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Hospital competition and quality with regulated prices

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Abstract

We analyse the effect of competition on quality in hospital markets with regulated prices, considering both the effect of free patient choice (monopoly versus competition) and increased competition through lower transportation costs (increased substitutability). With partially altruistic providers and a convex cost function that is non-separable in activity and quality, we show – in both cases – that the effect is generally ambiguous. In contrast to the received theoretical literature, this is consistent with, and potentially explains, the mixed empirical evidence.

Keywords: Hospitals; Competition; Quality

JEL Classification: H42; I11; I18; L13

1 Introduction

Quality is a major concern in health care. Recent and ongoing reforms in several countries to stimulate competition and patient choice in public hospital markets have highlighted the importance of establishing more knowledge about the relationship between competition and quality. Restricting attention to hospital markets with regulated prices – relevant

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for many European health care systems as well as the U.S. Medicare and Medicaid programmes – the received theoretical literature, though relatively scant, is consensual in predicting a positive relationship between competition and quality.¹ However, the empirical evidence is mixed. A few recent studies include Kessler and McClellan (2000) and Tay (2003) who find a positive relationship, Gowrisankaran and Town (2003) who find a negative relationship, and Mukamel et al. (2001) who find no effects.²

In this note we extend and generalise the received theoretical literature by simultaneously including (i) heterogeneous patients and elastic demand, (ii) partly altruistic providers, and (iii) convex costs that are non-separable in activity and quality. We analyse, first, the effect of a policy regime switch from monopoly to competition (i.e., introducing free patient choice), and, second, the effect of increasing the degree of competition through lower transportation costs (i.e., increasing the degree of substitutability among hospitals). In both cases, we show that the relationship between competition and quality is generally ambiguous and depends crucially on hospital cost structure and the degree of altruism.

2 Model

Consider a market for elective hospital treatment where n hospitals are equidistantly located on a circle with circumference equal to 1.³ There are two patient types – L and H – differing with respect to the gross valuation of treatment. Both types are uniformly distributed on the circle. A patient demands either one treatment from the most preferred hospital, or no treatment at all. The utility of, respectively, an H -type and a L -type patient located at x and being treated at hospital i , located at z_i , are given by

$$\begin{aligned} U^H(x, z_i) &= V - t|x - z_i| + q_i, \\ U^L(x, z_i) &= v - t|x - z_i| + q_i, \end{aligned} \tag{1}$$

¹See, e.g., Ma and Burgess (1993), Calem and Rizzo (1995), Gravelle and Masiero (2000) and Brekke et al. (2006, 2007).

²See Gaynor (2006) for a survey of theoretical and empirical literature on the relationship between hospital competition and quality.

³The main structure of the model is based on Brekke, Siciliani and Straume (2008). We refer to this paper for a more thorough discussion of some of the main assumptions.

where q_i is the quality at hospital i , t is a transportation cost parameter, and $V - v > 0$ measures the difference in the gross valuation of treatment between the two types. The H -segment constitutes a share λ of the total number of patients, which is normalised to 1. We focus on equilibria where the H -segment is fully covered, while the L -segment is only partially covered, i.e., some L -patients will not seek treatment in equilibrium. The former assumption means that there is competition (or scope for competition) in the market, while the latter assumption implies that total demand for hospital treatment is elastic with respect to quality.

Hospitals are prospectively financed by a public payer offering a lump-sum transfer T and a per-treatment price p . The objective function of hospital i is assumed to be given by

$$\pi_i(q_i, q_j) = T + pX_i(q_i, q_j) + \alpha B_i(q_i, q_j) - C(X_i, q_i), \quad (2)$$

where $X_i(q_i, q_j)$ is demand for hospital i treatment. The cost of supplying hospital treatments is given by the cost function $C(X_i, q_i)$, which is increasing in both quantity and quality, and is strictly convex. We assume $C_{Xq} \geq 0$, i.e., quality and quantity are (weakly) complements: an increase in quality is more costly when more patients are treated. The function $B_i(\cdot)$ gives the total benefit of the patients from receiving treatment at hospital i , while the parameter $\alpha \in [0, 1]$ captures the degree of altruism of the provider. We assume that hospitals cannot turn down patients seeking treatment, implying that we do not allow for explicit rationing.

The hospitals simultaneously and independently choose qualities, in order to maximise their objective functions. Maximising (2) with respect to q_i and applying symmetry, the equilibrium quality, q^* , is given by

$$\frac{\partial X_i(q^*)}{\partial q_i} [p - C_X(X_i(q^*), q^*)] + \alpha \frac{\partial B_i(q^*)}{\partial q_i} = C_q(X_i(q^*), q^*), \quad i = 1, 2. \quad (3)$$

The marginal benefit from quality is given by the higher revenues and the non-monetary benefit arising from altruism. The marginal cost of quality includes the direct marginal

cost of quality investments and the increased marginal cost of treatment that arises from the demand increase. The combination of altruistic preferences and increasing marginal treatment costs makes the sign of the profit margin, $p - C_X$, ambiguous in equilibrium. More specifically, the profit margin is negative in equilibrium if the marginal altruistic gain of a quality increase is larger than the direct marginal cost: $\alpha \frac{\partial B_i}{\partial q_i} > C_q$.

3 Competition and quality

Consider two distinctly different policy regimes: 1) a benchmark case of *no competition*, where patients are assigned to hospitals purely according to geographical distance and hospitals are in effect local monopolies; 2) *competition*, where patients are free to choose among hospitals when demanding treatment. The choice of policy regime affects the demand responsiveness to quality, $\partial X_i / \partial q_i$, which, in turn, affects the marginal altruistic utility gain, $\partial B_i / \partial q_i$. From (3) we see that these are the two channels through which competition might affect quality.

3.1 Monopoly

Without free patient choice, hospital i 's demand from the H -segment is exogenously given by $X_i^H = 1/n$. In the L -segment, the patient who is indifferent between treatment at hospital i and no treatment is located at x_i^L , given by $v - tx_i^L + q_i = 0$, yielding $x_i^L = (v + q_i) / t$. Total demand for hospital i from the L -segment is given by $X_i^L = 2x_i^L$. Total demand for hospital i (from both patient segments) is thus given by

$$X_i(q_i) = \frac{\lambda}{n} + (1 - \lambda) \frac{2(v + q_i)}{t} \quad (4)$$

while total utility for the patients treated at hospital i is given by

$$B_i(q_i) = \lambda 2 \int_0^{\frac{1}{2n}} (V + q_i - tx) dx + (1 - \lambda) 2 \int_0^{\frac{v+q_i}{t}} (v + q_i - tx) dx, \quad (5)$$

yielding

$$\frac{\partial X_i(q_i)}{\partial q_i} = \frac{2(1-\lambda)}{t} > 0 \quad (6)$$

and

$$\frac{\partial B_i(q_i)}{\partial q_i} = X_i(q_i). \quad (7)$$

Equilibrium quality under monopoly, $q^* = q^m$, is found by substituting (4)-(7) into (3).⁴

3.2 Competition

With free patient choice, the hospitals' quality choices affect demand also in the H -segment. Since the distance between hospitals is equal to $1/n$, the H -patient who is indifferent between seeking treatment at hospital i and hospital j is located at x_i^H , given by $V - tx_i^H + q_i = V - t(1/n - x_i^H) + q_j$, yielding $x_i^H = (q_i - q_j + \frac{t}{n})/2t$. Total demand for hospital i from the H -segment is given by $X_i^H = 2x_i^H$. Demand from the L -segment is the same as before. Total demand facing hospital i from both segments is thus given by

$$X_i(q_i, q_j) = \lambda X_i^H + (1-\lambda) X_i^L = \frac{2(1-\lambda)v + q_i(2-\lambda) - \lambda q_j}{t} + \frac{\lambda}{n}, \quad (8)$$

while the surplus to patients treated at hospital i is given by

$$B_i(q_i, q_j) = 2\lambda \int_0^{\frac{1}{2t}(q_i - q_j + \frac{t}{n})} (V + q_i - tx) dx + 2(1-\lambda) \int_0^{\frac{v+q_i}{t}} (v + q_i - tx) dx, \quad (9)$$

yielding

$$\frac{\partial X_i(q_i, q_j)}{\partial q_i} = \frac{2-\lambda}{t} \quad (10)$$

and

$$\frac{\partial B_i(q_i, q_j)}{\partial q_i} = X_i(q_i, q_j) + \frac{\lambda}{t} \left(V + \frac{q_i + q_j}{2} - \frac{t}{2n} \right). \quad (11)$$

⁴The second-order condition is given by $\partial^2 \pi_i / \partial q_i^2 = -\left(C_{XX} \frac{2(1-\lambda)}{t} + 2C_{Xq} - \alpha \right) \frac{2(1-\lambda)}{t} - C_{qq} < 0$, which holds for a sufficiently convex cost function.

Equilibrium quality under competition, $q^* = q^c$, is found by substituting (8)-(11) into (3) and setting $q_i = q_j = q^c$.⁵

3.3 Competition versus monopoly

A comparison of the two policy regimes with respect to equilibrium quality yields the following result:

Proposition 1 *Competition between hospitals lead to higher (lower) quality in equilibrium if the competitive segment (λ) is below (above) a threshold level $\hat{\lambda}$, given by*

$$\hat{\lambda} := 1 - t \left(\frac{\alpha - C_q(X_i(q^m), q^m) n}{2n\alpha(V - v)} \right). \quad (12)$$

The proof involves a straightforward comparison (including some algebraic manipulations) of the equilibrium condition in the two cases. The details are available upon request.

The effect of competition on quality is a result of two counteracting forces. On the one hand, competition increases the marginal altruistic gain of quality (cf. (7) and (11)), since hospitals can attract high-benefit patients by increasing quality. *Ceteris paribus*, this leads to higher hospital quality in equilibrium. On the other hand, competition increases the demand responsiveness to quality (cf. (6) and (10)). Whether or not this increases quality incentives depends on the sign of the profit margin, $p - C_X$. If the profit margin is positive, hospitals will compete more fiercely to attract patients also for profit-oriented reasons, and competition will unambiguously increase quality.

However, if the profit margin is negative, a more quality-responsive demand implies, *ceteris paribus*, that hospitals have less incentives to invest in quality. If this is the case, then the introduction of competition has an ambiguous effect on equilibrium quality. From (12) we see that $\alpha > 0$ is a necessary, but not sufficient, condition for a negative relationship between competition and quality. In general, competition is more likely to lead to lower

⁵The second-order condition is $\partial^2 \pi_i / \partial q_i^2 = - [(C_{XX} \frac{2-\lambda}{t} + 2C_{Xq} - \alpha) \frac{2-\lambda}{t} - \alpha \frac{\lambda}{2t} + C_{qq}] < 0$, which is always satisfied for a sufficiently convex cost function.

quality if the degree altruism is high and hospital density is low, relative to the direct marginal cost of quality.⁶

3.4 Increased substitutability

Given a policy regime of free patient choice, consider the effect of *increasing the degree of competition* in the market through lower transportation costs, increasing the substitutability among the hospitals in the market. Lower transportation costs have two different effects: it makes demand more responsive to quality changes and it increases total demand from the L -segment. Applying Cramer's rule, we obtain a generally indeterminate total effect:

$$\frac{\partial q^c}{\partial t} = \frac{-\frac{\partial X}{\partial t} \left[\frac{2-\lambda}{t} C_{XX} + C_{Xq} \right] - \left[\frac{2-\lambda}{t^2} (p - C_X) + \alpha \frac{\lambda}{t^2} (V + q^c) - \alpha \frac{\partial X}{\partial t} \right]}{\left(\frac{2-\lambda}{t} C_{XX} + C_{Xq} - \alpha \right) \frac{2(1-\lambda)}{t} - \alpha \frac{\lambda}{t} + C_{qq} + C_{Xq} \frac{2-\lambda}{t}} \geq 0. \quad (13)$$

The second-order condition ensures that the denominator is positive, so the sign of the expression is determined by the sign of the numerator. The first term is always positive (since $\partial X/\partial t < 0$). Using the first-order condition, we can show that the second term is also positive if $\alpha \frac{\lambda}{2n} > C_q(\cdot)$, i.e., if altruism is sufficiently high relative to the direct marginal cost of quality investments.⁷ In this case, $\partial q^c/\partial t > 0$, implying that increased competition unambiguously reduces quality.

On the other hand, if the profit margin is positive and sufficiently large, we obtain the standard result from the literature, that increased competition increases quality. Notice, however, that a positive profit margin is *not* a sufficient condition for increased competition to increase quality. Notice also that, even without altruism, it is not necessarily the case that lower transportation cost increases quality. By setting $\alpha = 0$ in (13) we still obtain $\frac{\partial q^*}{\partial t} \geq 0$, in contrast to the received literature. This is due to our assumptions of increasing marginal activity costs and non-separability in the cost function.

⁶Notice that $\hat{\lambda} > (<) 1$ if $C_q > (<) \frac{\alpha}{n}$, i.e., if the direct marginal cost of quality is larger (smaller) than the marginal altruistic gain in the monopoly equilibrium, implying a positive (negative) profit margin.

⁷Notice that this condition implies a negative profit margin, since $\frac{2-\lambda}{t}(p - C_X) = (C_q - \alpha \frac{\lambda}{2n}) - \left(\frac{\lambda}{t}(V + q^c) + \frac{2(1-\lambda)}{t}(v + q^c) \right)$ in equilibrium.

Summarising:

Proposition 2 *(i) Lower transportation costs have in general an indeterminate effect on quality, even if the profit margin is positive, and even if the degree of altruism is zero;*

(ii) Lower transportation costs always reduce quality if the degree of altruism is large relative to the direct marginal cost of quality;

(iii) If the profit margin is positive, the marginal cost of treatment is constant and the cost function is separable in quality and activity, then lower transportation costs always increase quality.

4 Concluding remarks

With partly altruistic health care providers and a general convex cost structure, a positive relationship between hospital competition and quality is no longer guaranteed. Therefore, our model is useful to clarify under which conditions we might expect competition to increase (resp., decrease) quality. For example, empirical findings that more competition reduces quality can, in our model, be explained by high levels of altruism, increasing marginal cost of activity and costs complementarity between activity and quality.

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