8. Hospital productivity in England's National Health Service

The National Health Service in England is one of the largest connected sets of public sector organizations in Europe, and on a par with the provincially run and more mixed health systems in large countries such as China and India. The vast bulk of NHS activivites (69 per cent of the output index in 2007–08) is made up of hospital and community health services (Peñaloza et al., 2010, p. 6). Most trusts operate just one or two hospitals, and hospital sizes vary from smaller 'district general hospitals' for a single city or area, through to large, multi-specialism hospitals in regional metropolitan areas and in Central London.

In this chapter we explore in detail what influences seem to shape the overall productivity of the acute hospital trusts in England. We begin by setting the scene, looking at successive governments' attempts to boost the efficiency of NHS hospitals by introducing elements of competition to attract patients between hospitals, interspersed with other periods where policy stressed more the integration of services and the stabilization of hospital budgets in a more predictable fashion. Our second section sets out the methods that we have adopted to compare productivity across the 154 acute hospital trusts. We use a parametric approach, and in addition to cost weights, we use a quality-weighting of trusts' overall outputs. As independent variables, we operationalize measures of management competence and innovativeness, and of the extent to which trusts make use of information and communication technologies (ICTs). The third section considers the results, which suggest that ICT use has a strong effect on productivity levels, and one that interacts with the influence of management practices.

8.1 THE SEARCH FOR GREATER EFFICIENCY IN NHS ACUTE HOSPITAL CARE

Successive governments have paid constant attention to how the hospital sector in the NHS was managed. There have been frequent reorganizations and new initiatives in almost every year of the last three decades. For most of the post-war period, budgets were allocated directly to hospitals by

top-level and regional NHS bodies (guided top-down by the Department of Health). Each ordinary hospital was assigned a local area for which it was (by and large) the dominant provider. Specialist care saw more movements of patients out of the locality, especially to larger hospitals in regional centres or London. But this did not qualify the basic arrangement where each local population primarily looked to its local hospital for treatment. Hospitals were given a bed capacity, budget and staffing levels to go along with this local need.

In 1988 the Conservative government under Margaret Thatcher resolved to make a radical change in this set up. Ministers sought to introduce a 'quasi-market' in healthcare, where the budget for treatments would be allocated to local consortia of family doctors (called general practitioners, or GPs in the UK). These groupings would purchase hospital care on behalf of their patients and would be able to take their custom to whichever hospital they liked, paying attention specifically to how good the care was and how much each treatment cost. The idea was that hospitals would no longer get a budget 'as of right', but instead have to compete with each other to attract patients to fill their beds, thereby creating a dynamic that was 'sure to' increase efficiency and cut NHS costs.

In the event, the new arrangements proved an expensive thing to try to set up from scratch, and the number of hospital managers and accountants soared to try to make an overly complex system work. Even establishing a list of hospital operations that everyone could agree on cost millions of pounds. The scope of competition between hospitals also quickly proved to be strongly limited both by patients' and GPs' lack of information about hospitals' performance, and by repeated government interventions in order to keep hospital budgets stable and prevent disruption as demand patterns changed.

From 1997 the Labour government under Tony Blair pursued a different course, initially scrapping the quasi-market provisions altogether, and seeking to reintegrate services in a joined up way. More importantly from 2000 on Labour raised health budgets strongly to improve care levels. Both measures improved the effectiveness of provision and boosted public confidence in the NHS, but ministers became frustrated that large spending increases did not seem to have proportionate effects on improving hospitals' performance. Later on in its term Labour reintroduced more diversification of healthcare providers in a different and more incremental fashion, with Independent Treatment Centres competing with mainline hospitals to undertake simpler sets of operations, especially in areas previously under-supplied. Ministers also took steps to improve choice and 'personalization' by requiring that hospitals publish much more information on their performance.

However, in other ways the avenues of 'citizen redress' in the NHS were radically reduced (with the complete abolition of bodies called Community Health Councils) and made more 'businesslike' and NHS-dominated (Dunleavy et al., 2010a). There were though a few offsetting trends later in Labour's period of office. New information websites like NHS Choices were opened from 2005 on, where patients could post testimonials or comments on their hospital care. By 2009, in consultation with their GPs, prospective patients could also exercise a limited choice of which of four hospitals to choose to have their operation in.

Yet towards the end of Labour's term in office, the withering away of patient redress avenues, and the constant reorganization of hospital regulation arrangements, both came home to roost, with spectacular crises in care at two English acute hospital trusts. One at Maidstone and Tonbridge Wells resulted in the deaths of over 90 patients, and illnesses for 1000 more, in a single year, through failure to recognize or control the outbreak of a common hospital infection, *Clostridium difficile* (Healthcare Commission, 2007). The second in Mid Staffordshire caused the premature deaths of at least 400 patients over three years through very poor care standards in its accident and emergency department, despite repeated local protests about unexplained deaths (Healthcare Commission, 2009).

In mid-2010 a Conservative–Liberal Democrat government took office, and the Conservative Health Secretary, Andrew Lansley, introduced a third version of a healthcare quasi-market in a reform bill that the government admitted would cost £1.8 billion, and which informed critics estimated would cost twice as much (*British Medical Journal*, 2010). In Parliament the bill attracted strong criticism from Labour and Liberal Democrat MPs as measures that would 'privatize' the NHS, and because the Coalition government needed to retain its majority the bill's provisions were extensively watered down. Consortia of GPs would still once again 'commission' care and have more options for where their patients went for treatment, but they would have to do this in consultation with hospital consultants and other health professionals. So the government claimed that the 'integration' of the NHS would not be jeopardized. At the same time alternative providers from the private sector and from the third sector (e.g., hospices for looking after dying patients) would be better able to compete with hospitals, and hospitals would be able to compete more with each other. It remains to be seen how much change in effective patient choice or GP choice will be introduced by the new wave of reform, and whether it will have positive efficiency effects (as ministers claim) or negative effects (Dunleavy, 2012b) on how healthcare is provided.

It is clear from NAO assessment of central government reorganization costs (National Audit Office, 2010b) that the investments made in

repeatedly reorganizing the architectural arrangements of the NHS have cumulatively cost billions of pounds over the last quarter century. There has also been a commitment of hundreds of millions of pounds in seeking to improve managerial practices and competencies, modernizing business processes, developing the leadership and managerial competencies of senior NHS administrators and trying to encourage the spread of what has been conventionally recognized as 'best practice' at different periods of time. Acute hospitals are very large and complex organizations, with an average of 4000 staff each, organized in strongly siloed professional/medical specialisms. They have a complex set of governance arrangements covering budgets, professional practice, the exercise of medical judgement, the standards for patient care, responding to new medical technologies and treatment innovations, meeting government-set targets for performance and staying on the right side of many different sets of regulatory provisions (administered by different quasi-governmental and professional bodies). Guiding hospitals through this maze of management issues so that they can recruit and retain the right staff, keep up to date in their treatment approaches, meet patient needs safely and effectively and yet stay within budgets and meet demanding governance requirements is hence a difficult task.

The importance of improving the 'quality' of hospital managers has accordingly been regularly stressed throughout the recent period – 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. Given this emphasis, many healthcare trusts have tried adopting different organizational and management approaches in recent years to improve the provision of their services.

A report from the NHS Confederation looked at the causes of failure in five underperforming hospital trusts (Protopsaltis et al., 2002; NHS Confederation, 2002). They argued that in all five cases hospital failure occurred as a result of:

- poor leadership, including a reluctance to make decisions and an unwillingness to delegate;
- problems with the trusts' internal organizational culture and a lack of clinical engagement;
- distraction, large projects occupying the majority of senior management time caused less attention to be paid to monitoring regular healthcare implementation;
- poor operational management, including inefficiency in clinical or operational areas;

- strategic and external problems, including a failure to address longer-run issues, make fundamental changes to clinical services, and poor quality control.

Incoming managers brought in to turnaround the five failing NHS trusts typically focused their activities on four things – internal restructuring; improving the trust's performance against core targets such as waiting times and financial viability, training staff better and improving the trusts' communication with eternal stakeholders. In addition, the report emphasized:

- giving detailed consideration to failures, in order to avoid adopting over-simplified solutions;
- adapting new strategies to differing circumstances;
- giving greater priority to preventing problems from arising, rather than fire-fighting those that arise;
- major cultural change inside failing trusts, including changing the chief executive;
- realistic expectations about the time needed for recommended changes to take effect.

The Healthcare Commission (2007) report on the poor handling of two *Clostridium difficile* infection outbreaks at the Maidstone and Tonbridge Wells hospital trust showed that the failures there cost the lives of more than 90 patients with many more seriously ill. Many of the problems itemized above also occurred in this case (and in fact recurred two or three times). In particular, the trust's management board allowed their infection control consultant to leave without being replaced for a long while, and failed to act promptly to recognize or combat the hospital infections crisis – chiefly because they were so distracted by many other big decisions – including correcting a budget deficit, implementing a big new PFI building project and applying to the government for 'foundation trust' status.

Closely associated with improving NHS management practices have been major government efforts (partly aided by the professions) to redress a severe deficit in the use of information and communication technologies by the NHS acute hospitals. During the 1980s and early 1990s a couple of more ambitious hospital IT projects failed badly, with bad publicity and criticisms in Parliament. These experiences put chief executives off from making large ICT investments. Pressure on budgets until 2001 also pulled all available resources into direct patient care. By the time that resources grew again, the hospital sector was strongly set in a low-tech pathway by dominant professional practices – amongst doctors, nurses and managers.

Although family doctors computerized some of their administration using small PC-based systems, hospitals wards had very few PCs and little modern ICT in place. They were consequently very slow to adopt modern forms of patient records and to seek to digitize information. Up to the time of writing (mid-2012) paper files and folders remain the dominant medium by which NHS hospital doctors, nurses and other medical professions record and retain information. Over several decades acute hospitals conspicuously failed to transform their business processes using network and database ICTs. They also made few moves to engage with their patients and stakeholders using internet-based digital processes. Substantial barriers seem likely to remain in the hospital sector, leaving it as one of the most conspicuously digital-lagging major service industries in the UK for some time to come.

However, a major commitment was made under Tony Blair's premiership in 2002, following which the NHS did invest significant resources in a highly centralized 'big bang' programme for introducing modern systems and technologies, called the National Programme for IT (NPfIT, pronounced 'NP fit'). This plan sought to create a secure 'national spine' (network) for inter-hospital communications, and for links between hospitals and with GPs. Massive change programmes affected many different areas, especially the creation of fully digitized patient records (accessible in a short form at any hospital), and the digitizing of all X-ray records.

The NPfIT approach was to be financed by large amounts of central funding, and implemented by means of a tightly centralized set of nationwide contracts with a few of the largest ICT firms, especially British Telecom (BT), the UK's former nationalized phone company, and Accenture, one of the 'big 4' world management and technology consultancy firms. On some estimates, by April 2010 the NHS had spent around £6 billion in rolling it out (*Computer Weekly*, 2010) and the total costs that were supposed to be spent eventually have been put as high as £13 billion. Some NPfIT features, such as the electronic patient care records, proved very difficult to even pilot, and had not been fully implemented nationwide by the time the programme was halted in autumn 2011. 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) became operational in 2009–11 to varying degrees at local and regional level.

Critics have argued that the NPfIT programme quickly followed a familiar UK template for large-scale government IT disasters (Public Administration Select Committee, 2011). Some key parts of the architecture, such as the provision of a fully digitized patient record, proved far more difficult to get right than was envisaged. As problems became evident,

Accenture pulled out of the whole programme, taking an estimated £200 million financial hit in the process. Critics argued by 2010–11 that the full delivery of some NPfIT features (such as the national 'spine' for inter-hospital and hospital-to-GP communications) and the partial implementation of most features at scale, should already have had some observable potential effects on efficiency or productivity levels. But evidence on these lines was actually very hard to come by, with the Department of Health unable to point to any study documenting realized benefits.

Early evaluations of NPfIT by the National Audit Office (NAO, 2008) seemed to bend over backwards to give the programme the benefit of the doubt, and NAO were criticized as vesting too much credence in Department of Health promises of future benefits. Later audit studies (NAO, 2011a) concluded that large parts of the spending undertaken represented poor value for money and that the scheme as a whole was not delivering benefits proportional to its costs. The Public Administration Select Committee (2011) recommended scrapping what remained of NPfIT and spending the remaining money on alternative schemes.

In response, ministers in the Conservative–Liberal Democrat government ceased completion of NPfIT as originally envisaged. They opted for a much lower-cost and more decentralized and voluntary approach, in which acute hospital trusts were no longer compelled to take on board the full set of NPfIT requirements. Trusts could now choose to buy into some more modest centrally promoted ICT initiatives, or not. How this new approach will work in combating the still evident under-use of ICTs within the acute hospital sector remains to be seen. The climate of very tight financial resources for the NHS inaugurated by Coalition ministers in 2010 seems unlikely to see hospitals committing substantial resources to ICT change. However, ICT initiatives that could directly and immediately foster cost or staffing reductions (for instance, automating patient records, or moving more booking systems for patient appointments online) may survive such financial pressures.

Given this political, management and ICT context, it is probably not surprising that the few research studies of the productivity of the NHS have tended to come to pessimistic conclusions. Most work looked at aggregate productivity trends in the health service at a meta-level. Castelli et al. (2007) examined a number of years from the late 1990s on, finding that productivity trends were generally negative over time. A similar pattern occurs in recent Office for National Statistics studies (ONS, 2008a), which argue that the productivity of healthcare provision as a whole in the UK fell consistently during the period of the greatest expansion of NHS funding in the noughties. The authors mention that such negative trends may be a consequence of the increased NHS spending that the

Labour government implemented from 1997. However, the quality adjustments that ONS makes to allow for improvements in NHS outputs are probably not enough to capture other key changes at this time, and critics have stressed that some perverse effects are incorporated here – as with the case of doctors spending more time with patients discussed already.

Amidst all the sound and fury over NHS reorganizations, it remains the case that information on how acute hospitals are operating remains scarce and patchy. Some management consultants claim large productivity gains remain to be made (McKinsey, 2010). Ministers still often seem to make decisions based on gut instincts, and perhaps the rapid generalization of something that seems to work well in pilot implementations. This pattern is not what might be expected if policy-making were genuinely evidence based.

8.2 METHODOLOGY AND VARIABLE SPECIFICATION

In the analysis below we seek to assess how far interconnecting management and increased ICT factors have begun to achieve trackable impacts on healthcare trusts' performance. Untangling the effects of these two variables within the NHS context should contribute to the wider literature on government productivity (reviewed in Chapters 1 and 7). And it should have significant interest for scholars in areas like health service management, e-health and perhaps health informatics. We focus only on acute hospital trusts because this sector absorbs a large portion of the healthcare budget, involves the biggest and most complex organizations, and handles the most difficult and expensive medical cases. We have seen above that government targets, advice and programmes designed to encourage the use of new ICTs and good management practices have all focused very heavily on acute trusts.

The Coverage of our Dataset

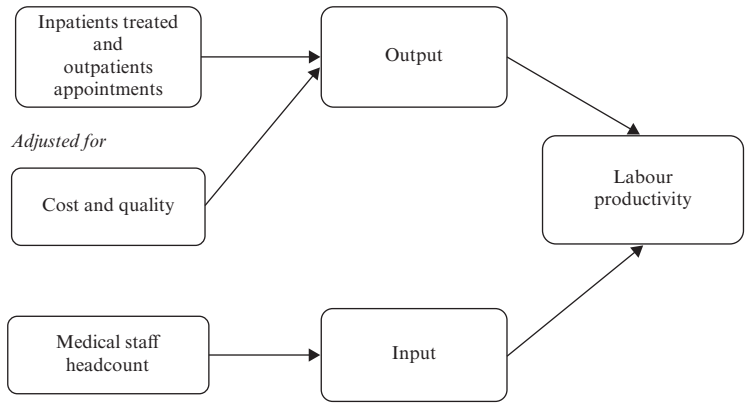
We assembled a dataset for the acute hospital trusts in England for the financial year 2007–08. We excluded hospitals in Scotland and Wales, because they were run under different policies set by the devolved governments of these two countries, and this would blur a focus on the roles that managerial modernization and ICTs played in shaping hospital productivity. All our cases operate within the framework of recent policy summarized in section 8.1 above.

Our dataset was 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.
- Data from the NHS Information Centre on complaints management and medical workforce. These are two separate datasets available on the centre's website. The first one includes the 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 the total number of medical staff broken down by grade in each health organization.
- Hospital Episodes Statistics is a database of 'Hospital providers', from which we took information on the numbers of finished consultant episodes, numbers of outpatients appointments, mean waiting times and patients' age.
- The NHS Staff Satisfaction Survey 2008 provided 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.
- We generated data on key independent variables covering each hospital trust's visible use of modernizing management practices and use of ICTs and solutions using web-censuses. The approach uses web-census methods as discussed in Chapter 7, and we explain below in the third sub-section how we collated information on 59 variables to compose a management modernization index and an ICT index for acute trusts.

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. In fact, our complete dataset includes slightly less than all English trusts, for several reasons (the Chapter Annex below gives a complete listing of those covered). While we were conducting the study, we found that 15 trusts had changed their name and eight trusts had merged into four new ones, while one trust had more of a primary care character (see notes to the Chapter Annex table). 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 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

Figure 8.1 Our approach to measuring the labour productivity (of medical staff) in NHS acute trusts



on complaints, patients' satisfaction levels or mean waiting times – the three variables that we used to quality adjust outputs (see below). Therefore, we ended up with a total dataset covering 153 acute trusts.

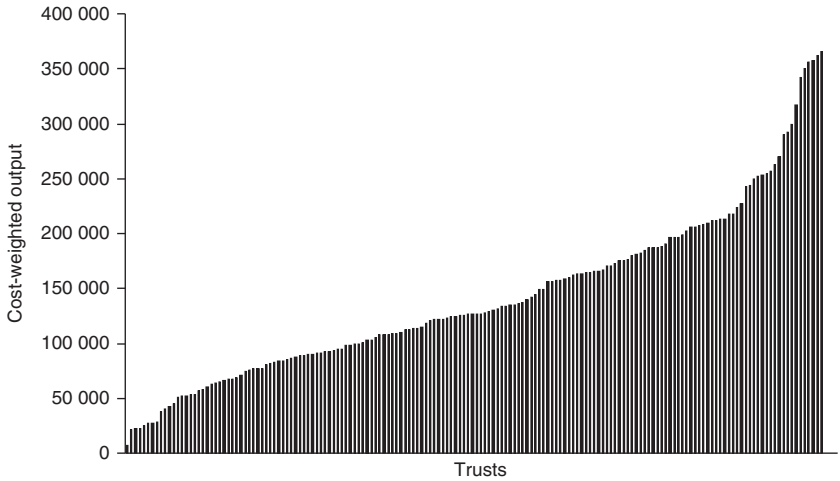
The key dependent variable for this analysis is labour productivity in the NHS acute sector, and Figure 8.1 shows the way in which this measure was constructed. We calculated this as the ratio of our measure of outputs to the numbers of medical staff (that is, doctors and nursing staff) in each trust. Labour productivity becomes a reliable comparable performance measure when used across different units but with a common denominator. Our output measure is primarily based upon the number of outpatient appointments and inpatient spells, but adjusted for cost relativities so as to account for the different costs of 'producing' a unit of outpatient appointments and of inpatient treatments.

To measure initial *outputs* we used the total number of inpatient spells (in 2007–08) at trust level, and the total number of outpatient appointments per trust in the same year 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'.

Cost-weighting Outputs

Turning to cost-weighting outputs we followed the methodology discussed in Chapter 1 and suggested by the Atkinson Report (2005b) and subsequent publications from the Office for National Statistics (ONS). Outpatient appointment and hospital spells data were both weighted according to the share of total administration costs involved in produc-

Figure 8.2 The distribution of cost-weighted outputs across acute hospital trusts



ing them. For this purpose, we used the data on administrative costs for inpatients and outpatients in the Kent University manual on NHS unit costs (PSSRU, 2007). From these data, we aggregated all the costs related to treating outpatients and those related to treating inpatient spells. The resulting unit costs were on average £479 for inpatients and £152 for outpatients, so that inpatient costs were somewhat more than three times more expensive that those for outpatients. This is consistent with other recent publications that also suggest a relationship of 3 to 1 in inpatient to outpatient costs (Castelli et al., 2007). Therefore, we multiplied the number of inpatients by 0.75 and the number of outpatient appointments by 0.25. Finally, we added the weighted inpatient and outpatient numbers to obtain a cost-weighted measure of output. Figure 8.2 shows the distribution of hospitals' cost-weighted outputs that resulted.

Our key methodological innovations in the analysis below focus on the development of means of further quality-weighting our cost-weighted output measures and on the specification of the independent variables relating to management practices and ICT use. We discuss each in turn.

Quality-weighting Outputs

Because quality variations across units may otherwise introduce the strong 'perverse' effects in productivity analyses discussed in Chapter 7, we also use quality weights to construct productivity measures, reflecting current

best practice in the study of productivity among decentralized public services where quality variations may potentially play a significant role and cannot plausibly be assumed to be constant (ONS, 2007a, 2007b).

There is ample evidence that the quality of service may vary widely across acute hospitals. For example, an outpatient appointment obtained with a delay of only two weeks should not be considered similar to one gained only after a ten weeks' delay. Similarly, having a timely operation to head off problems is a much better outcome for a patient than having emergency treatment once a crisis has occurred. There are obviously many dimensions of medical treatment and surgery quality that are exceptionally difficult to obtain information on, let alone systematic data. But we are focusing here on aggregate performance across trusts, and not on the performance in particular treatment areas (the focus in most medical studies).

Because of our trust-level focus, we chose as quality indicators average patient 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' tables for 2007–08, the complaints ratio from the NHS Information Centre for 2008–07 and patient satisfaction from a number of different Patient Satisfaction Scores included in the CEP database.

We proceeded by creating five-point 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 as follows:

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 for patients to be referred to treatment. We considered that any NHS trust with a mean waiting time exceeding 126 days (18 weeks) should be given a 0 per cent quality adjustment. Table 8.1 shows the whole interval breakdown and the percentage quality adjustments employed.

For mean patient satisfaction the data was compiled from information included in the CEP database on NHS trusts for five different patient satisfaction scores covering: overall experience; access and waiting; information and choice; relationships; and whether hospitals were clean, com-

Table 8.1 Mean waiting time adjustment

Mean Waiting Time (based on target)	Percentage (%) Quality Adjustment	Distribution of Trusts (%)
> 126	0	2
$\leq 126 > 94.5$	25	13
$\leq 94.5 > 63$	50	61
$\leq 63 > 31.5$	75	20
≤ 31.5	100	4

Table 8.2 Mean patient satisfaction adjustment

Mean Patient Satisfaction	Percentage (%) Quality Adjustment	Distribution of Trusts (%)
> 4	100	2
$> 3 \leq 4$	75	84
$> 2 \leq 3$	50	12
$> 1 \leq 2$	25	2
≤ 1	0	–

Table 8.3 Complaints completion ratio adjustment

Mean Complaints Ratio	Percentage (%) Quality Adjustment	Distribution of Trusts (%)
> 0.85	100	35
$\leq 0.85 > 0.7$	75	41
$\leq 0.7 > 0.55$	50	15
$\leq 0.55 > 0.4$	25	6
≤ 0.4	0	3

fortable 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 8.2 shows how this was implemented.

For the complaints completion ratio we used data from the NHS Information Centre on the percentage of complaints for each trust that were completed within the government target of 25 working days. We created the intervals shown in Table 8.3 and used the associated quality adjustment levels to adjust the measure of output for each trust.

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

$$CQWO = CWO * MWTA * MPSA * CCRA \quad (8.1)$$

Where

$CQWO$	=	cost- and quality-weighted output;
CWO	=	cost-weighted output;
$MWTA$	=	mean waiting time adjustment;
PSA	=	mean patient satisfaction adjustment;
CCA	=	complaints completion ratio adjustment.

To give a concrete illustration of what this step means, Table 8.4 shows an illustrative set of five trusts whose cost-adjusted output measures are also adjusted for quality.

As laid out in equation (8.1), our quality-wighting procedure provides a 100 per cent quality adjustment. To account for some extra variation in such weighting procedure, we also estimated three extra scenarios in which the total adjustment was in between the full cost- and quality-weighting and the cost-weighting. To illustrate such scenarios it was necessary to calculate the difference between the cost-weighted output and the full cost- and quality-weighted output:

$$\text{DIFF} = CWO - CQWO \quad (8.2)$$

We then calculated the intermediate weighting scenarios between a full cost- and quality-weighting and a cost-weighting at 75 per cent, 50 per cent and 25 per cent levels. A higher level indicates a value closer to the full cost- and quality-weighted figure:

$$CQWO\ 75\% = CWO - (\text{DIFF} * 0.75) \quad (8.3)$$

$$CQWO\ 50\% = CWO - (\text{DIFF} * 0.5) \quad (8.4)$$

$$CQWO\ 25\% = CWO - (\text{DIFF} * 0.25) \quad (8.5)$$

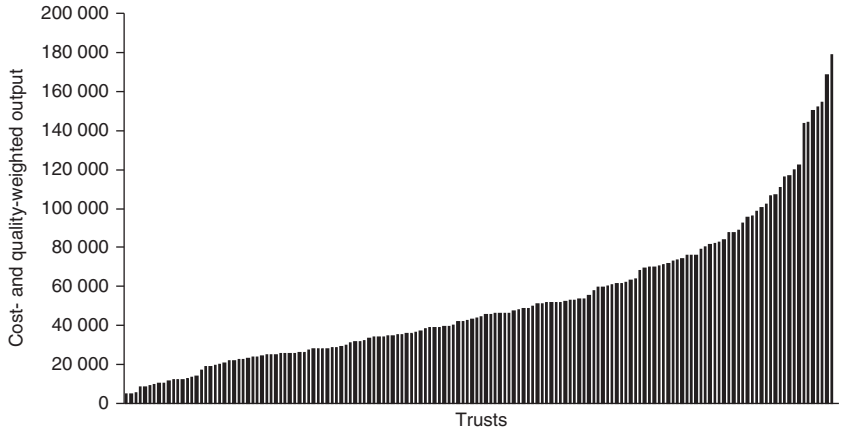
We therefore calculated three additional productivity estimates. These estimates were included in our regression models. The impact of quality-weighting on outputs distribution across trusts is shown in Figure 8.3 (for $CQWO$).

Inputs were defined as the number of medical staff per acute trust

Table 8.4 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	269 875.28	3.00	0.75	0.89	1.00	44.00	0.75	151 804.85
Heatherwood and Wesham Park Hospitals	163 795.08	3.00	0.75	0.61	0.50	58.00	0.75	46 067.37
Royal Free Hampstead	172 705.36	2.80	0.50	0.18	0.75	55.00	0.75	48 573.38
South London Health Care Trust	289 615.08	2.67	0.50	0.77	0.75	66.00	0.50	54 302.83
West Hertfordshire Hospitals	134 272.92	2.80	0.50	0.49	0.25	82.00	0.50	8 392.06

Figure 8.3 The distribution of cost- and quality-weighted outputs across acute hospital trusts



obtained from the NHS Information Centre (that is, covering doctors, nursing and other medical staff). 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 while still allowing 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 service outputs to patients. Our measure of inputs has most impact on improving the productivity data for those historically important teaching hospitals that are also major centres of medical research. Overall *labour productivity* was obtained by dividing the total cost- and quality-adjusted output measure (as defined above) by the level of medical staff inputs for each trust.

Specifying Independent Variables

There are a large number of possible influences upon the productivity of hospital services. In light of the discussion in section 8.1, Box 8.1 itemizes one potential set of influences. However, it is not easy to envisage being able to easily operationalize variables for many of these influences. It

BOX 8.1 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
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

should be apparent here that the potential influence of both the independent variables we focus on, namely management quality and innovativeness, and hospitals' ICT use, are not likely to have large effects on overall hospital productivity. So it is important to keep the limited maximum potential roles of management and ICTs in a clear perspective. The contributions that they make to shaping hospital productivity are likely to be small and perhaps rather subtle. We draw two implications.

First, it is important to control as far as possible for other influences that might affect trust-level productivity, such as most of those listed in Box 8.1. From extensive exploratory data analysis of bivariate relationships with cost- and quality-weighted hospital productivity, we constructed some key dummy variables that assume a value of one whenever a trust falls 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. This is also a region 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, with apparently strong adverse effects on hospital mortality rates, after controlling for many other factors (Hall et al., 2008).

Second, following on from Chapter 7, it is especially important to find indicators of the independent variables that we wish to focus on here that do not risk importing elements of other potential causal influences. In particular we are most interested in those aspects of management quality and innovativeness 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' scores for the proportion (percentage) of staff responding:

- that they 'attended taught courses in the last 12 months provided or paid by the trust';
- that they had 'job training in the last 12 months provided or paid by the trust';
- that they 'had a mentor in the last 12 months'; and
- that they 'shadowed someone in the last 12 months'.

We transformed these data into scores from 1 to 6, 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 deviations below the mean, 3 if the value fell between 0.5 and 0 standard deviations below the mean, and we allocated scores 4 to 6 in the same manner for scores above the mean.

To measure both the quality and nature of management practices in hospitals, and how far hospitals used ICT, we utilized a web-census technique discussed in section 7.3 in Chapter 7. We surveyed each of the 153 trusts' websites for multiple indicators that were scored 1 when present or 0 when absent. Scores were then cumulated into aggregate indicators of management practices and of ICT use.

To measure management quality and innovativeness non-reactively we developed a large set of 41 indicators grouped into seven categories bearing on the generic management approach used by hospital trusts and measured via their websites. These covered essentially:

- the provision of information about transactions and treatment interactions to patients;
- patient empowerment features;
- outreach information for the local community;

- trust accountability and ethos;
- performance tracking and standard settings;
- managing and recruiting talent; and
- human resource development practices.

Table 8.5 provides a full list of the 41 indicators involved. We used such a large number of elements here because overall management quality and innovativeness is a complex construct, for which there are no simple or decisive online indications of good or bad practice. Hence a cumulative score across a large number of small and partial indicators provides the most feasible and robust solution.

Assessing ICT use in hospital trusts is somewhat easier, since there are better online indications of good or bad practice, and hence we needed a shorter list of 18 indicators. However, in addition we looked for indicators that are remote from the management list and are specific to the ICT area. They fall 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 usability; and
- ICT innovations.

Table 8.6 (on page 254) provides a complete list of these indicators.

8.3 ANALYSIS AND RESULTS

The descriptive statistics for the dependent and independent variables included are given in Table 8.7.

The results suggest a mostly unskewed 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 do not expect (or need) trusts to be normally distributed across these control covariates.

We estimated ordinary least squares (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 model first using only the cost-adjusted labour productivity as the dependent variable (Model 1). Then we estimated four additional models (Models 2 to 5) in which we also incorporated a quality adjustment to our output measure and hence to our labour productivity measure. As explained before, we

Table 8.5 The composition of the management practices index

Dimension	Indicator	Management Practices
Patient interaction information	1	Hospital site links to NHS Direct website
	2	Information on how to cancel appointments is provided
	3	Accessibility maps/plans are available
	4	Information about visiting hours is provided
	5	Links to individual hospitals are provided
	6	Links are given to local Primary Care Trusts (PCTs) in the area
Patient empowerment features	7	A Freedom of Information link is present on the home page
	8	Patient Relationship Management is explained online
	9	A name or picture is available for the Caldicott Guardian[a]
	10	Trust phone lists are provided
Outreach information for local community	11	There is a link to at least one local hospital charity
	12	The background and history of the trust is described
	13	Links are given to open events organized by the trust
	14	Links are given to hospitals' services
	15	Links are given to the communications team
	16	News on each hospital in the trust is available on the site
	17	Information is given on trust's new building projects
	18	Links to trust press releases are available
Trust accountability and ethos	19	An organogram or another indication of the trust's structure is provided
	20	Details of past and future trust meetings are provided
	21	The agenda for the next trust meeting is provided
	22	Biographies of trust directors provided
	23	Information is given on the trust's overall goals
	24	Information is given on the trust's values
Performance tracking/ standards	25	Links to standards or to performance documents/ information are present
	26	The trust's annual audit letter is available
	27	The Hygiene Code inspection report is available
	28	Recent developments at the trust are shown
	29	Information about the Care Quality Commission is given

Table 8.5 (continued)

Dimension	Indicator	Management Practices
	30	Infection rates are available
	31	Link to Annual Health Check is present
	32	Link to Care Quality Commission summary statistics on the trust is given
Managing and recruiting talent	33	Information is available online on pay scales in the trust
	34	Information on the benefits of working in the trust is given
	35	Programmes or placements for medical students are available online
	36	Advice for staff moving to the area is given
	37	Volunteering possibilities are present and explained
	38	The trust says that it has a flexible approach to part-time working
Human resource development	39	Links to learning possibilities for non-medical staff (nurses, carers, etc.) are provided
	40	There is a dedicated research and development section or link
	41	A Centre for Postgraduate Professional Education exists in the trust

Note: a. Senior persons responsible for protecting the confidentiality of patient and service-user information and enabling appropriate information-sharing.

intended to estimate models in which the quality adjustment for the output and labour productivity measure was at 25, 50 and 75 per cent levels in between a full cost and a full cost and quality adjustment (Models 2 to 4). Model 5 uses our full cost- and quality-adjusted labour productivity model. The models also include an interaction term between our indices for ICT use and management practices. This helps 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 8.8 shows the results of our models. The goodness of fit of the regression model improves gradually as the cost- and quality-weighting increases (as shown in the results for the different intermediate scenarios). The data for Model 1 demonstrate that amongst our control variables only that for hospitals' location becomes significant – trusts outside London show an increase of more than 71 points in the cost-weighted productivity measure, compared to those in the capital. Overall, Model

Table 8.6 The composition of the ICT use index

Dimension	Indicator	IT Measures
Online information/ documentation	1	Information on IT expenditure for the current (or past) years provided
	2	IT strategy documentation is available online
	3	Document reading software is available online
	4	Annual Report and Trust Accounts are available online
Good practice on website features	5	Website readability features are present
	6	Site map is provided
	7	Website comment box is available
	8	Web pages are dated
	9	Web pages are recently updated
	10	Web accessibility link is provided
Web usability	11	Less than seven items in each section's menu
	12	There are not more than 15 items in each section's menu
	13	Website search engine works effectively to find materials
	14	Pop-up web survey is provided
IT innovations	15	Web 2.0 features (videos, podcasts, etc.) are present
	16	A system for patients to manage their appointments is available or promised
	17	Information on waiting times is provided online
	18	Online donations to hospital charity are possible

Table 8.7 Descriptive statistics for the variables employed in the analysis

Variable	N	Mean	SD	Min.	Max.
Cost-weighted productivity	166	318.7	144.4	105	1456.7
Cost- and quality-weighted productivity	153	124.9	108.2	13.9	818.4
Cost- and quality-weighted productivity 75%	153	174.5	112.9	41.1	978.6
Cost- and quality-weighted productivity 50%	153	224.3	121.8	62.3	1138.8
Cost- and quality-weighted productivity 25%	153	274.1	133.8	83.7	1297.4
Management practices	166	23.8	4.6	13	36
IT use	166	8.8	2.4	4	16
Interaction term (IT × 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

Table 8.8 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	27.15	32.51	33.57*	34.64*	35.709**
	(24.9)	(23.51)	(21.25)	(18.51)	(18.414)
Management practices	11.10	13.03	12.97	12.92*	12.867*
	(10.45)	(8.91)	(8.96)	(8.23)	(7.767)
ICT × management	–1.33	–1.54*	–1.55*	–1.56**	–1.58**
	(1.03)	(0.97)	(0.88)	(0.811)	(0.766)
General training	6.62	11.07	11.44	11.81	12.187
	(11.63)	(11.32)	(10.23)	(8.39)	(8.869)
Specialist	–6.57	42.44	64.84*	87.23**	108.634***
	(38.8)	(41.07)	(37.15)	(34.11)	(32.184)
Teaching	–53.57	–18.13	4.28	26.75	48.229
	(65.19)	(64.71)	(58.54)	(53.73)	(50.709)
London	–71.86**	–78.82**	–78.98**	–80.13***	–80.287***
	(35.3)	(34.11)	(30.86)	(28.33)	(26.733)
R^2	0.09	0.10	0.11	0.13	0.16
N	160	147	147	147	147

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

1 explains just 9 per cent of the variation in the dependent variable, while Model 5, with a full cost and quality adjustment, explains around 15 per cent of the variation in the dependent variable. The results for Models 2 to 5 confirm that they fit the data better, with increasing R^2 levels compared to Model 1. It is also worth noting that as the cost- and quality-weighting increases, more coefficients become significant. 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 also significantly more productive than generalist ones.

Three key explanations seem feasible here and will need further research to unpick. First, many Inner London or specialist hospitals are generally regarded by patients and GPs as the best in the country. Accordingly they may attract significantly more complex cases, whose treatment requires longer interventions – reducing the London hospitals' productivity performance on our measures. In other words there may be a substantial and

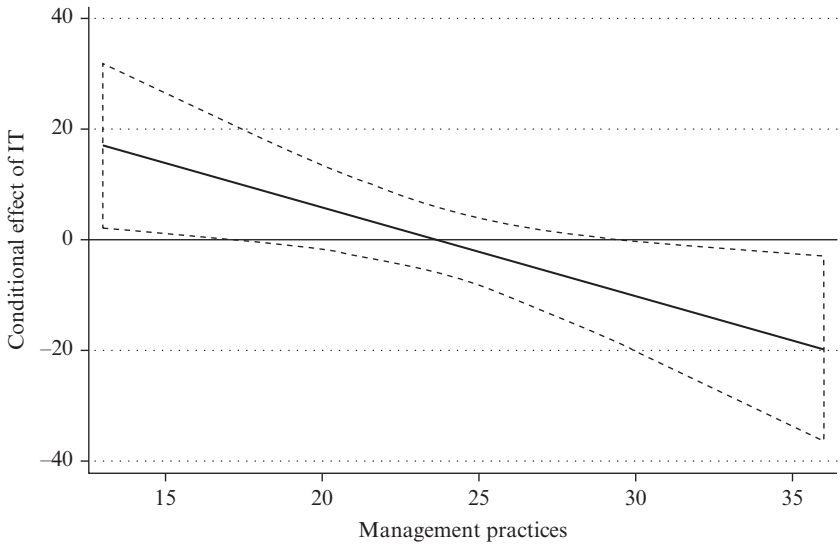
unmeasured quality difference between London and non-London trusts in the nature of the treatments involved. Second, London trusts' productivity may be adversely affected by an inability to attract nursing staff, given the capitals' higher costs of living and property prices, which previous research 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).

Across Models 2 to 5 the different coefficients become more significant as the cost- and quality-weighting increases. For the best fitting model, Model 5, the coefficients for the interaction term and its components are all significant. However, an important issue that arises when utilizing interaction terms in regression analysis is that the interpretation of the interaction term and its components cannot be made individually – because 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 explain, when the results are listed for the coefficients of an interaction term like ICT and management here, they represent the effect of each variable when the other one is set to zero. In this sense, looking at Model 5 in Table 8.8, 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 index is zero. Likewise, an increase of one unit in our measure of management index 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 for either the ICT or management indices – so that neither of these effects is likely to be observable in our data.

So 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 the management index and, vice versa, how the management index affects productivity given the 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 8.4 below shows the conditional effects of IT on productivity given the full range of values for our management index. These illustrations 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.

Figure 8.4 clearly shows that the positive effect of ICT on productivity decreases as our management practices index increases. Thus, for trusts with management scores of more than 17 (that is, nine-tenths of all trusts), the effect of ICT on productivity becomes indistinguishable from zero.

Figure 8.4 The conditional effects of hospital trust IT given management practices

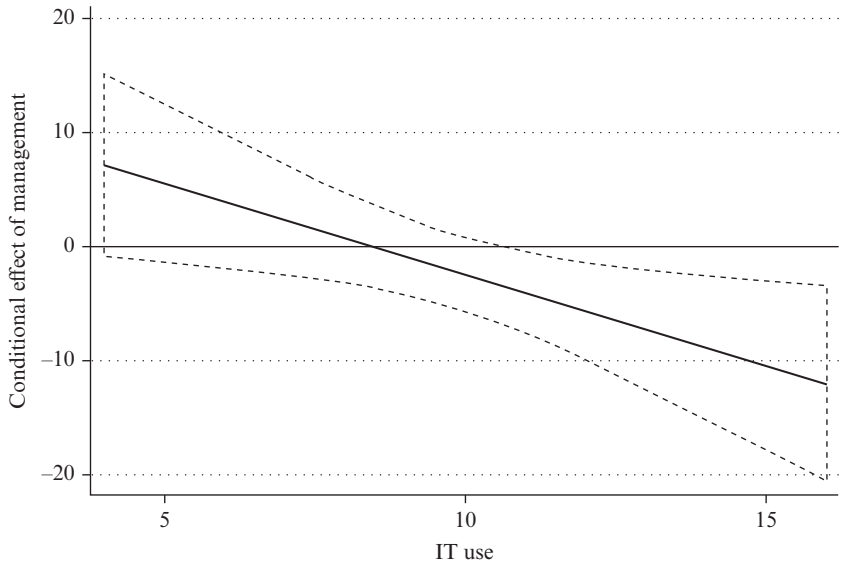


Note: The dashed line area represents limits the upper and lower 90% confidence intervals. The marginal effects and standard errors used for this figure were calculated according to results from Model 2.

Putting this another way, the results seem to indicate that in trusts with low to medium-low scores on our management index (comprising 11 per cent in our dataset) good ICT use can significantly help to increase productivity. However, our results also seem to suggest that as trusts become better managed so the pay-offs from using better ICT practices diminish. In fact, Figure 8.4 shows that in trusts with a management index score of 28 or more (comprising a sixth of the whole dataset) greater or more improved ICT use *negatively* affects productivity levels.

As mentioned before, it is also possible to model how management affects productivity given specific values of IT. Figure 8.5 shows the conditional effect of our management practices index on productivity given the full range of values of IT. The results here 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 to or higher than 11 (a condition affecting 23 per cent of the trusts) the effect of increasing scores on the management practices index on productivity is negative. We can interpret this result as suggesting that good management practices (as captured by our index) may not help to boost

Figure 8.5 The conditional effect of management practices given use of IT in hospital trusts



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

productivity once trusts already have a well-developed focus on employing modern ICTs productively

Comparative Discussion

Our core analysis was undertaken using data available in mid-2009 and revised in 2010. In considering the results above, we are fortunate to be able to compare them to a closely parallel analysis of hospital productivity in England carried out by an in-house economist at the National Audit Office, and discussed with the Department of Health (NAO, 2010d, 2010e and 2010f). This analysis used a large but different set of independent variables, dominated by multiple financial performance indicators, some patient-mix data, extensive data on hospital estates and the numbers of different staff, plus other official statistics. The dependent variable was also different, namely a 'reference cost index' showing how much it cost hospital X to treat its patients, divided by the average cost of all English hospitals for the same case mix of patients. (There were also some adjust-

ments for additional 'market forces factors', to allow for some regions of England being more expensive than others.) The dependent variable used by NAO was not quality-weighted. Nor did the dataset include anything resembling our staff training variables or indices for hospital management or ICT use. However, the NAO analysis was repeated using data from three different financial years, which is an improvement on our dataset.

The proportion of variance explained in the NAO analysis ranged from 27 to 36 per cent in a series of step-wise models (once specialist trusts were excluded, which previously raised the variance explained to higher levels). But the results here showed great variability in the variables that were assigned significance from one year to the next – strongly suggesting that the model was rather arbitrarily including variables for mathematical but not substantive reasons. (Step-wise regression enters variables in the order of their mathematical effects, and not a theoretically defined order.) Only two variables were present in all three year-models – namely the percentage of hospital floor area occupied (capturing trusts with surplus accommodation, often old premises of less functionality), and the operating surplus or deficit of trusts as a percentage of their total income (capturing how strong their financial management was). Trusts performing well here also had higher productivity. Three variables were present in two of the models – the trust's percentage bed occupancy (a measure of either effective management or perhaps levels of demand), and a dummy variable for large acute hospitals were both associated with higher productivity. The proportion of emergency to non-emergency admissions (i.e the rate of non-planned treatments) was negatively associated with productivity (in two models). Other variables assigned significance in one of the year-models included different staffing number and staffing ratio variables, more indicators of hospital size and type, and raw waiting lists times.

The NAO analysis then tried using alternative hierarchical models, where a more restricted set of explanatory variables were entered in the following order, said to be based on theory reasons: financial management; percentage of space occupied; percentage of emergency admissions (the main case-mix variable); total staff per bed; the turnover rate of doctors in the hospital; the percentage bed occupancy; and measures of hospital size and type. With this approach the three year-models here explained from 28 to 33 per cent of the variance and only three variables appeared in all of them – two being indicators of hospitals in a better financial state, and the last being the proportion of beds occupied. Three variables were present in two of the models – a dummy for acute teaching trusts was positively associated with productivity levels; meanwhile the total staff per bed ratio and the proportion of emergency admissions were negatively associated

Table 8.9 NAO estimates of the savings that would be achieved if all hospitals in England performed as well as the top 25 per cent of hospitals, across four main variables

Variable	2006–07	2007–08	2008–09	Average Values Included in the Main Report
Bed occupancy	760	1067	386	633
Total staff per bed	832		896	510
Emergency admissions	472	668		259
Occupied floor space	525			175
Total variables above	2589	1735	1282	1577

Note: £000s per year.

Source: NAO (2010d, p. 21).

with productivity. The percentage of space occupied was present in one model. None of the other variables made the cut.

Based on these last regression results, the NAO analysis estimated that if all the hospitals performed at the level of the top 25 per cent of hospitals, the NHS could save an average of £1.6 billion a year. However, the actual numbers involved varied strongly from one year to the next, as Table 8.9 demonstrates (in addition, the 95 per cent confidence intervals for each variable were very wide in every year).

There are evident problems here in moving from the regression analysis to policy implications because of a more general difficulty arising from the changing presence of variables in different year-models in the NAO analysis. When this phenomenon occurs in regression analysis it is normally a symptom either of problems in the variable specification, or of an incomplete variable set being present that omits some important causal factors. In such situations regression models can rather randomly tend to include and assign significance to whichever variable happens to do most work in capturing part of the explanatory effect of the omitted variables.

Nonetheless it seems likely on both theoretical and intuitive grounds that these four variables are indeed associated with productivity variations. The NAO main report points out some reasons why their chosen variables may influence productivity in a direct way:

- Higher bed occupancy lowers costs by using staffed facilities more intensively.
- Managing hospital care as effectively with fewer total staff per bed will also be cheaper.

- Reducing the share of emergency admissions implies more planned care happens, and less really acute care, which is much more expensive to undertake. Planned care is also likely to be better organized, with less risk of unintentional resource waste than emergency care.
- Those trusts using more of the building floor space that they occupy will pay less in rents.

But different interpretations are clearly feasible. A general 'managerialist' argument might well legitimately argue that each of the variables above should actually be interpreted as a different indication of the same underlying phenomenon, namely that better managed trusts have higher productivity. Specific alternate interpretations of some of the variables are also feasible, for example, that the emergency admissions variable responds to other care-mix variations not captured by the analysis.

Conclusions

This research has sought to develop an organizationally focused approach to productivity analysis. We undertook a relatively ambitious test of how the adoption of modernized management good practice and improved use of ICT affect productivity across NHS acute trusts. This area 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 unobtrusive 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 reviewed in Chapter 7 but they differ in detail and specificity. We would argue this is because using non-reactive measures removes the 'public relations' and 'spin' effects that are inherent in survey-based and other forms of 'reactive' approaches.

Our research also innovated in implementing an extended version of quality measurement at the trust level, to safeguard against the risks of perverse effects when comparing across decentralized units where large variations in quality are known to exist, and following current best practice in public sector productivity measurement. The results of our quantitative analysis yielded interesting results. On the one hand, in common with earlier work, 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 more serious patient cases

(from the point of view of London trusts), reflecting patients' and GPs' view that trusts in the London area generally are more expert and have better resources to manage complex interventions that require longer periods of care. In addition, Primary Care Trusts may only have been willing to pay the higher costs of London hospitals for a case mix that is 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 in the region, due to higher housing and living costs and so on. In addition, our results also show that specialist trusts are more productive than the rest, which may reflect these trusts' advantage over general hospitals that stems from dealing only with specific (mainly planned) kinds of interventions, for which their staff are well trained and prepared, and adequate in numbers.

More substantively, our quantitative analysis sheds 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 index we found that the effect of more or better ICT on hospital productivity is positive and significant – but only for trusts with a low and medium-low levels scores on the management index. The pay-offs of good ICT use on productivity levels appear to be higher for poorly managed trusts. However, the same result also shows that the effect of more extensive ICT development on productivity may actually be negative for trusts with medium-high or high levels of management. This may suggest that as trusts become more complex, it is possible for managements to develop an over-focus on using ICTs 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 our management index 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. Much work remains to be done on the further development of control variables in this analysis, and on the specification of quality-weighting and

of our management practices and ICT development indicators and aggregate indices. 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, 2010). In addition, by employing non-obtrusive measures to capture the role of ICT and management practices, this research shows the potential of applying such an approach to other areas in the public sector.

CHAPTER ANNEX ACUTE HEALTHCARE TRUSTS INCLUDED IN OUR DATABASE, AND SOME DATA CONSTRAINTS

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

Acute Trust Name	Number of Hospitals
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
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

Acute Trust Name	Number of Hospitals
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
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

Acute Trust Name	Number of Hospitals
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
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

Acute Trust Name	Number of Hospitals
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 eight trusts merged within our study period to form four 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 NHS Trust.

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 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 Berkshire 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 are no data available about complaints handling.