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Why does productivity vary across NHS hospital trusts in England? Untangling how management competence and the use of ICTs shape hospitals' performance

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Abstract: The NHS is one of the largest UK industries, yet the study of health service productivity has historically been very strongly limited by an inability to measure outputs or to control for quality variations across outputs, together with a now past prejudice against directly seeking to measure government sector productivity. Even the best modern analyses have also been constrained by difficulties in specifying relatively intangible independent variables that are of central interest. We contribute to overcoming these barriers by developing a cost-weighted and quality-weighted measure of outputs across 153 NHS hospital trusts in England covering inpatient hospital stays and outpatients appointments. We ally this with a web-census method for developing indicators of hospital trusts' management practices and development of information and communication technologies (ICTs) in services provision. We explore the influence of these two independent variables on productivity and find significant but interactive effects. Where acute trusts are poorly managed, developing ICTs has a striking effect in improving hospital productivity, but this effect tapers off in medium and well managed trusts. Improving management practices in trusts with already good levels of ICT has negative effects on productivity. Our findings also show strong London versus regional, and specialist hospital effects.

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The UK's National Health Service is one of the largest connected set of public sector organizations in Europe, and on a par with the more provincialised or mixed health systems of large countries such as China and India. How the UK system is managed has been a constant focus of government attention, and of frequent reorganizations and new initiatives, in almost every year of the last three decades. The investments made in improving managerial practices and competencies, modernizing business processes and developing NHS leadership and best practice have cumulatively cost hundreds of millions of pounds since 1997 when new Labour first took office. The importance of managerial quality continues to be regularly stressed not only in the professional discourse of NHS managers themselves, but also in the declarations of relevant government departments (especially the Department of Health) and many different health regulatory bodies. Not surprisingly, given this emphasis, many healthcare trusts have been adopting different organisational and management approaches in recent years to improve the provision of their services.

Historically the NHS was very slow to adopt modern ICTs and to seek to digitize information, transform business processes using network and database ICTs, and engage with their patients and stakeholders using internet-based digital processes. Substantial barriers remain that keep the UK's hospital sector one of the largest and most conspicuously digital-lagging service industries. However, since a major commitment made under Tony Blair's premiership in 2002, the NHS at national level has invested significant resources in the National Programme for IT (NPfIT). Some estimates argue that by April 2010, the NHS will have spent around £6 billion in rolling out of this programme (*Computer Weekly*, 2010). Some NPfIT features, such as the electronic patient care records, have not yet been fully implemented nationwide. But many of the supporting e-services and systems that form important parts of the national framework (such as online systems for storing and communicating digital X-ray pictures) are now operational to varying degrees at local and regional level. It seems safe to assume that the complete implementation of some NPfIT features and the partial implementation of most features on this massive scale should already be having some observable potential effects on productivity levels.

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In this paper we seek to assess how far these interconnecting factors have begun to achieve traceable impacts on healthcare trusts' performance. Untangling the effects of management quality and use of ICTs within the NHS context should contribute both to the wider literature on government productivity (which we review in section 1 below), as well as having significant interest for scholars in areas like health service management, e-health and perhaps health-informatics.

Our first main innovation concerns the key dependent variable for this analysis, which is labour productivity in the NHS acute sector. Calculated as the ratio of our measure of outputs to the number of medical staff, labour productivity becomes a reliable comparable performance measure when used across different units because of utilising a common denominator. Our output measure is primarily based upon the number of outpatient appointments and inpatients spells, but adjusted for cost relativities so as to account for the different costs of 'producing' a unit of outpatient appointments and inpatients spells. Because quality variations across units may otherwise 'perverse' effects into productivity analyses, we also quality weight our productivity measure, reflecting current best practice in the study of productivity among decentralised public services where quality variations may potentially play a significant role (ONS 2007). Our resulting productivity measure is thus a unit of cost-weighted and quality-weighted output per medical employee (that is doctors and nursing staff).

Our second key contribution is to innovate in how we develop independent variables that capture significant variations in the quality of management and the use of ICT across hospital trusts in England. We have developed a range of unobtrusive measures that we believe help us to 'fix' these variables with a better evidence base than previous studies. Our database incorporates measures of ICT and management practices that are based on web-census measures. Previous research in this area has employed measures based on surveys circulated among a tiny number of senior management or medical staff in each trust (most recently, see Bloom et al. 2009). Such restricted surveys may be methodologically sophisticated in various ways, for example in converting qualitative responses into multi-criteria and well-coded data. And interview-based measures can also probe directly to assess less tangible or externally visible aspects of management practices. Yet there is an inherent danger of

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any reactive survey method, of eliciting 'spin' or 'public relations' responses , and this problem is magnified when a whole organization's management practices or use of IT are characterized only on the basis of one or two respondents. Here we believe that web-census measures have a key role to play in developing non-reactive and unobtrusive measures of our key independent variables because they are based on indicators reflecting the presence or absence of multiple ICT and management practices in each organization's website (see Dunleavy, 2010 for a broader discussion).

We proceed as follows. The first section reviews the most relevant literature on ICT, management and productivity that has initially originated in private sector firms and organizations, and then looks at the recent shift of attention towards understanding the determinants also of public sector organizations' productivity. One of the main insights from this literature is that the effects of ICT and management on productivity are far from being independent from each other. Accordingly, interactive models are best fitted to empirically analyse the complex effects in this area. Section 2 introduces our methodology, which includes a new database covering 153 NHS acute trusts. We set out a new approach to calculating labour productivity ratios in hospitals, following scholarly and practitioner best practice on the measurement of public sector productivity (ONS, 2007; ONS, 2008). The database also incorporates new unobtrusive measures of ICT and management quality. Section 3 shows how we test for the interactive effects of ICT and management on hospital productivity, showing that the effects of ICT on productivity are conditional on levels of management, and vice-versa. One of the interesting insights is that ICT has a positive and statistically significant effect on productivity for trusts only with low to medium-low levels of management. This suggests that as hospital trusts get more complex and better managed, ICT may play a less central role in improving productivity. The conclusions summarise the preliminary findings of this research and suggest some paths for further work.

1. The general impact of management and ICT on productivity

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The literature on the determinants of productivity has expanded considerably in the private sector since the 1980s. Meanwhile, comparable empirical literature on the public sector has only started to build up in recent years, for several reasons. Until not too long ago, because of the difficulties of measuring outputs, government sector outputs were given the same price as the costs of producing them in national statistics and economic analyses. This is equivalent to assuming that productivity in the public sector is always flat. This 'flat productivity' technical assumption has never been justified, especially in the modern period where the public and private sectors often provide similar services – for example, it is clearly inconsistent to expect private sector healthcare to grow productivity each year, but not to have at least somewhat similar processes occur in public hospitals doing the self-same tasks. The business processes of government bureaucracies have also been extensively reviewed and transformed on private sector lines. We thus briefly review some of the most relevant literature on the private sector, and its carry-overs into the public sector.

Private corporations have invested heavily in improving their ICT and management practices, given that both are expected to affect productivity. Yet, how they specifically interplay has often been subject to some controversy. The biggest literature analyses the role of ICT in the private sector. Here scholars have usually followed a parametric approach, estimating a production function where ICT capital is considered as a separate input. Using regression analysis, these works then attempt to test whether ICT expenditure is statistically related to output. Early analyses following this approach found no clear evidence that ICT investment was significantly and positively related to output, coining the idea of an 'IT paradox' (Bailey and Gordon 1988; Solow 1987). However, later research since the 1990s has reversed position, finding strong evidence of a statistically positive relationship from ICT on productivity at the firm level (Brynjolfsson and Hitt 1996; Lichtenberg 1995). More recent literature has concluded that ICT indeed impacts positively on output and productivity. Earlier studies may not have found a significant relationship due to measurement problems because of relying on very aggregated data. Or alternatively, a dialectic of ICT advances in recent years in networking (which foster organizational centralization, especially of control functions) and in databases (which support decentralized work processes) may have substantially improved the contribution that

ICTs can make to productivity, when allied with other organizational and business process changes (Bloom et al, 2009).

Following a production approach, Bresnahan et al (2002) analysed a sample of 300 large US firms and they found that ICT investment contributed strongly to increased output and productivity. This study also employed survey data on organisational changes and management practices and was one of the first to demonstrate that ICT investment *combined with* changes in management practices leads to increased productivity. This key contribution is often referred as the organisational complementarity hypothesis. A similar approach has been followed by Caroli and Van Reenen (2001) and Bloom et al. (2005) in their analysis of manufacturing firms. These studies also find support for the complementarity hypothesis about ICT and management practices.

Providing further evidence to solve the apparent 'IT paradox' highlighted by studies in the 1980s and early 1990s, Brynjolfsson and Hitt (2003) found that computerization makes a contribution to measured productivity and output growth in the short term (using 1-year differences), which is consistent with normal returns to computer investments. However, they also found that the productivity and output contributions associated with computerization were up to 5 times greater over long periods (using 5-year to 7-year differences). Thus, this article makes the key point that investment in ICT may pay off most significantly after a certain 'adaptation period.' This insight has also been successfully tested by Bartel et al. (2007) in their analysis of firms in the valve manufacturing industry.

More recently, Giuri et al (2008) in an analysis with panel data from 680 small and medium sized (SME) Italian manufacturing firms found that ICT positively affects output and productivity. However, they do not find that ICT and organisational changes are related to increased productivity, contrary to the organisational complementarity hypothesis. The authors explain their finding on the grounds that compared with large firms, SME's face greater difficulties in managing different inventions at the same time – especially in finding and retaining highly skilled personnel and re-engineering their business processes to fully integrate ICT into their organization. They argue, accordingly, that the interaction between ICT and management may be more complex than perhaps analysts initially thought.

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Most private sector studies relied chiefly on measures of ICT expenditure to gauge organizational commitment to new computerization, automation or Internet-based technologies. Equally, while a firm may spend significantly on ICT, the specific impact of ICT infrastructure will depend on how much it is used by the firm's employees for productivity-enhancing activities. Especially since the advent of the Internet and web era, the most advanced technologies are no longer necessarily the most expensive ones in equipment or staffing terms. Instead of costs, the primary barriers to adopting web-based technologies may be cultural and organizational conservatism and lack of appropriate expertise. Accordingly more recent studies have increasingly sought to employ more direct measures of ICT use. For example, Aral et al. (2007) in a study of a large recruiting firm rely on innovative measures of ICT use, rather than on expenditure, to gain a much clear picture of the impact of ICT. They found that ICT use positively affects revenue and productivity in their detailed case study. Other studies in the private sector have adopted a similar approach (Bhansali and Brynjolfsson 2008).

Moving to the public sector, relatively fewer studies have looked at the impact of ICT on productivity (Landsbergen and Wolken 2001). Lehr and Lichtenberg (1998) found evidence that ICT investment positively contributes to output and productivity growth when applying a production function approach. Meanwhile, more recent work has found that the effect of ICT use and management practices on productivity is not an additive and independent one but, rather, an interactive one (Garicano and Heaton 2007). This finding is similar to the one of Caroli and Van Reenen (2001) and Bresnahan et al (2002) in the private sector.

In the specific area of health in the UK, recent studies have looked at aggregate productivity trends in the NHS for a number of years since the late 1990s. Their general conclusions are that productivity trends have generally been negative over time (Castelli et al 2007). A similar pattern has been found in recent ONS publications that also analyse productivity trends in healthcare provision in the UK (ONS 2008). These works mention that such negative trends may be a consequence of the significant investments in ICT and organisational changes that the Labour government has implemented since 1997. However, they do not provide any more

direct empirical evidence of how ICT and management affect the performance of English hospital trusts.

Turning to the influence of management quality and management practices on productivity, the literature here is smaller, partly because specifying the independent variable is more difficult. There are no easy to access or straightforward indicators of how organizations are managed equivalent to data on how much is spent of ICTs or how ICTs are deployed in attaining organizational objectives. One approach pioneered by Bloom and Van Reenen (Bloom et al, 2005) focuses on using carefully structured phone interviews to produce scale scores across many dimensions normally handled using rich qualitative data or accessed only via case studies. Applying this approach to a set of manufacturing firms with whom the consulting firm McKinsey has links, the analysts used phone calls to one or two people per firm to characterize the modernity of its management practices and their impacts on productivity and profitability. The analysis found that there were strong influences from the adoption of lean processes and more decentralized and open management practices that effectively communicated to the workforce how their activities shaped the patterns and trends in productivity.

Recently the same team has applied a similar approach to the analysis of how management practices influences hospital performance in England (Bloom, 2009). Again the independent variable is coded from information gained by phoning one or two people per trust, either senior administrators or a senior medical figure, and only sometimes both. A multivariate analysis controlling for a large number of other variables is used, and the conclusions generally find much the same influences of management practices on overall organizational performance as were found with manufacturing firms. The dependent variable focus here was less on productivity than on the rating of hospital trusts' overall performance by regulators, along with some other indicators (such as mortality rates)

Finally, some literature on innovation among public sector organisations makes the case for showing that investment on research and development and training of staff are significant drivers of output and productivity growth (McNabb 2006; Audretsch 2008). Thus, the possible effect of staff training should not be

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underestimated in empirical analysis of productivity among public sector organisations.

An interim conclusion from this review is that there seems to be considerable opportunities for improving on our knowledge by studying the determinants of productivity across healthcare trusts, since most of the evidence provided so far has tended to look at the aggregate level (Castelli et al 2007, ONS 2008). Second, the literature on productivity in the private and the public sector indicates that the effect of ICT and management on productivity should be explored further – especially because there is some potential for 'equifinality', meaning in this context that ICT and management may positively impact on productivity in different ways. Progress here is likely to depend in part on finding a better means of directly characterizing the management and ICT behaviours of organizations that are otherwise relatively intangible. Third, the effect of staff training should also be considered in empirical studies. We turn next to how these pointers can be acted upon.

2. Methodology and variable specification

Our study sought to cover all Acute Health Care and Foundation trusts in England, that is, the 171 organizations who between them are responsible for the management of all 478 hospitals. We focus only on acute healthcare trusts because this sector absorbs a large portion of the health care budget, involves the biggest and most complex organizations and handles the most difficult and expensive medical cases. These key characteristics mean that government targets, advice and programmes designed to encourage the use of new ICTs and management practices have all focused very heavily on acute trusts. So this is an area where we might hope to find the most evidence of management quality and ICT variables shaping overall productivity, if this proves to be the case.

While conducting the study, we found that 15 trusts have changed their name and 8 trusts have merged into 4 new ones, while one trust had more of a primary care character (see notes to Annex Table A.2). This brought the total number of trusts analysed down to 166. In the case of the trusts that merged, we did an average of the available data, so that our final measure of output and productivity reflected the work

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and resources of the hospitals included in the new trusts. For a further 13 trusts within this group we could not obtain a complete measure of output quality, and therefore, productivity. This is chiefly because there were no data available on complaints, patients satisfaction or mean waiting times – the three variables which we used to quality adjust outputs (see below). Therefore, we ended up with a total dataset covering 153 acute trusts.

The database contains variables such as output and productivity, use of ICT, management practices, staff satisfaction, R&D expenditure and training, amongst others. It was primarily constructed using data from the following sources:

- A database compiled by the Centre of Economic Performance (CEP) at the LSE on Acute trusts across England based on publicly available sources. From this database we took the relevant information on each Acute Trust related to service quality, waiting times and patient satisfaction.

- NHS Information Centre data on complaints management and Medical workforce. These are two separate databases available on the Centre's website. The first one, includes total number of complaints, complaints handled within the target time (25 working days), complaints handled outside the target times and complaints that are still being pursued. The second one, includes total number of medical staff broken down by grade in each health organisation.

- Hospital Episodes Statistics. This database from Hospital Providers contains data on finished consultant episodes, outpatients appointments, mean waiting times and patients' age.

- NHS Staff Satisfaction Survey 2008. This survey contains a series of variables about staff commitment to their work, whether training has been provided in the last year, and the amount of unpaid overtime.

- Web-censuses conducted by LSE Public Policy Group of hospital trusts' visible use of management practices and ICT practices. This was one of the major features of this research. We collected information on ICT use and Management practices in each Trust. Each measure was computed as the sum of the values for a number of dummy indicators related to the recorded presence or absence of specific ICT and Management aspects (For a detail of the composition of the ICT and Management measures see Tables A2 and A3 in the Annex).

Our key innovations focus on the development of cost-weighted and quality-weighted productivity measures, and on the specification of the independent variables relating to management practices and ICT use. We discuss each in turn.

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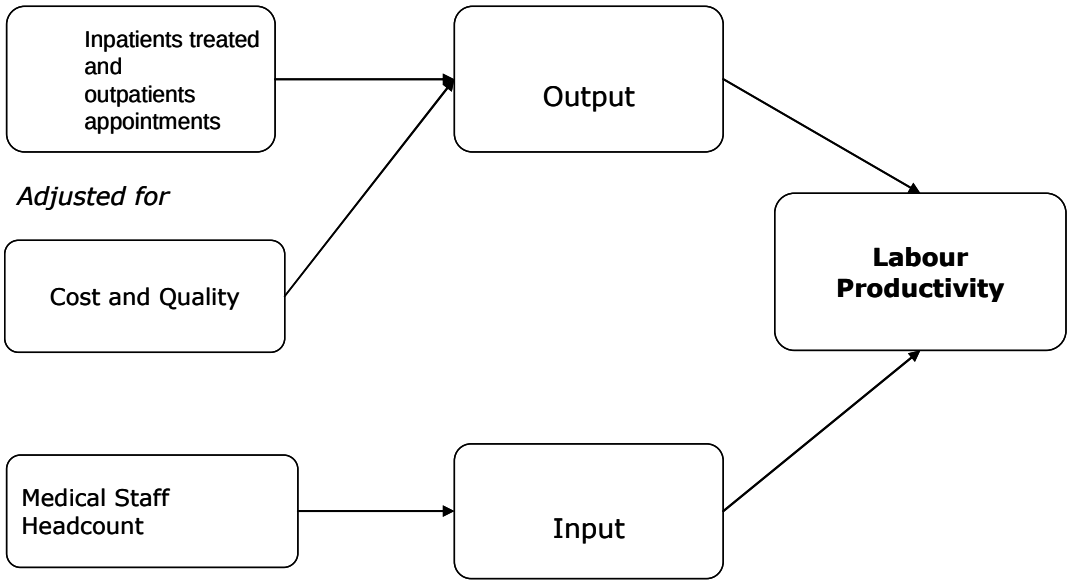
(a) Cost- and quality weighted productivity measures

To calculate labour productivity ratios for the different trusts we re-adapted the methodology for calculating productivity as developed in the Atkinson Review (2005) and different publications from the Office of National Statistics (ONS). This entailed calculating a cost and quality adjusted measure of output that was then divided by the number of medical staff in each trust. We explain our approach in further detail below, but Figure 1 provides an immediate overview of how labour productivity is calculated.

Figure 1: Our approach to measuring labour productivity in NHS acute trusts



To measure initial ***outputs*** we used the total number of inpatient spells (in 2007-8) at trust level, and the total number of outpatient appointments (also in 2007-8) also at trust level in order to create a single output measure. Information on inpatient spells and outpatient appointments were taken from the Hospital Episode Statistics database on Hospital Providers.

Turning to ***cost-weighting outputs*** we followed the methodology suggested by the Atkinson Report (2005) and subsequent publications from the Office of National Statistics (ONS). Outpatient appointment and hospital spells data were both weighted according to the share of total administrative costs involved in producing them. For this purpose, we used the data on administrative costs for inpatients and outpatients in

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the Kent University manual on NHS unit costs (2007). From these data, we aggregated all the costs related to treating outpatients and those related to treating inpatient spells. The results were on average £479 for inpatients and £152 unit costs for outpatients. This means that the relationship between inpatient and outpatient costs is 3 to 1 respectively. This is consistent with other recent publications that also suggest a relationship of 3 to 1 of inpatient to outpatient costs (Castelli et al 2007). Therefore, we multiplied the number of inpatients per 0.75 and the number of outpatient appointments per 0.25. Finally, we added the weighted inpatient and outpatient numbers to obtain a cost-weighted measure of output.

On ***quality-weighting outputs***, recent publications from the ONS (2007) have suggested that in estimating productivity in the public sector where services' quality cannot be plausibly assumed to be constant, output measures should also be weighted by quality. This recommendation is clearly very applicable to the case of hospitals, across which the quality of the service provided may vary significantly. For example, an outpatient appointment obtained with a delay of only 2 weeks should not be considered similar to one with a 10 weeks delay. For these reasons we adjusted our output measure not only by cost but by quality as well. As quality indicators we chose waiting times, patient satisfaction and the ratio of complaints resolved in target times, divided by the total complaints received per year. Clearly there are a large number of other quality measures that could be considered, and the three elements we have chosen are generic and non-medically specific ones. However, they do tap important aspects of patients' experience and represent relevant quality aspects; the data needed were widely available in the sources we consulted for this research; and the use of three measures adds additional checks and balances. We took mean waiting times from the HES online *Hospital providers* for 2007-8; the complaints ratio from the NHS Information Centre for 2008-7 and patient satisfaction from a number of different Patient Satisfactions Scores included the CEP database.[1]

We proceeded by creating five-points interval scales for each of the adjustment variables. Each interval was given a percentage adjustment that varied from 0 to 100 per cent. Then, we multiplied the output variable by the respective adjustment percentage for each of the three adjustment variables.

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(i) For mean waiting time we developed a five-point percentage weight scale based on the limit of 18 weeks established by the NHS as the maximum time it should take to patients to be referred to treatment. We considered that any NHS trust that has a mean waiting time exceeding 126 days (18 weeks) will be given a 0% quality adjustment. Table 1 below provides a detail of the whole interval breakdown and the percentage quality adjustments employed.

Table 1: Mean waiting time adjustment

Mean waiting time (based on target)	Percentage (%) quality adjustment	Distribution of trusts (%)
> 126	0	2
≤ 126 > 94.5	25	13
≤ 94.5 > 63	50	61
≤ 63 > 31.5	75	20
≤ 31.5	100	4

(ii) For mean patient satisfaction the data was compiled from data included in the CPE database on NHS trusts for five different Patient satisfaction scores covering: overall experience; access and waiting; information and choice; relationships; and whether hospitals were lean, comfortable and friendly. These used a five-point scale from 1 to 5 ranging from 'very dissatisfied' to 'very satisfied'. To employ these data, we took the mean result of these five questions.

Table 2: Mean patient satisfaction adjustment

Mean Patient Satisfaction	Percentage (%) quality adjustment	Distribution of trusts (%)
> 4	100	2
> 3 ≤ 4	75	84
> 2 ≤ 3	50	12
> 1 ≤ 2	25	2
≤ 1	0	-

(iii) For the complaints completion ratio we used data from the NHS Information Centre on the percentage of complaints for each trust that were

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completed within the target of 25 working days. Therefore, we created the following intervals and quality adjustment levels to adjust the measure of output for each Trust.

Table 3: Complaints completion ratio adjustment

Mean complaints ratio	**Percentage (%) quality adjustment**	**Distribution of trusts (%)**
>0.85	100	35
≤.85 > 0.7	75	41
≤ 0.7 > 0.55	50	15
≤ 0.55 > 0.4	25	6
≤ 0.4	0	3

Each trust's cost-weighted output was then multiplied by each of three corresponding quality adjustment percentage to obtain a cost and quality adjusted output measure in the following way:

$$\mathbf{CQWO = CWO * MWTA * MPSA * CCRA} \qquad (1)$$

Where: CQWO = Cost and quality weighted output

CWO = Cost weighted output

MWTA = Mean Weighting Time Adjustment

PSA = Mean Patient Satisfaction Adjustment

CCA = Complaints completion ratio Adjustment

To give a concrete illustration of what this step means, Table 4 overleaf shows an illustrative set of five trusts whose cost-adjusted output measures are also adjusted for quality.

As laid out in equation (1) above, our quality weighting procedure provides a 100% quality adjustment. To account for some extra variation in such weighting procedure, we also estimated three extra scenarios in which the total adjustment was set at 75%, 50% and 25% of the previous effect. To illustrate such extra adjusting mechanism, we can rewrite the adjustment equation as in (1) in the following way:

$$\text{CQWO } 75\% = \text{CWO} * (\text{MWTA} * \text{MPSA} * \text{CCRA}) * .75 \qquad (2)$$

$$= \text{CWO} * (\text{MWTA} * \text{MPSA} * \text{CCRA}) * .50$$

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= CWO *(MWTA*MPSA*CCRA)*.25

We therefore calculated three additional productivity estimates. These estimates were included our regression models.

Table 4: Examples of adjusted measures

TRUST NAME	Total cost weighted output	Overall patient satisfaction	Patient Satisfaction adjustment index	Complaints ratio	Complaints ratio adjustment index	Mean Waiting Time (days)	Mean waiting time adjustment index	Total cost and quality adjusted Output
OXFORD RADCLIFFE HOSPITAL	269875.28	3.00	0.75	0.89	1.00	44.00	0.75	151804.85
HEATHERWOOD AND WEXHAM PARK HOSPITALS	163795.08	3.00	0.75	0.61	0.50	58.00	0.75	46067.37
ROYAL FREE HAMPSTEAD	172705.36	2.80	0.50	0.18	0.75	55.00	0.75	48573.38
SOUTH LONDON HEALTH CARE TRUST	289615.08	2.67	0.50	0.77	0.75	66.00	0.50	54302.83
WEST HERTFORDSHIRE HOSPITALS	134272.92	2.80	0.50	0.49	0.25	82.00	0.50	8392.06

Overall ***productivity*** numbers were obtained by dividing the total cost and quality output measure by the number of medical staff (that is, both doctors and other medical staff) per acute trust obtained from the NHS Information Centre. We take into account here only the medical staff devoted to patient care, that is the total number of medical staff but *excluding* staff members on honorary contracts. These contracts are NHS appointments for senior academics in medical research (at the level of senior lecturer or professor) to provide them with the opportunity to be affiliated with a hospital but still allow them to focus on their research work. In most published analyses this important issue has not been picked up. However, we judged that these doctor-researchers should be excluded from the total number of relevant medical staff because they are not directly responsible for the delivery of health services. Our measure has most impact on improving the productivity data for historically important teaching hospitals that are also major centres of medical research

(b) Specifying independent variables

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There are a large number of possible influences upon the productivity of hospital services, and it is not easy to envisage being able to easily operationalise variables for many of these influences – of which Figure 2 provides one possible list. It should be apparent here that the potential influence of both management quality and hospitals' ICT use on overall productivity is not likely to be large. We draw two implications.

Figure 2: Possible main influences upon hospitals' productivity

- Numbers of medical and non-medical staff
- Training and morale of medical staff
- Training and morale of non-medical staff
- Quality of medical staff leadership and clinical audit and
- Professional culture of medical staff, especially awareness and adoption of innovations
- Research and development
- Modernity and suitability of hospital built estate
- Extent and modernity of medical equipment
- Organization of patient work-flows
- Other aspects of quality of services
- Top organizational leadership
- Overall organizational culture
- *Quality of management*
- *ICT use*

First, it is important to keep the potential roles of management and ICTs in a clear perspective: the contributions that they make to hospital productivity are likely to be small and perhaps rather subtle. From extensive exploratory data analysis of bi-variate relationships with cost- and quality- weighted hospital productivity, we selected some key dummy variables that assume a value of one whenever a Trust fall in any of these categories. These cover:

- specialist hospitals, those focusing on a limited range of patient conditions,
- teaching hospitals, which are the largest, most complex and most professionally important ones and
- trusts located in London, where special historical conditions apply to many of the largest hospitals, but also where the labour market conditions for securing full-time nurses are especially unfavourable and there is a strong dependence on agency and part-time nurses.

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Second, it is especially important to find indicators of our key independent variables here that do not risk importing elements of other potential causal influences. In particular, we are most interested in those aspects of management and ICT use that can be measured outside immediate medical treatment contexts, where professional influences are likely to prevail, and we need to control for staff training variables separately – which luckily is feasible to do from existing data.

To create a 'general training' variable, we chose a group of specific training-related variables from the NHS Staff Survey 2008. The 'general training' variable is therefore an average of the following variables' score: 'courses attended in the last 12 months provided or paid by the trust'; 'job training in the last 12 months provided or paid by the trust'; 'had a mentor in the last 12 months'; 'shadowed someone in the last 12 months'. We transformed these data into 1-6 scores according to the number of standard deviations from the mean of the originally measured variables. In this sense, we assigned 1 if the value fell more than 1 standard deviation below the mean, 2 if the value fell between 1 and 0.5 standard deviation below the mean, 3 if the value fell between 0.5 and 0 standard deviation, and so on.

To measure hospitals' use of ICTs and the quality/nature of their management practices we utilised a web-census technique. This kind of non-intrusive and non-reactive technique is increasingly used in social research, because it is low cost, generates comprehensive results in a reliable way, and avoids any possibility of receiving the respondent-biased answers common in survey research. Essentially web-census approaches build up indices from many small aspects of organizational behaviours, which can be objectively observed and coded for presence or absence online (Dunleavy, 2010). To populate the ICT use and management practice scores we hence surveyed each of the 153 trusts' websites for multiple indicators that were scored 1 or 0, depending on their presence or absence. Scores were then cumulated into aggregate ICT and management practices indicators.

To measure management quality and character, we developed a set of indicators grouped into seven categories bearing on the generic management approach used by hospital trusts. These covered – the provision of information about interactions to patients, patient empowerment features, outreach information for local community, trust accountability and ethos, performance tracking and standard

settings, managing and recruiting talent, and human resource development practices. Table A1 in the Annex provides a full list of the 43 indicators involved. To measure ICT use we looked for indicators remote from the management list and grouped into four different dimensions covering the provision of online information and documentation (which is a strong indicator of website development), good practice on website features, web useability and ICT innovations. Table A2 again provides a list of the 18 indicators involved.

3. Analysis and results

Table 5 below provides the descriptive statistics of the dependent and independent variables considered included in this study. The results suggest a mostly un-skewed pattern for the continuous variables. There is an understandably more skewed pattern for the dummy control variables, but this is not a problem because we expect trusts not to be normally distributed across these control covariates.

Table 5: Descriptive Statistics of the Variables employed in the analysis

Variable	*N*	Mean	SD	Min.	Max.
Cost weighted productivity	166	319.7	144.4	105	1456.7
Cost and quality weighted productivity	153	124.9	108.2	13.9	819.4
Cost and quality weighted productivity 75%	153	93.6	81.1	10.3	614.5
Cost and quality weighted productivity 50%	153	62.4	54.1	6.9	409.7
Cost and quality weighted productivity 25%	153	31.2	27.0	3.4	204.8
Management Practices	166	23.8	4.6	13	36
IT use	166	9.8	2.4	4	16
Interaction term (IT x Management Practices)	166	237.2	82.8	78	504
General Training	160	3.5	0.9	1	6
London	166	0.17	0.38	0	1
Teaching	166	0.04	0.21	0	1
Specialist	166	0.09	0.29	0	1

We estimated Ordinary Least Square (OLS) regression models using labour productivity as the dependent variable. To show the goodness of fit of our cost and quality productivity measure, we estimated one first model (Model 1) with cost-adjusted labour productivity as the dependent variable. Then, we estimated four additional models (Models 2 to 5) in which we also incorporated a quality adjustment

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to our output measure and hence to our labour productivity measure. As explained before, we intended to estimate models in which the quality adjustment for the output and labour productivity measure was at 25, 50 and 75% (Models 2 to 4), in addition to a full cost and quality adjusted labour productivity model (Model 5). The results confirm the better goodness of fit of the regression model when employing the cost- and quality-adjusted productivity measure. The models also include an interaction term between our indices for ICT use and management practices to check in particular on the expectation in the literature that the effect of each of these variables on productivity is conditional on the values assumed by the other variable in the interaction term. Table 6 below shows the results of our models.

The results for Model 1 show that amongst our control variables only that for hospitals' location becomes significant, showing that trusts outside London experience an increase of more than 54 points in the cost-weighted productivity measure, compared to those in the capital. The overall model explains just 20 percent of the variation in the dependent variable.

The results for Models 2 to 5 confirm that they fit, with the R^2 showing that they explain over 23 percent of the variation in the dependent variable (compared to just over 20 percent for Model 1). These results also confirm the previous finding in Model 1 that London trusts are significantly less productive than those located outside the capital, while specialist trusts are significantly more productive than generalist ones. Two key explanations seem feasible here and will need further research to unpick. First, London trusts may suffer in productivity terms because they are generally regarded by patients and GPs as the best in the country, which may mean that they attract significantly more complex cases, whose treatment requires longer interventions that, in turn, may reduce their productivity performance on our measures. In other words there may be a substantial and unmeasured quality difference between London and non-London trusts in the nature of the treatments involved. Second, London trusts' productivity may be adversely affected by an inability to attract nursing staff, given the capitals' higher costs of living and property prices, which previous research has linked to a greater use of agency nurses and temporary staff, with apparently adverse consequences for patient mortality and other factors (Hall et al. 2008).

Table 6: OLS estimates on labour productivity

Independent Variable	Model 1 (cost adjusted labour productivity)	Model 2 Cost and quality adjusted productivity (quality at 25%)	Model 3 Cost and quality adjusted productivity (quality at 50%)	Model 4 Cost and quality adjusted productivity (quality at 75%)	Model 5 (Full cost and quality adjusted labour productivity)
ICT Use	4.45 (11.318)	8.92** (4.603)	17.85** (9.207)	26.78** (13.811)	35.709** (18.414)
Management Practices	-0.776 (4.738)	3.21* (1.941)	6.433* (3.883)	9.65* (5.825)	12.867* (7.767)
ICT x Management	-0.278 (0.47)	-0.39** (0.191)	-0.79** (0.383)	-1.18** (0.578)	-1.58** (0.766)
General Training	1.483 (5.294)	3.046 (2.217)	6.093 (4.434)	9.14 (6.652)	12.187 (8.869)
Specialist	-24.449 (18.619)	27.40*** (8.046)	54.81*** (16.092)	82.22*** (24.138)	109.634*** (32.184)
Teaching	-33.167 (29.658)	12.30 (12.677)	24.61 (25.354)	36.92 (38.032)	49.229 (50.709)
London	-54.217*** (16.438)	-20.071*** (6.683)	-40.14*** (13.366)	-60.21*** (20.05)	-80.287*** (26.733)
R^2	0.20	0.23	0.23	0.23	0.23
N	157	147	147	147	147

Note: Standard errors between parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1% (two-tailed).

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Across Models 2 to 5 the different coefficients remain consistently significant across the different models in which the productivity measure has been adjusted by quality at 25, 50 75 and 100% (Models 2 to 5). The only variation observed is in the magnitude of such coefficients.

The coefficients for the interaction term and its components are all significant. However, one important issue arising when utilizing interaction terms in regression analysis is that the interpretation of the interaction term and its components cannot be made individually as the effect of one component of the interaction term on the outcome is conditional on the value of the other component. As Brambor et al (2006) clearly illustrate, the results listed for the coefficients of ICT and management represent the effect of each variable when the other one is set to zero. In this sense, looking at Model 5 in Table 6, we can say that a unit increase in ICT use leads to an increase in productivity of 35.7 points, but only when the Management Practices index is zero. Likewise, and increase of one unit in our measure of Management Practices leads to a productivity increase of 12 points but only when our ICT index is zero. In real life, none of our trusts received a score of zero in either ICT or Management Practices, so that neither of these effects is likely to be observable in our data.

The results in Models 2 to 5 for the interaction term only tell us that when our ICT and Management Practices indices increase at the same time, then there is a negative and statistically significant effect on productivity. However, what these results still do not tell us is how ICT affects productivity given the specific and real values observed for Management Practices and, vice versa, how Management Practices affects productivity given specific and real values of ICT. These are much more important and realistic situations for which a clear answer is needed. Graphical interpretation can help us to elucidate such interpretations. Figure 3 below shows the conditional effects of IT on productivity given the full range of values for Management Practices. These graphs were created upon the results with our cost- and quality-adjustments fully implemented (i.e. at the 100 per cent level), as in Model 5.

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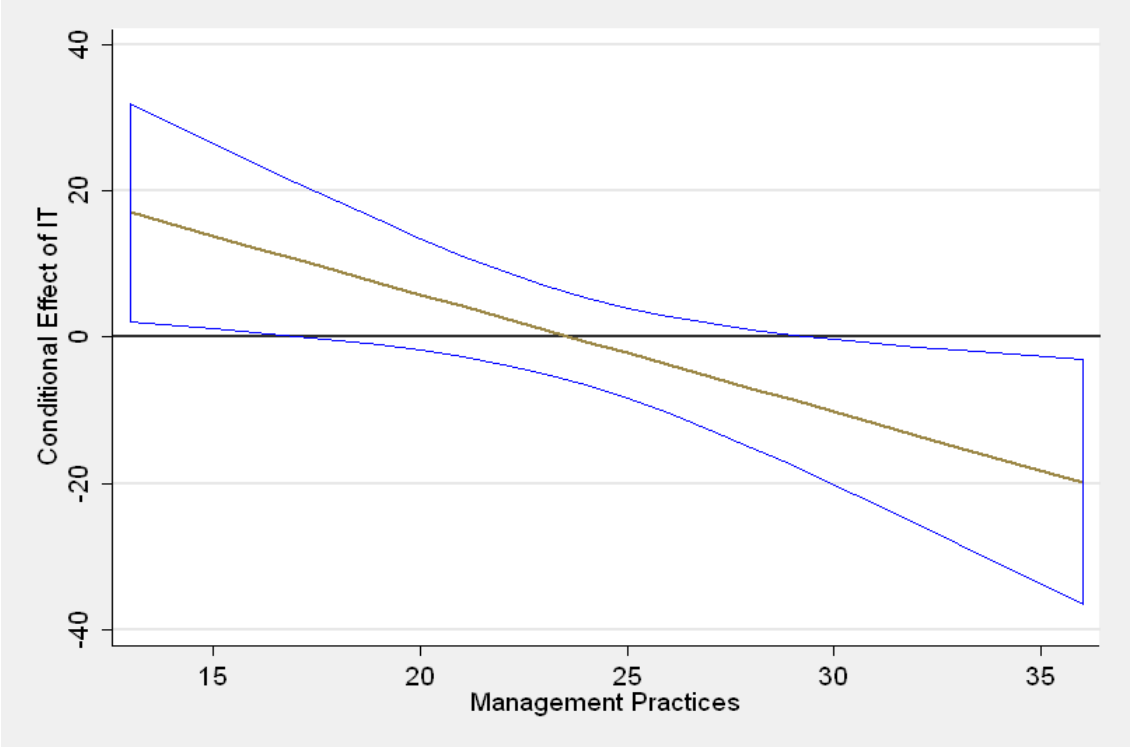
Figure 3: The conditional effects of IT



Note: The blue line area represents limits the upper and lower 90% confidence intervals. The marginal effects and standard errors used for this graph were calculated according to results from Model 2.

Figure 3 clearly shows that the positive effect of ICT on productivity decreases as Management Practices increases. Thus, for trusts with Management Practices scores of more than 17 (that is, nine tenths of all trusts), the effect of ICT on productivity becomes indistinguishable from zero. Put in another way, the results seem to indicate that in trusts with low to medium-low levels of Management (comprising 11 per cent of the trusts in our sample) good ICT use can significantly help to increase productivity. However, our results seem to suggest that as trusts become better managed, the pay-offs from better ICT use diminish. In fact, Figure 3 shows that in trusts with a Management Practice score of 28 or more (comprising a sixth of the whole dataset) ICT use negatively affect productivity levels.

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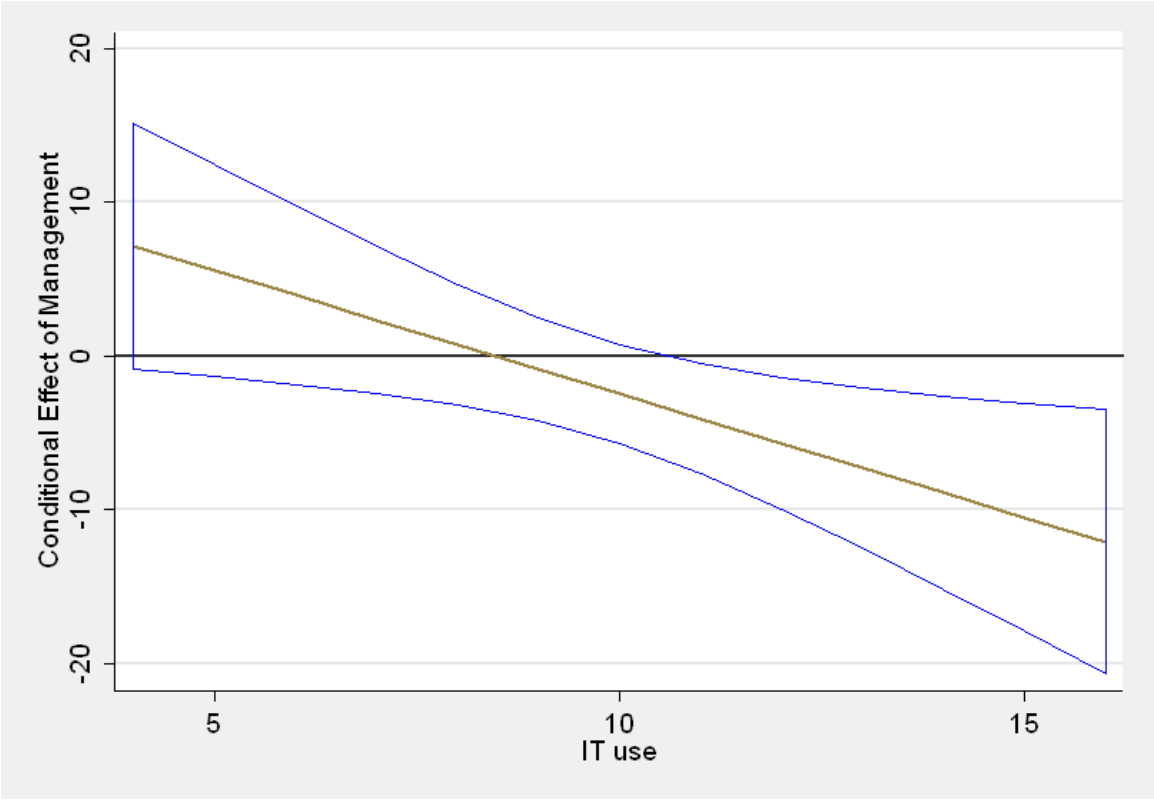
As mentioned before, it is also possible to model how Management affects productivity given specific values of IT. Figure 4 shows the conditional effect of Management Practices on productivity given the full range of values of IT.

Figure 4: The conditional effect of Management



Note: The blue line area limits the upper and lower 90% confidence intervals. The marginal effects and standard errors used for this graph were calculated according to results from Model 2.

The results from Figure 4 show that the effect of management on productivity is indistinguishable from zero for trusts with low and medium-low levels of ICT use. However, for trusts with an ICT use score equal or higher than 11 (23 percent of the total) the effect of Management Practices on productivity is negative. We can interpret this result as suggesting that good management practices may not help to boost productivity if trusts already have a well-developed focus on employing modern ICTs productively.

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Conclusions

This research has undertaken a relatively ambitious test of how the use of ICT and the adoption of good management practices affect productivity across NHS Acute trusts, an area that is certain to generate more research over the next few years, given its salience in political, service delivery and financial terms. Our approach is innovative in employing un-obtrusive and non-reactive measures for gauging ICT and management practices, drawn from a comprehensive web-census of all acute healthcare trusts in England. To our knowledge, this is the first time that such measures have been used in an empirical productivity study and the approach yields interesting insights. The results are broadly consistent with previous survey-based analysis of management influences, but differ in detail and specificity -we would argue because they remove the 'public relations' and 'spin' effects inherent in survey based or reactive approaches-.

Our research has also innovated in introducing a measure of output and productivity that is based on current best practice in public sector productivity measurement, as suggested by the Atkinson Report (2005) and successive ONS publications. We relied on a measure of output based on the total number of inpatient spells and outpatient appointments, cost- weighted according to the relative administration costs of delivering them. In addition, this measure was weighted by three useful measures of general service quality: waiting times, patient satisfaction and the complaints completion ratio. We further considered three additional scenarios in which the quality adjustment for the output measure was set at 25, 50 and 75%. Our cost- and quality-weighted measures of output were then divided by the total number of headcount staff dedicated to patient care in order to obtain a labour productivity measure. This was our key dependent variable employed for the quantitative analysis.

The results of our quantitative analysis yielded interesting results. On the one hand, we found that trusts in the London area are consistently less productive than those in the rest of the country. Initially, we believe that this may reflect an adverse selection of cases (from the point of view of London trusts), reflecting patients' and GP's view that trusts in the London area generally are equipped with better resources for complex interventions that require longer periods. In addition, primary care trusts may only be willing to pay the higher costs of London hospitals for a case mix that is

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on average less favourable for speedy completion of treatment. These effects may make London hospitals appear less productive, but chiefly because we have an untapped case-complexity dimension. Alternatively, or as well, the London results may show more difficulty in securing high quality nursing and other staff there, due to higher living costs etc. In addition, our results also show that specialist trusts are also more productive than the rest, which may reflect these trusts' advantage over general hospitals, advantages that stem from dealing only with interventions for which they are well staffed, trained and prepared.

More substantively, our quantitative analysis shed new light on the effects of management practices and ICT on productivity. Modelling the conditional effects of IT on productivity for the full range of values of our Management Practices variable, we found that the effect of ICT on productivity is positive and significant - but only for trusts with a low and medium-low levels scores on Management. This result illustrates that the pay-offs of good ICT use on productivity levels are higher for poorly managed trusts. However, it also shows that the effect of more extensive ICT development on productivity may be actually negative for trusts with medium-high and high levels of management. This suggests that as trusts become more complex, it is possible for managers to develop an over-focus on ICT that may not be beneficial for yielding high productivity levels.

Finally, modelling the conditional effects of management practices on productivity for the full range of values of our ICT variable shows that the effect of Management is negative on productivity for trusts with medium-high and high levels of ICT use. This result confirms our previous interpretation that once trusts are reasonably well-managed an excessive focus on ICT use may not be a good strategy for seeking to achieve sustained productivity levels.

All the results presented here are preliminary and it is important to bear in mind both that there are many other possible influences on trusts' productivity performances that have not yet been explored, and that quality-adjusted productivity itself is just one of the areas to look at when evaluating how NHS trusts employ resources efficiently and innovate. We are still working on the further development of control variables for this analysis and on the specification of quality-weighting and of our management practices and ICT development indicators and aggregate indices.

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Nonetheless, this work already provides some useful insights for practitioners in the health area and contributes by providing new and fresh evidence for the recent public sector productivity literature that has highlighted the interactive effects of new technologies and management on productivity (Garicano and Heaton 2007). In addition, by employing cutting-edge non-obtrusive measures to capture the role of ICT and management practices, this research shows the potential of applying such approach to other areas in the public sector.

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Annex

Table A1: The composition of the Management Practices index

Dimension	Indicator	MANAGEMENT PRACTICES
Patient Interaction information	1	Link to NHS Direct
	2	Information on how to cancel appointments provided
	3	Accessibility maps/plans available
	4	Information about visiting hours provided
	5	Link to individual hospitals provided
	6	Link to other local PCTs in the area
Patient empowerment features	7	FOI link present on home page
	8	Patient Relationship Management
	9	Caldicott Guardian's name or picture available
	10	trusts phone lists provided
Outreach information for local community	11	Link to local hospital charity
	12	Background and history of the Trust available
	13	Link to open events organised by the Trust
	14	Link hospitals services
	15	Link to communications team
	16	News on each hospital available in the site
	17	Information given on Trust's new building projects
	18	Link to press relases available
Trust Accountability and Ethos	19	Organigram or other indication of trust structure provided
	20	Past and future trust meetings provided
	21	Trust meeting agenda provided
	22	Biographies of trust directors provided
	23	Information on Trustwide goals
	24	Information on Trust's values
Performance Tracking / Standards	25	Link to standards or performance documents/information
	26	Annual audit letter available
	27	Hygiene code inspection report available
	28	Trust recent developments shown
	29	Care Quality Commission information
	30	Infection rates available
	31	Link to Annual Health check
	32	Link to Care Quality Commission summary statistics on the Trust
Managing and Recruiting Talent	33	Information on pay scales in the Trust
	34	Information on benefits of working in the trust
	35	Programmes or placements for medical students available
	36	Advice on moving to the area available

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Dimension	Indicator	MANAGEMENT PRACTICES
	37	Volunteering possibilities available
	38	Mention to flexible approach to work
Human Resource Development	39	Link to learning possibilities for non-medical staff (nurses, carers, etc.)
	40	Dedicated Research and development section or link
	41	Centre for Postgraduate Professional Education in the Trust

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Table A2: The composition of the ICT use index

Dimension	Indicator	IT MEASURES
Online information / documentation	1	Information of IT expenditure for the current (or past) years provided
	2	IT Strategy documentation availability
	3	Document reading software available
	4	Annual Report and Trust Accounts availability
Good Practice on Website Features	5	Website readability features
	6	Site map availability
	7	Website comment box available
	8	Web page are dated
	9	Web pages are updated
	10	Web accessibility link provided
Web usability	11	Less than 7 items in each section's menu
	12	More than 15 items in each section's menu
	13	Website search engine works properly
	14	Pop-up web survey
IT Innovations	15	Web 2.0 features (videos, podcasts, etc) present
	16	Development of online appointment management system
	17	Information on waiting times provided
	18	Online donations to hospital charity possible

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Table A3: Complete list of Acute Healthcare trusts and number of hospitals

Acute Trust Name	Number of Hospitals
Aintree University Hospitals NHS Foundation Trust	2
Airedale NHS Trust	1
Alder Hey Children's NHS Foundation Trust	2
Ashford and St Peter's Hospitals NHS Trust	2
Barking, Havering and Redbridge University Hospitals NHS Trust	2
Barnet and Chase Farm Hospitals NHS Trust	3
Barnsley Hospital NHS Foundation Trust	1
Barts and The London NHS Trust	3
Basildon and Thurrock University Hospitals NHS Foundation Trust	3
Basingstoke and North Hampshire NHS Foundation Trust	1
Bedford Hospital NHS Trust	2
Birmingham Children's Hospital NHS Foundation Trust	1
Birmingham Women's NHS Foundation Trust	1
Blackpool, Fylde and Wyre Hospitals NHS Foundation Trust	5
Bradford Teaching Hospitals NHS Foundation Trust	2
Brighton and Sussex University Hospitals NHS Trust	5
Bromley Hospitals NHS Trust	4
Buckinghamshire Hospitals NHS Trust	3
Burton Hospitals NHS Foundation Trust	1
Calderdale and Huddersfield NHS Foundation Trust	3
Cambridge University Hospitals NHS Foundation Trust	5
Central Manchester University Hospitals NHS Foundation Trust	5
Chelsea and Westminster Hospital NHS Foundation Trust	1
Chesterfield Royal Hospital NHS Foundation Trust	2
City Hospitals Sunderland NHS Foundation Trust	3
Clatterbridge Centre For Oncology NHS Foundation Trust	1
Colchester Hospital University NHS Foundation Trust	4
Countess Of Chester Hospital NHS Foundation Trust	2
County Durham and Darlington NHS Foundation Trust	6
Dartford and Gravesham NHS Trust	2
Derby Hospitals NHS Foundation Trust	4
Doncaster and Bassetlaw Hospitals NHS Foundation Trust	5
Dorset County Hospital NHS Foundation Trust	2
Ealing Hospital NHS Trust	1
East and North Hertfordshire NHS Trust	4
East Cheshire NHS Trust	4
East Kent Hospitals University NHS Foundation Trust	8
East Lancashire Hospitals NHS Trust	4
East Sussex Hospitals NHS Trust	4
Epsom and St Helier University Hospitals NHS Trust	5
Frimley Park Hospital NHS Foundation Trust	2
Gateshead Health NHS Foundation Trust	3
George Eliot Hospital NHS Trust	1
Gloucestershire Hospitals NHS Foundation Trust	6
Great Ormond Street Hospital For Children NHS Trust	1
Great Western Hospitals NHS Foundation Trust	5
Guy's and St Thomas' NHS Foundation Trust	2
Harrogate and District NHS Foundation Trust	3

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Acute Trust Name	Number of Hospitals
Heart Of England NHS Foundation Trust	3
Heatherwood and Wexham Park Hospitals NHS Foundation Trust	5
Hereford Hospitals NHS Trust	1
Hinchingbrooke Health Care NHS Trust	2
Homerton University Hospital NHS Foundation Trust	2
Hull and East Yorkshire Hospitals NHS Trust	4
Imperial College Healthcare NHS Trust	5
Ipswich Hospital NHS Trust	2
Isle Of Wight NHS PCT	1
James Paget University Hospitals NHS Foundation Trust	3
Kettering General Hospital NHS Foundation Trust	2
King's College Hospital NHS Foundation Trust	1
Kingston Hospital NHS Trust	1
Lancashire Teaching Hospitals NHS Foundation Trust	2
Leeds Teaching Hospitals NHS Trust	5
Liverpool Heart and Chest Hospital NHS Trust	1
Liverpool Women's NHS Foundation Trust	1
Luton and Dunstable Hospital NHS Foundation Trust	1
Maidstone and Tunbridge Wells NHS Trust	7
Mayday Healthcare NHS Trust	2
Medway NHS Foundation Trust	5
Mid Cheshire Hospitals NHS Foundation Trust	2
Mid Essex Hospital Services NHS Trust	6
Mid Staffordshire NHS Foundation Trust	2
Mid Yorkshire Hospitals NHS Trust	4
Milton Keynes Hospital NHS Foundation Trust	1
Moorfields Eye Hospital NHS Foundation Trust	1
Newham University Hospital NHS Trust	2
Norfolk and Norwich University Hospitals NHS Foundation Trust	2
North Bristol NHS Trust	5
North Cumbria University Hospitals NHS Trust	6
North Middlesex University Hospital NHS Trust	1
North Tees and Hartlepool NHS Foundation Trust	3
North West London Hospitals NHS Trust	4
Northampton General Hospital NHS Trust	1
Northern Devon Healthcare NHS Trust	5
Northern Lincolnshire and Goole Hospitals NHS Foundation Trust	5
Northumbria Healthcare NHS Foundation Trust	7
Nottingham University Hospitals NHS Trust	2
Nuffield Orthopaedic Centre NHS Trust	1
Oxford Radcliffe Hospitals NHS Trust	5
Papworth Hospital NHS Foundation Trust	1
Pennine Acute Hospitals NHS Trust	5
Peterborough and Stamford Hospitals NHS Foundation Trust	4
Plymouth Hospitals NHS Trust	5
Poole Hospital NHS Foundation Trust	1
Portsmouth Hospitals NHS Trust	4
Queen Elizabeth Hospital NHS Trust	1
Queen Mary's Sidcup NHS Trust	2
Queen Victoria Hospital NHS Foundation Trust	2
Robert Jones and Agnes Hunt Orthopaedic and District Hospital NHS Trust	1

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Acute Trust Name	Number of Hospitals
Royal Berkshire NHS Foundation Trust	4
Royal Bolton Hospital NHS Foundation Trust	1
Royal Brompton and Harefield NHS Trust	2
Royal Cornwall Hospitals NHS Trust	3
Royal Devon and Exeter NHS Foundation Trust	5
Royal Free Hampstead NHS Trust	5
Royal Liverpool and Broadgreen University Hospitals NHS Trust	5
Royal National Hospital For Rheumatic Diseases NHS Foundation Trust	5
Royal National Orthopaedic Hospital NHS Trust	2
Royal Surrey County Hospital NHS Trust	3
Royal United Hospital Bath NHS Trust	5
Royal West Sussex NHS Trust	5
Salford Royal NHS Foundation Trust	1
Salisbury NHS Foundation Trust	1
Sandwell and West Birmingham Hospitals NHS Trust	5
Scarborough and North East Yorkshire Health Care NHS Trust	4
Sheffield Children's NHS Foundation Trust	2
Sheffield Teaching Hospitals NHS Foundation Trust	4
Sherwood Forest Hospitals NHS Foundation Trust	4
Shrewsbury and Telford Hospital NHS Trust	4
South Devon Healthcare NHS Foundation Trust	1
South Downs Health NHS Trust	1
South Tees Hospitals NHS Trust	2
South Tyneside NHS Foundation Trust	3
South Warwickshire General Hospitals NHS Trust	2
Southampton University Hospitals NHS Trust	2
Southend University Hospital NHS Foundation Trust	1
Southport and Ormskirk Hospital NHS Trust	2
St George's Healthcare NHS Trust	3
St Helens and Knowsley Hospitals NHS Trust	2
Stockport NHS Foundation Trust	2
Surrey and Sussex Healthcare NHS Trust	4
Tameside Hospital NHS Foundation Trust	1
Taunton and Somerset NHS Foundation Trust	1
The Christie NHS Foundation Trust	1
The Dudley Group Of Hospitals NHS Foundation Trust	3
The Hillingdon Hospital NHS Trust	2
The Lewisham Hospital NHS Trust	1
The Newcastle Upon Tyne Hospitals NHS Foundation Trust	5
The Princess Alexandra Hospital NHS Trust	3
The Queen Elizabeth Hospital King's Lynn NHS Trust	1
The Rotherham NHS Foundation Trust	1
The Royal Bournemouth and Christchurch Hospitals NHS Foundation Trust	3
The Royal Marsden NHS Foundation Trust	2
The Royal Orthopaedic Hospital NHS Foundation Trust	1
The Royal Wolverhampton Hospitals NHS Trust	1
The Whittington Hospital NHS Trust	1
Trafford Healthcare NHS Trust	3
United Lincolnshire Hospitals NHS Trust	5
University College London Hospitals NHS Foundation Trust	5
University Hospital Birmingham NHS Foundation Trust	2

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Acute Trust Name	Number of Hospitals
University Hospital Of North Staffordshire NHS Trust	1
University Hospital Of South Manchester NHS Foundation Trust	2
University Hospitals Bristol NHS Foundation Trust	5
University Hospitals Coventry and Warwickshire NHS Trust	2
University Hospitals Of Leicester NHS Trust	3
University Hospitals Of Morecambe Bay NHS Trust	4
Walsall Hospitals NHS Trust	1
Walton Centre For Neurology and Neurosurgery NHS Trust	1
Warrington and Halton Hospitals NHS Foundation Trust	2
West Hertfordshire Hospitals NHS Trust	3
West Middlesex University Hospital NHS Trust	1
West Suffolk Hospitals NHS Trust	1
Weston Area Health NHS Trust	2
Whipps Cross University Hospital NHS Trust	2
Winchester and Eastleigh Healthcare NHS Trust	3
Wirral University Teaching Hospital NHS Foundation Trust	3
Worcestershire Acute Hospitals NHS Trust	4
Worthing and Southlands Hospitals NHS Trust	3
Wrightington, Wigan and Leigh NHS Foundation Trust	4
Yeovil District Hospital NHS Foundation Trust	1
York Hospitals NHS Foundation Trust	4

Other data constraints: We originally collected data on 171 trusts, but 8 trusts merged within our study period to form 4 new trusts, bringing the overall number down to 167. Good Hope Hospital NHS Trust and Birmingham Heartlands and Solihull NHS Trust merged into the new Heart of England NHS Foundation Trust; Hammersmith Hospitals NHS Trust and St Mary's NHS Trust merged into the new Imperial NHS Trust; Bromley Hospitals NHS Trust, Queen Elizabeth Hospital NHS Trust and Queen Mary's Sidcup NHS Trust merged into the new South London Healthcare Trust; Worthing and Southlands Hospitals NHS Trust and Royal West Sussex NHS Trust merged into the new Western Sussex Hospitals.

Fifteen trusts changed their names in our study period: Cardiothoracic Centre - Liverpool NHS Trust is now called Liverpool Heart and Chest Hospital NHS Trust; North Cheshire Hospitals NHS Trust is now called Warrington and Halton Hospitals NHS Foundation Trust; Royal Liverpool Children's NHS Trust is now called Alder Hey Children's NHS Foundation Trust; South Manchester University Hospitals NHS Trust is now called University Hospital of South Manchester NHS Foundation Trust; Chesterfield and North Derbyshire Royal Hospital NHS Trust is now called Chesterfield Royal Hospitals NHS Trust; Nottingham City Hospital NHS Trust is now called Nottingham University Hospitals NHS Trust; Southern Derbyshire Acute Hospitals NHS Trust is now called Derby Hospitals NHS Foundation Trust; Mid Staffordshire General Hospitals NHS Trust is now called Mid Staffordshire NHS Foundation Trust; North Staffordshire Hospital NHS Trust is now called University Hospital of North Staffordshire NHS Trust; North Hampshire Hospitals NHS Trust is now called Basingstoke and North Hampshire NHS Foundation Trust; Royal Berkshire and Battle Hospitals NHS Trust is now called Royal Berkshire NHS Foundation Trust; Royal National Hospital for Rheumatic Diseases NHS Trust is now called Bath Royal National Hospital for Rheumatic Diseases; Swindon and Marlborough NHS Trust is now called Great Western Hospitals NHS Trust; East Somerset NHS Trust is now called Yeovil District Hospital NHS Foundation Trust; Taunton and Somerset NHS Trust is now called Musgrove Park Hospital. One more body, the Isle of Wight trust, was removed from the study because it is a mixed body that is primarily a Primary Care Trust.

For 13 further trusts we could not obtain appropriate data on output quality. These trusts are: Plymouth Hospital NHS Trust, Weston Area Health NHS Trust, Princess Alexandra Hospital NHS Trust and United Lincolnshire Hospital NHS Trust for which the 'Complaints Index' is 0. Then, Robert Jones and Agnes Hunt Orthopaedic and District Hospital and Birmingham Children's Hospital NHS Trust for

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which ‘Mean Waiting Time’ is 0. Finally for Royal Bournemouth and Christchurch Hospital, Poole Hospital NHS Trust, Bath Royal National Hospital for Rheumatic Disease, Royal Berkeshire NHS Foundation Trust, King’s College NHS Trust, Homerton University Hospital NHS Trust and Sheffield Children’s NHS Foundation Trust no quality-adjusted output measure could be developed because there is no data available about complaints handling.

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