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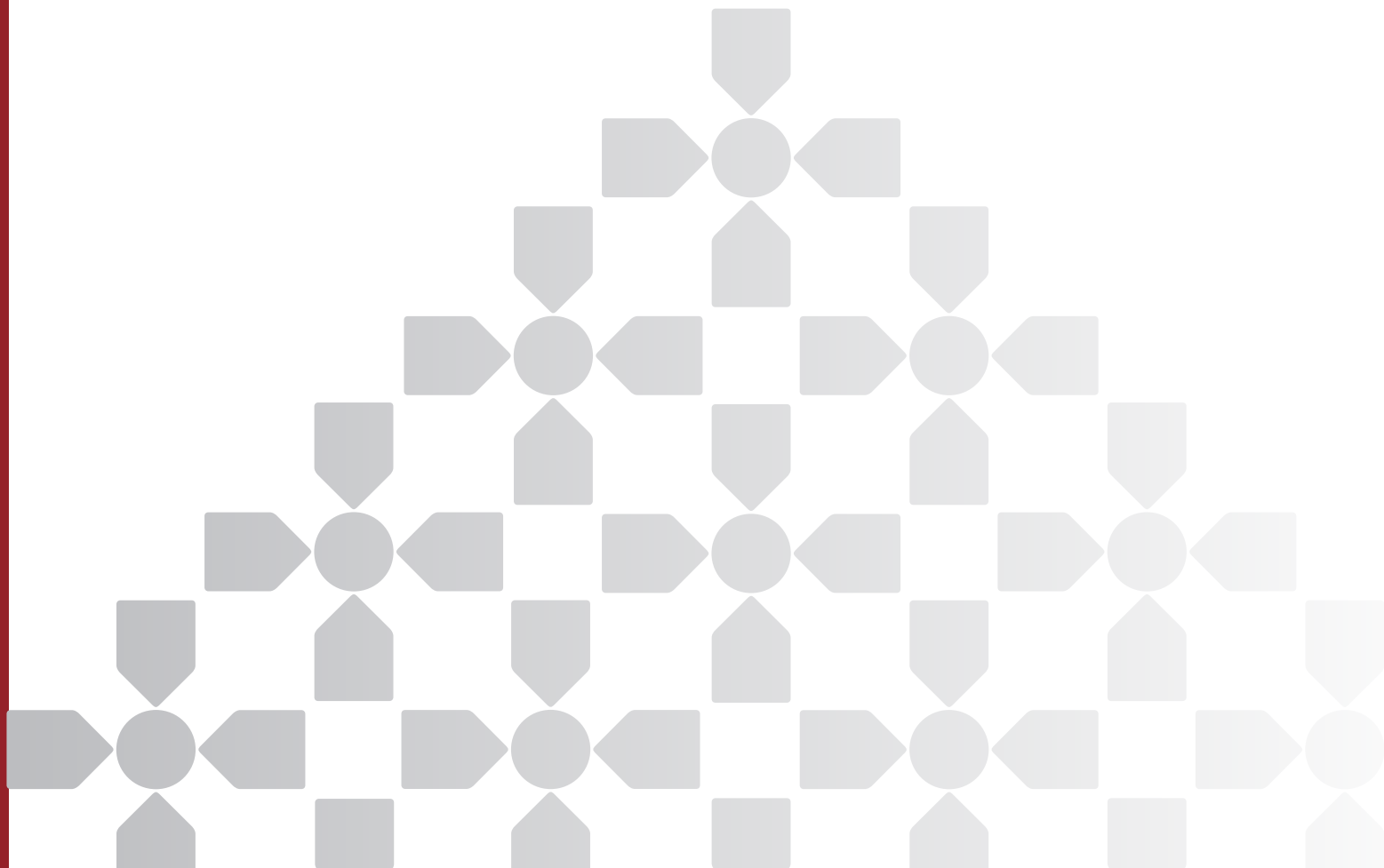

Hospital Mergers with Regulated Prices*

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Abstract

We study the effects of hospital merger in a spatial competition framework where semi-altruistic hospitals choose quality and cost-containment effort. Whereas a merger always leads to higher average cost efficiency, the effect on quality provision depends on the strategic nature of quality competition, which in turn depends on the degree of altruism and the effectiveness of cost-containment effort. If qualities are strategic complements, a merger leads to lower quality for all hospitals. If qualities are strategic substitutes, a merger leads to higher quality for at least one hospital and might also yield higher average quality provision and increased patient utility.

Keywords: Hospital mergers; Quality competition; Cost efficiency; Antitrust

JEL Classification: I11, I18, L13, L44

I. Introduction

The hospital industry has undergone substantial consolidation during the last decades both in the US and in Europe.[1] The stated motives for hospital mergers are that they facilitate efficiency gains and enhance the quality of care. However, there is a growing concern that the continuing consolidation may increase market power in the hospital industry and thereby lead to adverse effects for patients through lower quality of care.[2] Whereas in the past governments tended to encourage consolidation and antitrust authorities approved most of the hospital mergers, there is recently a clear tendency towards a more strict regulation of hospital mergers. In 2009 the UK government established the Cooperation and Competition Panel (CCP) with the authority of approving NHS hospital mergers. In January 2013 the Office of Fair Trading (OFT) referred for the first time a merger of two NHS foundation trusts to the Competition Commission stating:[3]

> "The evidence before the OFT is that the merger would combine two trusts that compete closely for GP referrals for many specialties and it is likely that the merger would result in few realistic alternative providers for patients and NHS commissioning groups. As a result, the OFT could not dismiss concerns that in several medical specialties [...] the merger might reduce the hospitals' incentives to continue to enhance the quality of those services over the minimum required standards and would result in less choice for commissioners wishing to reorganise services."

What do we know about the effects of hospital mergers on quality and cost efficiency? Not much. The empirical literature is very limited and the overall picture emanating from the few existing studies is rather inconclusive. Furthermore, there is, to our knowledge, no comprehensive theoretical analysis of merger effects on quality and cost efficiency in hospital markets under price regulation. Given the growing real-world importance of hospital mergers, this is clearly an important void in the literature, since standard merger analyses cannot be directly applied to the case of hospital mergers, because of institutional and behavioural idiosyncrasies.[4]

[1] A description of the consolidation and corresponding changes in concentration in the US and UK hospital markets can be found in the recent survey by Gaynor and Town (2012).

[2] For example, the merger simulations by Beckert et al. (2012) with data from the English NHS show that merging hospitals' demand would become substantially less sensitive to quality after the merger. This would lessen competition and might have adverse effects on patients.

[3] See the OFT webpage: http://www.oft.gov.uk/news-and-updates/press/2013/01-13#.U1ZGkm-KBdg

[4] In most OECD countries hospitals face regulated prices and compete only on quality. Furthermore, it is widely

The aim of the present paper is to contribute towards filling this void. We ask the following questions: How does a hospital merger affect the merging hospitals' incentives for quality and cost containment? How do competing hospitals respond to the merger? Do the effects of a merger depend on whether or not the merger involves hospital closure? What are the effects on consumer welfare? Which type of hospital mergers should be approved?

In order to answer these questions, we use a spatial competition framework with three *ex ante* identical hospitals symmetrically located on the Salop circle.[5] Hospitals are semi-altruistic and choose quality and cost-containment effort to maximise a weighted sum of profits and patients' utility from treatment. Patients select hospital based on travelling distance and quality, and the hospitals receive a regulated price for each patient treated.

In the benchmark model we focus on the anticompetitive effects of hospital mergers by assuming the merger implies coordination of supply (quality and cost-containment effort) among the merging hospitals. In addition, the merger is assumed to entail synergies in cost containment. In an extension to the benchmark model we allow for another type of cost synergies by considering closure of one of the merging hospitals, which implies savings of fixed costs.

Our analysis applies to an institutional setting where hospitals compete for patients on quality, but cannot set prices for their treatments. The case of regulated prices is relevant for most OECD countries, as well as the US Medicare, where activity-based funding of the Diagnosis Related Groups (DRG) type is the norm: each hospital receives a fixed price for each patient treated. Since prices are fixed, the scope for hospitals to increase prices following a merger is therefore precluded. How can mergers then damage patients? As highlighted above, the key concern is that a merger can reduce quality of care and increase patients travelling costs. Within the health sector, quality and choice remains possibly the key concern for health policymakers, which in turn is reflected in regulators' mandates. Indeed, in the UK, according to the recent guidelines from the Competition & Markets Authority (CMA), NHS mergers are likely to be investigated if there is a risk for adverse effects on patient choice and quality of care.[6]

We show that the effect of a hospital merger on quality and patient utility depends crucially on

recognised in the health economics literature that the standard paradigm of profit maximisation does not necessarily apply to health care providers, who tend to have somewhat broader objectives.

[5] A similar framework has been used by Gravelle (1999) and Nuscheler (2003) to study competition among physicians, and Brekke et al. (2011) for competition among hospitals with regulated prices.

[6] See the report "CMA guidance on the review of NHS mergers", 31 July 2014.

the strategic nature of quality competition: whether qualities are strategic substitutes or complements. If qualities are strategic complements, a merger will lead to lower quality at all hospitals in the market, regardless of whether the merger implies hospital closure or not. On the other hand, if qualities are strategic substitutes, at least one hospital will increase quality provision as a result of the merger, which might be enough to increase not only average quality in the market, but also total patient utility. In a merger with closure, quality increases at all remaining hospitals whenever qualities are strategic substitutes. Even if closure implies a larger increase in total travelling costs, patient utility will nevertheless increase either if hospitals are sufficiently altruistic or if the scope for cost containment is sufficiently large.

The strategic nature of quality competition depends on two salient features of the hospital sector: the degree of altruism and the interaction between quality and cost-containment incentives. If there is no scope for cost containment, qualities are strategic complements (substitutes) if altruism is sufficiently low (high) relative to the cost substitutability between quality and output. However, allowing for cost-containment effort, the nature of the strategic relationship changes. With only fixed quality costs, qualities are now strategic substitutes for any degree of altruism including the case of purely profit-maximising hospitals. If there are variable quality costs, quality decisions are strategic substitutes if altruism is sufficiently high or if cost-containment effort is sufficiently effective. Thus, cost-containment effort is an additional factor that contributes to making qualities strategic substitutes.

The effect of a hospital merger on cost efficiency is more uniformly positive. Regardless of the strategic nature of quality competition, a hospital merger (without closure) will always lead to higher cost-containment effort for at least one of the hospitals, and it might also increase cost efficiency at all hospitals, partly because such a merger increases the efficiency of cost-containment effort for the merged hospitals. In any case, average cost containment in the market increases as a result of the merger. The variable-cost merger synergy disappears if the merged entity closes down one of its hospitals after the merger. Nevertheless, the remaining hospitals will choose a higher level of cost-containment effort because of higher demand, which directly stimulates incentives for cost containment.

Our analysis offers a first coherent theoretical investigation of hospital mergers under price regulation. The standard model on mergers with endogenous price cannot be straightforwardly

applied to the hospital sector. Typically, prices are strategic complements and therefore a merger triggers an increase in price by the non-merging firm. In our model we show that qualities can be strategic substitutes when features specific to the hospital sector are introduced. A merger can therefore trigger an increase in quality by the non-merging hospital if the merged hospitals lower their quality. As a result, the welfare implications may not be as severe as when all providers reduce quality.

The assumption that health care providers are motivated or exhibit altruistic concerns is by now well recognised in the literatures of both health economics[7] and public economics.[8] We assume that health care providers are semi-altruistic, meaning that they care, at least to some extent, about the treatment benefit of their patient. Although physicians may not act as 'perfect' agents for the patients, it seems plausible that they may act at least as 'imperfect' ones (McGuire, 2000). The empirical evidence also suggests that altruism and motivation are important components of health care workers' job and that job satisfaction depends on both pecuniary and non-pecuniary aspects of employment.[9]

The rest of the paper is organised as follows. In the next section we give a brief overview of related literature and explain more precisely the contribution of our paper. In Section III we present the basic model. In Section IV we derive the (symmetric) Nash equilibrium in the pre-merger game. In Section V we derive the (asymmetric) Nash equilibrium in the post-merger game and analyse the effects of a hospital merger. In Section VI we analyse if and how our results might change if a merger leads to closure of one of the merging hospitals. In Section VII we discuss implications for competition policy. Finally, in Section VIII we summarise our findings and offer some concluding reflections.

II. Relation to existing literature

Our paper relates to the fairly large theoretical literature on quality competition in health care markets. This literature usually finds that if prices are regulated and providers are maximising

[7] See, e.g., Ellis and McGuire (1986), Chalkley and Malcomson (1998), Eggleston (2005). Heyes (2005), Jack (2005), Choné and Ma (2011), Kaarbøe and Siciliani (2011).

[8] See, e.g., Besley and Ghatak (2005, 2006), Dixit (2005), Murdock (2002), Lakdawalla and Philipson, (2006), Delfgaauw and Dur (2007, 2008), Glazer (2004), Makris (2009), Brekke et al. (2011, 2012), and Siciliani et al. (2013).

[9] See Page (1996), Le Grand (2003, chapter 2), Shields and Ward (2001), Antonazzo et al. (2003), Gregg et al. (2008), Ikenwilo and Scott (2007), Leonard and Masatu (2010).

profits, then more competition results in higher quality.[10] However, with semi-altruistic hospitals, some studies find that more competition does not necessarily increase quality (see, e.g., Brekke et al., 2011).[11] We extend this literature by focusing on mergers rather than the number of hospitals or the intensity of competition. Our study demonstrates that hospital mergers (without closure) do not have the same effects as reduced competition on market outcomes. In particular, we show that a merger may give hospitals opposing incentives with respect to quality and cost-containment effort depending on whether or not they take part in the merger. Thus, the impact of mergers on market outcome and social welfare is distinctly different from reducing the number of hospitals or relaxing the intensity of competition between a given number of competing hospitals.

There exists a couple of theoretical studies on hospital mergers. Calem et al. (1999) model quality (or quality-adjusted price) competition among hospitals and examine whether mergers enhance social welfare. In their model there is overutilisation of care due to insurance, and they find that mergers may be desirable since hospitals reduce quality, which in turn induces patients to consume less care. However, Gaynor et al. (2000) show that reduced competition in medical markets cannot have any efficiency-enhancing effects even in the presence of moral hazard, because insurers would respond to changes in the hospital market by altering the coinsurance rate. Another study is Brekke (2004) who analyses the profitability of mergers when hospitals negotiate wages with physician unions. Using a model with two hospitals that compete on quality and potentially also on prices, he finds that the profitability of a merger depends on the bargaining structure (centralised or decentralised) and the nature of competition (non-price or price competition). Our paper differs from these studies along several dimensions. The most crucial difference is that a merger in these papers leads to a monopolisation of the hospital market. Thus, the nature of the merger is very different, as an important feature of our merger analysis is how the non-merging hospitals respond to the merger.

The study by Gal-Or (1999a) considers hospital (and payer) mergers that do not monopolise the market.[12] She uses a model with imperfect competition in both the insurance and the hospital

[10] See, e.g., Gravelle (1999), Lyon (1999), Beita (2003), Nuscheler (2003), Brekke et al. (2006, 2007), Karlsson (2007) and Brekke et al. (2015).

[11] Our study is related to Brekke et al. (2011), but differs in several important ways. First, we study mergers rather than competition and show that the effects on quality provision are distinctly different due to the asymmetric responses by merging and non-merging hospitals. Second, we endogenise hospital costs and show that this may affect the nature of competition and thus the effect of hospital mergers. Finally, we also analyse welfare effects.

[12] See also Gal-Or (1999b) who study vertical mergers between hospitals and physician practices in a similar

market, and focuses on the bargaining between insurers and hospitals on the reimbursement rates.[13] In her model individuals choose insurer based on relative premiums and 'distance' to the most preferred insurer. However, the choice of hospital is only based on travel distance; i.e., there is no direct competition between hospitals. The incentive for hospitals to merge is to increase their bargaining power towards the insurers, but also to improve efficiency by closing down one hospital. She finds that hospitals are more likely to merge without consolidating their capacities the less competitive they are vis-à-vis the payer's market.

The empirical literature on the effects of hospital mergers on *quality* is very scant. The few existing studies tend to find no effect or very small negative effects. Ho and Hamilton (2000) find that mergers in California have no effect on the quality of care as measured by mortality rates for patients with heart attack and stroke, though readmission rates and early discharges for newborns increased in some cases. Capps (2005) focuses on mergers in the New York state during 1995-2000 and also find no effects for most quality indicators. Romano and Balan (2011) focus on two mergers in the Chicago suburbs and find little evidence that the mergers led to any quality improvements. Gaynor et al. (2012a) examine the impact of a large number of mergers in England, where prices are regulated, on a range of outcomes including financial performance, productivity, waiting times and clinical quality. They find little evidence that mergers had any effect on clinical quality but activity reduced and waiting times increased.

Empirical studies on the impact of hospital mergers on *cost-efficiency* are even more scarce. Dranove and Lindrooth (2003) examine mergers of previously independent hospitals and find that these hospitals experience post-merger cost decreases of 14 percent on average. A recent study by Harrison (2010) finds cost reductions immediately after the merger, but eventually costs rose to pre-merger levels. Thus, the long-term effects on cost-efficiency are less clear.

Although not directly related to mergers, our results on quality are in line with studies that find that reductions in competition, as measured by concentration indices, reduce quality for markets with regulated prices. For the US Medicare market, Kessler and McClellan (2000) and Kessler and Geppert (2005) find that market concentration significantly increases mortality. Recent studies on the English National Health Service (NHS) reforms in 2006 introducing patient choice and regulated

bargaining set-up.

[13] See also Gowrinsankaran et al. (2013) who study bargaining between hospitals and managed care organizations.

prices report similar findings (see Cooper et al., 2011; Gaynor et al., 2013). The effects of hospital concentration under price competition vary in all directions (see Gaynor and Town, 2012).

III. Model

Consider a market for health care services where three providers (hospitals), denoted by $i = 1, 2, 3$, are equidistantly located on a circle with circumference equal to 1.[14] A total mass of 1 consumers (patients) are uniformly distributed on the same circle. Each patient demands one unit of treatment from the most preferred provider. Patients are insured and hospital treatment is free at the point of consumption. The net utility of a patient located at z and seeking treatment at Hospital i, located at x_i, is given by

$$u_{z,x_i} = v + bq_i - t\,|z - x_i|\,, \tag{1}$$

where $q_i \geq 0$ is the quality offered by Hospital i; $b > 0$ is the marginal utility of quality; and $t > 0$ is the marginal disutility of travelling.[15] In order to ensure full market coverage for any $q_i \geq 0$ in all games considered, we assume $v > t/3$.

Each patient chooses the preferred hospital based on quality and travelling costs. The location (measured *clockwise* from Hospital i) of the patient who is indifferent between Hospital i and Hospital $i+1$ is given by

$$\widehat{z}_i^{i+1} = \frac{1}{6} + \frac{b\,(q_i - q_{i+1})}{2t}, \tag{2}$$

whereas the location (measured *anticlockwise* from Hospital i) of the patient who is indifferent between Hospital i and Hospital $i-1$ is given by

$$\widehat{z}_i^{i-1} = \frac{1}{6} + \frac{b\,(q_i - q_{i-1})}{2t}. \tag{3}$$

When each patient makes a utility-maximising choice, the demand for Hospital i is therefore a

[14] The assumption of three instead of n hospitals is made in order to make the analysis tractable. In a market with n hospitals the incentives for a non-merging hospital to provide quality in the post-merger game would depend on its relative positioning in space vis-à-vis the merged hospitals. However, as competition is localised, the strongest responses to a merger will always come from the merged hospitals' closest neighbours. Therefore, the assumption of three hospitals is without too much loss of generality.

[15] Empirical studies confirm that higher quality and shorter travelling distance increase the probability of choosing a health care provider. See, e.g., Folland (1983), Luft et al. (1990), Burns and Wholey (1992), Hodgkin (1996), Tay (2003), Howard (2005), Sivey (2012), Beckert et al (2012) and Gaynor et al. (2012b).

function of its own quality and the qualities of its two neighbours, and given by

$$D_i\left(q_i, q_j\right) = \widehat{z}_i^{i+1} + \widehat{z}_i^{i-1} = \frac{1}{3} + \frac{b}{t}\left(q_i - \frac{1}{2}\sum_{j \neq i} q_j\right). \tag{4}$$

The hospitals are assumed to be *ex ante* identical (apart from their location). The cost function of Hospital i is given by

$$C_i\left(q_i, D_i\right) = \left(\sigma_i + cq_i\right) D_i + \frac{k}{2} q_i^2 + F, \tag{5}$$

where $\sigma_i > 0$, $k > 0$, $F > 0$, and $c \geq 0$. If $c = 0$, quality provision involves only fixed costs and quality is a public good at hospital level. If $c > 0$, quality provision involves both variable and fixed costs, and quality and treatment volume are cost substitutes ($\partial^2 C_i / \partial q_i \partial D_i > 0$). This assumption implies constant marginal cost of treatment, but where the cost per patient is increasing in the quality provided.

Each hospital can reduce its treatment costs by expending effort on cost containment. More specifically, we assume $\sigma_i := \overline{\sigma} - \varepsilon_i$, where ε_i is the amount of cost-containment effort chosen by Hospital i. Thus, by expending effort in the amount of ε_i, total treatment costs will be reduced by an amount $\varepsilon_i D_i$. The disutility of cost containment effort is assumed to be strictly convex in the amount of effort expended: $\frac{w}{2}\varepsilon_i^2$, where $w > 0$.

Finally, hospitals are semi-altruistic in the sense that they, to some extent, take the *medically relevant* part of patient utility directly into account when making their decisions. More specifically, we assume that Hospital i ignores the travelling costs of their patients but attaches a weight $\alpha > 0$ to the remaining part of their total utility, $\left(v + bq_i\right) D_i$. Under these assumptions, the objective function of Hospital i can be written as

$$\Omega_i = \left(p + \varepsilon_i - \beta q_i\right) D_i + P - \frac{k}{2} q_i^2 - \frac{w}{2}\varepsilon_i^2, \tag{6}$$

where $p := \widehat{p} - \overline{\sigma} + \alpha v$, with $\widehat{p}$ being the fixed price that the hospital receives (from a third-party payer) per treatment, $\beta := c - \alpha b$, and $P := T - F$, with T being a lump-sum transfer (block grant) from the regulator. The regulatory instruments ($\widehat{p}$ and P) are assumed to be such that the each hospital has a non-negative payoff. However, we perform the analysis within a static regulatory

environment where any potential cost savings are captured by the hospitals.[16]

We make the following restrictions on parameter values throughout the analysis:

$$w > \underline{w} := \frac{2b^2}{t\left(3b\beta + kt\right)}, \quad \beta > \underline{\beta} := -\frac{kt}{3b}, \quad \underline{p} < p < \overline{p}, \tag{7}$$

where

$$\underline{p} := \max\left\{\frac{\lambda\left(2\theta + b\lambda\right)}{3bw\left(\theta + b\lambda\right)}, \frac{\lambda\left(\theta + 2b\lambda + wt^2k\right)}{3bw\left(\theta + b\lambda + wt^2k\right)}\right\}, \quad \overline{p} := \frac{\left(b\beta + 2kt\right)\left(2\theta + b\lambda\right)}{3b^2ktw}. \tag{8}$$

Parameters θ and λ are defined as $\theta := tw\left(2b\beta + kt\right) - b^2 > 0$ and $\lambda := tw\beta - b \lesseqgtr 0$.These restrictions ensure the existence of a Nash equilibrium with interior solutions in all games considered.

IV. Nash equilibrium in the pre-merger game

The first-order condition for optimal quality provision by Hospital i is given by

$$\frac{\partial \Omega_i}{\partial q_i} = \left(p + \varepsilon_i - \beta q_i\right)\frac{\partial D_i}{\partial q_i} - \beta D_i - kq_i = 0, \tag{9}$$

where $\partial D_i/\partial q_i = b/t$. The first term measures the marginal benefit of higher demand for a given quality level. A marginal quality increase attracts more patients to Hospital i and, for a given quality level, each of these patients has a value $p + \varepsilon_i - \beta q_i$ for the hospital. However, higher quality also increases both the marginal cost (cq_i) and the altruistic gain ($\alpha b q_i$) of treatment. The net effect is given by the second term in (9), which adds to (subtracts from) the benefit of higher quality if the degree of altruism is sufficiently high (low). Quality is optimally provided when the sum of these two terms is equal to the marginal cost of quality investments, which is given by the third term in (9).

The first-order condition[17] for optimal cost-containment effort by Hospital i is simply given by

$$\frac{\partial \Omega_i}{\partial \varepsilon_i} = D_i - w\varepsilon_i = 0, \tag{10}$$

and shows that the optimal effort is proportional to demand. This is entirely intuitive, since a higher treatment volume increases the incentives for reducing marginal treatment costs.

[16] See Brekke, Siciliani and Straume (2015) for an analysis of hospitals' incentives for quality and cost containment when surpluses (deficits) might be confiscated (covered) by the regulator.

[17] Second-order conditions are given in the Appendix.

The effects of a hospital merger on quality provision depend crucially on the nature of strategic interaction between the hospitals. It is instructive to characterise this in detail. From (9), the best-quality-response function of Hospital i, for a given level of cost containment, is given by

$$q_i\left(\varepsilon_i, q_j\right) = \frac{3b\left(p + \varepsilon_i + \frac{\beta}{2}\sum_{j\neq i} q_j\right) - t\beta}{3\left(2b\beta + kt\right)}. \tag{11}$$

We see that cost-containment effort and quality provision are complementary strategies for each hospital. This relationship is fairly straightforward. More cost containment increases the profit margin and therefore makes it more profitable to provide a higher level of quality. The cost-containment effort chosen by competing hospitals has no direct influence on quality provision (i.e., $\partial q_i/\partial \varepsilon_j = 0$).

The strategic relationship between quality provision at competing hospitals is less straightforward and given by

$$\frac{\partial q_i\left(\varepsilon_i, q_j\right)}{\partial q_j} = \frac{b\beta}{2\left(2b\beta + kt\right)} > (<)\, 0 \text{ if } \beta > (<)\, 0 \Leftrightarrow \alpha < (>)\, \frac{c}{b}. \tag{12}$$

For a given level of cost containment, the strategic nature of quality competition is determined by two different factors: (i) the degree of cost substitutability between quality and treatment volume, and (ii) the degree of altruism. If treatment costs do not depend on quality, and if there is no altruism, the hospitals' quality choices are strategically independent.

Cost substitutability between quality and output contributes to making qualities strategic *complements* (i.e., $\partial q_i/\partial q_j > 0$). If a hospital increases its quality, the competing hospitals lose demand, which in turn reduces their marginal cost of quality and increases their incentives for quality provision. On the other hand, altruism contributes to making qualities strategic *substitutes* (i.e., $\partial q_i/\partial q_j < 0$). Since the marginal altruistic gain from increasing quality provision depends positively on the number of patients treated, the demand loss caused by a quality increase by a competing hospital will therefore reduce the incentives to supply quality for altruistic reasons. Thus, for a given level of cost containment, whether qualities are strategic substitutes or complements depends on the degree of altruism relative to the degree of cost substitutability between quality and treatment volume.

If we allow each hospital to optimally adjust their choices of cost-containment effort in response to quality changes, by setting

$$\varepsilon_i\left(q_i, q_j\right) = \frac{1}{w}\left(\frac{1}{3} + \frac{b}{t}\left(q_i - \frac{1}{2}\sum_{j\neq i} q_j\right)\right), \tag{13}$$

the best-quality-response function of Hospital i is given by

$$q_i\left(q_j\right) = \frac{6bptw + \lambda\left(3b\sum_{j\neq i} q_j - 2t\right)}{6\theta}. \tag{14}$$

The strategic nature of quality competition is then characterised by

$$\frac{\partial q_i\left(q_j\right)}{\partial q_j} = \frac{b\lambda}{2\theta} > (<)\, 0 \text{ if } \lambda > (<)\, 0 \Leftrightarrow \beta < 0 \text{ or } w < \frac{b}{t\beta}\ \left(\beta > 0 \text{ or } w > \frac{b}{t\beta}\right). \tag{15}$$

If qualities are strategic substitutes for a given level of cost-containment effort (i.e., $\beta < 0$), allowing this effort to be optimally adjusted does not change the strategic nature of quality competition, since $\beta < 0$ implies $\lambda < 0$. However, if $\beta > 0$, optimal effort adjustments make qualities strategic substitutes if such effort is sufficiently effective in reducing treatment costs ($w < b/t\beta$). Thus, endogenous cost-containment effort is an additional factor that contributes towards making qualities strategic substitutes. The reason is that the incentive for cost containment depends positively on treatment volume. If a hospital increases quality provision, competing hospitals lose demand, which dampens the incentives of these hospitals to contain treatment costs. Less cost containment implies a lower profit margin which, in turn, reduces incentives for quality provision. Thus, the nature of strategic interaction between competing hospitals is determined by the sum of three different effects and is summarised as follows:[18]

Lemma 1 *When cost-containment effort is optimally adjusted, qualities are (i) strategic substitutes if altruism is sufficiently high compared to the marginal treatment cost of quality, ie $\alpha > c/b$, or if the marginal disutility of effort is sufficiently low, $w < b/\left(t\left(c - \alpha b\right)\right)$, (ii) strategically independent if $\alpha = \left(ctw - b\right)/btw$, and (iii) strategic complements otherwise.*

[18] In the Appendix we show that, in qualitative terms, the results in Lemma 1 are fairly general and do not strictly depend on the specific demand structure derived from the Salop model.

Solving the system of first-order conditions given by (9)-(10), quality and effort in the symmetric Nash equilibrium with interior solutions are given by

$$q_i^* = \frac{3bwp - \lambda}{3w\left(kt + b\beta\right)}, \quad \varepsilon_i^* = \frac{1}{3w}. \tag{16}$$

V. Hospital merger

Consider a merger between two of the hospitals.[19] We assume that such a merger does not lead to any hospital closures, either because a closure would not be approved by the regulator or because the potential fixed-cost synergies are too small.

A merger allows the two merger participants to reduce competition between them by coordinating their quality choices. In addition, we assume that a merger allows for efficiency gains by letting a given cost-containment effort apply to both of the merged hospitals. Thus, if Hospital i and Hospital j merge, the merged entity chooses q_i, q_j and ε_m to maximise joint payoff, where ε_m is the amount of cost-containment effort chosen by the management of the new merged entity and which reduces marginal treatment costs at both of the merged hospitals.[20] The maximisation problem of the merged entity in the post-merger game can therefore be expressed as

$$\max_{q_i, q_j, \varepsilon_m} \Omega_m := \left(p + \varepsilon_m - \beta q_i\right) D_i + \left(p + \varepsilon_m - \beta q_j\right) D_j + 2P - \frac{k}{2}\left(q_i^2 + q_j^2\right) - \frac{w}{2}\varepsilon_m^2. \tag{17}$$

The first-order condition for optimal quality at each of the merged hospitals is

$$\frac{\partial \Omega_m}{\partial q_i} = \left(p + \varepsilon_i - \beta q_i\right)\left(\frac{\partial D_i}{\partial q_i} + \frac{\partial D_j}{\partial q_i}\right) - \beta D_i - k q_i = 0, \tag{18}$$

whereas optimal cost-containment effort is given by

$$\frac{\partial \Omega_m}{\partial \varepsilon_m} = D_i + D_j - w\varepsilon_m = 0. \tag{19}$$

[19] A model with more than three hospitals would allow mergers also between non-neighboring hospitals. Without any cost synergies, such mergers would not change the equilibrium since competition is localised. Allowing for cost synergies would lead to lower marginal treatment costs and therefore higher quality for the merging hospitals.

[20] Since there is no direct strategic interaction between hospitals in the choice of cost-containment effort, such merger synergies have the same (qualitative) effects as any other type of synergy that leads to lower marginal treatment costs. For example, if hospitals have different marginal costs, a merger between a low-cost and a high-cost hospital would entail a similar type of efficiency gain if the merged entity can operate at the efficiency level of the low-cost hospital.

Compared with (9), we see that (18) has an additional negative term, $(p + \varepsilon_i - \beta q_i)(\partial D_j/\partial q_i) < 0$, which reflects the fact that the merger allows the hospitals to internalise a negative competition externality, which, all else equal, implies lower quality provision by the merged hospitals.[21] On the other hand, a merger increases incentives for cost containment (for given quality levels), as is evident from a comparison of (16) and (19). Higher cost-containment effort leads to lower treatment costs, which in turn stimulates incentives for quality provision. Thus, whether the merger leads to higher or lower quality provision by the merged hospitals is *a priori* uncertain.

The maximisation problem of the outside hospital is identical to the one in the pre-merger game and the first-order conditions for optimal quality and cost-containment effort are therefore given by (9). Let D_m denote total demand of the merged hospital. In the post-merger Nash equilibrium, quality and cost-containment by merged and non-merged hospitals, denoted (q_m, ε_m) and (q_o, ε_o), respectively, are then given by

$$q_m^* = \frac{3bpw(\theta + b\lambda) - tw(\beta(2\theta + b(tw\beta - 6b)) - 2bkt) - 3b^3}{3w\Phi}, \tag{20}$$

$$q_o^* = \frac{3bpw(2\theta - twb\beta) - \lambda\left(2\theta - b^2\right)}{3w\Phi}, \tag{21}$$

$$\varepsilon_m^* = \frac{D_m^*}{w}, \quad \varepsilon_o^* = \frac{D_o^*}{w} \tag{22}$$

where

$$D_m^* = \frac{2\left((b\beta + 2kt)(2\theta + b\lambda) - 3b^2ktwp\right)}{3\Phi}, \quad D_o^* = \frac{(b\beta + kt)\left(2\theta - b^2\right) + 3b^2ktwp}{3\Phi}, \tag{23}$$

and $\Phi := tw\left(3b\beta(b\beta + 2kt) + 2k^2t^2\right) - b^2(2b\beta + 3kt) > 0$.

In the remainder of this section we will explore how a merger affects quality provision and cost efficiency of all the hospitals in the market, how the patients are affected, and, finally, what determines the hospitals' incentives to merge.

Quality and cost efficiency

The effect of a hospital merger on quality provision can be stated as follows:[22]

[21] This is the mechanism highlighted by Katz (2014) in his brief discussion of hospital merger (from duopoly to monopoly).

[22] All proofs are in Appendix, which includes an exact characterisation of all the parameter thresholds that are

Proposition 1 *(i) If qualities are strategic complements, a hospital merger leads to lower quality for all hospitals. (ii) If qualities are strategic substitutes, there exists a threshold value of p, given by* $p_q \in \left(\underline{p}, \overline{p}\right)$*, such that a hospital merger leads to lower (higher) quality for the merged hospitals and higher (lower) quality for the non-merged hospital if the regulated price is sufficiently high (low), such that* $p > (<)\, p_q$*.*

As previously explained, a merger has two counteracting effects on the merged hospitals' incentives for quality provision. On the one hand, a merger allows the participants to internalise a negative competition externality by reducing their quality provision. On the other hand, the efficiency gain of the merger implies lower treatment costs, which in turn stimulates quality provision. The former (latter) effect dominates if the price ($\widehat{p}$) is sufficiently high (low), such that $p > (<)\, p_q$, which implies that quality competition is relatively strong (weak) in the pre-merger game, and where $p < p_q$ is possible only if qualities are strategic substitutes.

The response of the outside hospital depends entirely on the strategic nature of quality competition. If qualities are strategic complements, a hospital merger leads to lower quality for all hospitals in the industry. On the other hand, if qualities are strategic substitutes, the quality effects of a merger are heterogenous, with higher quality for at least one hospital in the industry. Quality will increase either for the merged hospitals because of sufficiently strong efficiency gains (if $p < p_q$) or for the non-merged hospital because of strategic substitutability (if $p > p_q$).

The effects of a hospital merger on cost efficiency are given as follows:

Proposition 2 *There exists a threshold value of p, given by* $p_\varepsilon \in \left(\max\left\{\underline{p}, p_q\right\}, \overline{p}\right)$*, such that a hospital merger leads to (i) higher (lower) cost-containment effort for the merging hospitals if the regulated price is sufficiently low (high), such that* $p < (>)\, p_\varepsilon$*; (ii) higher (lower) cost-containment effort for the non-merged hospital if the quality of the merging hospitals goes down (up); and (iii) higher average cost containment in the market.*

For the merged hospital, incentives for cost-containment effort are decided by two different factors. First, the merger in itself increases the effectiveness of cost-containment effort and therefore leads to higher effort, all else equal. If the merged hospital also increases its quality provision, this

reported in the remaining Propositions of the paper.

effect will be reinforced by higher demand, which increases incentives for cost containment. On the other hand, if the merged hospital's quality provision goes down, the direct positive effect of the merger on cost containment will be counteracted by reduced demand, which, all else equal, reduces the incentive to spend effort on containing treatment costs. The overall effect depends on both the direction and relative strength of these two effects. If the price is sufficiently high, such that $p > p_\varepsilon$, the decrease in quality provision (and thus treatment volume) by the merged hospital is sufficiently strong to outweigh the direct effect, implying that a merger makes the merged hospitals less cost-efficient. On the other hand, if the price is sufficiently low, such that $p < p_q < p_\varepsilon$, a merger will increase both quality and cost-efficiency of the merged hospitals.

For the non-merged hospital, the effect of the merger on cost efficiency depends entirely on how the merger affects equilibrium demand for this hospital. If the merger leads to lower (higher) quality by the merged hospital, the outside hospital will have higher (lower) demand in equilibrium and therefore spend more (less) effort on cost containment. A merger might increase cost efficiency for all hospitals in the market, and, in any case, the increase in cost containment for at least one of the hospitals is always sufficient to ensure that average cost containment in the market increases as a result of the merger.

Average quality and patient utility

A hospital merger affects patients in two ways. First, patients will generally experience a change in quality provision by merging and non-merging hospitals. Second, a merger implies a change from a symmetric to an asymmetric equilibrium, which implies an increase in total travelling costs.

Regarding quality provision, perhaps the most interesting corollary of Proposition 1 is that, if qualities are strategic substitutes, a hospital merger has heterogenous effects on patients: some patients benefit from higher quality while others suffer from lower quality. The effect of the merger on *average quality*, measured as the sum of qualities weighted by market shares, is given as follows:

Proposition 3 *A hospital merger increases average quality if qualities are strategic substitutes and one of the following two conditions is satisfied: (i) the regulated price is sufficiently low, such that $p < p_q$, or (ii) the regulated price is sufficiently high, such that $p > p_{\overline{q}}$, where $p_{\overline{q}} \in (p_q, \overline{p})$ if $\lambda < 0$. Otherwise, average quality goes down as a result of the merger.*

A necessary condition for a merger to increase average quality is that qualities are strategic substitutes, which implies that one of the hospitals will increase quality after the merger. If the merged hospitals increase quality (which happens if $p < p_q$), more than two thirds of patients experience higher quality as a result of the merger, which is enough to ensure that average quality goes up. On the other hand, if the non-merged hospital increases quality (which happens if $p > p_q$), the post-merger market share of the non-merged hospital must be sufficiently large to ensure that average quality increases. This requires that the post-merger quality difference between the hospitals is sufficiently large, which in turn requires that the price is sufficiently high. If p is above a threshold level $p_{\overline{q}}$ (which is higher than p_q), the post-merger market share of the non-merged hospital is sufficiently large to ensure that average quality in the market is higher after the merger.

It can easily be shown that the threshold value $p_{\overline{q}}$ is monotonically increasing in w. When cost-containment is more effective (lower w), the demand increase following the merger will be accompanied by a larger increase in cost-containment effort by the non-merged hospital, which in turn increases the hospital's incentive to provide higher quality. In other words, given that qualities are strategic substitutes, a lower w implies that the non-merged hospital responds more strongly to a quality reduction by the merged hospital, as can easily be confirmed from (15), thereby increasing the likelihood that average quality will increase as a result of the merger.

Even if a hospital merger increases average quality, total patient utility might nevertheless decrease when travelling costs are taken into account, because of higher average travelling costs in the (asymmetric) post-merger equilibrium.[23] Suppose that a merger leads to lower quality at the merged hospital and higher quality at the outside hospital. Some patients will then switch from the merged to the non-merged hospital and therefore obtain a higher quality of treatment than before the merger. However, these patients switch to the non-merged hospital not only because quality has increased at this hospital, but also because quality has dropped at the merged hospital. Thus, some of these patients might nevertheless suffer a reduction in utility, if their increase in travelling costs outweigh the increase in the quality they are offered.

[23] The total welfare effect of a hospital merger, which also takes the costs of quality provision into account, depends crucially on the regulated price level ($\widehat{p}$). Lower (higher) average quality provision implies, all else equal, a welfare loss if quality is underprovided (overprovided), which will be the case if the price is sufficiently low (high).

The total utility of the patients being treated at Hospital i is given by

$$B_i = \frac{12v - t}{36} + \frac{b}{4t}\left(\frac{(12v + 9bq_i + 2t)\, q_i}{3} - \frac{(6v + 3bq_i - t)}{3}\sum_{j \neq i} q_j - \frac{b}{2}\sum_{j \neq i} q_j^2\right). \tag{24}$$

Comparing total patient utility, summed over all hospitals, before and after the merger, we obtain the following result:

Proposition 4 *A hospital merger increases total patient utility if qualities are strategic substitutes and if one of the following conditions is satisfied: (i) the regulated price is sufficiently low, such that $p < p_q$, or (ii) the regulated price is sufficiently high, such that $p > p_u \in (p_{\overline{q}}, \overline{p})$, and either the marginal disutility of effort w or the net marginal treatment cost of quality β is sufficiently low. Otherwise, total patient utility goes down as a result of the merger.*

Qualities being strategic substitutes is a necessary condition for a merger to benefit patients since, otherwise, a merger leads to both lower quality and higher travelling costs. If, in addition, the merger leads to higher quality for the merged hospital (which happens if $p < p_q$), the increase in average quality is always large enough to outweigh the increase in total travelling costs. In this case, more than two thirds of the patients benefit from higher quality.

On the other hand, if the merger leads to higher quality for the outside hospital, an increase in average quality is not sufficient to increase total patient utility. In this case, the increase in average quality must be sufficiently high, which requires a sufficiently high quality increase by the outside hospital. The increase in average quality is large enough to increase total patient utility if the price is sufficiently high and either β or w are sufficiently low. From (15) it can easily be confirmed that a lower value of either β or w increases the magnitude of the outside hospital's quality response to the merger. Notice also that the threshold values of β and w (see the explicit values in the Appendix) decrease in t. Thus, the scope for a hospital merger to increase total patient utility increases when travelling is cheaper.

Finally, when considering the effects of a hospital merger on average quality and total patient utility, it is worth mentioning the importance of two of our key assumptions: semi-altruistic hospital objectives and endogenous cost efficiency. A necessary condition for a hospital merger to benefit patients is that qualities are strategic substitutes. This requires either that hospitals are sufficiently

altruistic or that the scope for cost containment is sufficiently large. Notice, however, that only one of these assumptions is needed to obtain qualitatively the same results as in Proposition 3 and 4. Thus, a merger between purely profit-oriented hospitals can increase both average quality and total patient utility if the scope for cost containment is sufficiently large. And even if cost containment is not possible, a hospital merger can have the same effects if the hospitals are sufficiently altruistic. The latter case also implies that the presence of cost synergies is not a necessary condition for a hospital merger to benefit patients.

Merger incentives

In the above analysis we have implicitly assumed that the hospitals actually have incentives to merge. It might be useful, though, to examine more closely what determines the hospitals' incentives to merge. By assumption, the hospitals have wider objectives than pure profit-maximisation, and the payoff functions of the hospitals include both monetary and non-monetary costs. If we assume that hospital merger decisions are made by the same decision makers who decide on cost-containment effort and quality provision, it would be reasonable to assume that the set of proposed mergers will be restricted to those that increase the joint payoff of the merger participants, potentially also with the additional constraint that such mergers are financially profitable.

Although the complexity of the equilibrium payoff expressions makes it infeasible to give a precise analytical characterisation of the set of payoff-increasing mergers, we can nevertheless give some general indications of what it takes for a merger to increase joint payoffs. As discussed in the previous subsection, a merger has two direct effects for the merger participants: it allows the merged hospitals (i) to internalise a negative competition externality in quality provision, and (ii) to realise an efficiency gain in cost containment. If qualities are strategic complements, it must be the case that a merger increases joint payoffs for the merger participants, since the response of the non-merged hospital (lower quality) increases the demand for the merged hospital.

The only way the incentives for a hospital merger can potentially be eliminated is if the following three conditions are met: (i) qualities are strategic substitutes, (ii) the merger leads to lower quality by the merger participants, and (iii) the response from the outside hospital is sufficiently strong. From Lemma 1 we know that strategic substitutability requires either that the degree of altruism is sufficiently strong or that the scope for cost containment is sufficiently high. It is

possible to show analytically that the first source of strategic substitutability alone is not enough to eliminate merger incentives, since a merger always increases joint payoff if cost containment is not possible.[24] However, notice that the absence of cost-containment effort also implies that there is no efficiency gain from the merger. Thus, increased scope for cost containment might increase rather than reduce merger incentives, even when qualities are strategic substitutes. Although a complete analytical characterisation is not feasible, it is possible to confirm (by numerical examples) that payoff-increasing mergers exist within all the parameter sets that define the different cases considered throughout our analysis.

VI. Extension: hospital closure

In this section we examine if and how our previous analysis depends on the assumption that a merger does not lead to hospital closure. Suppose that the merging hospitals decide to close down one of its two hospitals and allocate all production to the remaining hospital. This is profitable if the fixed-cost F is sufficiently large. A merger now implies that the market structure changes from a symmetric triopoly to a symmetric duopoly.[25] The first-order condition for optimal quality and cost-containment effort are given by (9) in the pre- and the post-merger games, the only difference being that demand for each hospital is given by (4) in the pre-merger game, whereas in the post-merger game the demand function for Hospital i is given by

$$D_i\left(q_i, q_j\right) = \frac{1}{2} + \frac{b}{t}\left(q_i - q_j\right); \quad i = m, o; \quad j = m, o; \quad i \neq j. \tag{25}$$

The symmetric Nash-equilibrium outcome (in terms of quality and effort) of the post-merger game with hospital closure is given by:

$$q_m^* = q_o^* = \frac{\left(2bp - t\beta\right)w + b}{2w\left(b\beta + kt\right)}, \quad \varepsilon_m^* = \varepsilon_o^* = \frac{1}{2w}. \tag{26}$$

The effects of the merger on equilibrium quality and effort are reasonably clear-cut:

Proposition 5 *Hospital closure leads to higher cost-containment effort and higher (lower) quality for all remaining hospitals if qualities are strategic substitutes (complements).*

[24] Details available upon request.

[25] With only two hospitals in the market, the equilibrium outcome in a Salop model will be symmetric regardless of how the firms are located.

Because of the symmetric nature of the post-merger game, the effects of the merger are similar for all hospitals in the market. The effect on cost containment is directly related to the fact that a hospital closure increases demand for the remaining hospitals in the market, which increases the hospitals' incentives to expend effort to reduce treatment costs.

The effect on the incentives for quality provision is slightly more involved. In the absence of altruism and cost-containment effort, higher demand increases the marginal cost of quality provision and each hospital will consequently choose a lower level of quality. However, this can be overturned either by a sufficiently high degree of altruism or a sufficiently strong scope for cost containment. Higher demand increases the marginal altruistic gain of quality investments, which – all else equal – leads to higher quality provision. More cost-containment effort increases the profit margin on each treatment and therefore also increases the incentive for quality provision in order to attract more patients. If either of these two mechanisms are sufficiently strong, a hospital merger leads to higher quality provision. Notice that the threshold levels for these two effects to yield higher or lower equilibrium quality as a result of the merger, correspond exactly to the threshold levels for qualities being strategic substitutes or complements.

Whether a hospital closure is beneficial for the patients is crucially determined by the nature of the strategic interaction between the hospitals. If qualities are strategic complements, hospital closure is unambiguously detrimental to patients since quality provision drops and travelling costs increase. On the other hand, if qualities are strategic substitutes, the increase in quality provision might be sufficient to outweigh the increase in travelling costs. With two hospitals in the market, located with a distance 1/3 between them, the total utility of patients attending Hospital i is

$$B_i = \frac{36v - 5t}{72} + \frac{b}{4t}\left(\left(4v + b\left(3q_i + q_j\right)\right)\left(q_i - q_j\right) + t\left(q_i + q_j\right)\right). \tag{27}$$

Proposition 6 *Hospital closure is always harmful to total patient utility if qualities are strategic complements. However, if qualities are strategic substitutes, then hospital closure increases total patient utility if either the degree of altruism (β) is sufficiently large or the marginal disutility of cost-containment effort (w) is sufficiently low.*

Hospital closure is beneficial for patients if hospitals are sufficiently altruistic, or if the scope for cost containment is sufficiently large. In either case, qualities are strategic substitutes for the

hospitals. Notice that the threshold values of β and w are decreasing in t, implying a larger scope for hospital closure to benefit patients when travelling costs are lower. The reason is twofold: First, a lower t implies that quality competition is more intense, because demand responds more strongly to quality changes, which in turn implies that the quality increase following hospital closure is larger (when qualities are strategic substitutes). Second, a lower t implies that the increase in total travelling costs when one hospital closes down is lower, which in turn makes it more likely that the quality increase is sufficiently high to compensate for the increase in travelling costs.

The incentives for the merged entity to close down one of the merging hospitals depend on the fixed-cost saving (F) that can be realised through closure. However, since the decision to close down a hospital also has implications for the effect of the merger on patient utility, the regulator might not allow this to happen. By comparing Propositions 4 and 6 we can characterise the conditions for which imposing a no-closure requirement should be used as a merger remedy by the regulator. Suppose that qualities are strategic substitutes ($\lambda < 0$). Then, if the regulated price is sufficiently low, such that $p < p_q$, and if both β and w are sufficiently high, a hospital merger will increase total patient utility only if both of the merging hospitals continue to operate after the merger. The reason is that a merger will lead to higher quality at the merging hospital because of relatively strong synergies in cost containment, an effect that disappears if one of the merging hospitals is closed down. In this case, using a no-closure requirement as a merger remedy would ensure that the benefits of a hospital merger are also transmitted to the patients. However, notice also that, for $p > p_q$, the scope for a hospital merger to increase patient utility is, perhaps paradoxically, larger if one of the merging hospitals is closed down. The reason is simply that hospital closure implies a quality increase across all remaining hospitals, which, for sufficiently low β or w, more than compensates for the increase in travelling costs.

VII. Implications for competition policy

What are the implications for competition policy regarding hospital mergers? Clearly, the competitive effects of mergers depend on market characteristics, which should be accounted for by competition authorities. In this paper, we have highlighted that hospital markets are different in that (i) hospital objectives include not just profits but also patients' benefit from treatment; (ii) prices for hospital services are regulated and cannot be set by the individual hospital; and

(iii) quality is the key strategic variable for hospitals for attracting patients and thus increasing revenues. These features imply that hospital mergers, in contrast to most other mergers, involve no price effects, and that the exploitation of market power may be constrained by altruism.

The key policy concern with hospital mergers is the possible adverse effects on quality due to the reduction of competition and patient choice. This is illustrated by the recent OFT review of a merger between two NHS foundation trusts in the UK: *"...it is likely that the merger would result in few realistic alternative providers for patients and NHS commissioning groups. As a result, ...the merger might reduce the hospitals' incentives to continue to enhance the quality of those services over the minimum required standards and would result in less choice..."*.[26] Our results show that this concern is valid, but not always. We show that the effects of hospital mergers crucially depend on the nature of quality competition. More precisely, if qualities are strategic complements, hospital mergers are always harmful to patient utility, as the merger reduces quality and increases travel costs. However, if qualities are strategic substitutes, hospital mergers may improve patient utility if the increase in (average) quality is sufficiently large relative to the increase in travel costs. Notice that these results are qualitatively the same for mergers that involve closure of one of the merging hospitals.

Competition authorities in most countries use a consumer welfare standard as the key benchmark in their merger control (Motta, 2004). A merger that is not expected to improve consumer welfare will not be approved, even though there are efficiency gains. This implies that only mergers with efficiency gains so large that prices drop after the merger will be approved. Thus, the merger control requires that the gains from the merger should be shared with consumers. We allow for efficiency gains from a hospital merger, where these gains are shared with consumers in terms of higher quality (rather than lower prices). Applying a consumer welfare standard, the implications for competition policy from our analysis can be summarised as follows.

Corollary 1 *Hospital mergers should not be allowed if qualities are strategic complements, i.e., when the degree of altruism or the scope for cost-containment is sufficiently low. If qualities are strategic substitutes, hospital mergers should be evaluated case-by-case, and approved only if either the degree of altruism or the scope for cost-containment is sufficiently high.*

[26] See the OFT webpage: http://www.oft.gov.uk/news-and-updates/press/2013/01-13#.U1ZGkm-KBdg

VIII. Concluding remarks

Our analysis provides a coherent framework for regulators and policymakers to investigate the effect of mergers in the hospital sector. We have used a spatial competition framework and assumed that hospitals face regulated prices and are semi-altruistic, and where a merger may or may not involve closure of one of the merging hospitals. A merger without closure implies variable-cost synergies in cost containment, whereas a merger with closure implies fixed-cost synergies.

Overall, our analysis suggests that a hospital merger is more likely to improve cost efficiency than to stimulate quality provision. Although incentives for cost containment might be lower for one of the hospitals after the merger, a hospital merger leads, on average, to increased cost efficiency in the hospital market. With hospital closure, the increase in cost efficiency is uniform across the remaining hospitals.

The effect of the merger on quality provision, on the other hand, depends crucially on the strategic nature of quality competition. Unless hospitals are sufficiently altruistic, or the scope for cost containment is sufficiently large, a merger will lead to lower quality for all hospitals in the market. Regardless of whether a merger involves hospital closure or not, a necessary condition for a merger to increase average quality provision is that qualities are strategic substitutes, which requires either that the hospitals are sufficiently altruistic, or that cost-containment effort is sufficiently effective. If the merger leads to hospital closure, this condition is also sufficient, whereas in the case of no closure, average quality increases only for a subset of the parameter values. A higher average quality provision is a necessary, but not sufficient, condition for increased patient utility, since a merger also implies an increase in average travelling costs.

Our work highlights the importance of knowing, from a regulatory perspective, if hospitals' qualities are strategic substitutes, complements or independent. A natural framework to test for this empirically is a spatial econometrics one, where a hospital's quality is regressed against the quality of their rivals. We are aware of only one paper in the literature which test for hospital strategic interaction. Gravelle, Santos and Siciliani (2014) employ a sample of English hospitals in 2009–10 and a set of 16 quality measures including mortality rates, readmission, revision and redo rates, and three patient reported indicators. They find that a hospital's quality is positively associated with the quality of its rivals for seven out of the sixteen quality measures. There are

no statistically significant negative associations. In those cases where there is a significant positive association, an increase in rivals' quality by 10% increases a hospital's quality by 1.7% to 2.9%. The finding suggests that qualities are either strategically independent or mildly complements. Within our model, the results are consistent with the assumption of costs being increasing in quality (which generates strategic complementarity) being weakly stronger than the one due to altruism and cost containment (which generates strategic substitution). The empirical study does not control for cost-containment effort. Future work may be able to tell whether the possible strategic complementarity in quality is affected after controlling explicitly for effort. It may also be of interest to test for strategic substitution or complementarity in cost containment effort, and to test for the robustness of the existing finding in different institutional contexts and countries.

Besides the strategic nature of quality competition, our analysis also shows that the effects of a merger – on quality, cost efficiency and patient utility – depend crucially on the magnitude of the regulated price that hospitals receive per treatment. This might indicate a potential role for price adjustments as a merger remedy. In a second-best scenario, where the price is set to maximise social welfare, it is clearly true that the optimal price would depend on the market structure and that the welfare effects of a merger could therefore be improved by a post-merger adjustment of the price. In practice though, this seems to be a rather unrealistic scenario. Merger policy and industry price regulation are conducted by different government bodies (competition authorities and, in our case, health authorities) and hospital prices are usually set according to some cost-based pricing rule. For these reasons, we have chosen not explore the effects of hospital mergers under optimal price regulation in the present paper.

Finally, we should point out that hospital mergers in practice may also involve other types of variable-cost synergies (apart from cost reductions related to cost-containment effort). All else equal, any merger synergy that increases the profit margin will increase the scope for quality-improving hospital mergers.

Appendix

Second-order conditions

In the *pre-merger* game and in the *post-merger game with closure*, the second-order conditions are given by

$$\frac{\partial^2 \pi_i}{\partial q_i^2} = -\left(\frac{2b\beta + kt}{t}\right) < 0, \quad \frac{\partial^2 \pi_i}{\partial \varepsilon_i^2} = -w < 0, \quad \frac{\partial^2 \pi_i}{\partial q_i^2}\frac{\partial^2 \pi_i}{\partial \varepsilon_i^2} - \left(\frac{\partial^2 \pi_i}{\partial q_i \partial \varepsilon_i}\right)^2 = \frac{\theta}{t^2} > 0, \tag{A1}$$

whereas, in the *post-merger game without closure*, the second-order conditions are

$$\frac{\partial^2 \Omega_m}{\partial q_i^2} = -\left(\frac{2b\beta + kt}{t}\right) < 0, \quad \frac{\partial^2 \Omega_m}{\partial \varepsilon_m^2} = -w < 0, \tag{A2}$$

and

$$\frac{\partial^2 \Omega_m}{\partial q_i^2}\frac{\partial^2 \Omega_m}{\partial \varepsilon_m^2} - \left(\frac{\partial^2 \Omega_m}{\partial q_i \partial \varepsilon_m}\right)^2 = \frac{8tw\left(2b\beta + kt\right) - b^2}{4t^2} > 0. \tag{A3}$$

All conditions are satisfied for $\beta > \underline{\beta}$ and $w > \underline{w}$.

Quality competition with general demand functions

Let $D_i(\cdot)$ be a general demand function for Hospital i with standard properties. The strategic relationship w.r.t. quality when effort is optimally adjusted can be derived from (9) in Section IV, and is given by

$$sign\left(\frac{\partial q_i\left(q_j\right)}{\partial q_j}\right) = sign\left(\frac{\partial^2 \Omega_i}{\partial q_j \partial q_i}\right)_{\varepsilon_i = \frac{D_i}{w}} = \frac{1}{w}\frac{\partial D_i}{\partial q_j}\frac{\partial D_i}{\partial q_i} - \beta\frac{\partial D_i}{\partial q_j} + \left(p + \varepsilon_i - \beta q_i\right)\frac{\partial^2 D_i}{\partial q_j \partial q_i}. \tag{A4}$$

The first term represents the effect on quality competition via effort choices and is negative. Thus, cost-containment effort contributes towards making qualities strategic substitutes. The second term represents the effect via changes in the profit margin and the sign of this term depends on the sign of β. It is positive (negative) if α is sufficiently small (large). Thus, altruism also contributes towards making qualities strategic substitutes. The sign of the third term is ambiguous and depends on the sign of $\partial^2 D_i / \partial q_j \partial q_i$ (which is zero in the Salop model).

Proof of Proposition 1

A comparison of (16) and (20)-(21) yields

$$q_m^* - q_i^* = -\frac{b\theta\left(3kptw + \beta\lambda\right)}{3w\left(b\beta + kt\right)\Phi}, \quad q_o^* - q_i^* = -\frac{b^2\lambda\left(3kptw + \beta\lambda\right)}{3w\left(b\beta + kt\right)\Phi}. \tag{A5}$$

We see that $q_m^* > (<)\, q_i^*$ if $p < (>)\, p_q := -\beta\lambda/3ktw$. Notice first that

$$\overline{p} - p_q = 2\left(\frac{tw\left(3b\beta\left(b\beta + 2kt\right) + 2k^2t^2\right) - \left(2b\beta + 3kt\right)b^2}{3b^2ktw}\right). \tag{A6}$$

Since the numerator in (A6) is monotonically increasing in w, and since $\lim_{w\to\underline{w}}\left(\overline{p} - p_q\right) > 0$, it follows that $p_q < \overline{p}$ for the entire parameter space that guarantees equilibrium existence. Furthermore, we have

$$p_q - \underline{p} = \min\left\{-\frac{\lambda\Phi}{3bktw\left(\theta + b\lambda + wkt^2\right)}, -\frac{\lambda\Phi}{3bktw\left(\theta + b\lambda\right)}\right\} > 0 \text{ if } \lambda < 0. \tag{A7}$$

Thus, $p_q \in \left(\underline{p}, \overline{p}\right)$ only if $\lambda < 0$, which implies that $q_m^* > q_i^*$ (which requires $p < p_q$) is possible only if $\lambda < 0$. From (A5) we have that $q_o^* < q_i^*$ if $p < p_q$ (which implies $\lambda < 0$). For $p > p_q$, then $q_o^* > (<)\, q_i^*$ if $\lambda < (>)\, 0$. *Q.E.D.*

Proof of Proposition 2

A comparison of (16) and (22) yields

$$\varepsilon_m^* - \varepsilon_i^* = \frac{\left(b\beta + 2kt\right)\left(2\theta + b\lambda\right) - 3b^2ktwp - \Phi}{3w\Phi}, \quad \varepsilon_o^* - \varepsilon_i^* = \frac{b^2\left(3kptw + \beta\lambda\right)}{3w\Phi}, \tag{A8}$$

where and $\varepsilon_o^* > (<)\, \varepsilon_i^*$ if $p > (<)\, p_q$ and $\varepsilon_m^* > (<)\, \varepsilon_i^*$ if $p < (>)\, p_\varepsilon := \left(\left(b\beta + 2kt\right)\left(2\theta + b\lambda\right) - \Phi\right)/3b^2ktw$. Since

$$p_\varepsilon - \max\left\{\underline{p}, p_q\right\} = \min\left\{\frac{\frac{\Phi\theta}{\left(tw(3b\beta+kt)-2b^2\right)}}{3b^2ktw}, \frac{\frac{\left(\theta+wkt^2\right)\Phi}{\left(tw(3b\beta+2kt)-2b^2\right)}}{3b^2ktw}, \frac{\Phi}{3b^2ktw}\right\} > 0 \tag{A9}$$

and $p_\varepsilon - \overline{p} = -\Phi/3b^2ktw < 0$, it follows that $p_\varepsilon \in \left(\max\left\{\underline{p}, p_q\right\}, \overline{p}\right)$. The change in average cost containment effort is given by

$$D_m^*\varepsilon_m^* + D_o^*\varepsilon_o^* - \varepsilon_i^* = \frac{1}{w}\left(\left(D_m^*\right)^2 + \left(D_o^*\right)^2 - \frac{1}{3}\right). \tag{A10}$$

Using the fact that $D_o^* = 1 - D_m^*$, the expression in (A10) can be written as $(2/3w)\left(1 - 3D_m^* + 3\left(D_m^*\right)^2\right)$, which is positive for all $D_m^* \in (0, 1)$. *Q.E.D.*

Proof of Proposition 3

Defining average equilibrium quality as $\overline{q}^* := \sum_i D_i^* q_i^*$, the effect of a hospital merger on average quality is given by

$$\Delta\overline{q}^* = \frac{b\begin{bmatrix} 3b^2kpt^2w^2\left(b\beta+kt\right)-3b^4\left(2b\beta+3kt\right) \\ -tw\left(b\beta\left(b\beta+2kt\right)\left(7\theta-11b^2\right)+4k^2t^2\left(\theta-2b^2\right)\right)\end{bmatrix}\left(3kptw+\beta\lambda\right)}{9w\left(b\beta+kt\right)\Phi^2}. \tag{A11}$$

The sign of $\Delta\overline{q}^*$ depends on the sign of the numerator, where $\left(3kptw+\beta\lambda\right) > (<)\, 0$ if $p > (<)\, p_q$. The expression in the square brackets is monotonically increasing in p and is positive (negative) if

$$p > (<)\, p_{\overline{q}} := \frac{tw\begin{bmatrix} tw\left(2b\beta+kt\right)\left(7b\beta\left(b\beta+2kt\right)+4k^2t^2\right) \\ -6b^2\left(3b\beta\left(b\beta+2kt\right)+2k^2t^2\right)\end{bmatrix}+3b^4\left(2b\beta+3kt\right)}{3b^2kt^2w^2\left(b\beta+kt\right)}, \tag{A12}$$

where

$$p_{\overline{q}} - p_q = \frac{\Phi\left(2\theta+b\lambda\right)}{3b^2kt^2w^2\left(b\beta+kt\right)} > 0, \quad p_{\overline{q}} - \overline{p} = \frac{\Phi\lambda}{bkt^2w^2\left(b\beta+kt\right)} < 0 \text{ if } \lambda < 0, \tag{A13}$$

and

$$p_{\overline{q}} - \overline{p} = \frac{\Phi\lambda}{bkt^2w^2\left(b\beta+kt\right)} < 0 \text{ if } \lambda < 0. \tag{A14}$$

Thus, $\Delta\overline{q}^* > 0$ either if $p < p_q$ (which implies $\lambda < 0$) or if $p > p_{\overline{q}}$, which is possible only if $\lambda < 0$. *Q.E.D.*

Proof of Proposition 4

With three hospitals in the market, the total utility of patients attending Hospital i is given by (24). Inserting the equilibrium quality values in the pre- and post-merger equilibria and summing over all hospitals in the market, the effect of a hospital merger on total patient utility is given by

$$\Delta B^* = \frac{b^2\begin{bmatrix} 3b^2kpt^2w^2\left(b\beta+kt\right)-6b^4\left(2b\beta+3kt\right) \\ +tw\begin{pmatrix} b^3\beta\left(37b\beta+73kt\right)+24b^2k^2t^2 \\ -tw\left(b\beta\left(29b^2\beta^2+44k^2t^2+71bkt\beta\right)+8k^3t^3\right)\end{pmatrix}\end{bmatrix}\left(3kptw+\beta\lambda\right)}{18w\left(b\beta+kt\right)\Phi^2}. \tag{A15}$$

The sign of ΔB^* depends on the sign of the numerator, where $(3kptw + \beta\lambda) > (<) 0$ if $p > (<) p_q$. The expression in the square brackets is monotonically increasing in p and is positive (negative) if

$$p > (<) p_u := \frac{6b^4 (2b\beta + 3kt) - tw \begin{pmatrix} b^3\beta (37b\beta + 73kt) + 24b^2k^2t^2 \\ -tw \left(b\beta \left(29b^2\beta^2 + 44k^2t^2 + 71bkt\beta\right) + 8k^3t^3\right) \end{pmatrix}}{3b^2kt^2w^2 (b\beta + kt)}, \quad \text{(A16)}$$

where

$$p_u - p_{\overline{q}} = \frac{(2\theta + b\lambda)\,\Phi}{3b^2kt^2w^2 (b\beta + kt)} > 0, \quad p_u - \overline{p} = -\frac{2\left(3b^2 - tw (4b\beta + kt)\right)\Phi}{3b^2kt^2w^2 (b\beta + kt)}. \quad \text{(A17)}$$

$\Delta B^* > 0$ if either $p < p_q$ (which implies $\lambda < 0$) or $p > p_u$, which is only possible if $p_u < \overline{p}$, which requires either $\beta < -kt/4b$ or $w < 3b^2/t (4b\beta + kt)$. *Q.E.D.*

Proof of Proposition 5

A comparison of (16) and (26) yields $q_m^* - q_i^* = -\lambda/ (6w (b\beta + kt))$ and $\varepsilon_m^* - \varepsilon_i^* = 1/6w > 0$, where $q_m^* > (<) q_i^*$ if $\lambda < (>) 0$. *Q.E.D.*

Proof of Proposition 6

The change in total patient utility when the number of hospitals in a symmetric Nash equilibrium reduces from three to two is given by

$$\Delta B^* = \frac{b^2}{6w (b\beta + kt)} - \frac{t (4b\beta + kt)}{18 (b\beta + kt)}, \quad \text{(A18)}$$

which is always positive if $\beta < -kt/4b$. For $\beta > -kt/4b$, the second term is negative and $\Delta B^* > 0$ if the first term is sufficiently large, which requires $w < 3b^2/t (4b\beta + kt)$. *Q.E.D.*

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