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Hospital Competition in the National Health Service: Evidence from a Patient Choice Reform

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*Prosjektet har mottatt forskningsmidler fra
det alminnelige prisreguleringsfondet.*

Hospital Competition in the National Health Service: Evidence from a Patient Choice Reform*

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Abstract

We study the impact of exposing hospitals in a National Health Service (NHS) to non-price competition by exploiting a patient choice reform in Norway in 2001. The reform facilitates a difference-in-difference research design due to geographical variation in the scope for competition. Using rich administrative data covering the universe of NHS hospital admissions from 1998 to 2005, we find that hospitals in more competitive areas have a sharper reduction in AMI mortality, readmissions, and length of stay than hospitals in less competitive areas. These results indicate that competition improves patient health outcomes and hospital cost efficiency, even in the Norwegian NHS with large distances, low fixed treatment prices, and mainly public hospitals.

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1 Introduction

Health care is one of the most important sectors in the economy. OECD countries spend on average 9 percent of their GDP on health care (OECD, 2017). Health care is also crucial for individuals' well-being and the health in the population more broadly. The organisation of the delivery of health care is therefore of great importance.

The health care sector has traditionally been, and still is, extensively regulated in many countries, implying limited, or in some countries even no, use of market mechanisms.[1] This has particularly been the case in countries with a National Health Service (NHS), such as the UK, the Scandinavian countries, and the Southern European countries. The last decades, however, many countries, including countries with a NHS, have introduced market-oriented reforms introducing provider competition in the delivery of health care.

Despite the extensive adoption of market-oriented reforms across countries, there is still a lack of strong evidence on the impact of introducing competition in the provision of health care, especially from outside the US and England.[2] Most of the existing studies, which are based on the US Medicare program, exploit cross-sectional variation in market structure over time to identify the impact of competition. However, a potential problem with this approach is that market structure is not exogenous and possibly related to hospital performance along dimensions such as quality of care.[3]

In this study, we follow the approach by Cooper et al. (2011) and Gaynor et al.

[1] There are notable exceptions, such as the US where market mechanims have been in place for a long time for the delivery of health care.

[2] See Gaynor and Town (2011) for an extensive overview of the literature on competition in health care markets.

[3] High-quality hospitals are likely to have a larger share of the market (more patients) than low-quality hospitals. The presence of a high-quality hospital may also deter entry of new hospitals into the market.

(2013), who study the impact of hospital competition by exploiting an exogenous policy reform introducing patient choice in the English NHS in 2006. While the reform applied to all NHS hospitals at the same time, geographical variation in market structure prior to the reform facilitates a difference-in-difference (DiD) research design, where hospitals in less competitive areas serve as a control for hospitals in more competitive areas. In Norway there was a similar reform in 2001, where the government introduced nationwide patient choice within the Norwegian NHS, replacing an administrative system where patients were referred to the closest hospital offering the relevant treatment within their county of residence. The new policy therefore implied a switch from a situation where the NHS hospitals were local monopolists in their catchment area to a scheme with potential for non-price competition among NHS hospitals.

While the policy reforms introducing patient choice in the English and the Norwegian NHS are fairly similar, there are also important differences across the two NHS systems that . First, England had a gradual roll-out of their fixed price (Payment by Result) funding scheme in the period prior to the reform, with the full scale implementation of this scheme coinciding with the patient choice reform.[4] In Norway, however, a fixed price payment scheme based on diagnosis related groups (DRG) were in place since 1997 and did not change before (or after) the policy reform. Second, while England implemented a more purely fixed price scheme, Norway had a mixed payment scheme which was partly based on fixed prices and partly on block grants. An important implication of this is that the fixed DRG prices in Norway were cut by the share of funding that was based on block grants, which means that Norwegian NHS hospitals were facing lower fixed treatment prices than their English counterparts. Third, the NHS hospitals in England are organised as free-standing trusts, whereas the majority of the NHS hospitals in Norway are public. Following shortly after the policy reform, the public hospitals were corporatised in Norway with ownership being transferred from county-level to state-level.

[4] See Gaynor et al. (2013) for a more detailed description of the roll-out of the Payment by Result scheme in the English NHS.

Finally, a quick glance at the map reveals that travel distances are substantially larger in Norway than in England. Thus, the contribution of our study is to provide more evidence on the causal effects of hospital competition from outside the US and England, and to contribute to the robustness and external validity of the findings in the existing literature.

To do so, we have assembled a rich dataset based on detailed administrative data covering the universe of hospital admissions in the Norwegian NHS over eight years from 1998 to 2005. For the analysis, the data are aggregated to quarterly observations at hospital and DRG level. We use a similar DiD research design as Cooper et al. (2011) and Gaynor et al. (2013), where the reform dummy is interacted with a treatment (competition) intensity variable specific for each hospital. This implies that the impact of hospital competition is identified by comparing the differential effects between hospitals in less competitive are with hospitals in more competitive areas before and after the reform. Treatment (competition) intensity is captured by estimating a Hirschman-Herfindahl Index (HHI) for each hospital based on predicted patient flows prior to the reform to account for endogenous market structure, as in Gaynor et al. (2013).[5] The effects of exposing the NHS hospitals to competition are estimated controlling for time trends, patient case mix (age, gender, comorbidities) at hospital and DRG level, and hospital and DRG fixed effects.

Based on the DiD approach, we obtain the following results. First, we find that the introduction of (non-price) competition in the Norwegian NHS, induced by the patient choice reform, is associated with a sharper decline in acute myocardial infarction (AMI) mortality rates for hospitals in more competitive (less concentrated) areas compare to hospitals in less competitive (more concentrated) areas. The effect is, however, modest in that a 10 percent increase in the average HHI leads to a 1.7 percent fall in the AMI mortality rate, implying a reduction of 40 AMI deaths per year in total among the

[5] Cooper et al. (2013) use also HHIs based on predicted patient flows, but compute these for each period, including periods after the patient choice reform.

Norwegian NHS hospitals. We find no significant effects on stroke or overall hospital mortality. These pro-competitive findings on hospital quality are consistent with the findings by Cooper et al. (2011) and Gaynor et al. (2013) from the English NHS, but the effects are more modest, which can be explained by lower fixed (DRG) prices due to partial block grant funding, publicly owned hospitals with less profit orientation, or simply longer travel distances and thus less intense competition.

Second, we find that the introduction of competition in the Norwegian NHS is associated with a sharper reduction in readmission rates for hospitals in more competitive areas compared to hospitals in less competitive areas after the reform. The effect is equally strong for both elective and emergency treatments, though the patient choice reform only applied to elective treatments, suggesting a positive spillover effect also on emergency treatments of exposing NHS hospitals to competition. As the results for elective readmissions may potentially be biased due to changes in patient flows induced by the patient choice reform, it is ensuring that the effects for emergency treatments are similar. A readmission usually reflects that the first treatment was associated with complications, implying that lower readmission rates signals higher hospital quality. Thus, this finding supports the pro-competitive results for AMI mortality. Cooper et al. (2011) and Gaynor et al. (2013) do not consider the effects on hospital readmissions.

Third, we find that the patient choice reform induced a sharper decline in length of stay at NHS hospitals in more competitive areas compared to NHS hospitals in less competitive areas, indicating a pro-competitive effect on hospital cost efficiency. As for readmissions, the effects are statistically significant for both elective and emergency treatments, suggesting a positive spillover effect of the patient choice reform on emergency treatments. For length of stay, we also find a differential effect of competition depending on hospital ownership, where the private non-profit hospitals in the NHS reduce length of stay more than the public hospitals, possibly reflecting more profit orientation or harder budget constraints. Cooper et al. (2011) and Gaynor et al. (2013)

find similar effects on length of stay, but do not investigate possible differential effects of ownership or for elective vs. emergency treatments.

We rationalise the findings in a theoretical analysis, showing that the effects of (non-price) competition, induced by patient choice, on hospital quality and cost efficiency depend on hospitals' profit orientation and price-cost margins. In particular, if hospitals are profit oriented and face positive price-cost margins, competition will improve both hospital quality and cost efficiency. However, if hospitals are less profit oriented (more altruistic) and face negative price-cost margins, then competition has in general ambiguous effects on hospital quality and cost efficiency. Since hospitals in the Norwegian NHS are mainly public and the fixed (DRG) prices are low due to a mixed funding scheme, it is far from obvious that the introduction of competition would have positive quality and cost efficiency effects. However, our empirical analysis identifies, as in the English NHS, pro-competitive effects following the patient choice reform.

In summary, our study provides evidence that exposing NHS hospitals to non-price competition saves lives, reduces complications, and shortens hospital stays, which suggest that competition improves patient welfare and possibly also total welfare. These findings are consistent with evidence from the English NHS provided by Cooper et al. (2011) and Gaynor et al. (2013), but also with several US studies focusing on the provision of hospital care to Medicare patients where prices are also fixed, e.g., Kessler and McClellan (2001).[6] Our study of the Norwegian NHS therefore extends the robustness and thus the external validity of the positive effects of exposing hospitals to non-price competition.

The rest of the paper is organised as follows: Section 2 explains in more detail the relation of our study to existing literature; Section 3 presents our theoretical analysis of hospital competition; Section 4 explains the institutional setting and the policy reforms of the Norwegian NHS; Section 5 presents the data and descriptive statistics; Section 6 describes our empirical strategy; Section 7 presents the results; and Section 8 concludes

[6] See Gaynor and Town (2011) for a review of the literature on hospital competition.

the paper.

2 Related literature

Our paper relates primarily to the empirical literature on the impact of competition in hospital markets.[7] The evidence on the effect of competition is mostly from the US and the UK, and has mixed findings.[8] In the US, Kessler and McClellan (2000) find that AMI mortality is higher for Medicare patients in more concentrated markets.[9] They also find that hospitals in less concentrated areas have lower expenditures when Medicare introduced fixed (DRG) prices, and conclude that (non-price) competition among US hospitals is welfare improving. Shen (2003) finds that competition (measured by the number of hospitals) interacted with the Medicare payment leads to lower AMI mortality for Medicare patients after 1990. In contrast, Gowrisankaran and Town (2003) find that AMI and pneumonia mortality rates are higher for Medicare patients in less concentrated markets in the Los Angeles area. Mukamel et al. (2001) find no effect of competition (measured by concentration) on overall hospital mortality for Medicare patients. A recent study by Colla et al. (2016) finds that competition reduces AMI mortality, has no effect on emergency readmissions for hip and knee replacement, and reduces quality for dementia patients in the Medicare.[10]

In England, Propper et al. (2004) and Burgess et al. (2008) find that more competition increases AMI mortality in the 1990s when the internal market was introduced

[7] There is also a large theoretical literature on hospital competition. Gaynor (2006) shows that profit-maximising hospitals respond to competition by improving quality of care when prices are fixed, while this effect is generally ambiguous with flexible prices. Brekke et al. (2011) show that the positive effect of hospital competition on quality with fixed prices holds also for semi-altruistic hospitals unless the degree of altruism is sufficiently high. See also Brekke et al. (2010) for a study on quality competition with flexible prices.

[8] See Gaynor and Town (2011) for an extensive literature review.

[9] In a related paper, Kessler and Geppert (2005) find that the AMI mortality rate for high-risk Medicare patients is higher in concentrated markets, while there is no such effect for low-risk patients.

[10] There is also an interesting strand of literature on the interaction between information and competition in hospital markets. For example, Chou et al (2014) find that report cards on the quality of providers reduced CABG mortality for more severely ill patients in more competitive areas.

and hospital prices were not fixed but negotiated with local health authorities. Burgess et al. (2008), however, find that competition did reduce significantly waiting times, and this may be due to purchasers negotiating mostly on waiting times rather than on clinical quality. The most recent empirical literature from England finds that competition increases quality. Bloom et al. (2015) instrument for competition with the marginality of local Parliamentary seats and find that hospitals in more competitive areas had lower AMI mortality. Cooper et al. (2011) and Gaynor et al. (2013) find, as mentioned previously, that hospitals in more competitive areas had sharper reductions in AMI mortality following the patient choice reform of 2006. Gaynor et al. (2013) also found that competition reduced length of stay but did not affect expenditure or volume of admissions. Feng et al. (2015) find that competition is positively associated with health gains for hip replacement patients, where the health gain is measured by the difference in patient reported health outcomes (PROMs) before and after the surgery. Cooper et al. (2016) find that the entry of a private hospital in the NHS market reduced pre-operative length of stay for hip and knee replacement patients. For Italy, Berta et al. (2016) find that competition does not affect quality.

The contribution of our study to this literature is two-fold. First, we contribute to the existing literature by providing causal evidence on the impact of hospital competition by exploiting an exogenous policy reform in the Norwegian NHS, taking the same approach as Cooper et al. (2011) and Gaynor et al. (2013). This approach deals with the endogeneity of market structure that possibly affects the estimates in studies using cross-sectional variation in market concentration over time. Second, our study contribute to the external validity of the effects of hospital competition by providing evidence from outside the US and England. Compared to the US, the institutional setting in the Norwegian NHS is very different along many dimensions, including ownership structure, use of market mechanisms, extent of flexible vs. fixed prices, etc. Compared to the English NHS, the institutional setting in the Norwegian NHS is also different along a few dimensions, including the level of the fixed prices, the ownership structure, and the geographic distribution of hospitals and patients. Despite low fixed (DRG) prices, public hospitals, and long travel distances, we still find positive effects of competition on hospital quality and cost efficiency, indicating a welfare improvement of the reorganisation of the delivery of health care. In the next section, we present mechanisms that might possibly explain these findings.

3 Theory

Suppose that there are two hospitals, denoted by subscripts i and j, in a given market for secondary health care.[11] Demand for Hospital i, measured by number of treatments, is given by $x_i(q_i, q_j, \theta)$, where $q_k \geq \underline{q}$ is the quality of Hospital $k = i, j$. The lower bound on hospital quality represents the minimum treatment quality hospitals are allowed to offer, implying that $q < \underline{q}$ can be interpreted as malpractice. We assume that x_i is increasing in q_i and decreasing in q_j. The effect of competition is captured by the parameter θ, which measures the degree of patient choice, implying that a higher value of θ represents a market with more competition. We assume that $\partial x_i/\partial\theta > (<)\, 0$ if $q_i > (<)\, q_j$. Thus, for a given distribution of qualities across hospitals, patient choice increases (reduces) demand for hospitals with higher (lower) quality. Furthermore, we assume that $\partial^2 x_i/\partial\theta\partial q_i > 0$, implying that patient choice makes demand for each hospital more responsive to quality changes. This is, intuitively, the key effect of competition in markets where the providers compete on quality.

The objective function of Hospital i is assumed to be given by

$$\pi_i = T + px_i(q_i, q_j, \theta) - c(x_i(q_i, q_j, \theta), q_i, e_i) + \alpha B_i(x_i(q_i, q_j, \theta), q_i) - g(e_i). \qquad (1)$$

[11] As long as the market is symmetric, the analysis can easily be extended to n hospitals. However, only two hospitals are needed in order to illustrate all the potential mechanisms at play.

The hospital payment system is characterised by the contract (p, T), where each hospital receives a fixed price p per treatment and a lump-sum payment T. Total treatment costs are given by a cost function $c(\cdot)$ which depends on the total number of treatments (x_i), quality (q_i) and the amount of cost-containment effort (e_i) exerted by the hospital.

We assume that, by spending more effort on cost containment, the hospital can (i) reduce the total costs of a given treatment volume and quality provision $(\partial c/\partial e < 0)$, (ii) reduce the marginal cost of treatments $(\partial^2 c/\partial e_i \partial x_i < 0)$ for a given quality level and (iii) possibly also reduce the marginal cost of quality provision for a given treatment volume $(\partial^2 c/\partial e_i \partial q_i \leq 0)$. The disutility of exerting cost-containment effort is given by a strictly convex function $g(e_i)$.

We also assume that the providers are semi-altruistic in the sense that patient utility is part of the hospitals' objectives. More specifically, we assume that the decision-makers at Hospital i to some extent take into account the total utility of patients treated at the hospital, given by $B_i(\cdot)$, which is increasing in x_i and q_i. The degree of altruism is captured by the parameter α, implying that a purely profit-oriented hospital is characterised by $\alpha = 0$.

Suppose that the two hospitals play a non-cooperative game where they simultaneously choose quality and cost-containment effort. The first-order conditions for Hospital i are given by

$$\frac{\partial \pi_i}{\partial q_i} = p\frac{\partial x_i}{\partial q_i} - \frac{\partial c}{\partial x_i}\frac{\partial x_i}{\partial q_i} - \frac{\partial c}{\partial q_i} + \alpha\left(\frac{\partial B_i}{\partial x_i}\frac{\partial x_i}{\partial q_i} + \frac{\partial B_i}{\partial q_i}\right) = 0, \tag{2}$$

$$\frac{\partial \pi_i}{\partial e_i} = -\frac{\partial c}{\partial e_i} - \frac{\partial g}{\partial e_i} = 0. \tag{3}$$

We consider a symmetric equilibrium with interior solutions, where $q_j = q_i > \underline{q}$ and $e_j = e_i > 0$. The Nash equilibrium is then characterised by the following 2-equation system:

$$F_q := \left.\frac{\partial \pi_i}{\partial q_i}\right|_{q_j=q_i, e_j=e_i} = 0, \tag{4}$$

$$F_e := \left.\frac{\partial \pi_i}{\partial e_i}\right|_{q_j=q_i, e_j=e_i} = 0. \tag{5}$$

We are interested in characterising how more competition (increased patient choice, measured by θ) affects equilibrium quality provision and cost efficiency. Differentiation of (4)-(5) yields

$$\begin{bmatrix} \frac{\partial F_q}{\partial q_i} & \frac{\partial F_q}{\partial e_i} \\ \frac{\partial F_e}{\partial q_i} & \frac{\partial F_e}{\partial e_i} \end{bmatrix} \begin{bmatrix} dq_i \\ de_i \end{bmatrix} + \begin{bmatrix} \frac{\partial F_q}{\partial \theta} \\ \frac{\partial F_e}{\partial \theta} \end{bmatrix} d\theta = 0, \tag{6}$$

where equilibrium existence requires $\partial F_q/\partial q_i < 0$, $\partial F_e/\partial e_i < 0$ and $\Delta := (\partial F_q/\partial q_i)(\partial F_e/\partial e_i) - (\partial F_e/\partial q_i)(\partial F_q/\partial e_i) > 0$, and where

$$\frac{\partial F_q}{\partial e_i} = -\frac{\partial^2 c}{\partial e_i \partial x_i}\frac{\partial x_i}{\partial q_i} - \frac{\partial^2 c}{\partial e_i \partial q_i}, \tag{7}$$

$$\frac{\partial F_e}{\partial q_i} = -\frac{\partial^2 c}{\partial x_i \partial e_i}\frac{\partial (x_i + x_j)}{\partial q_i} - \frac{\partial^2 c}{\partial q_i \partial e_i}, \tag{8}$$

$$\frac{\partial F_q}{\partial \theta} = \left(p - \frac{\partial c}{\partial x_i} + \alpha \frac{\partial B_i}{\partial x_i}\right)\frac{\partial^2 x_i}{\partial \theta \partial q_i}, \tag{9}$$

and

$$\frac{\partial F_e}{\partial \theta} = 0. \tag{10}$$

The symmetry assumption has two implications that that are important for the derivation of (7)-(10). First, when both hospitals provide the same quality level, patient choice has no direct effect on demand; i.e., $\partial x_i/\partial \theta = 0$. Second, notice that

$$\left.\frac{\partial x_i}{\partial q_i}\right|_{q_j=q_i} = \frac{\partial x_i}{\partial q_i} + \left.\frac{\partial x_i}{\partial q_j}\right|_{q_j=q_i} = \frac{\partial x_i}{\partial q_i} + \frac{\partial x_j}{\partial q_i} = \frac{\partial (x_i + x_j)}{\partial q_i}. \tag{11}$$

3.1 Competition and quality provision

Applying Cramer's Rule on (6), the effect of competition on equilibrium quality provision is given by

$$\frac{\partial q_i}{\partial \theta} = \frac{1}{\Delta}\left(\frac{\partial F_e}{\partial \theta}\frac{\partial F_q}{\partial e_i} - \frac{\partial F_q}{\partial \theta}\frac{\partial F_e}{\partial e_i}\right). \tag{12}$$

Since $\Delta > 0$, $\partial F_e/\partial e_i < 0$ and $\partial F_e/\partial \theta = 0$, we have

$$sign\left(\frac{\partial q_i}{\partial \theta}\right) = sign\left(\frac{\partial F_q}{\partial \theta}\right), \tag{13}$$

which implies that

$$\frac{\partial q_i}{\partial \theta} > (<)\, 0 \quad if \quad p - \frac{\partial c}{\partial x_i} + \alpha\frac{\partial B_i}{\partial x_i} > (<)\, 0. \tag{14}$$

An effect (positive or negative) of competition on equilibrium quality provision requires that the equilibrium is an interior solution with $q_i > \underline{q}$. Thus, the condition in (14) needs to be seen in conjunction with the first-order condition for optimal quality provision, given by (2).[12] For this purpose, it is useful to re-write (2) as follows:

$$\left(p - \frac{\partial c}{\partial x_i} + \alpha\frac{\partial B_i}{\partial x_i}\right)\frac{\partial x_i}{\partial q_i} + \alpha\frac{\partial B_i}{\partial q_i} = \frac{\partial c}{\partial q_i}, \tag{15}$$

Comparing (14) and (15), we see that the sign of $\partial q_i/\partial \theta$ is given by the sign of the first term on the left-hand side of (15).

Consider first the special case of purely profit-oriented hospitals (i.e., $\alpha = 0$). It is evident from (15) that, if an interior solution exists, each hospital will choose a quality level that implies a positive price-cost margin (i.e., $p - \partial c/\partial x_i > 0$). This implies, from (14), that $\partial q_i/\partial \theta > 0$. Because of continuity, this result holds also for sufficiently small

[12] These conditions represent a generalised version of the main result derived in Brekke et al. (2011), where competition is explicitly modelled as a switch from local monopolies to localised competition in a spatial framework.

values of α. Thus, if the degree of altruism is sufficiently low, competition leads to higher quality.[13] The intuition behind this result is straightforward. If the marginal patient is profitable to treat, a sufficiently profit-oriented hospital will react to competition (which implies a more quality-elastic demand) by increasing quality in order to attract more patients.

However, a sufficiently high degree of altruism might introduce a counteracting incentive. All else equal, altruism stimulates incentives for quality provision. This creates not only a larger scope for the existence of an interior-solution equilibrium, but it also creates a scope for an interior solution with a negative price-cost margin (i.e., $p - \partial c/\partial x_i < 0$). In this case, competition has two counteracting effects on the incentives for quality provision. On the one hand, hospitals have an incentive to 'compete' to avoid treating unprofitable patients (since $p - \partial c/\partial x_i < 0$), implying lower quality. On the other hand, the presence of semi-altruistic preferences creates an incentive for 'altruistic competition' to treat more patients, implying higher quality. Overall, competition will lead to less quality provision in equilibrium if the former effect is stronger than the latter. From (14)-(15) we see that the scope for a negative relationship between competition and quality (i.e., $\partial q_i/\partial \theta < 0$) is larger if p is relatively low, and if $\partial B_i/\partial q_i$ is large relative to $\partial B_i/\partial x_i$ (i.e., if the hospitals care more about the quality offered to patients than how many patients are treated).

[13] Alternatively, if an interior solution does not exist, i.e., if

$$\left(p - \frac{\partial c}{\partial x_i} + \alpha \frac{\partial B_i}{\partial x_i}\right) \frac{\partial x_i}{\partial q_i} + \alpha \frac{\partial B_i}{\partial q_i} < \frac{\partial c}{\partial q_i}$$

for all $q_i \geq \underline{q}$, each hospital will choose quality at the minimum level and (a marginal increase in) competition has no effect on equilibrium quality provision.

3.2 Competition and cost efficiency

Applying once more Cramer's Rule to (6), the effect of competition on equilibrium cost-containment effort is given by

$$\frac{\partial e_i}{\partial \theta} = \frac{1}{\Delta}\left(\frac{\partial F_e}{\partial q_i}\frac{\partial F_q}{\partial \theta} - \frac{\partial F_q}{\partial q_i}\frac{\partial F_e}{\partial \theta}\right). \tag{16}$$

Since $\Delta > 0$ and $\partial F_e/\partial\theta = 0$, we have

$$sign\left(\frac{\partial e_i}{\partial \theta}\right) = sign\left(\frac{\partial F_e}{\partial q_i}\frac{\partial F_q}{\partial \theta}\right) = sign\left(\frac{\partial F_e}{\partial q_i}\frac{\partial q_i}{\partial \theta}\right). \tag{17}$$

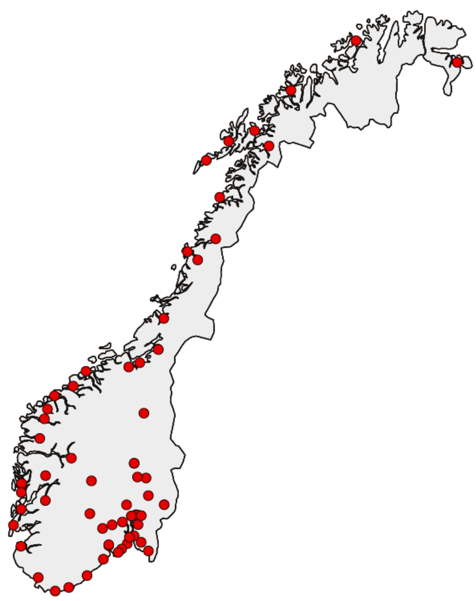
Thus, under the condition $\partial F_e/\partial q_i > 0$, competition leads to higher (lower) cost efficiency if it also leads to higher (lower) quality provision. The condition $\partial F_e/\partial q_i > 0$ requires that either (i) higher quality provision leads to higher total demand for hospital treatment, i.e., $\partial\left(x_i + x_j\right)/\partial q_i > 0$, or (ii) more cost-containment effort reduces the marginal cost of quality provision for a given treatment volume, i.e., $\partial^2 c/\partial e_i \partial q_i < 0$.

If (i) holds, a positive relationship between competition and quality provision implies that competition also leads to a higher treatment volume at each hospital, which gives each hospital a stronger incentive to increase the profit margin by reducing marginal treatment costs. If (ii) holds, a positive relationship between competition and quality provision also gives each hospital a stronger incentive to reduce the marginal cost of quality provision through cost-containment effort. Obviously, the logic is reversed for the case of a negative relationship between competition and quality provision. Thus, if (i) and/or (ii) holds, quality and cost-containment effort are complementary strategies for each hospital. On the other hand, if total demand for hospital treatment is fixed and if it is not possible to reduce the marginal cost of quality provision through cost-containment effort, then competition has no effect on hospital cost efficiency.

4 Institutional background and NHS reforms

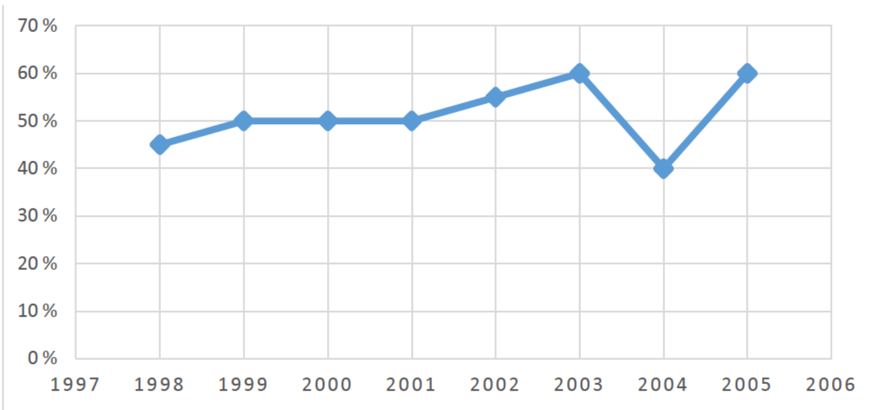
Norway has a mandatory health insurance scheme provided by the government and financed through general taxation. Almost all health care is provided by the National Health Service (NHS) with only a very limited private provision alongside. Primary care is provided by publicly funded physicians, so-called general practitioners (GPs), that are gatekeepers, implying that patients need a referral to access secondary care. Secondary care is provided by NHS hospitals. During our analysis period from 1998 to 2005, there are in total 64 NHS hospitals in Norway with 58 being public and 6 private non-profit. Figure 1 shows the geographical distribution of the 64 hospitals in the Norwegian NHS, revealing substantial variation in the density of hospitals across the country, with highest (lowest) hospital density in Eastern (Northern) Norway.

FIGURE 1: Distribution of NHS hospitals in Norway, 1998 - 2005



The NHS hospitals are funded by a combination of block grants and fixed prices per patient (treatment). The block grant payment is a sort of capitation scheme (risk-adjusted fixed payment per inhabitant in the catchment area), whereas the fixed prices are based on the diagnosis related groups (DRG) system. The mixed funding scheme, which was introduced in 1997 in the Norwegian NHS, implies that the fixed DRG prices are cut according to the relative share of block grant and fixed price funding. During the analysis period, the share of the fixed DRG price funding fluctuates between 40 to 60 percent, as shown in Figure 2. Thus, the NHS hospitals receive between 40 to 60 percent of the fixed treatment prices, which are set equal to the average cost across NHS hospitals within each DRG, during this period.

FIGURE 2: Fixed (DRG) price share of total hospital funding, 1998 to 2005.



Health care within the NHS is almost free at the point of use. For hospital care, there are virtually no patient copayments. For primary care, patients are charged copayments, but only up to an annual expenditure cap, which was less than NOK 2000 (£200 or $250) during the period 1998 to 2005. After the cap is reached, there is 100 percent insurance coverage for all additional copayments. However, as common in NHS systems, access to secondary care is rationed through waiting lists.

Motivated by large differences in waiting lists across geographical regions, the Norwegian government introduced a *patient choice reform* in the NHS in 2001, replacing an administrative system where GPs automatically referred patients to the closest hospital offering the relevant treatment within their county of residence. The reform changed this system drastically, as patients were entitled with the right to choose among any NHS hospital across the whole of Norway for elective (non-acute) treatments. Since Norway is a wide country with large distances, the government also allowed for reimbursement of travel expenditures to stimulate the exercise of patient choice within the NHS. A separate website was also set up with information on quality indicators and waiting time, so that patients, and perhaps more importantly their GPs, could make informed choices of hospital.

Following the patient choice reform, the public hospitals were corporatised into so-called state-owned health enterprises, and ownership was transferred from the county-level to the state-level. The motivations behind this ownership reform, which was implemented in 2002, were mainly to enforce harder budgets and reduce the political influence on the governance of the public hospitals. The public hospitals were also given more financial autonomy, including the possibility of transferring surpluses (or deficits) across years. Norway was also divided into five health regions each with a regional health authority governing the provision hospital care within their health region, which were previously done by 19 county administrations prior to the reform. Thus, public hospitals were given more autonomy and financial flexibility, which could make them more responsive to patient choice, as gain (loss) of patients would increase (reduce) revenues. Notably, the reforms in the Norwegian NHS have clear parallels to the reforms in the English NHS studied by Cooper et al. (2011) and Gaynor et al. (2013), which allow for comparison of results.

5 Data and descriptive statistics

To analyse the effects of exposing NHS hospitals to competition, we have assembled a rich database with panel information at the hospital and DRG level on a wide set of variables, including mortality, readmission, length of stay, hospital characteristics, patient characteristics, etc. The primary data source is the Norwegian Patient Registry (NPR), which covers the universe of hospital episodes in the Norwegian NHS.[14] From this registry we have obtained detailed patient level information over a period of eight years from 1998 to 2005, comprising around 250,000 admissions in 64 hospitals. For each hospital episode, we observe a set of patient characteristics (age, gender, comorbidities, municipality of residence, etc.), treatment characteristics (date of admission, diagnosis, DRG, emergency or elective, regular admission or readmission, etc.), and hospital characteristics (university, regional or local hospital, address, ownership status, etc.). Since the data include patient and hospital identifiers, we can compute travel distances and patient flows by using a distance matrix containing information in terms of kilometers and time. All hospitals in our sample provide emergency treatments, leaving us with a sample of 64 hospitals, where 6 are private non-profit and the residual 58 are public. However, for the analysis of AMI and stroke mortality, we exclude hospitals with very few patients in order to avoid the problem of variability of rates from small denominators, reducing our sample to 61 hospitals. The data are aggregated such that the unit

[14] More information is available on the webpage of the Norwegian Directorate of Health: https://helsedirektoratet.no/english/norwegian-patient-registry

of observation is at hospital level or hospital-DRG level per quarter.

TABLE 1: Descriptive statistics

Variable	Mean	Std. Dev.	N
DRG-Hospital level data			
Lenght of stay (elective)	5.195	8.894	103045
Lenght of stay (emergency)	5.882	6.112	146516
Readmission rates (elective)	0.128	0.242	103045
Readmission rates (emergency)	0.161	0.208	146516
Average age (elective)	57.267	19.477	103045
Average age(emergency)	58.831	19.792	146516
Proportion male (elective)	0.498	0.371	103045
Proportion male (emergency)	0.486	0.303	146516
Average comorbidities (elective)	1.143	1.231	103045
Average comorbidities (emergency)	1.334	1.153	146516
Hospital level data			
Mortality	0.03	0.012	1910
Mortality AMI	0.140	0.074	1752
Mortality stroke	0.131	0.074	1765
HHI	6073.791	1607.157	1910

Table 1 presents the summary statistics of all variables used in the regressions. The average hospital in our sample has a length of stay of 5.2 and 5.9 days for elective and emergency patients, respectively. 12.8 percent of elective patients are readmitted to the hospitals, whereas the same figure for emergency patients is 16.1 percent. Patients receiving emergency (elective) treatment are on average 58.8 (57.3) years old, 48.6 (49.8) percent men, and have on average 1.3 (1.1) comorbidities. Thus, emergency patients appear to be slightly more severe than elective patients. Furthermore, the average hospital in our sample has an overall mortality rate of 3 percent, AMI mortality rate of 14 percent, and stroke mortality rate of 13.1 percent. These are in-hospital mortality rates. We would have liked to also have information on post-hospital discharge mortality rates (e.g., 30 day AMI mortality rate), but this was not available for us during this period. However, most studies do find similar effects for both in-hospital and after discharge mortality rates.[15] Finally, the Hirschman-Herfindahl Index (HHI) at 6073 implies a fairly high degree of market concentration in the Norwegian NHS. We compute the HHI at hospital level based on patient flows, which will be described in more detail below.

6 Empirical strategy

To estimate the effects of competition on hospitals' provision of care, we exploit a policy reform introducing nation-wide patient choice in Norway in January 2001 for elective (non-acute) treatments. The new scheme replaced an administrative system where GPs were obliged to referred patients to the closest NHS hospital within the county of residence. After the reform, patients (or the GPs acting as the patients' agent) can choose among any NHS hospital in Norway, depending on their preferences regarding location, quality, waiting time, etc. Since prices are regulated and copayments are basically zero for hospital care within the NHS, the patient choice reform possibly induces non-price competition among the NHS hospitals in Norway.

Based on the theoretical analysis in Section 2, we predict that the introduction of (or simply harder) non-price competition induces hospitals to improve their quality of care if they are sufficiently profit oriented and face a positive price-cost margin (i.e., the regulated DRG price exceeds the marginal cost). However, if hospitals are sufficiently patient utility oriented (altruistic), the effect of competition is generally ambiguous. Indeed, in the case of a negative price-cost margin, the introduction of competition may have adverse effects on hospitals' incentives to improve quality of care. We also identify a positive relationship between quality and cost-containment effort, implying that the effect of competition on hospitals' cost efficiency is qualitatively similar to the effect on quality. The predictions from the theoretical analysis in Section 2 can therefore be

[15] See, for instance, Kessler and McClellan (2001) and Gaynor et al. (2013).

summarised as follows:

TABLE 2: Predicted effects of hospital competition on quality and cost efficiency

		Hospital preferences	
		Profit oriented	*Patient utility oriented*
Price-cost	*Positive*	+	+
margin	*Negative*	0	–

The majority of hospitals in the Norwegian NHS have public ownership, which makes it less obvious that profit maximisation is their key objective. Moreover, the mixed hospital payment scheme with partly block grant funding implies a significant cut in the DRG prices (around 50 percent), which may result in negative price-cost margins, especially if hospitals operate close to their capacity limits. These observations suggest, according to our theoretical predictions, that the effect of introducing competition in the Norwegian NHS is an open, and indeed empirical, question.

Our empirical strategy to identify the effects of competition on hospitals' provision of care builds on the work by Cooper et al. (2011) and Gaynor et al. (2013). The idea is simply that while the treatment (i.e., the reform introducing competition) is common to all NHS hospitals, the intensity of the treatment (i.e., the scope for competition) varies significantly across geographical regions depending on the distribution of patients and hospitals. This feature facilitates a difference-in-difference (DiD) research design, where the effects of competition are identified by using hospitals located in areas with limited or no scope for competition as the counterfactual.

A key issue, though, is to obtain a treatment (or competition) intensity measure for each hospital. We follow the approach taken by Kessler and McClellan (2001) by estimating a predicted Herfindahl-Hirschman index (HHI) for each hospital based on individual patient flow information. This approach is also adopted by Cooper et al.

(2011) and Gaynor et al. (2013). A key difference in their approaches is that Cooper et al. (2011) use instantaneous HHIs based on patient flows in each period both before and after the English patient choice reform, whereas Gaynor et al. (2013) use only a pre-reform HHIs based on patient flows for a given year prior to the reform. As patient flows after the reform are likely to depend on quality differences between hospitals, we take the same approach as Gaynor et al. (2013) in order to avoid possible endogeneity issues when estimating the effects of hospital competition.

To derive the predicted HHIs for each hospital, we first estimate the probability that patient i chooses hospital h out of a total of H hospitals using the following conditional logit model at individual patient level

$$P_{ih} = \frac{exp(\alpha + \beta_1 km_{ih} + \beta_2 min_{ih} + \beta_3' km_{ih}\boldsymbol{X_i} + \beta_4' min_{ih}\boldsymbol{X_i})}{\sum_{l=1}^{H} exp(\alpha + \beta_1 km_{il} + \beta_2 min_{il} + \beta_3' km_{ih}\boldsymbol{X_i} + \beta_4' min_{ih}\boldsymbol{X_i})}, \qquad (18)$$

where km_{ih} is the distance in kilometers from patient i's municipality of residence to the municipality where hospital h is located, and min_{ih} is the same distance measured in minutes of travel. We also include the interactions between distance measures and a vector of patient characteristics (age and gender) denoted by $\boldsymbol{X_i}$. To reduce computational complexity, we include in the choice set of each patient only the hospital where the patient was treated and the four closest hospitals where the patient did not get treated. The estimates are derived using data from 1998, which is our first year of observation prior to the patient choice reform.

Based on the estimated individual patient choice probabilities, we compute the hospital-specific HHIs following the same two-step procedure as in Cooper et al. (2011) and Gaynor et al. (2013). First, the HHI in each municipality is calculated as the sum of squared patient shares across all hospitals where the residents in the municipality migrates to for all elective care.[16] Second, the HHI for each hospital is calculated as

[16] Our analysis is based at municipality level, which are larger areas than the defined neighbourhoods in Cooper et al. (2011) and Gaynor et al. (2013) and zip-codes in Kessler and McClellan (2001). However,

a weighted average of the HHIs for the municipalities severed by the hospital, where the weights are the shares of the hospital's patients that live in each municipality. We calculate hospital-specific HHIs based on both actual and predicted patient flows.

FIGURE 3: Kernel density estimates for the distribution of actual and predicted HHIs

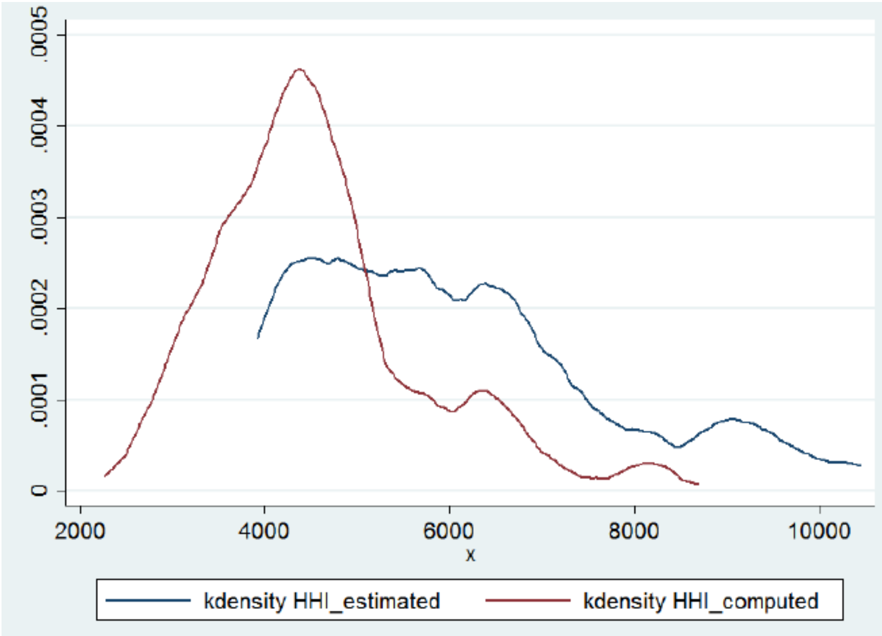


Figure 3 displays the kernel densities for the predicted HHIs (based on patient flow data from 1998) and the actual HHIs (based on patient flow data from 1998 to 2005).[17] The predicted HHIs tends to be more concentrated than the actual HHIs, which may be due to changes in the actual patient flows induced by hospital competition after the patient choice reform in 2001. Since hospital-specific HHIs based on actual patient flows are likely to be endogenous, we use only HHIs based on predicted patient flows prior to the reform (year 1998) as the treatment (competition) intensity measure in the analysis.

As explained above, we apply a DiD approach to estimate the effect of competition on

there are more than 400 municipalities in Norway which implies an average population size of around 45,000 inhabitants.

[17] The correlation between the two measures is 0.39.

hospitals' care provision, where the predicted pre-reform HHIs (specific for each hospital) are interacted with a post-reform dummy (common to all hospitals). The predicted pre-reform HHIs are treatment intensity dummies, reflecting the intensity of competition each hospital is facing after the reform. This approach implies that we are essentially estimating the change in hospital quality and cost-efficiency before and after the reform, using hospitals located in less competitive areas as a control group. We estimate the following DiD regression model

$$Y_{hdt} = \gamma_{hd} + \lambda_t + \delta\left(D_t * HHI_h\right) + \beta X'_{hdt} + \varepsilon_{hdt}, \tag{19}$$

where h denotes the hospital, d the DRG, and t the quarter. Y_{hdt} is the dependent variable of interest, which is either readmission rates, mortality rates (AMI, stroke, and overall), or length of stay. D_t is a post-reform dummy taking the value 1 for all periods after the reform was implemented in January 2001 and 0 otherwise. HHI_h is the predicted pre-reform HHIs specific for each hospital that are interacted with the post-reform dummy. Thus, δ is the DiD coefficient capturing the effect of introducing competition among the NHS hospitals.

In the regression, we also include hospital-DRG fixed effects (γ_{hd}) that control for unobserved (and observed) hospital and treatment specific heterogeneity which are invariant over time. This implies that the effects of competition are estimated using only within hospital and DRG variation over time in our outcome variables. For overall mortality, we include only hospital fixed effects due to very low (often zero) mortality rates for many of the DRGs. For AMI and stroke mortality, we exclude hospitals that treat less than three patients in each quarter. The regression model also includes time dummies (λ_t) to control for time trends in our outcome variables, and a vector of observed characteristics (X'_{hdt}) of each hospital's patient population (average age, gender and comorbidity at DRG level) which vary over time. This implies that we control for changes in the composition of each hospital's patient population that may possibly be induced by changes in patient flows after the policy reform. Finally, ε_{hdt} is random noise.

7 Results

Our theoretical analysis in Section 2 demonstrates that the effects of exposing hospitals to (non-price) competition through patient choice are generally ambiguous. If hospitals are sufficiently profit motivated and face a positive price-cost margin, competition is likely to improve hospital quality and cost-efficiency. However, if hospitals face negative price-cost margins, competition may have adverse effects, especially when hospitals are highly altruistic. The impact of (non-price) competition on hospitals' provision of care is therefore an empirical question. This is particularly the case for the Norwegian NHS with mainly public hospitals facing relatively low DRG prices due to a mixed funding scheme. In this section we report the results from our empirical analysis, described in the previous section, on the impact of hospital quality and cost efficiency. By the end, we also report results on whether hospital ownership matters for the effects of exposing hospitals to (non-price) competition by exploring differential effects on public and private (non-profit) hospitals.

7.1 Hospital quality

Hospital quality is measured by both mortality and readmission, where a reduction in mortality and readmission rates indicate higher quality. For mortality, we use AMI and stroke mortality rates, which are acute illnesses with a non-negible change of death, as well as overall mortality rates. While mortality rates are measured at the hospital level, readmissions are measured at the hospital-DRG level, as explained above. For readmissions, we also estimate the effects separately for acute and elective treatments, where the former is less exposed to endogeneity issues related to changes in the patient population induced by the patient choice reform. This is also a main argument for focusing on AMI and stroke mortality.

TABLE 3: DiD estimates of the impact of competition on hospital mortality

VARIABLES	(1) Mortality Stroke	(2) Mortality AMI	(3) Mortality
Reform*HHI	-0.114	0.167**	-0.0767
	(0.136)	(0.0783)	(0.0619)
Average age (emergency)	0.0247	0.0201*	0.0293***
	(0.0164)	(0.0118)	(0.0102)
Proportion male (emergency)	0.211	0.832	0.0895
	(1.267)	(1.241)	(0.234)
Average comorbidities in hospital (emerg.)	-0.128	0.0130	0.160**
	(0.142)	(0.102)	(0.0646)
Constant	-3.269***	-3.173***	-4.961***
	(0.821)	(0.682)	(0.558)
Observations	1,765	1,752	1,910
R^2	0.058	0.076	0.230
Number of hospitals	61	61	64
Hospital dummies	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3 reports our DiD estimates of the impact of exposing NHS hospitals to competition on hospital quality measured by (in-hospital) mortality rates. The estimates control for time trends, patient population charateristics, and hospital fixed effects. The first column presents the estimates for stroke mortality, the second for AMI mortality, and the third for overall hospital mortality. While the DiD coefficients for stroke and overall mortality are small and statistically insignificant, we find a positive and statistically significant effect on AMI mortality. The DiD coefficient implies that a 10 percent fall (i.e., 600 points reduction) in the HHI is associated with a 1.67 percent fall in the AMI mortality. This amounts to a reduction of 0.23 percentage points at the mean AMI mortality rate of 14 percent in the sample, implying around 40 fewer deaths in total per year across the 61 NHS hospital in the sample. These findings are in line with Cooper et al. (2011) and Gaynor et al. (2013), though the magnitude of the effects are slightly smaller in our study.[18] This can be due to weaker incentives for competition in the Norwegian NHS than in the English NHS because of the mixed payment scheme (implying a lower DRG price) or simply longer travel distances. However, we do not find any adverse quality effects of exposing the NHS hospitals to competition, which, according to our theoretical analysis, indicates that the Norwegian hospitals are concerned about profits

[18] Gaynor et al. (2013) also report a significant positive DiD estimate for overall mortality, but the coefficient is very small.

and face non-negative price-cost margins.

TABLE 4: DiD estimates of the impact of competition on hospital readmissions

	(1)	(2)
VARIABLES	Readmission (elective)	Readmission (emergency)
Reform*HHI	0.778***	0.743***
	(0.0550)	(0.0432)
Average age	0.00466***	0.00630***
	(0.000488)	(0.000464)
Proportion male	0.0152	-0.0306*
	(0.0170)	(0.0176)
Average comorbidities	0.0452***	0.0630***
	(0.00715)	(0.00711)
Constant	-3.502***	-2.925***
	(0.0386)	(0.0357)
Observations	102,441	145,699
R^2	0.079	0.124
Number of hospital-DRG	7,536	8,054
DRG-Hospital dummies	Yes	Yes
Time dummies	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4 reports our DiD estimates of the effect of competition on hospital readmission rates. The estimates control for time trends, patient population charateristics, and hospital-DRG fixed effects. The first column presents the estimates for readmissions for elective treatments, whereas the second column presents the estimates for emergency treatments, which are less likely to be prone to selection issues due to changes in patient flows after the policy reform. The DiD coefficients indicate a positive significant effect of market concentration on both emergency and elective readmission rates. The estimated coefficients imply that a 10 percent fall in a hospital's HHI on average results in a 7.4 (7.8) percent fall in the emergency (elective) readmission rates. These findings indicate that exposing the NHS hospitals to (stronger) competition reduces the underlying risk of being readmitted, which is an indicator for better hospital quality. These effects are estimated using only within hospital and DRG variation.

7.2 Hospital cost-efficiency

We also examine whether the pro-competition reform had any impact on hospital cost efficiency measured by mean length of stay. While competition may not have a direct impact on incentives to expend effort on reducing treatment costs, there may be indirect effects through the impact of competition on quality, as described in Section 2. In particular, the incentive to improve cost efficiency and thus the profit margin is increasing in a hospital's demand, which implies that quality and cost-containment incentives are complementary strategies. Thus, to the extent that competition induces higher quality and in turn demand, we expect to find a positive effect on (mean) length of stay.

TABLE 5: DiD estimates of the impact of competition on length of stay

	(1)	(2)
VARIABLES	Lenght of stay (elective)	Lenght of stay (emergency)
Reform*HHI	0.144***	0.0917***
	(0.0304)	(0.0180)
Average age	0.00808***	0.0109***
	(0.000449)	(0.000371)
Proportion male	-0.132***	-0.0580***
	(0.0132)	(0.0117)
Average comorbidities	0.204***	0.157***
	(0.00549)	(0.00453)
Constant	0.876***	0.846***
	(0.0311)	(0.0252)
Observations	102,441	145,699
R^2	0.067	0.071
Number of hospital-DRG	7,536	8,054
DRG-Hospital dummies	Yes	Yes
Time dummies	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5 reports our DiD estimates of the effect of competition on hospital cost efficiency measured by mean length of stay. The estimates control for time trends, patient population charateristics, and hospital-DRG fixed effects. The first column presents the estimates for mean length of stay for elective treatments, whereas the second column presents the estimates for mean length of stay for emergency treatments, which are less likely to be endogenous due to changes in patient flows after the reform. The DiD coefficients are positive and significant for mean length of stay for both elective and emergency treatments, with the effect being slightly stronger for elective treatments. The estimates imply that a 10 percent fall in the HHI on average results in a 0.9 (1.4) percent fall in the mean length of stay for emergency (elective) treatments. At the mean length of stay in the sample of 5.9 (5.2) days for emergency (elective) treatments, this amount to a reduction of 1.3 (1.8) hours per emergency (elective) treatment.

7.3 Hospital ownership: public vs. private

Finally, we examine whether hospital ownership matters for the effects of the pro-competition reform in the Norwegian NHS. In particular, we analyse whether private (non-profit) hospitals in the NHS respond differently to competition than their public counterparts. There are only six private non-profit hospitals in the NHS in the period, so the results need to be interpreted with some caution. To analyse the potential ownership effect, we estimate the following regression model:

$$Y_{hdt} = \gamma_{hd} + \lambda_t + \delta\left(D_t * HHI_h\right) + \theta\left(D_t * P_h\right) + \phi\left(D_t * HHI_h * P_h\right) + \beta X'_{hdt} + \varepsilon_{hdt}, \quad (20)$$

where P_h is a dummy variable taking value one if the hospital is private and zero otherwise (it is equal to one in 9,983 observations).[19] ϕ is the coefficient capturing the differential ownership effect of exposing hospitals to competition, where the ownership dummy is interacted with the reform dummy and the pre-reform HHIs for each hospital. The estimates for mortality and readmission are not statistically significant. However, we do find differential effects of competition depending on hospital ownership for length

[19] One of the six private hospitals changed ownership and became public in 2003 (Orkdal hospital). For this hospital, the dummy P takes value 1 only until December 2002.

of stay. These results are reported in Table X.

TABLE 6: DiD estimates of differential ownership effect of competition on length of stay

VARIABLES	(1) Lenght of stay (elective)	(2) Lenght of stay (emergency)
Reform*HHI	0.108***	0.0708***
	(0.0306)	(0.0185)
Reform*Private	-12.71***	-6.307***
	(2.227)	(1.086)
Reform*HHI*Private	0.946***	0.469***
	(0.167)	(0.0810)
Average age	0.00810***	0.0109***
	(0.000449)	(0.000371)
Proportion male	-0.132***	-0.0581***
	(0.0132)	(0.0117)
Average comorbidities	0.204***	0.157***
	(0.00549)	(0.00453)
Constant	0.874***	0.845***
	(0.0311)	(0.0252)
Observations	102,441	145,699
R^2	0.068	0.071
Number of hospitals-DRG	7,536	8,054
DRG-Hospital dummies	Yes	Yes
Time dummies	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The coefficients capturing differential ownership effects are positive and statistically significant, indicating that the private non-private hospitals respond on average more strongly to competition by reducing length of stay more than the public NHS hospitals. The effect is slightly stronger for elective treatments than for emergency treatments, but this can be partly driven by endogenous changes in patient flows after the reform, though we control for changes in each hospital's patient population (age, gender and comorbidity). It is therefore comforting that we observe similar effects in the length of stay for emergency treatments. In any case, these results indicate that both public and private (non-profit) hospitals respond to competition by improving quality and cost efficiency, with the private hospitals being slightly more responsive in terms of cost efficiency. According to our theoretical analysis, this can be explained by stronger profit motivation and/or higher price-cost margins.

8 Concluding remarks

In this paper we have studied the impact of introducing (non-price) competition among hospitals in the NHS on the provision of care. Our empirical analysis exploits a policy reform that implemented nationwide patient choice in the Norwegian NHS in 2001, replacing an administrative scheme where patients were allocated to the closest hospital within their county of residence. The reform facilitates a DiD research design due to exogenous variation in the scope for competition based on the geographical distribution of hospitals and patients. To capture this variation in market structure, we compute a HHI for each hospital based on (predicted) patient flows prior to the policy reform using individual patient level data. Using rich administrative data with quarterly information over eight years from 1998 to 2005, we estimate the effects of exposing NHS hospitals in Norway to competition on hospital quality (mortality and readmission) and cost efficiency (length of stay), controlling for time trends, patient population characteristics, and hospital and DRG fixed effects.

The results show that hospitals in more competitive areas have a sharper reduction in AMI mortality rates, readmission rates, and length of stay than hospitals in less competitive areas after the policy reform. The estimates for stroke and overall hospital mortality are small and not statistically significant. We also find that the private non-profit hospitals within the NHS respond more strongly to competition by reducing length of stay more sharply than the public hospitals. These findings are rationalised in a theoretical model where competition, induced by patient choice, is generally ambiguous, but more likely to have a positive impact on hospital quality and cost efficiency if hospitals are profit motivated and face a positive price-cost margin. It is therefore interesting to find a pro-competitive effect in the Norwegian NHS where hospitals are mainly public and the regulated DRG prices are low due to a mixed funding scheme. Our results are consistent with findings from a similar reform in the English NHS, but the effects are more modest, which may be due lower DRG prices and possibly also longer travel distances in Norway.

While these findings indicate that exposing NHS hospitals to (non-price) competition (through patient choice) saves lives, reduces complications, and shortens hospital stays, we would like to stress some limitations of our study. First, while our findings point in the direction that competition is welfare improving, we have not done a full welfare analysis, which would require detailed information about hospital costs and possibly also other factors affecting patient utility such as waiting time. Second, we have only data on in-hospital mortality rates, whereas other studies also have information on mortality rates (30 days) after being discharged from hospitals. If hospitals discharge patients in a poorer state when being exposed to competition, improvements in in-hospital mortality rates may be artificially driven by the fact that patients die after being discharged. While we cannot rule out this possibility, there are a several observations that go in opposite direction, including the reduction in readmissions (complications). Moreover, there are no explicit incentive for hospitals to manipulate their in-hospital mortality rates as a response to competition. Monitoring and rankings are based on post-hospital (30 days) discharge mortality rates. Importantly, studies that have both in-hospital and post-hospital mortality rates tend to find similar (not opposite) effects of competition on the two measures. Third, our distance measures are based on municipality of residence, and thus more crude than the ones used in the studies from England (defined neighbourhoods) and the US (zip-codes). However, the municipality structure in Norway is highly decentralised, except for in some urban areas. Moreover, the geographical distribution of patients and hospitals is such that the majority of patient flows are across rather than within municipalities.

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