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Human Resource Management, Complementarity and Organisational Performance

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Abstract

A feature of public sector organisations is the presence of substantial variations in productivity. What drives organisational productivity and its persistence? Using a rich panel on NHS hospitals in England, we trace the variation in productivity back to differences in *clusters* of complementary management practices. We introduce the *indeterminacy effect* of management practices, provide systematic evidence on the *non-linearity effect* and the *complementarity effect* of the practices, and identify several practically significant clusters of management practices involving incentives, workplace flexibility, job training, team quality and job design. The complementary character of management practices explains why low performing organisations remain low performing over time.

Keywords: Public sector organisations, Healthcare, Human Resource Management, NHS, Complementarity, Cluster analysis, Correlated Random Effects, Productivity, Quality Adjustment

JEL codes: I1, M5, M20, D22, C1, L2

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1 Introduction

A quotidian feature of public healthcare organisations is the presence of substantial variations in both productivity and patient outcomes (Branch et al., 2012). In a major study of US hospitals, Chandra et al. (2016) found material differences in both productivity (Total Factor Productivity, TFP) and heart attack survival rates. Moreover, these are related: a patient treated at a 90th percentile productivity hospital is expected to survive more than 1.55 times longer than one treated similarly at a 10th percentile hospital. In the UK, Castelli et al. (2015) and Aragon et al. (2017) found material productivity variation between English NHS acute hospital organisations (also known as hospital trusts). 90th productivity percentile hospitals are 1.54 times more productive than those in the 10th percentile. Figure 1 plots the data they construct. Furthermore, productivity dispersion persists over time. Regressing these productivity measures on their one-year lags yields autoregressive coefficients 0.86 and 0.93 respectively: productive hospitals tend to remain so.

Figure 1: Variations in Productivity (Total and Labour) across NHS Trusts 2010/11 to 2012/13

Healthcare systems worldwide are under severe pressure from ageing populations, rising costs of medical technologies, increasing expectations and tight budgets. Given the evidence of enormous variations in efficiency levels among public health organisations, there appear to be large opportunities to mitigate these pressures using current resources. Any effort at improving performance demands understanding of why some hospitals perform better. This paper investigates drivers of the performance heterogeneity by focusing on *clusters* of management practices.

The literature offers a rich list of explanations for the heterogeneity in performance. A series of papers refers to internal drivers. Rafferty et al. (2007) and Needleman et al. (2011) find a positive relationship between human capital (e.g. nurse staffing) and healthcare quality. Menachemi et al. (2008), Miller and Tucker (2011), McCullough et al. (2013) and Dranove et al. (2014) identify a positive relationship between health information technology and outcomes. Gaynor et al. (2005), O'Brien et al. (2008) and Hentschker and Mennicken (2014) document a positive relationship between hospital volume and quality of care, and productivity.

Another body of literature examines the role of external factors. A key result is that competition, provided prices are regulated, has a positive impact on healthcare productivity (Bijlsma et al., 2013; Bloom et al., 2015; Chandra et al., 2015; Propper, 2012). Other researchers have studied the impacts of government policies (Gaynor et al., 2012), public reporting of performance (Gupta, 2017) and provision of information (Katz, 2013).

A fundamental insight from the empirical literature is that variations in physical assets, human capital and technologies across hospitals only partially account for the productivity dispersion (Bradley et al., 2012, 2010; Hoeks et al., 2010; Roland and Rosen, 2011). "Finer" measures of human capital and technology would still leave the dispersion largely unexplained (Bender et al., 2016; Cummins and Violante, 2002; Galindo-Rueda and Haskel, 2005; Sakellaris and Wilson, 2004). Critically, the impact of factors such as human capital and technology on performance depends on complementary managerial practices and organisational features (Bresnahan et al., 2002).

These findings have led attention towards management practices and organizational factors (Janke et al., 2018). Bloom et al. (2014), McConnell et al. (2014), Rumbold et al. (2015) and Bloom et al. (2015) find that the quality of management practices and hospital performance are highly correlated, suggesting a possible role of management practices. The evidence is that, as it is the organization of resources and management routines that ultimately link hospital inputs to outputs, then as the organizational characteristics of a hospital change, so does the production function (May, 1947).

This study will build on this emerging literature that argues for the impact of management practices. We distinguish between Operation Management (OM) and Human Resource Management (HRM) practices (Siebers et al., 2008). OM practices include information and communication technology, process control, Just-in-Time and lean practice methods. HRM practices relate to functions such as recruitment, training, performance appraisal, opportunities to develop, flexible work schemes, social securities and labour welfare. Bartel (2004) finds that more innovative HRM practices lead to higher performance in the banking sector. Ichniowski and

Shaw (1999) provide evidence on the impact of innovative HRM systems in the steel industry. Black and Lynch (2004) argue that workplace innovations such as employee involvement and profit sharing played a pivotal role in the surge in productivity in the 1990s. West et al. (2002, 2006) and Vermeeren et al. (2014) document a strong association between HRM practices and performance in healthcare. Our aim is to extend the study of the role of HRM practices to the public sector, where labour accounts for the major costs of production. Our first hypothesis runs as:

HRM Hypothesis: Human resource management matters. Typical practices such as training and development, appraisal, team work, engagement, flexible working practices and employee.

The theory, however, emphasises the importance of complementarities. Management practices complement each other and their total impact is larger than the sum of their individual impacts when they are utilized in conjunction (Holmstrom and Milgrom, 1994). Teams are more effective in organisations where they are complemented by group incentives, training, effective communication and work-place flexibility (Brynjolfsson and Milgrom, 2013; Milgrom and Roberts, 1995). Organizations that complement management practices with enhanced compensation policies experience higher productivity (Ichniowski et al., 1997). It is *clusters* of complementary management practices that shape performance, not individual practices. An otherwise optimal management practice may alone have no impact. There are significant complementarities between managerial and organizational practices (West et al., 2006). There are also complementarities between management practices and other production inputs such as human capital (Milgrom and Roberts, 1990) and firm characteristics (e.g., decentralization) (Bloom et al., 2012). Alternative alignments of management practices and hospital characteristics give rise to different productivity levels. Our second and more central hypothesis runs as:

Complementarity Hypothesis: Variations in *clusters* of management practices are partly responsible for the productivity dispersion. The total impact of management practices in organisations where they are implemented as a package are likely to be larger.

The above analysis suggests that when some members of a complementary set of practices are absent, the incomplete cluster may have little or no impact. Further, the quality or strength of a complementary practice may require to reach a *threshold* to have any impact (Meagher and Strachan, 2013). Weak management practices may have no noticeable impact. These intuitions point to the non-linear effect of management practices:

Non-linearity Hypothesis: Management practices require to reach certain thresholds to have any impact on performance. Otherwise, they may have no noticeable effect.

We construct a panel on drivers of hospital productivity for the years 2010/11 to 2012/13. We borrow the data on the total factor and labour productivity measures from Aragon et al. (2015). We use a measure of patient satisfaction with hospital services to construct quality adjusted productivity measures. We draw on the NHS Staff Survey to construct measures of HRM practices. The panel helps shed light on *specific* channels through which management practices shape productivity. As a methodological innovation, we first employ machine learning clustering techniques to identify clusters of HRM practices and next test the significance of the clusters using econometrics techniques. We take some steps to address endogeneity issues and the robustness of the results.

We make several contributions. We introduce and provide evidence on the *non-linearity effect*, provide systemic evidence on the *complementarity effect*, document the effect of *clusters* of management practices, and identify several practically significant clusters of management practices. We provide evidence that workplace flexibility improves productivity *only* with proper incentives. Workforce training gives rise to higher productivity only when it is complemented with adequate incentives. Only when jobs are well designed, teams are well structured and proper incentives are *simultaneously* in place, staff enjoys higher productivity. Our results on the *cluster effect* of HRM practices suggest that the focus of policy should be on *clusters* of best practices, not individual practices. The results explain why it is challenging to imitate good management practices, showing that good practices come in forms of *clusters* and that adopting individual practices will be ineffective. While our data come from the healthcare sector, the empirical validity of the findings extend to the public sector at large (Brown, 2004; Gould-Williams, 2003). For brevity, we only report the key findings in the text, and delegate extra expositions and full results to an online supplementary file.

2 Productivity Measures, Data and Descriptive Statistics

Productivity is defined as the ratio of outputs to inputs. The productivity of a single hospital can be measured as:

$$\text{Productivity of hospital trust } h = \frac{\text{Outputs}_h}{\text{Inputs}_h} \quad (1)$$

In the NHS, Castelli et al. (2015), Aragon et al. (2015), Jones and Charlesworth (2013) and Dunleavey and Carrera (2010) measure productivity as the ratio of total output produced to total

input expenditure incurred to produce the output. Hospital output includes all healthcare goods and services that are delivered. Hospital inputs include labour, capital and intermediate production factors (e.g., drugs) (Aragon et al., 2015). If the inputs used in measuring productivity only consist of labour, the measure is known as labour productivity. If the inputs encompass all of a hospital's inputs, the measure is called total factor productivity (TFP). Our productivity data come from Aragon et al. (2015), who build cost-adjusted labour and total factor productivity measures for all NHS hospitals in England, using Hospital Episode Statistics (HES) from NHS Digital and Reference Cost (RC) database. The productivity measures are obtained by standardising each hospital's TFP and labour productivity score using the national averages to provide a relative-percentage interpretation. If a hospital's h productivity score is 10.5, this implies that the hospital is 10.5% more productive compared to the national average. The online supplementary file fully describes the construction of the measures.

Measuring hospital performance requires a quality-adjusted productivity measure. We follow Dunleavy and Carrera (2010) in using patient satisfaction as our quality indicator to adjust the productivity measures. Using patient experience attenuates the case-mix adjustment bias affecting mortality and readmission rates. We take the data for patient experience from the NHS Adult Inpatient and Outpatient Surveys. Inpatient patient experience scores are summarized on a scale of 0–100 and calculated as average of five domains: access and waiting, quality of care, information and choice, building closer relationships, cleanliness and comfort. Patient experience of outpatient services is scored between 0–100 and is measured as an average of five questions across the care pathway: pre-visit, during the visit and the post-visit-period. Both scores are weighted by age and gender to avoid case-mix adjustment bias. We arrange the satisfaction scores in an ascending order and divide them into five equally spaced intervals. A quality weighting factor for each of these intervals is created and are assigned to each hospital h depending on their satisfaction score. The weighting factor ranges from 0.2 to 1 in increments of 0.2, where 0.2 represents lowest possible weight and 1 represents maximum. We multiply the quality adjustment factors with the cost-weighted output for each hospital and divide it by its total inputs. The final measure is standardised to obtain relative productivity scores. The online appendix explains the construction of the weighted measures in detail. The online appendix also considers adjusting the productivity measures using Hospital Standardised Mortality Ratio.

Data on HRM practices are from NHS Staff Surveys (NSS) for the years 2010 to 2012. We select 10 HRM practices from the survey, including several variables that reflect senior management practices and leadership quality. They are decentralization of decision making

(*Decisions*), suggesting ideas for improving services (*Ideas*), effective communication between senior management and staff (*Communication*), and senior managers acting on staff feedback (*Feedback*). The responses on survey questions for these variables are Likert type measured on a five point scale from strongly disagree to strongly agree. We construct the metrics by taking their Positive Response Rate (PRR) i.e. the percentage of respondents who agree or strongly agree. The four practices constitute the key elements of Appelbaum et al. (2000) high-performance work system and measure staff's perceptions of the HRM environment. We add several other HRM variables:

Team Quality measures team effectiveness. The index is constructed by taking the average of PRR of three questions: team members often discuss team effectiveness, communicate closely with each other and have a set of shared objectives. *Flexible* measures the percentage of respondents who are using flexible working options. *Training* measures the percentage of respondents who had on-the-job training. The data for 2012 are estimated using the average of values for 2010 and 2011. *Intention to Leave* measures the extent to which staff are considering leaving their organisation. We take the variable as an indirect measure of the adequacy of incentives. Data for 2012 are mean imputed. *Job-Satisfaction* reflects the extent to which employees are satisfied with the recognition they receive for good work and the extent to which their work is valued. *Job-Design* measures the extent to which jobs have clear goals, provide clear feedback on performance and give staff the opportunity to participate in decision making. The data for 2012 are estimated using a simple mean imputation method from 2008 to 2011.

Table 1 shows the correlation test results for HRM variables. Consistent with the complementary hypothesis, the variables are highly correlated. Hospitals that adopt one HRM practice are likely to adopt other practices.

Table 2 shows that HRM practices have experienced changes in their mean scores during the period. Figure S1 in the online supplementary file reveals considerable variation among the HRM variables. The majority of variation are due to between-variation as opposed to within variation (online table S3).

We control for Teaching status, Foundation Trust (FT) status and size measured by number of beds. FT hospitals are not-for-profit public organizations that exercise greater managerial autonomy from direct government control. We also control for skill-mix by including the proportion of medical, nursing and support staff to total staff. Different patient groups may demand different care requirements. Recognizing this, we include percentage of female patients and admissions in various age groups. We control for the proportion of patients ad-

Table 1: Correlations of HRM Practices

	<i>Decisions</i>	<i>Ideas</i>	<i>Communication</i>	<i>Feedback</i>	<i>Team Quality</i>	<i>Flexible</i>	<i>Training</i>	<i>Job-Satisfaction</i>	<i>Intention to leave</i>
<i>Decisions</i>									
<i>Ideas</i>	0.62****								
<i>Communication</i>	0.87****	0.46****							
<i>Feedback</i>	0.74****	0.61****	0.55****						
<i>Team Quality</i>	0.34****	0.41****	0.30****	0.34****					
<i>Flexible</i>	0.16****	0.07	0.29****	-0.08	0.14**				
<i>Training</i>	0.14**	0.29****	0.14**	0.16**	0.18****	0.19****			
<i>Job-Satisfaction</i>	0.73****	0.46****	0.80****	0.48****	0.30****	0.46****	0.30****		
<i>Intention to leave</i>	-0.32****	-0.45****	-0.28****	-0.33****	-0.17****	-0.38****	-0.42****	-0.54****	
<i>Job-Design</i>	0.65****	0.64****	0.51****	0.70****	0.46****	0.06	0.23****	0.61****	-0.47****

**** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

mitted as emergencies. Regional differences are accounted for by controlling for the number of GPs per 100,000 resident population, Market Forces Factor (MFF) and a dummy variable for London. Table A.1 defines the variables and gives the data sources, and online table S4 provides the summary statistics.

3 Exploring Complementarities

Economic theory predicts complementarities among management practices. It suggests “work-place practices tend to *cluster more than random chance* would predict.” (Brynjolfsson and Milgrom, 2013). Despite progress, the theory is still silent on which particular clusters of practices are most critical for performance, and empirical findings are diverse. Appelbaum et al. (2000) find the cluster of incentive pay, employment security, merit-based promotions and reduced status distinctions as critical. Ichniowski et al. (1997) documents the complementary role of incentive pay and employment security. Bloom and Van Reenen (2007) offer evidence on the importance of incentive pay, employment security, merit-based promotions and performance review. A reason that may partly explain the diverse results is the lack of a method for systematically identifying complementary practices. We use machine learning clustering techniques to identify clusters of HRM practices. As the analysis is exploratory, the data are pooled together across the periods.

Table 2: Definition of HRM Practices

HRM Dimension	2010/11				2011/12				2012/13			
	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max
<i>Senior Management</i>												
1. Decisions	24.92	5.4	12.00	38.00	25.01	5.36	8.00	40.00	27.94	5.44	9.00	46.00
2. Communication	24.9	5.87	10.0	42.0	25.26	5.78	8.00	44.00	34.15	6.66	13.00	53.00
3. Feedback	29.3	5.49	15.00	47.00	29.26	4.94	11.00	44.00	26.13	5.68	7.00	44.00
4. Ideas	38.26	7.49	17.00	61.00	38.41	7.06	19.00	58.00	36.74	5.48	23.00	52.00
<i>Flexible</i>	62.66	3.95	53.00	82.00	60.97	4.52	47.00	73.00	66.29	3.16	57.00	74.00
<i>Training</i>	34.12	3.59	23.00	42.00	32.77	3.76	24.00	43.00	33.77	3.15	24.00	42.00
<i>Team Quality</i>	74.53	2.25	66.00	79.20	74.49	2.28	66.00	79.20	74.56	2.15	67.70	79.20
<i>Intention to Leave</i>	21.15	2.75	14.75	30.00	22.37	3.16	15.50	31.00	21.67	2.32	16.38	27.88
<i>Job-Satisfaction</i>	58.84	3.10	51.40	68.30	58.34	3.24	48.40	66.40	62.49	3.16	53.30	69.60
<i>Job-Design</i>	3.406	0.07	3.180	3.580	3.404	0.07	3.210	3.600	3.388	0.06	3.240	3.550

3.1 Clustering Analysis

Clustering techniques organize observations into groups such that there is high-intra group similarity but low-inter group similarity. For start, we use *K-means clustering* (weighted K-nearest neighbours), which groups the observations into a pre-specified number of clusters and helps discern dominant clusters graphically (James et al., 2013). Setting the number of clusters at 3 offers well-defined clusters of the observations. Figure 2 shows the clusters for the HRM variables and total factor productivity.

Some interesting patterns emerge. High productivity (red cluster) and low productivity (blue cluster) hospitals *both* could belong to cases where Ideas, Decisions, Feedback, Team quality and Job design mostly lie above their median. The two clusters are reasonably sharply separated by Intention-to-leave. The high productivity cluster represents hospitals where Intention-to-leave mainly lies below its median. Also, high productivity hospitals are mainly those with a flexible working environment whereas low productivity observations belong to cases where workplace flexibility is below the median. Similar facts are found for labour productivity in online supplementary figure S2.

Nearest-neighbours clustering provides a qualitative representation. To test the significance of the clusters, one requires separating the clusters numerically. We turn to *hierarchical clustering*, which builds a hierarchy of clusters that differ in terms of closeness. The result is a tree structure, called dendrogram, that can be summarised at various levels of complexity (James et al., 2013). We summarise the results into 10 clusters so that each contains adequate observations. Table A.2 (and online supplementary Table L3) report the clusters.

Consistent with *K-means clustering*, several clear complementary patterns emerges. High productivity hospitals belong to clusters where senior management practices, Job satisfaction, Team quality, Job design and workplace flexibility take values above their medians *but* Intention-to-leave takes a value below its median. This suggests senior management practices, flexibility in workplace, Team quality and Training are complementary. Hospitals with lowest total factor productivity belong to clusters where senior management variables mainly lie above their medians, Flexible and Training lie below their median but Intention-to-leave lies above its median (exceptions in clusters with few observations). An interpretation of this result is that senior management practices will fail to have any positive impact unless other complementary practices such as adequate incentives or workplace flexibility and training are in place. A missing complementary practice may render a whole set of management practices ineffective. We use econometric techniques to test the significance of these clusters.

Figure 2: K-Nearest Neighbour Clustering: Total Factor Productivity

This graph describes the outcome of K-means clustering (weighted K-nearest neighbours, KNN R package), which groups the sample into a pre-specified number of clusters. The number of clusters is pre-specified at 3 to obtain well-defined sub-groups of the observations. The variable set includes the quality-adjusted total factor productivity in addition to the set of management practices used in the study. The red cluster refers to high productivity cases where as the blue cluster refers to low productivity cases.

4 Correlated Random Effects

There are two common panel regression estimators: Fixed Effects (FE) and Random Effects (RE). Both recognise the possibility of unobserved hospital heterogeneity effects, captured by c_i :

$$y_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + c_i + u_{it}; \quad t = 1, 2, \dots, T \quad (2)$$

where u_{it} represents a random component that is independent of $\mathbf{x}_{it}$. Random Effects treats unmeasured characteristics c_i as a component of the independent error term u_{it} (i.e., $Cov(\mathbf{x}_{it}, c_i) = 0, t = 1, 2, \dots, T$). Fixed effects dispenses with the assumption that c_i is uncorrelated with the explanatory variables $\mathbf{x}_{it}$. The technique adopts a ‘within estimation’ specification using time demeaning to remove unobserved heterogeneity c_i .

Fixed effects requires considerable ‘within-unit’ variation over time. Otherwise, the estimator will generate large standard errors. Our variables are persistent over time, making the FE estimator inefficient. Instead, we turn to Correlated Random Effects (CRE) technique, which is comparable to the FE estimator (Wooldridge, 2013).

Consider equation (2). In CRE, we model correlation between c_i and $\mathbf{x}_{it}$. Since c_i is constant over time, it can be correlated with the average level of the $\mathbf{x}_{it}$. Let $\bar{\mathbf{x}}_i = T^{-1}\sum_{t=1}^T \mathbf{x}_{it}$ be time averages. It is plausible to assume the simple linear relationship

$$c_i = \alpha + \lambda \bar{\mathbf{x}}_i + r_i, \quad (3)$$

where r_i is, by assumption, uncorrelated with each x_{it} . Substituting (3) into (2) gives:

$$y_{it} = \alpha + \beta_i \mathbf{x}_{it} + \lambda \bar{\mathbf{x}}_i + r_i + u_{it} \quad (4)$$

The equation has a composite error term $r_i + u_{it}$, consisting of a time-invariant unobservable r_i and the idiosyncratic shocks, u_{it} . Since u_{it} is, by assumption, uncorrelated with $\mathbf{x}_{it}$, for all s and t , u_{it} is uncorrelated with $\bar{\mathbf{x}}_i$. Equation (4) can be estimated using random effects estimation. The addition of $\bar{\mathbf{x}}_i$ controls for the correlation between c_i and the sequence $\{\mathbf{x}_{it} : t = 1, 2, \dots, T\}$. Wooldridge (2013, Ch. 14.3) shows that $\hat{\beta}_{CRE} = \hat{\beta}_{FE}$, where $\hat{\beta}_{FE}$ stands for FE estimates. As in Goerke and Pannenberg (2011), we assume that c_i may only be correlated with certain variables, $\mathbf{x}_{it}$, and only introduce the within-hospital means of variables of interest in the regressions.

5 Empirical Analysis

We set ourselves the task that the effect of individual management practices is indeterminate (*indeterminacy effect*). For a practice to have noticeable impact, the intensity / quality of management practices should reach a threshold (*non-linearity effect*) and the practice should be a member of a complementary cluster (*complementary effect*). This section turns to econometric analysis to provide evidence of these effects. We start by showing that individual practices may have no effect. Once we account for non-linearities and complementarities, management practices substantially affect performance. The next section identifies some practically significant clusters of HRM practices that drive performance. The online appendix investigates the robustness of our results.

5.1 The Indeterminacy Effect

Our first hypothesis relates to the indeterminacy of the effect of individual management practices. Our basic model to test the effect takes the form:

$$y_{it} = \alpha + \beta_i x_{it} + \gamma_i \mathbf{m}_{it-1} + \lambda_i \bar{\mathbf{m}}_i + u_{it} \quad (5)$$

where $\mathbf{m}_{it}$ stands for a vector of HRM practices and $\bar{\mathbf{m}}_i$ for their within-hospital means. The coefficients of the lagged HRM variables γ_i represent FE estimates whereas the coefficients of the averages λ_i represent RE estimates. The errors are adjusted for heteroskedasticity and year dummies are included to reduce omitted variable bias. To avoid multicollinearity, we estimate separate models using subsets of uncorrelated HRM practices.

Table A.3 reports our preliminary results for the TFP measure. Each column includes a set of not highly correlated management variables. Column 1 includes Ideas, Flexible and Training. The FE coefficient of Ideas fails to be significant but its RE coefficient, 0.796, is significant at 1%. Better management of ideas in the workplace positively correlates with higher total factor productivity. The FE coefficient of Flexible is significant at 1% and negative, suggesting that within-hospital increases in workplace flexibility lower productivity. The RE coefficient is positive and significant. Workplace flexibility and higher productivity are positively correlated. The FE coefficient of Training is significant and negative whereas its RE coefficient is insignificant and positive. The remaining columns replace Ideas with Decisions, Communication and Feedback. The statistical pattern remains the same. Only the RE coefficients of the practices are significant except for Feedback. The FE coefficients of Flexible and Training remain negative. The year dummies indicate significant year fixed effects.

Online Table L1 reports the results for labour productivity. The FE coefficients of senior management variables appear as significant at 10%, except for Communication. An 1–unit increase in variables Ideas and Decision is associated with 0.212% and 0.321% increase in labour productivity. The FE coefficients of Flexible and Training are significant with a negative sign. While these results offer some evidence on possible impact of management practices, they are far from being conclusive. The FE estimates are either insignificant or have the wrong sign. Evidently, there are multiple possible explanations for these findings. They can be due to mis-measurement, small sample size and noise in the data. Consistent with the theory, though, the results may well indicate the indeterminacy of the effect of individual practices. Management practices begin to have meaningful impact only when their quality / strength reach a required threshold and are in the presence of complementary practices.

5.2 The Non–linearity Effect

Meagher and Strachan (2013) investigate non-linearities in the impact of management practices on firm performance using a Gaussian process and a continuous piece-wise linear approach with probabilistically smoothed endogenous breaks. The analysis reveals significant evidence of a U-shaped relationship, with the biggest returns to management occurring when practices are at their highest levels. Here, we adopt a simpler approach. We test the effect by comparing impacts of HRM practices in sub-samples wherein the strength of the practices differ. We calculate the median of the within-hospital means of the senior management variables and test the coefficient of each variable in the sub-sample where the within-unit mean of the variable is equal to or exceeds its median. Table A.4 reports the results for the TFP measure. For the sake of space we include only the coefficients of variables of interest. The full set of results are reported in table S5.

The FE coefficient of Ideas is 0.434, significant at 1%, the FE coefficient of Decisions is 0.459, significant at 5%, and the FE coefficient of Feedback is 0.440, significant at 10%. These estimates are substantially different than the results for the full sample in Table A.3, suggesting that the strength of HRM practices matters. The negative FE coefficient of Training is no longer significant. The coefficient of Flexible continues to be negative and significant at 10%. Online supplementary table, L2, reports similar results for labour productivity. We find no evidence of serial correlation in the panel results using *Breusch—Godfrey* test. These results provide evidence on the indeterminacy effect that the intensity of management practices should reach a certain threshold to have any impact. An immediate implication of the non-linearity effect is that the introduction of individual practices alone are not enough. The quality and intensity of

the practices matter too.

5.3 The Complementarity Effect

The non-linearly effect shows the importance of thresholds. The direction of the impact of management practices primarily depends on the presence of other practices - the complementarity effect. The literature provides several ways of testing complementarities. An approach is to examine the statistical significance of an HRM practice in sub-samples where other complementary practices exceed a certain threshold. The exploratory analysis pointed to the complementarity of senior management practices. To test this, we construct an indicator variable that takes value one when the within-hospital mean of Ideas exceeds its median and zero otherwise, and test the fixed effects coefficients of the other HRM variables in the sub-sample where the indicator variable takes value one. Table A.5 reports the partial results whereas the full set of results are reported in table S6. The first three columns belong to total factor productivity whereas the remaining columns belong to labour productivity. In the TFP columns, the FE coefficients of the lagged Decisions, 0.708, Communications, 0.420, and Feedback, 0.541, are all significant at 1%.

When ideas are managed effectively, a within-hospital change in other senior management variables will have a positive impact on productivity. None of these FE coefficients are significant in the sub-sample where the indicator variable takes zero. The FE coefficient of workplace flexibility appears as significant at 1% across the three columns. The variable's random effects coefficient is no longer significant. Training loses significance too. This is either because Training varies little within the sub-sample or because better managed hospitals already enjoy a highly trained workforce. We find similar results in columns 4 through 6 for labour productivity. Repeating the analysis for other HRM practices in the cluster, such as, Feedback yields similar results. In hospitals where an HRM practice, e.g., Ideas, exceeds a threshold, enhancing other complementary practices increases productivity. Management practices show strong complementarity effects.

A more effective approach to testing complementarity is to interact management variables with each other (Ichniowski et al., 1997). In one form, this can be achieved by constructing an indicator variable that captures various levels (e.g., quartile) of a management variable, and interact it with other practices. That is to test a model of the form:

$$y_{it} = \alpha + \beta_i \mathbf{x}_{it} + \gamma_i m_{it-1} + \eta_i \times I \times m_{it-1} + \lambda_i \bar{m}_i + u_{it} \quad (6)$$

where $\mathbf{x}_{it}$ stand for control variables, m_{it} stands for the HRM variable, I refers to the indicator

variable. η_i reflects the marginal effect of the HRM variable in the sub-sample where the indicator takes value one. The total FE coefficient of m_{it} is given by $\gamma_i + \eta_i$.

The clustering analysis suggests high productivity hospitals belong to clusters where intention-to-leave, our indirect measure of incentive adequacy, is low but workplace flexibility is sufficiently strong. To test this, we calculate the within-group mean of Intention-to-leave for each hospital, and estimate the four quartiles of the distribution of the within-group mean to construct four dummy variables, each taking value 1 for a hospital if its within-group mean falls in the quartile and otherwise zero. We interact the indicator with Flexible to investigate how incentives interact with workplace flexibility to impact productivity. That is, we test a model of the form:

$$y_{it} = \alpha + \beta_i \mathbf{x}_{it} + \gamma_i fl_{it-1} + \eta_i \times I \times fl_{it-1} + \lambda_i \bar{fl}_i + u_{it} \quad (7)$$

where fl_{it} stands for Flexible and I refers to the Intention-to-leave dummy variable.

Table A.6 presents the key results (full results reported in table S7). Column 1 reports the results for the case where the within-group mean of Intention-to-leave falls in the lowest quartile. Column 2 reports the results for the case where the within-group-mean of the variable falls in the second quartile, and so forth. Returning to the first column, the FE coefficient of the lagged variable Flexible is negative (-0.399) and significant at 1%. The coefficient of the interaction term, 0.443 , is positive and significant at 1%. This means the overall FE estimate of Flexible for hospitals where the intention to leave is low is $-0.399 + 0.443 = 0.044$. One unit increase in workplace flexibility will increase productivity by 0.044 unit. In column 4, where the within-group mean of Intention-to-leave is equal or above the third quartile, both FE coefficients of Flexible (-0.296) and the interaction term (-0.307) are negative and significant at 5%. Overall, the coefficient of Flexible in the upper quartile is $-0.296 - 0.307 = -0.603$. Assuming Intention-to-leave captures incentives, when incentives are poor, an increase in workplace flexibility can lower productivity. With adequate incentives, increasing workplace flexibility may increase productivity. Supplementary table L4 for labour productivity further strengthens the insights.

Similarly, the impact of workforce training depends on whether proper incentives are in place. Table A.7 reports the results for total factor productivity (online table S7). In the sub-sample where the within-hospital mean of Intention-to-leave falls in the lowest quartile, the total FE coefficient of Training is $-0.265 + 0.524 = 0.259$, implying a positive impact. In trusts where the within-hospital mean of Intention-to-leave lies in the upper quartile, the total FE coefficient for Training is $-0.043 - 0.415 = -0.458$, indicating a negative impact. The

FE coefficients fail to be significant in the second and third quartiles. With weak incentives, workforce training may bring little improvement. Whether a management practice positively or negatively impacts productivity depends on other practices. Supplementary table L5 for labour productivity offers further support.

The complementary hypothesis also implies synergies between HRM practices and production inputs. Human capital inputs are more productive in effectively managed hospitals. Or, the proportion of emergency patients has a lesser negative impact in well-managed hospitals. We test these conjectures by constructing a composite measure, *Management*, for senior management variables using principal component analysis. We use the composite measure to define an indicator that takes value one when the within-hospital mean of the composite management index exceeds its median and otherwise zero. We interact the variable with the proportion of medical staff, the nurses and emergency patients. The first three columns in Table A.8 report the partial results (full results reported in supplementary table S8). The interaction coefficients represent FE estimates. The interaction coefficient for medical staff, 1.613, is significant at 1%. In hospitals where the within-group mean of the management index exceeds the median, the total effect of medical staff is $-0.948 + 1.61 = 0.662$. In the presence of relevant management practices, the variable medical staff has a positive impact on total factor productivity. A similar interpretation applies to nurses and the proportion of emergency patients. The negative effect of the proportion of emergency patients is lower in hospitals with better management practices. The FE coefficients for labour productivity in the table follow a similar pattern. Production inputs are more effective with complementary management practices.

Further evidence on the complementarity of HRM practices can be seen by *jointly* interacting Job Satisfaction, Team Quality and Job Design with factors of production. We construct an indicator variable that takes value one when the within-hospital means of these variables exceed their medians and otherwise zero. The variable is interacted with proportions of medical staff, nurses and emergency patients. The last three columns in Table A.8 report the results. The interaction terms are significant. In hospitals where the within-hospital means of the HRM variables exceed their medians, human capital variables contribute to productivity more strongly. These results require that the within-hospital mean of the three variables *jointly* exceeds the median of the variables' within-group averages. It is the cluster of human resources that can impact productivity (Ichniowski et al., 1997). Supplementary table L6 provides similar results for labour productivity.

Similar findings are obtained when we adjust the cost-adjusted productivity scores using Hospital Standardized Mortality Ratio (HSMR) (section 5 in the supplementary file). The

findings are robust to the inclusion of other controls such as London to capture regional differences. Our data are observational; intention-to-leave may capture factors beyond incentives; and there are challenges in testing complementarity. While these call for caution, the results are consistent with our most plausible theoretical assumptions. Implementing HRM practices in isolation may not produce the desired effects and it may be counter-productive for an organization (Ichniowski et al., 1997; Vermeeren et al., 2014). It is the cluster of HRM practices that matters for performance.

As well as pointing out the systemic character of public management, the findings suggest the intricacy of arranging management practices. To identify clusters that mechanistically contribute to productivity requires further technical research, including qualitative research of how the new management practices are brought into effect. Yet insights gained from such investigation have significant potential. Management might gain knowledge of which practices work with which in order to achieve the desired outcomes of effective public management.

6 Conclusion

A facet of public sector organisations is considerable variation in productivity. This presents substantial scope for improvements. We investigate the role of HRM practices in public organisations using data on the NHS acute hospital trusts. NHS trusts are large public organisations, some with more than 4,500 employees. We make several contributions. We introduce and provide evidence on the *non-linearity effect*, provide systemic evidence on the *complementarity effect*, document the effects of *clusters* of management practices and identify several practically significant clusters.

Our analysis suggests that the effects of individual HRM practices are *indeterminate*. The direction of the effect of a practice is determined *within* a cluster. Workplace flexibility improves performance only if the organisation effectively manages ideas, communications and employee feedback and implements an adequate incentive system. If any of these elements is missing, e.g., if incentives are inadequate, workplace flexibility can lower productivity. In a poorly aligned cluster of HRM practices, workplace flexibility can weaken organizational attachment, give rise to staff absenteeism and turnover and worsen job attitudes. A similar insight applies to the effect of training in public organisations. Without adequate incentives, workforce training may have little impact. Our analysis also reveals the *joint* importance of team quality, job design and proper incentives. It is the *joint* presence of these factors along with high quality senior managerial practices that yield higher human capital productivity. Once some of these factors are missing, human capital productivity is likely to fall. The com-

plementary character of management practices highlights the importance of internal organisational design and the leadership role in putting an optimal cluster of practices in place. Organisational change necessitates a *holistic* shift from one cluster of practices to another. Adopting clusters of optimal management practices can noticeably increase productivity using current resources.

It is difficult to establish causality using survey data in an observational setting. Hospitals that acquire better reputation might be able to draw better managerial talents into their team, which may change the work environment. Such latent common causes can give rise to correlation among individual management practices. Controlling for additional drivers partially deals with endogeneity. Our results are, however, in line with the theoretical reasoning given earlier and are consistent with an emerging body of experimental findings (Bloom et al., 2013; Bruhn et al., 2018; Giorcelli, 2016). Further progress calls for appropriate instrumental variables.

Any policy use of our results necessitates understanding why HRM practices differ across organisations. We aim to investigate management heterogeneity in our future research, furthering the research in Bloom et al. (2015). It would be interesting to replicate our study for other public organisations.

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Appendix Tables

Table A.1: Data Definitions and Sources

<i>Data</i>	<i>Definition</i>
Teaching	Equal to 1 if hospital is Teaching trust and 0 otherwise http://www.nr1s.npsa.nhs.uk/
Foundation Trust	Equal to 1 if hospital has FT status and 0 otherwise (Monitor)
Hospital Beds	Average number of available beds (NHS England)
Market Forces Factor (MFF)	MFF * 100 (Dept. of Health)
GP	General Practitioners per 100,000 population (NHSD)
Patients aged 0–14 (%)	Proportion of patients (FCE) under 14 years of age (NHSD)
Patients aged 15–44 (%)	Proportion of patients (FCE) between 15 and 44 years of age (NHSD)
Patients aged 45–59 (%)	Proportion of patients (FCE) between 45 and 59 years of age (NHSD)
Patients aged over 60 (%)	Proportion of patients (FCE) aged over 60 years of age (NHSD)
Proportion of Emergency patients (%)	(Emergency admissions / Total admissions) * 100 (NHSD)
Proportion of female patients (%)	(Female admissions / Total admissions) * 100 (NHSD)
Medical Staff (%)	(Medical workforce / Total Staff) * 100
Nursing Staff (%)	(Nursing workforce / Total Staff) * 100
Total Staff (%)	Total clinical & non-clinical staff
Management: Decisions	% who answered agree and strongly agree to ‘Senior managers here try to involve staff in important decisions’. Standardized to 0–100 scale (NSS)
Management: Feedback	% who answered agree and strongly agree to ‘Senior managers act on staff feedback’. Standardized to 0–100 scale.(NSS)
Management: Ideas	% who answered agree and strongly agree to ‘Senior Managers encourage staff to suggest new ideas for improving services’. The data for 2012 was not available and thus it was estimated by mean imputation. Standardized to 0–100 scale (NSS)
Management: Communication	% who answered agree and strongly agree to ‘Communication between senior management and staff is effective’. Standardized to 0–100 scale (NSS)
Flexible Working Practice	% using flexible working options. Data for 2012 was mean imputed using the scores from 2008–2012 (Key summary score from NSS) (NSS)
Training	Percentage of respondents who had any supervised on-the-job training (NSS)
Team Quality	Effective Team Working (NSS)
Intention to Leave (%)	The extent to which staff are considering leaving their organisation, and looking for a new job either within or outside of the NHS (NSS)

Continued on next page...

Table A.1: Data Definitions and Sources

<i>Data</i>	<i>Definition</i>
Job-Satisfaction	Average positive response rates of 7 measures of staff job-satisfaction (NSS)
Job-Design	Quality of job-design (NSS)

Table A.2: Hierarchical Clustering Analysis: Total Factor Productivity

Group.1	Labour	Prop. Emergency	Ideas	Decisions	Feedback	Flexible	Job-Satisfaction	Team Quality	Job-Design	Training	Intention to Leave	Observations
1	17.12	37.66	55.93	47.29	54.77	46.33	67.61	54.23	65.22	37.72	19.88	49
2	60.00	35.41	58.87	50.00	57.66	52.71	72.95	59.11	67.02	40.19	18.47	24
3	-69.53	39.66	42.22	39.32	49.44	37.59	51.41	53.31	59.39	28.75	24.15	58
4	-30.94	37.41	49.05	42.53	54.11	40.65	61.42	53.99	61.25	35.54	21.58	112
5	38.65	37.14	48.15	33.01	44.98	37.53	50.28	49.90	51.71	36.67	21.44	76
6	-22.07	36.55	34.47	28.89	39.36	37.91	47.64	41.32	45.74	29.76	22.63	80
7	99.54	34.00	43.62	41.85	52.03	49.69	64.70	59.15	59.84	39.92	18.82	8
8	-49.11	34.06	69.50	66.67	78.10	42.50	80.27	62.44	86.88	40.32	20.12	12
9	32.42	33.92	12.77	1.09	4.65	46.25	26.56	48.78	24.47	24.19	25.85	2
10	-68.13	35.91	17.02	23.04	27.91	23.50	29.77	51.51	29.36	9.03	28.82	5

Table A.2 summarises the clustering results for the total factor productivity measure. We use hierarchical clustering that requires no pre-specified number of clusters and builds a hierarchy of clusters that differ in terms of closeness. The method is applied to the HRM variables joined with the total factor productivity measure. We summarise the resulting dendrogram into 10 clusters so that each cluster contains an adequate number of observations.

Table A.3: Base Model: Total Factor Productivity

	(1)	(2)	(3)	(4)
Intercept	−118.3 (176.4)	−114.1 (174.0)	−102.0 (174.9)	−158.5 (176.2)
Structural				
Teaching Trust	−5.168 (8.034)	−0.357 (8.137)	0.299 (8.038)	1.813 (8.240)
Foundation Trust	4.721 (4.912)	7.791 (4.977)	6.769 (4.918)	7.117 (5.106)
Hospital Beds	0.011 (0.010)	0.005 (0.010)	0.003 (0.010)	0.002 (0.010)
Regional				
MFF	−2.523 (0.571)***	−2.878 (0.586)***	−2.917 (0.592)***	−2.592 (0.619)***
GP per 100,000	2.388 (0.534)***	2.327 (0.569)***	2.396 (0.569)***	2.432 (0.580)***
Patient				
Prop. Emergency	−1.155 (0.478)**	−1.117 (0.455)**	−1.150 (0.446)**	−1.127 (0.458)**
Prop. Female	0.462 (1.213)	0.730 (1.212)	0.675 (1.226)	0.786 (1.234)
Patients aged 0–14	2.606 (1.046)**	2.949 (1.135)***	2.860 (1.131)**	3.010 (1.106)***
Patients aged 45–59	2.737 (1.874)	2.394 (1.941)	1.973 (1.931)	2.337 (1.881)
Patients aged over 60	2.264 (0.694)***	2.721 (0.745)***	2.702 (0.759)***	2.806 (0.741)***
Skill-Mix				
Prop. Medical	−0.333 (0.799)	−0.052 (0.841)	−0.028 (0.848)	−0.014 (0.848)
Prop. Nurse	0.049 (0.553)	0.199 (0.558)	0.271 (0.550)	0.193 (0.566)
HRM				
Idea	0.189 (0.120)			
Decisions		0.270 (0.172)		
Communication			0.123 (0.166)	
Feedback				0.328 (0.164)**
Flexible	−0.362 (0.139)***	−0.385 (0.144)***	−0.362 (0.142)**	−0.378 (0.142)***
Training	−0.205 (0.119)*	−0.209 (0.120)*	−0.191 (0.123)	−0.226 (0.122)*
Average				
Idea	0.796 (0.242)***			
Decisions		0.767 (0.349)**		
Communication			0.778 (0.322)**	
Feedback				0.423 (0.350)
Flexible	0.706 (0.358)**	0.681 (0.344)**	0.663 (0.333)**	0.748 (0.346)**
Training	0.289 (0.260)	0.391 (0.298)	0.363 (0.313)	0.437 (0.317)
Year Dummies				
2011/12	−10.28 (3.706)***	−9.939 (3.582)***	−9.276 (3.595)**	−10.25 (3.566)***
2012/13	−12.89 (4.813)***	−12.92 (4.742)***	−11.98 (4.739)**	−13.09 (4.612)***
R^2	0.338	0.326	0.321	0.309
Adj. R^2	0.321	0.310	0.305	0.293
N	421	421	421	421

Table A.3 reports the results for total factor productivity. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. They appear in each model twice: once in their original form and once as within-hospital means. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns also include time dummies, with the period 2010/11 being taken as the base period. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.4: Total Factor Productivity: Above Individual HRM Medians

	(1)	(2)	(3)	(4)
HRM				
Ideas	0.434 (0.159)***			
Decisions		0.459 (0.213)**		
Communication			0.183 (0.219)	
Feedback				0.440 (0.247)*
Flexible	−0.622 (0.187)***	−0.415 (0.206)**	−0.380 (0.220)*	−0.325 (0.187)*
Training	0.013 (0.177)	−0.012 (0.199)	−0.002 (0.192)	−0.162 (0.182)
Average				
Ideas	0.801 (0.503)			
Decisions		1.221 (0.563)**		
Communication			1.422 (0.540)***	
Feedback				1.036 (0.688)
Flexible	0.455 (0.428)	1.021 (0.551)*	1.359 (0.495)***	1.060 (0.581)*
Training	0.304 (0.371)	0.188 (0.411)	−0.268 (0.384)	0.073 (0.430)
R^2	0.407	0.390	0.417	0.349
Adj. R^2	0.369	0.352	0.377	0.314
N	224	218	217	209

Table A.4 reports the TFP results for trusts where the within-hospital means of the senior management variables exceed their medians. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns include time dummies and other controls. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.5: Simple Complementarity Results

	(1)	(2)	(3)	(4)	(5)	(6)
HRM						
Decisions	0.708 (0.221)***			0.718 (0.221)***		
Communication		0.420 (0.180)**			0.360 (0.180)**	
Feedback			0.541 (0.196)***			0.499 (0.205)**
Flexible	−0.746 (0.198)***	−0.668 (0.199)***	−0.693 (0.192)***	−0.608 (0.198)***	−0.519 (0.199)***	−0.546 (0.207)***
Training	−0.032 (0.184)	−0.002 (0.187)	−0.024 (0.189)	−0.082 (0.184)	−0.039 (0.187)	−0.066 (0.191)
Average						
Decisions	0.211 (0.440)			0.056 (0.440)		
Communication		0.307 (0.441)			0.301 (0.441)	
Feedback			−0.103 (0.486)			−0.180 (0.519)
Flexible	0.349 (0.454)	0.298 (0.451)	0.413 (0.466)	0.436 (0.454)	0.361 (0.451)	0.489 (0.473)
Training	0.461 (0.398)	0.423 (0.414)	0.469 (0.428)	0.610 (0.398)	0.560 (0.414)	0.621 (0.419)
R^2	0.393	0.372	0.329	0.359	0.336	0.329
Adj. R^2	0.357	0.337	0.298	0.325	0.305	0.298
N	224	224	224	224	224	224

Table A.5 tests complementarity in its simplest form using an indicator that takes value one when the within-hospital mean of the Ideas exceeds or is equal to its median. The table examines the FE coefficients of the remaining senior management variables in the subsample where the indicator takes value one. The first three columns are for total factor productivity whereas the last three columns for labour productivity. All models include year dummies. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.6: Total Factor Productivity: Incentives & Workplace Flexibility

	(1)	(2)	(3)	(4)
<i>HRM Variables & Interactions</i>				
Flexible	−0.399 (0.144)***	−0.349 (0.146)**	−0.294 (0.144)**	−0.296 (0.140)**
Avg. Flexible	0.643 (0.328)*	0.924 (0.375)**	0.873 (0.364)**	0.775 (0.366)**
milFlex	0.443 (0.112)***	−0.001 (0.095)	−0.131 (0.095)	−0.307 (0.086)***

Table A.6 segments the data according to the four quartiles of the within-group mean of Intention-to-Leave to investigate the interaction between incentives and workplace flexibility. Column 1 reports the results for hospitals where within-group mean of Intention-to-leave falls in the first quartile. Column 2 through 4 are for the remaining quartiles. The dependent variable is total factor productivity. The interaction term is milFlex. The coefficient of the original-form reports the FE estimate and the coefficient of the within-group mean reports the RE estimate. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.7: Total Factor Productivity: Incentives & Workforce Training

	(1)	(2)	(3)	(4)
<i>HRM Variables & Interactions</i>				
Training	−0.265 (0.128)**	−0.117 (0.136)	−0.136 (0.126)	−0.043 (0.136)
Avg. Training	0.389 (0.291)	0.606 (0.282)**	0.627 (0.288)**	0.468 (0.281)*
milTrain	0.524 (0.145)***	−0.125 (0.125)	−0.069 (0.143)	−0.415 (0.109)***
R^2	0.318	0.280	0.275	0.294
Adj. R^2	0.304	0.268	0.263	0.282
N	421	421	421	421

Table A.7 segments the data using the within-group mean of the Intention-to-leave variable to investigate the interaction between incentives and workforce training. Column 1 reports hospitals where within-group mean of Intention-to-leave is in the first quartile. Column 2 through 4 belong to the remaining quartiles. The dependent variable is total factor productivity. The interaction term is milTrain. Training appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form reports the FE estimate and the coefficient of the within-group mean reports the RE estimate. All models include year dummies. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.8: Interaction Models: Human Capital Measures

	(1)	(2)	(3)	(4)	(5)	(6)
Prop. Emergency	−0.371 (0.638)	−0.382 (0.624)	−0.788 (0.629)	−0.283 (0.642)	−0.264 (0.625)	−0.517 (0.620)
<i>Skill-Mix (lagged)</i>						
Prop. Medical	−0.948 (1.326)	0.095 (1.313)	0.162 (1.277)	−0.164 (1.185)	0.134 (1.170)	0.121 (1.210)
Prop. Nurse	0.096 (0.557)	−0.155 (0.573)	0.133 (0.556)	0.137 (0.531)	−0.038 (0.534)	0.116 (0.534)
<i>Averages</i>						
Prop. Medical	−0.460 (2.282)	−0.578 (2.275)	−0.708 (2.277)	−0.720 (2.192)	−0.583 (2.176)	−0.574 (2.193)
Prop. Nurse	0.337 (1.200)	0.265 (1.223)	0.223 (1.208)	−.239 (1.203)	−.334 (1.222)	−0.350 (1.215)
Prop. Emergency	−1.008 (0.754)	−1.050 (0.747)	−0.924 (0.758)	−.774 (0.761)	−.786 (0.747)	−.710 (0.765)
<i>Interactions</i>						
dMPropmed	1.613 (0.467)***			1.334 (0.581)**		
dMPropnurse		0.641 (0.172)***			0.609 (0.215)***	
dMEmer			0.520 (0.150)***			0.518 (0.206)**
R^2	0.298	0.303	0.303	0.285	0.291	0.294
Adj. R^2	0.285	0.290	0.289	0.272	0.278	0.281
N	417	417	417	417	417	417

Table A.8 tests that human capital inputs are more productive and variables such as proportion of emergency patients has lower adverse impact in effectively managed organisations. We create two indicators. The first takes one when the within-hospital mean of the composite management index exceeds its median and zero otherwise. The second takes one when the within-hospital means of Job satisfaction, Team quality and Job design exceed their medians and otherwise zero. Columns 1 through 3 report the results for when we interact the first indicator with the measures of human capital and proportion of emergency patients. Columns 4 through 6 belong to the second indicator. The coefficients of the original-form variable report FE estimates and the coefficients of the within-group mean report RE estimates. All models include year dummies. Robust standard errors are in parentheses. The dependent variable is total factor productivity *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Supplementary File

This document contains supplementary materials to support the analysis in the main text. The document is intended for on-line publication. Section 1 follows Aragon et al. (2015) to explain how the quality-adjusted productivity measures are constructed. Section 2 reports supplementary figures. Section 3 reports full tables of results which were given incompletely in the text for the sake of brevity. Section 4 reports labour productivity results, mirroring the results in the text for total factor productivity. Section 5 reports the robustness results discussed in the paper.

1 Productivity Measure

The methodology to construct quality adjusted hospital productivity is based on the approach taken by Dunleavey and Carrera (2010). To construct weights, the satisfaction scores across the hospitals for each year are arranged in an ascending order, and are then divided into five equally spaced intervals. A quality weighting factor for each of these intervals is created and are assigned to each hospital h depending on their respective satisfaction score. The weighting factor ranges from 0.2 to 1 in increments of 0.2, where 0.2 represents lowest possible weight and 1 represents maximum. Tables S1 and S2 provide these intervals and their respective quality adjustment weights for inpatient and outpatient satisfaction scores respectively. Quality adjustment weight for inpatient satisfaction score is denoted by q_h^{Inp} , whereas its outpatient counterpart is denoted by q_h^{Out} . If a hospital h 's inpatient and outpatient satisfaction score lies in the interval $72 < q \leq 76.1$ and $80.1 < q \leq 84.2$, then its respective quality adjustment weights would be assigned the following values: $q_h^{Inp} = 0.4$, $q_h^{Out} = 0.8$. The final weight, q_h , is composed of these two individual weights i.e. $q_h = \{q_h^{Inp}, q_h^{Out}\}$.

The two weights based on their respective inpatient and outpatient scores are then multiplied by the cost weighted output, and then divided by total input expenditure of each hospital h . These two data are obtained from Aragon et al. (2015). The ratio is then standardised to arrive at the final score for quality adjusted productivity. Tables S1 and S2 are based on data for the year 2012/13. Similar tables and quality adjusted hospital productivity using the same

Table S1: Inpatient Satisfaction Score Adjustment: 2012/13

<i>Inpatient Satisfaction Score Interval (q^{Inp})</i>	<i>Adjustment Weight (q_h^{Inp})</i>
$q \leq 72$	0.2
$72 < q \leq 76.1$	0.4
$76.1 < q \leq 80.1$	0.6
$80.1 < q \leq 84.2$	0.8
$q > 84.2$	1

This table provides the quality adjustment weights to each of the 5 equally spaced inpatient satisfaction score intervals. Satisfaction scores below or equal to 72 is assigned the lowest weight (0.2), and scores above or equal to 84.2 is assigned the highest weight

methodology have also been created for the other two years i.e. 2010/11 and 2011/12. These tables are not reported for the sake of brevity.

Table S2: Outpatient Satisfaction Score Adjustment: 2012/13

<i>Outpatient Satisfaction Score Interval (q^{Out})</i>	<i>Adjustment Weight (q_h^{Out})</i>
$q \leq 76.7$	0.2
$76.7 < q \leq 79.6$	0.4
$79.6 < q \leq 82.6$	0.6
$82.6 < q \leq 85.5$	0.8
$q > 85.5$	1

This table provides the quality adjustment weights to each of the 5 equally spaced outpatient satisfaction score intervals. Satisfaction scores below or equal to 76.7 is assigned the lowest weight (0.2), and scores above or equal to 85.5 is assigned the highest weight

This methodology to construct quality adjusted hospital productivity is also very similar to approaches taken by Aragon et al. (2015) and Castelli et al. (2015). The only major difference concerns the methodology to construct and use quality adjustment weights. The quality adjustment factor, q_h , under Aragon et al. (2015) and Castelli et al. (2015), is constructed by standardising each hospital's quality indicator by the national average i.e. quality measure for all hospitals. Furthermore, the quality data is designed to reflect the quality-adjusted life years, and is obtained from accessing detailed patient-level data from Hospital Episode Statistics and ONS mortality database.

Aragon et al. (2015) define the measure of output for hospital productivity as follows:

$$X_h = \sum_{j=1}^J x_{jh} \bar{c}_j \quad (1)$$

where x_{jh} represents output category j with $j = 1, 2, \dots, J$ for hospital h . $\bar{c}_j$ is the cost weight and is defined as $\bar{c}_j = c_j/\hat{c}$ where c_j represents the national average cost for patients allocated to output j and $\hat{c}$ is the national average cost across all patients. The main difference between the productivity measure employed in this paper and the one used in Aragon et al. (2015) is that allowance is made for quality adjustment for each hospital. q_h is the quality adjustment factor for hospital h , where $q_h = \{q_h^{Inp}, q_h^{Out}\}$. q_h or its two components, q_h^{Inp} and q_h^{Out} is multiplied to cost-weighted output in equation (1) to obtain quality-weighted hospital output for each hospital h :

$$X_h^Q = \sum_{j=1}^J x_{jh} \bar{c}_j q_h \quad (2)$$

If there are multiple quality indicators, then we simply weight the hospital by as many quality adjustment factors. The output measure is based on Healthcare Resource Groups (HRG). HRGs is used to classify patients into different patient groups to take into account their diverse healthcare needs and treatments. Hospital output in equation (1) or (2) take into account all healthcare services produced by NHS hospitals. These include not only inpatient and outpatient but also accident & emergency, diagnostics, maternity, mental amongst others. Measure of total inputs is given by equation (3)

$$Z_h^{TF} = Z_h^L + E_h^M + E_h^K = Z_h^{DL} + E_h^A + E_h^M + E_h^K \quad (3)$$

where

$$Z_h^L = Z_h^{DL} + E_h^A \quad (4)$$

is the total labour expenditure consisting of direct labour and agency staff expenditure where

$$Z_h^{DL} = \sum_{n=1}^N z_{nh} \omega_n \quad (5)$$

z_{nh} is the volume of input type n for example medical or nursing staff for $n = 1 \dots N$ and ω_n is the national average wage for input type n . E_h^A is total expenditure on agency staff where E_h^M and E_h^K represent total expenditure for intermediate inputs and capital. Combining equations (2) and (4) yields labour productivity ratio:

$$P_h^L = \frac{X_h^Q}{Z_h^L} = \frac{\sum_{j=1}^J x_{jh} \bar{c}_j q_h}{\sum_{n=1}^N z_{nh} \omega_n + E_h^A} \quad (6)$$

and combining equations (2) and (3) gives TFP ratio for each hospital:

$$P_h^{TF} = \frac{X_h^Q}{Z_h^{TF}} = \frac{\sum_{j=1}^J x_{jh} \bar{c}_j q_h}{\sum_{n=1}^N z_{nh} \omega_n + E_h^A + E_h^M + E_h^K} \quad (7)$$

For the purposes interpretation and comparison across hospitals, TFP and labour productivity

ratios are standardized using national average and multiplied by 100:

$$P_h^{S,L} = \left\{ \left[\left(\frac{X_h^Q}{Z_h^L} \right) / \frac{1}{H} \sum_h \frac{X_h^Q}{Z_h^L} \right] - 1 \right\} \times 100 \quad (8)$$

$$P_h^{S,TF} = \left\{ \left[\left(\frac{X_h^Q}{Z_h^{TF}} \right) / \frac{1}{H} \sum_h \frac{X_h^Q}{Z_h^{TF}} \right] - 1 \right\} \times 100 \quad (9)$$

Equations (8) and (9) provides a relative interpretation of productivity. For example, if a hospital's standardized labour productivity index or score is 10 then this implies that labour productivity in that hospital is 10% higher than national average.

2 Supplementary Figures

Figure S1: Distribution of 10 HRM Practices

This diagram provides the distribution of the 10 human resource management practices. IT shows that there exists considerable variations in the use of these practices across the NHS hospitals.

Figure S2: K-Nearest Neighbour Clustering: Labour Productivity

This graph describes the outcome of K-means clustering (weighted K-nearest neighbours, KNN R package), which groups the sample into a pre-specified number of clusters. The number of clusters is pre-specified at 3 to obtain well-defined sub-groups of the observations. The variable set includes the quality-adjusted labour productivity in addition to the set of management practices used in the study. The red cluster refers to high productivity cases where as the blue cluster refers to low productivity cases.

3 Supplementary Tables

Table S3: Between and Within Variation Statistics: HRM Practices

<i>HRM Practices</i>	<i>Between Std.Dev</i>	<i>Within Std.Dev</i>	<i>Min (Within)</i>	<i>Max (Within)</i>
<i>Senior Management</i>				
Decisions	4.76	2.87	17.94	35.23
Communication	5.49	5.02	17.72	44.72
Feedback	4.74	2.92	20.25	35.25
Ideas	6.12	3.00	30.48	48.82
<i>Flexible</i>	3.42	2.94	51.94	74.94
<i>Training</i>	3.22	1.54	28.55	38.55
<i>Team Quality</i>	2.27	0.00	74.53	74.53
<i>Intention to Leave</i>	2.51	1.30	16.46	27.21
<i>Job-Satisfaction</i>	2.72	2.45	53.00	67.37
<i>Job-Design</i>	0.06	0.03	3.32	3.50

Table S3 presents the within and the between variation of the 10 human resource management practices. It provides within (i.e. at hospital level) variation summary statistics for HRM practices measured using standard deviation alongside within minimum and maximum values. The table also provides between variations as a comparison to the within counterpart. The within-variation tells us how does an individual hospital vary at any particular time point from its individual mean. It is calculated by taking the mean of the standard deviations for hospitals in the sample data.

Table S4: Summary Statistics for Other Hospital and Patient led Factors

Variables	Definition	2010/11		2011/12		2012/13	
		Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev
Structural							
Teaching Status	Equal to 1 if hospital is Teaching and 0 otherwise	0.21	0.41	0.21	0.41	0.22	0.41
Foundation Trust	Equal to 1 if hospital has FT status and 0 otherwise	0.51	0.50	0.54	0.50	0.57	0.5
Beds	Average number of available beds	742.87	328.84	739.13	338.77	750.96	342.00
Regional							
London	Equal to 1 if hospital located in London and 0 otherwise	0.17	0.37	0.17	0.37	0.15	0.36
MMF (%)	MMF * 100	108.62	7.30	108.48	7.09	108.24	6.91
GP	Number of GPs per 100,000 resident population	68.35	3.79	63.38	3.95	67.32	3.77
Patient-Led							
Prop Emergency (%)	(Emergency admissions / Total admissions) * 100	37.57	5.77	36.93	5.49	37.41	5.52
Prop Female (%)	(Female admissions / Total admissions) * 100	56.92	2.82	56.67	2.79	56.53	2.65
Patients aged 0–14 (%)	Proportion of patients (FCE) under 14 years of age	11.24	3.64	11.10	3.74	11.10	3.65
Patients aged 15–44 (%)	Proportion of patients (FCE) between 15 and 44 years of age	27.42	5.07	26.61	4.91	25.73	4.60
Patients aged 45–59 (%)	Proportion of patients (FCE) between 45 and 59 years of age	15.48	1.75	15.62	1.82	15.69	1.80
Patients aged over 60 (%)	Proportion of patients (FCE) aged over 60 years of age	45.54	7.23	46.26	7.30	47.02	6.98
Skill-Mix							
Prop Medical (%)	(Medical workforce / Medical + non-medical workforce) * 100	11.14	1.97	11.76	2.24	11.61	2.56
Prop Nurse (%)	(Nursing workforce / Medical + non-medical workforce) * 100	32.57	3.89	30.96	2.82	31.16	2.81

Table S4 provides brief variable definitions for the control variables, and their corresponding summary statistics, mean and standard deviation.

Table S5: Total Factor Productivity: Above Individual HRM Medians

	(1)	(2)	(3)	(4)
Intercept	−105.6 (222.9)	−406.6 (227.6)*	−242.7 (218.1)	−432.3 (261.1)*
Structural				
Teaching Trust	−0.298 (11.21)	−4.020 (11.35)	−2.468 (10.66)	−5.019 (12.14)
Foundation Trust	4.415 (6.474)	3.480 (7.312)	3.752 (7.086)	2.316 (7.046)
Hospital Beds	−0.006 (0.013)	0.023 (0.023)	0.034 (0.020)*	0.034 (0.023)
Regional				
MFF	−2.577 (0.976)***	−1.988 (0.900)**	−2.425 (0.726)***	−1.725 (0.946)*
GP per 100,000	2.196 (0.705)***	2.325 (0.836)***	2.486 (0.879)***	2.941 (0.967)***
Patient				
Prop. Emergency	−1.378 (0.463)***	−0.725 (0.638)	−0.528 (0.574)	−0.760 (0.653)
Prop. Female	1.203 (1.629)	1.685 (1.355)	0.492 (1.406)	1.006 (1.548)
Patients aged 0–14	2.724 (1.429)*	4.086 (1.505)***	2.671 (1.410)*	4.530 (1.554)***
Patients aged 45–59	1.526 (2.237)	4.166 (2.314)*	1.320 (2.412)	3.143 (2.402)
Patients aged over 60	2.350 (0.843)***	3.695 (0.890)***	2.928 (0.850)***	3.566 (0.965)***
Skill-Mix				
Prop. Medical	−0.926 (1.314)	−0.172 (1.082)	−0.084 (1.016)	−0.772 (0.995)
Prop. Nurse	0.252 (0.718)	−0.100 (0.782)	0.276 (0.750)	0.076 (0.782)
HRM				
Ideas	0.434 (0.159)***			
Decisions		0.459 (0.213)**		
Communication			0.183 (0.219)	
Feedback				0.440 (0.247)*
Flexible	−0.622 (0.187)***	−0.415 (0.206)**	−0.380 (0.220)*	−0.325 (0.187)*
Training	0.013 (0.177)	−0.012 (0.199)	−0.002 (0.192)	−0.162 (0.182)
Average				
Ideas	0.801 (0.503)			
Decisions		1.221 (0.563)**		
Communication			1.422 (0.540)***	
Feedback				1.036 (0.688)
Flexible	0.455 (0.428)	1.021 (0.551)*	1.359 (0.495)***	1.060 (0.581)*
Training	0.304 (0.371)	0.188 (0.411)	−0.268 (0.384)	0.073 (0.430)
R ²	0.407	0.390	0.417	0.349
Adj. R ²	0.369	0.352	0.377	0.314
N	224	218	217	209

Table S5 reports the TFP results for trusts where the within-hospital means of the senior management variables exceed their medians. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns include time dummies and other controls. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table S6: Simple Complementarity Results

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	−56.73 (229.9)	−17.81 (242.3)	−69.49 (243.8)	0.793 (229.93)	37.37 (242.31)	−1.278 (236.8)
Structural						
Teaching Trust	6.376 (10.84)	4.771 (11.12)	5.145 (11.60)	5.005 (10.84)	3.596 (11.12)	3.921 (12.38)
Foundation Trust	5.845 (6.669)	5.007 (6.570)	5.025 (6.853)	7.593 (6.669)	6.834 (6.570)	6.790 (6.790)
Hospital Beds	−0.011 (0.013)	−0.012 (0.013)	−0.012 (0.013)	−0.005 (0.013)	−0.006 (0.013)	−0.006 (0.014)
Regional						
MFF	−3.148 (1.066)***	−3.249 (1.114)***	−2.770 (1.165)**	−3.086 (1.066)***	−3.200 (1.114)***	−2.733 (1.205)**
GP per 100,000	2.085 (0.758)***	2.078 (0.765)***	2.020 (0.786)**	1.938 (0.758)**	1.933 (0.765)**	1.857 (0.783)**
Patient						
Prop. Emergency	−1.226 (0.463)***	−1.295 (0.489)***	−1.232 (0.489)**	−1.440 (0.463)***	−1.473 (0.489)***	−1.418 (0.507)***
Prop. Female	1.314 (1.589)	1.118 (1.666)	1.175 (1.670)	0.522 (1.589)	0.337 (1.666)	0.354 (1.680)
Patients aged 0–14	3.220 (1.506)**	3.049 (1.504)**	3.257 (1.548)**	2.480 (1.506)	2.295 (1.504)	2.389 (1.576)
Patients aged 45–59	1.392 (2.362)	0.957 (2.418)	1.465 (2.381)	1.253 (2.362)	0.725 (2.418)	1.193 (2.448)
Patients aged over 60	2.864 (0.861)***	2.700 (0.883)***	2.753 (0.911)***	2.380 (0.861)***	2.231 (0.883)**	2.207 (0.914)**
Skill-Mix						
Prop. Medical	−0.313 (1.421)	−0.122 (1.456)	−0.369 (1.447)	2.196 (1.421)	2.342 (1.456)	2.132 (1.634)
Prop. Nurse	0.621 (0.741)	0.773 (0.746)	0.540 (0.764)	0.218 (0.741)	0.345 (0.746)	0.119 (0.781)
HRM						
Decisions	0.708 (0.221)***			0.718 (0.221)***		
Communication		0.420 (0.180)**			0.360 (0.180)**	
Feedback			0.541 (0.196)***			0.499 (0.205)**
Flexible	−0.746 (0.198)***	−0.668 (0.199)***	−0.693 (0.192)***	−0.608 (0.198)***	−0.519 (0.199)***	−0.546 (0.207)***
Training	−0.032 (0.184)	−0.002 (0.187)	−0.024 (0.189)	−0.082 (0.184)	−0.039 (0.187)	−0.066 (0.191)
Average						
Decisions	0.211 (0.440)			0.056 (0.440)		
Communication		0.307 (0.441)			0.301 (0.441)	
Feedback			−0.103 (0.486)			−0.180 (0.519)
Flexible	0.349 (0.454)	0.298 (0.451)	0.413 (0.466)	0.436 (0.454)	0.361 (0.451)	0.489 (0.473)
Training	0.461 (0.398)	0.423 (0.414)	0.469 (0.428)	0.610 (0.398)	0.560 (0.414)	0.621 (0.419)
Year Dummies						
2011/12	−16.04 (4.885)***	−13.81 (4.997)***	−15.28 (4.739)***	−15.23 (4.885)***	−12.64 (4.997)**	−14.13 (5.082)***
2012/13	−22.21 (6.114)***	−19.70 (6.178)***	−20.65 (5.950)***	−21.18 (6.114)***	−18.23 (6.178)***	−19.24 (6.324)***
R^2	0.393	0.372	0.329	0.359	0.336	0.329
Adj. R^2	0.357	0.337	0.298	0.325	0.305	0.298
N	224	224	224	224	224	224

Table S6 tests complementarity in its simplest form using a dummy variable that takes value one when the within-hospital mean of the Ideas exceeds or is equal to its median. The table examines the fixed effects coefficients of the remaining senior management variables in the subsample where the dummy variable takes value one. The first three columns report the results for total factor productivity whereas the last three columns reports the results for labour productivity. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table S7: Total Factor Productivity: Incentives & Workplace Flexibility

	(1)	(2)	(3)	(4)
Intercept	−27.94 (175.4)	−64.06 (184.1)	−60.83 (182.9)	−63.21 (183.8)
<i>Structural</i>				
Teaching Trust	−0.512 (7.447)	5.029 (8.084)	3.924 (8.163)	4.054 (8.043)
Foundation Trust	9.893 (4.805)**	12.364 (5.342)**	11.951 (5.343)**	10.657 (5.155)**
Hospital Beds	0.001 (0.009)	−0.003 (0.010)	−0.003 (0.010)	−0.002 (0.009)
<i>Regional</i>				
MFF	−2.255 (0.559)***	−2.255 (0.615)***	−2.306 (0.619)***	−2.095 (0.586)***
GP per 100,000	2.254 (0.543)***	2.219 (0.577)***	2.234 (0.574)***	2.268 (0.561)***
<i>Patients</i>				
Prop. Emergency	−0.961 (0.456)**	−0.980 (0.483)**	−0.944 (0.484)*	−1.028 (0.478)**
Prop. Female	0.041 (1.217)	0.125 (1.291)	0.140 (1.282)	−0.028 (1.272)
Patients aged 0–14	1.797 (1.114)	2.092 (1.156)*	2.007 (1.157)*	2.150 (1.150)*
Patients aged 45–59	1.358 (1.885)	1.794 (1.982)	1.931 (1.947)	1.656 (2.024)
Patients aged over 60	1.735 (0.714)**	2.203 (0.753)***	2.129 (0.749)***	2.164 (0.756)***
<i>Skill-Mix</i>				
Prop. Medical	−0.299 (0.817)	−0.283 (0.871)	−0.266 (0.881)	−0.355 (0.852)
Prop. Nurse	0.313 (0.531)	0.191 (0.566)	0.260 (0.565)	0.207 (0.558)
<i>HRM Variables & Interactions</i>				
Flexible	−0.399 (0.144)***	−0.349 (0.146)**	−0.294 (0.144)**	−0.296 (0.140)**
Avg. Flexible	0.643 (0.328)*	0.924 (0.375)**	0.873 (0.364)**	0.775 (0.366)**
miFlex	0.443 (0.112)***	−0.001 (0.095)	−0.131 (0.095)	−0.307 (0.086)***
<i>Year Dummies</i>				
2011/12	−6.347 (3.501)*	−8.017 (3.476)**	−7.468 (3.483)**	−8.329 (3.466)**
2012/13	−7.633 (4.252)*	−9.852 (4.363)**	−9.256 (4.308)**	−10.022 (4.342)**
R^2	0.328	0.282	0.282	0.299
Adj. R^2	0.314	0.270	0.270	0.286
N	421	421	421	421

Table S7 segments the data according to the four quartiles of the within-group mean of the variable Intention-to-Leave to investigate the interaction between incentives and workplace flexibility (Flexible). Column 1 reports the results for hospitals where within-group mean of Intention-to-leave is below or equal to the first quartile. Columns 2 through 4 respectively reports the results for the remaining quartiles. The dependent variable in all the models is the quality-adjusted total factor productivity measure. In addition to the interaction term miFlex, Flexible appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form variable reports the fixed effects estimate and the coefficient of the within-group mean reports the random effects estimate. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table S8: Total Factor Productivity: Incentives & Workforce Training

	(1)	(2)	(3)	(4)
Intercept	−61.19 (176.2)	−120.46 (186.9)	−131.1 (187.6)	−106.8 (187.7)
<i>Structural</i>				
Teaching Trust	−0.274 (7.642)	4.842 (7.969)	4.262 (8.305)	4.476 (8.122)
Foundation Trust	9.731 (4.895)**	12.352 (5.437)**	12.109 (5.412)**	10.812 (5.285)**
Hospital Beds	0.001 (0.009)	−0.003 (0.009)	−0.003 (0.009)	−0.003 (0.009)
<i>Regional</i>				
MFF	−2.311 (0.535)***	−2.261 (0.591)***	−2.230 (0.594)***	−2.068 (0.563)***
GP per 100,000	2.358 (0.535)***	2.345 (0.559)***	2.349 (0.555)***	2.421 (0.539)***
<i>Patients</i>				
Prop. Emergency	−0.917 (0.465)**	−0.935 (0.492)*	−0.907 (0.496)*	−0.940 (0.484)*
Prop. Female	0.488 (1.242)	0.840 (1.322)	0.839 (1.326)	0.348 (1.345)
Patients aged 0–14	1.870 (1.122)*	2.164 (1.149)*	2.162 (1.161)*	2.131 (1.163)*
Patients aged 45–59	1.166 (1.862)	1.819 (1.971)	2.033 (1.967)	1.499 (2.033)
Patients aged over 60	1.884 (0.733)**	2.344 (0.775)***	2.363 (0.779)***	2.280 (0.789)***
<i>Skill-Mix</i>				
Prop. Medical	−0.037 (0.847)	−0.180 (0.880)	−0.131 (0.888)	−0.112 (0.878)
Prop. Nurse	0.277 (0.498)	0.182 (0.520)	0.213 (0.520)	0.205 (0.512)
<i>HRM Variables & Interactions</i>				
Training	−0.265 (0.128)**	−0.117 (0.136)	−0.136 (0.126)	−0.043 (0.136)
Avg. Training	0.389 (0.291)	0.606 (0.282)**	0.627 (0.288)**	0.468 (0.281)*
milTrain	0.524 (0.145)***	−0.125 (0.125)	−0.069 (0.143)	−0.415 (0.109)***
<i>Year Dummies</i>				
2011/12	−1.484 (2.539)	−2.241 (2.495)	−2.102 (2.533)	−2.200 (2.487)
2012/13	−1.765 (2.838)	−2.894 (2.909)	−2.974 (2.899)	−2.886 (2.902)
R^2	0.318	0.280	0.275	0.294
Adj. R^2	0.304	0.268	0.263	0.282
N	421	421	421	421

Table S8 segments the data using the within-group mean of the Intention-to-leave variable to investigate the interaction between incentives and workforce training (Training). Column 1 reports the results for hospitals where within-group mean of Intention-to-leave is below or equal to the first quartile. Columns 2 through 4 respectively report the results for the remaining quartiles. The dependent variable in all the models is the quality-adjusted total factor productivity measure. In addition to the interaction term miTrain, Training appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form variable reports the fixed effects estimate and the coefficient of the within-group mean reports the random effects estimate. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table S9: Interaction Models: Human Capital Measures

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	−20.54 (178.7)	−6.780 (177.3)	−6.683 (176.0)	−27.91 (187.5)	−20.38 (185.6)	−15.82 (184.0)
<i>Structural</i>						
Teaching Trust	1.030 (7.786)	0.360 (7.723)	0.781 (7.708)	4.771 (8.202)	4.521 (8.272)	4.419 (8.245)
Foundation Trust	10.22 (5.239)*	10.06 (5.194)*	10.42 (5.181)**	10.24 (5.114)**	9.870 (5.062)**	10.36 (5.046)***
Hospital Beds	0.003 (0.009)	0.004 (0.009)	0.004 (0.009)	0.001 (0.010)	0.002 (0.0)	0.002 (0.010)
<i>Regional</i>						
MFF	−2.929 (0.661)***	−2.987 (0.645)***	−2.837 (0.639)***	−2.550 (0.637)***	−2.589 (0.623)***	−2.517 (0.625)***
GP per 100,000	2.492 (0.586)***	2.415 (0.588)***	2.431 (0.596)***	2.121 (0.597)***	2.009 (0.599)***	2.055 (0.602)***
<i>Patient</i>						
Prop. Emergency	−0.371 (0.638)	−0.382 (0.624)	−0.788 (0.629)	−0.283 (0.642)	−0.264 (0.625)	−0.517 (0.620)
Prop. Female	0.449 (1.292)	0.410 (1.288)	0.313 (1.282)	0.597 (1.317)	0.645 (1.292)	0.505 (1.289)
Patients aged 0–14	2.864 (1.166)**	2.890 (1.147)**	2.777 (1.151)**	2.165 (1.192)*	2.232 (1.202)*	2.132 (1.192)*
Patients aged 45–59	1.797 (2.038)	1.869 (2.034)	1.528 (2.021)	1.667 (2.067)	1.790 (2.059)	1.754 (2.074)
Patients aged over 60	2.392 (0.740)***	2.375 (0.732)***	2.339 (0.729)***	2.344 (0.790)***	2.351 (0.787)***	2.283 (0.782)***
<i>Skill–Mix (lagged)</i>						
Prop. Medical	−0.948 (1.326)	0.095 (1.313)	0.162 (1.277)	−0.164 (1.185)	0.134 (1.170)	0.121 (1.210)
Prop. Nurse	0.096 (0.557)	−0.155 (0.573)	0.133 (0.556)	0.137 (0.531)	−0.038 (0.534)	0.116 (0.534)
<i>Averages</i>						
Prop. Medical	−0.460 (2.282)	−0.578 (2.275)	−0.708 (2.277)	−0.720 (2.192)	−0.583 (2.176)	−0.574 (2.193)
Prop. Nurse	0.337 (1.200)	0.265 (1.223)	0.223 (1.208)	−.239 (1.203)	−.334 (1.222)	−0.350 (1.215)
Prop. Emergency	−1.008 (0.754)	−1.050 (0.747)	−0.924 (0.758)	−.774 (0.761)	−.786 (0.747)	−.710 (0.765)
<i>Interactions</i>						
dMPropmed	1.613 (0.467)***			1.334 (0.581)**		
dMPropnurse		0.641 (0.172)***			0.609 (0.215)***	
dMEmer			0.520 (0.150)***			0.518 (0.206)**
<i>Year Dummies</i>						
2011/12	−1.384 (2.199)	−1.336 (2.197)	−1.455 (2.196)	−1.332 (2.205)	−1.297 (2.202)	−1.383 (2.208)
2012/13	−1.156 (3.046)	−1.135 (3.011)	−1.298 (3.022)	−1.788 (3.072)	−1.627 (3.072)	−1.747 (3.086)
R ²	0.298	0.303	0.303	0.285	0.291	0.294
Adj. R ²	0.285	0.290	0.289	0.272	0.278	0.281
N	417	417	417	417	417	417

Table S8 tests the idea that human capital inputs, e.g., medical staff, are more productive and variables such as proportion of emergency patients has lower adverse impact in effectively managed hospitals. We create two indicator variables. The first binary variable takes one when the within-hospital mean of the composite management index exceeds its median and zero otherwise. The second indicator variable takes one when the within-hospital means of Job satisfaction, Team quality and Job design exceed their medians and otherwise zero. Columns 1 through 3 report the results for when we interact the first binary variable with the measures of human capital and proportion of emergency patients in the sample. Columns 4 through 6 reports the results for the second binary variable. The complementarity hypothesis implies that the coefficients of the interacted terms will be statistically significant and positive. The variables of interest appear twice: once in their original form and once as within-hospital means. The coefficients of the original-form variable reports fixed effects estimates and the coefficients of the within-group mean reports random effects estimates. All the models include year dummies. Robust standard errors are given in parentheses. The dependent variable is quality-adjusted total factor productivity *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4 Labour Productivity Results

This section replicates the results for our quality—adjusted labour productivity measure. Interpretations of the results are similar to those given in the text for the total factor productivity measure. The comments on the individual tables further shed light on the variables entering the models.

Table L1: Hierarchical Clustering: Labour Productivity

Group.1	Labour	Prop. Emergency	Ideas	Decisions	Feedback	Flexible	Job-Satisfaction	Team Quality	Job-Design	Training	Intention to Leave	Observations
1	35.30	36.16	55.60	43.85	50.86	48.77	67.56	56.68	62.87	41.75	19.67	53
2	-33.08	38.35	40.06	33.89	44.59	40.80	53.23	48.38	50.87	32.60	22.33	122
3	71.82	33.88	60.49	47.83	58.03	48.21	67.41	59.12	68.59	41.78	18.41	21
4	-44.37	35.41	55.73	51.46	61.90	38.99	68.60	57.32	71.11	38.71	21.10	52
5	-1.74	37.66	50.60	41.42	52.98	38.41	59.16	49.14	60.58	33.72	21.03	55
6	-76.83	39.75	44.01	42.30	52.09	37.86	53.10	55.00	64.98	25.35	24.26	35
7	26.96	36.45	39.69	28.57	40.96	37.60	45.80	47.34	46.24	33.44	22.21	49
8	-48.84	38.58	27.36	25.16	36.13	32.86	35.49	40.96	35.49	23.50	25.55	28
9	138.83	42.23	43.62	42.39	53.49	51.88	69.34	58.29	62.23	32.26	17.97	4
10	-7.98	32.86	79.79	62.77	72.97	39.06	77.78	61.71	86.44	37.90	18.55	8

Table L1 summarises the clustering results for the labour productivity measure. We use hierarchical clustering that requires no pre-specified number of clusters and builds a hierarchy of clusters that differ in terms of closeness. The method is applied to the HRM variables joined with the labour productivity measure. We summarise the resulting dendrogram into 10 clusters so that each cluster contains an adequate number of observations.

Table L2: Base Model: Labour Productivity

	(1)	(2)	(3)	(4)
Intercept	−60.53 (174.2)	−61.47 (171.8)	−48.02 (172.3)	−98.51 (174.5)
Structural				
Teaching Trust	−4.090 (8.203)	0.984 (8.365)	1.560 (8.323)	3.118 (8.478)
Foundation Trust	6.647 (4.765)	10.01 (4.877)**	8.975 (4.782)*	9.495 (4.993)*
Hospital Beds	0.014 (0.010)	0.008 (0.010)	0.006 (0.010)	0.005 (0.010)
Regional				
MFF	−2.488 (0.573)***	−2.767 (0.585)***	−2.821 (0.582)***	−2.476 (0.623)***
GP per 100,000	2.046 (0.547)***	2.203 (0.515)***	2.205 (0.550)***	2.225 (0.560)***
Patient				
Prop. Emergency	−1.414 (0.465)***	−1.366 (0.445)***	−1.387 (0.435)***	−1.352 (0.446)***
Prop. Female	−0.219 (1.220)	0.057 (1.218)	−0.010 (1.230)	0.079 (1.241)
Patients aged 0–14	2.186 (1.021)**	2.487 (1.107)**	2.395 (1.102)**	2.472 (1.074)**
Patients aged 45–59	2.416 (1.853)	2.124 (1.933)	1.677 (1.922)	2.007 (1.875)
Patients aged over 60	1.917 (0.689)***	2.349 (0.744)***	2.327 (0.759)***	2.385 (0.740)***
Skill-Mix				
Prop. Medical	1.394 (0.895)	1.677 (0.950)*	1.682 (0.965)*	1.677 (0.981)*
Prop. Nurse	−0.218 (0.533)	−0.083 (0.537)	−0.009 (0.529)	−0.105 (0.545)
HRM				
Ideas	0.212 (0.120)*			
Decisions		0.321 (0.169)*		
Communication			0.119 (0.164)	
Feedback				0.309 (0.167)*
Flexible	−0.302 (0.136)**	−0.332 (0.139)**	−0.303 (0.137)**	−0.318 (0.137)**
Training	−0.215 (0.115)*	−0.226 (0.117)*	−0.198 (0.120)*	−0.231 (0.118)*
Average				
Idea	0.766 (0.238)***			
Decisions		0.617 (0.352)*		
Communication			0.719 (0.332)**	
Feedback				0.335 (0.354)
Flexible	0.755 (0.352)**	0.756 (0.338)**	0.726 (0.326)**	0.817 (0.342)**
Training	0.386 (0.247)	0.514 (0.285)*	0.472 (0.299)	0.556 (0.301)*
Year Dummies				
2011/12	−10.30 (3.666)***	−9.980 (3.538)***	−9.153 (3.547)**	−10.07 (3.528)***
2012/13	−13.52 (4.815)***	−13.62 (4.735)***	−12.44 (4.723)***	−13.49 (4.607)***
R^2	0.336	0.319	0.313	0.300
Adj. R^2	0.319	0.303	0.298	0.285
N	421	421	421	421

Table L2 reports the initial results for quality-adjusted labour productivity. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. They appear in each model twice: once in their original form and once as within-hospital means. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns also include time dummies, with the period 2010/11 being taken as the base period. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table L3: Labour Productivity: Above Individual HRM Medians

	(1)	(2)	(3)	(4)
Intercept	−55.13 (214.9)	−328.3 (220.3)	−176.6 (213.4)	−361.4 (254.4)
Structural				
Teaching Trust	−1.674 (12.05)	−3.937 (11.58)	−0.829 (10.61)	−3.801 (12.35)
Foundation Trust	6.043 (6.376)	5.400 (7.226)	5.849 (6.970)	4.935 (6.970)
Hospital Beds	0.001 (0.014)	0.027 (0.023)	0.039 (0.020)*	0.038 (0.023)*
Regional				
MFF	−2.600 (1.017)**	−1.814 (0.896)**	−2.167 (0.696)***	−1.516 (0.923)
GP per 100,000	2.074 (0.710)***	2.060 (0.859)**	2.239 (0.910)**	2.563 (0.984)***
Patient				
Prop. Emergency	−1.584 (0.477)***	−0.827 (0.626)	−0.672 (0.570)	−0.862 (0.646)
Prop. Female	0.466 (1.607)	0.946 (1.337)	−0.350 (1.392)	0.363 (1.539)
Patients aged 0–14	2.078 (1.489)	3.134 (1.519)**	1.920 (1.395)	3.610 (1.483)**
Patients aged 45–59	1.392 (2.245)	3.502 (2.333)	0.517 (2.391)	2.668 (2.334)
Patients aged over 60	1.933 (0.845)**	3.103 (0.877)***	2.476 (0.857)***	3.008 (0.944)***
Skill-Mix				
Prop. Medical	1.595 (1.455)	1.565 (1.202)	1.358 (1.194)	0.744 (1.190)
Prop. Nurse	−0.136 (0.737)	−0.662 (0.761)	−0.338 (0.747)	−0.467 (0.761)
HRM				
Ideas	0.425 (0.162)***			
Decisions		0.464 (0.215)**		
Communication			0.104 (0.219)	
Feedback				0.347 (0.267)
Flexible	−0.480 (0.203)**	−0.353 (0.194)*	−0.307 (0.224)	−0.275 (0.184)
Training	−0.033 (0.176)	−0.047 (0.198)	−0.032 (0.188)	−0.170 (0.184)
Average				
Ideas	0.832 (0.510)			
Decisions		1.098 (0.584)*		
Communication			1.542 (0.585)***	
Feedback				1.070 (0.738)
Flexible	0.514 (0.452)	1.062 (0.548)*	1.350 (0.509)***	1.120 (0.578)*
Training	0.431 (0.369)	0.393 (0.404)	−0.069 (0.374)	0.236 (0.408)
Year Dummies				
2011/12	−15.39 (5.133)***	−9.584 (4.691)**	−8.183 (5.012)	−8.292 (4.758)*
2012/13	−20.32 (6.367)***	−14.86 (6.501)**	−12.68 (6.628)*	−13.34 (6.098)**
R^2	0.376	0.363	0.391	0.320
Adj. R^2	0.341	0.328	0.353	0.288
N	224	218	217	209

Table L3 reports the results for the quality-adjusted labour productivity measure for the sub-samples where the within-hospital means of the senior management variables exceed their medians. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns include time dummies and other controls. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table L4: Labour Productivity: Incentives & Workplace Flexibility

	(1)	(2)	(3)	(4)
Intercept	41.17 (172.5)	11.84 (180.72)	15.01 (179.56)	11.30 (180.4)
<i>Structural</i>				
Teaching Trust	1.127 (7.725)	6.396 (8.170)	5.436 (8.283)	5.487 (8.176)
Foundation Trust	12.31 (4.78)**	14.56 (5.322)***	14.17 (5.319)***	12.94 (5.137)**
Hospital Beds	0.004 (0.009)	−0.000 (0.010)	−0.000 (0.010)	0.000 (0.009)
<i>Regional</i>				
MFF	−2.272 (0.575)***	−2.277 (0.634)***	−2.321 (0.635)***	−2.125 (0.607)***
GP per 100,000	2.060 (0.526)***	2.021 (0.562)***	2.036 (0.558)***	2.068 (0.548)***
<i>Patients</i>				
Prop. Emergency	−1.227 (0.449)***	−1.240 (0.474)***	−1.208 (0.475)**	−1.285 (0.470)***
Prop. Female	−0.715 (1.219)	−0.650 (1.288)	−0.642 (1.281)	−0.791 (1.271)
Patients aged 0–14	1.400 (1.075)	1.645 (1.120)	1.564 (1.118)	1.712 (1.118)
Patients aged 45–59	0.999 (1.879)	1.329 (1.962)	1.448 (1.928)	1.231 (2.000)
Patients aged over 60	1.397 (0.699)**	1.817 (0.736)**	1.751 (0.732)**	1.788 (0.741)**
<i>Skill-Mix</i>				
Prop. Medical	1.436 (0.931)	1.461 (0.991)	1.477 (0.997)	1.389 (0.968)
Prop. Nurse	0.073 (0.514)	−0.070 (0.549)	−0.010 (0.549)	−0.045 (0.538)
<i>HRM Variables & Interactions</i>				
Flexible	−0.336 (0.140)**	−0.286 (0.141)**	−0.240 (0.140)*	−0.239 (0.138)*
Avg. Flex	0.717 (0.323)**	0.986 (0.370)***	0.939 (0.360)***	0.844 (0.362)**
milFlex	0.418 (0.116)***	−0.009 (0.092)	−0.115 (0.093)	−0.288 (0.083)***
<i>Year Dummies</i>				
2011/12	−6.243 (3.426)*	−7.829 (3.414)**	−7.355 (3.429)**	−8.117 (3.405)**
2012/13	−8.109 (4.253)*	−10.192 (4.353)**	−9.676 (4.315)**	−10.357 (4.339)**
R^2	0.318	0.275	0.274	0.289
Adj. R^2	0.304	0.263	0.263	0.277
N	421	421	421	421

Table L4 segments the data according to the four quartiles of the within-group mean of the variable Intention-to-Leave to investigate the interaction between incentives and workplace flexibility. Column 1 reports the results for hospitals where within-group mean of Intention-to-leave is below or equal to the first quantile. Columns 2 through 4 respectively reports the results for the remaining quartiles. The dependent variable in all the models is the quality-adjusted labour productivity measure. In addition to the interaction term miFlex, Flexible appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form variable reports the fixed effects estimate and the coefficient of the within-group mean reports the random effects estimate. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table L5: Labour Productivity: Incentives & Workforce Training

	(1)	(2)	(3)	(4)
Intercept	−3.035 (172.3)	−59.09 (183.0)	−67.70 (183.1)	−45.34 (183.2)
<i>Structural</i>				
Teaching Trust	1.236 (7.879)	6.289 (8.086)	5.633 (8.475)	5.937 (8.243)
Foundation TRust	11.83 (4.832)**	14.34 (5.403)***	14.07 (5.376)***	12.819 (5.241)**
Hospital Beds	0.003 (0.009)	−0.000 (0.009)	−0.000 (0.009)	−0.000 (0.009)
<i>Regional</i>				
MFF	−2.310 (0.542)***	−2.260 (0.603)***	−2.236 (0.604)***	−2.075 (0.575)***
GP per 100,000	2.188 (0.513)***	2.173 (0.542)***	2.174 (0.536)***	2.245 (0.522)***
<i>Patients</i>				
PropEmergency	−1.172 (0.455)**	−1.184 (0.482)**	−1.155 (0.485)**	−1.190 (0.474)**
PropFemale	−0.114 (1.236)	0.218 (1.320)	0.218 (1.321)	−0.261 (1.333)
Patients aged 0–14	1.501 (1.075)	1.770 (1.110)	1.756 (1.120)	1.742 (1.124)
Patients aged 45–59	0.880 (1.873)	1.491 (1.971)	1.682 (1.956)	1.174 (2.017)
Patients aged over 60	1.568 (0.717)**	2.011 (0.761)***	2.018 (0.764)***	1.947 (0.774)**
<i>Skill-Mix</i>				
Prop. Medical	1.606 (0.957)*	1.476 (0.996)	1.527 (1.000)	1.539 (0.989)
Prop. Nurse	0.039 (0.488)	−0.071 (0.505)	−0.044 (0.506)	−0.043 (0.500)
<i>HRM Variables & Interactions</i>				
Training	−0.274 (0.123)**	−0.131 (0.129)	−0.145 (0.121)	−0.055 (0.128)
Avg. Training	0.496 (0.276)*	0.713 (0.268)***	0.733 (0.274)***	0.576 (0.269)**
milTrain	0.516 (0.148)***	−0.112 (0.119)	−0.078 (0.136)	−0.408 (0.106)***
<i>Year Dummies</i>				
2011/12	−2.429 (2.499)	−3.191 (2.476)	−3.047 (2.511)	−3.147 (2.465)
2012/13	−3.585 (2.857)	−4.718 (2.923)	−4.778 (2.922)	−4.698 (2.922)
R ²	0.314	0.275	0.271	0.289
Adj. R ²	0.300	0.264	0.259	0.277
Num. obs.	421	421	421	421

Table L5 segments the data using the within-group mean of the Intention-to-leave variable to investigate the interaction between incentives and workforce training (Training). Column 1 reports the results for hospitals where within-group mean of Intention-to-leave is below or equal to the first quantile. Columns 2 through 4 respectively report the results for the remaining quartiles. The dependent variable in all the models is the quality adjusted labour productivity measure. In addition to the interaction term miTrain, Training appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form variable reports fixed effects estimates and the coefficient of the within-group mean reports random effects estimates. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table L6: Interaction Models : Human Capital Measures (Labour)

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	53.37 (177.9)	65.49 (176.3)	65.47 (175.05)	45.89 (183.4)	53.26 (181.3)	57.27 (179.0)
<i>Structural</i>						
Teaching Trust	3.278 (7.996)	2.597 (7.934)	2.874 (7.909)	6.449 (8.245)	6.208 (8.318)	6.070 (8.342)
Foundation Trust	13.19 (5.204)**	13.03 (5.160)**	13.29 (5.135)***	12.89 (4.992)**	12.63 (4.945)**	12.99 (4.913)***
Hospital Beds	0.003 (0.009)	0.003 (0.009)	0.004 (0.009)	0.002 (0.010)	0.003 (0.010)	0.003 (0.010)
<i>Regional</i>						
MPF	-2.953 (0.684)***	-3.014 (0.668)***	-2.889 (0.658)***	-2.646 (0.649)***	-2.680 (0.633)***	-2.612 (0.632)***
GP per 100,000	2.348 (0.568)***	2.282 (0.571)***	2.299 (0.578)***	1.999 (0.581)***	1.894 (0.582)***	1.929 (0.585)***
<i>Patient</i>						
Prop. Emergency	-0.437 (0.603)	-0.447 (0.592)	-0.821 (0.596)	-0.350 (0.605)	-0.332 (0.591)	-0.590 (0.585)
Prop. Female	-0.368 (1.309)	-0.399 (1.305)	-0.481 (1.299)	-0.188 (1.311)	-0.147 (1.285)	-0.272 (1.279)
Patients aged 0–14	2.166 (1.147)*	2.202 (1.124)*	2.120 (1.128)*	1.562 (1.168)	1.619 (1.175)	1.534 (1.166)
Patients aged 45–59	1.349 (2.040)	1.421 (2.033)	1.125 (2.021)	1.274 (2.050)	1.380 (2.036)	1.377 (2.048)
Patients aged over 60	1.945 (0.737)***	1.934 (0.728)***	1.907 (0.725)***	1.923 (0.778)**	1.926 (0.775)**	1.866 (0.770)**
<i>Skill-Mix (lagged)</i>						
Prop. Medical	-0.589 (1.222)	0.332 (1.219)	0.393 (1.189)	0.071 (1.107)	0.375 (1.090)	0.363 (1.126)
Prop. Nurse	0.165 (0.547)	-0.389 (0.570)	0.128 (0.550)	-0.120 (0.525)	-0.297 (0.537)	-0.139 (0.530)
<i>Averages</i>						
Prop. Medical	0.343 (2.250)	0.244 (2.245)	0.131 (2.251)	0.140 (2.159)	0.274 (2.138)	0.292 (2.144)
Prop. Nurse	1.086 (1.190)	1.026 (1.214)	0.990 (1.200)	0.538 (1.186)	0.455 (1.207)	0.417 (1.198)
Prop. Emergency	-1.265 (0.707)*	-1.304 (0.702)*	-1.192 (0.710)*	-1.043 (0.713)	-1.056 (0.701)	-0.975 (0.715)
<i>Interactions</i>						
dMPropmed	1.422 (0.459)***			1.353 (0.590)**		
dMPropnurse		0.575 (0.169)***			0.605 (0.216)***	
dMEmer			0.478 (0.147)***			0.534 (0.208)**
<i>Year Dummies</i>						
2011/12	-0.824 (2.137)	-0.780 (2.136)	-0.886 (2.135)	-0.760 (2.145)	-0.730 (2.145)	-0.812 (2.150)
2012/13	-2.184 (2.983)	-2.160 (2.954)	-2.300 (2.965)	-2.764 (3.036)	-2.602 (3.027)	-2.727 (3.042)
R ²	0.285	0.290	0.291	0.278	0.286	0.290
Adj. R ²	0.272	0.277	0.277	0.266	0.273	0.276
N	417	417	417	417	417	417

This table tests the idea that human capital inputs, e.g., medical staff, are more productive and variables such as proportion of emergency patients has lower adverse impact in effectively managed hospitals. We create two indicator variables. The first binary variable takes one when the within-hospital mean of the composite management index exceeds its median and zero otherwise. The second indicator variable takes one when the within-hospital means of Job satisfaction, Team quality and Job design exceed their medians and otherwise zero. Columns 1 through 3 report the results for when we interact the first binary variable with the measures of human capital and proportion of emergency patients in the sample. Columns 4 through 6 reports the results for the second binary variable. The complementarity hypothesis implies that the coefficients of the interacted terms will be statistically significant and positive. The variables of interest appear twice: once in their original form and once as within-hospital means. The coefficients of the original-form variable reports fixed effects estimates and the coefficients of the within-group mean reports random effects estimates. All the models include year dummies. Robust standard errors are given in parentheses. The dependent variable is quality-adjusted labour productivity *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5 Additional Robustness Analysis Results

The following tables provide the results that arise from our alternative measures of quality-adjusted total factor productivity and labour productivity. The order of the tables mirrors the order in the main sections in the text that report our data analysis. In general, the same interpretation applies to the tables except that the dependent variables are adjusted using different quality measures. The comments on individual tables are expected to be self-explanatory.

Table R1: Base Model: Total Factor Productivity

	(1)	(2)	(3)	(4)
Intercept	−572.3 (264.8)**	−544.3 (269.1)**	−524.1 (275.3)*	−619.9 (269.2)**
Structural				
Teaching Trust	12.20 (12.90)	19.35 (12.45)	21.36 (12.44)*	22.90 (12.23)*
Foundation Trust	7.397 (6.891)	11.28 (7.089)	10.43 (7.049)	10.55 (7.222)
Hospital Beds	0.009 (0.015)	0.001 (0.014)	−0.004 (0.013)	−0.004 (0.013)
Regional				
MFF	−1.589 (1.020)	−2.376 (1.006)**	−2.242 (1.009)**	−1.941 (1.060)*
GP per 100,000	2.347 (0.881)***	2.205 (0.931)**	2.336 (0.947)**	2.451 (0.946)***
Patients				
Prop. Emergency	−1.351 (0.745)*	−1.369 (0.727)*	−1.373 (0.735)*	−1.372 (0.751)*
Prop. Female	3.783 (2.308)	4.208 (2.253)*	4.011 (2.271)*	4.284 (2.295)*
Patients aged 0–14	4.833 (1.907)**	5.507 (2.054)***	5.130 (2.060)**	5.529 (2.007)***
Patients aged 45–59	9.441 (3.324)***	8.824 (3.471)**	7.882 (3.500)**	8.370 (3.457)**
Patients aged over 60	3.397 (1.182)***	4.203 (1.264)***	4.063 (1.284)***	4.382 (1.230)***
Skill-Mix				
Prop. Medical	−0.159 (1.786)	0.361 (1.792)	0.126 (1.762)	0.448 (1.773)
Prop. Nurse	0.087 (0.910)	0.338 (0.891)	0.389 (0.892)	0.397 (0.898)
HRM				
Ideas	0.012 (0.201)			
Decisions		0.383 (0.301)		
Communication			−0.198 (0.317)	
Feedback				0.246 (0.306)
Flexible	−0.685 (0.246)***	−0.716 (0.253)***	−0.657 (0.245)***	−0.686 (0.248)***
Training	0.021 (0.221)	−0.010 (0.220)	0.093 (0.228)	0.005 (0.230)
Averages				
Ideas	1.564 (0.414)***			
Decisions		1.500 (0.491)***		
Communication			1.663 (0.528)***	
Feedback				1.218 (0.472)**
Flexible	0.355 (0.559)	0.258 (0.559)	0.229 (0.558)	0.331 (0.562)
Training	0.050 (0.370)	0.195 (0.419)	0.112 (0.440)	0.214 (0.440)
Year Dummies				
2011/12	−15.520 (6.537)**	−16.573 (6.424)**	−15.070 (6.322)**	−16.268 (6.423)**
2012/13	−19.991 (8.207)**	−21.994 (8.092)***	−19.366 (7.937)**	−21.126 (8.056)***
R²	0.170	0.163	0.156	0.148
Adj. R²	0.162	0.155	0.148	0.140
N	420	420	420	420

Table R1 reports the initial results for quality-adjusted total factor productivity. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. They appear in each model twice: once in their original form and once as within-hospital means. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns also include time dummies, with the period 2010/11 being taken as the base period. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table R2: Base Model: Labour Productivity

	(1)	(2)	(3)	(4)
Intercept	−551.7 (274.9)**	−531.1 (281.1)*	−508.1 (286.6)*	−601.5 (281.2)**
Structural				
Teaching Trust	14.62 (13.70)	22.63 (13.45)*	24.54 (13.51)*	26.19 (13.26)**
Foundation Trust	10.74 (6.922)	15.20 (7.230)**	14.28 (7.109)**	14.60 (7.324)**
Hospital Beds	0.013 (0.015)	0.003 (0.014)	−0.001 (0.013)	−0.001 (0.013)
Regional				
MFF	−1.486 (1.066)	−2.193 (1.049)**	−2.080 (1.028)**	−1.745 (1.106)
GP per 100,000	2.195 (0.901)**	2.037 (0.955)**	2.172 (0.969)**	2.270 (0.969)**
Patient				
Prop. Emergency	−1.742 (0.758)**	−1.735 (0.748)**	−1.727 (0.753)**	−1.711 (0.768)**
Prop. Female	3.178 (2.444)	3.650 (2.400)	3.431 (2.415)	3.693 (2.442)
Patients aged 0–14	4.863 (2.023)**	5.504 (2.173)**	5.119 (2.174)**	5.453 (2.119)**
Patients aged 45–59	10.043 (3.482)***	9.500 (3.655)***	8.487 (3.682)**	8.969 (3.644)**
Patients aged over 60	3.198 (1.248)**	4.001 (1.336)***	3.860 (1.357)***	4.139 (1.299)***
Skill-Mix				
Prop. Medical	1.805 (1.874)	2.332 (1.885)	2.077 (1.856)	2.372 (1.887)
Prop. Nurse	−0.313 (0.911)	−0.077 (0.889)	−0.026 (0.890)	−0.033 (0.895)
HRM				
Ideas	0.046 (0.198)			
Decisions		0.456 (0.306)		
Communication			−0.189 (0.326)	
Feedback				0.220 (0.302)
Flexible	−0.580 (0.244)**	−0.619 (0.248)**	−0.553 (0.241)**	−0.579 (0.244)**
Training	−0.014 (0.215)	−0.056 (0.216)	0.059 (0.227)	−0.023 (0.225)
Averages				
Ideas	1.608 (0.424)***			
Decisions		1.375 (0.520)***		
Communication			1.644 (0.569)***	
Feedback				1.184 (0.495)**
Flexible	0.386 (0.561)	0.323 (0.560)	0.280 (0.556)	0.389 (0.566)
Training	0.160 (0.362)	0.354 (0.419)	0.253 (0.438)	0.363 (0.438)
Year Dummies				
2011/12	−16.022 (6.590)**	−17.124 (6.489)***	−15.412 (6.396)**	−16.522 (6.492)**
2012/13	−20.233 (8.382)**	−22.392 (8.276)***	−19.456 (8.134)**	−21.101 (8.262)**
R^2	0.183	0.170	0.164	0.154
$Adj. R^2$	0.173	0.161	0.156	0.146
N	420	420	420	420

Table R2 reports the initial results for quality-adjusted labour productivity. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. They appear in each model twice: once in their original form and once as within-hospital means. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns also include time dummies, with the period 2010/11 being taken as the base period. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table R3: Above Individual HRM Medians: Total Factor Productivity

	(1)	(2)	(3)	(4)
Intercept	−418.4 (374.4)	−759.7 (378.5)**	−654.0 (344.9)*	−775.8 (377.345)**
Structural				
Teaching Trust	11.42 (15.96)	23.83 (17.32)	19.45 (14.83)	25.96 (17.75)
Foundation Trust	5.409 (10.99)	8.432 (10.031)	10.71 (9.015)	10.92 (9.289)
Hospital Beds	−0.023 (0.024)	0.005 (0.028)	0.034 (0.024)	0.026 (0.026)
Regional				
MFF	−1.233 (2.159)	−0.489 (1.726)	−0.790 (1.213)	−0.249 (1.571)
GP	1.297 (1.206)	−0.176 (1.607)	0.772 (1.533)	0.293 (1.475)
Patient				
Prop. Emergency	−2.286 (1.029)**	−0.675 (1.104)	−0.466 (0.784)	−0.463 (0.967)
Prop. Female	2.255 (2.870)	3.962 (2.776)	3.007 (2.994)	3.072 (3.159)
Patients aged 0–14	4.460 (2.542)*	6.411 (2.889)**	4.877 (2.771)*	7.194 (2.859)**
Patients aged 45–59	9.382 (3.889)**	10.48 (4.592)**	7.268 (4.820)	8.360 (4.924)*
Patients aged over 60	2.982 (1.457)**	5.370 (1.625)***	4.196 (1.569)***	5.016 (1.578)***
Skill-Mix				
Prop. Medical	−1.452 (2.653)	−0.381 (2.474)	−0.333 (2.152)	−1.327 (2.170)
Prop. Nurse	0.603 (1.249)	−0.254 (1.310)	−0.258 (1.223)	−0.169 (1.205)
HRM				
Ideas	0.256 (0.275)			
Decisions		0.401 (0.374)		
Communication			−0.238 (0.454)	
Feedback				0.005 (0.395)
Flexible	−0.720 (0.373)*	−0.503 (0.419)	−0.490 (0.342)	−0.325 (0.336)
Training	0.636 (0.362)*	0.852 (0.374)**	0.889 (0.385)**	0.591 (0.367)
Averages				
Ideas	1.788 (0.932)*			
Decisions		2.427 (1.062)**		
Communication			2.690 (1.258)**	
Feedback				2.749 (1.343)**
Flexible	0.756 (0.944)	1.084 (0.990)	1.485 (0.731)**	1.176 (0.870)
Training	−0.492 (0.540)	−0.692 (0.673)	−1.023 (0.631)	−0.747 (0.669)
Year Dummies				
2011/12	−18.125 (9.435)*	−14.309 (9.772)	−12.937 (8.673)	−9.550 (9.152)
2012/13	−26.550 (10.319)**	−22.110 (11.889)*	−18.869 (10.545)*	−17.740 (11.005)
R^2	0.187	0.193	0.220	0.172
Adj. R^2	0.169	0.174	0.199	0.155
N	223	217	216	208

Table R3 reports the results for the quality-adjusted total factor productivity measure for the sub-samples where the within-hospital means of the senior management variables exceed their medians. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns include time dummies and other controls. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table R4: Above Individual HRM Medians: Labour Productivity

	(1)	(2)	(3)	(4)
Intercept	−446.2 (387.3)	−773.6 (395.0)*	−679.8 (367.9)*	−780.4 (393.2)**
Structural				
Teaching Trust	12.85 (17.63)	28.100 (19.02)	24.55 (16.46)	31.22 (19.72)
Foundation Trust	9.546 (11.13)	13.09 (10.29)	15.05 (9.224)	15.51 (9.484)
Hospital Beds	−0.013 (0.025)	0.011 (0.028)	0.040 (0.025)	0.031 (0.026)
Regional				
MFF	−0.928 (2.302)	−0.074 (1.805)	−0.299 (1.243)	0.116 (1.624)
GP per 100,000	1.183 (1.235)	−0.423 (1.707)	0.564 (1.628)	−0.120 (1.589)
Patient				
Prop. Emergency	−2.575 (1.033)**	−0.934 (1.119)	−0.755 (0.840)	−0.735 (1.001)
Prop. Female	1.669 (3.062)	3.654 (3.006)	2.581 (3.266)	2.762 (3.412)
Patients aged 0–14	4.192 (2.802)	6.198 (3.151)*	4.759 (2.971)	7.023 (3.016)**
Patients aged 45–59	10.24 (4.232)**	11.173 (4.911)**	7.789 (5.180)	9.108 (5.192)*
Patients aged over 60	2.760 (1.563)*	5.116 (1.743)***	4.041 (1.719)**	4.758 (1.681)***
Skill-Mix				
Prop. Medical	1.300 (2.938)	1.530 (2.624)	1.183 (2.195)	0.287 (2.223)
Prop. Nurse	−0.100 (1.324)	−1.097 (1.309)	−1.108 (1.258)	−0.909 (1.222)
HRM				
Ideas	0.238 (0.274)			
Decisions		0.418 (0.391)		
Communication			−0.355 (0.482)	
Feedback				−0.122 (0.404)
Flexible	−0.502 (0.395)	−0.370 (0.391)	−0.341 (0.350)	−0.215 (0.320)
Training	0.549 (0.364)	0.765 (0.376)**	0.807 (0.379)**	0.545 (0.358)
Averages				
Ideas	1.982 (0.990)**			
Decisions		2.365 (1.195)**		
Communication			2.951 (1.417)**	
Feedback				2.984 (1.522)*
Flexible	0.862 (1.006)	1.162 (1.012)	1.500 (0.777)*	1.278 (0.895)
Training	−0.307 (0.561)	−0.434 (0.694)	−0.775 (0.647)	−0.580 (0.666)
Year Dummies				
2011/12	−16.974 (10.065)*	−14.645 (9.605)	−12.626 (8.996)	−9.288 (9.077)
2012/13	−24.185 (11.085)**	−21.887 (11.847)*	−18.092 (10.935)*	−17.047 (11.115)
R^2	0.185	0.189	0.222	0.178
Adj. R^2	0.168	0.170	0.200	0.160
N	223	217	216	208

Table R4 reports the results for the quality-adjusted labour productivity measure for the sub-samples where the within-hospital means of the senior management variables exceed their medians. Column 1 through 4 each includes a set of not highly correlated management variables. Management variables are lagged by one year. The coefficients of the original-form variables report FE estimates and the coefficients of the within-group means report RE estimates. The columns include time dummies and other controls. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table R5: Total Factor Productivity: Incentives & Workplace Flexibility

	(1)	(2)	(3)	(4)
Intercept	−458.4 (281.5)	−519.3 (286.1)*	−517.2 (287.7)*	−505.0 (282.1)*
Structural				
Teaching Trust	21.16 (12.32)*	29.03 (11.99)**	27.60 (12.27)**	27.15 (11.89)**
Foundation Trust	15.77 (7.179)**	20.33 (7.870)**	19.96 (7.886)**	17.03 (7.403)**
Hospital Beds	−0.008 (0.013)	−0.014 (0.013)	−0.013 (0.013)	−0.012 (0.013)
Regional				
MFF	−1.180 (1.058)	−1.157 (1.119)	−1.227 (1.125)	−0.880 (1.074)
GP per 100,000	2.045 (0.974)**	2.029 (0.976)**	2.050 (0.975)**	2.116 (0.929)**
Patient				
Prop. Emergency	−1.022 (0.736)	−1.045 (0.770)	−0.994 (0.770)	−1.154 (0.754)
Prop. Female	3.460 (2.485)	3.625 (2.554)	3.672 (2.558)	3.273 (2.525)
Patients aged 0–14	3.804 (2.122)*	4.183 (2.092)**	4.075 (2.095)*	4.197 (2.124)**
Patients aged 45–59	7.879 (3.355)**	8.503 (3.571)**	8.690 (3.504)**	8.063 (3.622)**
Patients aged over 60	2.729 (1.287)**	3.425 (1.266)**	3.330 (1.274)**	3.318 (1.280)**
Skill-Mix				
Prop. Medical	−0.109 (1.819)	−0.069 (1.884)	−0.047 (1.901)	−0.171 (1.836)
Prop. Nurse	0.486 (0.862)	0.321 (0.941)	0.421 (0.936)	0.283 (0.919)
HRM Variables & Interactions				
Flexible	−0.753 (0.243)**	−0.684 (0.246)**	−0.606 (0.246)**	−0.596 (0.243)**
Avg. Flex	0.295 (0.580)	0.686 (0.624)	0.616 (0.603)	0.454 (0.616)
milFlex	0.639 (0.217)**	0.010 (0.142)	−0.177 (0.159)	−0.516 (0.144)**
Year Dummies				
2011/12	−13.323 (6.181)**	−15.776 (6.218)**	−14.993 (6.207)**	−16.437 (6.229)**
2012/13	−17.791 (7.627)**	−21.010 (7.911)**	−20.160 (7.841)**	−21.383 (7.931)**
R^2	0.144	0.117	0.118	0.135
Adj. R^2	0.138	0.112	0.113	0.129
N	420	420	420	420

Table R5 segments the data according to the four quartiles of the within-group mean of the variable Intention-to-Leave to investigate the interaction between incentives and workplace flexibility (Flexible). Column 1 reports the results for hospitals where within-group mean of Intention-to-leave is below or equal to the first quartile. Columns 2 through 4 respectively reports the results for the remaining quartiles. The dependent variable in all the models is the quality-adjusted total factor productivity measure. In addition to the interaction term miFlex, Flexible appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form variable reports the fixed effects estimate and the coefficient of the within-group mean reports the random effects estimate. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table R6: Labour Productivity: Incentives & Workplace Flexibility

	(1)	(2)	(3)	(4)
Intercept	−416.9 (292.3)	−476.0 (296.3)	−473.5 (297.8)	−466.6 (292.8)
Structural				
Teaching Trust	24.39 (13.24)*	32.59 (12.83)**	31.16 (13.10)**	30.69 (12.78)**
Foundation Trust	19.70 (7.366)***	24.19 (8.172)***	23.77 (8.176)***	21.06 (7.661)***
Hospital Beds	−0.005 (0.013)	−0.011 (0.013)	−0.011 (0.013)	−0.010 (0.013)
Regional				
MFF	−1.097 (1.127)	−1.084 (1.193)	−1.152 (1.200)	−0.803 (1.152)
GP per 100,000	1.864 (1.001)*	1.845 (1.008)*	1.867 (1.005)*	1.937 (0.962)**
Patient				
Prop. Emergency	−1.394 (0.754)*	−1.415 (0.789)*	−1.364 (0.791)*	−1.528 (0.772)**
Prop. Female	2.749 (2.627)	2.922 (2.691)	2.962 (2.698)	2.585 (2.665)
Patients aged 0–14	3.753 (2.239)*	4.125 (2.204)*	4.010 (2.210)*	4.178 (2.238)*
Patients aged 45–59	8.301 (3.526)**	8.883 (3.726)**	9.072 (3.663)**	8.520 (3.777)**
Patients aged over 60	2.466 (1.346)*	3.164 (1.321)**	3.068 (1.331)**	3.080 (1.338)**
Skill-Mix				
Prop. Medical	1.866 (1.913)	1.908 (1.987)	1.931 (1.999)	1.791 (1.937)
Prop. Nurse	0.088 (0.863)	−0.097 (0.950)	−0.000 (0.941)	−0.100 (0.922)
HRM Variables & Interactions				
Flexible	−0.648 (0.241)***	−0.573 (0.244)**	−0.498 (0.243)**	−0.487 (0.243)**
mFlex	0.346 (0.583)	0.750 (0.636)	0.678 (0.614)	0.508 (0.623)
milFlex	0.657 (0.228)***	0.000 (0.143)	−0.177 (0.159)	−0.519 (0.142)***
Year Dummies				
2011/12	−13.369 (6.296)**	−15.870 (6.362)**	−15.111 (6.334)**	−16.483 (6.363)***
2012/13	−17.387 (7.911)**	−20.651 (8.190)**	−19.826 (8.121)**	−20.998 (8.206)**
R^2	0.153	0.124	0.126	0.142
Adj. R^2	0.146	0.119	0.120	0.136
N	420	420	420	420

Table R6 segments the data according to the four quartiles of the within-group mean of the variable Intention-to-Leave to investigate the interaction between incentives and workplace flexibility. Column 1 reports the results for hospitals where within-group mean of Intention-to-leave is below or equal to the first quartile. Columns 2 through 4 respectively reports the results for the remaining quartiles. The dependent variable in all the models is the quality-adjusted labour productivity measure. In addition to the interaction term milFlex, Flexible appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form variable reports the fixed effects estimate and the coefficient of the within-group mean reports the random effects estimate. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table R7: Total Factor Productivity: Incentives & Workforce Training

	(1)	(2)	(3)	(4)
Intercept	-520.4 (287.7)*	-610.4 (290.1)**	-631.9 (293.8)**	-586.9 (291.7)**
<i>Structural</i>				
Teaching Trust	18.35 (12.62)	26.05 (11.75)**	25.38 (12.37)**	25.25 (11.98)**
Foundation Trust	13.59 (6.752)**	18.30 (7.532)**	18.18 (7.482)**	15.78 (7.252)**
Hospital Beds	-0.006 (0.013)	-0.011 (0.012)	-0.011 (0.013)	-0.011 (0.012)
<i>Regional</i>				
MFF	-0.989 (1.034)	-0.907 (1.123)	-0.829 (1.132)	-0.601 (1.103)
GP per 100,000	2.088 (0.950)**	2.099 (0.929)**	2.124 (0.920)**	2.216 (0.876)**
<i>Patient</i>				
Prop. Emergency	-0.953 (0.754)	-0.995 (0.777)	-0.953 (0.784)	-1.016 (0.761)
Prop. Female	3.520 (2.405)	4.079 (2.420)*	4.066 (2.436)*	3.279 (2.466)
Patients aged 0–14	3.675 (2.232)	4.054 (2.143)*	4.045 (2.172)*	4.003 (2.210)*
Patients aged 45–59	7.646 (3.442)**	8.482 (3.556)**	8.829 (3.571)**	8.021 (3.659)**
Patients aged over 60	2.754 (1.323)**	3.440 (1.297)***	3.495 (1.315)***	3.344 (1.332)**
<i>Skill-Mix</i>				
Prop. Medical	0.650 (1.806)	0.411 (1.886)	0.488 (1.901)	0.540 (1.856)
Prop. Nurse	0.290 (0.811)	0.140 (0.873)	0.182 (0.872)	0.126 (0.851)
<i>HRM Variables & Interactions</i>				
Training	-0.106 (0.190)	0.138 (0.244)	0.088 (0.241)	0.234 (0.241)
Avg. Training	0.198 (0.442)	0.510 (0.449)	0.544 (0.458)	0.313 (0.437)
milTrain	0.796 (0.300)***	-0.241 (0.190)	-0.077 (0.231)	-0.617 (0.187)***
<i>Year Dummies</i>				
2011/12	-1.702 (4.139)	-2.849 (4.127)	-2.673 (4.210)	-2.871 (4.103)
2012/13	-2.647 (4.701)	-4.232 (4.838)	-4.420 (4.903)	-4.323 (4.877)
R^2	0.134	0.109	0.106	0.121
Adj. R^2	0.129	0.104	0.101	0.116
N	420	420	420	420

Table R7 segments the data using the within-group mean of the Intention-to-leave variable to investigate the interaction between incentives and workforce training (Training). Column 1 reports the results for hospitals where within-group mean of Intention-to-leave is below or equal to the first quartile. Columns 2 through 4 respectively report the results for the remaining quartiles. The dependent variable in all the models is the quality-adjusted total factor productivity measure. In addition to the interaction term milTrain, Training appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form variable reports the fixed effects estimate and the coefficient of the within-group mean reports the random effects estimate. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table R8: Labour Productivity: Incentives & Workforce Training

	(1)	(2)	(3)	(4)
Intercept	−488.6 (297.1)	−581.8 (298.8)*	−602.9 (302.1)**	−558.9 (299.7)*
<i>Structural</i>				
Teaching Trust	21.73 (13.55)	29.76 (12.61)**	29.08 (13.24)**	28.98 (12.88)**
Foundation Trust	17.28 (6.868)**	22.00 (7.758)**	21.87 (7.713)**	19.46 (7.444)**
Hospital Beds	−0.003 (0.013)	−0.008 (0.012)	−0.008 (0.012)	−0.008 (0.012)
<i>Regional</i>				
MFF	−0.897 (1.095)	−0.817 (1.191)	−0.741 (1.201)	−0.499 (1.171)
GP per 100,000	1.936 (0.967)**	1.947 (0.950)**	1.971 (0.942)**	2.070 (0.899)**
<i>Patient</i>				
Prop. Emergency	−1.316 (0.768)*	−1.354 (0.791)*	−1.312 (0.799)	−1.375 (0.770)*
Prop. Female	2.987 (2.533)	3.572 (2.549)	3.561 (2.563)	2.749 (2.584)
Patients aged 0–14	3.659 (2.348)	4.055 (2.257)*	4.043 (2.286)*	4.003 (2.324)*
Patients aged 45–59	8.103 (3.621)**	8.987 (3.727)**	9.325 (3.737)**	8.500 (3.817)**
Patients aged over 60	2.536 (1.382)*	3.242 (1.351)**	3.294 (1.372)**	3.146 (1.388)**
<i>Skill-Mix</i>				
Prop. Medical	2.501 (1.923)	2.259 (2.011)	2.335 (2.020)	2.378 (1.977)
Prop. Nurse	−0.110 (0.815)	−0.265 (0.878)	−0.221 (0.875)	−0.251 (0.856)
<i>HRM Variables & Interactions</i>				
Training	−0.148 (0.186)	0.101 (0.237)	0.053 (0.234)	0.205 (0.234)
Avg. Training	0.339 (0.441)	0.665 (0.451)	0.699 (0.461)	0.456 (0.439)
milTrain	0.823 (0.312)**	−0.239 (0.188)	−0.080 (0.230)	−0.648 (0.190)**
<i>Year Dummies</i>				
2011/12	−3.919 (4.129)	−5.095 (4.162)	−4.911 (4.223)	−5.080 (4.131)
2012/13	−5.044 (4.820)	−6.687 (4.987)	−6.863 (5.050)	−6.740 (5.026)
R^2	0.149	0.122	0.119	0.135
Adj. R^2	0.142	0.117	0.114	0.129
N	420	420	420	420

Table R8 segments the data using the within-group mean of the Intention-to-leave variable to investigate the interaction between incentives and workforce training (Training). Column 1 reports the results for hospitals where within-group mean of Intention-to-leave is below or equal to the first quartile. Column 2 through 4 respectively report the results for the remaining quartiles. The dependent variable in all the models is the quality adjusted labour productivity measure. In addition to the interaction term milTrain, Training appears in each column twice: once in its original form and once as a within-hospital mean. The coefficient of the original-form variable reports fixed effects estimates and the coefficient of the within-group mean reports random effects estimates. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table R9: Interaction Models: Human Capital Measures

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	−435.9 (267.0)	−419.9 (265.5)	−417.3 (267.2)	−390.6 (280.0)	−375.0 (278.3)	−374.3 (279.7)
<i>Structural</i>						
Teaching Trust	16.14 (10.62)	14.73 (10.68)	15.62 (10.81)	20.35 (11.503)*	18.86 (11.604)	19.76 (11.74)*
Foundation Trust	15.39 (7.648)**	14.707 (7.536)*	15.47 (7.543)**	19.86 (7.837)**	19.18 (7.714)**	19.87 (7.727)**
Hospital Beds	0.000 (0.012)	0.002 (0.012)	0.001 (0.012)	−0.000 (0.012)	0.002 (0.012)	0.001 (0.012)
<i>Regional</i>						
MFF	−1.744 (1.206)	−1.892 (1.170)	−1.662 (1.170)	−1.692 (1.336)	−1.848 (1.300)	−1.627 (1.297)
GP per 100,000	2.257 (0.923)**	2.190 (0.930)**	2.195 (0.933)**	2.151 (0.949)**	2.091 (0.956)**	2.097 (0.960)**
<i>Patient</i>						
Prop. Emergency	0.807 (1.412)	0.790 (1.394)	0.324 (1.391)	0.724 (1.402)	0.707 (1.388)	0.270 (1.381)
Prop. Female	3.162 (2.458)	3.153 (2.443)	2.988 (2.451)	2.478 (2.622)	2.471 (2.609)	2.330 (2.613)
Patients aged 0–14	4.991 (2.206)**	5.153 (2.168)**	4.921 (2.166)**	4.647 (2.318)**	4.818 (2.278)**	4.606 (2.274)**
Patients aged 45–59	8.565 (3.747)**	8.744 (3.729)**	8.244 (3.718)**	8.987 (3.917)**	9.158 (3.895)**	8.710 (3.887)**
Patients aged over 60	3.440 (1.256)***	3.451 (1.245)***	3.380 (1.247)***	3.106 (1.327)**	3.121 (1.316)**	3.060 (1.318)**
<i>Skill-Mix</i>						
Prop. Medical	−1.878 (1.846)	−0.738 (1.811)	−0.646 (1.795)	−1.581 (1.773)	−0.529 (1.738)	−0.447 (1.726)
Prop. Nurse	−0.331 (0.936)	−0.638 (0.882)	−0.289 (0.922)	−0.744 (0.919)	−1.033 (0.882)	−0.701 (0.911)
<i>Averages</i>						
Prop. Medical	2.988 (3.700)	2.906 (3.686)	2.714 (3.697)	3.798 (3.915)	3.730 (3.902)	3.550 (3.915)
Prop. Nurse	−0.459 (1.744)	−0.522 (1.730)	−0.580 (1.744)	0.419 (1.766)	0.368 (1.758)	0.309 (1.767)
Prop. Emergency	−2.584 (1.401)*	−2.653 (1.396)*	−2.493 (1.408)*	−3.058 (1.381)**	−3.126 (1.380)**	−2.974 (1.386)**
<i>Interactions</i>						
dMPropmed	1.792 (0.628)***			1.645 (0.639)**		
dMPropnurse		0.798 (0.234)***			0.754 (0.237)***	
dMEmer			0.599 (0.194)***			0.563 (0.195)***
<i>Year Dummies</i>						
2011/12	−2.517 (3.830)	−2.433 (3.826)	−2.593 (3.829)	−2.664 (3.826)	−2.584 (3.822)	−2.735 (3.826)
2012/13	−3.982 (5.196)	−3.872 (5.143)	−4.116 (5.168)	−5.240 (5.317)	−5.130 (5.270)	−5.359 (5.293)
R ²	0.128	0.135	0.132	0.137	0.144	0.141
Adj. R ²	0.122	0.129	0.126	0.131	0.137	0.135
N	416	416	416	416	416	416

Table R9 tests the idea that human capital inputs, e.g., medical staff, are more productive in effectively managed hospitals. To test this idea, we create a dummy variable that takes value one when the within-hospital mean of the composite management index exceeds its median and zero otherwise. The variable is then interacted with the measures of human capital in the sample. The hypothesis implies that the coefficient of the interacted terms will be statistically significant and positive. The first three columns report the results for total factor productivity and the last three columns report the results for labour productivity. The variables of interest (Prop.Medical, Prop.Nurse and Prop.Emergency) appear in each column twice: once in their original form and once as within-hospital means. The coefficients of the original-form variable reports fixed effects estimates and the coefficients of the within-group mean reports random effects estimates. All the models include year dummies. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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