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Abstract

Prospective payment systems fund hospitals based on a fixed-price regime that does not directly distinguish between specialist and general hospitals. We investigate whether current prospective payments in England compensate for differences in costs between specialist orthopaedic hospitals and trauma and orthopaedics (T&O) departments in general hospitals. We employ reference cost data for a sample of hospitals providing services in the trauma and orthopaedics specialty. Our regression results suggest that specialist orthopaedic hospitals have on average 13.5% lower profit margins. Under the assumption of break-even for the average trauma and orthopaedics department, two of the three specialist orthopaedic hospitals appear to make a loss on their activity. The same holds true for almost 34% of departments in our sample. Variations in the salary of doctors, scale economies, other hospital status (e.g. foundation trust, teaching hospital), and quality of care explain only a small proportion of such differences.

JEL Classification: I18, H51, D24

Key words: specialist hospitals, orthopaedics, hospital costs, HRG, tariff, reference costs.

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1. Introduction

Prospective payment systems (PPSs) are common to reimburse hospitals across OECD countries (Busse, Schreyögg, & Smith, 2006; Moreno-Serra & Wagstaff, 2010). Originally introduced in the US Medicare during the 1980s, PPSs are characterised by a patient classification system (PCS) that categorises patients into homogeneous groups. The hospital receives a fixed tariff for every patient falling into a given group, and therefore has an incentive to contain costs.

In its purest form, a PPS system reimburses hospitals only according to the volume and type of patients treated and not on the basis of the hospital's organisational characteristics. For example, under the German PPS the fixed price in a given group does not depend on hospital's ownership status or membership to the national insurance programme (Klein-Hitpaß & Scheller-Kreinsen, 2015). Other PPSs instead take organisational settings into account. For instance, in the French PPS prices differ for public and private hospitals (Busse, Geissler, & Quentin, 2011). Similarly, in the US Medicare, teaching hospitals receive a higher tariff (Dafny, 2005). In some countries, the payment system provides greater compensation to allow for the costs of specialist care. The PPS of the Lombardy region in Italy applies a tariff top-up to all hospitals with 'high specialisation' units (Ettelt, Thomson, Nolte, & Mays, 2006). The Austrian PPS employs a similar system by grouping patients considering whether they receive treatments at specialist departments such as geriatric, remobilisation, palliative or neuropsychiatric for children and youths (Busse et al., 2011). In England, hospitals are paid extra if their patients receive specialised care (Daidone & Street, 2013).

Some health care systems feature hospitals that specialise exclusively on providing a particular type of service such as cardiology, orthopaedics, or ophthalmology.[1] Specialisation

[1] There are specialist hospitals in America (Araújo, Barros, & Wanke, 2014; Carey, Burgess, & Young, 2009), Europe (Ettelt et al., 2006), Asia (Kim, Park, Jang, Lee, & Kim, 2013), India (Chanda, 2002), and Africa (Castro-Leal, Dayton, Demery, & Mehra, 1999).

is an organisational form which is supposed to generate the benefits of the 'focused factory' exhibiting greater efficiency, quality and responsiveness, and intensifying competition (Herzlinger, 1996; Schneider et al., 2008; Skinner, 1974). In the US, the Medicare Payment Advisory Commission showed that specialist hospitals did not have lower average costs than general hospitals.[2] Whilst the cost of cardiac hospitals was not significantly different from general hospitals, orthopaedic and surgical hospitals had 20 percent higher inpatient costs. Higher costs were due to more specialised and costly facilities, higher staffing level, better quality of care, but also excess capacity and low inpatient volumes (MedPAC, 2005, 2006).

Such findings have stimulated empirical research on specialist hospitals' costs. Barro, Huckman, and Kessler (2006) study the impact of specialist cardiac hospitals on overall expenditure and quality in the US between 1996 and 1999. They find that entry of specialist hospitals reduces expenditure growth without affecting outcomes. Carey, Burgess, and Young (2008) investigate the cost efficiency of US specialist hospitals between 1998 and 2004. They find higher level of inefficiency in orthopaedic and surgical hospitals compared to general hospitals. Kim et al. (2013) analyse South Korean specialty orthopaedic hospitals between 2010 and 2012, which are found to apply higher patients' charges than general hospitals. The authors suggest that such higher charges are due to greater set-up costs, investment, staffing and treatment costs.

The present study contributes to this limited empirical literature by investigating the financial viability of specialist orthopaedic hospitals relative to general hospitals in the English National Health Service (NHS). Our primary objective is to test whether costs of specialist orthopaedic hospitals are higher than trauma and orthopaedics (T&O) departments in general hospitals even *after* accounting for differences in revenues. In other words, we test whether the current DRG-type payment system covers the costs of specialist orthopaedic hospitals relative to general hospitals.

Our econometric strategy employs four regressions. The first regression model compares

[2] Costs are standardised by controlling for case-mix, input prices, and hospital characteristics (e.g. teaching status).

unit costs between specialist orthopaedic hospitals and T&O departments in general hospitals without any additional controls, i.e. it provides raw differences in costs. In a second regression, we compare unit costs *after* controlling for differential payments (due to different DRGs and other tariff corrections). This is our key model and provides differences in profit margins between the two types of hospital: given that DRG prices are fixed, any differences in costs after controlling for differences in payment will be reflected in the profit margin. In the third regression, we *explain* any differences in profit margins (i.e. in costs after controlling for payment) as a function of possible determinants such as hospital characteristics, scale economies, quality and salaries. Our fourth regression examines the heterogeneity in profit margins across specialist hospitals. We estimate these models by weighted least square (WLS).

Our first regression suggests that specialist orthopaedic hospitals have on average 11.3% higher unit costs. After controlling for the payment system, our second regression and key finding suggests that specialist orthopaedic hospitals have 13.5% higher costs, and therefore lower profit margins, than T&O departments in general hospitals. Differences in profit margins between specialist orthopaedic hospitals and T&O departments in general hospitals are most evident for elective activity (22.6%), long non-elective (38.8%) and short non-elective activity (34.1%) and, to a lesser extent, for day case (2.9%) activity. Our third regression suggests that such differences can be explained only to a small extent by differences in hospital characteristics, scale economies, quality and salaries.

In England, the majority of hospitals are funded through a PPS known as the national tariff payment system (NTPS).[3] Two key elements of the NTPS are the currency and the tariff. The currency for inpatient care is the healthcare resource group (HRG) (Grašič, Mason, & Street, 2015), which classifies patients into homogeneous groups based on diagnosis, procedure and some patients characteristics (Busse et al., 2011). The tariffs vary by HRG and admission type (elective or non-elective) and reflect the national cost averaged across all

[3] More than 60% of hospital income comes from the NTPS. The remaining part is agreed in the NHS standard contract on the basis of actual activity (Department of Health, 2012).

hospitals within an HRG (Department of Health, 2013b).[4] An additional payment for excess bed days is also made for patients whose length of stay is beyond a threshold, called the trim point, which like the tariff varies by HRG and admission type.[5] Both the base and excess bed day tariffs are adjusted by the market forces factor (MFF) index to account for exogenous geographical differences in input prices (Department of Health, 2013a). Tariffs are inflated if the patient receives specialised services under specific HRGs (Daidone & Street, 2013).[6] With such a payment system, specialist hospitals are likely to obtain higher revenues owing to the greater proportion of patients within an HRG who receive a specialised service.

We focus on specialist orthopaedic hospitals because trauma and orthopaedics is the specialty with the fourth highest volume of patients, after general medicine, general surgery, and paediatrics. In 2013, 6.7% of patients were treated in a T&O department. As reported by Briggs (2012), 35% of patients below the age of 65 years undergo an orthopaedic procedure such as hip and knee replacement. There are 144 acute hospital trusts in the English NHS with a T&O department, and three specialist hospitals that focus exclusively on providing orthopaedic services.[7] We use data at HRG level from the financial year 2013-14. Our main source is the reference cost (RC) database from which we collect the unit cost, i.e. the cost per patient, of each inpatient HRG delivered through the T&O specialty of each hospital in our sample. Unit costs at HRG level comprehensively capture the cost of the hospital activity (Department of Health, 2014).

To the best of our knowledge, this is one of the first attempts to study differences in profit

[4] Some tariffs are also set by taking clinical practice into account. The best practice tariff (BPT) applies for a small number of HRGs that satisfy three criteria, such as high impact (i.e. high volumes, significant variation in practice, or significant impact on outcomes), strong evidence base on what constitutes best practice, and clinical consensus on the characteristics of best practice. This adjustment aims to improve quality by increasing the tariff in presence of specific hospital practices (Department of Health, 2013a).

[5] The trim point is the maximum expected length of stay for a patient falling under a specific HRG. It is defined by the Department of Health in order to identify unusually long lengths of stay and statistical outliers (Department of Health, 2013a).

[6] Top-ups are allowed for Children's, orthopaedic, spinal and neurosciences specialised services. Whilst all hospitals can obtain the top-up for specialised orthopaedic services, top-ups for the other specialised services are paid to a restricted number of eligible providers.

[7] Public and private treatment centres also help to tackle the high demand of orthopaedic services by providing specific treatments, such as hip and knee replacements.

margins between specialist hospitals and departments within general hospitals undertaking similar activities. Previous work has focused on either costs (e.g. MedPAC, 2005, 2006) or revenues (e.g. Kim et al., 2013). Our analysis is at HRG level, rather than patient level, making use of cost data that all English hospitals are required to report annually to the Department of Health. This is because we focus on controlling for differences in payment across hospital types whereas payment is by HRG. As cost data are available only at DRG-level in most countries, the general methodological approach that we employ can easily be replicated in studies elsewhere, either to compare specialist and general hospitals, or to make other types of comparison, such as between teaching and non-teaching hospitals.

The paper is structured as follows. Section 2 provides the economic framework. Section 3 describes the econometric strategy. Section 4 describes the data and shows descriptive statistics. Section 5 presents the results. Section 6 discusses and concludes.

2. Economic framework

Under a PPS, hospitals are funded according to the number and type of patients treated. In the English payment system, the total revenue of hospital $k = 1,...,K$ for providing HRG $j = 1,...,J$ (R_{jk}) are:

$$R_{jk} = R_{jk}^{IN} + R_{jk}^{EB} = p_{jk}^{IN}\left(1+te_{jk}\right)y_{jk} + p_{jk}^{EB}\left(1+te_{jk}\right)q_{jk} \quad (1)$$

where R_{jk}^{IN} is the total revenue of hospital *k* for treating patients under HRG *j* (up to the maximum expected length of stay called the trim point, see footnote 5 in Section 1), which we define *inlier* revenue; R_{jk}^{EB} is the total revenue of hospital *k* for the bed days beyond the trim point (or excess bed days) produced under HRG *j*, which we define *excess bed day* revenue; p_{jk}^{IN} is the HRG price received by hospital *k* for treating a patient falling under HRG *j*, which we define *inlier* price; p_{jk}^{EB} is the price received by hospital *k* for a single excess bed day produced under HRG *j*, which we define *per diem* price; *t* is the tariff top-up on specialised orthopaedic services, which is constant across HRGs and hospitals; e_{jk} is the proportion of patients in hospital *k* falling under HRG *j* receiving a specialised orthopaedic

treatment; y_{jk} is the number of patients admitted in hospital *k* under HRG *j*;[8] and q_{jk} is the number of excess bed days produced in hospital *k* under HRG *j*.

The HRG prices p_{jk}^{IN} and p_{jk}^{EB} can be written more explicitly as:

$$p_{jk}^{IN} = \alpha_j^{IN} z_k \tag{2}$$

$$p_{jk}^{EB} = \alpha_j^{EB} z_k \tag{3}$$

where α_j^{IN} is the tariff for treating a patient falling under HRG *j*, the *inlier* tariff; α_j^{EB} is the tariff of each excess bed day under HRG *j*, the *excess bed day* tariff. These do not vary by hospital. In contrast, z_k is a market forces factor index capturing exogenous geographical differences in hospital input prices that varies depending on the hospital's location.

The total cost of hospital *k* for providing HRG *j* is:

$$C_{jk} = C_{jk}^{IN} + C_{jk}^{EB} = c_{jk}^{IN} y_{jk} + c_{jk}^{EB} q_{jk} \tag{4}$$

where C_{jk}^{IN} is the total cost of hospital *k* for treating patients under HRG *j* (up to the trim point), which we define *inlier* cost; C_{jk}^{EB} is the total cost of hospital *k* for the excess bed days produced under HRG *j*, which we define *excess bed day* cost; c_{jk}^{IN} is the *inlier* unit cost of hospital *k* for HRG *j*, and c_{jk}^{EB} is the *per diem* unit cost of hospital *k* for each excess bed day falling under HRG *j*. Since the national tariffs are set equal to the average cost, we can write them more explicitly as:

$$\alpha_j^{IN} = \frac{\sum_k c_{jk}^{IN} y_{jk}}{\sum_k y_{jk}} \quad \text{and} \quad \alpha_j^{EB} = \frac{\sum_k c_{jk}^{EB} q_{jk}}{\sum_k q_{jk}} \tag{5}$$

Therefore, the total profit function of hospital *k* for providing HRG *j* is:

$$\pi_{jk} = R_{jk}^{IN} - C_{jk}^{IN} + R_{jk}^{EB} - C_{jk}^{EB} = \left[p_{jk}^{IN} \left(1 + te_{jk}\right) - c_{jk}^{IN} \right] y_{jk} + \left[p_{jk}^{EB} \left(1 + te_{jk}\right) - c_{jk}^{EB} \right] q_{jk} \tag{6}$$

[8] The number of patients is expressed by the number of finished consultant episodes (FCEs). A FCE is a hospital episode for a patient under the care of an individual consultant.

The profit margin, i.e. the profit per patient for HRG *j* in hospital *k*, defined with $\tilde{\pi}_{jk} = \pi_{jk} / y_{jk}$ is instead:

$$\tilde{\pi}_{jk} = p_{jk}^{IN}\left(1+te_{jk}\right)-c_{jk}^{IN}+\left[p_{jk}^{EB}\left(1+te_{jk}\right)-c_{jk}^{EB}\right]\frac{q_{jk}}{y_{jk}} \quad (7)$$

where $p_{jk}^{IN}\left(1+te_{jk}\right)-c_{jk}^{IN}$ is the *inlier* profit margin of hospital *k* for HRG *j*, and $p_{jk}^{EB}\left(1+te_{jk}\right)-c_{jk}^{EB}$ is the profit margin of hospital *k* for each excess bed day produced under HRG *j*, i.e. the *per diem* profit margin. The key insight is that the main drivers of profitability are given by differences between the national tariff and cost of each HRG within a hospital.

Given that the national tariff reflects the average cost within the same HRG across all hospitals (i.e. prices are exogenous and fixed), differences in profitability are driven by differences in hospitals' unit costs. To illustrate this point, suppose that a specialist orthopaedic hospital *s* and a T&O department in general hospital *g* have the same volume of patients and excess bed days ($y_s = y_g$, $q_s = q_g$), the same location ($z_s = z_g$), and the same proportion of top-up tariffs ($e_s = e_g$). Then, differences in profits will be equal to:

$$\pi_g - \pi_s = \left(c_s^{IN} - c_g^{IN}\right) y_g + \left(c_s^{EB} - c_g^{EB}\right) q_g \quad (8)$$

where $\pi_g - \pi_s > 0$ implies that the specialist orthopaedic hospital has lower profit margins than the T&O department in a general hospital. The primary objective of the empirical analysis in Sections 3 and 4 is to estimate differences in profit margins, or equivalently in unit costs, after controlling for differences in payments that are outside of hospitals' control. As equation (8) illustrates, this in turn provides differences in profitability, which are not compensated by the payment system and may be due to a range of factors, some within and some outside of hospital control.

2.1. Determinants of hospital costs

There are several factors that may explain differences in unit costs between specialist and general hospitals (Bradford, Kleit, Krousel-Wood, & Re, 2001; Gutacker et al., 2013). We

summarise these in the following function:

$$c_{jk} = c\left(r_k, m_k, d_k, l_k, x_{jk}, u_k\right) \tag{9}$$

where r_k includes input prices that vary across hospitals and that are not captured fully by the market forces adjustment (mentioned above), m_k is a vector of hospital characteristics (e.g. the hospital is a teaching hospital), d_k accounts for economies of scale, l_k is the quality in orthopaedic surgery, x_{jk} is a vector of patients' characteristics within HRG *j* not captured by the HRG classification system, and u_k captures efficiency. Below, in our empirical analysis, we are able to control for most of these factors.

Differences among patients are a primary source of cost variation across hospitals. Although the HRG classification aims to standardise treatments within each group, patient characteristics such as gender, age, or severity of illness may influence the patient's complexity with consequent implications on costs.

Costs may also be driven by differences across departments and providers (Street, Scheller-Kreinsen, Geissler, & Busse, 2010). For instance, hospitals may differ in the mix of staff employed. Hospitals in London may have to pay higher wages to attract staff to areas with a higher cost of living. Teaching hospitals may have higher costs because educational activity is under-compensated. Departments treating higher volumes of patients may have lower average costs owing to economies of scale or better efficiency. Costs may also vary according to the quality of care.

3. Econometric specification

We focus on three key specifications. The dependent variables are the *inlier* unit cost (c_{jk}^{IN}) or the *per diem* unit cost (c_{jk}^{EB}). Since each HRG within each hospital involves a different number of patients or excess bed days, all models are estimated by *weighted* least squares, where the weight is given by the number of patients (y_{jk}) or the number of excess bed days (q_{jk}). This implies that observations with a higher number of patients or excess bed days have greater influence on estimates.

In the first regression, we test whether *inlier* or *per diem* unit costs are on average higher in specialist orthopaedic hospitals, before accounting for any differences in payments across hospitals:

$$\ln\left(c_{jk}\right) = \mu + \beta s_k + \varepsilon_{jk} \tag{10}$$

where c_{jk} is the *inlier* or *per diem* unit cost of HRG *j* in hospital *k*, μ is the intercept, s_k is a dummy equals one if hospital *k* is a specialist orthopaedic hospital, and ε_{jk} is the error term. This model estimates the difference in unit costs between specialist orthopaedic hospitals and T&O departments in general hospitals. The estimated coefficient for the specialist orthopaedic hospital category is $\hat{\beta}$. This translates into $\tilde{\beta} = \exp\left(\hat{\beta}\right) - 1$ indicating lower or higher costs compared with T&O departments in general hospitals, which can also be expressed as $\tilde{\beta} = \left(c_s - c_g\right)/c_g$ (Bamezai, Zwanziger, Melnick, & Mann, 1999, p. 240; Halvorsen & Palmquist, 1980). A positive $\tilde{\beta} > 0$ implies higher *inlier* or *per diem* unit costs in specialist orthopaedic hospitals. This, however, does not necessarily imply that specialist orthopaedic hospitals will have lower profit margins because no account is taken of the hospital payment. For example, specialist orthopaedic hospitals may provide on average more expensive treatments that are fully compensated by a higher HRG tariff.

Our second, and main, econometric specification accounts for differences in payments across specialist orthopaedic hospitals and T&O departments in general hospitals:

$$\ln\left(c_{jk}\right) = \mu + \beta s_k + \gamma \ln\left(z_k\right) + \delta e_{jk} + \alpha_j + \varepsilon_{jk} \tag{11}$$

where z_k is the market forces factor index, e_{jk} is the proportion of specialised services, and α_j is a vector of HRG fixed effects which controls for differences in average cost for each HRG; in turn, this controls for the fixed prices at HRG level which are set precisely equal to the average cost within each HRG.

This specification compares unit costs across specialist orthopaedic hospitals and T&O departments in general hospitals, after differences in unavoidable factor prices and payments made via the tariffs are taken into account. The MFF captures exogenous geographical

differences in non-medical staff and capital prices (e.g. land, buildings). The tariffs are subtracted through the HRG fixed effects that capture the average unit cost of each HRG. Moreover, the proportion of specialised orthopaedic services allows us to also control for the tariff adjustment defined in the payment rule.

A positive $\tilde{\beta} > 0$ now implies that specialist orthopaedic hospitals exhibit lower profit margins compared with T&O departments in general hospitals, as highlighted in the Economic Framework in equation (8). This would have implications for the financial sustainability of specialist orthopaedic hospitals.

All regression models are estimated separately for *inlier* and *per diem* unit costs. This is a natural choice since the HRG price is computed separately for *inlier* and *excess bed day* activity. We use the estimates of the separate models to compute an *overall* measure of profitability. Following equation (8), the percentage difference in profit margins between specialist orthopaedics hospitals and T&O departments in general hospitals, evaluated at the average volume of patients ($\bar{y}$) and excess bed days ($\bar{q}$), can be written as:

$$\frac{\bar{\pi}_g - \bar{\pi}_s}{\bar{C}_g} = \frac{\left(\bar{c}_s^{IN} - \bar{c}_g^{IN}\right)\bar{y} + \left(\bar{c}_s^{EB} - \bar{c}_g^{EB}\right)\bar{q}}{\bar{c}_g^{IN}\bar{y} + \bar{c}_g^{EB}\bar{q}} \tag{12}$$

where $\bar{\pi}_s$ and $\bar{\pi}_g$ are the specialist orthopaedic hospitals and the general hospitals' total profit respectively averaged across HRGs and hospitals, $\bar{C}_g$ is the general hospitals' total cost averaged across HRGs and hospitals, the superscript *IN* and *EB* indicate the *inlier* and *excess bed day* activity respectively, $\bar{c}_s$ and $\bar{c}_g$ are respectively the specialist orthopaedic hospitals and the general hospitals' unit cost averaged across HRGs and hospitals.

In equation (12), the difference in profit $\bar{\pi}_g - \bar{\pi}_s$ is expressed as a percentage of the general hospitals' total cost $\bar{C}_g$ in order to be consistent with the interpretation of profitability of the *inlier* ($\tilde{\beta}^{IN}$) and *excess bed day* ($\tilde{\beta}^{EB}$) activity. For instance, using econometric specification (11), we have estimates of $\bar{c}_s^{IN} - \bar{c}_g^{IN} = \tilde{\beta}^{IN}\bar{c}_g^{IN}$ and $\bar{c}_s^{EB} - \bar{c}_g^{EB} = \tilde{\beta}^{EB}\bar{c}_g^{EB}$, which substituted into $\left(\bar{\pi}_g - \bar{\pi}_s\right)/\bar{C}_g$ provides the percentage difference in the *overall* profit margin per patient treated between specialist orthopaedic hospitals and

T&O departments in general hospitals, after allowing for differences in unit costs of excess bed days. Standard errors of the *overall* estimates are bootstrapped using 1,000 replications.

Suppose that model (11) provides a positive $\hat{\beta} > 0$ therefore implying that specialist orthopaedic hospitals are less financially viable. The finding could be due to a number of competing reasons which we account for in our third model. This adds controls that may explain possible differences in unit costs after controlling for differences in payments and, therefore, profitability:

$$\ln\left(c_{jk}\right) = \mu + \beta s_k + \gamma \ln\left(z_k\right) + \delta e_{jk} + \theta \ln\left(w_k\right) + \lambda' m_k + \rho' d_k + \phi' \ln\left(l_k\right) + \alpha_j + \varepsilon_{jk} \qquad (13)$$

The additional controls are the salary of doctors w_k, a vector of hospital characteristics m_k such as foundation status, teaching, and location in London, a vector of dummies capturing volume d_k to capture possible economies of scale, and a vector of quality measures l_k such as patient outcomes for hip and knee replacement.

The estimated coefficient $\hat{\beta}$ provides an average effect across specialist orthopaedic hospitals. There may be heterogeneity in terms of their financial position, with some exhibiting lower deficits and others higher surpluses. To explore such heterogeneity, as part of sensitivity analysis, we estimate our fourth hospital Fixed Effects model in which costs are now directly standardised by the market forces factor z_k:

$$\ln\left(c_{jk} / z_k\right) = \mu + \beta' h_k + \delta e_{jk} + \alpha_j + \varepsilon_{jk} \qquad (14)$$

In this specification the specialist orthopaedic hospital dummy (s_k) in model (11) is replaced with a vector of hospital dummy variables h_k, and the vector β includes a coefficient for each hospital dummy. Suppose that the *k*-th estimated coefficient of vector β is positive $\hat{\beta}_k > 0$. This means that the T&O department of hospital *k* has lower profit margins than the average T&O department.[9] Unit costs are now standardised because the MFF, z_k, is perfectly

[9] Such an interpretation implies a different computation of the *overall* profitability evaluated at the average volumes $\bar{y}$ and $\bar{q}$, which becomes $\left(\bar{\pi}_k - \bar{\pi}\right)/\bar{C} = \left[\left(\bar{c}_k^{IN} - \bar{c}^{IN}\right)\bar{y} + \left(\bar{c}_k^{EB} - \bar{c}^{EB}\right)\bar{q}\right]/\left(\bar{c}^{IN}\bar{y} + c^{EB}\bar{q}\right)$, where $\bar{\pi}_k$ and $\bar{c}_k$ are the hospital *k*'s total profit and unit cost respectively averaged across HRGs and hospitals, $\bar{\pi}$ and $\bar{c}$

collinear with hospital dummies, h_k.

Unit costs are left-skewed. We take the logarithm of unit costs to improve model fit. In addition, we apply the logarithmic transformation to all continuous variables, except for variables expressed as percentages, in order to interpret the related estimated coefficients as elasticities. Dummy variables are interpreted as semi-elasticities.

4. Data

Our sample includes all inpatient HRGs delivered in the T&O department across 134 English hospitals. Our primary source of data is the 2013-14 NHS reference costs (RC) database, which contains information about both activity and costs and is used by the Department of Health to calculate national tariffs.[10] For every admission type of every single HRG in each hospital, it comprises information on *inlier* unit costs, *per diem* unit costs, number of patients and excess bed days. *Inlier* and *per diem* unit costs are identified through a top-down approach. This consists of grouping hospital total costs into direct costs (e.g. doctors, nurses), indirect costs (e.g. linen, catering) and overheads (e.g. managers, administrative employees).[11] Such costs are attributed to each hospital specialty and broken down into HRGs. Costs are further split by admission type: day case, elective, short non-elective and long non-elective. Admission of non-elective patients is unplanned. Day case and short non-elective patients do not have an overnight stay in hospital. Elective and long non-elective patients have at least one overnight stay. If the patient's length of stay is longer than a number of days specific to their HRG, additional days beyond this trim point are termed excess bed days.

The RC database, therefore, records the unit cost of every admission type under every

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are the total profit and unit cost respectively averaged across HRGs and hospitals, $\overline{C}$ is the total cost averaged across HRGs and hospitals, $\left(\overline{c}_k^{IN} - \overline{c}^{IN}\right) = \tilde{\beta}^{IN}\overline{c}^{IN}$ and $\left(\overline{c}_k^{EB} - \overline{c}^{EB}\right) = \tilde{\beta}^{EB}\overline{c}^{EB}$. Also in this case, the standard errors of the *overall* estimates are bootstrapped using 1,000 repetitions.

[10] https://www.gov.uk/government/publications/nhs-reference-costs-2013-to-2014.

[11] The costing process in 2013-14 was implemented using HRG version 4+ (Department of Health, 2014).

single HRG in each hospital. It provides the unit cost for treating a patient up to the length of stay trim point, which we define as *inlier* unit cost, and the unit cost of a bed day beyond the trim point, which we define as *per diem* unit cost.

Our sample for the analysis of *inlier* unit costs consists of 79,253 observations across 1,287 HRGs and 134 hospitals. Only a subset of observations has a length of stay that goes beyond the trim point. The sample for the analysis of per diem unit costs is therefore smaller, comprising 16,111 observations. Of the 79,253 observations employed for investigating *inlier* unit costs, 14,187 refer to day case, 18,208 to elective care, 19,537 are short non-elective, and 27,285 are long non-elective.[12]

For each HRG in each hospital we have a measure of the proportion of specialised orthopaedic services, which was obtained using summarised data originally from HES (Bojke, Grašič, & Street, 2015).[13] We collect several variables at hospital level. We construct a dummy taking value equal to one if the hospital is a specialist orthopaedic hospital, which is our key focus. We construct similar dummies for hospitals that are foundation trusts, teaching hospitals, and are located in London. Information on foundation trust status comes from the RC database, teaching hospitals are listed in the Organisation Patient Safety Incident workbook,[14] and the location in London is extracted from the health and social care information centre (HSCIC).[15] Using data from the NHS statistics, we construct dummies related to the size of the T&O department (small, medium, large, and very large), which are defined on the quartiles of the T&O beds distribution of all hospitals.[16] The RC database reports the market forces factor index that reflects hospitals' unavoidable geographical differences in non-medical staff and capital prices. From the HSCIC, we obtain data on

[12] Of the 15,970 observations producing excess bed days, 4,052 are elective and 11,918 are long non-elective.

[13] The count of specialised services is implemented by following the rules defined in the Prescribed Specialised Services (PPS), and not the criteria specified in the Specialised Services National Definition Sets (SSNDS).

[14] http://www.nrls.npsa.nhs.uk/patient-safety-data/organisation-patient-safety-incident-reports/directory/

[15] http://www.hscic.gov.uk/home.

[16] http://www.england.nhs.uk/statistics/http://www.england.nhs.uk/statistics/.

doctors[17] such as age, grade, full time equivalent ratio,[18] minimum and maximum salary to estimate the salary of each doctor employed in the T&O department of every hospital.[19] We then average doctors' salaries within each hospital. The HSCIC also provides PROMs (patient-reported outcome measures) data at hospital level. It includes the case-mix adjusted average change health status before and after the surgery taken from self-reports by patients having hip or knee replacement. We employ this as a measure of quality (Gutacker et al., 2013).

4.1. Descriptive statistics

Table 1 contains descriptive statistics of the variables measured at HRG level for the sample with observations of all admission types.[20] Our sample includes three specialist orthopaedic hospitals and 131 T&O departments in general hospitals. Specialist orthopaedic hospitals have on average higher *inlier* unit costs than T&O departments (£5,204 vs £2,992) and a higher number of patients per admission type per HRG (20 vs 12). The proportion of patients receiving specialised services per HRG is higher in specialist orthopaedic hospitals (1%) than T&O departments (0.1%).

The lower part of Table 1 also provides descriptive statistics for excess bed days. *Per diem* unit costs are on average higher in specialist orthopaedic hospitals (£465) rather than T&O departments in general hospitals (£301). There are on average 22 excess bed days per admission type per HRG, but many more in the specialist orthopaedic hospitals (45) than in T&O departments (22). The proportion of specialised services at HRG level with a *per diem* unit cost is also higher in specialist orthopaedic hospitals (2.7% vs 0.1%).

[17] Our definition of 'doctors' includes consultants, associate specialists, staff grade doctors, specialty doctors, HPCA (homeopathic pharmaceuticals and chemist association) doctors, and other doctors. It excludes doctors in training.

[18] The full time equivalent ratio is the proportion of the total number of paid hours during a period over the number of working hours in that period.

[19] The salary of a doctor employed in the T&O department is estimated through an s-shape function of age, minimum and maximum salary. Further details are provided in section A.1 of the appendix.

[20] Descriptive statistics of the variables measured at HRG level for the sample with day case and elective observations are reported in Table A1, and short non-elective and long-non elective observations are described in Table A2.

Table 2 illustrates descriptive statistics of the variables measured at hospital level. 80 (60%) hospitals have foundation status, and 28 (21%) trusts are teaching hospitals. Two of the specialist orthopaedic hospitals are foundation trusts but none is a teaching hospital. 15 hospitals are in London, one of which is specialised. On the basis of the quartile division, a T&O department is categorised as small if has less than 48 specialty beds. It is medium if has beds between 48 and 61. It is large if its beds are between 62 and 80, and very large if it has more than 80 specialty beds. Unsurprisingly, all specialist orthopaedic hospitals are considered very large. The MFF index varies between 1.003 and 1.298, and is on average 1.076. A doctor working in T&O earns on average £86,664. Doctors in specialist orthopaedic hospitals are paid on average 5.6% more than doctors in T&O departments.

Of all patients treated in the T&O specialty, 9.5% receive a hip replacement and 6.7% undergo a knee replacement.[21] Specialist orthopaedic hospitals have a higher average health gain for hip (0.442 vs 0.424) and knee (0.317 vs 0.315) replacement.

5. Results

Table 3 provides the estimation results of model (10), (11) and (13) for *inlier* and *per diem* unit costs when all admission types are included in the sample. This reports the estimated coefficient for each variable. Recall that unit costs are in logs. We can convert the dummy variables' estimated coefficient, for example $\hat{\beta}$, as $\tilde{\beta} = \exp\left(\hat{\beta}\right) - 1$ to report percentage changes (Halvorsen & Palmquist, 1980).

The first column of Table 3 shows the estimates of model (10), indicating raw differences in unit costs between specialist orthopaedic hospitals and T&O departments in general hospitals. Specialist orthopaedic hospitals have on average 16.1% ($\exp(0.149) - 1$) higher *inlier* unit costs. In contrast, they have on average 14.4% lower *per diem* unit costs.

The second column of Table 3 illustrates the results of model (11). This model provides

[21] We compute these percentages by selecting the codes W37, W38, W39, W46, W47, W48, W93, W94 and W95 for hip replacement, and W40, W41, W42 and O18 for knee replacement.

estimates of differences in unit costs after accounting for differences in payments. The specialist orthopaedic hospital dummy's estimated coefficient is therefore interpreted as the difference in profit margins between specialist orthopaedic hospitals and T&O departments in general hospitals. Specialist orthopaedic hospitals have on average 20.4% lower *inlier* profit margins but 24.1% higher *per diem* profit margins. A 1% increase in the proportion of specialised services lowers *inlier* profit margins by 1.2%. A 1% increase in MFF increases *inlier* profit margins by 0.95%.

The third column of Table 3 displays the estimates of model (13). We investigate whether differences in profit margins can be explained by our additional variables, but these tend to explain only a small amount of these differences. The *inlier* and *excess bed day* specialist orthopaedic hospital dummy's estimated coefficient never switches its sign or loses its statistical significance. We find that a 10% increase in the average salary of doctors increases *inlier* unit costs by 1.6%; foundation trusts have on average 4.7% lower *inlier* unit costs; teaching trusts have 4.7% higher *inlier* unit costs; and hospitals in London have on average 2.5% lower *inlier* costs after accounting for the MFF index.

Estimates on size dummies suggest the presence of non-linear economies of scale. Medium and large T&O departments have 0.9% and 1.2% lower *inlier* costs than small T&O departments, respectively. Very large T&O departments (which include the specialist orthopaedic hospitals) appear to exhibit diseconomies of scale with 5.1% higher *inlier* costs than smaller T&O departments.

The patient outcomes for hip and knee replacement have on average a different impact on *inlier* costs. A 10% higher average health change of patients having hip replacement are associated with 2.7% higher costs. A 10% increase in the average health change for knee replacement implies instead 1.2% lower *inlier* costs.

So far, we have presented our findings on specialist orthopaedic hospitals for *inlier* and *excess bed day* hospital activity, separately. Table 4 reports the *overall* percentage change in unit costs ($\tilde{\beta}$) between specialist orthopaedic hospitals and T&O departments in general hospitals for each admission type. For brevity, consider all admission types. The first column

of Table 4 shows the percentage changes derived from model (10). The *overall* unit costs in specialist orthopaedic hospitals are 11.3% greater than T&O departments', although the estimated coefficient is not statistically significant.

The second column refers to model (11). When hospital revenues are taken into account, specialist orthopaedic hospitals have on average 13.5% lower *overall* profit margins than T&O departments, at 1% of statistical significance. This means that specialist orthopaedic hospitals are less financially viable than T&O departments under the current NTPS.

Finally, the third column of Table 4 illustrates the percentage change related to model (13). The *overall* profit margins in specialist orthopaedic hospitals are 10.5% lower than T&O departments after controlling for some key determinants, which include the salary of doctors, hospital characteristics, specialty size, and quality.

5.1. Sensitivity analysis

As a sensitivity analysis, we estimate the same three models for each admission type. Sign, magnitude and statistical significance of the specialist orthopaedic hospital dummy's estimated coefficient are substantially consistent across admission types. As shown in Table 4 (second column), *overall* differences in profitability between specialist orthopaedic hospitals and T&O departments in general hospitals are found for elective (22.6%), long non-elective (38.8%), short non-elective (34.1%) and, to a lesser extent, by day case (2.9%) activity.

Finally, estimation of model (14) shows wide variation in *overall* (*inlier*) profit margins across hospitals from 38% (40.6%) higher to 37.5% (38.6%) lower than the average T&O department, as shown in Figure 1. On average, 30 T&O departments (22.4%) have significantly lower *overall* profit margins, and 28 (20.9%) have significantly higher *overall* profit margins. If we assume that the average department breaks even, then T&O departments with lower profit margins may run a deficit. Specialist orthopaedic hospitals never have *overall* (*inlier*) profit margins significantly higher than the average. In particular, the Robert Jones and Agnes Hunt orthopaedic hospital (minus 19.9%) and the Royal orthopaedic hospital (minus 35.2%) have statistically significant lower *overall* profit margins than the

average. The Royal National orthopaedic hospital has average *overall* profit margins. The latter finding is due to higher profit margins on the day case activity (40.6%), as shown in Table 5.

6. Discussion and conclusion

The English National Tariff Prospective System is used to reimburse hospitals according to the amount and mix of activity that they undertake. Like most prospective payment systems, there is a recognition that HRGs imperfectly account for all patient or exogenous hospital characteristics that might influence costs (Busse, 2012; Monteith, 2013). As such, payment adjustments include top-ups to the tariff if patients received particular specialised care and payment corrections allow for differential costs of labour and capital across the country. These refinement help ensure a fair reimbursement system that rewards hospitals according to the care that they provide, not the advantageous circumstances in which they might operate (Daidone & Street, 2013; Grašič et al., 2015).

Given these payment adjustments, hospitals that provide care at a cost below tariff should be more profitable. Arguably specialist hospitals should be in a strong position to benefit financially from these arrangements. By focussing on a limited set of services they should be able to better exploit informational or organisational advantages associated with specialisation. Such advantages derive from concentrating on a specific, defined caseload that enhances learning-by-doing and attracts staff with particular expertise and more easily allows efficient practice in care delivery to be identified and operationalised (Schneider et al., 2008).

If these advantages obtain in practice, not just theory, we would expect specialist hospitals to earn higher profits than general hospitals that undertake similar activities. Such were our expectations, but they have not been realised in this study. We have analyses the revenues and costs associated with delivery of trauma orthopaedic services in all three specialist orthopaedic hospitals and all 131 T&O departments in general hospitals in England. We find that, compared to the national average, profit margins are 13.5% lower in specialist orthopaedic hospitals. Profits are lower across all patient types: whether elective or non-

elective admissions, and for day case patients or those with short or long lengths of stay.

These lower profits cannot be explained by the characteristics of the hospital such as their teaching status or geographical location, nor by the number of the T&O patients treated, nor by variation in doctors' salaries. Lower profits are observed even after these are taken into account. Similarly, lower profits are not the consequence of specialist hospitals providing higher quality care. We account for changes in health status reported by patients that have either hip or knee replacement using the national data that underpin the best practice tariff pay-for-performance scheme. Differentially lower profits are still observed.

Nor does it appear that the differences are due simply to patients in specialist hospitals having care needs that are inadequately reflected in the design of HRGs. Payment arrangements allow for this possibility, with excess bed day payments made for patients with long lengths of stay and additional compensation provided to cover the costs of those identified as having received specialised care. We account for these revenue adjustments in our analysis.

This leaves two remaining explanations. First, there may be factors that explain costs that we have been unable to observe and account for. These might include other measures of patient complexity or organisational characteristics. But, if these matter for our analysis, they should also be considered for inclusion in payment arrangements, our analysis mirroring these as closely as possible.

The second explanation is that specialist hospitals may not be as efficient as advocates proclaim. At least for the T&O services that we consider, it may be better financially to manage and operate services as part of a larger organisational entity. This might allow T&O departments to benefit from economies of scope, including access to a larger pool of staff and shared facilities such as operating theatres and pharmacy. That said, being part of a general hospital does not guarantee better financial performance. 19.4% of the T&O departments in this study had not statistically different *overall* profit margins than the least profitable of the three specialist hospitals.

Future research may be required before a definitive recommendation about the most profitable way to organise trauma and orthopaedic services. But we have set out a methodology that can be applied to other types of hospital service and in other settings, to investigate the extent to which differences in costs between groups of hospitals are adequately covered by prospective payment systems.

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Tables and Figures

Table 1 – Descriptive statistics of variables measured at HRG level.

	Variables at HRG level	All hospitals				Specialist hospitals				General hospitals			
		Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Inlier	Inlier unit cost	3,036	3,495	22	129,419	5,204	5,204	8,578	173	2,992	3,297	22	78,447
	Number of FCE	12.2	37.4	1	1,622	20.0	20.1	57.43	1	12.1	36.9	1	1,622
	Number of specialised services	0.05	0.73	0	55	0.50	0.65	4	0	0.04	0.42	0	26
	Proportion of specialised services (%)	0.1	1.7	0.0	100.0	1.0	1.1	6.1	0.0	0.1	1.5	0.0	100.0
	Number of HRGs	1,287				423				1,275			
	Observations	79,253				1,582				77,671			
Excess bed day	Per diem unit cost	305	474	20	54,422	465	2,867	65	54,422	301	187	20	9,499
	Number of excess bed days	22.3	35.5	1	715	44.8	81.8	1	715	21.7	33.4	1	538
	Number of specialised services	0.11	1.31	0	55	1.95	7.56	0	55	0.07	0.56	0	26
	Proportion of specialised services (%)	0.2	2.0	0.0	69.2	2.7	9.6	0.0	69.2	0.1	1.3	0.0	45.6
	Number of HRGs	678				183				665			
	Observations	16,111				373				15,738			

Table 2 – Descriptive statistics of variables measured at hospital level.

Variables at hospital level	All hospitals			
	Mean	SD	Min	Max
Specialist orthopaedic hospital	0.022	0.148	0	1
Market forces factor	1.076	0.064	1.003	1.298
Salary of doctors (£10,000)	8.664	0.744	6.596	10.060
Foundation hospital	0.597	0.492	0	1
Teaching hospital	0.209	0.408	0	1
London	0.112	0.316	0	1
Small department	0.299	0.459	0	1
Medium department	0.254	0.437	0	1
Large department	0.231	0.423	0	1
Very large department	0.216	0.413	0	1
Primary hip replacement score	0.425	0.028	0.311	0.476
Primary knee replacement score	0.315	0.028	0.215	0.396
Number of trusts	134			

Table 3 – Estimation results when all admission types are included.

Regressors	Inlier			Per diem		
	(10)	(11)	(13)	(10)	(11)	(13)
Specialist orthopaedic hospital	0.149	0.185	0.149	-0.156	-0.276	-0.221
	(0.018)***	(0.009)***	(0.009)***	(0.017)***	(0.021)***	(0.022)***
Log of market forces factor		0.940	0.853		0.386	0.383
		(0.028)***	(0.044)***		(0.067)***	(0.113)***
Proportion of specialised services (%)		1.223	1.172		0.323	0.341
		(0.109)***	(0.108)***		(0.126)**	(0.125)***
Log of salary of doctors			0.166			-0.268
			(0.019)***			(0.047)***
Foundation hospital			-0.048			0.054
			(0.003)***			(0.008)***
Teaching hospital			0.046			0.018
			(0.004)***			(0.009)**
London			-0.025			0.057
			(0.008)***			(0.020)***
Medium department			-0.009			0.022
			(0.005)**			(0.013)*
Large department			-0.012			0.004
			(0.005)**			(0.013)
Very large department			0.050			-0.052
			(0.005)***			(0.013)***
Log of hip replacement health change			0.271			-0.743
			(0.026)***			(0.068)***
Log of knee replacement health change			-0.115			0.066
			(0.021)***			(0.053)
Constant	7.617	7.550	5.780	5.552	5.528	7.984
	(0.003)***	(0.002)***	(0.219)***	(0.004)***	(0.006)***	(0.545)***
HRG fixed effects	NO	YES	YES	NO	YES	YES
Observations	79,253	79,253	79,253	16,111	16,111	16,111
R-squared	0.001	0.804	0.807	0.005	0.130	0.152

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 4 – Differences in unit costs between specialist orthopaedic hospitals and T&O departments in general hospitals.

	Inpatient activity	(10)	(11)	(13)
All admission types	Overall[1]	0.113	0.135	0.105
		(0.083)	(0.032)***	(0.032)***
	Inlier	0.161	0.204	0.161
		(0.018)***	(0.009)***	(0.009)***
	Per diem	-0.144	-0.241	-0.198
		(0.017)***	(0.021)***	(0.022)***
Elective	Overall[1]	0.253	0.226	0.135
		(0.071)***	(0.026)***	(0.025)***
	Inlier	0.310	0.282	0.182
		(0.022)***	(0.011)***	(0.012)***
	Per diem	-0.225	-0.248	-0.254
		(0.022)***	(0.025)***	(0.032)***
Long non-elective	Overall[1]	0.598	0.388	0.330
		(0.131)***	(0.046)***	(0.045)***
	Inlier	0.741	0.499	0.418
		(0.063)***	(0.035)***	(0.035)***
	Per diem	-0.140	-0.192	-0.131
		(0.034)***	(0.040)***	(0.040)***
Short non-elective		0.313	0.341	0.395
		(0.134)**	(0.099)***	(0.096)***
Day case		-0.071	0.029	0.041
		(0.024)***	(0.016)*	(0.018)**

[1] Standard errors are bootstrapped and reported in parentheses

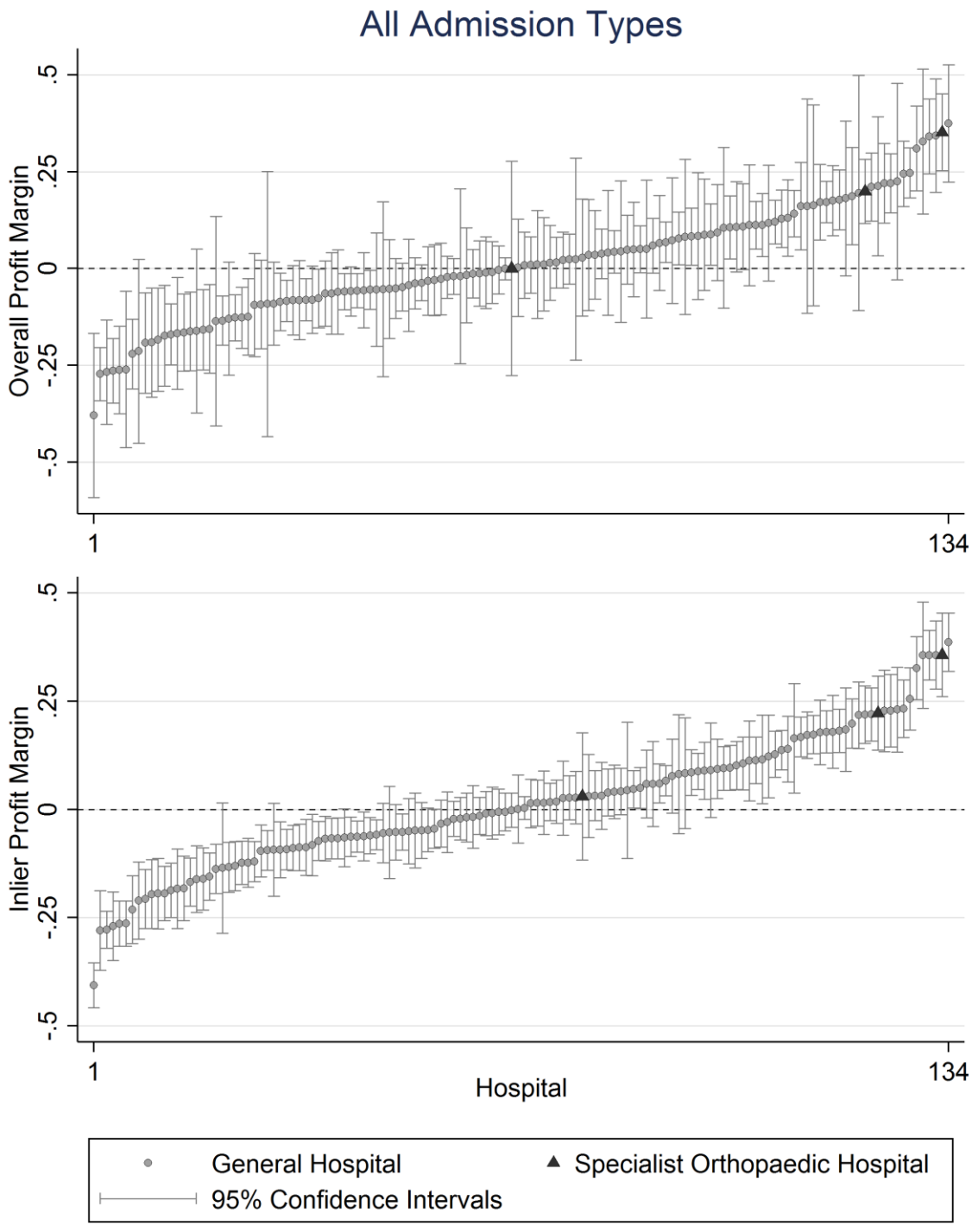
*** p<0.01, ** p<0.05, * p<0.1

Table 5 – Specialist orthopaedic hospitals' *overall* profit margins.

Specialist orthopaedic hospital	All admission types	Day case	Elective	Short non-elective	Long non-elective
Royal National Orthopaedic Hospital NHS Trust	0.0%	40.6%*	-30.6%*	-84.2%*	-80.6%*
Robert Jones And Agnes Hunt Orthopaedic Hospital NHS Foundation Trust	-19.9%*	-21.5%*	-18.0%*	4.2%	-4.8%
Royal Orthopaedic Hospital NHS Foundation Trust	-35.2%*	-29.5%*	-29.0%*	-70.7%*	-30.6%*

* significantly different from the average hospital at 5%

Figure 1 – Distribution of *overall* and *inlier* profit margins.



Appendix

A.1 Estimation of the salary of doctors

We assume that the salary of doctors follows an s-shape function depending on age, minimum and maximum salary. This means that salary rises with increasing returns in the first half of the working life, and it goes up with decreasing returns during the second half. In symbols, we estimate the salary as follows:

$$w_{nk} = f_{nk} \cdot W\left(w^{\min}, w^{\max}, A_{age}\right) \tag{15}$$

where w_{nk} is the salary of doctor $n(=1,...,N)$ in hospital k, f_{nk} is the full time equivalent ratio[24], W is the s-shape salary function, $w^{\min}$ and $w^{\max}$ are the minimum and maximum salary associated to the doctor's grade, and A_{age} is a coefficient varying depending on the doctor's age. The salary function W can be represented as follows:

$$W\left(w^{\min}, w^{\max}, A_{age}\right) = \begin{cases} w^{\min} & \text{if} \quad age < 30 \\ w^{\min} + \dfrac{w^{\max} - w^{\min}}{A_{age}} & \text{if} \quad 30 \le age < 50 \\ w^{\max} - \dfrac{w^{\max} - w^{\min}}{A_{age}} & \text{if} \quad 50 \le age < 70 \\ w^{\max} & \text{if} \quad age \ge 70 \end{cases} \tag{16}$$

where,

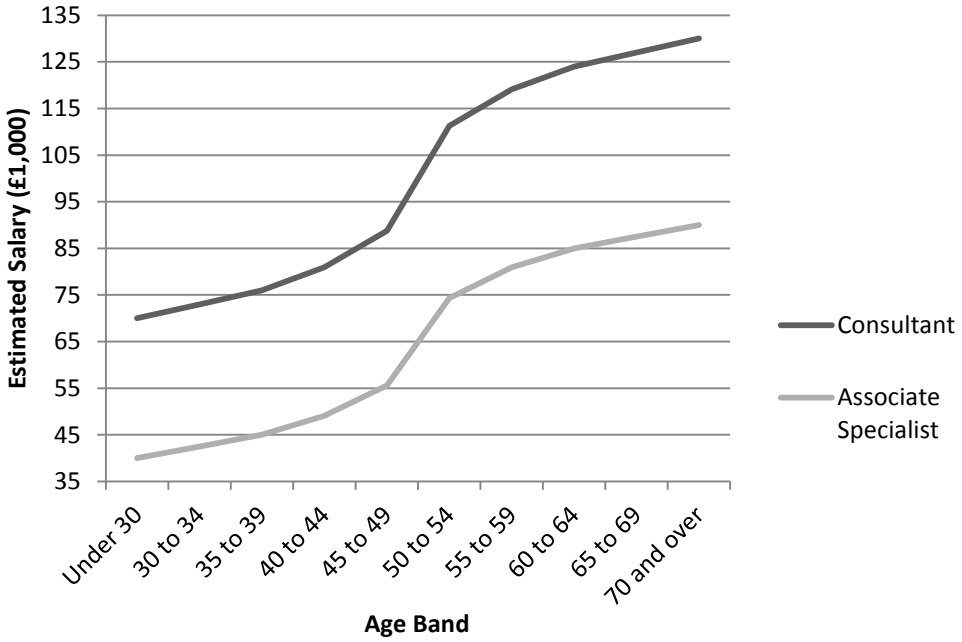
$$A_{age} = \begin{cases} 20 & \text{if} \quad 30 \le age \le 34 \quad \text{or} \quad 65 \le age \le 69 \\ 10 & \text{if} \quad 35 \le age \le 39 \quad \text{or} \quad 60 \le age \le 64 \\ 5.5 & \text{if} \quad 40 \le age \le 44 \quad \text{or} \quad 55 \le age \le 59 \\ 3.2 & \text{if} \quad 45 \le age \le 54 \end{cases} \tag{17}$$

In Figure A1, we illustrate the salary function $W(\cdot)$ for consultant and associate specialist

[24] The full time equivalent ratio is the proportion of the total number of paid hours during a period over the number of working hours in that period.

doctors.

Figure A1 – Estimated salary function for consultants and associate specialists



The average salary of doctors in hospital k (w_k) is therefore calculated as follows:

$$w_k = \frac{\sum_n w_{nk}}{N_k} \tag{18}$$

Table A1 – Descriptive statistics for day case and elective activity.

	Variables at HRG level	All hospitals		Specialty hospitals		General hospitals	
		Mean	SD	Mean	SD	Mean	SD
	Day case						
	Inlier unit cost	1,408	876	1,490	973	1,406	872
	Number of FCE	26	67	33	77	25	66
	Number of specialised services	0.07	0.75	0.43	3.10	0.06	0.52
	Proportion of specialised services (%)	0.2	1.8	0.6	4.2	0.2	1.6
	Number of HRGs	509		239		490	
	Observations	14,187		442		13,745	
	Elective						
Inlier	Inlier unit cost	3,682	3,633	5,993	8,875	3,585	3,200
Inlier	Number of FCE	16	42	23	57	15	41
Inlier	Number of specialised services	0.07	0.94	0.60	4.03	0.05	0.47
Inlier	Proportion of specialised services (%)	0.2	2.3	1.2	6.2	0.2	1.9
Inlier	Number of HRGs	731		357		696	
Inlier	Observations	18,208		729		17,479	
Excess bed day	Per diem unit cost	358	897	563	3,450	344	245
Excess bed day	Number of excess bed days	19	34	49	92	17	25
Excess bed day	Number of specialised services	0.24	1.91	1.65	6.66	0.14	0.88
Excess bed day	Proportion of specialised services (%)	0.4	2.9	2.5	9.0	0.3	1.8
Excess bed day	Number of HRGs	312		151		281	
Excess bed day	Observations	4,087		257		3,830	

Table A2 – Descriptive statistics for short non-elective and long non-elective activity.

	Variables at HRG level	All hospitals		Specialty hospitals		General hospitals	
		Mean	SD	Mean	SD	Mean	SD
	Short non-elective						
	Inlier unit cost	1,255	1,387	2,214	3,431	1,249	1,363
	Number of FCE	6	12	1	1	6	12
	Number of specialised services	0.03	0.39	0.20	1.90	0.03	0.36
	Proportion of specialised services (%)	0.1	0.8	0.4	3.8	0.1	0.8
	Number of HRGs	839		101		837	
	Observations	19,573		123		19,450	
	Long non-elective						
Inlier	Inlier unit cost	4,730	4,254	10,181	12,150	4,672	4,050
Inlier	Number of FCE	8	17	3	3	8	18
Inlier	Number of specialised services	0.04	0.76	1.31	6.28	0.03	0.37
Inlier	Proportion of specialised services (%)	0.1	1.7	1.9	8.4	0.1	1.4
Inlier	Number of HRGs	1,028		175		1,026	
Inlier	Observations	27,285		288		26,997	
Excess bed day	Per diem unit cost	286	162	247	148	287	162
Excess bed day	Number of excess bed days	23	36	35	53	23	36
Excess bed day	Number of specialised services	0.07	1.02	2.61	9.25	0.04	0.40
Excess bed day	Proportion of specialised services (%)	0.1	1.6	3.2	10.8	0.1	1.1
Excess bed day	Number of HRGs	650		86		646	
Excess bed day	Observations	12,024		116		11,908	