chalkley and Malcomson 1998a, b; Montefiori 2008). These assumptions ensure full market coverage.

The location of the marginal patient, that is the patient who is indifferent between hospital i and hospital j, is: $d_i = \frac{\alpha}{2}\left(q_i - q_j\right) + \frac{1}{2};\ \ i,\ j = a,\ b;\ i \neq j.$

Because the mass of patients uniformly distributed on the unit-length line market is normalized to 1, then the location of the marginal patient d_i is also the demand D_i for hospital $(i = a,\ b)$.

2.3 Social Welfare

In this chapter we are also interested in evaluating the equilibriums in light of the effects on welfare. Coherently with the existing literature, social welfare is considered as the sum of individuals' payoffs. Henceforth two addendum have to be jointly considered: the hospital and the consumer surpluses.

The consumer surplus, knowing that patients are uniformly distributed on the unit-length line market and that the market is fully covered, is given by the sum of the surplus referred to those receiving the treatment from hospital A and the surplus of those receiving treatment from B:

$$S_i = \int_0^{D_i} U(q_i,\ l_i)\, dl_i \tag{3}$$

where S_i is the overall surplus attained from patients receiving medical care from hospital i $(i = a,\ b)$.

[4] In some cases the disutility in distance γ is interpreted in relation to the utility in quality α (Brekke et al. 2012a), i.e., by normalizing α to 1 and interpreting γ as a relative marginal disutility.

Note that, for sake of clarity, the letter d in Eq. 2 (referring to patient's distance from hospital) has been substituted with the letter l (maintaining exactly the same meaning of d) in order to avoid chaos in the formula for integrals.

Using Eq. 1 and summing it up with 3, the social welfare W can then be defined as:

$$W = \sum_{i=a}^{b} \pi_i + \sum_{i=a}^{b} S_i. \tag{4}$$

3 The Simultaneous Nash–Cournot Equilibrium

3.1 Benchmark

In this section the hypothesis of two hospitals with symmetric costs and symmetric objectives, that compete in a context of perfect information, is assumed. This scenario is intended to be the benchmark[5] to which we compare the next ones.

The hospitals aim at profit maximization. This is the case when two private hospitals compete for patients, or, alternatively, when the public hospitals pursue the profit maximization goal.

Hospitals behave strategically in a non-cooperative game by setting the quality level that maximizes the profit. Because hospitals perfectly know other hospitals best reply, they set their quality taking into account the competitor's reaction. The quality setting is provided in Eq. 5

$$q_i = \frac{M}{c} - \frac{\gamma}{\alpha}; \quad i = a,\ b. \tag{5}$$

3.2 Symmetric Objectives but Asymmetric Costs

In this scenario it is assumed that both hospitals maximize their profits but they face different marginal production costs. The context is still that of perfect information. Again, the non-cooperative game is solved to identify the Nash-equilibrium quality level

$$q_i = \frac{M}{3}\left(\frac{2}{c_i} + \frac{1}{c_j}\right) - \frac{\gamma}{\alpha}. \tag{6}$$

Substituting Eq. 6 in 1, the Nash equilibrium hospital's profit can be identified:

[5] The benchmark coincides with the results provided in Montefiori (2005).

$$\pi_i = \frac{\left(\mathrm{M}\alpha c_i - \mathrm{M}\alpha c_j - 3\gamma c_i c_j\right)^2}{18 c_i c_j^2 \alpha\gamma}; \quad i,j = a,\ b; \ \ i \neq j. \tag{7}$$

Looking at Eq. 7 it clearly emerges that when hospitals face the same cost c (i.e., $c_{\mathrm{a}} = c_b = c$) then the hospitals provide the same quality level (Eq. 5) and get the same level of profit $\frac{c\gamma}{2\alpha}$.[6]

Assuming that the hospital's participation constraint is met and that $c_i < c_j \leq M$, then the equilibrium level for quality will be $q_i > q_j$. The market share is then given by:

$$D_i = \frac{1}{2} - \frac{\Omega}{6}; \quad \mathrm{i} = \mathrm{a},\ \mathrm{b}$$

where:

$$\Omega = \frac{M\alpha\left(c_i - c_j\right)}{\gamma c_i c_j}; \ \text{and} \ -3 \leq \Omega \leq 3; \ \mathrm{i,j} = \mathrm{a},\ \mathrm{b}; \ \mathrm{i} \neq \mathrm{j}. \tag{8}$$

Ω assumes value zero when $c_i = c_j$; the two hospitals will equally share the market.

Ω will be greater than zero when $c_i > c_j$ and lower than zero when $c_j > c_i$.

The more efficient hospital will be able to get a larger share of the market by the higher quality level it will be able to provide with respect to the competitor. As a consequence, higher profits are expected.

3.3 Asymmetric Objectives and Asymmetric Costs

It is possible that the two hospitals have asymmetric objectives. In fact, if, on the one hand, profit maximization is a reasonable assumption for private hospitals, on the other, public hospitals may pursue objectives different from profit maximization, such as social welfare or reputation (see Levaggi and Montefiori (2013) for details), In this section it is assumed that the public hospital A aims at quality maximization (under the assumption of hard budget constraint) while the private hospital B still aims at profit maximization. This setting reflects to some extent the "excellence" case provided in Levaggi and Montefiori (2013) but with the striking difference that, in their model, the public hospital interprets its budget as soft and that the regulator systemically bails out the public hospital deficit.

Henceforth in this section it is assumed that the public hospital aims at quality maximization under the assumption of hard budget constraint. In order to avoid negative profit, hospital A takes into account hospital B's best reply, and sets the

[6] See Montefiori (2005) for details.

maximum quality that can be provided, avoiding the risk of incurring negative profits. In doing so the public hospital's quality setting is:

$$q_a = \frac{M}{c_a}. \tag{9}$$

The hospital B quality level can then be written as:

$$q_b = \frac{1}{2}\left(\frac{M}{c_a} + \frac{M}{c_b} - \frac{\gamma}{\alpha}\right). \tag{10}$$

From Eq. 10 it is possible to derive the market share served by each hospital:

$$D_a = \frac{3}{4} - \frac{\Omega}{4}; \ D_b = \frac{13}{4} + \frac{\Omega}{4}. \tag{11}$$

Equation 10 suggests that in most cases hospital A will provide higher quality with respect to the private hospital B. This implies that when the two hospitals have the asymmetric objectives presented in this scenario but the same marginal cost c then the public hospital market share will be 75 % of the entire market. However, this share might be reduced when the public hospital is inefficient, i.e., when $c_a < c_b$. In fact, because of public hospital inefficiencies, it could be the case that q_b was not lower than q_a. In particular this applies when the following condition is met:

$$c_a \geq \frac{Mc_b\alpha}{M\alpha - \gamma c_b}. \tag{12}$$

It is straightforward to verify that, when condition 12 holds with equality, the two hospitals provide the same quality level[7] and, as a consequence, they equally share the market.

4 The Sequential Stackelberg Equilibrium: Symmetric Objectives but Asymmetric Costs

When hospitals differ in management or size, a sequential game might take place. Assuming hospital A to be public (or a large hospital) and B private (or a small hospital), then one might expect that the former was the leader while the latter the follower, in a sort of Stackelberg sequential game.

In this section it is assumed that both hospitals, regardless of their ownership, maximize profits and it is assumed that they face different marginal costs (due to their dimensional structure, for instance).

Hospitals share the market with reference to a single DRG.

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[7] $q = \frac{M}{c} - \frac{\gamma}{\alpha}$.

The leader tries to take advantage of the fact that it is the first mover. However this advantage does not result in a better outcome with respect to the competitor's. Let's see the timing of the game.

The leader moves first taking the follower's best reply into account. The follower observes the quality level set by the leader and, in turn, sets its profit maximizing quality level.

The equilibrium quality settings for hospital A and hospital B will turn out to be:

$$q_a = \frac{M}{2}\left(\frac{c_a + c_b}{c_a c_b}\right) - \frac{3\gamma}{2\alpha} \tag{13}$$

$$q_b = \frac{M}{4}\left(\frac{c_a + c_b}{c_a c_b}\right) + \frac{M}{2c_b} - \frac{5\gamma}{4\alpha} \tag{14}$$

while the market share is, respectively:

$$D_a = \frac{3}{8} - \frac{\Omega}{8};\ \ D_b = \frac{5}{8} + \frac{\Omega}{8}. \tag{15}$$

Equations (13) and (14) suggest that for any $c_a > \frac{M\alpha c_b}{M\alpha + \gamma c_b}$ the quality provided by hospital B will be greater than the quality provided by A ($q_a < q_b$).

The demand function of each hospital reflects the quality level provided.

It is straightforward to grasp from the conditions above that, under the assumption that the two hospitals face the same marginal cost ($c_a = c_b$), the leader turns out to be the loser. The counterintuitive outcome obtained, comes from the two-stage game we have defined. The hospitals compete on quality, given the fixed price M per treated patient. The hospital which sets its quality level first loses, even when it takes the competitor's reaction function into account. In fact, the follower observes the leader setting its quality and, only at a second stage, sets its quality level in order to maximize its profit. The hospital will find it profitable to set a slightly higher quality with respect to the rival. By this behavior the follower gets a larger share of the market ($D_b > D_a$) and in so doing it increases its profit. Summing up, in the case that both hospitals face the same costs and have the same revenue function, the second mover wins. Few authors, with reference to industrial economics, have found something similar. For instance Beato and Mas-Colell (1984) find, under specific assumptions, the same odd result. However, in the long-run, the interesting result is that the sequential equilibrium converges towards the simultaneous equilibrium outcome that we have identified in the previous sections.[8]

[8] The two-stage sequential competition on quality can be extended dynamically. The equilibrium outcome found is not actually dynamically stable. The hospitals will move from it in subsequent stages of the game. If we preserve the game structure of the equilibrium, we can assume the leader will be able to react to the follower's behavior in the next stage of the game. The leader will respond to the follower's quality, maximizing a new objective function where the

5 Uncertainty

Up to this point, perfect observation of quality level, by patients, has been assumed. However this assumption is not respondent to the health care market in which it is unrealistic to consider perfect information, at least with reference to patients' ability to observe the actual quality level provided by hospitals. For this reason, in this section the perfect information assumption is relaxed and patients' biased observation of quality is introduced. To cope with this issue the Montefiori (2005) model is extended (refer to it for details) in this section. Patient behavior is affected by the "perceived quality" $\tilde{q}$ which depends on the actual quality and on an error term:

$$\tilde{q}_i(q_i,\ \varepsilon_i)\ \text{where}\ \varepsilon_i \sim N(0,\ \sigma_i^2).$$

Basically, the model suggested in Montefiori (2005) is adopted here but with the striking difference that the error term is characterized by heteroskedasticity; its variance σ^2 varies according to a patient's distance from the hospital.

Patient utility can then be written as[9]:

$$U_{pz}^i = \alpha q_i - \gamma d_i - \beta \sigma_i^2 d_i \qquad (16)$$

where $\tilde{q}$ is the perceived quality and σ_i^2 is the variance of the error term weighted by the distance parameter d. When patients are close to the hospital $(d \to 0)$ then the model assumes an error variance which tends to zero. On the other hand, a larger value for d allows for larger uncertainty, represented by an error term variance that tends to σ_i^2 $(d \to 1)$.

Solving the simultaneous equation systems represented by the hospital's stochastic reaction functions, the equilibrium levels for quality are derived (Eq. 17).

$$q_i = \frac{1}{3}\left[M\left(\frac{2}{c_i} + \frac{1}{c_j}\right) - \frac{\beta}{\alpha}\left(\sigma_i^2 + 2\sigma_j^2\right)\right] - \frac{\gamma}{\alpha}. \qquad (17)$$

The undesirable consequence in terms of quality deriving from the observation bias is easily detectable from Eq. 17: because of the term $-\frac{\beta}{3\alpha}\left(\sigma_i^2 + 2\sigma_j^2\right)$ that enters the utility function and represents patient uncertainty on quality, the quality equilibrium level provided by hospitals is noticeably reduced. Obviously this turns out to be a gain for the hospitals, in terms of larger profits, and a loss for patients,

(Footnote 8 continued)
competitor's quality is given. In this way we define a third stage new equilibrium. This equilibrium will change again in the fourth stage when the follower will move after the observation of the leader's quality. Unavoidably the long-run equilibrium will converge to that already found in the simultaneous quality choice. Hospitals' long-run dynamic competition converges towards the simultaneous Nash equilibrium. In the long-run hospitals competing in a multi stage game produce the same result as in the simultaneous equilibrium.

[9] See Montefiori (2005) for details and required mathematical steps.

in terms of a reduction in their surplus (this statement will be extended in the simulation section).

6 Simulations

In this section numerical simulations for the scenarios previously investigated are provided. This part aims at providing numerical values to help in grasping information about the equilibrium outcome obtained in the different scenarios.

However, before starting with the numerical analysis, there are general assumptions that have to be set to implement the analysis. All the assumptions declared herewith will remain unchanged for all the simulations presented hereafter, in order to render the outcomes comparable to each other.

Settings are defined in order to render as simple as possible the simulation, but trying to avoid any loss in generality. Assumptions concern the parameters α, γ and M. In particular, the parameter α that refers to the marginal utility of quality is set equal to 1; the parameter γ that refers to the marginal disutility of distance is set equal to 1 and the reimbursement M, received by hospitals for each patient treated, is set equal to c_a times c_b. In order to maintain the reimbursement M constant and equal to μ, the cost c_i is set equal to the ratio $\frac{\mu}{c_j}$, where $i, j = a, b$.

μ is a value exogenously determined and constant.

By these settings we are able to focus on the marginal costs relationship/ratio rather than on the their absolute value (which is not relevant for our purposes). In particular, given an equal value for the reimbursement M, the product of hospitals' marginal costs ($c_a \cdot c_b$) stays unchanged and equal to the constant value μ.

In fact, if we allow one hospital to vary its cost, then, from the general equilibrium point of view, it would mean a "general system" resource injection if costs decrease, and in a resource decrease if the opposite occurs.

An alternative hypothesis that has been considered was to set the reimbursement M equal to the sum of the marginal costs ($c_i + c_j$). By doing this we were able to isolate the relative cost effect and "compensate" for the "endowment" effect. However, it has to be noticed that even with this different setting, the results found in the simulations wouldn't change in relative terms, while they would necessarily change in absolute value.

6.1 Simulation 1: Symmetric Objectives but Asymmetric Costs

The simulation reported in Table 1 provides the results when the two hospitals aim at profit maximization but they face asymmetric costs. The first column refers to the ratio (c_a/c_b) between the two hospitals' marginal costs.

Table 1 Simulation 1

$\frac{c_a}{c_b}$	q_a	q_b	$\sum_{i=a}^{b} q_i$	π_a	π_b	$\sum_{i=a}^{b} \pi_i$	D_a	D_b	Ω	S_a	S_b	$\sum_{i=a}^{b} S_i$	W
0.7	2.40	2.02	4.43	2.51	0.73	3.24	0.69	0.31	−0.19	1.42	0.58	2.00	5.24
0.8	2.30	2.06	4.36	2.16	1.03	3.19	0.62	0.38	−0.12	1.23	0.72	1.95	5.14
0.9	2.22	2.11	4.33	1.85	1.32	3.17	0.56	0.44	−0.06	1.08	0.84	1.92	5.09
1	2.16	2.16	4.32	1.58	1.58	3.16	0.50	0.50	0.00	0.96	0.96	1.91	5.07
1.1	2.12	2.22	4.33	1.34	1.83	3.17	0.45	0.55	0.05	0.85	1.07	1.92	5.09
1.2	2.08	2.27	4.35	1.13	2.05	3.18	0.40	0.60	0.10	0.76	1.18	1.93	5.12
1.3	2.05	2.33	4.38	0.94	2.26	3.20	0.36	0.64	0.14	0.68	1.28	1.96	5.16

The following factors are reported in the subsequent columns: the quality levels provided by hospital A and hospital B respectively; the overall quality level provided; the individual and overall profits; the demand respectively for hospital A and B expressed in terms of market share (D_a and D_b); the surplus of those consumers who demand medical care from hospital A (S_a); the surplus of those consumers who demand medical care from hospital B (S_b); the overall consumer surplus ($S_a + S_b$); and, in the last column, the social welfare W, which is given by the sum of hospital profits and consumer utility.

Looking at Table 1 we can consider the row where the ratio between marginal cost (c_a/c_b) is equal to 1 as the benchmark. This row presents the equilibrium outcome for the different variables of interest when the two hospitals face identical marginal costs. As a consequence, their behavior is symmetric in the sense that they provide the same quality level, serve the same market share and get the same profit.

Moving from the cost equivalence condition (rows above or below the benchmark) we investigate the effects of cost differences between the hospitals. The condition of $c_a/c_b \neq 1$ may also be regarded as a difference in a hospital's efficiency in providing a given level of quality for treating a given number of patients.

Table 1 shows that when the hospital faces lower marginal costs with respect to the competitor, its marginal relative cost for quality decreases and, as a consequence, it has the opportunity to increase its market share by a quality improvement. Remember that it is assumed that one hospital's cost reduction is "compensated" by the other's cost increase in such a way that $c_a\ c_b = \gamma$ and assuming no changes in the reimbursement M. To this extent, differences in marginal costs cause, because of the increase in the overall level of quality, the increase in the patients' surplus but also an increase in the hospitals' overall profits (the loss for the less efficient hospital is more than compensated by the gain for the other).

From the social planner perspective the asymmetry in costs between the two hospitals seems to be a desirable goal. In fact the interesting result that emerges from this scenario is that differences in hospitals' costs increase the patient surplus. This comes from the fact that the overall amount of quality tends to increase as the difference in costs increases, assuming the reimbursement M stays constant. The competition between the two hospitals, when they differ in efficiency (i.e., in their cost parameter c), incentivises the hospital with lower costs to increase the quality (which turn out to be cheaper for him with respect to the competitor's) in order to serve a larger share of the market and earn extra profits.

This result would be reduced for higher levels of γ ($\gamma > 1$) (where γ is the patients disutility because of distance) but increased for higher values of α ($\alpha > 1$) (where α is the patient utility because of quality).

The hypothesis of different marginal costs reflects the case when large sized hospitals compete with small sized hospitals, the latter characterized by a reduced ability to attract patients by means of quality (Montefiori and Resta 2009). Small sized hospitals with a limited catchment area are useful, from the social welfare perspective, in order to avoid negative utility for patients located nearby who, otherwise, are forced to require medical care from the large sized (high quality) hospitals located far away. In fact, for furthest away patients, the greater utility because of the quality level provided is not sufficient to compensate for disutility because of the distance.

6.2 Asymmetric Objectives and Asymmetric Costs

A mixed market where the two hospitals have asymmetric objectives is assumed here. The public hospital (hospital A) pursues the "*excellence*" goal (see Levaggi and Montefiori 2013) through quality maximization, while the private hospital (hospital B) is still interested in profit maximization.

When the public hospital provides a high level for the quality variable, the resultant consequences on profit are difficult to foresee.

On the one hand, a higher quality increases revenue via the demand mechanism, on the other it increases the costs that depend on the quality itself and on the number of patients. Because of the afore mentioned effects and the hard budget constraint, the public hospital has to take into account the private hospital "best reply" in order to avoid negative profits: the increase in cost has to be balanced by an equivalent increase in revenue.

Looking at Table 2 we can observe, with reference to the symmetric cost case (i.e., when the c_a/c_b ratio is equal to 1), a neat overall quality increase. This outcome is due to the higher quality provided by the public hospital, but also to the higher quality provided by the private one. In fact the latter is forced to react to the high quality provided by the competitor by increasing in turn its quality in order to reduce the loss in terms of profit and contain the market share loss. Comparing the benchmark provided in Table 1 with Table 2 (we have to look at the row with $c_a/c_b = 1$ with reference to both tables) we note that the quality provided by A moves from 2.16 to 3.16, while the quality of B from 2.16 to 2.66. This overall quality increase is obtained at the expense of the hospitals' profit. The public hospital's profit is equal to zero, by the "*excellence*" setting. However, hospital B's profit is positive and equal to 0.4. Note that the benchmark hospital B profit was equal to

Table 2 Simulation 2

$\frac{c_a}{c_b}$	q_a	q_b	$\sum_{i=a}^{b} q_i$	π_a	π_b	$\sum_{i=a}^{b} \pi_i$	D_a	D_b	Ω	S_a	S_b	$\sum_{i=a}^{b} S_i$	W
0.8	3.54	2.68	6.22	0	0.04	0.04	0.93	0.07	−0.71	2.85	0.19	3.04	6.28
0.9	3.33	2.67	6.00	0	0.19	0.19	0.83	0.17	−0.33	2.43	0.43	2.86	6.05
1	3.16	2.66	5.82	0	0.40	0.40	0.75	0.25	0.00	2.09	0.63	2.72	5.89
1.1	3.02	2.67	5.68	0	0.75	0.75	0.67	0.33	0.30	1.81	0.81	2.62	5.78
1.2	2.89	2.68	5.56	0	0.90	0.90	0.61	0.39	0.58	1.56	0.98	2.54	5.71
1.3	2.77	2.69	5.46	0	1.16	1.16	0.54	0.46	0.83	1.36	1.13	2.48	5.67
1.37*	2.70	2.70	5.40	0	1.35	1.35	0.50	0.50	1.00	1.23	1.23	2.03	5.24

* Limiting case where condition (12) is met with equality, i.e., $c_a = \frac{Mc_b\alpha}{M\alpha - \gamma c_b}$

1.58. As previously mentioned, the behavior of hospital B is imposed to contain the loss in terms of market share. In fact, that high level of quality provided by A drastically reduces its demand. To cope with this collapse in the demand, it has to invest in (costly) quality. Nonetheless, the private hospital market share falls from 50 % of the benchmark to 25 % of the present scenario.

Moving to patient surplus, a forgone but substantial increase is obtained. From the social welfare perspective the increase in patient surplus overcomes the profit decrease, moving upwards from 5.07 of the benchmark to 5.89.

Simulation 2 highlights the important result that a publicly managed hospital pursuing an objective different from profit maximization could noticeably improve social welfare. This result would be even more amplified in the case that the publicly managed hospital was characterized by high levels of efficiency (i.e., when the c_a/c_b is lower than 1). The presence of a publicly managed hospital which pursues objectives different from profit maximization would ensure the market with higher level of: patient surplus (*S*), general welfare (*W*) and quality (*q*) with respect to the case of Table 1 where two profit maximizer hospitals compete for patients. Unfortunately publicly managed hospitals are generally characterized by higher levels of inefficiencies with respect to privately owned ones. If the afore- mentioned inefficiencies are symbolized by high values of the marginal cost *c*, and these inefficiencies reach the threshold value of $c_a/c_b = 1.37$ (the condition of Eq. 12), then the equilibrium outcome would experience a neat curb in terms both of quality and consumer surplus. In the case of very high values of inefficiency ($c_a/c_b >> 1.37$) for the public hospital, the afore mentioned results may change in sign and a socially undesirable outcome may turn out to be the unavoidable consequence.

6.3 Sequential Stackelberg Equilibrium

Here, the scenario presented in Sect. 4 is analyzed by simulations. The two hospitals have symmetric objectives but they do not move simultaneously. In a sequential-Stackelberg game, hospital A, assumed to be the leader, moves first

Table 3 Simulation 3

$\frac{c_a}{c_b}$	q_a	q_b	$\sum_{i=a}^{b} q_i$	π_a	π_b	$\sum_{i=a}^{b} \pi_i$	D_a	D_b	Ω	S_a	S_b	$\sum_{i=a}^{b} S_i$	W
0.7	1.71	1.68	3.39	2.83	1.77	4.59	0.52	0.48	−1.13	0.75	0.69	1.45	6.04
0.8	1.68	1.76	3.44	2.43	2.04	4.47	0.46	0.54	−0.71	0.67	0.80	1.47	5.94
0.9	1.67	1.83	3.50	2.08	2.27	4.35	0.42	0.58	−0.33	0.61	0.90	1.51	5.86
1	1.66	1.91	3.57	1.78	2.47	4.25	0.38	0.63	0.00	0.55	1.00	1.55	5.80
1.1	1.67	1.99	3.66	1.51	2.65	4.16	0.34	0.66	0.30	0.51	1.10	1.61	5.76
1.2	1.68	2.07	3.75	1.27	2.81	4.08	0.30	0.70	0.58	0.46	1.20	1.66	5.74
1.30	1.69	2.15	3.84	1.06	2.95	4.01	0.27	0.73	0.83	0.42	1.30	1.72	5.73

whereas hospital B, which is the follower, moves after observing the competitor's behavior.

The results of the simulation presented in Table 3 show that the advantage of the first move in this kind of sequential-Stackelberg game is not an real advantage.

Looking at the row where the hospitals face symmetric costs ($c_a/c_b = 1$) of Table 3, it is noticeable that the leader (hospital A) gets a lower profit with respect to the follower (hospital B). In other words, we get the surprising result that the leader is the loser. Because of the Stackelberg competition we observe a general quality curb, by which hospitals are able to increase their profits. This produces a general welfare improvement (5.80 instead of 5.07 provided in the benchmark of Table 1) but the latter is obtained at the expense of patients who noticeably reduce their general welfare (from 1.91 of the benchmark to 1.55 in the present scenario).

Still looking at Table 3 it is possible to note that the condition $c_a < \frac{Mc_b\alpha}{M\alpha-\gamma c_b}$(see Sect. 4 for details) which determines $q_a > q_b$ is verified when the ratio c_a/c_b falls below the value 0.8. The policy implication is that a sequential quality choice is able to get the highest level of social welfare when the leader shows a very low marginal cost with respect to the follower. By this condition it is possible to improve the overall amount of profits but still at the expense of the overall amount of patient utility.

Summing up, it is possible to state that when a Stackelberg competition takes place a lower level of quality (and as a consequence a lower level of consumer surplus) is the expected outcome. On the other hand, hospitals (in particular the followers) gain in terms of profit. The Stackelberg competition allows for a social welfare improvement (W). However, only hospitals benefit from this setting (with respect to the benchmark outcome) whereas the consumers are penalized.

6.4 Uncertainty: Symmetric Objectives but Asymmetric Costs

In this section we are interested in understanding better the role played by uncertainty in affecting the equilibrium outcome.

All the assumptions previously defined apply to this part. Moreover, the relationship between the error term variances has to de described. For this purpose, remembering that patients' choice is driven by the perceived quality $\tilde{q}$ which is biased because of the error ε_i, the product of the variances of the error term $\left(\sigma_a^2 \cdot \sigma_b^2 = 1\right)$ is assumed constant and equal to 1 but the ratio $\frac{\sigma_a^2}{\sigma_b^2}$ of variances is allowed to vary. This quoted ratio value is reported in the second column of Table 4. Remember that the error term affecting the perceived quality is characterized by heteroskedasticity, i.e., its variance varies according to the distance from the provider of medical care.

In Table 4 different scenarios of cost and variance are matched up. In the first column, as provided in previous tables, one can read the marginal cost relationship between hospitals. The second column considers different variance scenarios characterized by different variances in the error term of the equation describing the perceived quality (see Sect. 5). In particular, when the ratio c_a/c_b is equal to 1, the hospitals face the same marginal cost, or, in other words, they show the same level of efficiency. It is possible to note the negative consequences of quality observation bias with respect to the benchmark provided in Table 1. In fact the quality level is lower (if compared with the equilibrium values of Table 1) because of the term $-\frac{\beta}{3\alpha}\left(\sigma_i^2 + 2\sigma_j^2\right)$ (see Eq. 17) which enters the utility function and represents patients uncertainty on quality. Obviously this turns out to be a gain for the hospitals in terms of larger profits and a loss for patients in terms of a reduction in their surplus. In fact, the quality perception bias reduces the hospital incentive to compete via quality for patients. This comes from the fact that, by setting the heteroskedasticity in the error term variance, the result is, in practice, a greater disutility in distance. The latter increases the location rent for hospitals that find it profitable to skimp on quality.

The scenarios of Table 4 where $\frac{\sigma_a^2}{\sigma_b^2} = 1$ are the only ones comparable with those provided in previous sections. In fact, the other rows of Table 4 are characterized (differently from Tables 1, 2, 3) by a different ratio of the error term variances (that are not detectable in the case of perfect information).

Looking at Table 4 it is possible to note that an increase in the competitor's variance (with respect to its own variance) allows a gain in terms of profit for the hospitals with the lower variance. On the other hand as long as we move from the condition of equality in variances we record a patients' loss in terms of utility. However, from the social welfare perspective, the latter is compensated by the profit gain of hospitals. From the hospital perspective a large variance in the perceived quality is an opportunity because it allows for greater profits, however a larger variance with respect to the competitor's is a cost. In fact, the hospital with the larger variance is forced to increase its quality level and as a consequence its costs will increase. On the other hand, when the variance is low, it is possible to serve a larger share of the market even if providing a lower quality.

Thus hospitals benefit from the market uncertainty but in order to maximize their profit they wish to reduce (possibly below the competitor's level) their own variance (in the perceived quality they offer) so as to take the maximum advantage from this kind of asymmetry in information. By this effort/strategy they are able to

Table 4 Simulation 4

$\frac{c_a}{c_b}$	$\frac{\sigma_a^2}{\sigma_b^2}$	q_a	q_b	$\sum_{i=a}^{b} q_i$	π_a	π_b	$\sum_{i=a}^{b} \pi_i$	D_a	D_b	S_a	S_b	$\sum_{i=a}^{b} S_i$	W
0.8	0.7	1.22	1.11	2.33	3.75	2.60	6.34	0.57	0.43	0.40	0.27	0.673	7.02
	0.8	1.26	1.10	2.35	3.66	2.65	6.31	0.57	0.43	0.41	0.28	0.683	6.99
	0.9	1.28	1.08	2.36	3.59	2.70	6.29	0.56	0.44	0.41	0.28	0.688	6.98
	1	1.30	1.06	2.36	3.53	2.75	6.29	0.56	0.44	0.41	0.27	0.689	6.97
	1.1	1.31	1.05	2.36	3.49	2.80	6.29	0.55	0.45	0.41	0.27	0.687	6.98
	1.2	1.33	1.03	2.36	3.44	2.85	6.30	0.55	0.45	0.41	0.27	0.682	6.98
	1.3	1.34	1.01	2.35	3.41	2.90	6.31	0.55	0.45	0.41	0.27	0.676	6.99
0.9	0.7	1.15	1.15	2.30	3.56	2.81	6.37	0.54	0.46	0.35	0.30	0.650	7.02
	0.8	1.18	1.14	2.32	3.47	2.87	6.34	0.54	0.46	0.36	0.30	0.662	7.00
	0.9	1.20	1.13	2.33	3.40	2.92	6.32	0.53	0.47	0.36	0.30	0.667	6.99
	1	1.22	1.11	2.33	3.34	2.97	6.32	0.53	0.47	0.37	0.30	0.668	6.98
	1.1	1.24	1.09	2.33	3.29	3.03	6.32	0.52	0.48	0.37	0.30	0.666	6.99
	1.2	1.25	1.08	2.33	3.25	3.08	6.33	0.52	0.48	0.37	0.30	0.662	6.99
	1.3	1.26	1.06	2.32	3.22	3.13	6.35	0.52	0.48	0.36	0.17	0.656	7.00
1	0.7	1.09	1.21	2.29	3.38	3.00	6.38	0.51	0.49	0.32	0.33	0.643	7.02
	0.8	1.12	1.19	2.31	3.29	3.06	6.35	0.51	0.49	0.32	0.33	0.655	7.00
	0.9	1.14	1.18	2.32	3.22	3.11	6.33	0.50	0.50	0.33	0.33	0.661	6.99
	1	1.16	1.16	2.32	3.16	3.16	6.32	0.50	0.50	0.33	0.33	0.662	6.99
	1.1	1.18	1.15	2.32	3.11	3.21	6.33	0.50	0.50	0.33	0.33	0.661	6.99
	1.2	1.19	1.13	2.32	3.07	3.27	6.34	0.49	0.51	0.33	0.33	0.657	7.00
	1.3	1.20	1.11	2.31	3.04	3.32	6.35	0.49	0.51	0.33	0.32	0.652	7.01
1.1	0.7	1.04	1.26	2.30	3.21	3.16	6.37	0.49	0.51	0.29	0.36	0.646	7.02
	0.8	1.07	1.25	2.32	3.12	3.22	6.34	0.48	0.52	0.30	0.36	0.659	7.00
	0.9	1.10	1.23	2.33	3.05	3.27	6.32	0.48	0.52	0.30	0.36	0.665	6.99
	1	1.12	1.22	2.33	2.99	3.33	6.32	0.47	0.53	0.30	0.36	0.667	6.98
	1.1	1.13	1.20	2.33	2.94	3.38	6.32	0.47	0.53	0.31	0.36	0.666	6.99
	1.2	1.14	1.18	2.32	2.90	3.43	6.33	0.47	0.53	0.30	0.36	0.663	7.00
	1.3	1.15	1.16	2.31	2.87	3.48	6.35	0.46	0.54	0.30	0.35	0.658	7.01
1.2	0.7	1.00	1.32	2.32	3.05	3.31	6.35	0.47	0.53	0.27	0.39	0.658	7.01
	0.8	1.04	1.30	2.34	2.96	3.36	6.32	0.46	0.54	0.28	0.39	0.671	6.99
	0.9	1.06	1.29	2.35	2.89	3.42	6.30	0.46	0.54	0.28	0.40	0.678	6.98
	1	1.08	1.27	2.35	2.83	3.47	6.30	0.45	0.55	0.28	0.40	0.680	6.98
	1.1	1.09	1.25	2.35	2.78	3.52	6.30	0.45	0.55	0.28	0.39	0.679	6.98
	1.2	1.11	1.24	2.34	2.74	3.57	6.31	0.44	0.56	0.28	0.39	0.676	6.99
	1.3	1.11	1.22	2.33	2.71	3.62	6.33	0.44	0.56	0.28	0.39	0.672	7.00

contain costs by reducing the quality level they have to provide in order to maximize their profits and serve a larger portion of the market.

It is also clear that the fact that, because we have heteroskedasticity and that the variance of the error term is affected by distance, a more effective monopolistic rent (because of the spatial differentiation of the market) is detectable. This is the consequence of the fact that the quality level provided is noticeably lower with respect to the other scenarios. In this setting the quality "attractive power" is considerably reduced. To this extent, it is not convenient for hospitals to invest too much on (costly) quality but it would be better to invest on (cheaper) advertising, exploiting information asymmetry to their own advantage (Montefiori 2008). Hospitals have an interest in controlling variance and reducing asymmetric information. Reducing their quality variance would determine a direct increase in profit. Thus they will invest money in "information activity". We can also observe that both the hospitals and the purchaser have an interest in reducing information asymmetry. The hospital aims to reduce the variance in its own quality in order to boost its demand (even when low quality levels are provided), the purchaser aims to decrease uncertainty to avoid hospital incentives on quality curbing.

6.5 Uncertainty: Asymmetric Objectives and Asymmetric Costs

In this section the conditions of asymmetric objectives and asymmetric costs (and their interactions) in a context of uncertainty are investigated by numerical simulation. The results are provided in Table 5.

In this scenario uncertainty only affects the quality provided by the private hospital B, by a lower optimal level set for quality. On the contrary, the behavior of public hospital A, intended at quality maximization (the "excellence" goal), is not affected by uncertainty.

Uncertainty allows for higher profits for the private hospital even if the behavior of the public hospital considerably reduces its scope. If we compare the case in which $c_a/c_b = 1$ and $\frac{\sigma_a^2}{\sigma_b^2} = 1$ of Table 5 with those of Table 4 we can

Table 5 Simulation 5

$\frac{c_a}{c_b}$	$\frac{\sigma_a^2}{\sigma_b^2}$	q_a	q_b	$\sum_{i=a}^{b} q_i$	π_a	π_b	$\sum_{i=a}^{b} \pi_i$	D_a	D_b	S_a	S_b	$\sum_{i=a}^{b} S_i$	W
0.8	0.7	3.54	2.26	5.80	0	0.28	0.28	0.86	0.14	2.36	0.30	2.657	2.94
	1	3.54	2.18	5.72	0	0.37	0.37	0.84	0.16	2.26	0.33	2.588	2.96
	1.3	3.54	2.11	5.65	0	0.45	0.45	0.82	0.18	2.18	0.35	2.529	2.98
0.9	0.7	3.33	2.25	5.58	0	0.47	0.47	0.81	0.19	2.10	0.38	2.485	2.95
	1	3.33	2.17	5.50	0	0.58	0.58	0.79	0.21	2.01	0.41	2.420	3.00
	1.3	3.33	2.10	5.43	0	0.68	0.68	0.78	0.22	1.94	0.42	2.365	3.04
1	0.7	3.16	2.24	5.41	0	0.66	0.66	0.77	0.23	1.89	0.45	2.349	3.01
	1	3.16	2.16	5.32	0	0.79	0.79	0.75	0.25	1.81	0.48	2.287	3.08
	1.3	3.16	2.09	5.25	0	0.90	0.90	0.73	0.27	1.74	0.49	2.235	3.14
1.1	0.7	3.02	2.25	5.26	0	0.85	0.85	0.73	0.27	1.72	0.52	2.239	3.09
	1	3.02	2.17	5.18	0	1.00	1.00	0.71	0.29	1.64	0.54	2.181	3.18
	1.3	3.02	2.10	5.11	0	1.12	1.12	0.70	0.30	1.58	0.55	2.131	3.25
1.2	0.7	2.89	2.26	5.14	0	1.04	1.04	0.70	0.30	1.57	0.58	2.149	3.19
	1	2.89	2.18	5.06	0	1.20	1.20	0.68	0.32	1.50	0.60	2.094	3.29
	1.3	2.89	2.11	4.99	0	1.33	1.33	0.66	0.34	1.44	0.60	2.046	3.37

observe a striking difference in hospital B profits. The behavior of hospital A which aims at excellence noticeably reduces the location rent of hospital B which is forced to keep up the quality level provided in order to retain market share. In other words, it is possible to state that the presence of a publicly owned hospital aiming at quality maximization in a health care market characterized by uncertainty is able to contain the negative effects (in terms both of quality and patient surplus) determined by information asymmetry.

7 Conclusions

This work has shown by a theoretical analysis and numerical simulations the role played by heterogeneous objectives, asymmetric costs and uncertainty in affecting the equilibrium outcome in a duopoly market for health care in which hospitals compete à la Hotelling for patients.

The analysis implemented draws from the ascertainment that globalization is affecting the market for health care. Very soon, hospitals that are very different in terms of ownership/objectives and costs (such as public hospitals, for profit and non-profit private hospitals, teaching hospitals) will compete in a spatially differentiated market.

However very little is known about the consequences of this competition and hospitals (as well as Countries) still seem to be unprepared to cope with this new framework.

The analysis provided in the paper aims to put some light on this new scenario. In particular, the understanding of patient and hospital behavior, with particular reference to patient disutility on distance and quality observation bias, are aspects of great relevance which deserve the attention of the policy maker. The aim is to provide, through the analysis of the present work, new informative tools at the policy maker's disposal, to implement an efficient and effective regulation activity.

For this reason the aspects on which the paper has mainly focused are patient mobility (rigidity) and uncertainty. With reference to the latter it has to be noticed that the literature refers to health care as a "*credence good*" (Montefiori 2008), i.e., a good whose quality cannot be correctly evaluated by consumers/patients even after they have experienced the services. The role played by uncertainty in affecting the market for care is therefore evident, a fortiori when medical care is provided by hospitals located far away from the patient who has to judge them.

The study provides the result that asymmetric costs, in the case that both hospitals are profit maximizers, allow for a social welfare improvement. The presence of a more efficient hospital, i.e., a hospital characterized by lower values of marginal cost, sets the conditions for an overall quality improvement. In fact, if on the one hand, the more efficient hospital gain shares of the market by increasing the quality it provides, on the other the less efficient hospital is forced to keep quality upwards in order to reduce its loss (via the demand mechanism which is quality driven). This result is amplified when the patient mobility is high but it is limited in scope when the patient mobility is low. Note that patient mobility depends on two key elements: patients' utility on quality and patients disutility on distance.

The chapter shows that the presence of a publicly managed hospital which pursues the objective of quality maximization (*excellence*) is able to ensure, in general, higher levels of quality, patient surplus and welfare. This result comes from the fact that the private hospital is forced to react to the public hospital quality setting by investing on costly quality and, in so doing, avoiding a large loss of market share. However, in the limiting case of a very high level of public hospital inefficiency, the welfare gain may change in sign and the undesirable effect could even be an equilibrium outcome less desirable than the benchmark (in which only profit maximizers hospitals are in).

Another aspect of relevance treated in the article concerns the role of uncertainty in affecting the equilibrium. Because it is unrealistic to assume that patients have the ability to perfectly observe the quality provided by hospitals, the concept of *perceived quality* is introduced. Specifically, a particular type of error characterized by a heteroskedastic variance, has been used to investigate hospital behavior and market equilibrium.

What the study highlights are the negative consequences belonging to the presence of asymmetric information in the health market. In particular, the presence of uncertainty reduces the overall quality, decreases the patient surplus and increases the hospital's profit. Hospitals tend to take advantage from uncertainty curbing their costly quality and, in doing so, increasing their profit. Uncertainty causes an increase in the rigidity of patient mobility, benefitting the hospitals with a more effective monopolistic rent as a direct consequence of the market differentiation.

However the presence of publicly owned (and managed) hospitals aiming at quality maximization (the reference is to the case of excellence previously quoted) is able to contrast the location rent strengthened by uncertainty, and, at the same time, contain the negative effects (in terms of quality and consumers' surplus) caused by the asymmetry of information.

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