Hotelling competition on quality in the health care market.

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Abstract: This paper aims to theoretically analyse recent health system reforms. Generally patients are free to choose, within the region they live in, the best provider among the private "accredited" and public ones.

The criterion patients use to choose the provider which fits their expectations best is not, at least in a tax financed system, the price of the treatment since patients do not pay directly for the treatment they receive.

Crucial in determining their choice is the quality level and the provider spatial location.

In a normative perspective we want to analyse hospitals' Nash/Counot and Stackelberg equilibriums in a Hotelling spatial competition scenario.

Because of asymmetric information, patients could be unable to observe the true quality provided. Thus the demand for health care services is assumed to depend on a perceived quality (different from true quality). New equilibrium outcomes are investigated when patient choice is affected by uncertainty.

JEL Classification Numbers: I11, L13

1. Introduction

The purpose of this paper is to examine, in a very simple setting, the equilibrium outcomes when hospitals compete on quality in order to get an efficient number of patients.

Patient behaviour is investigated when they need health care services. The "health good" is horizontally and vertically differentiated. According to Hotelling (1929) spatial competition model, we assume that only two hospitals serve the market. They are located at the extremes of a line unit length and patients are uniformly distributed on that line. The health services provided by the two hospitals are characterised by different quality levels.

A tax financed health system is supposed where patients do not pay directly for the health care services they receive. The purchaser is assumed to be a government agency who freely chooses contract terms and payment form.

This paper studies the case when a prospective payment is implemented and patients are free to choose the hospital they prefer, i.e. the quality/distance mix that allows for utility maximisation.

This framework is motivated by the fact that we believe it best represents the health market features. We jointly study the hospital's and consumer's behaviour which maximise respectively profit and utility functions.

The goal is a better understanding of recent health system reforms which introduce prospective payment scheme (DRG based) and free choice by patients[1]. The expected outcome is efficiency in production and a high quality level. The former should be obtained by the prospective payment scheme, the latter should be obtained by the demand mechanism, consistent with natural competition between providers for the marginal consumer. Providers need to increase the quality supplied to get the marginal patient and consequently increase their demand.

This paper is complementary to the existing literature both in health and industrial economics.

Gravelle (1999) analyses the competition amongst providers in the private and public systems for the quality of service and the number of care providers. The paper focuses on capitation contracts in which providers receive an initial payment for each patient who registers with them. It is concerned with the way in which competition between providers affects the quality of service and, via the number of providers, patient access to services.

Gravelle and Masiero (2000) investigate the case when general practitioners are horizontally and vertically differentiated and compete for patients via their imperfect observed quality. They consider the extent to which switching costs and imperfect patient information about quality interact to blunt incentives for quality. Patients improve their knowledge of the characteristics of the practice they join after experiencing its services. There are initial errors in judging quality and

[1] e.g. the Italian case

switching costs which lock some of the mistaken patients into the wrong GP. Furthermore they are interested in whether competition between general practitioners leads to appropriate levels of information and switching costs or whether additional regulation is required. They are concerned with errors and welfare consequences.

An application of the standard Hotelling spatial competition model to the secondary health care market in order to study the different hospital strategies and the Cournot/Stackelberg equilibrium outcomes under a prospective payment scheme, has not been analysed to our knowledge.

With reference to the literature in industrial economics, there are a number of papers studying the features of Cournot and Stackelberg's leader-follower model of oligopoly. Beato and Mas-Colell (1984) find that, under specific assumptions, the stackelberg's leader turns out to be the loser.

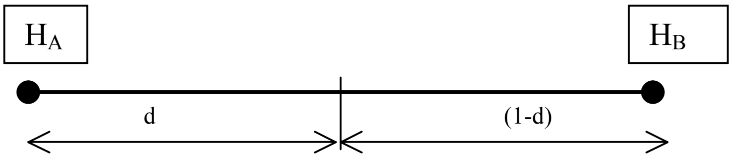
The present study will provide the same odd result.

In section 2, we introduce the consumer utility function. It is affected by distance and quality provided. The identification of the marginal consumer allows us to define the demand each hospital faces. In section 3, we investigate the hospital profit function and its behaviour. The subsequent sections 4 and 5 show respectively the Cournot and Stackelberg equilibriums. In section 6, we present a dynamic extension of the Stackelberg equilibrium. We then introduce the implications of uncertainty and we analyse how it affects the outcomes already found. Section 8 summarises our conclusions.

2. The consumer utility function

The study refers to a single DRG (Diagnosis Related Group).

Only two hospitals serve the market. They are located at the extremes of a line unit length. Patients are uniformly distributed on that line.



Patient utility function depends on the quality they receive for treatment and on the provider's distance from patient's location.

$$U_{pz} = \begin{cases} \alpha q_a - \gamma d \\ \alpha q_b - \gamma(1-d) \end{cases}$$

where

α denotes how quality enters the utility function

γ denotes the disutility because of the distance (d)

Patients will be indifferent between hospital A and hospital B when:

$$\alpha q_a - \gamma d = \alpha q_b - \gamma(1-d)$$

solving for d

(1) $d = \dfrac{\alpha}{2\gamma}(q_a - q_b) + \dfrac{1}{2}$

The distance d represents the demand for hospital A and, at the same time, the location of the marginal consumer.

We can easily observe that

If $d=1/2$ (the middle of the unit length line) then hospitals are offering exactly the same quality: $q_a=q_b$

If $d=0$ then the demand for hospital A converges to zero:

$q_a=q_b-\gamma/\alpha$

$q_b=q_a+\gamma/\alpha$

All the patients demand treatment at hospital B.

If $d=1$ then the opposite (of the previous case) occurs:

$q_a=q_b+\gamma/\alpha$

$q_b = q_a - \gamma/\alpha$

All patients demand treatment from hospital A. Hospital A's quality level, if compared with B's, compensates the disutility because of the greater distance patients have to cover. Only the patient situated in *d=1* (i.e. the marginal one) will be indifferent between hospital A and B.

In general "health" is considered as a good that cannot be given up. Nonetheless we assume that if the quality level each hospital can offer is lower than a minimum level (normalised to zero) patients prefer not to receive any treatment provided that the risks they incur are bigger than the disease they suffer from the treatment.

In other words when q_i is lower than zero, the hospital providing that quality level faces zero demand regardless of the quality provided by its rival.

Similarly, patients ask for health services only when the expected utility is at least as great as the reservation utility $\overline{U}$.

We require that

either

$$\alpha q_a - \gamma d \geq \overline{U}$$

or

$$\alpha q_b - \gamma(1-d) \geq \overline{U}$$

To simplify the analysis we set the reservation utility equal to zero.

To take into account the participation constraint, we need to rewrite the equation for distance (or equivalently the demand equation) as follows:

$$(2)\ d_i = [\frac{\alpha}{2\gamma}(q_i - q_j)] + [(\frac{1}{2})^{D_1}(\frac{\alpha q_i}{\gamma})^{D_2}]$$

where

D_1 is a dummy variable which assumes value 0 when $q_i=q_j$ and value 1 when $q_i \neq q_j$.

D_2 is a dummy variable which assumes value 1 when $q_i=q_j$ and value 0 when $q_i \neq q_j$.

It is easy to verify that all the statements above hold for the new demand equation (see appendix 1 for details).

3. The hospital's behaviour

The hospital maximises its profit function. It is self-interested and it is concerned with quality through the demand mechanism.

Because of the payment scheme adopted by the purchaser (fixed price per treated patient), the hospital receives an ex ante defined price M per treated patient. M is set to satisfy the hospital's participation constraint. M has to be great enough to cover all the costs the hospital incurs in treating d_i patients at q_i ($i = a, b$) quality level.

We consider the analysis refers to a single Drg (diagnosis related group), that is, patients with the same disease and an equivalent (on average) amount of resources required to be treated.

Given M, the hospitals will set quality level in order to maximise their profits. Through the q variable hospitals can control demand.

We assume symmetric information on cost and revenue functions.

Revenues are given by the ex-ante-fixed-price-per-treated-patient times the number of patients. In this case the number of patients is equal to the demand for health services.

The demand hospital i faces is:

$$d_i(q_i, q_j) = [\frac{\alpha}{2\gamma}(q_i - q_j)] + [(\frac{1}{2})^{D_1}(\frac{\alpha q_i}{\gamma})^{D_2}]$$

Defining M the fixed price, the hospital's revenues (R) are:

$$R = Md_i(q_i, q_j)$$
$$i = a, b$$
$$i \neq j$$

where M is exogenous to the hospital and arbitrarily chosen by the purchaser.

The monetary costs (C) to hospital i are:

$$C_i(d_i(q_i, q_j), q_i)$$

Costs depend on the number of patients and on the quality level provided. The demand d depends both on the quality offered by hospital A and hospital B. Thus we can rewrite the cost function in its explicit form directly as:

(3) $$C_i(q_i, q_j) = c[\frac{\alpha}{2\gamma}(q_i - q_j) + (\frac{1}{2})^{D_1}(\frac{\alpha q_i}{\gamma})^{D_2}]q_i$$

where

c is a cost parameter associated to the number of patients and to the quality provided.

F_i are the fixed costs of *i-th* hospital.

The hospital will maximise the following profit function:

$$\underset{q_i}{Max}\,\Pi_i = M[\frac{\alpha}{2\gamma}(q_i - q_j) + (\frac{1}{2})] - c[\frac{\alpha}{2\gamma}(q_i - q_j) + (\frac{1}{2})]q_i - F_i$$

(4) $s.t.$

$$U_{pz}(q_i, q_j, d_s) \geq \overline{U}$$

where s indicates the *s-patient* and d_s its distance from the hospital.

In this simple framework the only variable the hospital can set is q_i.

4. Cournot equilibrium

We suppose the two hospitals compete on quality.

We suppose symmetric information on revenues and cost functions. Hospitals behave independently.

Because they face the same cost and the same revenues they reach a symmetric equilibrium, i.e. an equivalent reaction function.

Solving the maximisation problem we obtain:

$$q_i(q_j) = \frac{1}{2}(q_j + \frac{M}{c} - \frac{\gamma}{\alpha})$$

Hospital i sets its quality level according to a few elements. The quality increases in the competitor's quality, in the fixed price and in the parameter associated to the quality relevance in patient utility function, it decreases in the cost parameter and in the distance patient disutility.

The behaviour of hospital B is perfectly symmetric to the behaviour of hospital A.

We are considering the Cournot case. Functions for q_a and q_b represent the reaction function for each hospital.

Solving the system:

$$\begin{cases} q_a = \frac{1}{2}[q_b + \frac{M}{c} - \frac{\gamma}{\alpha}] \\ q_b = \frac{1}{2}[q_a + \frac{M}{c} - \frac{\gamma}{\alpha}] \end{cases}$$

we get:

$$q_a = q_b = \frac{M}{c} - \frac{\gamma}{\alpha}$$

The two hospitals will behave symmetrically and will choose the same quality level. The quality provided can be shifted by the purchaser through the fixed price M. The quality is decreasing in c (the cost parameter), decreasing in γ (the patient distance disutility) and increasing in α (patient utility for quality).

A bigger value of M allows for a quality rise. If γ is high, then demand will result inelastically with respect to quality. The hospital's control of demand through quality is low. Thus, ceteris paribus, the hospital's incentives to increase quality because of the demand mechanism is low.

The purchaser sets M in order to meet the hospital participation constraint. Considering the hospital is forced to choose a quality level above the minimum enforceable, the fixed price M has to be set at least as great as $c\gamma/\alpha$.

If $M = \frac{c\gamma}{\alpha}$ then both hospital A and hospital B will choose a quality level equal to zero value.

Studying the profit function (using the dummy variables to take into account the patient participation constraint)

(5) $\Pi_i = M[\frac{\alpha}{2\gamma}(q_i - q_j) + (\frac{1}{2})^{D_1}(\frac{\alpha q_i}{\gamma})^{D_2}] - c[\frac{\alpha}{2\gamma}(q_i - q_j) + (\frac{1}{2})^{D_1}(\frac{\alpha q_i}{\gamma})^{D_2}]q_i - F_i$

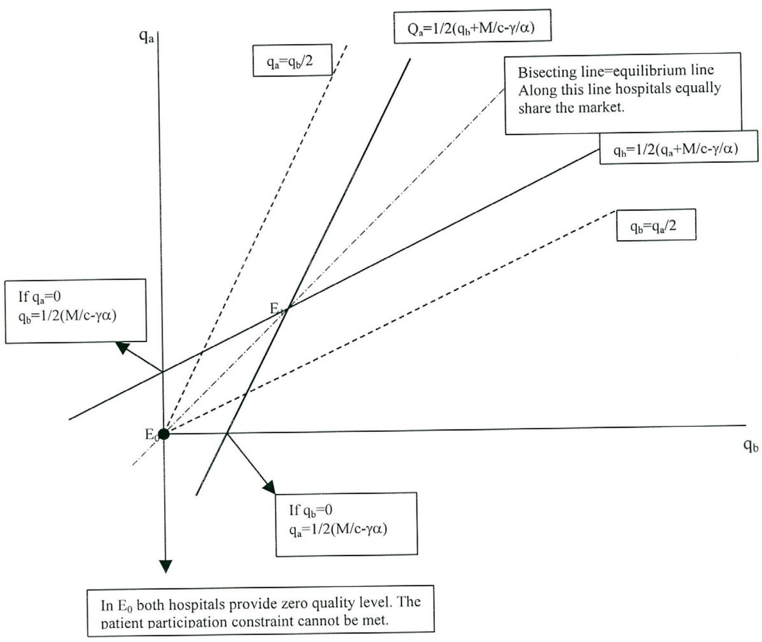
we verify that when quality is set to zero, the hospitals face a negative profit ($\Pi_i = -F_i$) equal to fixed costs. In fact, with a zero quality the patient participation constraint cannot be satisfied and no patient demands health care services.

The minimum quality level to cover all the market and to equally share patients is: $q_a = q_b = \gamma/2\alpha$. This result implies a price $M = \frac{3c\gamma}{2\alpha}$, i.e. a price M 50% bigger than the previous one.

If the purchaser sets M according to the above equation, he will meet both the hospital and the patient participation constraint.

Recalling that $d_a = d_b = 1/2$ and that, given M equal to $3c\gamma/2\alpha$, $q_a = q_b = \gamma/2\alpha$, we can derive the hospital profit: $\Pi_i = \frac{c\gamma}{2\alpha} - F_i$

Graphically we can draw the equilibrium outcome:



5. Stackelberg equilibrium

In this section we assume a two stage game. Hospital A can move first, taking into account the reaction of hospital B. According to the literature we define hospital A as *the leader* and hospital B as *the follower*.

Usually the leader can get a better outcome than the follower because of its advantage: the leader moves first and he acts taking into account the follower's reaction.

Substituting B's reaction function in A's demand function, we derive a new demand for A only depending on quality A.

B's reaction function:

$$q_b = \frac{1}{2}[q_a + \frac{M}{c} - \frac{\gamma}{\alpha}]$$

The leader maximises:

(6) $\underset{q_a}{Max}\Pi_a = M[d_a(q_a)] - c[d_a(q_a)]q_a - F$

s.t

$$\alpha q_a - \gamma d_a(q_a) - \overline{U} \geq 0$$

$$q_a \geq 0$$

where

$$[d_a(q_a)] = \frac{\alpha q_a}{4\gamma} - \frac{\alpha M}{4\gamma c} + \frac{3}{4}$$

Thus we can write the Lagrangean:

$$L(q_a, \lambda) = M[d_a(q_a)] - c[d_a(q_a)]q_a - F + \lambda[\alpha q_a - \gamma d_a(q_a) - \overline{U}]$$

Using Kuhn-Tucker we get the following first order conditions:

$$\frac{\partial L}{\partial q_a} \leq 0; q_a \geq 0; q_a[\frac{\partial L}{\partial q_a}] = 0$$

$$\frac{\partial L}{\partial \lambda} \geq 0; \lambda \geq 0; \lambda[\frac{\partial L}{\partial \lambda}] = 0$$

$$\overline{U} = 0$$

Solving the problem (see appendix 3 for details) we get a result where the two hospitals choose the following quality levels:

$$q_a = \frac{M}{c} - \frac{3\gamma}{2\alpha}$$

$$q_b = \frac{M}{c} - \frac{5\gamma}{4\alpha}$$

Because the quality provided by the follower is greater than the leader quality, the follower will serve a greater portion of the market:

$$d_a = 3/8$$

$$d_b = 5/8$$

Looking at the profit we observe a very odd result:

$$\Pi_a = \frac{9c\gamma}{16\alpha} - F$$

$$\Pi_b = \frac{25\gamma c}{32\alpha} - F$$

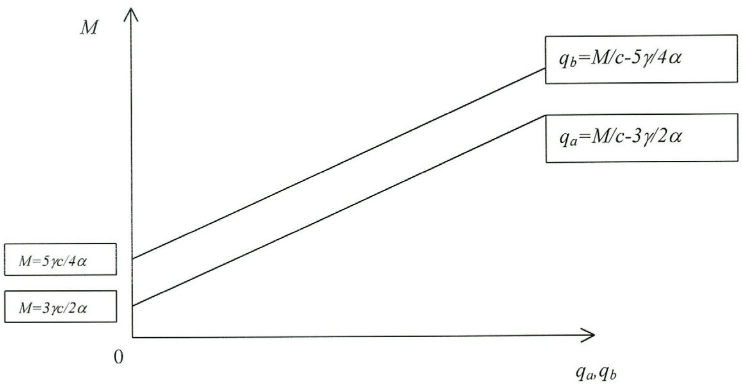
In this scenario the leader is the loser.

The counterintuitive outcome we get comes from the two stage game we have defined. The hospitals compete on quality, given the fixed price per treated patient. The hospital which sets first its quality level loses, even if it can take into account the competitor reaction function.

In fact, the follower observes the leader setting its quality. In the second stage of the game, the follower sets its quality level solving its profit maximisation problem. The hospital will find it profitable to set its quality equal to the rival's quality plus a bit (i.e. plus $\gamma/4\alpha$).

In this way the follower covers a bigger portion of the market line and can increase its profits serving the marginal consumers.

In this scenario, where both hospitals face the same cost and revenue functions, the hospital which moves at the second stage wins.



It is interesting to compare the Cournot and the Stackelberg equilibriums found.

COURNOT	STACKELBERG
$q_a=q_b=M/c-\gamma/\alpha$	$q_a=M/c-3\gamma/2\alpha$
$q_b=q_a=M/c-\gamma/\alpha$	$q_b=M/c-5\gamma/4\alpha$
$M=3c\gamma/2\alpha$	$M=15c\gamma/8\alpha$
$q_b=q_a=\gamma/2\alpha$	$q_a=3\gamma/8\alpha$; $q_b=5\gamma/8\alpha$
$\pi_a=\pi_b=c\gamma/2\alpha-F$	$\pi_a=9c\gamma/16\alpha-F$; $\pi_b=25c\gamma/32\alpha-F$

From the social welfare point of view we can state that the Cournot equilibrium is more efficient than the Stackelberg one.

Given the same value of M in the two scenarios, we observe that the quality provided by each hospital in the Stackelberg case is lower than the quality provided in the Cournot one.

If the purchaser wants all the patients placed along the unit length line to meet their participation constraint, then he has to pay a higher price ($M^S>M^C$) with Stackelberg competition.

Nonetheless, the higher value of M, the general amount of quality provided in the two scenarios, is exactly the same. In the first case the two hospitals provide the same amount of quality, in the second the leader provides a lower level of quality than the follower, but in both cases the quality provided sums to γ/α.

Because of the difference in the quality level and in the fixed price, the profit each hospital can attain in the Stackelberg case is always greater than hospitals can get in Cournot equilibrium.

To conclude, we can state that the Stackelberg competition is more profitable for the hospitals than the Cournot competition, but from the purchaser (i.e. the social welfare) point of view the opposite applies.

6. Extending the Stackelberg equilibrium

The Stackelberg case can be extended dynamically.

The equilibrium outcome we have found is not dynamically stable. The hospitals will move from it in the next stage 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 behaviour in the subsequent stage of the game. The leader will respond to the follower's quality, maximising a new objective function where the competitor's quality is given.

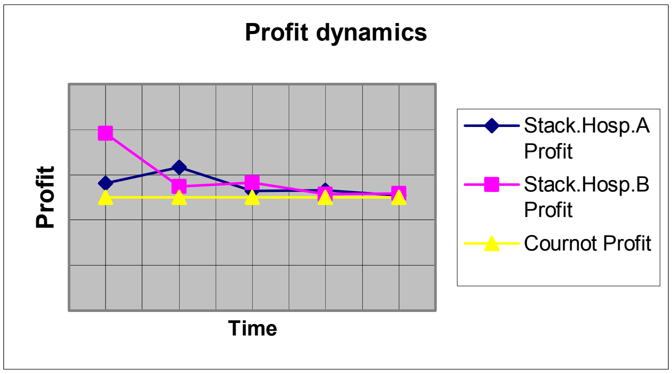
In this way we define a third stage new equilibrium. This equilibrium will change again in the fourth stage when the follower will move after the leader's quality observation.

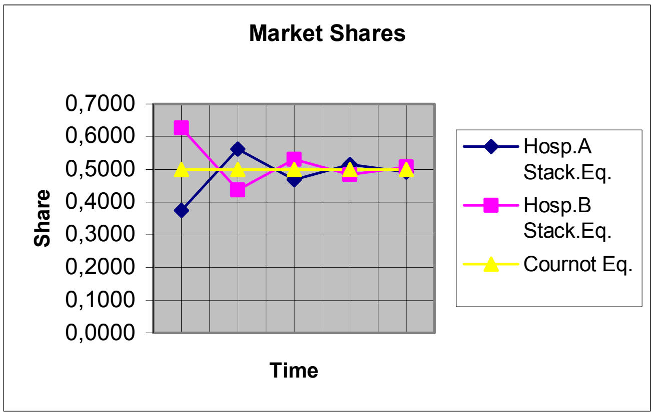
We can summarise the game by the following table:

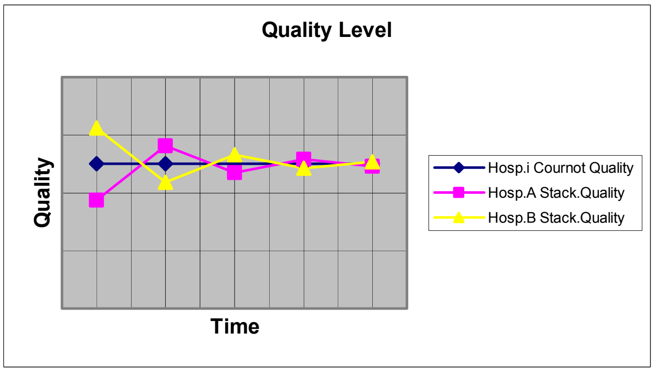
1 equilibrium outcome (1st stage)	
The leader moves first	$q_a = \frac{M}{C} - \frac{3}{2}\frac{\gamma}{\alpha}$ $d_a = \frac{3}{8}$ $\Pi_a = \frac{9}{16}\frac{\gamma c}{\alpha} - F$
The follower reacts setting (2nd stage) :	$q_b = \frac{M}{C} - \frac{5}{4}\frac{\gamma}{\alpha}$ $d_b = \frac{5}{8}$ $\Pi_b = \frac{25}{32}\frac{\gamma c}{\alpha} - F$
2 equilibrium outcome (3rd stage)	
The leader reacts to the follower	$q_a = \frac{M}{C} - \frac{9}{8}\frac{\gamma}{\alpha}$ $d_a = \frac{9}{16}$ $\Pi_a = \frac{81}{128}\frac{\gamma c}{\alpha} - F$
The follower's new equilibrium values are:	$q_b = \frac{M}{c} - \frac{5}{4}\frac{\gamma}{\alpha}$ $d_b = \frac{7}{16}$ $\Pi_b = \frac{70}{128}\frac{\gamma c}{\alpha} - F$
3 equilibrium outcome (4th stage)	
The follower reacts and sets:	$q_b = \frac{M}{c} - \frac{17}{16}\frac{\gamma}{\alpha}$ $d_b = \frac{17}{32}$ $\Pi_b = \frac{289}{512}\frac{c\gamma}{\alpha} - F$
The leader's new equilibrium values	$q_a = \frac{M}{c} - \frac{9}{8}\frac{\gamma}{\alpha}$ $d_a = \frac{15}{32}$

are:	$\Pi_a = \frac{135}{256}\frac{c\gamma}{\alpha} - F$
4 equilibrium outcome (5th stage)	
The leader reacts and sets:	$q_a = \frac{M}{c} - \frac{33}{32}\frac{\gamma}{\alpha} \quad d_a = \frac{33}{64}$ $\Pi_a = \frac{1089}{2048}\frac{\gamma c}{\alpha} - F$
The follower's new equilibrium values are:	$q_b = \frac{M}{c} - \frac{17}{16}\frac{\gamma}{\alpha} \quad d_b = \frac{31}{64}$ $\Pi_b = \frac{527}{1024}\frac{\gamma c}{\alpha} - F$
5 equilibrium outcome (6th stage)	
The follower reacts and sets:	$q_b = \frac{M}{c} - \frac{65}{64}\frac{\gamma}{\alpha} \quad d_b = \frac{65}{128}\frac{\gamma}{\alpha} \quad \Pi_b = \frac{4225}{8192}\frac{\gamma c}{\alpha} - F$
The leader's new equilibrium values are:	$q_a = \frac{M}{c} - \frac{33}{32}\frac{\gamma}{\alpha} \quad d_a = \frac{63}{128} \quad \Pi_a = \frac{2079}{4096}\frac{\gamma c}{\alpha} - F$
…….	

Using the graphical representation for profits, market shares and quality levels:







Hospitals' dynamic competition converges towards the Cournot Equilibrium.

In the long-run hospitals competing in a multi stage game produce the same result as in the Cournot equilibrium.

As we can easily observe from the graphs above, we note that the profits and the market shares and the quality level converge, in the long-run dynamics, towards the Cournot outcomes.

This result implies that the Cournot case is more efficient, at least from the social welfare point of view; it reaches the desirable stable equilibrium outcome in the first stage of the game and a lower amount of money (the fixed price per treated patient) is required to get all the market served.

7. Uncertainty

In health care market, patients are generally unable to perfectly observe the true quality level provided. Thus the demand for health care services is assumed to depend on a perceived quality. Expectations and errors are introduced in the model.

The new patient utility function depends on provider distance and on perceived quality, different from true quality.

$$U_{pz} = u(\tilde{q}, d)$$

where

$\tilde{q}$ is the perceived quality

d is the distance

and

$$\frac{\partial U_{pz}}{\partial \tilde{q}} \geq 0; \frac{\partial^2 U_{pz}}{\partial \tilde{q}^2} \leq 0; \frac{\partial U_{pz}}{\partial d} \leq 0; \frac{\partial^2 U_{pz}}{\partial d^2} \leq 0$$

The patient chooses hospital *i* when the expected utility from the uncertain quality $\tilde{q}_i$ is bigger than expected utility from hospital *j* with uncertain quality $\tilde{q}_j$:

$$E[u(\tilde{q}_a, d)] \geq E[u(\tilde{q}_b, d)]$$

If we assume a bounded uncertainty, i.e. the "random" quality $\tilde{q}$ is very close to the expected quality $\overline{q} = E(\tilde{q})$ for every state of the world, then we can use the following approximation:

$$u(\tilde{q}, d) \approx u(\overline{q}, d) + (\tilde{q} - \overline{q}) u_{\tilde{q}}^{'}(\overline{q}) + (\tilde{q} - \overline{q})^2 \frac{u_{\tilde{q}}^{''}(\overline{q})}{2}$$

Using expectations:

$$E[u(\tilde{q}, d)] \approx u(\overline{q}, d) + \frac{\mathrm{var}(\tilde{q}) u_{\tilde{q}}^{''}(\overline{q})}{2}$$

given

$$\mathrm{var}(\tilde{q}) = E[(\tilde{q} - \overline{q})^2]$$

In order not to change the functions employed we apply directly the average-variance method.

If we suppose the perceived quality as equally and normally distributed with $\overline{q}$ mean and σ_q^2 variance, then the new utility function for the patient, in its explicit form, can be written as

$$U_{pz} = \begin{cases} \alpha \overline{q}_a - \gamma d - \beta \sigma_{q_a}^2 \\ \alpha \overline{q}_b - \gamma + \gamma d - \beta \sigma_{q_b}^2 \end{cases}$$

with

$$\frac{\partial U_{pz}}{\partial \overline{q}} \geq 0; \frac{\partial U_{pz}}{\partial d} \leq 0; \frac{\partial U_{pz}}{\partial \sigma^2} \leq 0$$

Patient utility is increasing in average quality, decreasing in distance and quality variance.

The demand the hospital i faces is defined as

$$d_i = \frac{\alpha}{2\gamma}(\overline{q}_i - \overline{q}_j) - \frac{\beta}{2\gamma}(\sigma^2_{q_i} - \sigma^2_{q_j}) + \frac{1}{2}$$

In the new scenario, patients cannot observe the true quality level provided.

They maximise an expected utility function where two new elements enter: the perceived quality mean and variance.

Obviously the resulting demand for each hospital will not depend directly upon the quality provided because of the observation bias.

Under the hypothesis that hospitals' control is limited to the quality choice variable, they will behave in the same way as in the deterministic scenario, but with a different expected payoff.

Under Cournot competition, hospitals maximise the quality according to eq.(4). but the profit function is given by:

$$(7)\ \Pi_i = M[\frac{\alpha}{2\gamma}(\overline{q}_i - \overline{q}_j) - \frac{\beta}{2\gamma}(\sigma^2_{q_i} - \sigma^2_{q_j}) + \frac{1}{2}] - c[\frac{\alpha}{2\gamma}(\overline{q}_i - \overline{q}_j) - \frac{\beta}{2\gamma}(\sigma^2_{q_i} - \sigma^2_{q_j}) + \frac{1}{2}]q_i - F_i$$

If the average quality is assumed equal to the true quality, knowing they will provide the same quality level, we can rewrite the profit function:

$$(8)\ \Pi_i = M[-\frac{\beta}{2\gamma}(\sigma^2_{q_i} - \sigma^2_{q_j}) + \frac{1}{2}] - c[-\frac{\beta}{2\gamma}(\sigma^2_{q_i} - \sigma^2_{q_j}) + \frac{1}{2}]q_i - F_i$$

Equation (8) shows the relevance assumed by the quality variance in determining the hospital profit.

The quality hospital variance has two main effects:

it increases the quality level required to meet the patient participation constraint and, given a specific quality level, a lower variance with respect to the competitor, allows for higher profits.

Thus, even if the hospitals choose the same quality level, a higher share of the market can be served and, consequently, different profits can be attained.

In the Stackelber competition the uncertainty determines a better outcome.

We have shown in the previous section that the follower uses information concerning leader's quality to steal, by a small increase in his quality level (with respect to his rival), the marginal patients. Now they face an expected demand which reflects the perceived quality, a small difference is not enough to grant them the marginal consumer. Because of observation bias, they are conscious a small difference is not easily observable by patients.

In the long run deterministic case, the Stackelberg equilibrium moves towards the Cournot outcomes. In the stochastic scenario it is reasonable to expect a faster convergence to the Cournot stable equilibrium since the competition on small quality differences could turn out to be useless if not harmful; as the cost function depends on real quality while the revenue function depends on perceived quality.

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". For example they could prefer advertising expenditure to quality increase (Montefiori 2002).

We observe from the model that both the hospitals and the purchaser have an interest in reducing information asymmetry.

Hospitals aim to reduce the variance in quality in order to boost their demand, the purchaser aims to decrease uncertainty to avoid hospital incentives on quality curbing.

8. Conclusion

The recent health system reforms (e.g. the case of Italy) have introduced a prospective payment scheme (DRG based) and free choice by patients. The expected outcome is efficiency in production and a high quality level.

The former should be obtained by the prospective payment scheme, the latter should be obtained by the demand mechanism, consistent with natural competition between providers for the marginal consumer. Providers need to increase the quality supplied to get the marginal patient and consequently increase their demand.

The spatial hospital competition for quality provides very different results depending on the theoretical competition model implemented.

The Cournot scenario allows for hospitals' positive profits. When the purchaser aims to maximise the social welfare function, his main concern should be to meet the marginal-consumer-participation-constraint, i.e. to cover all the unit length line market. He will get this goal defining the fixed-price-per-treated-patient as suggested in the model and in such a way to meet both the hospital individual rationality constraint and indirectly (through the hospital's behaviour) the patient participation constraint.

The price the purchaser sets in the prospective payment scheme allows for a quality level above the minimum enforceable level normalised to zero.

At that quality level, the marginal consumer who is, in the Cournot competition, situated exactly in the middle of the unit length line market, gets a non-negative utility payoff and he will ask for health care services indifferently from hospital A or hospital B.

If we shift to a multi-stage game allowing for a Stackelberg leader and for a follower, we verify a very odd result. The Stackelberg leader turns out to be the loser.

From a social welfare point of view we observe the Stackelberg equilibrium as inefficient with respect to the Cournot equilibrium.

The purchaser needs to set a higher price per treated patient in order to cover all the unit length market. Furthermore the total amount of quality provided is exactly the same (lower with the same value of M and consequently with some marginal patients unable to meet their participation constraint).

Both the hospitals get a higher profit, thanks to the higher price accorded.

Proceeding in our analysis we check that the Stackelberg equilibrium is not dynamically stable. If we allow for further stages, it moves from the first unstable point towards a stable one.

The stable point will be attained after several iterations and it will coincide with the Cournot equilibrium outcome.

Thus we can state that the Cournot equilibrium represents the long run stable Stackelberg equilibrium.

The purchaser doesn't benefit from these dynamic adjustments which drive towards a more efficient solution only after several steps, i.e. after a long period of time. On the other hand the long-run equilibrium determines a higher social cost (because of the short-run deficiencies and the higher M required).

Because of asymmetric information, patients are unable to observe the true quality. Thus it is necessary to assume that demand for health care services depends on a perceived quality (different from the true quality).

In the second section of this paper we change the patient utility function to explain the effects of information asymmetry in the health care market.

Analysing the Cournot scenario under uncertainty, it is possible to verify that hospitals don't have incentives to deviate from the equilibrium. We expect the hospitals to provide the same true quality level. Because of asymmetric information, patients are unable to observe the true quality and their choice will be driven by perceived quality. Hospitals can face different demand (they could lose the marginal consumer), even providing the same quality level, and consequently different profits.

The Cournot equilibrium is stable in the long run.

Under Stackelberg competition the uncertainty determines a better outcome.

Because in the long run it moves towards the Cournot outcomes, it is reasonable to expect a faster convergence to it, since competing in small quality differences could turn out to be useless, if not harmful, as the cost function depends on real quality while the revenue function depends on perceived quality.

Policy Implications

This paper is intended to provide a theoretical contribution to the information asymmetry issue but the results attained can be used for practical applications.

The public purchaser can choose a fixed price per patient in order to get all the market demand satisfied. According to the model this price will be able to push the quality level upwards (above the minimum enforceable level) in order to meet the marginal consumer participation constraint. The purchaser allows for the hospitals to make positive profits. It means that a social welfare function, as defined for example in Chalkley and Malcomson (1998a), cannot be maximised.

To conclude we can state that the public purchaser can choose a fixed price per patient in order to attain the desired level of quality but the social welfare is not at the optimal level.

We observe from the model that both the hospitals and the purchaser have an interest in reducing the information asymmetry.

Hospitals aim to reduce the variance in quality in order to boost their demand, the purchaser aims to decrease uncertainty to avoid hospital incentives on quality curbing.

These conclusions are supported by the fact that many countries are introducing prospective payment schemes and free choice by patients in addition to the provision of a wider range of information directed at citizens.

Appendix 1

$$d_i = [\frac{\alpha}{2\gamma}(q_i - q_j) + [(\frac{1}{2})^{D_1}(\frac{\alpha q_i}{\gamma})^{D2}]$$

where

D_1 is a dummy variable which assumes value 0 if q_a=q_b and value 1 otherwise

D_2 is a dummy variable which assumes value 1 if q_a=q_b and value 0 otherwise.

If the hospitals offer the same quality level, then the market is equally shared between them:

$$q_i = q_j$$
$$d = 1/2$$

From *i*'s hospital demand we derive the quality level:

$$q_i = q_j = \frac{\gamma}{2\alpha}$$

The value set for quality is the minimum that allows the two hospitals to share the market and get the marginal patient situated in the middle of the line.

d=0 means that the demand for hospital A is zero, while B can cover all the market [(1-d)=1]. In this case we necessarily observe two different quality levels, thus $q_i \neq q_j$.

The study of the demand equation produces the following result:

$$q_a = q_b - \frac{\gamma}{\alpha}$$
$$q_b = q_a + \frac{\gamma}{\alpha}$$

The opposite applies in case *d=1*:

$$q_a = q_b + \frac{\gamma}{\alpha}$$
$$q_b = q_a - \frac{\gamma}{\alpha}$$

All patients located on the line prefer hospital A to hospital B. They generally receive a utility at least as great as the one they receive going to hospital B, independently from the location. Obviously, the closer they are to the provider, lower the distance disutility is and the bigger the net utility they receive.

As demonstrated, the new formulation does not change the result but it takes into account the patient participation constraint.

Appendix 2

$$\underset{q_i}{Max}\,\Pi_i = M[\frac{\alpha}{2\gamma}(q_i - q_j) + \frac{1}{2}] - c[\frac{\alpha}{2\gamma}(q_i - q_j) + \frac{1}{2}]q_i$$

FOC

$$q_i = \frac{1}{2}(q_j + \frac{M}{c} - \frac{\gamma}{\alpha})$$

$$q_i = q_j = \frac{M}{c} - \frac{\gamma}{\alpha}$$

The purchaser will set $M \geq \frac{c\gamma}{\alpha}$ in order to meet the hospital's participation constraint and taking into account that the hospital cannot provide a quality level below the minimum enforceable level, set equal to zero.

If M is set equal to $c\gamma/\alpha$ then the maximising value of q the hospital i chooses is given by:

$$q_i = \frac{q_j}{2}$$

The only equilibrium can be reached when $q_i=q_j=0$.

Appendix 3

Stackelberg equilibrium

Leader

$$\underset{q_a}{Max}\Pi_a = M[d_a(q_a)] - c[d_a(q_a)]q_a - F$$

s.t

$$\alpha q_a - \gamma d_a(q_a) - \overline{U} \geq 0$$

$$q_a \geq 0$$

where

$$[d_a(q_a)] = \frac{\alpha q_a}{4\gamma} - \frac{\alpha M}{4\gamma c} + \frac{3}{4}$$

Thus we can write the Lagrangean:

$$L(q_a, \lambda) = M[d_a(q_a)] - c[d_a(q_a)]q_a - F + \lambda[\alpha q_a - \gamma d_a(q_a) - \overline{U}] =$$

$$M[\frac{\alpha q_a}{4\gamma} - \frac{\alpha M}{4\gamma c} + \frac{3}{4}] - c[\frac{\alpha q_a^2}{4\gamma} - \frac{\alpha M}{4\gamma c}q_a + \frac{3}{4}q_a] - F + \lambda[\alpha q_a - \frac{\alpha}{4}q_a + \frac{\alpha}{4c}M - \frac{3\gamma}{4} - \overline{U}]$$

Using Kuhn-Tucker we get the following first order conditions:

$$1)\frac{\partial L}{\partial q_a} : \frac{M\alpha}{4\gamma} - \frac{c\alpha}{2\gamma}q_a + \frac{\alpha}{4\gamma}M - \frac{3}{4}c + \frac{3}{4}\alpha\lambda \leq 0;$$

$$q_a \geq 0;$$

$$q_a[\frac{\partial L}{\partial q_a}] = 0$$

$$2)\frac{\partial L}{\partial \lambda} : \frac{3}{4}\alpha q_a + \frac{\alpha M}{4c} - \frac{3}{4}\gamma - \overline{U} \geq 0;$$

$$\lambda \geq 0;$$

$$\lambda[\frac{\partial L}{\partial \lambda}] = 0$$

Assuming:

$$\overline{U} = 0$$

Solving for q_a equations 1 and 2 we obtain:

$$1) q_a \geq \frac{M}{c} - \frac{3\gamma}{2\alpha} + \frac{3\gamma\lambda}{2c}$$

$$2) q_a \geq -\frac{M}{3c} + \frac{\gamma}{\alpha}$$

Looking at eq.2 we observe that the quality will be strictly greater than zero if the purchaser of health services sets $M \leq 3\gamma c/\alpha$.

Eq.1 suggests that when $M \geq 3\gamma c/2\alpha - 3\gamma\lambda/2$ then the quality level will be greater than zero. The purchaser knows the range within to choose the price M. If the provider is a government agency which aims to maximise the social welfare function and the social welfare decreases in taxes (we are in a tax financed system), then we can assume the constraint not binding, i.e. $M < 3\gamma c/\alpha$.

Furthermore, if we want eq.2 to be nested in eq.1 in order to set λ equal to zero, we require $M \geq 15\gamma c/8\alpha$, i.e. when M is greater or equal to that value we see that the constraint is not binding and the first equation ensures a quality at least as great as the one required by the constraint.

To sum up we can say that the condition

$$\frac{\partial L}{\partial \lambda} > 0$$

is always satisfied if the purchaser sets M lower than

$3\gamma c/\alpha$ (quality level greater than zero) but greater than (or equal to) $15\gamma c/8\alpha$. (constraint not binding).

Thus $15\gamma c/8\alpha \leq M < 3\gamma c/\alpha$.

Because of this result, the Lagrangean multiplier (λ) is zero in order to satisfy the complementary slackness condition:

$$\lambda[\frac{\partial L}{\partial \lambda}] = 0$$

Because the provider's goal is to get the desired quality level at minimum cost, he will set the fixed price M equal to $15\gamma c/8\alpha$.

Thus, because q_a is greater than zero, the complementary slackness condition for the first equation $q_a[\frac{\partial L}{\partial q_a}] = 0$

indicates that at the optimum level we need:

$$\frac{\partial L}{\partial q_a} = 0$$

To conclude, we can state that the leader will set his quality according to:

$$q_a = \frac{M}{c} - \frac{3\gamma}{2\alpha}$$

Turning the attention to the follower reaction function we can define the quality level provided by hospital B:

$$q_b = \frac{M}{c} - \frac{5\gamma}{4\alpha}$$

We can observe that $q_b > q_a$.

Easily we can obtain the values of d_a and d_b:

$d_a = 3/8$

$d_b = 5/8$

Hospital B setting a higher quality level than hospital A serves a larger demand for health treatment.

Substituting the demand values in the profit functions we get:

$$\Pi_a = \frac{9c\gamma}{16\alpha} - F$$

$$\Pi_b = \frac{25\gamma c}{32\alpha} - F$$

Surprisingly the leader gets a lower profit than the follower.

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