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Does Hospital Competition Improve Efficiency? The Effect of the Patient Choice Reform in England

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The effect of the patient choice reform in England

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Abstract

We use the 2006 relaxation of constraints on patient choice of hospital in the English NHS to investigate the effect of hospital competition on dimensions of efficiency including indicators of resource management (admissions per bed, bed occupancy rate, proportion of day cases, cancelled elective operations, proportion of untouched meals) and costs (cleaning services costs, laundry and linen costs, reference cost index for overall and elective activity). We employ a *quasi* difference-in-difference approach and estimate seemingly unrelated regressions and unconditional quantile regressions with data on hospital trusts from 2002/03 to 2010/11. Our findings suggest that increased competition had mixed effects on efficiency. An additional equivalent rival increased admissions per bed and the proportion of day cases by 1.1 and 3.8 percentage points, and reduced the proportion of untouched meals by 3.5 percentage points, but it also increased the number of cancelled elective operations by 2.6%. Unconditional quantile regression results indicate that hospitals with low efficiency, as measured by fewer admissions per bed and a smaller proportion of day cases, are more responsive to competition.

JEL classification: C21, H51, I11, I18, L1

Keywords: competition, efficiency, choice, hospital, difference-in-difference.

1. Introduction

The efficiency of health care systems is a key goal for policy makers across OECD countries. Some of these, such as Australia, England, and Nordic countries, pursue greater efficiency by stimulating hospital competition through policies that give individuals the right to choose among hospitals (Cookson and Dawson, 2012, Propper, 2012, Palangkaraya and Yong, 2013).

In this paper, we use the 2006 English NHS relaxation of constraints on patient choice of hospital to investigate whether there was any effect of the exposure to greater competition on hospital efficiency. The aim of the reform was to induce hospitals to compete on quality and to enhance efficiency. The theory suggests that, under a DRG-type payment system, patient choice may affect efficiency in different ways through its interaction with quality. Higher quality implies greater volumes of patients and, in turn, larger incentives to improve efficiency by containing costs to increase the profit margin on each extra patient (Ma, 1994). But making an additional effort to increase quality may reduce the cost-containment effort (Brekke et al., 2012).

The previous empirical literature (reviewed briefly in section 1.2) focuses on unit costs and length of stay (e.g Cooper et al., 2012, Gaynor et al., 2013) measured at the aggregate level or for a specific procedure (hip and knee replacement). We provide a richer analysis by examining a wider range of efficiency dimensions. Hospitals may increase efficiency by treating more patients for a given number of beds. We therefore examine admissions per bed, bed occupancy, cancelled elective operations, and the proportion of day cases. Hospitals may also become more efficient via better management of amenities. We therefore examine the percentage of untouched meals, cleaning services costs and linen and laundry costs. Hospitals may also reduce unit costs which we measure through the reference cost index (RCI), which compares a hospital's total costs with the national average total costs for the same mix of services and is used by the policy maker to assess hospital efficiency (Department of Health, 2014).

We analyse samples of public hospital trusts from the financial year 2002/03 to 2010/11. As with studies such as Cooper et al. (2012) and Gaynor et al. (2013), we use the 'Patient Choice' reform as a natural experiment and use a *quasi* difference-in-difference approach. This empirical strategy exploits the variation in market structure facing different hospitals, under the plausible argument that hospitals in more competitive areas are more likely to change their behaviour after the relaxation of constraints on patient choice of provider. Unlike previous studies, we estimate the *quasi* difference-in-difference regressions for our nine efficiency indicators simultaneously through Seemingly Unrelated Regressions (SUR) (Zellner, 1962, 1963). SUR is supposed to improve the precision of the estimates, since we have a wide range of hospital efficiency outcomes which are potentially correlated. We also use the Unconditional Quantile Regression (UQR) approach suggested by Firpo et al. (2009) to investigate whether the effect of competition varies for more or less efficient hospitals. Competition is measured through the 'equivalent' number of rivals (Kessler and McClellan, 2000), which is calculated as the inverse of the predicted Herfindahl-Hirschman index (HHI).

Our findings suggest that competition has mixed effects on efficiency. After the Choice policy, one more equivalent rival increases efficiency as measured by admissions per bed by 1.1% and the proportion of day cases increases by 3.8 percentage points and decreases the proportion of untouched meals by 3.5 percentage points. But the number of cancelled elective operations increases by 2.6%.[1] There are no statistically significant effects on the other five efficiency indicators

[1] We analyse the log of admissions per bed and cancelled elective operations. The effect of market structure on these indicators is therefore expressed as a percentage change. Instead, proportion of day cases and untouched meals are studied in their natural units and the effect of market structure is interpreted in percentage points.

(bed occupancy, cleaning services costs, laundry and linen costs, and RCI for all admissions and for elective admissions). We also find that SUR has generally better explanatory power than OLS and standard errors are smaller in most cases. The UQR results indicate that hospitals exhibiting low efficiency and facing greater competition may be more responsive to the Choice reform. For instance, one more equivalent rival increases admissions per bed by 2.2% for hospitals with fewer admissions per bed (25th quantile), but there is no statistically significant effect for hospitals with more admissions per bed (e.g. 50th or 75th quantile).

The next two sections briefly describe the related literature and the institutional background in the English NHS. Section 2 explains the econometric strategy. Section 3 describes the data, and Section 4 provides the results. Section 5 concludes.

1.1. Related studies

A number of empirical studies investigate the effect of competition on efficiency in the US (Gaynor and Town, 2011). Early studies suggest that hospital competition leads to an inefficient use of resources under a retrospective payment system (e.g. Joskow, 1980, Robinson and Luft, 1985).[2] Later studies find evidence of lower hospital costs in more competitive areas after the introduction of a prospective payment system and managed care (Zwanziger and Melnick, 1988, Bamezai et al., 1999).[3] For example, Kessler and McClellan (2000) and Kessler and Geppert (2005), find that hospital competition has a welfare-enhancing effect by reducing costs and increasing quality for heart attack patients.

For the UK, Söderlund et al. (1997) find no association between competition and unit cost after the introduction of the NHS internal market.[4] Gaynor et al. (2013) focus on a more recent reform that aimed to stimulate competition among hospitals through Patient Choice (see section 1.2 for details on the reform). The authors implement a *quasi* difference-in-difference estimator and find that competition reduced length of stay but did not change expenditure per admission.[5] Cooper et al. (2012) also exploit the Patient Choice reform and find that it reduced the pre-surgery length of stay of elective procedures such as hip and knee replacement, hernia repair, and arthroscopy more in competitive areas. By contrast, Bloom et al. (2015) use an IV strategy on a cross-section of hospitals in 2006 and find that competition increases average length of stay.

Our study contributes to this literature in three ways. First, we extend the analysis of length of stay and unit costs to a wider set of efficiency indicators. We include measures of resource management such as admissions per bed, bed occupancy rate, cancelled operations, proportion of day cases and untouched meals, and cost indicators such as cleaning services costs and laundry and linen costs, and the RCI as an alternative indicator to unit costs. Second, we estimate simultaneously the regressions for our indicators by SUR to account for correlations across the error terms. Third, we test whether the effect of competition on efficiency varies at different quantiles of the efficiency distribution using the UQR estimator of Firpo et al. (2009).

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[2] A retrospective payment system reimburses hospitals for the actual costs incurred for each patient.

[3] In 1982, hospitals in California were paid a fixed price for each patient treated, and new pro-competition laws allowed insurance companies to offer patients health care plans after negotiating the price with providers.

[4] The NHS internal market reform was introduced in 1991 and it stimulated competition by separating the roles of financier and supplier of health care services. Suppliers (hospitals trusts) had to compete to secure contracts, and therefore income, offered by the purchaser. The internal market was abolished some years later in 1997.

[5] Gaynor et al. (2013) study other aspect of hospital performance such as total number of admissions, total number and share of elective admissions, and total expenditure. They also investigate the effect of competition on quality as measured by heart attack and overall mortality.

1.2. Institutional background

The English National Health Service (NHS) provides healthcare which is universal, tax financed, and free at the point of use. The Department of Health distributes capitated funding to around 150 local health authorities, which use it to pay for secondary health care provided to NHS patients by public and private hospitals. Public hospitals are run by NHS Trusts or NHS Foundation Trusts, the latter having greater financial autonomy. Some NHS hospital trusts are teaching trusts providing research and teaching, and some are specialist trusts focusing on a limited range of conditions or client groups. Private hospitals are small, with no more than 50 beds, and overall provide about 6.5% of hospital beds (Boyle, 2011). They mostly focus on elective surgical procedures and, unlike public hospitals, they can refuse to treat highly severe patients (Mason et al., 2008).

Hospitals are mainly funded through a prospective payment system, the National Tariff Payment System. This is based on Healthcare Resource Groups (HRGs), a patient classification system similar to the American Diagnosis-Related Group. HRGs are groups of patients who are homogeneous with respect to diagnoses, procedures, and some patient characteristics. A fixed tariff is calculated for each HRG group as its national cost averaged across providers, but with adjustments for individual hospitals to reflect exogenous variations in input prices and the higher costs of specialised care (Department of Health, 2013).

Hospital competition has been encouraged by relaxing restrictions on patients' choice of hospital for elective care. Before 2006, elective patients were mainly restricted to the set of hospitals in contract with their local health authority. In 2006, patients were given the right to be offered a choice of at least four hospitals for elective care. Since 2008, patients have been allowed to choose any qualified provider (Department of Health, 2009). Choice is facilitated through the website 'NHS Choices', which provides information on some aspects of hospital performance (e.g. mortality, waiting times).

2. METHODS

To assess the impact of the Patient Choice reform on efficiency, we employ the following baseline model (Model I):

$$y_{kt} = \mu + \beta \bar{M}_k d_{t \geq 2006\text{-}07} + X_{kt}\theta + \lambda_t + \alpha_k + \varepsilon_{kt} \quad (1)$$

where y_{kt} is an efficiency indicator for hospital $k=1,...,K$ in year t=2002/03,…,2010/11; μ is the intercept; $\bar{M}_k = \left(1/T_k^{pre}\right)\sum_{t=2002\text{-}03}^{2005\text{-}06} M_{kt}$ measures the average pre-reform market structure of hospital k, with M_{kt} being the market structure of hospital k in year t and T_k^{pre} the number of pre-reform years for hospital k; $d_{t\geq 2006/07}$ is a dummy equal to one from year 2006/07 onwards, when the policy was introduced; X_{kt} is a vector of hospital-level control variables (e.g. percentage of male patients, patient age); λ_t and α_k are respectively year dummies to account for time trend (e.g. of technical progress) and hospital fixed effects to allow for time-invariant unobserved factors; and ε_{kt} is an idiosyncratic error term. We use $\bar{M}_k$ instead of M_{kt} in equation (1) to avoid potential endogeneity due to, for example, low quality and efficiency of some hospitals affecting entry by rivals after the reform.

Model I is a *quasi* difference-in-difference regression because it uses a variable with differing *treatment intensity* rather than a treatment or control group (Angrist and Pischke, 2008, p. 175). The idea is that the patient choice policy affects to a greater extent areas with more providers (i.e. more competitive areas) than areas with fewer providers (i.e. less competitive areas). The English NHS fits this empirical strategy because of the high geographical variation in the English hospital market structure.[6]

The coefficient β in Model I is our difference-in-difference estimator. It indicates whether the effect of competition on efficiency changed after the reform. For example, $\beta>0$ implies that after the choice reform, hospitals in more competitive areas experience a greater increase in the efficiency indicator compared to hospitals in less competitive areas. β is identified under the common trend assumption (i.e. efficiency in both more competitive and less competitive areas follow the same trend in the absence of the reform).

We estimate Model I for nine efficiency indicators. These outcomes are likely to be influenced by common unobservable factors (e.g. unmeasured patient characteristics) and to respond to exogenous shocks (e.g. introduction of a new medical technology). As a result, the error terms across the nine regressions may be correlated. The single-equation OLS estimator neglects such correlations which, if accounted for, may allow more efficient estimates. We, therefore, estimate Model I jointly for all the efficiency indicators via a SUR model.

SUR and OLS are equivalent if there is no correlation between error terms (Zellner, 1962). Even when errors are correlated, SUR and OLS are equivalent if the covariates exhibit greater collinearity across regressions than within regressions. If covariate collinearity within regressions is greater than across regressions, SUR will still provide more efficient estimates (Baltagi, 2011, p. 245). This latter condition is likely to be met in our study because, although using mostly the same covariates across regressions, the inclusion of hospital dummies (i.e. the hospital fixed effects) may induce some collinearity within regressors, and also because of the heterogeneity of the different efficiency

[6] For instance, hospitals in London generally compete with more than ten rivals within a radius of 30 km but some hospitals in the North East of England do not face any rival within the same radius.

indicators we use.[7] We estimate SUR by maximum likelihood and we cluster standard errors within hospitals to allow for the serial correlation of errors over time. We test the validity of SUR against OLS using a Breusch-Pagan (1979) test on the stacked error terms to verify the hypothesis of independent equations (i.e. no correlation between error terms).

As in Kessler and McClellan (2000), we test whether the effect of the market structure on efficiency is non-linear using Model II:

$$y_{kt} = \mu + Q_k d_{t \geq 2006\text{-}07} \beta + X_{kt}\theta + \lambda_t + \alpha_k + \varepsilon_{kt}\,, \quad (2)$$

where Q_k is a vector of three dummies constructed on the quartile of the pre-reform market structure ($\bar{M}_k$) distribution: a dummy equal to one for the second quartile (hospitals subject to low competition), one for the third quartile (high competition), and another for the fourth quartile (very high competition). The omitted dummy for the first quartile (hospitals subject to the lowest competition) is the reference category.

We also estimate Model III that, differently from the previous models, controls for time-varying market structure:

$$y_{kt} = \mu + \beta M_{kt} d_{t \geq 2006\text{-}07} + \delta M_{kt} + X_{kt}\theta + \lambda_t + \alpha_k + \varepsilon_{kt}\,. \quad (3)$$

The coefficient β in equation (3) has the same interpretation as in Model I, while δ captures the effect of competition in the pre-reform period.

As an additional robustness check, we implement Model IV, a more flexible version of Model III, which allows β to vary in each period as follows:

$$y_{kt} = \mu + P_t M_{kt} \beta + \rho M_{kt} + X_{kt}\theta + \lambda_t + \alpha_k + \varepsilon_{kt}\,, \quad (4)$$

where P_t is a vector of year dummies, excluding year 2005/06. This model provides information on the evolution of the effect of competition on efficiency in each pre- and post-reform year. We expect a significant effect of competition on efficiency in the post-reform years and no effect in the pre-reform years.

All the above models focus on the effect of competition on *average* efficiency. It may be argued that there is more scope for competition to affect efficiency when efficiency is low. In general, the effect of market structure on efficiency might vary (non-linearly) depending on the levels of the efficiency indicators. To investigate this, we implement in Model V the UQR approach suggested by Firpo et al. (2009) as follows:

$$R_\tau\left(y_{kt}\right) = \mu_\tau + \beta_\tau \bar{M}_k d_{t \geq 2006\text{-}07} + X_{kt}\theta_\tau + \lambda_t + \alpha_k + \varepsilon_{kt}\,, \quad (5)$$

[7] Intuitively, by using a lot of different efficiency indicators, the conditional mean function of each indicator is likely to be affected differently by covariates, choice policy and hospital fixed-effects, thus reducing the potential of collinearity across regression on different outcomes.

where $R_\tau(y_{kt})$ captures the τ^{th} unconditional quantile of the efficiency indicator distribution.[8] Estimates from this approach have an interpretation similar to model I: $\beta_\tau>0$ indicates that, as a result of the choice policy, hospitals in the τ^{th} *unconditional* quantile of the efficiency indicator distribution and located in more competitive areas experience a greater increase in the efficiency indicator compared to similar hospitals located in less competitive areas.[9] We focus on the 10th, 25th, 50th, 75th, and 90th unconditional quantiles and we bootstrap clustered standard errors using 1,000 replications.[10]

[8]More formally, $R_\tau(y_{kt})$ is the Recentered Influence Function (RIF) calculated as $RIF(y_{kt};q_\tau)=q_\tau+(\tau\text{-}1[y_{kt}\leq q_\tau])/f_y(q_\tau)$, where q_τ is the τ^{th} quantile of y_{kt}, $1[y_{kt}\leq q_\tau]$ is a dummy equal to one when y_{kt} is below q_τ, and $f_y(q_\tau)$ is the estimated density function at q_τ. The density function is estimated assuming a Gaussian kernel and using the optimal bandwidth that minimises the mean integrated squared error.

[9] Using UQRs to evaluate the effect of a change in policy provides several advantages compared to the alternative approach of conditional quantile regressions (CQR) introduced by Koenker and Bassett (1978). In CQRs, the covariates have the effect of redefining the quantiles of the dependent variable distribution (Borah and Basu, 2013): a hospital in the top of the efficiency indicator distribution may end up in the bottom of the conditional distribution. Hence, we cannot conclude whether explanatories have bigger or smaller effects on hospitals in particular quantiles. A further limitation of the conditional quantile approach concerns fixed effects, which must be treated as pure location shifters that remain constant across quantiles (e.g. Canay, 2011). This might be a strong assumption in empirical applications. In our case, for example, fixed effects are likely to capture unobserved case-mix, which needs to yield the same effect on the outcome for all hospitals, regardless of their *conditional* efficiency.

[10] We perform all estimations in Stata. We fit SUR through the command *gsem*. The unconditional quantile regression is implemented using *xtrifreg* (Borgen, 2016).

3. DATA

3.1. Efficiency indicators

We have nine efficiency indicators from 2002/03 to 2010/11.[11] As a measure of resource management, we use the number of *admissions per bed* calculated with data on admissions from NHS Digital and on beds from the NHS statistics. Other indicators of resource management are *bed occupancy rate* and number of *cancelled elective operations* for non-clinical reasons from the NHS statistics, and *proportion of day cases* and *proportion of untouched meals* from the NHS Digital. We also use cost indicators including *cleaning services costs* and *laundry and linen costs* from the NHS Digital, and *RCI* and *elective RCI* which are available from the reference cost database.[12]

3.2. Measure of hospital market structure

We capture the market structure through the '*equivalent*' *number of rival hospitals*, including both public and private providers. This is calculated as the inverse of the Herfindahl-Hirschman Index (HHI) based on hospitals' predicted patient flows.[13] Following Kessler and McClellan (2000), we calculate the HHI for hospital k as follows:

$$HHI_k = \sum_o S_{ko} HHI_o = \sum_o S_{ko} \sum_k \left(S_{ok} \right)^2 \qquad (6)$$

where S_{ko} is the predicted market share of hospital k's patients living in neighbourhood o within 30 km; and HHI_o indicates the concentration of patients across neighbourhoods, which is calculated through the predicted share of patients living in neighbourhood o admitted to hospital k (S_{ok}).[14] The hospital HHI (HHI_k) can be interpreted as a weighted average of the neighbourhood HHI (HHI_o), which helps to identify each hospital's market.[15] The inverse of hospital HHI (HHI_k^{-1}) represents therefore the number of rivals that would exist if patients were uniformly distributed across hospitals. The equivalent number of rivals is constructed using data from Hospital Episode Statistics (Gravelle et al., 2014).

3.3. Other control variables

We include a number of control variables: the *percentage of male patients*, *percentage of patients between 15 and 59*, *60 and 74*, and *older than 74 years* (the reference category is the age range between 0 and 14), and *percentage of emergency admissions*. We also use a dummy for *Foundation Trusts*. Information for these variables comes from the NHS Digital. In addition, we control for exogenous variation in input prices (e.g. nurses, buildings) through the *market forces factor* (*MFF*)

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[11] Table A4 has the links to the websites where each variable was collected.

[12] Cleaning services costs include all pay (e.g. salaries) and non-pay (e.g. equipment) costs for both in-house or contracted out cleaning services. Laundry and linen costs are defined in a similar way.

[13] To predict the patient flows, we estimate the following Poisson choice model for each year: $E\left(I_{ko} \mid distance_{ko}, z_k, L_o \right) = \exp\left(\phi_1 distance_{ko} + \phi_2 distance_{ko}^2 + \boldsymbol{\phi}_3' z_k + \boldsymbol{\chi}' \boldsymbol{L}_o \right)$, where I_{ko} is the number of hospital k's patients living in neighbourhood o, $distance_{ko}$ is the distance between neighbourhood o's centroid and hospital k located within 30 km, z_k is a vector of hospital type dummies to control for public hospitals, foundation trusts, and teaching hospitals, and L_o is a vector of LSOA dummies.

[14] The patient share S_{ok} is the ratio between the number of hospital k's patients living in neighbourhood o (I_{ko}) and the number of patients living in neighbourhood o (I_o), while S_{ko} is computed dividing I_{ko} by the number of hospital k's patients (I_k).

[15] The neighbourhood is a small geographical area called LSOA (Lower Super Output Area), which includes on average 1,500 inhabitants but no less than 1,000.

index collected from the reference cost database. We also add the *number of beds* to the regressions for cancelled elective operations, cleaning services costs, and laundry and linen costs.

3.4. Descriptive statistics

Table 1 provides descriptive statistics. The sample includes between 143 (laundry and linen costs) and 173 (RCI) hospitals observed on average for a period of almost 9 years. In each year, there are on average 110 admissions per bed. The bed occupancy rate is 86%. 30.7% of patients are on average admitted as day cases, and hospitals cancel on average 359 elective operations in a year. On average, 7.6% of meals served to patients remain untouched, the cleaning services and the laundry and linen costs are respectively £2,842,000 and £807,000. The reference cost indexes are 100 by construction: a RCI greater than 100 indicates that a hospital's total costs are greater than the national average total costs for the same HRG groups.[16]

Table 1 – Descriptive statistics.

Variable	Def	Obs	Trust	Year	Mean	SD			Min	Max
						Overall	Between	Within		
Efficiency indicator										
Admissions per bed	E	1,498	171	8.76	110	31	25	18	38	319
Bed occupancy rate (%)	E	1,503	172	8.74	86.0	6.3	5.3	3.5	50.5	99.2
Proportion of day cases (%)	E	1,477	169	8.74	30.8	8.6	7.9	3.5	4.6	90.5
Cancelled elective operations	I	1,477	170	8.69	360	288	250	142	6	2426
Proportion of untouched meals (%)	I	1,382	160	8.64	7.6	5.4	3.7	4.0	0.0	49.0
Cleaning services costs (£1,000)	I	1,381	159	8.69	2,842	1,823	1,580	901	69	12,941
Laundry and linen costs (£1,000)	I	1,215	143	8.5	807	488	459	160	40	2,864
Reference cost index	I	1,516	173	8.76	100.8	12.9	11.5	5.8	66.0	195.8
Elective reference cost index	I	1,498	171	8.76	100.2	16.5	13.6	9.3	60.5	197.3
Measure of market structure										
Equivalent number of rivals (HHI^{-1})					3.7	2.5	2.4	0.7	1.0	13.6
Control variable										
Percentage of male patients (%)					44.1	4.8	4.7	0.9	14.8	65.3
Percentage of patients between 0 and 14 years (%)					13.5	13.1	12.9	1.2	0.0	94.2
Percentage of patients between 15 and 59 years (%)					44.4	8.0	7.8	1.6	5.8	74.3
Percentage of patients between 60 and 74 years (%)					21.0	5.9	5.7	1.1	0.0	47.0
Percentage of patients older than 74 years (%)					20.8	6.2	6.1	1.3	0.0	42.8
Percentage of emergency admissions (%)					35.2	9.6	9.1	2.7	0.2	61.8
Number of beds					686	382	374	65	31	2,523
Foundation trust					0.287	0.453	0.301	0.339	0	1
Market forces factor					1.003	0.074	0.074	0.014	0.886	1.323

E=positive indicator of efficiency, I=negative indicator of efficiency.

Descriptive statistics for competition measure and control variables are calculated on the admissions per bed's sample.

[16] Table A2 provides the unconditional quantiles of the efficiency indicators.

Although all indicators are used to capture efficiency, we expect admissions per bed, bed occupancy rate, and proportion of day cases to be positively correlated with efficiency, while the others to be negatively correlated. Table A1 of the Appendix shows simple pairwise correlations. For example, admissions per bed is positively correlated with bed occupancy rate and negatively correlated with the RCIs. Similarly, the bed occupancy rate is negatively correlated with the RCIs, and the proportion of day cases is negatively correlated with the laundry and linen costs. Correlations are generally low and mostly below 30%.

Figure 1 illustrates the trend in some efficiency indicators from 2002/03 to 2010/11.[17] Over the whole period, we note a positive time trend in admissions per bed, cleaning services costs, and laundry and linen costs. A negative trend is instead observed for the percentage of untouched meals. Bed occupancy rate, rate of day cases, and cancelled elective operations have a positive trend only from or after 2006/07. Cancelled elective operations, however, decrease from 2009/10 to 2010/11.

Table 1 also shows descriptive statistics on covariates. There are on average 3.7 equivalent rivals. 44.1% of patients are male, 13.5% are between 0 and 14 years old, 44.4% are between 15 and 59, 21% are between 60 and 74, and 20.8% are older than 74 years. 35.2% of patients are admitted in an emergency. Hospitals have on average 686 beds. 28.3% of trusts are Foundation Trusts, and the MFF is on average 1 by construction.

[17] We omit the trend of the RCIs because their annual average equals 100 by construction.

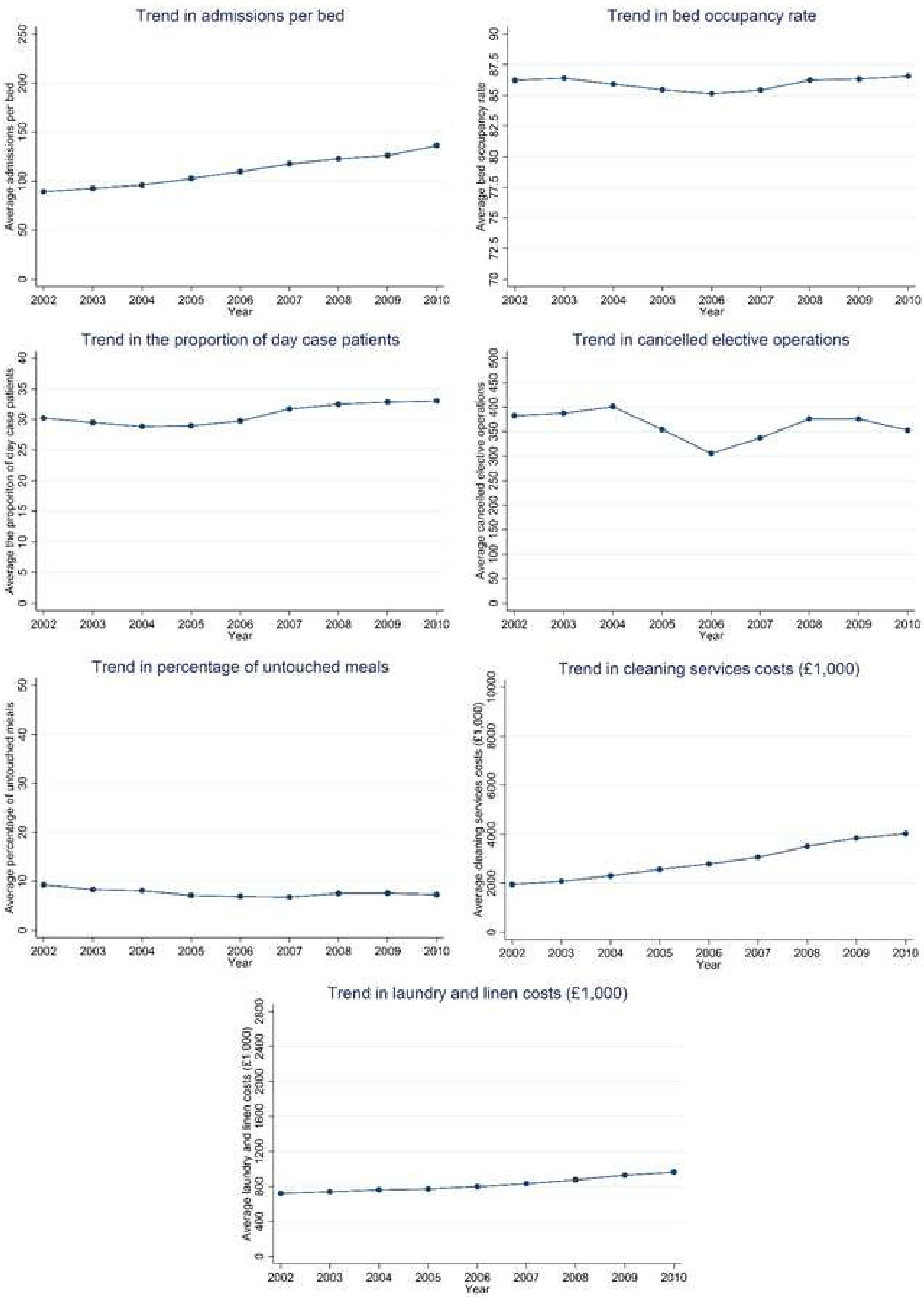

Figure 1 – Trend in the efficiency indicators from 2002/03 to 20010/11

4. Results

Table 2 shows the results for Model I. The key coefficient indicates whether the effect of competition on efficiency changed after the policy. It is statistically significant at 5% level in the regression for admissions per bed, proportion of day cases, cancelled elective operations, and proportion of untouched meals. One more equivalent rival increases on average admissions per bed by 1.1%. Table A3 in the appendix suggests that this is due to competition reducing beds but having no effect on admissions.[18]

Competition increases efficiency when measured by the proportion of day cases and untouched meals. An additional equivalent rival increases the proportion of day cases by 0.38 percentage points and reduces the proportion of untouched meals by 0.35 percentage points. In contrast, competition reduces efficiency when measured as cancelled elective operations: one more equivalent rival increases cancelled elective operations by 2.6%.

Table 2 also displays the coefficients on control variables. For instance, the proportion of male patients is associated with a higher proportion of day cases (0.323). A one percentage point increase in patients between 60 and 74 years old is associated with more admissions per bed by 1.2%. A higher proportion of emergency patients is associated with a lower proportion of day cases (-0.646). Foundation trusts are associated with greater inefficiency having on average fewer admissions per bed by 3% and a lower bed occupancy by one percentage point. The bottom of Table 2 reports the p-value for the Breusch-Pagan test, which indicates the presence of correlation among the error terms across regressions. This suggests that SUR may have better explanatory power than OLS thanks to its higher precision of the estimates (i.e. lower standard errors).[19]

Table 3 has the key results for Model II, in which the policy break dummy is interacted with three dummies indicating whether a hospital is subject to low competition, high competition or very high competition, respectively. The reference category indicates hospitals subject to very low competition. The estimates suggest that the choice policy has a greater effect on efficiency for hospitals exposed to high or very high competition compared to hospitals exposed to very low competition. Admissions per bed decrease by 5.2% and the proportion of untouched meals reduces by 2.18 percentage points for hospitals exposed to very high competition. The proportion of day cases goes up by 1.09 and 2.1 percentage points for hospitals facing high competition and very high competition, while the RCI falls by 2.7 points for hospitals facing high competition.

Table 4 illustrates the key results for Model III and IV. Model III controls for market structure varying over time. Compared to Model I, the key coefficient is unchanged for admissions per bed and proportion of day cases, but it is no longer significant at 5% level for cancelled elective operations and proportion of untouched meals. The association between competition and efficiency before the reform (δ) is never statistically significant at 5% level. The association between competition and efficiency after the reform ($\beta+\delta$) is significant only for the admissions per bed: an additional equivalent rival increases admissions per bed by 1.5% (0.9%+0.6%) after the reform.

[18] Evidence on beds is weak in model I and III but stronger in model IV (Table A3). In Model I, an additional equivalent rival reduces beds by 0.5%, but this estimate is only significant at 10% level. We observe higher statistical significance in model IV: an additional equivalent rival significantly reduces beds by 0.6% in 2007/08, 0.8% in 2008/09, and 1.3% in 2010/11.

[19] The Breusch-Pagan test suggests that SUR is favoured also for Model II, III, and IV.

Table 2 – Competition and efficiency: Model I

Regressor	Log of admissions per bed	Bed occupancy rate	Proportion of day cases	Log of cancelled operations	Proportion of untouched meals	Log of cleaning services costs	Log of laundry and linen costs	Reference cost index	Elective reference cost index
Policy break 2006/07*Pre-reform HHI^{-1}	0.011	0.053	0.381	0.026	-0.347	0.0004	-0.005	-0.306	-0.516
	(0.004)**	(0.120)	(0.118)***	(0.013)**	(0.172)**	(0.007)	(0.008)	(0.275)	(0.391)
Proportion of male patients	-0.001	-0.036	0.323	-0.033	-0.008	-0.001	-0.002	-0.053	0.108
	(0.004)	(0.152)	(0.147)**	(0.017)*	(0.242)	(0.009)	(0.009)	(0.257)	(0.417)
Proportion of patients between 15 and 59	0.018	-0.043	0.019	-0.017	-0.178	0.018	0.005	-0.509	-0.447
	(0.004)***	(0.143)	(0.120)	(0.014)	(0.171)	(0.010)*	(0.007)	(0.283)*	(0.420)
Proportion of patients between 60 and 74	0.012	-0.185	1.085	0.011	-0.273	0.010	-0.003	-0.424	-0.855
	(0.006)**	(0.205)	(0.172)***	(0.021)	(0.238)	(0.011)	(0.012)	(0.361)	(0.637)
Proportion of patients beyond 74	-0.002	0.120	-0.303	0.014	-0.098	0.006	0.021	-0.200	0.267
	(0.005)	(0.172)	(0.143)**	(0.019)	(0.244)	(0.012)	(0.010)**	(0.309)	(0.568)
Proportion of emergency patients	-0.007	-0.035	-0.646	-0.020	-0.106	0.004	0.000	0.006	0.336
	(0.002)***	(0.055)	(0.056)***	(0.006)***	(0.069)	(0.003)	(0.003)	(0.119)	(0.178)*
Log of beds				-0.013		0.088	0.318		
				(0.248)		(0.101)	(0.080)***		
Foundation trust	-0.030	-1.021	-0.505	0.079	-0.283	0.015	0.116	0.309	1.143
	(0.012)**	(0.441)**	(0.328)	(0.054)	(0.541)	(0.024)	(0.539)	(0.801)	(1.439)
Market forces factor	0.348	7.295	-16.257	-0.120	-27.029	-0.347	0.028	-1.691	-29.030
	(0.280)	(8.839)	(9.187)*	(1.053)	(12.636)**	(0.568)	(0.029)	(20.431)	(27.186)
Constant	3.694	86.790	42.691	8.049	52.485	6.388	3.568	137.249	142.996
	(0.474)***	(15.379)***	(13.890)***	(2.257)***	(17.983)***	(1.291)***	(1.000)***	(29.858)***	(47.614)***

SUR estimation. All regressions control for hospital and year fixed effects. Policy break 2006/07 is an indicator for years 2006/7 to 2010/11.
Breusch-Pagan test for diagonal variance-covariance matrix: p-value<0.0001.
Clustered standard errors in parentheses, *** p-value<0.01, ** p-value<0.05, * p-value<0.1

Table 3 – Competition quartiles and efficiency: Model II

Efficiency indicator	2nd quartile	3rd quartile	4th quartile
Log of admissions per bed	0.011	0.026	0.052
	(0.022)	(0.022)	(0.023)**
Bed occupancy rate	0.549	1.285	0.951
	(0.661)	(0.691)*	(0.815)
Proportion of day cases	0.809	1.085	2.104
	(0.626)	(0.497)**	(0.744)***
Log of cancelled elective operations	-0.025	0.084	0.119
	(0.079)	(0.081)	(0.084)
Proportion of untouched meals	-1.342	-1.805	-2.175
	(0.908)	(0.948)*	(1.043)**
Log of cleaning services costs	-0.036	-0.054	-0.021
	(0.038)	(0.048)	(0.045)
Log of laundry and linen costs	0.055	-0.009	0.020
	(0.054)	(0.046)	(0.046)
Reference cost index	-0.369	-2.702	-1.892
	(1.147)	(0.998)***	(1.497)
Elective reference cost index	2.473	-2.331	-3.301
	(1.939)	(1.986)	(1.973)*

SUR estimation. In addition to hospital and year fixed effects, all regressions control for gender, age categories, emergency admissions, foundation trusts, and market forces factor. The regressions for cancelled elective operations, cleaning services costs, and laundry and linen costs also control for beds.
Quartile dummies are constructed on the pre-reform HHI^{-1}: 2nd quartile=low-competition market, 3rd quartile=high-competition market, 4th quartile=very high-competition market; 1st quartile=very low-competition market (reference category).
Breusch-Pagan test for diagonal variance-covariance matrix: p-value=0.000
Clustered standard errors in parentheses.
***** p-value<0.01, ** p-value<0.05, * p-value<0.1**

Table 4 – Competition and efficiency: with time varying competition

Regressor	Log of admissions per bed	Bed occupancy rate	Proportion of day cases	Log of cancelled operations	Proportion of untouched meals	Log of cleaning services costs	Log of laundry and linen costs	Reference cost index	Elective reference cost index
				Model III					
Policy break*HHI^{-1}	0.009	0.051	0.329	0.022	-0.256	0.002	0.00002	-0.186	-0.422
	(0.004)**	(0.110)	(0.105)***	(0.011)*	(0.156)	(0.006)	(0.007)	(0.220)	(0.338)
HHI^{-1}	0.006	0.020	-0.277	-0.003	-0.156	-0.019	-0.013	-0.556	-0.387
	(0.007)	(0.208)	(0.170)	(0.027)	(0.306)	(0.010)*	(0.015)	(0.370)	(0.710)
				Model IV					
Dummy 2002/03*HHI^{-1}	-0.004	-0.007	-0.246	-0.016	0.567	0.024	0.012	0.122	-0.533
	(0.006)	(0.214)	(0.179)	(0.034)	(0.317)*	(0.015)*	(0.012)	(0.460)	(0.713)
Dummy 2003/04*HHI^{-1}	-0.004	-0.036	-0.134	-0.018	0.178	-0.007	0.018	-0.129	-0.268
	(0.004)	(0.144)	(0.137)	(0.020)	(0.225)	(0.018)	(0.010)*	(0.269)	(0.489)
Dummy 2004/05*HHI^{-1}	-0.002	-0.042	-0.035	-0.024	0.347	0.004	-0.007	-0.094	0.204
	(0.003)	(0.105)	(0.086)	(0.013)*	(0.192)*	(0.007)	(0.009)	(0.190)	(0.383)
Dummy 2006/07*HHI^{-1}	0.003	-0.221	0.161	0.010	0.118	0.008	0.002	0.014	-0.197
	(0.004)	(0.099)**	(0.087)*	(0.009)	(0.114)	(0.006)	(0.006)	(0.258)	(0.353)
Dummy 2007/08*HHI^{-1}	0.008	0.195	0.239	0.025	0.070	-0.005	0.001	-0.603	-0.542
	(0.004)*	(0.171)	(0.138)*	(0.013)*	(0.153)	(0.010)	(0.009)	(0.255)**	(0.382)
Dummy 2008/09*HHI^{-1}	0.006	0.205	0.292	0.024	-0.015	0.006	0.001	-0.204	-0.531
	(0.005)	(0.205)	(0.113)***	(0.015)	(0.253)	(0.006)	(0.009)	(0.250)	(0.446)
Dummy 2009-10*HHI^{-1}	0.008	-0.001	0.350	-0.002	-0.374	0.003	0.002	-0.189	-0.546
	(0.005)	(0.161)	(0.126)***	(0.019)	(0.200)*	(0.006)	(0.009)	(0.253)	(0.480)
Dummy 2010/11*HHI^{-1}	0.013	0.153	0.423	-0.016	-0.353	0.005	0.007	-0.356	-0.691
	(0.005)**	(0.174)	(0.155)***	(0.018)	(0.193)*	(0.007)	(0.009)	(0.279)	(0.489)
HHI^{-1}	0.004	0.044	-0.359	0.014	-0.096	-0.016	-0.009	-0.504	-0.555
	(0.008)	(0.228)	(0.186)*	(0.028)	(0.335)	(0.013)	(0.016)	(0.401)	(0.735)

SUR estimation. In addition to hospital and year fixed effects, all regressions control for gender, age categories, emergency admissions, number of beds, foundation trusts, and market forces factor. The regressions for cancelled elective operations, cleaning services costs, and laundry and linen costs also control for beds.

Post-reform effect of market structure (p-value) in Model III ($\beta+\delta$). Log of admission per bed: 0.015 (0.014); bed occupancy rate: 0.071 (0.745); proportion of day cases: 0.052 (0.753); log of cancelled operations: 0.019 (0.469); proportion of untouched meals: -0.412 (0.155); log of cleaning services costs: -0.017 (0.114); log of laundry and linen costs: -0.013 (0.360); reference cost index: -0.742 (0.101); elective reference cost index: -0.809 (0.214).

Breusch-Pagan test for diagonal variance-covariance matrix: p-value=0.000. Clustered standard errors in parentheses, *** p-value<0.01, ** p-value<0.05, * p-value<0.1

Model IV analyses how the effect of competition on efficiency changes in every year before and after the policy implementation. Considering the proportion of day cases, for example, the estimated coefficient on the interaction term is negative and insignificant in the pre-reform periods, and increasingly positive and significant in the post-reform periods. Such estimates clearly indicate a persistent effect of the reform on efficiency as captured by the proportion of day cases.

Table 5 illustrates UQR results. They suggest that less efficient hospitals tend to respond more to competition. This is the case of efficiency outcomes as the admissions per bed, the percentage of day cases and, to a lesser extent, the percentage of untouched meals. For hospitals with fewer admissions per bed (25th quantile), an additional equivalent rival increases admissions per bed by 2.2%. Similarly, for hospitals with lower proportions of day cases (10th or 25th quantile), an additional equivalent rival increases such proportions by 0.91 or 0.4 percentage points. If hospitals have a high proportion of untouched meals (75th quantile), an additional equivalent rival decreases untouched meals by 0.43 percentage points, even though this result is only significant at 10% level. Finally, when hospitals have fewer cancelled elective operations (10th quantile), an additional equivalent rival leads to an increase in this indicator by 7.2%.

Table 5 – Effects of competition at different efficiency quantiles: Model V

Efficiency indicator	10th	25th	50th	75th	90th
Log of admissions per bed	0.019	0.022	0.002	-0.010	-0.009
	(0.015)	(0.011)**	(0.008)	(0.008)	(0.010)
Bed occupancy rate	0.461	0.147	-0.079	-0.183	-0.211
	(0.408)	(0.190)	(0.148)	(0.191)	(0.252)
Proportion of day cases	0.914	0.396	0.220	0.101	0.277
	(0.372)**	(0.201)**	(0.202)	(0.255)	(0.377)
Log of cancelled elective operations	0.072	0.035	0.011	0.017	0.041
	(0.037)**	(0.023)	(0.022)	(0.022)	(0.026)
Proportion of untouched meals	-0.076	-0.196	-0.168	-0.429	-0.627
	(0.160)	(0.128)	(0.144)	(0.245)*	(0.469)
Log of cleaning services costs	0.018	-0.037	-0.031	-0.007	0.053
	(0.036)	(0.023)	(0.022)	(0.020)	(0.035)
Log of laundry and linen costs	-0.075	-0.021	0.010	-0.018	0.016
	(0.046)	(0.020)	(0.018)	(0.015)	(0.032)
Reference cost index	-0.419	-0.319	-0.233	-0.532	0.062
	(0.281)	(0.248)	(0.250)	(0.424)	(1.068)
Elective reference cost index	0.295	-0.316	-0.395	-0.390	-1.934
	(0.501)	(0.386)	(0.487)	(0.742)	(1.592)

Unconditional quantile regression. In addition to hospital and year fixed effects, all regressions control for gender, age categories, emergency admissions, number of beds, foundation trusts, and market forces factor. The regressions for cancelled elective operations, cleaning services costs, and laundry and linen costs also control for beds.
Bootstrapped clustered standard errors (using 1,000 replications) in parenthesis.

***** p-value<0.01, ** p-value<0.05, * p-value<0.1**

5. Discussion and conclusion

This study has investigated whether competition improves some dimensions of hospital efficiency in England using the exogenous variation generated by the Patient Choice reform and the geographical variation in the market structure. We find that greater competition induces hospitals to increase their efficiency by increasing admissions per bed and proportion of day cases, and by reducing the proportion of untouched meals. In contrast, hospitals appear less efficient in terms of cancelled elective operations. The effect of the choice reform is larger for hospitals facing more rivals. We also observe that less efficient hospitals generally respond more to competition.

Hospitals may have varied their efficiency levels, due to the increase of patient choice, by spreading their fixed costs on a larger share of hospital treatment reimbursements, which explains the increase in admissions per bed and the proportion of day cases. Our findings on admissions per bed are in line with the recent concerns about the reduction of beds in NHS hospitals (Hosken, 2016). Also the result on the proportion of day cases is largely coherent with the reduction in pre-surgery and overall length of stay on specific elective procedures found by Cooper et al. (2012). The authors highlight that "by 2010, patients were 41.7% more likely to receive surgery on the day that they were admitted to the hospital than they were in 2002" (Cooper et al., 2012, p.17-18). Similarly, hospitals might have reduced their variable sunk costs, e.g. by reducing the proportion of untouched meals and other wasted items. However, the efficiency improvements in the previous dimensions may have also brought English NHS hospitals close to or over their full capacity levels, especially in the case of NHS clinician and nursing workforce understaffing (Bates, 2005). If this is the case, the increases in admissions per bed and proportion of day cases may have also caused a rise in the number of cancelled elective operations. In fact, since NHS hospitals cannot refuse emergency patient treatments, cancelling elective operations is the most likely mechanism that hospitals have to release pressure due to excess demand of overall hospital services (i.e. the sum of emergency and elective admissions) compared to the hospital equilibrium levels. Hospitals can also increase waiting times as another viable mechanism to reduce excess demand pressure. But this alternative mechanism was not available to English NHS hospital management (and clinicians) in the years following the Choice policy (i.e. 2006-2011) due to the waiting time reforms, which imposed heavy hospital management penalties on hospitals with long waiting times (Propper et al., 2008). Cancelled elective operations may have increased also because of some distortions in the payment arrangements. Cookson et al. (2017) show that providers were more likely to cancel elective operations until 2009/10 (our penultimate analysed financial year). Hospitals could cancel operations and still receive a tariff until 2009/10 and, therefore, the authors suggest that this produced an incentive to cancel operations to increase revenues. Such behaviour may have been exacerbated once competition had been introduced in 2006.

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APPENDIX

Table A1 – Pairwise correlations across efficiency indicators

Efficiency indicator	Def	(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Log of admissions per bed	E	1.0000									
(2) Bed occupancy rate	E	0.2018*		1.0000							
(3) Proportion of day cases	E	0.1028*		-0.1041*	1.0000						
(4) Log of cancelled elective operations	I	-0.0181		0.1674*	0.0551	1.0000					
(5) Proportion of untouched meals	I	0.0405		0.0159	-0.0199	0.0134	1.0000				
(6) Log of cleaning services costs	I	0.2821*		0.2116*	-0.1088*	0.5955*	-0.002	1.0000			
(7) Log of laundry and linen costs	I	0.1926*		0.3147*	-0.2760*	0.6670*	0.0185	0.8133*	1.0000		
(8) Reference cost index	I	-0.2197*		-0.1566*	0.0982*	-0.1022*	-0.0121	-0.0550	-0.1696*	1.0000	
(9) Elective reference cost index	I	-0.2575*		-0.1590*	-0.045	-0.1227*	-0.0267	-0.0904*	-0.1776*	0.7412*	1.0000

E=positive indicator of efficiency, I=negative indicator of efficiency

*** = statistically significant at 5% level after Bonferroni adjustment**

Table A2 – Unconditional quantiles of the efficiency indicators

Efficiency indicator	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
Admissions per bed	75	91	109	126	142
Bed occupancy rate	78.2	82.8	86.6	90.2	93.3
Proportion of day cases	22.1	26.4	30.0	34.6	39.1
Cancelled elective operations	86	154	284	475	763
Proportion of untouched meals	2.4	4.2	6.4	9.6	14.5
Cleaning services costs	987	1,547	2,440	3,676	5,207
Laundry and linen costs	280	465	709	1,052	1,430
Reference cost index	88.2	92.6	98.0	106.3	116.2
Elective reference cost index	82.2	88.9	97.2	108.6	122.6

Table A3 – Competition, admissions, and beds.

Regressor	Model	Log of admissions	Log of beds
Policy break 2006/07*Pre-reform HHI^{-1}	I	0.006 (0.004)	-0.005 (0.003)*
Policy break 2006/07*HHI^{-1}	III	0.004 (0.003)	-0.005 (0.003)
HHI^{-1}		-0.001 (0.005)	-0.007 (0.004)*
Dummy 2002/03*HHI^{-1}	IV	-0.008 (0.005)*	-0.005 (0.004)
Dummy 2003/04*HHI^{-1}		-0.004 (0.004)	-0.001 (0.003)
Dummy 2004/05*HHI^{-1}		-0.003 (0.003)	-0.003 (0.002)
Dummy 2006/07*HHI^{-1}		0.003 (0.003)	-0.001 (0.002)
Dummy 2007/08*HHI^{-1}		0.004 (0.003)	-0.006 (0.003)**
Dummy 2008/09*HHI^{-1}		-0.002 (0.004)	-0.008 (0.003)**
Dummy 2009/10*HHI^{-1}		0.001 (0.004)	-0.007 (0.004)*
Dummy 2010/11*HHI^{-1}		0.003 (0.004)	-0.013 (0.004)***
HHI^{-1}		-0.002 (0.006)	-0.005 (0.005)
Observations		1,516	1,507
Number of trusts		173	172
Average		73,232	682

OLS estimation. In addition to hospital and year fixed effects, all regressions control for gender, age categories, emergency admissions, foundation trusts, and market forces factor.

Clustered standard errors in parentheses.

***** p-value<0.01, ** p-value<0.05, * p-value<0.1**

Table A4 – Data sources

Variable	Link
Efficiency indicator	
Admissions	http://content.digital.nhs.uk/article/2021/Website-Search?q=title%3A%22Hospital+Episode+Statistics%2C+Admitted+patient+care+-+England%22+or+title%3A%22Hospital+Admitted+Patient+Care+Activity%22&go=Go&area=both
Day cases	
Beds	https://www.england.nhs.uk/statistics/statistical-work-areas/bed-availability-and-occupancy/bed-data-overnight/
Bed occupancy rate	
Cancelled elective operations	https://www.england.nhs.uk/statistics/statistical-work-areas/cancelled-elective-operations/cancelled-ops-data/
Proportion of untouched meals	http://hefs.hscic.gov.uk/DataFiles.asp
Cleaning services costs	
Laundry and linen costs	
Reference cost index	http://webarchive.nationalarchives.gov.uk/+/http://www.dh.gov.uk/en/Managingyourorganisation/NHScostingmanual/DH_129310?PageOperation=email
	https://www.gov.uk/government/collections/nhs-reference-costs
Covariate	
Patient gender	http://content.digital.nhs.uk/article/2021/Website-Search?q=title%3A%22Hospital+Episode+Statistics%2C+Admitted+patient+care+-+England%22+or+title%3A%22Hospital+Admitted+Patient+Care+Activity%22&go=Go&area=both
Patient age	
Emergency admissions	
Foundation trusts	http://hefs.hscic.gov.uk/DataFiles.asp
Market forces factor	http://webarchive.nationalarchives.gov.uk/+/http://www.dh.gov.uk/en/Managingyourorganisation/NHScostingmanual/DH_129310?PageOperation=email
	https://www.gov.uk/government/collections/nhs-reference-costs