THE UNIVERSITY of York

Final report:

Efficiency Analysis of PFI schemes

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Executive summary

The National Audit Office (NAO) contracted the Centre for Health Economics (CHE) to help advise on and undertake analysis to assess the relative efficiency of services delivered through hospital Private Finance Initiative (PFI) contracts.

This final report compares PFI contracts that cover both Estates maintenance (Hard Facilities Management (FM)) and various Hotel (Soft FM) services, such as cleaning, catering, laundry, and portering. There 34 are schemes that have some combination of these services. We use a technique termed Data Envelopment Analysis in undertaking the comparative exercise.

Overall, given the amount that organisations pay, there is substantial variation in the amount of Hard and Soft FM services received. This variation is not due to differences in geographical variation in the cost of labour, the size of the hospital, whether it is a Foundation Trust or teaching or specialist hospital, or its geographical location.

There may be other reasons for the observed variation. Potential explanations include data reporting error, differences in the quality of services, contract specifications, type of building or the proportion of the site that has been financed through PFI. It has not been possible to explore these factors due to the lack of reliable data. Therefore the results of this analysis should not be treated as a definitive analysis of the efficiency of PFI contracts, but as a tool to identify contracts where an in-depth exploration of costs and their drivers would be of benefit.

Organisations that currently appear to receive relatively fewer services given the amounts they pay may be able to negotiate more competitive prices when undertaking their periodic market testing or benchmarking of Soft FM services. Conversely Trusts which appear to have a good deal on the basis of the volume of services which they receive for the price may be at risk of price increases when services are benchmarked or market tested.

Introduction

The National Audit Office (NAO) contracted the Centre for Health Economics (CHE) to help advise on and undertake analysis to assess the relative efficiency of services delivered through hospital Private Finance Initiative (PFI) contracts. This forms part of a study undertaken by the NAO's Private Finance Value for Money team on the "The performance and management of hospital PFI contracts".

A PFI contract is a bundle of services delivered through a single lead contractor (the PFI ProjectCo), normally using multiple subcontractors, and with a single overarching contractual mechanism. These services relate to the provision of a secondary healthcare building (a hospital). Contracts can be divided into two types:

1. Hard Facilities Management (FM). At a minimum the contract covers the maintenance and upkeep of that building.

2. Soft FM. Contracts often also cover some or all of the hotel services, such as:
    - cleaning;
    - catering;
    - portering;
    - laundry;
    - security;
    - switchboard;
    - helpdesk; and
    - car parking.

Scope of work

The efficiency analysis was undertaken in two stages.

The first stage considered:

- the most suitable modelling techniques, and their advantages and disadvantages;
- the feasibility of using these techniques to draw conclusions about the value for money of services delivered through PFI contracts;
- suggested specifications for the model;
- existing available data to be used in the modelling; and
- data gaps that could be filled through an NAO survey of Trusts.

A report on this stage of the work was completed in March 2009.

The second stage of the work involved:

- creating the model;
- using data provided by the NAO from its survey of Trusts, and
- using existing sources of data to run the model and corresponding analysis; and
- advising on the results of the analysis in the form of a short report.

During this stage of the work we conducted analysis of the survey of PFI schemes conducted by the NAO which asked a range of questions about the scheme's structure and operational performance. Data were also collected about the annual unitary charge for each sub-component of the contract, the value of deductions (if any), incidents of unavailability, and logging of maintenance issues.

Having considered this report, NAO and CHE jointly decided not to use the survey information for the purposes of the efficiency analysis but instead to use the data contained in the Estates Return Information Collection (ERIC). ERIC is a compulsory annual return for all hospital sites covering the cost, quality and volume of estates services.

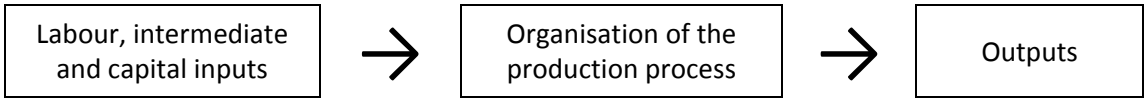
We estimated various efficiency models using the ERIC data, sharing the results with the NAO throughout the analytical process. During these discussions we arrived at a preferred model specification and decided to undertake efficiency analysis of only those PFI schemes that were a combination of both hard and soft FM. Reports on these analyses were provided in August 2009, September 2009 and October 2009. This final report provides an overview of the chosen analytical technique; describes the ERIC data; specifies the chosen set of models; and presents the results of the analysis.

A brief overview of data envelopment analysis

Generally speaking, organisations that fall under the NAO's remit face limited competitive pressure that might otherwise encourage them to innovate and adopt cost minimising behaviour. If such pressure is weak, there may be scope for better utilisation of resources. Efficiency analyses aim to identify which organisations are doing better than others in either their overall operation or in specific areas of operation. This information may be used to stimulate better use of resources, either by encouraging organisations to act of their own volition or through the use of tailored incentives.

The fundamental building block of efficiency analysis is the production process. In very simple terms, the production process can be pictured as in Figure 1. The organisation employs inputs (labour, capital, equipment, etc) and converts these into some sort of output. The middle box, where this production process takes place, is critical to whether some organisations are better than others at converting inputs into outputs.

Figure 1 Simplified production process



The middle box is actually something of a ´black box´ because it is usually very difficult for outsiders to observe what goes on inside the organisation and how its production process is organised. This inability to observe the production process directly is a fundamental challenge for those seeking to analyse efficiency. Nevertheless, it is possible to think of a ´gold standard´ production process that describes the best possible way of organising production, given the prevailing technology. This gold standard is termed the ´production frontier´, which marks the maximum output an organisation could secure, given its level and mix of inputs. Any other scale of operation or input mix would secure a lower ratio of output to input. Organisations that have adopted this gold standard are efficient – they are operating at the frontier of the prevailing technological process.

But organisations might be operating some way short of this gold standard: Equipment might be outmoded, staff may not be working to their full capacity, capital resources might stand idle periodically. These, and multiple other reasons, might explain inefficiency.

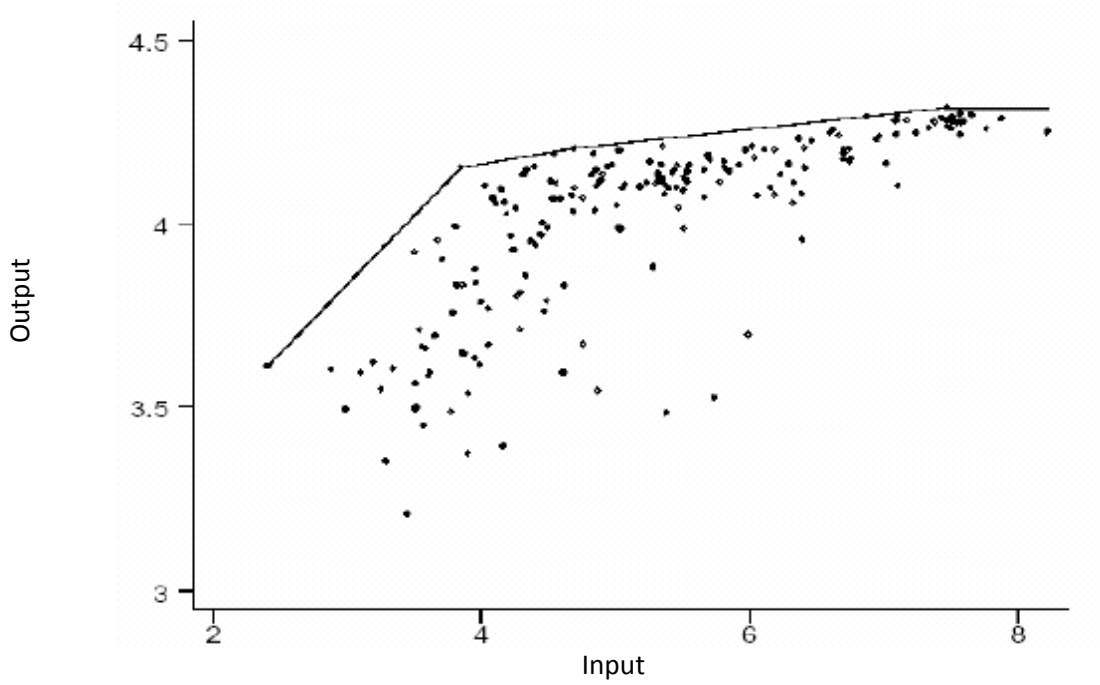
To assess whether there is better scope for utilisation of resources, insight can be gained by comparing organisations involved in similar activities. Rather than attempting to prise open the ´black box´, such comparative analysis concentrates on the extremes depicted in the diagram. Information about what goes in (inputs to the production process) and what comes out (outputs of the production process) allows comparison of input-output combinations of organisations that produce similar things. If an organisation uses less input to produce one unit of output than another organisation, the former is more ***productive***.

If we want to assess organisations that produce different amounts of output, we need to make judgements about whether there are economies of scale. Organisations can then be judged in terms of their relative ***efficiency***.

Data Envelopment Analysis is a commonly used empirical technique to assess efficiency. To illustrate the technique, consider the set of organisations as depicted in Figure 2, all of which use one type of input to produce one type of output. DEA assesses efficiency in two stages. First, a frontier is identified based on those organisations achieving the highest output mix given their inputs. Second, each organisation is assigned an efficiency score by comparing its output/input ratio to that of efficient organisations.

When applying DEA the location and the shape of the efficiency frontier is determined by the data, using the simple notion that an organisation that employs less input than another to produce the same amount of output can be considered more efficient. Those organisations with the highest ratios of output to input are considered 100% efficient, and the efficiency frontier is constructed by joining up these organisations in the input-output space. The frontier thus comprises a series of linear segments connecting one efficient organisation to another.

Figure 2 An example of a DEA frontier enveloping a set of organisations



Inefficient organisations are 'enveloped' by this efficiency frontier. The inefficiency of the organisations within the frontier boundary is calculated relative to this frontier, and every inefficient organisation is assessed relative to some linear combination of efficient organisations. The chosen efficient organisations are referred to as its 'peers'.

DEA also yields specific input or output targets for each organisation. For example, input targets indicate the specific amounts by which a particular organisation should be able to reduce its consumption of particular inputs without reducing output. In calculating the targets DEA compares the input-output mix of the organisation to a linear combination of efficient peers that uses similar or identical levels of input but produced more output.

DEA models can be run for both constant returns to scale (CRS) and a more flexible variable returns to scale (VRS) (as shown in Figure 2) which may be appropriate when not all organisations can be considered to be operating at an optimal scale.

Figure 2 illustrates DEA for the case of a single output – single input scenario. While useful for illustrative purposes, in this situation DEA does not offer much beyond a straightforward comparison of the output-input ratios. It is possible to compare PFI schemes that cover only hard FM on this more straightforward basis.

DEA offers analytical insight, however, when organisations employ multiple inputs to produce different types of output. Thus it is appropriate when considering PFI schemes that are a mixture of hard and soft FM. DEA offers a way to assess the different types of services included in the contract.

If there are M inputs and S outputs, then the production frontier becomes a surface in M+S dimensional space. The efficiency of each organisation is the distance it lies from this surface - the maximum extent by which it could reduce its inputs given its current level of outputs.

Efficiency in DEA is therefore defined as the ratio of the weighted sum of outputs of an organisation divided by a weighted sum of its inputs. A separate linear programme is estimated for each organisation. It seeks for each organisation the set of output weights and input weights that maximizes the efficiency of that organisation, subject to the important constraint that – when they are applied to all other organisations – none can be more than 100% efficient. The weights can take any non-negative value, and in general a different set of weights is computed for each organisation. Thus, the weights are a central feature of DEA. They are chosen to cast the organisation in the 'best possible light', in the sense that no other set of weights will yield a higher level of efficiency.

Put more formally, DEA computes technical efficiency (*TE*) by solving for each organisation ($i = 1...I$) the following mathematical program:

$$\max\left(\frac{w_i \times y_{11}}{\sum_{m=1}^{M} z_m \times x_{m1}}\right) \text{ subject to: } \frac{w_i \times y_{1i}}{\sum_{m=1}^{M} z_m \times x_{mi}} \leq 1 \text{ for } i = 1...I$$

where y_{11} is the quantity of output 1 for organisation 1, w_i is the weight attached to output *y*, and $w_i > 0$. We may have more than one input and so x_{m1} is the quantity of input *m* for organisation 1, z_m is the weight attached to input *m*, and $z_m > 0$, $m = 1,\ldots, M$.

Organisations are sometimes subject to different operational constraints, meaning that they are unable to reach the same production frontier as other organisations, even if they are fully efficient. For example if labour costs are higher in some parts of the country than others, organisations based in the high cost areas will have to pay more for an equivalent staffing complement. If information about these constraints is available, they can be taken into account. One way to do this is to 'correct' observed costs for differential labour costs in a manner akin to risk adjustment. We explore and allow for this possibility in our analysis by adjusting for the market forces factor (MFF).

Data

After assessing various sources of data, we decided to use the Estates Return Information Collection (ERIC) compiled by the NHS Information Centre for the year 2007-08. This return forms the central collection of estates and facilities data in support of the assessment of performance for the occupied healthcare estate in England. This includes delivery of healthcare services from property procured under PFI Agreements. Cost figures represent the total cost to the NHS organisation for the supply of the particular estates and facilities service being reported on, inclusive of service fee and relevant proportion of unitary payment costs.

In our analysis the organisational unit is defined as the PFI scheme. We evaluate these schemes by assessing what hard and soft FM services are delivered (each scheme's 'output') given the cost of the contract (the scheme's 'input').

We used the following variables to represent the 'outputs' of PFI contracts that cover both hard and soft FM:

1. Floor area. This is used to indicate what services have been secured in the maintaining the estate (hard FM) and from the cleaning contract.
2. Meals served. This captures services provided through the catering component of the contract.
3. Laundry pieces. This captures services provided through the laundry component of the contract.
4. Occupied beds. This captures services provided through the portering component of the contract.

Definitions of the variables capturing these services are provided in Table 1. We agreed not to consider inputs or outputs for security, switchboard, helpdesk or car parking as these tend to be relatively minor components of the total contract value.

Table 1 Output definitions

Outputs	Definition
Gross internal site floor area	The total internal floor area of all buildings including temporary buildings or premises or part therein, occupied or non-occupied, which constitute the site operated by the NHS Trust and is either owned by the NHS Trust or as defined within the terms of a lease, Service Level Agreement, or tenancy agreement.
Number of patients served meals	Number of patients served meals is obtained by dividing 'Gross cost of patient services (£)' by 'Cost of feeding one patient per day (patient meal day) (£)'.
Laundry pieces per annum	This is the total annual number of laundry and linen pieces, including disposables, used by the organisation but excluding any laundered or provided for other organisations.
Occupied beds	Annual average daily number of occupied patient beds, in wards staffed and open over night (i.e. 24 hours).

Source: http://www.dh.gov.uk/en/Managingyourorganisation/Estatesandfacilitiesmanagement/PropertyManagement/DH_4117912.

We used the following as input measures, capturing the cost of the PFI scheme:

1. Total costs, calculated as Total Estate Services Costs plus Total FM (Hotel Services) Costs.
2. Maintenance costs.
3. Cleaning costs.
4. Laundry costs.
5. Portering costs.

These are defined in Table 2 below.

Table 2 Input definitions

Inputs	Definition
Total costs	Sum of the 5 input costs provided below.
Total Building and Engineering Maintenance Costs	Total pay and non-pay cost for the provision of building and engineering maintenance services, to maintain the whole of the building fabric, sanitary ware, drainage, engineering infrastructure, systems and plant etc. both internally and externally to the buildings
Cleaning Services Costs	The total pay and non-pay cost of cleaning services for the site.
Gross cost of catering operations	Total pay and non-pay expenditure on catering operations.
Total Laundry and Linen Cost	Total pay and non-pay costs paid by the Organisation in relation to the provision of laundry and linen services.
Portering Service Costs	The total pay and non-pay cost for the provision of all portering services for the organisation site.

Source: http://www.dh.gov.uk/en/Managingyourorganisation/Estatesandfacilitiesmanagement/PropertyManagement/DH_4117912.

Model specifications and modelling approach

For the modelling approach, we employ a variable returns to scale technology which allows us to ascertain whether a scheme is operating under constant, increasing or decreasing returns to scale. This formulation is required if any variables appear as ratios.[1] VRS envelopes data more tightly than CRS and, hence, efficiency scores are greater.

We employ an input orientation since we're interested in how much cost can be proportionally reduced holding output constant.

We compute and compare four DEA models, specified as a ratio of weighted outputs over weighted inputs. The model specifications are as follows:

Model 1 $\frac{\text{Floor area, meals served, laundry pieces, occupied beds}}{\text{Total cost adjusted for MFF}}$

Model 2 $\frac{\text{Floor area, meals served, laundry pieces}}{\text{Costs of maintenance, catering, cleaning and laundry, adjusted for MFF}}$

Model 3 $\frac{\text{Floor area, laundry pieces, occupied beds}}{\text{Costs of maintenance, catering, laundry and portering, adjusted for MFF}}$

Model 4 $\frac{\text{Floor area, laundry pieces}}{\text{Costs of maintenance, cleaning and laundry, adjusted for MFF}}$

The rationale for estimating four models is that PFI contracts do not always cover the full range of hard and soft FM services. Model 1 includes all the soft FM services that we consider, but only those organisations that contract for all of these will be included in the comparative analysis. At the other extreme, model 4 captures only the cleaning and laundry components of soft FM services, as well as hard FM services. Most hard and soft FM contracts cover these components, allowing more organisations to be included in the assessment. In addition, catering costs have a large number of missing values. Hence models were run specifically excluding these services to assess whether efficiency estimates were sensitive to their exclusion.

In preliminary analyses we assessed whether efficiency scores were related to characteristics of the Trust which, if so, might suggest that they face differential operational

[1] Hollingsworth, B. and Smith, P. (2003) The use of ratios in data envelopment analysis, *Applied Economics Letters*, 10(11): 733-735

constraints. This assessment involved performing a regression analysis of the estimated efficiency score on variables that might capture these constraints. This was specified as a Tobit model, because the efficiency score can only take values between 0 and 1 (where 1=100% efficient). The characteristics we considered were the market forces factor (MFF), teaching status, a London dummy, specialist status, Foundation Trust status, bed numbers, and Strategic Health Authority codes. The MFF index is designed to capture unavoidable differences that NHS organisations face in the prices of labour, land and buildings.

MFF proved significant (p<0.05) in all four models but none of the others were significant. The results suggested that the higher the MFF, the lower the efficiency score. This is as expected – the cost of the PFI schemes is likely to be higher in hospitals facing higher factor costs. In view of this, we adjusted the costs reported for each service area by the Trust's MFF.

For each model we report the distribution of efficiency scores, the number of times that each PFI scheme acts as a peer for others, whether schemes face constant, increasing or decreasing returns to scale, and the maximum potential 'savings' that might be realised if schemes considered less than efficient, were to become fully efficient.

If a scheme is operating under constant returns to scale, a proportional increase in inputs will lead to a proportional increase in outputs. Under increasing returns, in contrast, a scheme ought to be realising more output given their cost. Such a scheme may likely be experiencing decreasing average costs and should be able to receive more services than it currently does, given the schemes cost.

The potential 'savings' which are presented are considered the maximum that might be realised because DEA assumes that all of the distance from the frontier is due to inefficiency. In reality much of the distance may arise for other reasons, including data reporting error, differences in the quality of services, contract specifications, type of building or the proportion of the site that has been financed through PF

Results

A summary of the results is reported in Table 3 below, with results for each model following. The codes and names of each organisation are provided in Table 9.

It tends to be the case that as more inputs and outputs are added to a DEA model, an increasing number of schemes appear to excel at one particular aspect of performance and are classified as efficient. The larger the number of input and output variables used in relation to the number of schemes in the model, the more schemes are considered fully efficient and, hence, the less discriminating the DEA model.

We see therefore that Model 1 is much less discriminating than Model 4 since it has a greater number of schemes on the frontier and a higher mean efficiency. Model 4 is the most discriminating because it has the largest sample size and the smallest number of inputs and outputs. Model 4 produces the lowest mean efficiency and the highest variation in efficiency estimates.

The number of times that a scheme is used as a peer for other units is indicative of its overall efficiency. Those schemes which act as a peer the greatest number of times are often considered the 'global leader'.

- Several schemes act as 'peers' for others. This means that, even though they pay similar amounts to other organisations, they receive more services. Calderdale Royal Hospital (RWY02) and Queen Elizabeth Hospital (RG222) often act as peers to other organisations, indicative of their overall efficiency.
- There is just one scheme that appears on the DEA frontier across all four model specifications, suggesting that it gets relatively good value for money whatever combination of services is considered. This is Bodmin Hospital (RJ866).
- Schemes which are efficient across 3 of the model specifications are Great Western Hospital (RN325) and Calderdale Royal Hospital (RWY02).
- Newham General Hospital (RNHB1) is ranked in the bottom five across all four DEA models. This suggests that it receives fewer services than would be expected for the amount paid for them.
- Worcestershire Royal Hospital (RWP50) appears in the bottom five in three models which also suggests it receives fewer services than other Hard and Soft FM schemes of a similar cost.

Overall, given the amount that organisations pay, there is substantial variation in the amount of Hard and Soft FM services received. This variation is not due to differences in geographical variation in the cost of labour, the size of the hospital, whether it is a Foundation Trust or teaching or specialist hospital, or its geographical location.

There may be other reasons for the observed variation. Potential explanations include data reporting error, differences in the quality of services, contract specifications, type of building or the proportion of the site that has been financed through PFI. It has not been possible to explore these factors due to the lack of reliable data. Therefore the results of this analysis should not be treated as a definitive analysis of the efficiency of PFI contracts, but as

a tool to identify contracts where an in-depth exploration of costs and their drivers would be of benefit.

Table 3 Summary of DEA models and results

	Model 1	Model 2	Model 3	Model 4
Outputs	Floor area Meals Laundry pieces Occupied beds	Floor area Meals Laundry pieces	Floor area Laundry pieces Occupied beds	Floor area Laundry pieces
Inputs	Total cost divided by market forces factor	Sum of following costs divided by market forces factor: Maintenance cost Catering cost Cleaning cost Laundry cost	Sum of following costs divided by market forces factor: Maintenance cost Cleaning cost Laundry cost Portering cost	Sum of following costs divided by market forces factor: Maintenance cost Cleaning cost Laundry cost
Returns to scale Orientation	VRS Input orientation	VRS Input orientation	VRS Input orientation	VRS Input orientation
Sample size Number on frontier	15 10	15 10	26 8	34 6
Mean efficiency Min efficiency Max efficiency Standard deviation	96.1% 75.2% 100% 7.2%	93.2% 66.4% 100% 10.9%	83.5% 33.8% 100% 18.9%	62.4% 10.8% 100% 25.4%
Global peers/leaders	RG222, RM102, RN325, RWY02	5PD06,RN325, RNLAY	RJZ01, RWY02	RG303
Schemes that are efficient	5PD06 RF4QH RG222 RJ701 **RJ866** RM102 RN325 RNLAY RWY02 RX1RA	5PD06 RF4QH RG222 RJ701 **RJ866** RM102 RN325 RNLAY RWY02 RX1RA	 RFW99 **RJ866** RJZ01 RKB01 RN325 RWX51 RWY02 RXPCC	 RG303 **RJ866** RJZ01 RNA01 RWX51 RXPCC
Bottom 5 schemes	 RBN01 RLQ01 **RNHB1** RTH08 RWP50	 RBN01 RLQ01 **RNHB1** RTH08 RWP50	RAX01 RM202 **RNHB1** RRV10 RWP50	 RBF03 RM202 **RNHB1** RRV10 RX3MM

Model 1

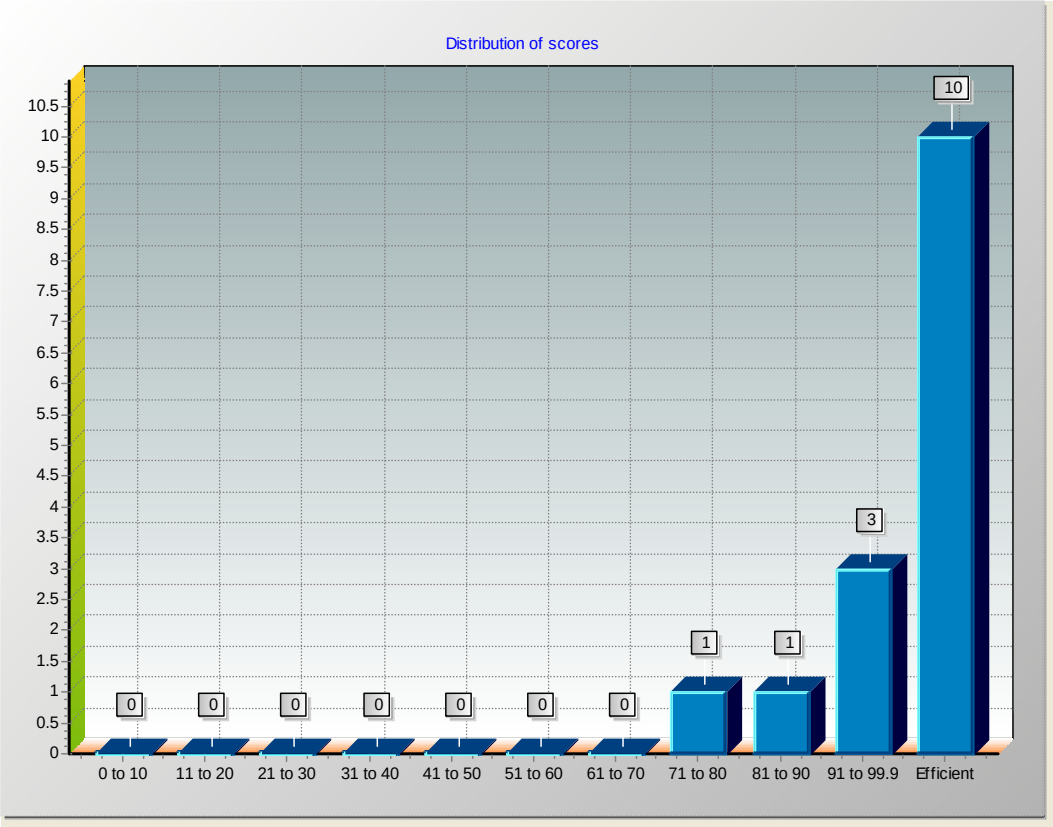
Our first model is the most fully specified, including each measure of output associated with the 5 service areas, namely maintenance, catering, cleaning, laundry and portering. Inputs are defined as total cost.

Model 1	Floor area, meals served, laundry pieces, occupied beds
	Total cost adjusted for MFF

Only fifteen PFI schemes cover all these services. When analysing small samples in DEA, there is a high likelihood that schemes will not have 'peers' in the relevant input-output space. This may be simply because they have particular low or high levels of one type of output. If so, DEA will place them on the frontier because of this distinctive feature.

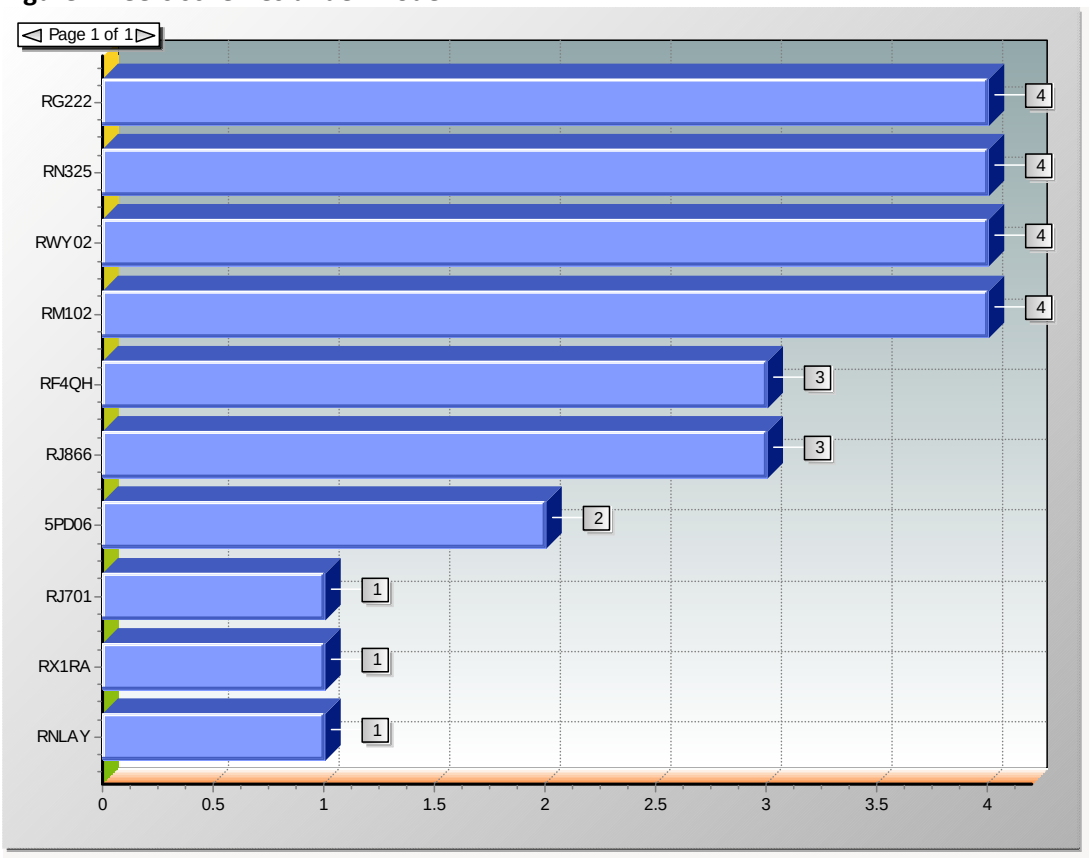
It is probable that this explains the high number of PFI schemes considered 100% efficient under this model. Figure 3 plots the distribution, with 10 schemes on the frontier.

Figure 3 Distribution of efficiency scores under model 1



The number of times that schemes are used as a peer for another scheme is indicative of their efficiency. As shown in Figure 4 Queen Elizabeth Hospital (RG222), Great Western Hospital (RN325), Calderdale Royal Hospital (RWY02) and Norfolk & Norwich University Hospital (RM12) each act as a reference to four other schemes. These four schemes are considered the 'global leaders' under this model.

Figure 4 Peers schemes under model 1



In **Table 4** we report the efficiency scores and the scale of operation. For schemes judged less than fully efficient (less than 100%) the current value of the scheme is compared to the target cost in order to estimate the maximum level of savings that might be realised were these schemes to be fully efficient. For example, Newham General Hospital (RNHB1) appears to be paying up to £1.75m more than comparable PFI schemes for a similar level and mix of hard and soft FM services. This 'maximum saving', however, assumes that the inputs and outputs are all perfectly measured and the entire shortfall from the target cost saving is inefficiency.

Table 4 Efficiency scores and target improvements under model 1

Unit name	Score	Scale	Value (£k)	Target (£k)	Maximum savings (£k)
RF4QH	100%	Constant			
RG222	100%	Constant			
RJ866	100%	Constant			
RWY02	100%	Constant			
5PD06	100%	Constant			
RN325	100%	Constant			
RNLAY	100%	Constant			
RJ701	100%	Constant			
RM102	100%	Constant			
RX1RA	100%	Constant			
RBN01	94%	Increasing returns	10,295	9,673	622
RLQ01	94%	Decreasing returns	3,743	3,513	230
RWP50	94%	Increasing returns	6,409	6,001	408
RTH08	85%	Increasing returns	12,489	10,659	1,830
RNHB1	75%	Increasing returns	7,059	5,309	1,750
Maximum total savings					4,840

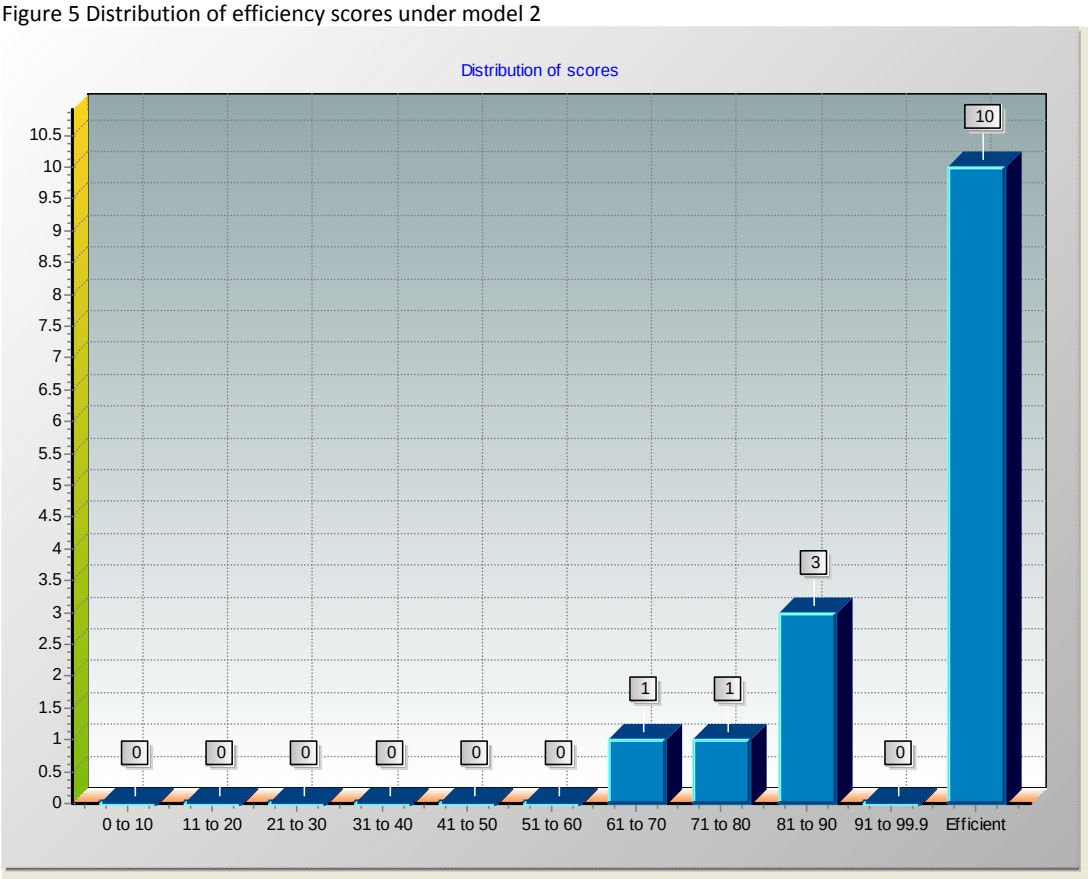
Model 2

Model 2 excludes portering services from the analysis. This involves excluding occupied beds as an output and the costs associated with portering. Occupied beds is considered to be the least reliable indicator of output in the models as many other factors, will influence level of portering activity.

Model 2	Floor area, meals served, laundry pieces
	Costs of maintenance, catering, cleaning and laundry, adjusted for MFF

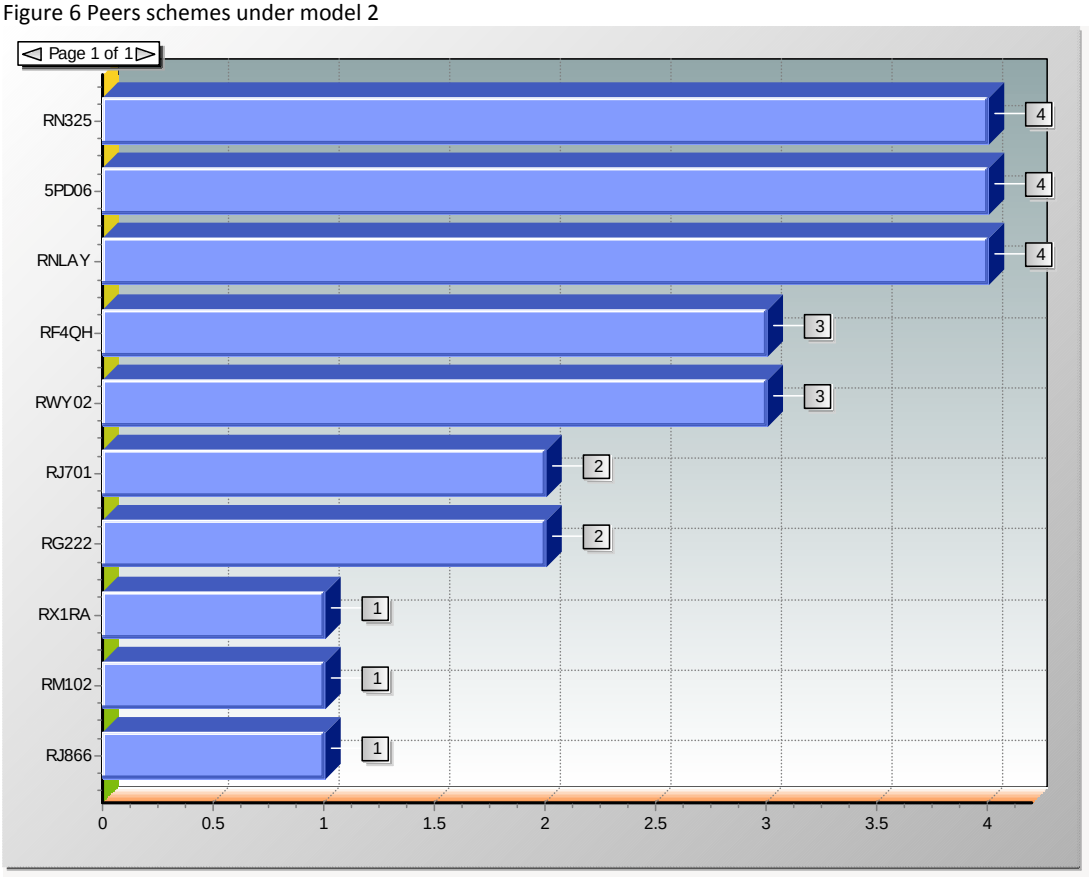
As previously 15 schemes are included in the analysis and 10 are estimated as being fully efficient (**Figure 5**).

Figure 5 Distribution of efficiency scores under model 2



In Model 2 there are three schemes which each act as a reference to four other schemes, making them the ‘global leaders’. These are Great Western Hospital (RN325), Danetre Hospital (5PD06) and Cumberland Infirmary (RNLAY).

Figure 6 Peers schemes under model 2



As we might expect, since average efficiency is lower in each consecutive model compared to Model 1, the potential efficiency savings increase each time.

Table 5 Efficiency scores and target improvements under model 2

Unit name	Score	Scale	Value (£k)	Target (£k)	Maximum savings (£k)
RG222	100%	Constant			
RX1RA	100%	Constant			
RF4QH	100%	Constant			
RM102	100%	Constant			
RNLAY	100%	Constant			
RWY02	100%	Constant			
5PD06	100%	Constant			
RJ701	100%	Constant			
RJ866	100%	Constant			
RN325	100%	Constant			
RLQ01	88%	Decreasing returns	5,597	4,346	1,251
RWP50	84%	Decreasing returns	5,656	4,746	910
RBN01	81%	Increasing returns	8,646	7,025	1,621
RNHB1	78%	Increasing returns	5,597	4,346	1,251
RTH08	66%	Increasing returns	10,916	7,250	3,666
Maximum total savings					8,699

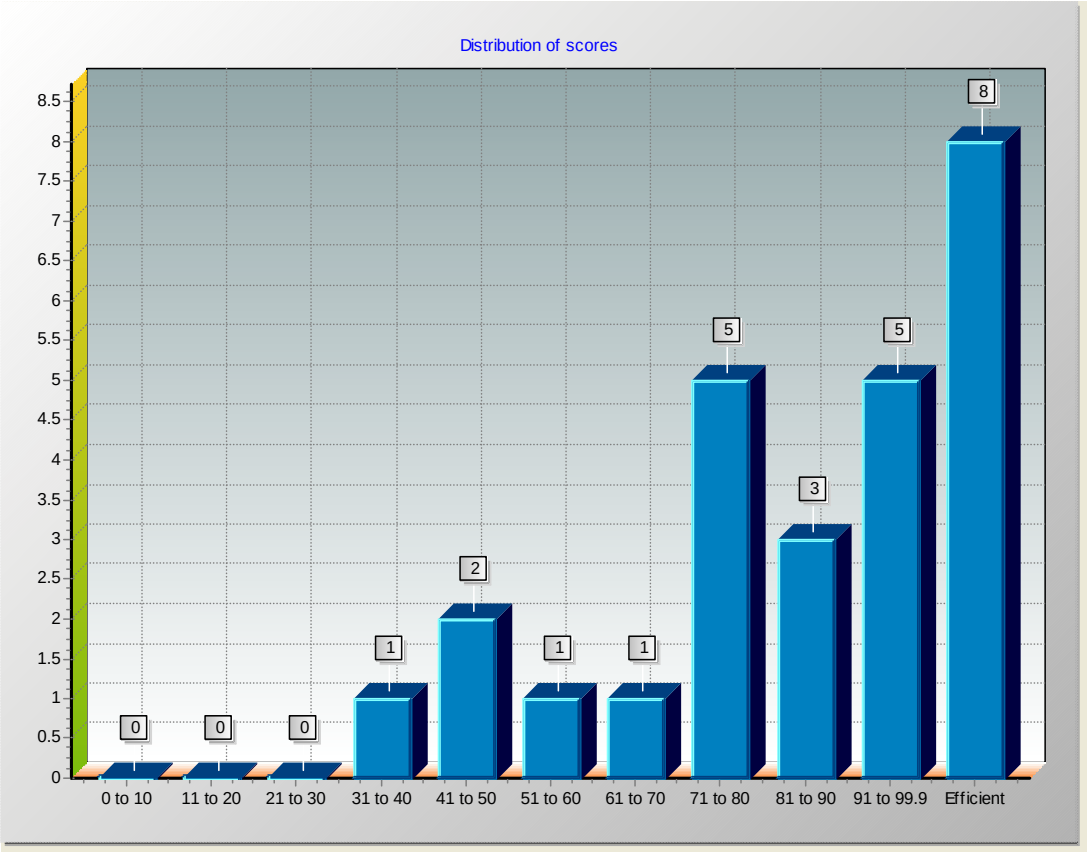
Model 3

In our third model we exclude catering from the analysis. This involves excluding the number of meals requested and the cost of catering.

Model 3	Floor area, laundry pieces, occupied beds
	Costs of maintenance, cleaning, laundry and portering, adjusted for MFF

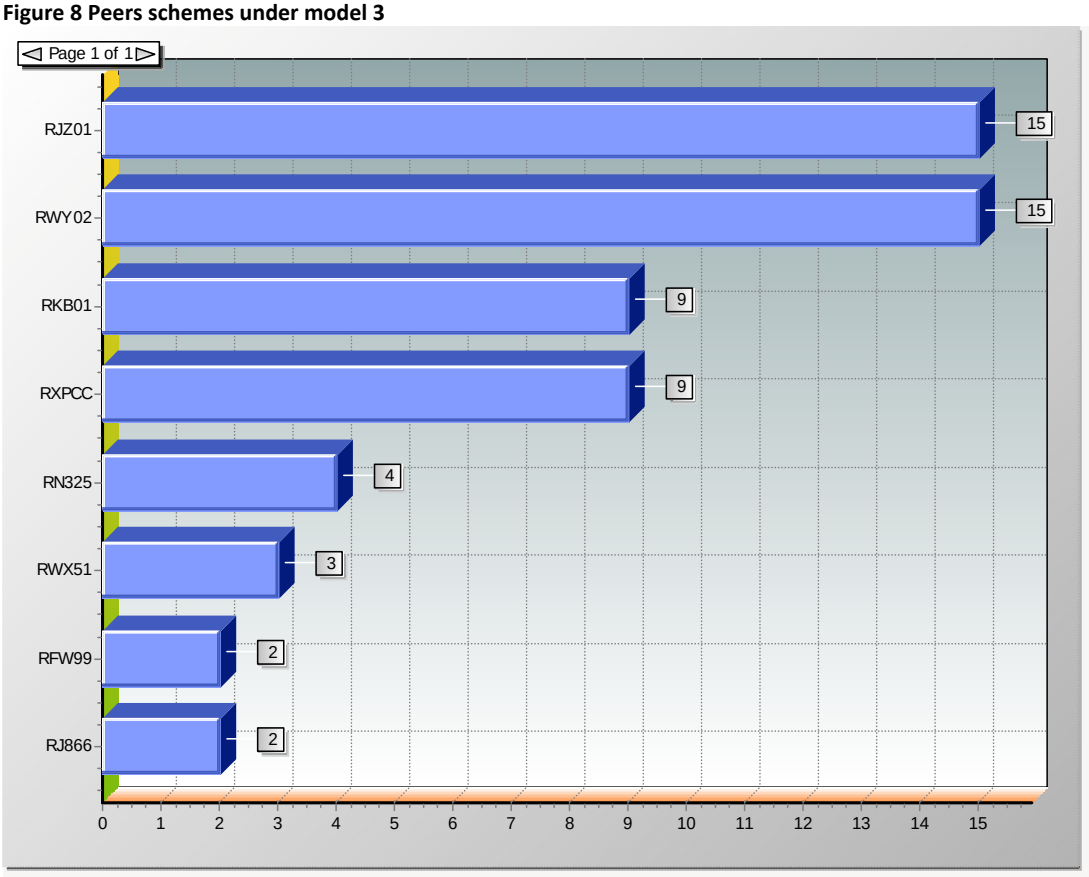
This specification allows more schemes to be included in the analysis, the sample size increasing to 26 schemes. The larger sample means that more schemes are likely to have comparators with broadly similar mixes of output and input. In turn, this reduces the likelihood of schemes being located on the frontier. As Figure 7 shows, only eight schemes are judged to be fully efficient under model 3.

Figure 7 Distribution of efficiency scores under model 3



In this case there are 2 schemes which each act as a reference to 15 other schemes, making them the ‘global leaders’. These are Kings College Hospital (RJZ01) and Calderdale Royal Hospital (RWY02).

Figure 8 Peers schemes under model 3



Maximum potential cost savings under this model, assuming again that there is no measurement error and the entire shortfall from the target cost saving is inefficiency, amount to nearly £37 million.

Table 6 Efficiency scores and target improvements under model 3

Unit name	Score	Scale	Value (£k)	Target (£k)	Maximum savings (£k)
RFW99	100%	Constant			
RJZ01	100%	Constant			
RWX51	100%	Constant			
RJ866	100%	Constant			
RN325	100%	Constant			
RWY02	100%	Constant			
RXPCC	100%	Constant			
RKB01	100%	Constant			
5PD06	99%	Decreasing returns	295	291	4
RM102	97%	Increasing returns	10,217	9,875	342
RG222	94%	Decreasing returns	4,778	4,510	268
RX1RA	92%	Increasing returns	9,158	8,419	739
RLQ01	92%	Decreasing returns	2,747	2,523	224
RNLAY	90%	Decreasing returns	5,986	5,392	594
RF4QH	89%	Increasing returns	8,840	7,887	953
RBN01	83%	Increasing returns	8,203	6,845	1,358
RXPBA	79%	Increasing returns	2,198	1,731	467
RTH08	75%	Increasing returns	9,962	7,451	2,511
RJ701	74%	Increasing returns	12,418	9,212	3,206
RVL01	73%	Decreasing returns	4,902	3,572	1,330
RXPCP	71%	Increasing returns	4,586	3,279	1,307
RWP50	70%	Decreasing returns	6,283	4,410	1,873
RAX01	60%	Decreasing returns	6,640	3,988	2,652
RNHB1	50%	Decreasing returns	6,212	3,133	3,079
RM202	47%	Increasing returns	15,173	7,191	7,982
RRV10	34%	Increasing returns	12,108	4,089	8,019
Maximum total savings					36,908

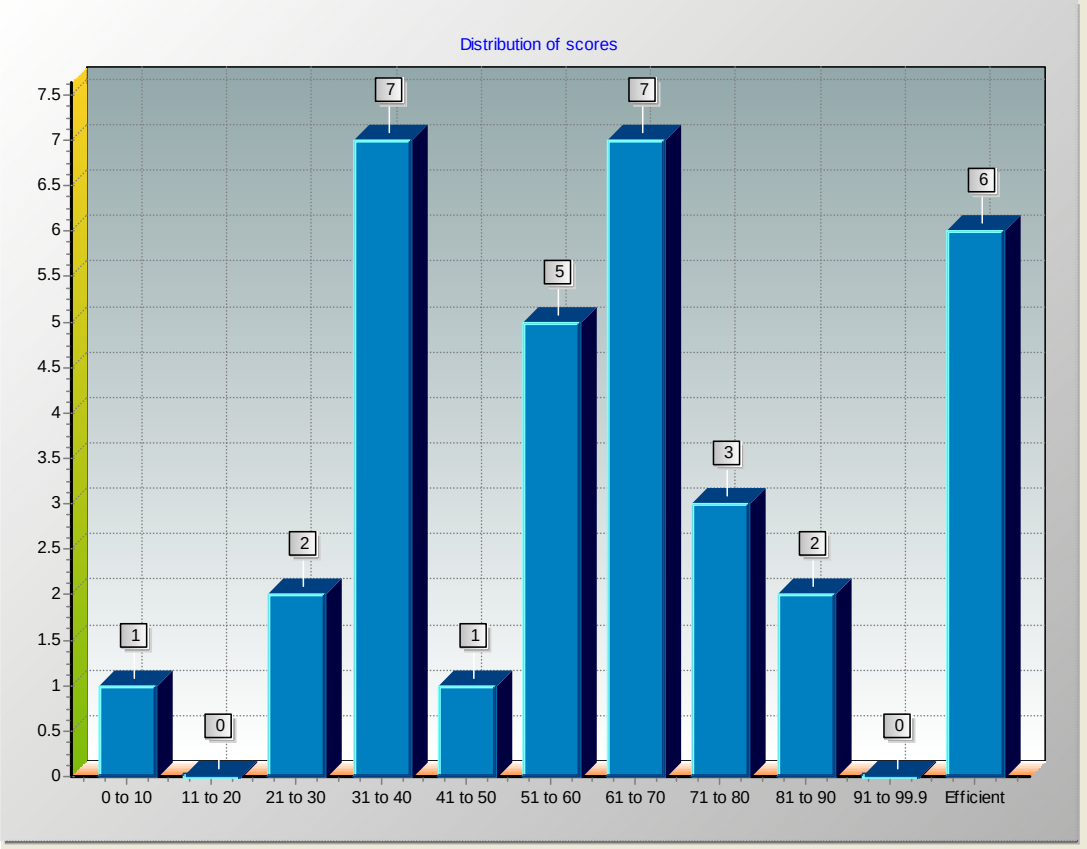
Model 4

In our fourth model we exclude both catering and portering services, thereby restricting the analysis to consideration of the hard FM (maintenance of the estate) and cleaning and laundry services.

$$\text{Model 4} \qquad \frac{\text{Floor area, laundry pieces}}{\text{Costs of maintenance, cleaning and laundry, adjusted for MFF}}$$

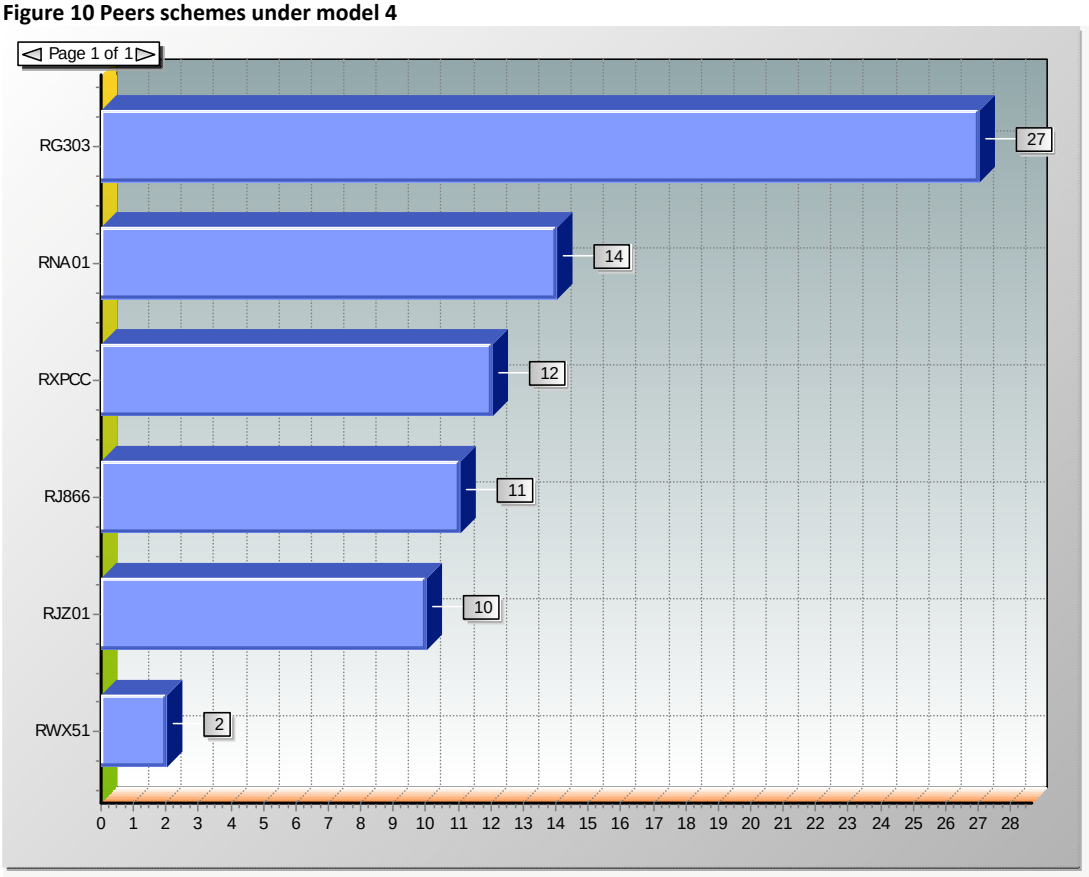
The advantage of this more restrictive specification is that it allows more schemes to be included. The analysis now includes 34 schemes, six of which form the frontier (Figure 9).

Figure 9 Distribution of efficiency scores under model 4



In this model, Princess Royal University Hospital (RG303) acts as a reference to 27 other schemes making it the 'global leader'. This scheme likely has a similar input-output combination to many other schemes making it a suitable peer.

Figure 10 Peers schemes under model 4



Model 4 includes the largest number of schemes, exhibits the lowest average efficiency, places the fewest number of schemes on the frontier, and is the most discriminating model. Taken together these factors imply the greatest potential efficiency savings overall (£71 million).

Table 7 Efficiency scores and target improvements under model 4

Unit name	Score	Scale	Value (£k)	Target (£k)	Maximum savings (£k)
RJ866	100%	Constant			
RXPCC	100%	Constant			
RG303	100%	Constant			
RJZ01	100%	Constant			
RWX51	100%	Constant			
RNA01	100%	Constant			
RN325	89%	Increasing returns	5,316	4,730	586
5PD06	88%	Decreasing returns	237	209	28
RXQ50	80%	Increasing returns	4,254	3,388	866
RXPBA	78%	Increasing returns	1,905	1,482	423
RN707	74%	Increasing returns	3,699	2,733	966
RX1RA	71%	Increasing returns	7,263	5,126	2,137
RWY02	70%	Decreasing returns	2,188	1,534	654
RKB01	68%	Increasing returns	8,309	5,652	2,657
RFW99	67%	Increasing returns	2,627	1,751	876
RNLAY	65%	Increasing returns	5,318	3,480	1,838
RXQ02	65%	Increasing returns	5,490	3,579	1,911
RM102	65%	Increasing returns	8,881	5,773	3,108
RBN01	59%	Increasing returns	6,553	3,866	2,687
RG222	58%	Increasing returns	4,158	2,396	1,762
RLQ01	57%	Decreasing returns	2,373	1,355	1,018
RJ701	55%	Increasing returns	10,684	5,889	4,795
RXPCP	51%	Increasing returns	3,999	2,052	1,947
RVL01	42%	Decreasing returns	4,430	1,841	2,589
RWP50	40%	Decreasing returns	5,530	2,226	3,304
RTH08	39%	Increasing returns	8,389	3,306	5,083
RAX01	38%	Decreasing returns	5,327	2,044	3,283
5LG01	36%	Decreasing returns	1,043	376.03	667
RF4QH	34%	Increasing returns	7,248	2,491	4,757
RNHB1	34%	Decreasing returns	4,751	1,624	3,127
RM202	32%	Increasing returns	12,124	3,859	8,265
RBF03	28%	Decreasing returns	1,981	544	1,437
RX3MM	27%	Increasing returns	743	201	542
RRV10	11%	Increasing returns	11,049	1,191	9,858
Maximum total savings					71,171

Graphical representation of sensitivity analysis

The following two diagrams show how sensitive each organisation's efficiency score is to the four model specifications.

Figure 11 shows the variation in efficiency scores for the 15 schemes that are included in all four DEA models. In every case, the lowest efficiency score is that from model 4 and the highest is that from model 1, with the scores from models 2 and 3 lying between these extremes. The length of the vertical line indicates the variation in each scheme's efficiency score across all four models. For many cases the variation is substantial, with many schemes being assessed as fully efficient under one model or another.

Figure 11 Sensitivity analysis of efficiency scores to model specification, schemes in all models

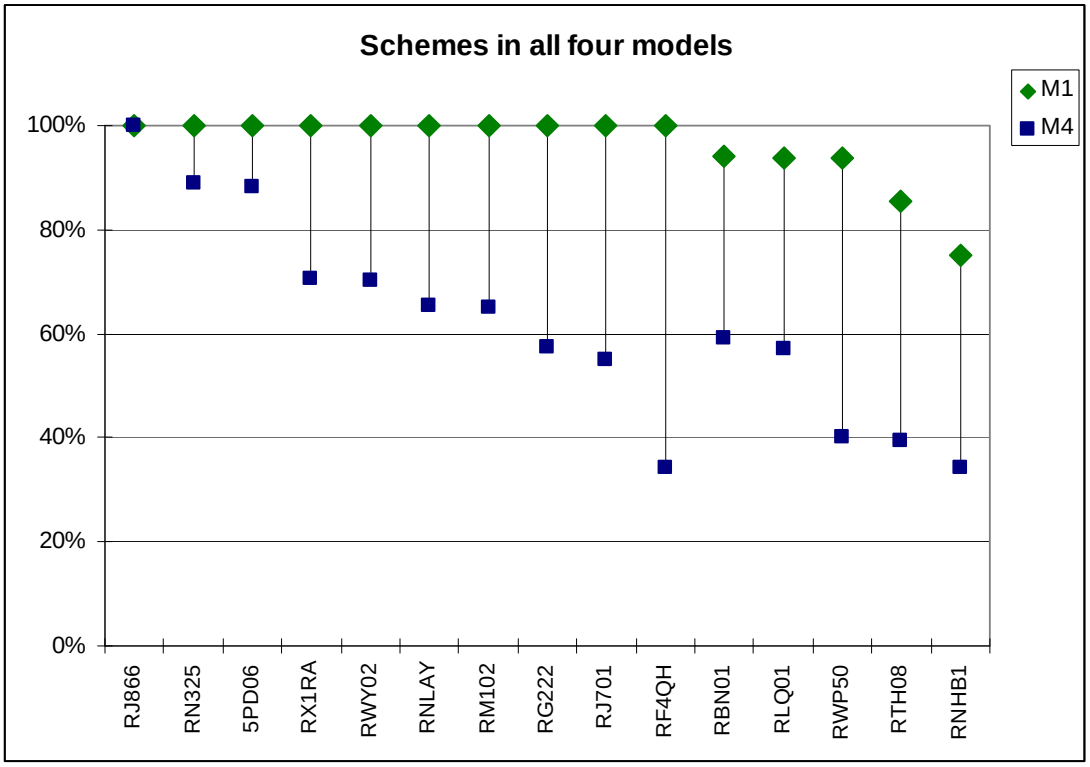
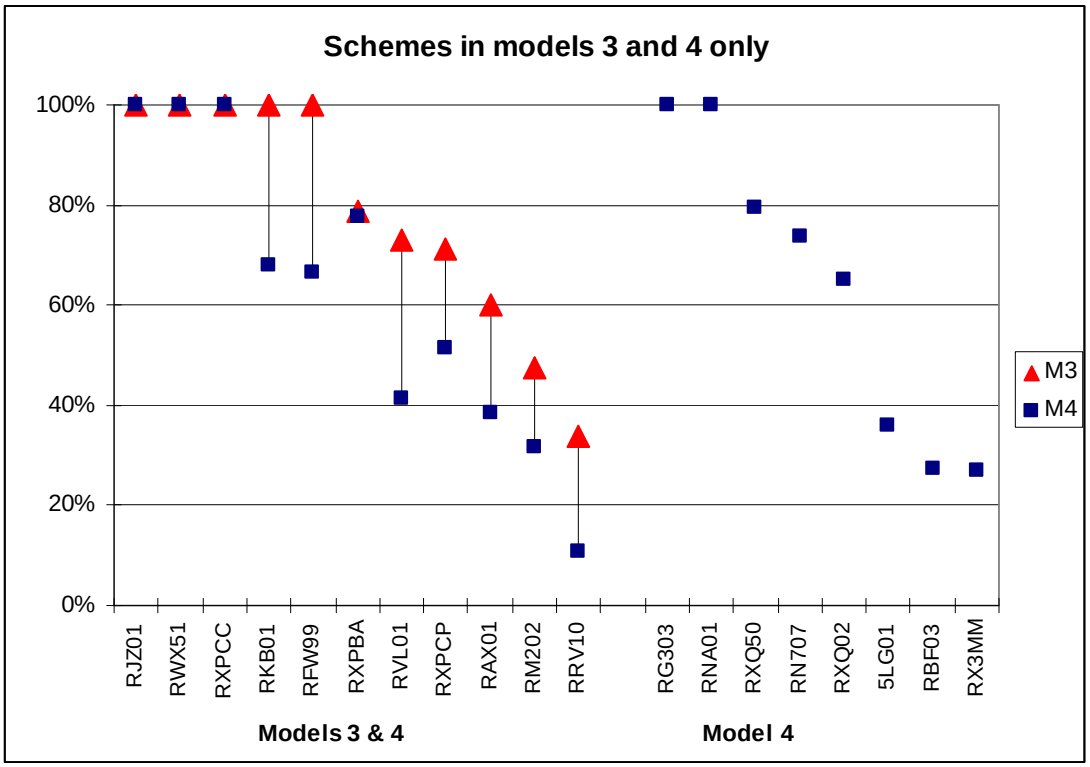


Figure 12 is split into two parts. On the left hand side, variation in efficiency scores is reported for those schemes that only appear in models 3 and 4 (there were no other schemes included in different combinations of models). As would be expected, the vertical lines are not as long as in the previous graph because only two models are being compared. Nevertheless, model 3 provides higher estimates of each scheme's relative efficiency.

On the right hand side, the efficiency scores from model 4 are reported for those schemes that appear only in this model.

Figure 12 Sensitivity analysis of efficiency scores to model specification, schemes in models 3 and 4 only


Schemes in models 3 and 4 only
100%
80%
60%
40%
20%
0%
RJZ01
RWX51
RXPCC
RKB01
RFW99
RXPBA
RVL01
RXPCP
RAX01
RM202
RRV10
RG303
RNA01
RXQ50
RN707
RXQ02
5LG01
RBF03
RX3MM
M3
M4
Models 3 & 4
Model 4

Overall potential improvement

Finally we provide estimates of the potential savings that might be generated were the least efficient schemes to perform as well as their peers. The estimates in Table 8 are generated by considering the percentage reduction in costs that the scheme would have to make in order to become efficient.

We focus on the ten least efficient schemes as identified under model 4. The potential savings are calculated as the difference between their observed cost value and their target cost value.

Some of these schemes appear in the other model specifications, where each has a higher efficiency score than under model 4. For these schemes, we also calculate their potential savings from these models. These separate calculations provide a range of estimated cost savings for each of the ten schemes, the most challenging improvements being derived from model 4. As the efficiency estimates are sensitive to model specification, we recommend that the lower estimated savings are the most realistic estimates of the potential for improvement.

As an example, Newham General Hospital (RNHB1) appears under all four model specifications and is in the bottom 10 in Model 4. If it were able to reduce costs proportionally (contract inputs) so that the scheme could move onto the frontier as depicted by its equivalent efficient peers with similar input-output combinations, then it could reduce costs by 66% in Model 4 (equivalent to £3.13 million). Under alternative model specifications, savings are £1.75 million (Model 1), £1.25 million (Model 2) and £3.08 million (Model 3). Given this sensitivity to model specification, we suggest that the lowest figure should be considered the maximum amount by which costs could be reduced.

The total maximum theoretical potential savings of bringing the bottom 10 schemes from Model 4 onto the frontier in Model 4 would amount to £24.8 million. These estimates are of course produced by a DEA model which assumes no measurement error and does not allow for differences in the quality of service provision. These assumptions could be readily challenged, and imply that DEA estimates are likely to overestimate potential efficiency savings.

Conclusion

This is the final report arising from a study commissioned by the NAO to inform its analysis of operational PFI hospital contracts.

The report compares PFI contracts that cover both Hard Facilities Management and various Hotel services, such as cleaning, catering, laundry, and portering. We use a technique termed Data Envelopment Analysis for the comparative exercise.

There are 34 schemes that have some combination of hard and soft FM services. We use Estates Return Information Collection (ERIC) data to assess what services are delivered under these schemes and the associated cost. We specify four DEA models and assess the sensitivity of efficiency estimates to these specifications.

- One scheme appears to be relatively economic, whatever combination of services is considered. This is Bodmin Hospital (RJ866).
- Similarly, Calderdale Royal Hospital (RWY02) and Queen Elizabeth Hospital (RG222) appear to receive more Hard and Soft FM services than other schemes of a similar cost.
- In contrast, Newham General Hospital (RNHB1) and Worcestershire Royal Hospital (RWP50) appear to receive fewer services than other Hard and Soft FM schemes of a similar cost.

Overall, given the amount that organisations pay, there is substantial variation in the amount of Hard and Soft FM services received. The level of variation is dependent on the specifications of the model used but all models indicate variation amounting to millions of pounds. This variation is not due to differences in factor prices, the size of the hospital, whether it is a Foundation Trust or teaching or specialist hospital, or its geographical location. Therefore the results of this analysis should not be treated as a definitive analysis of the efficiency of PFI contracts, but as a tool to identify contracts where an in-depth exploration of costs and their drivers would be of benefit.

There may be other reasons for the observed variation. Potential explanations include data reporting error and differences in the quality of services, contract specifications or in the proportion of the site that has been financed through PFI. It has not been possible to explore these factors due to the lack of reliable data.

The findings of this work can be used as a means of identifying organisations that currently appear to receive relatively fewer services given the amounts they pay. We suggest that the Department works with these Trusts to understand whether the difference is justified by factors not considered in these model, or whether it is genuine cost inefficiency. Those Trusts which appear to pay more for their PFI services may be able to negotiate more competitive prices when undertaking their periodic market testing or benchmarking of Soft FM services. It would be possible to carry out similar exercises on future ERIC datasets, and to widen the analysis to all hospitals. Improvements in the completeness and quality of ERIC data would allow the Department to have more certainty that variations identified by such analysis are genuine.

Table 8 Range of potential savings of bottom 10 schemes from Model 4 assessed across all 4 models, £k

	Model 1				Model 2				Model 3				Model 4				Overall
	Value	Target	Savings	% Improve	Value	Target	Savings	% Improve	Value	Target	Savings	% Improve	Value	Target	Savings	% Improve	Potential savings
RWP50	6409	6001	408	6.36%	5656	4746	911	16.10%	6283	4410	1873	29.81%	5530	2226	3304	59.74%	408
RTH08	12489	10659	1830	14.66%	10916	7250	3666	33.58%	9962	7451	2511	25.21%	8389	3306	5083	60.59%	1830
RAX01									6640	3988	2652	39.94%	5327	2044	3283	61.62%	2652
5LG01													1043	376	667	63.93%	667
RF4QH									8840	7887	954	10.79%	7248	2491	4757	65.63%	954
RNHB1	7059	5309	1750	24.79%	5597	4346	1252	22.36%	6212	3133	3080	49.57%	4751	1624	3127	65.81%	1252
RM202									15173	7191	7982	52.60%	12124	3859	8265	68.17%	7982
RBF03													1981	544	1437	72.54%	1437
RX3MM													743	201	542	72.94%	542
RRV10									12108	4089	8019	66.23%	11049	191	9858	89.22%	8019
Total	36844	32856	3988	11%	31465	25637	5828	19%	65218	38149	27069	42%	58186	17863	40323	69%	24788

Table 9 Look-up table for site code, Trust and site name

SITE CODE	TRUST NAME	SITE NAME
5LG01	WANDSWORTH PCT	QUEEN MARYS HOSPITAL
5P53X	SURREY PCT	FARNHAM HOSPITAL
5PD06	NORTHAMPTONSHIRE TEACHING PCT	DANETRE HOSPITAL
5QCQ9	HAMPSHIRE PCT	LYMINGTON HOSPITAL
5QQ54	DEVON PCT	TIVERTON & DISTRICT HOSPITAL
5QQ62	DEVON PCT	DAWLISH HOSPITAL
RATGM	NORTH EAST LONDON MENTAL HEALTH NHS TRUST	GOODMAYES HOSPITAL
RAX01	KINGSTON HOSPITAL NHS TRUST	KINGSTON HOSPITAL
RBF03	NUFFIELD ORTHOPAEDIC NHS TRUST	NUFFIELD ORTHOPAEDIC CENTRE
RBN01	ST HELENS AND KNOWSLEY HOSPITALS NHS TRUST	WHISTON HOSPITAL
RC971	LUTON AND DUNSTABLE HOSPITAL NHS FOUNDATION TRUST	LUTON AND DUNSTABLE HOSPITAL
RF4QH	BARKING, HAVERING AND REDBRIDGE HOSPITALS NHS TRUST	QUEEN'S HOSPITAL
RFW99	WEST MIDDLESEX UNIVERSITY HOSPITAL NHS TRUST	WEST MIDDLESEX UNIVERSITY HOSPITAL
RG222	QUEEN ELIZABETH HOSPITAL NHS TRUST	QUEEN ELIZABETH HOSPITAL
RG303	BROMLEY HOSPITALS NHS TRUST	PRINCESS ROYAL UNIV. HOSPITAL
RGQ01	IPSWICH HOSPITAL NHS TRUST	THE IPSWICH HOSPITAL NHS TRUST
RGT01	CAMBRIDGE UNIVERSITY HOSPITALS NHS FOUNDATION TRUST	ADDENBROOKE'S HOSPITAL SITE
RHQNG	SHEFFIELD TEACHING HOSPITALS NHS FOUNDATION TRUST	NORTHERN GENERAL HOSPITAL
RJ201	THE LEWISHAM HOSPITAL NHS TRUST	THE LEWISHAM HOSPITAL NHS TRUST
RJ701	ST GEORGE'S HEALTHCARE NHS TRUST	ST GEORGE'S HOSPITAL
RJ866	CORNWALL PARTNERSHIP NHS TRUST	BODMIN HOSPITAL
RJZ01	KING'S COLLEGE HOSPITAL NHS FOUNDATION TRUST	KINGS COLLEGE HOSPITAL
RK5BC	SHERWOOD FOREST HOSPITALS NHS FOUNDATION TRUST	KINGS MILL HOSPITAL
RKB01	UNIVERSITY HOSPITALS COVENTRY AND WARWICKSHIRE NHS TRUST	WALSGRAVE HOSPITAL
RKEQ4	THE WHITTINGTON HOSPITAL NHS TRUST	THE WHITTINGTON HOSPITAL
RLQ01	HEREFORD HOSPITALS NHS TRUST	COUNTY HOSPITAL
RM102	NORFOLK AND NORWICH UNIVERSITY HOSPITAL NHS TRUST	NORFOLK & NORWICH UNIVERSITY HOSP
RM202	UNIVERSITY HOSPITAL OF SOUTH MANCHESTER NHS FOUNDATION TRUST	WYTHENSHAWE HOSPITAL
RN325	SWINDON AND MARLBOROUGH NHS TRUST	GREAT WESTERN HOSPITAL
RN707	DARTFORD AND GRAVESHAM NHS TRUST	DARENT VALLEY
RNA01	DUDLEY GROUP OF HOSPITALS NHS TRUST	RUSSELLS HALL HOSPITAL
RNHB1	NEWHAM UNIVERSITY HOSPITAL NHS TRUST	NEWHAM GENERAL HOSPITAL
RNLAY	NORTH CUMBRIA ACUTE HOSPITALS NHS TRUST	CUMBERLAND INFIRMARY
RNZ00	SALISBURY NHS FOUNDATION TRUST	SALISBURY HEALTH CARE NHS TRUST
RR807	LEEDS TEACHING HOSPITALS NHS TRUST	WHARFEDALE GENERAL HOSPITAL
RR813	LEEDS TEACHING HOSPITALS NHS TRUST	ST JAMES'S UNIVERSITY HOSPITAL
RRV10	UNIVERSITY COLLEGE LONDON NHS FOUNDATION TRUST	UNIVERSITY COLLEGE LONDON HOSPITAL
RTD01	THE NEWCASTLE UPON TYNE HOSPITALS NHS FOUNDATION TRUST	FREEMAN HOSPITAL
RTE03	GLOUCESTERSHIRE HOSPITALS NHS FOUNDATION TRUST	GLOUCESTER ROYAL HOSPITAL
RTFDR	NORTHUMBRIA HEALTHCARE NHS FOUNDATION TRUST	HEXHAM GENERAL HOSPITAL
RTFED	NORTHUMBRIA HEALTHCARE NHS FOUNDATION TRUST	WANSBECK GENERAL HOSPITAL
RTH08	OXFORD RADCLIFFE HOSPITALS NHS TRUST	THE JOHN RADCLIFFE HOSPITAL
RTRAT	SOUTH TEES HOSPITALS NHS TRUST	JAMES COOK UNIVERSITY HOSPITAL
RV831	NORTH WEST LONDON HOSPITALS NHS TRUST	CENTRAL MIDDLESEX HOSPITAL
RVL01	BARNET AND CHASE FARM HOSPITALS NHS TRUST	BARNET GENERAL HOSPITAL
RWA01	HULL AND EAST YORKSHIRE HOSPITALS NHS TRUST	HULL ROYAL INFIRMARY
RWA16	HULL AND EAST YORKSHIRE HOSPITALS NHS TRUST	CASTLE HILL HOSPITAL
RWK46	EAST LONDON NHS FOUNDATION TRUST	NEWHAM CENTRE FOR MENTAL HEALTH
RWP50	WORCESTERSHIRE ACUTE HOSPITALS NHS TRUST	WORCESTERSHIRE ROYAL HOSPITAL
RWX51	BERKSHIRE HEALTHCARE NHS FOUNDATION TRUST	PROSPECT PARK HOSPITAL
RWY02	CALDERDALE AND HUDDERSFIELD NHS FOUNDATION TRUST	CALDERDALE ROYAL HOSPITAL
RX1RA	NOTTINGHAM UNIVERSITY HOSPITALS NHS TRUST	QUEEN'S MEDICAL CENTRE

RX3MM	TEES, ESK AND WEAR VALLEYS NHS TRUST	WEST PARK HOSPITAL
RX4E2	NORTHUMBERLAND, TYNE AND WEAR NHS TRUST	ST GEORGES HOSPITAL, MORPETH
RX4W4	NORTHUMBERLAND, TYNE AND WEAR NHS TRUST	WALKERGATE PARK HOSPITAL
RXH06	BRIGHTON AND SUSSEX UNIVERSITY HOSPITALS NHS TRUST	THE ROYAL ALEXANDRA CHILDREN'S HOSI
RXK02	SANDWELL AND WEST BIRMINGHAM HOSPITALS NHS TRUST	CITY HOSPITAL
RXPBA	COUNTY DURHAM AND DARLINGTON NHS FOUNDATION TRUST	BISHOP AUCKLAND GENERAL HOSPITAL
RXPCC	COUNTY DURHAM AND DARLINGTON NHS FOUNDATION TRUST	CHESTER LE STREET COMMUNITY HOSPIT
RXPCP	COUNTY DURHAM AND DARLINGTON NHS FOUNDATION TRUST	UNIVERSITY HOSPITAL NORTH DURHAM
RXQ01	BUCKINGHAMSHIRE HOSPITALS NHS TRUST	AMERSHAM HOSPITAL
RXQ02	BUCKINGHAMSHIRE HOSPITALS NHS TRUST	STOKE MANDEVILLE HOSPITAL
RXQ50	BUCKINGHAMSHIRE HOSPITALS NHS TRUST	WYCOMBE HOSPITAL
RXR10	EAST LANCASHIRE HOSPITALS NHS TRUST	BURNLEY GENERAL HOSPITAL
RXR20	EAST LANCASHIRE HOSPITALS NHS TRUST	ROYAL BLACKBURN HOSPITAL