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Discussion paper

Hospital Mergers with Regulated Prices

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Hospital Mergers with Regulated Prices*

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Abstract

We study the effects of a hospital merger using a spatial competition framework with semi-altruistic hospitals that invest in quality and expend cost-containment effort facing regulated prices. We find that the merging hospitals always reduce quality, whereas non-merging hospitals respond by increasing (reducing) quality if qualities are strategic substitutes (complements). A merger leads to higher average treatment cost efficiency and, if qualities are strategic substitutes, might also increase average quality in the market. If a merger leads to hospital closure, the resulting effect on quality is positive (negative) for all hospitals in the market if qualities are strategic substitutes (complements). Whether qualities are strategic substitutes or complements depends on the degree of altruism, the effectiveness of cost-containment effort, and the degree of cost substitutability between quality and treatment volume.

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

JEL Classification: I11, I18, L13, L44

*This paper is a revised version of a former working paper titled "Hospital mergers: a spatial competition approach". The current paper differs in that we consider semi-altruistic (rather than purely profit-maximising) hospitals, and allow for cost-containment effort, though ignoring price competition.

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1 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 and antitrust authorities tended to approve 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.[3] 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:[4]

> "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.[5] 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

[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] In the US, the Federal Trade Commission (FTC) has recently been more aggressive *and successful* in challenging hospital mergers (see Gaynor and Town, 2012).

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

[5] See Section 2 for a more detailed literature review.

literature, since standard merger analyses cannot be directly applied to the case of hospital mergers, because of institutional and behavioural idiosyncrasies.[6]

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 (not part of the merger) respond to the merger? Do the effects of a merger depend on whether or not the merger involves hospital closure? What are 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.[7] Hospitals are semi-altruistic and choose quality and cost-containment effort to maximise a weighted sum of profits and patient utility. 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 this case the only motive for the merger is to obtain higher profits through the exercise of market power.[8] In an extension to the benchmark model we also allow for direct efficiency gains by considering closure of one of the merging hospitals and thus 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. Within the health sector, quality remains possibly the key concern for health policymakers, which in turn is reflected in regulators' mandates. Indeed, in the UK, where prices are

[6] For example, in most OECD countries hospitals tend to face regulated prices and compete only on quality. Furthermore, it is widely recognised in the health economics literature that the standard paradigm of profit maximisation might be less well suited to describe the behaviour of hospitals and other health care providers, who tend to have somewhat broader objectives.

[7] 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.

[8] This assumption is consistent with the merger simulations by Beckert et al. (2012) with data from the English NHS. They find that merging hospitals' demand would become substantially less sensitive to quality after the merger. This would lessen competition and have adverse effects on patients.

regulated, hospital mergers have to be approved by the Co-operation & Competition Panel. Mergers are allowed only if there remains sufficient choice and competition for patients.[9]

The main results of our study are the following: First, the merging hospitals always reduce quality, but the response from the non-merging hospital depends on the nature of the hospitals' strategic interaction. If quality decisions are strategic substitutes (complements), the non-merging hospital responds to the merger by increasing (reducing) its quality. Whether qualities are strategic complements or substitutes 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, then qualities are strategic complements (substitutes) if altruism is sufficiently low (high) relative to the cost substitutability between quality and output, and strategically independent in case of no altruism and only fixed quality cost (i.e., no cost substitutability between output and quality). However, allowing for cost-contaiment 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. With variable quality costs (i.e., cost substitutability between output and quality), then quality decisions are (i) still strategic substitutes if altruism is sufficiently high or the cost-containment effort sufficiently effective, and (ii) strategic complements otherwise. Thus, cost-containment effort is an additional factor that contributes to making qualities strategic substitutes. If so, average quality in the market may increase after the merger because of the increase in quality by non-merging hospitals. The effect on consumer welfare is therefore *a priori* not clear. For the special case of no altruism and no variable quality costs, we show that patients are never better off with the merger because any increase in average quality is more than offset by higher travelling costs.

Second, the merging hospitals always reduce cost-containment effort, whereas the non-merging hospital responds by increasing its cost-containment effort. Therefore, such efforts are always strategic substitutes. The profit gain of expending effort on reducing costs depends crucially on the treatment volume and thus demand. Since the merging hospitals reduce their quality (more than the non-merging hospital) and thus receive lower demand, their incentive for cost-containment effort is lower. The opposite is true for the non-merging hospital. We show that the average cost-containment effort (weighted with market shares) is higher after the merger.

[9] For further details, see www.ccpanel.org.uk.

Third, the merger effects change when the merger involves closure of one of the hospitals. A hospital closure leads to higher cost-containment effort for all hospitals, since each hospital's demand is higher than before the merger. However, the effect on quality is ambiguous. If qualities are strategic substitutes (complements), for example due to altruism or interaction between quality and cost-containment effort, hospital closure leads to higher (lower) quality for all hospitals in the market. In the case when closure leads to higher quality, we show that consumer welfare may also increase despite the fact that average travelling distance is increased. This is in contrast to the results when a merger does not involve closure.

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, and this result arises when features specific to the hospital sector are introduced (i.e., altruism and cost-containment effort). A merger can therefore trigger an increase in quality by the non-merging hospital. As a result, the welfare implications may not be as severe as when all providers reduce quality (as one would expect in the standard model). Moreover, since prices are fixed, the welfare effects of a merger will be conditional on the specific price set by the regulator, and the standard model does not apply.

The assumption that health care providers are motivated or exhibit altruistic concerns is by now well recognised in both the health and public economics literature.[10] We assume that health care providers are semi-altruistic, meaning that they care, at least to some extent, about patient utility. Becoming a physician requires several years of demanding training on how to cure patients and medical schools in many countries require their graduating students to take a modernised version of the Hippocratic Oath. Thus, 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'

[10] Within the health economics literature, see for example Ellis and McGuire (1986), Chalkley and Malcomson (1998), Eggleston (2005). Heyes (2005), Jack (2005), Choné and Ma (2011), Kaarbøe and Siciliani (2011). Within the public economics literature the assumption of motivated agents is shared by 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).

job and that job satisfaction depends on both pecuniary and non-pecuniary aspects of employment.[11]

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 3 we present the basic model. In Section 4 we derive the (symmetric) Nash equilibrium in the pre-merger game. In Section 5 we derive the (asymmetric) Nash equilibrium in the post-merger game and analyse the effects of a hospital merger. In Section 6 we analyse if and how our results might change if a merger leads to closure of one of the merging hospitals. Finally, in Section 7 we summarise our findings and offer some concluding reflections.

2 Relation to existing literature

Our paper relates to the fairly large literature on quality competition in health care markets. This literature usually finds that if prices are regulated and providers are maximising profits, then more competition results in higher quality.[12] However, with semi-altruistic hospitals, some studies find that more competition does not necessarily increase quality (see, e.g., Brekke et al., 2011). We extend this literature by focusing on mergers (with and without closure) 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 (moral hazard), and they find that mergers may be desirable since hospitals reduce quality (or increase quality-adjusted prices), which in turn induces patients to consume less care. However, Gaynor et al. (2000) show that reduced

[11] 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).

[12] See e.g., Gravelle (1999), Lyon (1999), Beita (2003), Nuscheler (2003), Brekke et al. (2006, 2007), Karlsson (2007) and Brekke et al. (2011). The latter study show that if hospitals are semi-altruistic more competition may result in lower quality.

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 (say 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.[13] She uses a model with imperfect competition in both the insurance and the hospital market, and focuses on the bargaining between insurers and hospitals on the reimbursement rates.[14] 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 (and thus profits) 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.

[13] See also Gal-Or (1999b) who study vertical mergers between hospitals and physician practices in a similar bargaining set-up.

[14] Gowrinsankaran et al. (2013) have a similar focus and develop a bargaining model where coinsurance rates are exogenously given but hospital prices are a result of bargaining between hospitals and managed care organizations. Estimating the model on claims and discharge data from Northern Virginia they show that bargaining significantly restrain hospital prices and increases the *effective* price sensitivity of patients.

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 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).

3 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.[15] 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.[16] The net utility of a patient located at z and seeking treatment at Hospital i, located at x_i, is given by

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

[15] The assumption of three instead of n hospitals is made in order to make the analysis tractable. In a market with n hospitals there would be ex post differences among the non-merging hospitals, where the incentives for a non-merging hospital to provide quality in the post-merger game 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.

[16] As long as prices are regulated, the analysis is fully robust to the inclusion of patient copayments.

where $q_i \geq \underline{q}$ is the quality offered by Hospital i; $b > 0$ is the marginal utility of quality; and $t > 0$ is the marginal disutility of travelling.[17] The lower bound on quality, $\underline{q}$, is the minimum quality a hospital can offer without facing malpractice charges. For simplicity, and without loss of generality, we set $\underline{q} = 0$. Furthermore, in order to ensure full market coverage for any $q_i \geq 0$, we assume $v > t/6$.

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

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

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

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

When each patient makes a utility-maximising choice, the demand for Hospital i is therefore a function of its own quality and the qualities of its two neighbours, and given by

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

Several of our results rely on the relative size of the parameters b and t. As we can see from (4), a high (low) value of b relative to t implies a high (low) *demand responsiveness to quality*, and we will subsequently use this terminology when referring to the relative size of b and t.

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 $c \geq 0$. Notice that if $c = 0$ then quality provision involves only fixed costs and quality is a public good at hospital level. However, if $c > 0$, then quality

[17] The responsiveness of providers' demand to quality has been tested empirically by 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). These studies model hospital patients' choice using conditional logit models. They find that higher quality and shorter distance increase the probability of choosing a provider. Demand elasticities with respect to quality are positive but relatively small for most procedures and conditions. Distance is systematically the key predictor of hospital choice.

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 is consistent with constant returns to scale with respect to the number of patients treated when the cost per patient is increasing in the quality provided.

We also assume that each hospital can reduce its treatment costs by expending effort on cost containment. More specifically, we assume that $\sigma_i := \overline{\sigma} - \varepsilon_i$, 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, we assume that hospitals are semi-altruistic in the sense each they, to some extent, take patient utility directly into account when making their decisions. The objective function of Hospital i is assumed to be given by

$$\Omega_i = (p + \varepsilon_i - cq_i) D_i - \frac{k}{2} q_i^2 - \frac{w}{2}\varepsilon_i^2 - F + \alpha B_i, \tag{6}$$

where $p := \widehat{p} - \overline{\sigma}$, with $\widehat{p}$ being the fixed price that the hospital receives (from a third-party payer) per treatment. The three first terms constitute the hospital's profits, the fourth term is the disutility of cost-containment effort, whereas the last term is the altruistic component of the hospital's objective function, where $\alpha > 0$ measures the degree of altruism and B_i is the total utility of the patients being treated at Hospital i, which is given by

$$\begin{aligned} B_i &= \int_0^{\widehat{z}_i^{i+1}} (v + bq_i - ts)\, ds + \int_0^{\widehat{z}_i^{i-1}} (v + bq_i - ts) \\ &= \frac{(12v - t)}{36} + \frac{b}{4t}\left(\frac{(12v + 9bq_i + 2t)\, q_i}{3} - \frac{(6v + 3bq_i - t)}{3} \sum_{j \neq i} q_j - \frac{b}{2} \sum_{j \neq i} q_j^2 \right). \end{aligned} \tag{7}$$

We assume that the hospitals make their decisions on quality and cost-containment effort simultaneously, and we look for the unique Nash equilibrium in pure strategies of such a game.

4 Nash equilibrium in the pre-merger game

The first-order conditions for optimal quality and cost-containment effort by Hospital i are given by, respectively,

$$\frac{\partial \Omega_i}{\partial q_i} = \frac{b\left(p + \varepsilon_i + \alpha v\right)}{t} + \frac{b\alpha - 2c}{6} + \frac{b\left(3b\alpha - 4c\right) - 2kt}{2t} q_i - \frac{b\left(b\alpha - 2c\right)}{4t} \sum_{j \neq i} q_j = 0 \tag{8}$$

and

$$\frac{\partial \Omega_i}{\partial \varepsilon_i} = \frac{1}{3} + \frac{b}{t}\left(q_i - \frac{1}{2}\sum_{j \neq i} q_j\right) - w\varepsilon_i = 0. \tag{9}$$

The second-order conditions are satisfied if

$$k > b\left(\frac{b}{t^2 w} + \frac{3b\alpha - 4c}{2t}\right), \tag{10}$$

which we assume to be true.

The effects of a hospital merger on quality provision depend crucially on the nature of strategic interaction between the hospitals. It is therefore instructive to characterise this in detail. From (8), the best-quality-response function of Hospital i, for a given level of cost containment, is given by

$$q_i\left(\varepsilon_i, q_j\right) = \frac{12b\left(p + \varepsilon_i + \alpha v\right) + \left(b\alpha - 2c\right)\left(2t - 3b\sum_{j \neq i} q_j\right)}{6\left(2\left(2bc + kt\right) - 3\alpha b^2\right)}. \tag{11}$$

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

$$\frac{\partial q_i\left(\varepsilon_i, q_j\right)}{\partial q_j} = \frac{b}{2}\left(\frac{2c - b\alpha}{2\left(2bc + kt\right) - 3b^2\alpha}\right) > (<)\, 0 \text{ if } \alpha < (>)\, \frac{2c}{b}. \tag{12}$$

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, then

competing hospitals' quality choices are strategically independent (which in a sense implies that they are not actually competing). However, 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 provision (when $c > 0$). These hospitals will therefore respond by increasing their quality. 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 (notice, from (7), that $\partial^2 B_i/\partial q_j \partial q_i < 0$).[18] All else equal, a unilateral quality increase by one hospital will therefore be met by quality reductions from the competing hospitals in the market. Consequently, 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, the best-quality-response function of Hospital i is given by

$$q_i\left(q_j\right) = \frac{12btw\left(p+\alpha v\right) + \left(tw\left(b\alpha - 2c\right) + 2b\right)\left(2t - 3b\sum_{j\neq i} q_j\right)}{6\left(tw\left(4bc + 2kt - 3\alpha b^2\right) - 2b^2\right)}, \tag{13}$$

which implies that the strategic nature of quality competition is characterised by

$$\frac{\partial q_i\left(q_j\right)}{\partial q_j} = \frac{b}{2}\left(\frac{tw\left(2c - b\alpha\right) - 2b}{tw\left(4bc + 2kt - 3b^2\alpha\right) - 2b^2}\right). \tag{14}$$

If $\alpha > 2c/b$, which makes qualities strategic substitutes for a given level of cost-containment effort, allowing this effort to be optimally adjusted does not change the strategic nature of quality competition. However, if $\alpha < 2c/b$, optimal effort adjustments make qualities strategic substitutes if such effort is sufficiently effective in reducing treatment costs (i.e., if w is sufficiently low). 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

[18] From (7) we get

$$\frac{\partial^2 B_i}{\partial q_j \partial q_i} = -\frac{b^2}{4t} < 0.$$

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:

Lemma 1 *When cost-containment effort is optimally adjusted, qualities are (i) strategically independent if* $\alpha = 2\left(\frac{ctw-b}{btw}\right)$*, (ii) strategic substitutes if* $\alpha > \frac{2c}{b}$ *or* $w < \frac{2b}{t(2c-b\alpha)}$*, and (iii) strategic complements otherwise.*

In other words, qualities are strategic substitutes either if the degree of altruism is sufficiently high, or if cost-containment effort is sufficiently effective. Solving the system of first-order conditions given by (8)-(9), quality and effort in the symmetric Nash equilibrium are given by

$$q_i^* = \frac{2b + w\left(6b\left(p + \alpha v\right) + t\left(b\alpha - 2c\right)\right)}{6w\left(bc + kt - \alpha b^2\right)}, \tag{15}$$

$$\varepsilon_i^* = \frac{1}{3w}. \tag{16}$$

In this equilibrium, total patient utility is given by

$$U^* := \sum_i B_i^* = \frac{4b^2 + btw\left(3b\alpha - 5c\right) + 12bw\left(bp + cv\right) + ktw\left(12v - t\right)}{36w\left(bc + kt - \alpha b^2\right)}. \tag{17}$$

5 Hospital merger

Now consider a merger between two of the hospitals. Throughout the analysis in this section we assume that 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. In the *post-merger* game, the hospital that does not take part in the merger (the 'outsider') chooses quality and cost-containment effort, denoted q_o and ε_o, respectively, to maximise its objective function, whereas the merged entity, which now consists of two hospitals, chooses quality and cost-containment effort at each of its hospitals (denoted q_m and ε_m) to maximise their joint objectives.

In the asymmetric Nash equilibrium, the outsider provides quality

$$q_o^* = \frac{\left[\begin{array}{c} 8kt^2w\left(b+3bpw-ctw\right)-2b\left(3b^2\left(3pw+1\right)-ctw\left(11b+18bpw-8ctw\right)\right) \\ +\alpha bw\left[4kt^2w\left(t+6v\right)-6b^2tw\alpha\left(t+4v\right)-b\left(15bt+18bv-20ct^2w+24bptw-36ctvw\right)\right] \end{array}\right]}{6w\Phi}, \tag{18}$$

and chooses effort

$$\varepsilon_o^* = \frac{b^2\left(b\alpha-c\right)\left(3b+2tw\left(3b\alpha-4c\right)\right)+kt\left(3b^2\left(2w\left(p+\alpha v\right)-1\right)-2tw\left(b\left(5b\alpha-6c\right)-2kt\right)\right)}{3w\Phi}, \tag{19}$$

whereas each of the merger participants offers quality

$$q_m^* = \frac{\left[\begin{array}{c} 4kt^2w\left(b+3bpw-2ctw\right)-2b\left(b-2ctw\right)\left(3b+9bpw-5ctw\right) \\ +bw\alpha\left[2tw\left(3kt\left(t+2v\right)-\alpha b^2\left(5t+12v\right)\right)+4bctw\left(7t+9v\right)-3b^2\left(5t+6v+8ptw\right)\right] \end{array}\right]}{6w\Phi}. \tag{20}$$

and chooses effort

$$\varepsilon_m^* = \frac{2b^2\left(b\alpha-c\right)\left(3b+tw\left(3b\alpha-5c\right)\right)-kt\left(6b^2\left(w\left(p+\alpha v\right)+2\right)+tw\left(b\left(17b\alpha-24c\right)-8kt\right)\right)}{6w\Phi}, \tag{21}$$

where

$$\Phi := b^2\left(b\alpha-c\right)\left(3b+2tw\left(2b\alpha-3c\right)\right)+kt\left(tw\left(4kt-3b\left(3b\alpha-4c\right)\right)-5b^2\right)>0. \tag{22}$$

The effects of the merger on quality provision and treatment cost efficiency are given as follows:

Proposition 1 *A hospital merger leads to*

(i) lower quality for the merged hospitals, whereas the non-merged hospital will increase (reduce) quality provision if qualities are strategic substitutes (complements);

(ii) less (more) cost-containment effort expended by the merged (non-merged) hospitals;

(iii) higher average cost containment in the market.

Proof. In Appendix. ■

The intuition for the drop in quality for the merged hospitals is fairly straightforward. A merger allows the participants to internalise a negative competition externality by reducing their quality

provision.[19] However, the response from the outside hospital depends crucially on the strategic nature of the game. If qualities are strategic complements, the outside hospital will respond by reducing its quality as well. However, if qualities are strategic substitutes, a merger will lead to higher quality provision by the hospital not taking part in the merger. From Lemma 1 we know that this occurs either if hospitals are sufficiently altruistic or if the scope for cost containment is sufficiently high.

The hospitals' responses to the merger in terms of cost-containment effort are explained by demand effects. The merged hospitals' drop in quality leads, in equilibrium, to lower market shares for these hospitals and a higher market share for the non-merged hospital. Since the incentive for expending effort on cost containment is positively related to treatment volume, the merger-induced changes in effort choices follow (in qualitative terms) the changes in market shares. It also turns out that, regardless of whether qualities are strategic complements or substitutes, the change in cost-containment effort is higher for the outside hospital than for the merged hospitals, in the sense that average cost-containment effort (weighted by demand) goes up. In other words, a merger leads to overall increased treatment cost efficiency in the market.

Arguably the most important part of the results stated in Proposition 1 is that a hospital merger can have different effects on quality provision for merged and non-merged hospitals. When qualities are strategic substitutes, a hospital merger might actually lead to higher average quality provision in the market, if the strategic response from the outside hospital is sufficiently strong. If this is the case, the effect of the hospital merger on total patient utility is *a priori* ambiguous. Because of the asymmetric nature of the post-merger equilibrium, a merger always leads to higher total travelling costs. However, this might possibly be outweighed by a higher average quality provision. Otherwise, if average quality provision goes down, a hospital merger is always harmful for total patient utility. If qualities are strategic substitutes, some patients (among those attending the non-merged hospital) still benefit from the merger, whereas if qualities are strategic complements, a hospital merger reduces the utility of all patients in the market.

While patients always benefit from higher quality provision, the social welfare assessment of a hospital merger must also take the costs of quality provision into account. However, when the

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

treatment price is regulated, the welfare effects of a hospital merger depends crucially on the regulated price level ($\widehat{p}$), which, in some sense, makes a welfare analysis of a hospital merger less interesting. For example, 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).

Special case: $\alpha = c = 0$

In order to facilitate a precise analytical characterisation of the effect of a hospital merger on average quality provision and total patient benefit, let us consider the special case of no altruism and quality-independent treatment costs. From Lemma 1 we know that, in this case, qualities are strategic substitutes. In the pre-merger equilibrium, quality and total patient utility are given by

$$q_i^* = \frac{b\left(3pw+1\right)}{3ktw}, \tag{23}$$

$$U^* = v + \frac{b^2}{kt}\left(p + \frac{1}{3w}\right) - \frac{t}{12}, \tag{24}$$

while, in the post-merger equilibrium, quality and total patient utility are

$$q_m^* = \frac{b\left(3pw+1\right)\left(2kt^2w-3b^2\right)}{3wkt\left(4kt^2w-5b^2\right)}, \tag{25}$$

$$q_o^* = \frac{b\left(3pw+1\right)\left(4kt^2w-3b^2\right)}{3wkt\left(4kt^2w-5b^2\right)}, \tag{26}$$

$$\overline{U}^* = v + \frac{180b^6\left(3pw+1\right) + kt^2w\left(8kt^2w\left(b^2\left(48pw+31\right)-6kt^2w\right) + b^4\left(72pw\left(pw-12\right)-371\right)\right)}{36ktw\left(4kt^2w-5b^2\right)^2}. \tag{27}$$

Average quality provision in the post-merger equilibrium is then given by

$$\overline{q}^* := 2D_m^*q_m^* + D_o^*q_o^* = \frac{b\left(3pw+1\right)\left[45b^4 + 4kt^2w\left(3b^2\left(pw-6\right)+8kt^2w\right)\right]}{9ktw\left(4kt^2w-5b^2\right)^2}. \tag{28}$$

In order to increase the relevance of our analysis, we will restrict the set of potential hospital mergers to the ones that are profitable.

Proposition 2 *In the case of no altruism and quality-independent treatment costs, there exists a non-empty set of parameters, defined by* $p \in \left(\underline{p}, \overline{p}\right)$ *and* $k \in \left(\underline{k}, \overline{k}\right)$*, for which a profitable merger*

increases average quality provision in the market. Nevertheless, no parameter set exists for which a profitable merger increases consumer welfare.

Proof. In Appendix. ■

This result shows that a hospital merger might indeed lead to higher average quality provision in the market. A necessary condition for this to occur is that the parameter k is sufficiently low. It is perhaps more instructive to state this condition in terms of demand responsiveness to quality. It is worth noticing that the upper threshold $\overline{k}$ is increasing in b and decreasing in t (the exact expressions for the upper and lower bounds on p and k are given in the Appendix). Thus, the condition $k < \overline{k}$ is equivalent to b being sufficiently high relative to t. In other words, a necessary condition for a merger to increase average quality provision is that the demand responsiveness to quality is sufficiently high. When demand responds strongly to quality changes, the competition between hospitals is relatively intense and the strategic response to quality changes from competing hospitals is correspondingly strong.[20] Thus, if $k < \overline{k}$ (or, equivalently, if b is sufficiently high relative to t) the strategic response from the outside hospital is sufficiently strong to make average quality provision increase as a result of the merger.[21]

When qualities are strategic substitutes, more than one third of the patients in the market will benefit from a hospital merger.[22] However, at least in the special case considered here, the increase in average quality provision is not sufficient to increase total (or average) patient utility. In other words, even if the 'average patient' enjoys higher quality, his utility decreases. This is actually not so surprising. As previously explained, a hospital merger leads to higher average quality provision only if the strategic response from the outside hospital is sufficiently strong. But this means that the post-merger equilibrium will be relatively asymmetric, implying a relatively large increase in total (and average) travelling costs for the patients in this market. Thus, for the parameter configurations

[20] For $\alpha = c = 0$, the strategic response to quality changes in the pre-merger game (cf. (14)) is given by

$$\frac{\partial q_i\left(q_j\right)}{\partial q_j} = \frac{b}{2}\left(\frac{-b}{wkt^2 - b^2}\right) < 0,$$

and it is straightforward to see that the size of this effect (in absolute value) is decreasing in k and t, and increasing in b.

[21] The other parameter restrictions, $k > \underline{k}$ and $p \in \left(\underline{p}, \overline{p}\right)$, ensure equilibrium existence and merger profitability.

[22] The patients benefiting from the merger are those patients who choose the outside hospital in both the pre-merger and the post-merger equilibrium: these patients enjoy higher quality without having to pay higher travelling costs. In addition, among those patients who choose one of the merger candidates in the pre-merger equilibrium but switch to the outside hospital in the post-merger equilibrium, there are some who are located sufficiently close to the indifferent consumer in the pre-merger equilibrium so that the increase in quality outweighs the increase in travelling costs.

where a merger increases average quality provision, this gain will be outweighed by the increase in average travelling costs.

6 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 instead that the merging hospitals decide to close down one of its two hospitals and allocate all production to the remaining hospital. Hospital closure allows the merging parties to realise fixed-cost savings and will be profitable if F is sufficiently large. Thus, the analysis in this extension applies to cases where the realisation of fixed-cost savings is a relatively important motivation for the hospital merger.

In the case of hospital closure, a merger implies that the market structure changes from a symmetric triopoly to a symmetric duopoly.[23] The post-merger demand function for Hospital i is given by

$$D_i\left(q_i, q_j\right) = \frac{1}{2} + \frac{b\left(q_i - q_j\right)}{t}; \quad i = m, o; \quad j = m, o; \quad i \neq j. \tag{29}$$

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

$$q_m^* = q_o^* = \frac{2b + 2w\left(2bp - ct\right) + \alpha bw\left(4v + t\right)}{4w\left(kt + bc - \alpha b^2\right)}, \tag{30}$$

$$\varepsilon_m^* = \varepsilon_o^* = \frac{1}{2w}. \tag{31}$$

In this equilibrium, total patient utility is given by

$$\overline{U}^* = \frac{18b^2 + 36bw\left(bp + cv\right) - 23bctw + 14b^2t\alpha w + ktw\left(36v - 5t\right)}{36w\left(kt + bc - b^2\alpha\right)}. \tag{32}$$

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

Proposition 3 *A hospital closure leads to higher cost-containment effort for all hospitals and higher (lower) quality for all hospitals if qualities are strategic substitutes (complements).*

[23] The post-merger duopoly is, in a sense, asymmetric in terms of locations. However, with only two hospitals in the market, the equilibrium outcome in a Salop model will be symmetric regardless of how the firms are located.

Proof. In Appendix. ■

Notice first that, because of the symmetric nature of the post-merger game, the effects of the merger (on quality and effort) are similar for all hospitals in the market. The explanation for the effects is directly related to the fact that a hospital closure increases demand for the remaining hospitals in the market. This demand increase strengthens the hospitals' incentives to expend effort to reduce treatment costs.

The effect on the hospitals' 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 (because of higher demand) 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 (altruism and cost-containment effort) 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. Once more, we can offer an exact characterisation of the effect of a hospital merger (with closure) on patient utility by considering the special case $\alpha = c = 0$.

Proposition 4 *In the case of no altruism and quality-independent treatment costs, there exists a non-empty set of parameters, defined by* $k \in \left(\underline{\underline{k}}, \overline{\overline{k}}\right)$ *and* $p > \underline{\underline{p}}$*, for which a hospital closure leads to higher total patient utility.*

Proof. In Appendix. ■

The intuition for this result is similar to the intuition given for the results in Proposition 2. Once more, the upper bound $\overline{\overline{k}}$ is increasing in b and decreasing in t, implying that the conditions given in Proposition 4 can be stated in terms of the demand responsiveness to quality (the lower bounds on k and p are needed to ensure equilibrium existence). If demand responds sufficiently strongly to quality changes, a merger-induced hospital closure will increase total patient utility. In this case the quality increase is sufficiently strong to outweigh the increase in travelling costs. As we confirmed in the previous section, this was not possible in the case of a merger without hospital closure (cf. Proposition 2). Here, in contrast, a merger (with closure) can lead to higher quality for all hospitals in the market, making the potential increase in average quality much larger. The (perhaps surprising) implication is that, all else equal, a hospital merger is more likely to be beneficial to patients when the merger involves hospital closure.

7 Concluding remarks

Our analysis provides a coherent framework to 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. The main part of the analysis focuses exclusively on anticompetitive effects, where a hospital merger implies coordination of quality provision and cost-containment effort. The benchmark model is subsequently extended to consider efficiency gains through fixed costs savings due to hospital closure.

In Table 1 we summarise our findings on the hospital merger effects.

Table 1. Summary of results on hospital merger effects

	Coordination		Closure	
	Complements	Substitutes	Complements	Substitutes
Quality				
* Merging hospitals	-	-	-	+
* Outside hospital	-	+	-	+
* Average	-	+/-	-	+
Cost containment				
* Merging hospitals	-	-	+	+
* Outside hospital	+	+	+	+
* Average	+	+	+	+
Patient utility	-	-*	-	+/-

* This result is based on the special case of $\alpha = c = 0$

We show that mergers that do not involve hospital closure generate poor incentives for merging hospitals: both quality and cost-containment incentives are weakened irrespective of whether quality decisions are strategic substitutes or complements. The results are not as negative for the non-merging hospitals: cost-containment effort always increases. Quality may also increase if altruism is relatively high, if the degree of cost substitutability between quality and treatment volume is sufficiently low, or if the scope for cost reductions is sufficiently large. Therefore, both quality and cost-containment effort can be strategic substitutes. The average quality may even increase as a result of this strategic interaction when demand responsiveness to quality is sufficiently high. But consumer welfare is less likely to increase even if average quality increases, because a merger increases overall travelling costs for patients. A merger always improves overall treatment cost efficiency in the market, though, because the increase in cost-containment effort by the non-merging hospital outweighs the corresponding effort reduction by the merging hospitals.

When we consider mergers that involve hospital closure, we find that both quality and cost-containment incentives will improve following a merger if qualities are strategic substitutes. Since

a closure increases the volume of patients treated for each hospital, the hospital has an incentive to provide more quality for altruistic reasons and to increase cost-containment efforts (since these generate a return on a larger number of patients). In turn, the increase in effort increases the mark-up which strengthens the incentive to provide quality for profit-related reasons. Because of higher average quality, consumer welfare is more likely to increase despite the increase in average travelling costs. The opposite holds when altruism is low, the scope for cost reductions is limited, and the marginal cost of treatment is increasing in quality. In this case qualities are strategic complements and a merger leads not only to higher travelling costs, but also to lower quality, which makes patients worse off.

What are the implications for competition policy regarding hospital mergers? As Table 1 illustrates, hospital mergers tend to be bad news for consumer welfare due higher travelling costs and, in most cases, lower quality. These are exactly the concerns raised by the UK government when establishing the Co-operation and Competition Panel in 2008 (now a part of Monitor) and the Office of Fair Trading when dealing with the merger between the Royal Bournemouth and Christchurch Hospitals NHS Foundation Trust and Poole Hospital NHS Foundation Trust. Our study shows that the only exception is when the merger involves closure and quality decisions are strategic substitutes. In this case, we show (for the special case of $\alpha = c = 0$) that the higher travelling costs may be more than offset by the increase in quality, making the average patient better off. However, the merger effects on hospital cost efficiency are more positive. In fact, average cost efficiency always increases after the merger irrespective of the strategic nature of competition or whether the merger involves closure or not. Thus, the total welfare effect of hospital mergers, including the hospital surplus, are less clear. 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 higher cost-containment effort). If these synergies increase the profit margin, this will counteract and possibly offset the incentive to lower quality for the merging hospitals and our results can consequently be reversed if variable-cost synergies are sufficiently strong. Thus, our study demonstrates that hospital merger policy should account for the strategic nature of competition among hospitals, and thus the responses by hospitals not taking part in the merger, as well as the type of merger (closure or coordination) and the effects on cost efficiency.

Appendix: Proofs

Proof of Proposition 1. (i) A comparison of (20) and (15) yields,

$$q_m^*-q_i^* = -\frac{bt\left(tw\left(4bc+2kt-3\alpha b^2\right)-2b^2\right)\left(2w\left(b\alpha-c\right)^2+k\left(2\left(3pw+1\right)+\alpha w\left(6v-t\right)\right)\right)}{6w\left(bc+kt-\alpha b^2\right)\Phi} < 0. \tag{A1}$$

Notice that equilibrium existence (with interior solutions) in the pre- and post-merger equilibria requires that $\Phi > 0$ and $bc + kt - \alpha b^2 > 0$, implying that the denominator in (A1) is positive, whereas the positive sign of the numerator is confirmed by applying the second-order condition given by (10). A comparison of (18) and (11) yields

$$q_o^* - q_i^* = \frac{b^2t\left(2b-tw\left(2c-b\alpha\right)\right)\left(2w\left(b\alpha-c\right)^2+k\left(2\left(3pw+1\right)+\alpha w\left(6v-t\right)\right)\right)}{6w\left(bc+kt-\alpha b^2\right)\Phi}, \tag{A2}$$

where the sign of the expression is determined by the sign of $2b - tw\left(2c - b\alpha\right)$. Thus, $q_o^* > q_i^*$ if $\alpha > \frac{2c}{b}$ or $w < \frac{2b}{t(2c-b\alpha)}$. Otherwise, $q_o^* < q_i^*$. From Lemma 1, these conditions correspond exactly to the conditions for strategic substitutability/complementarity. (ii) A comparison of (21) and (16) yields

$$\varepsilon_m^* - \varepsilon_i^* = -\frac{b^2t\left(2w\left(b\alpha-c\right)^2+k\left(2+w\left(6p+\alpha\left(6v-t\right)\right)\right)\right)}{6w\Phi} < 0, \tag{A3}$$

whereas a comparison of (19) and (16) yields

$$\varepsilon_o^* - \varepsilon_i^* = \frac{b^2t\left(2w\left(b\alpha-c\right)^2+k\left(2+w\left(6p+\alpha\left(6v-t\right)\right)\right)\right)}{3w\Phi} > 0. \tag{A4}$$

(iii) Applying the pre- and post-merger equilibrium outcomes with respect to effort and market shares, we derive

$$2D_m^*\varepsilon_m^* + D_o^*\varepsilon_o^* - \varepsilon_i^* = \frac{b^4t^2\left(2w\left(b\alpha-c\right)^2+k\left(2+w\left(6p+\alpha\left(6v-t\right)\right)\right)\right)^2}{6w\Phi^2} > 0. \tag{A5}$$

Q.E.D.

Proof of Proposition 2. Comparing (28) with (23), and (27) with (24), the effect of a hospital merger on average quality and patient utility is given by, respectively,

$$\overline{q}^* - q_i^* = -\frac{2b\left(3pw+1\right)\left[15b^4 + 2kt^2w\left(4kt^2w - 3b^2\left(pw+4\right)\right)\right]}{9ktw\left(4kt^2w - 5b^2\right)^2} \tag{A6}$$

and

$$\overline{U}^* - U^* = -\frac{2b^2\left(3pw+1\right)\left[15b^4 + kt^2w\left(8kt^2w - b^2\left(3pw+23\right)\right)\right]}{9ktw\left(4kt^2w - 5b^2\right)^2}. \tag{A7}$$

The sign of (A6) depends on the sign of the expression in the square brackets in the numerator. It is easily confirmed that $\overline{q}^* > q_i^*$ if $k_0 < k < \overline{k}$, where

$$k_0 := \frac{b^2\left(3\left(4+pw\right) - \sqrt{3}\sqrt{8+3\left(8+pw\right)pw}\right)}{8t^2w} \tag{A8}$$

and

$$\overline{k} := \frac{b^2\left(3\left(4+pw\right) + \sqrt{3}\sqrt{8+3\left(8+pw\right)pw}\right)}{8t^2w} \tag{A9}$$

It remains to be shown that the parameter set defined by $k_0 < k < \overline{k}$ is non-empty in equilibrium. There are two potentially binding conditions to consider: (i) Equilibrium existence requires non-negative hospital payoffs. Assume for simplicity that $F = 0$. In this case payoffs are positive in equilibrium if

$$k > k_1 := \frac{b^2\left(3pw+1\right)^2}{t^2w\left(6pw+1\right)}. \tag{A10}$$

(ii) Merger profitability requires

$$k > k_2 := \frac{b^2\left(17+\sqrt{33}\right)}{8t^2w}. \tag{A11}$$

If these two conditions are met, it is easily confirmed that the second-order conditions in both games (pre- and post-merger) are also satisfied. The parameter set defined by $k_0 < k < \overline{k}$ is non-empty in equilibrium if, for some parameter values, $\overline{k} > \max\left\{k_1, k_2\right\}$. The relevant

comparisons are:

$$\overline{k} - k_1 = \frac{3b^2\left[\frac{2}{3} + \frac{9}{2}pw\left(1-2pw\right) + \frac{\left(\sqrt{3}+6\sqrt{3}pw\right)}{6}\sqrt{8+3\left(8+pw\right)pw}\right]}{4t^2w\left(6pw+1\right)}, \tag{A12}$$

$$\overline{k} - k_2 = \frac{b^2\left(\sqrt{3}\sqrt{8+3pw\left(pw+8\right)}+3pw-\sqrt{33}-5\right)}{8t^2w}. \tag{A13}$$

It is easily confirmed that $\overline{k} > k_2$ if $p > \frac{5\sqrt{33}+17}{w\left(51+3\sqrt{33}\right)} \approx \frac{0.6701}{w}$. The sign of $\overline{k} - k_1$ depends on the sign of the expression in the square brackets in the numerator of (A12). Defining $a := pw$, it can be verified that the polynomial equation

$$\frac{2}{3} + \frac{9}{2}a\left(1-2a\right) + \frac{\left(\sqrt{3}+6\sqrt{3}a\right)}{6}\sqrt{8+3\left(8+a\right)a} = 0 \tag{A14}$$

has one positive root, $a = 2.4073$, and that the polynomial is positive for $a < 2.4073$. Thus, the parameter set defined by $k_0 < k < \overline{k}$ is non-empty if $\underline{p} < p < \overline{p}$, where $\underline{p} := \frac{0.6701}{w}$ and $\overline{p} := \frac{2.4073}{w}$. In this case, a hospital merger increases average quality provision (i.e., $\overline{q}^* > q_i^*$) if $\underline{k} < k < \overline{k}$, where $\underline{k} = \max\left\{k_0, k_1, k_2\right\}$. Turning now to the effect of a merger on total patient utility, the sign of (A7) depends on the sign of the expression in the square brackets in the numerator. It is easily confirmed that $\overline{U}^* > U^*$ if $\underline{k}' < k < \overline{k}'$, where

$$\underline{k}' := \frac{b^2\left(23+3pw-\sqrt{49+3\left(46+3pw\right)pw}\right)}{16t^2w} \tag{A15}$$

and

$$\overline{k}' := \frac{b^2\left(23+3pw+\sqrt{49+3\left(46+3pw\right)pw}\right)}{16t^2w}. \tag{A16}$$

Applying the conditions (A10)-(A11), we have

$$\overline{k}' - k_1 = \frac{b^2\left(7+9\left(5-14pw\right)pw+\left(6pw+1\right)\sqrt{49+3\left(46+3pw\right)pw}\right)}{16t^2w\left(6pw+1\right)} \tag{A17}$$

and

$$\overline{k}' - k_2 = \frac{b^2\left(3pw-11-2\sqrt{33}+\sqrt{49+3\left(46+3pw\right)pw}\right)}{16t^2w}. \tag{A18}$$

It is easily confirmed that $3pw - 11 - 2\sqrt{33} + \sqrt{49 + 3\left(46 + 3pw\right)pw} > 0$, and thus $\overline{k}' > k_2$, if $p > \frac{11\sqrt{33}+51}{w\left(51+3\sqrt{33}\right)} \approx \frac{1.6735}{w}$. Using the definition $a := pw$, it can be verified that the polynomial equation

$$7 + 9\left(5 - 14a\right)a + \left(6a + 1\right)\sqrt{49 + 3\left(46 + 3a\right)a} = 0 \tag{A19}$$

has one positive root, $a = 1.2258$, and that the polynomial is negative for $a > 1.2258$. This implies that $\overline{k}' < k_1$ if $p > \frac{1.6735}{w}$, which is the condition for $\overline{k}' < k_2$. Thus, no parameter set exists for which a profitable merger increases total consumer utility. *Q.E.D.*

Proof of Proposition 3. Comparing (31) and (16) yields

$$\varepsilon_m^* \left(= \varepsilon_o^*\right) - \varepsilon_i^* = \frac{1}{6w} > 0. \tag{A20}$$

Comparing (30) and (15) yields

$$q_m^* \left(= q_o^*\right) - q_i^* = -\frac{\left(tw\left(2c - b\alpha\right) - 2b\right)}{12w\left(kt + cb - \alpha b^2\right)}. \tag{A21}$$

We see that $q_m^* > q_i^*$ if $\alpha > \frac{2c}{b}$ or $w < \frac{2b}{t(2c-b\alpha)}$. Otherwise, $q_m^* < q_i^*$. From Lemma 1, these conditions correspond exactly to the conditions for strategic substitutability/complementarity. *Q.E.D.*

Proof of Proposition 4. Comparing (17) and (32), setting $\alpha = c = 0$, yields

$$\overline{U}^* - U^* = \frac{\left(12pw + 5\right)\left(kt^2w - b^2\right)}{72kt^2w^2} > 0 \text{ if } k < \overline{\overline{k}} := \frac{3b^2}{wt^2}. \tag{A22}$$

In the symmetric equilibria there is only one binding condition for equilibrium existence, namely that of non-negative hospital payoffs. For $F = 0$, this condition is $k > \underline{\underline{k}} := \frac{(3pw+1)^2}{(6pw+1)}\frac{b^2}{t^2w}$. It is easily confirmed that $\overline{\overline{k}} > \underline{\underline{k}}$ if $p > \underline{\underline{p}} := \frac{2+\sqrt{2}\sqrt{3}}{3w}$. Thus, if $p > \underline{\underline{p}}$, hospital closure increases total patient utility if $\underline{\underline{k}} < k < \overline{\overline{k}}$. *Q.E.D.*

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