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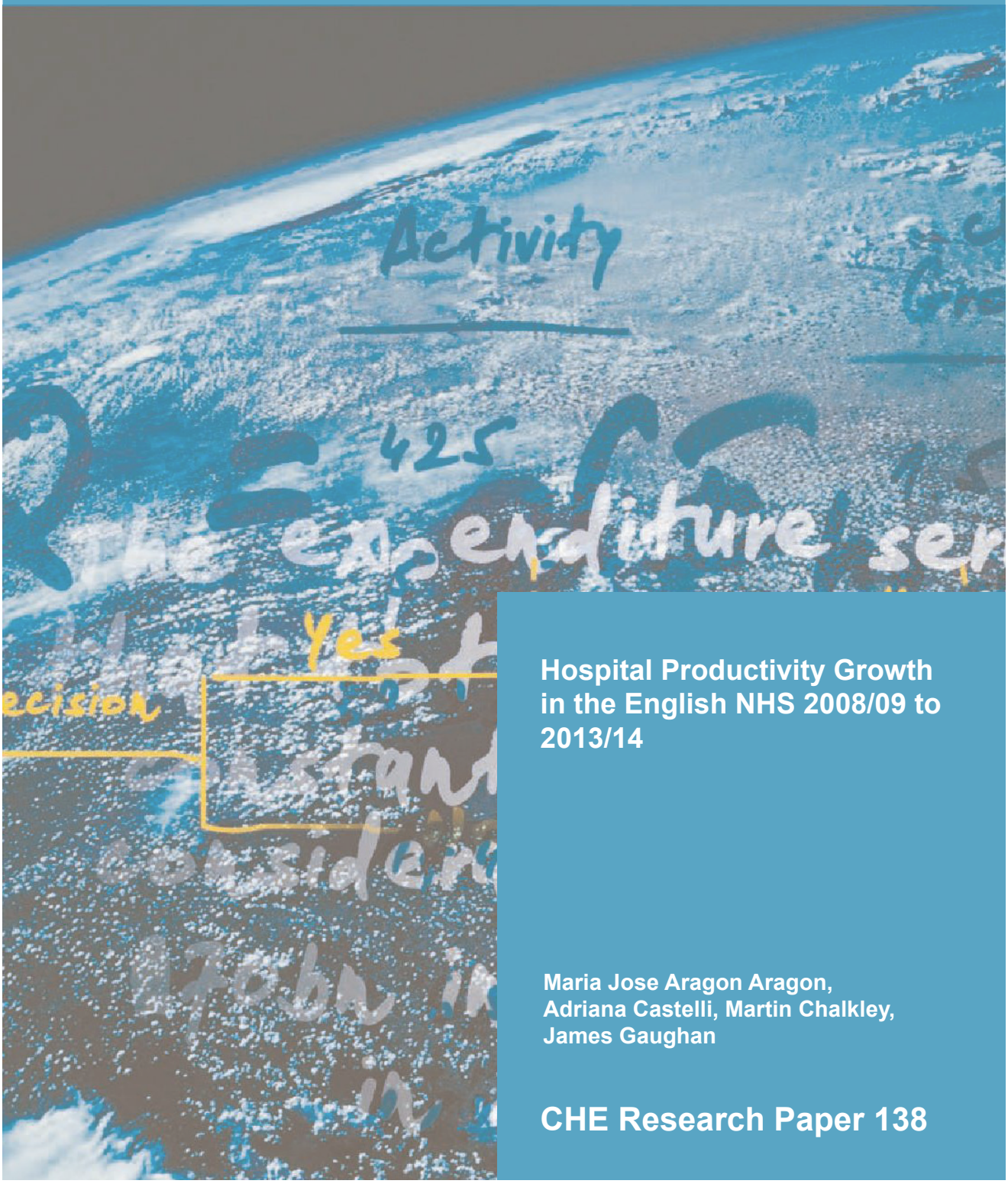

Hospital Productivity Growth in the English NHS 2008/09 to 2013/14

Maria Jose Aragon Aragon,
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CHE Research Paper 138

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Executive Summary

Context

This report is concerned with the extent to which NHS hospital Trusts make better use of resources over time by increasing the number of patients they treat and the services they deliver for the same or fewer inputs.

The ratio of all outputs to all inputs is termed Total Factor Productivity (TFP) and growth in TFP is vital to achieving patient care with increasingly limited resources.

Measures of TFP for the NHS as a whole are well-established but any aggregate measure may reflect a diversity of experience and performance across individual Trusts.

In this report we extend earlier studies to determine whether measures of TFP growth at the level of individual Trusts can establish consistently high performers - Trusts that habitually exhibit above average TFP growth.

This work is potentially important because it may establish a benchmark figure for high performance and thus enable setting realistic targets for efficiency savings, and identify Trusts that are exemplars of good performance so that others can learn from their practices and methods.

Meeting the challenges to measuring performance

Earlier work has established one challenge to using Trust level measures of TFP which is that such measures will be influenced by accounting practices and historic circumstances.

To address that challenge we focus on growth in TFP since by taking the difference in performance over two periods of time, any influences on TFP that are constant over time (like accounting practices or the historically high stock of capital and hence depreciation) are netted out.

A further challenge is that the NHS has undergone, and continues to undergo, structural changes so that the attribution of outputs and inputs (the components of TFP) to individual producing units such as Trusts changes over time.

Our work addresses this second challenge by considering multiple measures of productivity growth, each one considering only two adjacent years, that we term links.

A further challenge is that Trusts change in size and composition through a process of closures and mergers. Any mismatch in the timing of undertaking the obligations to purchase inputs and producing outputs risks being spuriously reflected in TFP.

To meet this challenge we restrict attention to Trusts that have not been subject to such changes over the period for which we measure their TFP growth.

Methods

We use established methods for aggregating inputs and outputs using Laspeyres volume indices. The components of outputs we use are comprehensive and include inpatient, outpatient, A&E, other therapies and diagnostic tests and numerous other services provided by hospitals.

We measure inputs directly as the number and type of individuals employed and utilise indirect measures (expenditures incurred) to capture capital and intermediate inputs.

Findings

Our key finding is that measured TFP growth at Trust level exhibits substantial - even extraordinary - volatility. A Trust that has high measured growth one year may have low or negative growth the next, followed again by high growth the next.

This volatility is manifest in simple descriptive statistics and in measures of persistence and it is a consequence of volatility in both of the components (inputs and outputs) of the TFP measure.

Real TFP growth is the consequence of improvements in the utilization and deployment of inputs and it is implausible that the changes in the ratios of aggregated inputs and outputs we observe are driven solely by real growth.

We hypothesise that our measured TFP growth is the combination of some underlying real changes and a number of potentially large nominal effects.

The nominal effects may be errors in the data, or artifacts of the data recording process, or consequences of changes in accounting conventions and practices or consequences of practices that cause differences in the timing of the recording of inputs and outputs.

We investigate one potential cause by restricting the set of inputs to directly measured labour and thereby avoiding a number of issues with the reporting of capital expenditure, but find that whilst the volatility of TFP growth is moderated it remains substantial.

Conclusions

We have adopted tried and tested methods for measuring aggregate productivity and we have accounted for previously identified challenges in translating these measures to individual hospital Trusts in a dynamic and changing NHS.

Nevertheless, we conclude that these methods do not produce credible measures of productivity growth for individual hospital Trusts.

Whatever is the underlying real growth in productivity of an individual Trust it appears to be masked or submerged by nominal factors that perturb the measurement of both inputs and outputs from year to year.

Restricting attention to labour inputs alone, reduces the exhibited volatility, but not to an extent that gives confidence in the measured TFP growth being an accurate reflection of real growth.

Our results therefore indicate that translating the apparatus of aggregate productivity measurement to individual Trusts is not sufficient and that there is a need to develop a new approach to measuring productivity growth at the hospital level.

1. Introduction

In the current economic climate, the need to assess National Health Service (NHS) Productivity is ever more important, both to account for how resources are used and to identify ways of achieving higher Productivity. In the last few years NHS hospital Trusts have been encouraged to introduce measures to cut down costs whilst at the same time increasing the number of patients treated. It is therefore all the more important for policy makers, hospital managers and other stakeholders to have ways of accurately assessing the productivity of single NHS hospital Trusts. Measuring variation in productivity growth across providers and over time allows 1) to identify Trusts with persistently strong performance, signalling the presence of good practice, and 2) to form expectations on future potential Trusts' productivity growth and health care costs' growth, if best practice is followed. Investigating exemplars of good practice might help identify which Trust characteristics (financial, managerial, medical practices, or a combination of these) promote good performance, and so identify lessons which can be shared with other Trusts to improve their own performance.

In this work we set out to assess the growth in Outputs, Inputs and Total Factor Productivity (TFP) of NHS hospital Trusts in England over the period 2008/09 - 2013/14. We do so by means of Laspeyres volume indices. Further, we investigate whether there is persistence over time in growth rates of the Productivity measure in Trusts. If Productivity is largely driven by internal management policies and culture within a Trust, we would expect Productivity growth in period t to be strongly correlated with Productivity in previous and following periods.

The period covered by this study has seen one of the greatest re-configurations of the English NHS in recent times. In 2010, the Coalition Government announced in the White Paper 'Equity and excellence: Liberating the NHS' (Department of Health 2010), that Primary Care Trusts (PCTs) - administrative bodies responsible for commissioning primary, community and secondary care from health care providers in England, as well as for delivering health care services (mostly community care services) to patients - were to be dismantled, with a proposal to move the purchasing of health care goods and services to groups of GPs (now known as Clinical Commissioning Groups or CCGs). PCTs were formally abolished in the Health and Social Care Act 2012, with the final date of operation set for the 31st March 2013. During the transition period, some PCTs continued to be operative performing some or all their functions, whilst other transferred all their activity to Acute and/or Community Trusts. Moreover, members of staff and other assets (buildings, land, intermediate goods) may have also changed employer and ownership at different times during the transition period. Therefore, it is highly likely that the re-configuration of the NHS may have caused issues of consistency and reliability of hospital data collected and reported by hospital Trusts affected by this change both in terms of activity and staff numbers and inputs expenditure.

The structure of the report is as follows. Details on how we calculate the Laspeyres Output, Input and Productivity growth indices are outlined in Section 2, together with a description of the analyses performed to look for trends and to identify potential patterns of growth over time in the Productivity measure. NHS Output and Input data are described in Section 3, with results reported in Section 4. Section 5 includes a discussion of our findings as well as concluding remarks.

2. Methods

Total Factor Productivity (TFP) growth of each NHS hospital Trust (hereafter referred to simply as Trusts) is calculated combining data on the array of Outputs produced and Inputs used. In particular, we construct an Output growth index (X) and Input growth index (Z), with Total Factor Productivity growth $\triangle TFP$, calculated as the ratio of the growth of the amount of Outputs produced to the amount of all Inputs used to produce that Output (Bojke et al. 2012):

$$\triangle TFP = [X/Z] - 1 \tag{1}$$

To estimate TFP it is necessary to define and measure both Output and Input indices for each Trust. Growth in both NHS Outputs and Inputs can be calculated directly or indirectly (OECD 2001). A *direct* volume measure aggregates information about the volume of each type of Output (Input) produced using their prices as weights; whilst an *indirect* measure usually relies on other type of information, e.g. expenditure.

Following Dawson et al. (2005),[1] we construct a set of paired year-on-year Output, Input and Productivity indices at Trust level. In order to account for changes in the availability and sources of data used, we adopt the imputation method developed by Castelli et al. (2011).

Trust Outputs consists of all healthcare goods and services delivered to NHS patients in one of the diverse care settings.[2] As NHS goods and services are delivered free at the point of use, the index uses unit costs as weights, instead of prices, to aggregate the different types of NHS Output produced, which is in line with recommendations made in the National Accounting literature (Atkinson 2005; Eurostat 2001).

Inputs into the health care system consist of Labour, Intermediate goods and services, and Capital. As comprehensive volume data on all factors of production are not available for all inputs, we employ a *mixed* method in determining the growth in NHS Inputs. The mixed method combines a direct volume measure of NHS Labour Input (excluding Agency staff) and an indirect measure, relying on expenditure data, for Agency staff, Intermediate goods and services and Capital. This is in line with recommendations to use, wherever possible, direct volume measures in the national accounts (World Bank 1993; Eurostat 2001). Given that expenditure is driven by both the volume and price of Inputs, and being interested in determining change in the volume of Inputs used in two adjacent years, we isolate the change in volume from the change in prices. We do this by converting *nominal* expenditure into *constant* expenditure using a price deflator for each Input.

The details of how the growth rates for the Outputs, Inputs and Productivity measures are calculated can be found in the following sub-sections.

[1] Dawson et al. (2005) have developed an NHS Output index that was utilised in the Atkinson Review (Atkinson 2005) and is also used in the the UK National Accounts (Office for National Statistics 2009; Office for National Statistics 2012).

[2] A full list of settings can be found in Section 3.1, and details of how many Trusts report activity in each of them in Appendix A.

2.1. Outputs

Hospital Output comprises of all healthcare goods and services produced and delivered by Trusts. Since information on physical quantities (volume) and unit cost (prices) for all healthcare goods and services is available, a direct volume growth index can be calculated as (Bojke et al. 2015):

$$X_{h(0,t)} = \frac{\sum_{j=1}^{J} x_{hjt} c_{j0}}{\sum_{j=1}^{J} x_{hj0} c_{j0}} \tag{2}$$

where x_{jht} represents the number of patients or healthcare goods/services of Output type j in Trust h; c_{jt} indicates the unit cost of healthcare Output j, and the time period is indicated by either 0 (base year) or t (current year).

Healthcare Outputs are produced across a range of healthcare settings, details of which are provided in Section 3.1. Patients differ vastly in terms both of healthcare needs and requirements. Usually this is addressed by classifying patients into homogeneous groups, such as Healthcare Resource Groups (HRGs). Moreover, these different healthcare Outputs need to be aggregated into one single index, as shown in Equation 2, and prices are normally used to this end. However, healthcare goods and services in England are delivered free of charge at the point of use, which means that prices for each Output j are not available. We therefore use unit costs data as weights, a common practice when measuring non-market Outputs in the national accounts, with the caveat that costs reflect producer rather than consumer valuations of Outputs (Eurostat 2001).

2.2. Inputs

'There are three main categories of Inputs: Labour, Intermediate goods and services and Capital. Labour Input comprises of all types of staff (medical and non-medical) employed by Trusts, including any bank and Agency staff. Intermediate Inputs include all non-Labour Inputs, such as utilities, medications and drugs, disposable supplies and equipment. Capital is usually defined as any non-Labour Input with an asset life of more than a year. Information on the physical quantities and prices of Labour Inputs are available, allowing for the calculation of a direct volume growth measure; volume and price information for Intermediate goods and services and Capital Inputs are not available and we use indirect measures of Input growth, based on expenditure data on these categories of Inputs, as suggested in the literature (Eurostat 2001; OECD 2001). In this work, we use a mixed method, in which we combine the direct growth volume measure for NHS Labour input with the indirect volume growth measure for the remaining factors of production, as in Street and Ward (2009).

2.2.1. Direct method

When volume and price information for any Input are available, it is possible to calculate a Laspeyres volume index for the growth in these Inputs. Equation 3 depicts the case for NHS Labour growth for each Trust (h) for any two years using the volume (z) for each type of Labour Input (n, with $n = 1, ..., N$) of the two years and their respective price (ω), in this case salary, from the base year:

$$Z^{DL}_{h(0,t)} = \frac{\sum_{n=1}^{N} z_{hnt} \omega_{n0}}{\sum_{n=1}^{N} z_{hn0} \omega_{n0}} \tag{3}$$

2.2.2. Indirect method

The indirect method uses expenditure data. Growth in healthcare expenditure is driven by both changes in volume and prices of Inputs. As we are interested in determining the change in the volume of Inputs used in any two adjacent years, we isolate the change in the volumes of Inputs from the change in their respective prices. Thus, we convert *nominal* expenditure into *constant* expenditure using appropriate price deflators π_{Et} for each Input expenditure (Street and Ward 2009).

Denoting NHS staff Labour expenditure as L and Agency / bank staff Labour expenditure as A, Intermediate goods and services expenditure as M and Capital expenditure as K, and using specific deflators for each factor of production, the indirect Input growth index can be written as:

$$Z^{Ind}_{h(0,t)} = \frac{Exp_{ht}\pi_{Et}}{Exp_{h0}} = \frac{L_{ht}\pi_{Lt} + A_{ht}\pi_{At} + M_{ht}\pi_{Mt} + K_{ht}\pi_{Kt}}{L_{h0} + A_{h0} + M_{h0} + K_{h0}} \tag{4}$$

2.2.3. Mixed method

Substituting the direct Labour growth index from Equation 3 for the Labour expenditure (L) (NHS staff only) component of the indirect Input growth index, we can specify the mixed Input growth index as:

$$Z^{Mix}_{h(0,t)} = Z^{DL}_{h(0,t)} * propL + Z^{Ind}_{h(0,t)} * (1 - propL) \tag{5}$$

where $propL = L/TE$ denotes the proportion of NHS staff Labour (L) expenditure with the exclusion of expenditure on Agency staff (A) in total expenditure (TE).

One can use the proportion of Labour expenditure of the earliest year (0), the latest year (t) or the average between the two.

2.3. Productivity

Using the growth rates calculated for Outputs (X) and Inputs (Z), we can calculate the Productivity growth rate for any two adjacent years and for each Trust as:

$$\triangle TFP_{h(0,t)} = \frac{X_{h(0,t)}}{Z^{Mix}_{h(0,t)}} - 1 \tag{6}$$

Using the year-on-year Productivity growth rates, we can assess the Productivity growth over longer periods of time for each Trust by means of a chained index:

$$\prod_{t=0}^{T}\left(\frac{X_{h(0,t)}}{Z^{Mix}_{h(0,t)}} - 1\right) = \left(\frac{X_{h(0,t)}}{Z^{Mix}_{h(0,t)}} - 1\right) \times \left(\frac{X_{h(t,t+1)}}{Z^{Mix}_{h(t,t+1)}} - 1\right) \times ... \times \left(\frac{X_{h(T-1,T)}}{Z^{Mix}_{h(T-1,T)}} - 1\right) \tag{7}$$

where each link of the chain is represented by Equation 6 for the relevant two consecutive years. From here onwards, we will use the term '*link*' to refer to any two adjacent years over which we calculate growth.

2.4. Analysing trends in hospital Trusts' Productivity growth rates

If Trust Productivity is largely driven by management policies and culture within a Trust, we would expect these characteristics to persist over time with Productivity growth in one period being strongly related to growth in previous and following periods. Such dependence would be reflected in a stable ordering of the growth of the Productivity measure over time. We start by counting the number of times Trusts are in different quartiles. If relative growth rates are persistent, we would observe most Trusts remaining in the same quartile of the ordered growth measure most of the time.

Second, we consider how likely Trusts are to change quartile from one link to the next. Since there are four quartiles and the probabilities must add up to one, there are three probabilities that define the move from one quartile to any of the four in the following link. A Trust that is in Q1 in one link, can stay in Q1 in the following link (with probability p_{11}), or move to Q2 (with probability p_{12}), Q3 (with probability p_{13}) or Q4 (with probability $p_{14} = 1 - p_{11} - p_{12} - p_{13}$). A Trust in Q2 can move to Q1 (with probability p_{21}), stay in Q2 (with probability p_{22}), move to Q3 (with probability p_{23}) or Q4 (with probability $p_{24} = 1 - p_{21} - p_{22} - p_{23}$). Similarly for Q3 and Q4. Therefore the transition probabilities for movements between quartiles can be calculated using the observed movements between adjacent links observed in the data (using STATA 13 (StataCorp. 2013) command $\mathrm{xttrans}$).

Finally, we calculate the overall growth rates of the Productivity measure for all the Trusts that remain unchanged, i.e. are not affected by mergers or closures, in the period 2008/09 - 2013/14 by means of a chain index (see Equation 7, Section 2.3). We then classify the Trusts' overall growth rates into quartiles and count the number of times those Trusts were in different quartiles in the different links to see how overall growth relates to growth in each of the five links (2008/09-2009/10, 2009/10-2010/11, etc.).

We also describe and analyse the growth of Outputs and Inputs. Bojke et al. (2012) in their analysis of national productivity in the English NHS suggested and found evidence of a temporal lag between the period when changes in Inputs occurred and the period in which adjustments in the Outputs were recorded. In particular, Bojke et al. (2012) found that an increase (decrease) in the growth of Inputs usually preceded an increase (decrease) in the growth of Outputs. We look for a similar pattern in the growth of the Inputs and Outputs measures at Trust level, across all links, not just for the one year lag.

3. Data

3.1. Outputs

Two datasets are used to calculate the volume and prices of the services provided by each Trust: Hospital Episode Statistics (HES) and Reference Costs (RC).

The Hospital Episode Statistics database records information about every patient treated in hospital (episode of care), amounting to around 18m episodes per year. Activity in HES is aggregated using HRGs, which form the Output categories for the hospital inpatient setting. Each *episode*[3] is mapped to a cost from the RC database. The defining characteristics of the mapping process are the HRG of the episode and whether the episode is elective or non-elective. If an episode does not have a cost, then the average cost of elective or non-elective HRGs is used.

Our unit of inpatient activity is a *spell*,[4] which can be made up of multiple episodes if a patient is transferred from the care of one consultant to another. The cost of each spell is the sum of the costs allocated to each episode in that spell. The HRG code of each spell is allocated based on the most expensive HRG within each spell. If there are multiple HRGs that are jointly the most expensive, the first of those HRGs to occur in the spell is used. Finally, a spell constitutes an elective inpatient Output if the first episode in the spell is elective, and non-elective otherwise.

Volumes of activity and costs for healthcare goods and services produced and delivered in non-inpatient settings are taken from the Reference Costs returns. These settings are: Outpatients, A&E, Chemo/Radiotherapy & High Cost Drugs, Community Care, Community Mental Health, Diagnostic Tests, Radiology, Rehabilitation, Renal Dialysis, Specialist Services and Other.[5]

For all of these settings, a healthcare Output is defined by three identifying characteristics, namely department code, currency code and service code. Each combination of these identifiers is treated as a single Output and the cost of this Output is given by the national average unit cost.

3.2. Inputs

There are two main sources of data in terms of Inputs, the Electronic Staff Record (ESR) and the Trusts' financial accounts.

The Electronic Staff Record (ESR), available through the NHS iView workforce database (`https://iview.ic.nhs.uk/`), provides information regarding the number of Full Time Equivalents (FTEs) for over 480 different types of NHS staff,[6] with national earnings data extracted from the NHS Payroll and Human Resources system. These data are compiled for single financial years.[7]

[3] Single observation representing continuous care of a patient by the same consultant.
[4] Continuous care of a patient in the same Trust.
[5] Not all Trusts have activity in each of these settings in each financial year. For details see Appendix A.
[6] The number of different types of NHS staff has increased over the time period considered. The figure above refers to the most recent financial years.
[7] There are two Trusts, RFS and RP6, that started to submit data to ESR in 2011/12. In the years when they do not submit data to ESR, we use an indirect method to calculate growth in the Labour component of Inputs, i.e. we use expenditure data and the same deflator used for Agency.

Expenditure data for non-Foundation Trusts are derived from the Trusts' Financial Returns (TFRs) up to 2011/12 and from the Financial Monitoring and Accounts (FMAs) from 2012/13 onwards. Expenditure data for Foundation Trusts are derived from the Consolidated NHS Financial Trust Accounts for all financial years. Expenditure on Agency staff are reported as a separate expenditure item in the TFRs up until 2011/12. In subsequent years, FMAs report only one Labour expenditure entry. Thus, we use Agency expenditure data provided by the Department of Health (DH) to identify this item of Labour expenditure.

Additionally, we use two deflators from the Hospital and Community Health Services (HCHS) Pay and Price Series to deflate expenditure on all Inputs, namely the Pay Cost Index (PCI) to deflate Agency staff expenditure and the Health Service Cost Index (HSCI) to deflate Intermediate and Capital expenditures.

Our study covers six financial years from 2008/09 to 2013/14. We therefore present results for five pairs of consecutive years (referred to as *links*), see Figure 1.

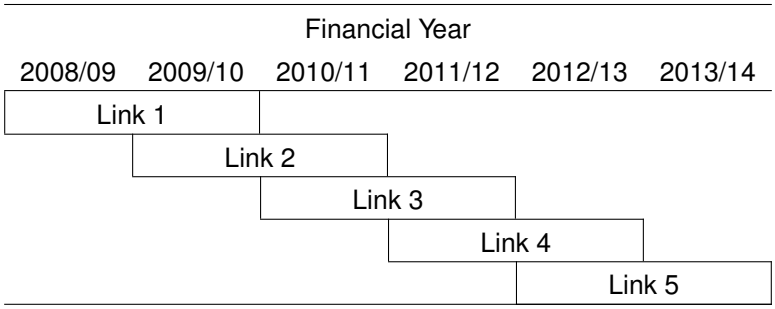

Figure 1: Financial Years and Links

3.3. Data Quality

As mentioned previously, during the period covered by this study, the English NHS changed its structure. At the start of the period, Primary Care Trusts (PCTs) commissioned care from Acute Hospital Trusts but also provided some care, mostly in the community care setting, directly. By the end of the period, PCTs had been wound up, with the commissioning responsibilities of PCTs transferred to newly created Clinical Commissioning Groups (CCGs) and the directly provided activity to a combination of existing Acute Trusts and newly formed Community Trusts. This process occurred across the NHS but not instantaneously or simultaneously for all providers. It is therefore highly likely that the re-configuration has caused issues of consistency and reliability of the data over time, both for activity (Outputs) and staff numbers and expenditure (Inputs) reported by Trusts affected by the change.

To check the consistency of the data over time, we compare Outputs and Inputs levels for the two financial years of each link (both expressed in Pounds of the same year) using scatter plots.

3.4. Temporal Correlations of *Unchanged Trusts*

Unchanged Trusts are those that did not experience any organisational change during the period of analysis. Specifically, Trusts that existed in the financial year 2008/09 and had not merged or closed by the end of the financial year 2013/14.[8]

In order to investigate whether the levels of Outputs and Inputs of each Trust are similar over time we make use of scatterplots. The temporal correlations are shown in the following Figures, with the value of Outputs (Inputs) in a financial year on the horizontal axes and the value of Outputs (Inputs) in the following year reported on the vertical axes (both expressed in Pounds of the same year). Figure 2 shows the inter-temporal correlations for Outputs and Figure 3 those for Inputs.

Both of these plots indicate a very high degree of correlation between levels of Outputs and Inputs in each pair of years. These plots also suggest some variation in the nature of correlations for Outputs vs Inputs and over time. Inter-temporal correlation for Outputs is quite consistent over time.

There is greater variation in the inter-temporal correlation for Inputs, which can be noted in particular with regard to the links 2009/10-2010/11 and 2010/11-2011/12. For these two links there are more outlier Trusts compared to the line of best fit than for other links. The greater variation might be due to the structural changes occurring at that time in the NHS in England. In particular, for the financial year 2011/12, we find that some Trusts report increases in the number of NHS Staff employed and in Capital investments. Some of these increases may be due to the gradual take-over of community care activity previously delivered by the now dismantled PCTs.

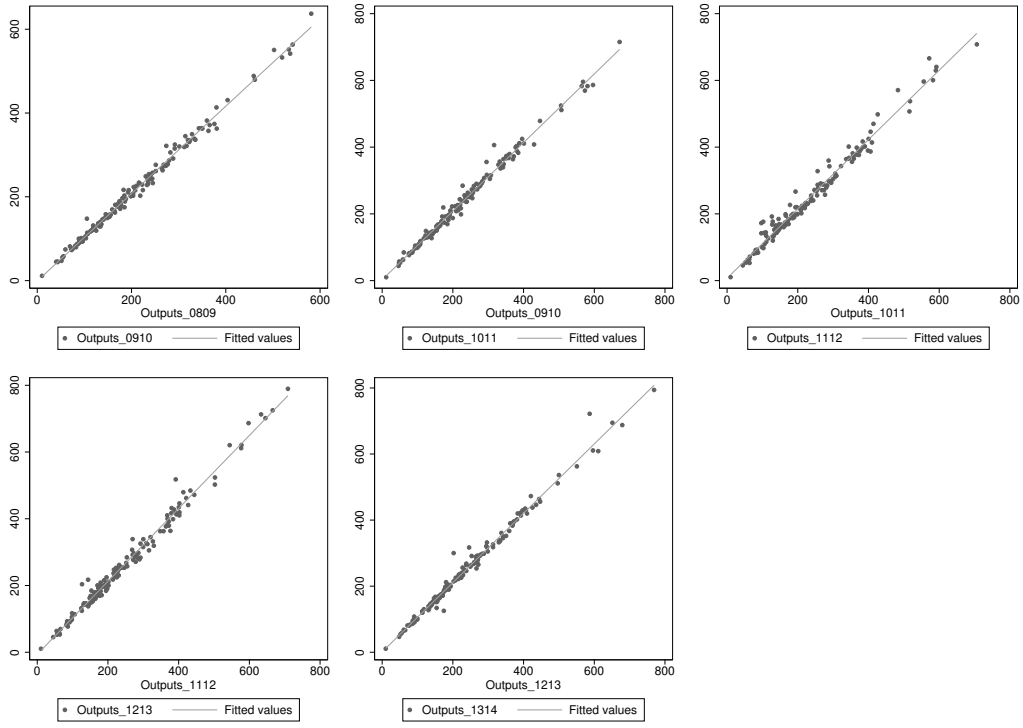

Figure 2: Outputs

[8] For a full list of Trusts mergers and closures see Appendix C.

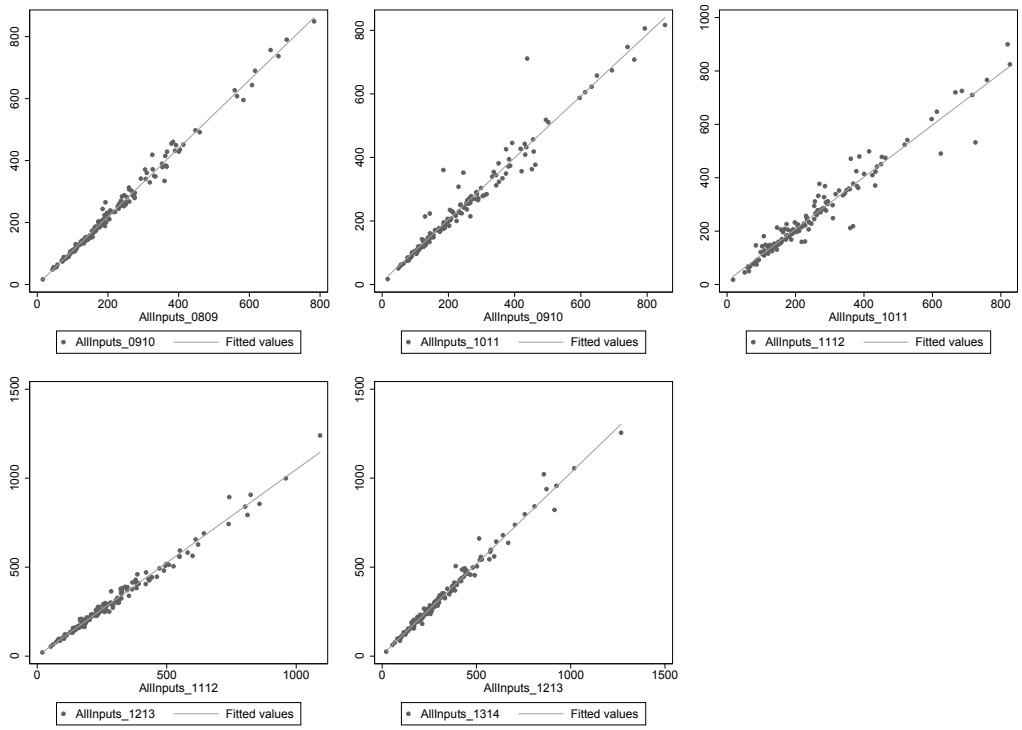

Figure 3: Inputs

4. Results

We first present descriptive statistics for the growth of the Outputs, Inputs and Productivity measures using all Trusts in each link (Section 4.1). These measures are calculated following the methodology described in Section 2 and using the data described in Section 3.

All other results focus on the subset of Trusts that remain unchanged over the period of analysis, i.e. Trusts that existed in the financial year 2008/09 and have not merged or closed by the end of the financial year 2013/14.[9] We refer to them as '*unchanged Trusts*' (Section 4.2). There are 151 *unchanged Trusts* over the six year period covered in this work.

For the *unchanged Trusts* we first provide descriptive statistics for the growth of the Outputs, Inputs and Productivity measures (Section 4.2.1), we then analyse whether the growth of the Inputs measure precedes that of the Outputs measure (Section 4.2.2).

An in-depth analysis of the growth of Productivity measure for the *unchanged Trusts* is provided in Section 4.2.3. First, we determine how persistent the relative growth of the Trusts' Productivity measure is by counting the number of times each Trust is in a given quartile of growth (Section 4.2.3.1). Second, we calculate the transition probabilities of moving from one growth quartile of the Productivity measure in link t to the same or a different quartile in link $t+1$ (Section 4.2.3.2). Further, we calculate our measure of productivity growth (using a chain index, Equation 7) over the whole period of time covered in our analysis (hereafter referred to as *'overall growth'*). We provide some descriptive analyses of this measure and compare the Trusts' positioning in a quartile using their *overall growth* rate with their positioning in a quartile using the growth rate of their respective Productivity measures in each link (Section 4.2.3.3). Because the presence of Trusts with extreme growth may change the thresholds of the quartiles in each link, as a sensitivity check, we repeat the above analyses for an alternative grouping of the Trusts using absolute values, with results provided in Appendix F.

4.1. All Trusts

Descriptive statistics of the Trusts' growth rates, for each link, are reported in Tables 1, 2 and 3 for the Outputs, Inputs, and Productivity measures respectively. Trusts showing 'extreme' growth, defined as growth that is more than 3 standard deviations (s.d.) away from the mean, can be identified by using the information provided in the last two rows of the Tables. For example, using the information contained in Table 1, in L1 Trusts with extreme growth are those with an Output measure growth rate below -12.89% (3.91 - 3 $\times$ 5.60) or above 20.71% (3.91 + 3 $\times$ 5.60).

Note that in 2013/14 one Trust closed in the middle of the financial year (30th September) and its activity was taken over by two Acute Trusts (which are included in our analyses) and one Community Trust (our study focuses on Acute Trusts, and therefore does not include Community Trusts). Details of the Trusts involved can be found in Appendix C. As a consequence, the Trust that closed in the middle of the financial year 2013/14 shows a large reduction in its activity (outputs) and the inputs required for producing this activity when compared to the previous year's (financial year 2012/13) activity and inputs. This can be seen in link L5. This is due to the fact that once the Trust ceased to exist, it stopped recording activity and inputs used. At the same time, Trusts that have taken over the activity are likely to show a

[9] For a full list of Trusts mergers and closures see Appendix C.

higher increase in the volume of activity for the financial year 2013/14 compared to the previous year than would be normally expected had the take-over not taken place. These Trusts (and all others involved in mergers, see Appendix C) are removed from the analysis from Section 4.2 onwards, where we focus on Trusts that existed from the start of our time series and that have not been involved in mergers or closures by the end of our study period.

Table 1: Descriptive Statistics for the Growth Rates of the Outputs Measure. All Trusts

	L1	L2	L3	L4	L5
Number of Trusts	166	166	164	160	161
Minimum	-8.16	-11.78	-16.73	-16.80	-88.18
25th Percentile	1.01	0.66	1.66	1.13	2.12
Median	3.58	3.69	4.62	5.93	5.07
75th Percentile	6.43	6.29	9.96	10.37	7.29
Maximum	40.28	46.01	78.05	60.87	108.14
Mean	3.91	4.48	7.94	6.40	5.43
Standard Deviation (s.d.)	5.60	7.03	12.16	8.79	12.83

In total (considering all links) we find fifteen Trusts with a growth rate of their Outputs measure more than three s.d. away from the mean growth rate for that year. With the exception of one, all of the outliers are positive outliers, that is have unusually high growth of their Outputs measure. In links L1 and L4, there are two Trusts in each link with extreme growth in their Outputs measure. We find that this extreme growth can be reconciled back to high growth in the 'Chemotherapy/Radiotherapy and High Cost Drugs' and 'Inpatient' settings. In links L2 and L3, the extreme growth is mostly driven by the setting 'Community Care', which coincides with the closure of the provider arms of Primary Care Trusts (PCTs), whose activity started to be transferred either to newly formed Community Trusts or to existing Acute Trusts from 2010/11. The unusually high mean value of output growth in L3 might also reflect the reconfiguration process. A small number of extreme values can have a large effect on this measure. Further, we note that the transfer of activity from PCTs to Acute Trusts might also cause large increases in the growth of Trusts' Output measure, but not so large as to be identified as 'extreme' as defined here. Finally, in link L5, for two of the three Trusts, extreme growth can be explained by either their closure or take-over by another Trust.

Table 2: Descriptive Statistics for the Growth Rates of the Inputs Measure. All Trusts

	L1	L2	L3	L4	L5
Number of Trusts	166	166	164	160	161
Minimum	-5.98	-18.70	-31.71	-9.01	-30.18
25th Percentile	5.56	-2.89	-0.53	0.52	1.79
Median	8.64	0.69	2.40	4.36	4.90
75th Percentile	11.99	3.60	7.64	9.71	7.71
Maximum	43.71	112.42	73.60	27.73	54.76
Mean	9.78	2.57	5.11	5.47	5.32
Standard Deviation (s.d.)	7.15	14.37	14.12	7.00	7.96

For the Inputs measure, we find that in three links (L1 to L3), four Trusts have extreme growth, one link (L5) has three Trusts with extreme growth, and one link (L4) has two Trusts with extreme growth. Changes in Capital (the most common cause of extreme growth in the Inputs measure) are due to Trusts reporting investments in new buildings or changes in funding such as Private Funding Initiatives. All of these require adjustments to the financial accounts. However, in one of the links (L3) the extreme growth appears to be driven also by changes in the Labour component of Inputs, coinciding with a period of re-organisation of the English NHS with Primary Care Trusts (PCTs) gradually disappearing as NHS organisations and part of their staff being transferred to NHS hospital Trusts. Finally, in L5 two of the three Trusts involved in a closure and re-distribution of activity are among those with extreme growth in the Inputs measure.

Details regarding how much each type of Output (Input) contributes to overall growth in the Outputs (Inputs) measure for each link and how much variation there is in their relative size across Trusts can be found in Appendix B.

Table 3: Descriptive Statistics for the Growth Rates of the Productivity Measure. All Trusts

	L1	L2	L3	L4	L5
Number of Trusts	166	166	164	160	161
Minimum	-27.39	-51.41	-24.05	-27.50	-83.07
25th Percentile	-8.76	-0.79	-1.21	-5.44	-3.62
Median	-5.22	3.93	2.56	1.14	-0.16
75th Percentile	-1.16	7.91	6.20	7.20	3.76
Maximum	30.81	53.95	66.32	44.52	43.95
Mean	-5.02	3.16	3.51	1.26	0.15
Standard Deviation (s.d.)	7.17	11.71	11.03	9.86	10.92

The extreme growth rates in the Outputs and Inputs measures recorded for some Trusts over the five links will have repercussions on the respective growth of the Trust's Productivity measure, by artificially inflating/deflating it. As mentioned before, in some cases the extreme changes can be identified as being driven by one particular type of output and/or input, but this does not rule out that other Trusts will also have extreme growth in their Productivity measure where the source of the extreme changes is less traceable or obvious. We explore this issue by removing the Trusts we have identified as having extreme growth in their measures of Outputs and/or Inputs in part of the analysis in Section 4.2.3.2.

4.2. Unchanged Trusts

Unchanged Trusts are those that did not undergo any organisational change during the period of analysis. Specifically, Trusts that existed in the financial year 2008/09 and have not merged or closed by the end of the financial year 2013/14.[10]

[10] For a full list of Trusts mergers and closures see Appendix C.

4.2.1. Descriptive Statistics

Descriptive statistics of the growth rates calculated in each link for the *unchanged Trusts* are reported in Tables 4, 5 and 6 for the Outputs, Inputs, and Productivity measures respectively. For some links, e.g. L5, these tables show smaller interquartile ranges and differences between minimum and maximum than Tables 1, 2 and 3. This is expected as they do not include Trusts that underwent structural changes that might translate into big changes in Outputs and Inputs and/or how these were recorded. However, system wide reconfiguration changes such as the transfer of some PCT activity to Acute Trusts remains, as reflected in the higher mean values of Output growth in L3 and L4.

Table 4: Descriptive Statistics for the Growth Rates of the Outputs Measure. Unchanged Trusts

	L1	L2	L3	L4	L5
Number of Unchanged Trusts	151	151	151	151	151
Min	-8.16	-11.78	-16.73	-16.80	-28.15
25th Percentile	0.98	0.56	1.63	0.73	2.22
Median	3.54	3.55	4.73	5.88	5.07
75th Percentile	6.41	6.18	9.92	9.79	7.35
Max	40.28	38.12	78.05	60.87	48.37
Mean	3.96	4.15	8.09	6.19	5.33
Standard Deviation	5.67	6.38	12.51	8.88	6.53

Table 5: Descriptive Statistics for the Growth Rates of the Inputs Measure. Unchanged Trusts

	L1	L2	L3	L4	L5
Number of Unchanged Trusts	151	151	151	151	151
Min	-5.02	-17.46	-31.71	-9.01	-12.05
25th Percentile	5.44	-2.11	-0.68	0.51	1.90
Median	8.24	1.04	2.13	4.32	4.91
75th Percentile	11.68	4.59	7.37	9.84	7.76
Max	38.55	112.42	73.60	27.73	30.51
Mean	9.21	3.27	4.92	5.47	5.24
Standard Deviation	5.95	14.67	14.20	7.06	6.33

4.2.2. Lag Growth between Inputs and Outputs Measures

Bojke et al. (2012) found that at the national level positive (negative) growth in Inputs in period t is followed by positive (negative) growth in Outputs in period $t+1$. We look for the same pattern at Trust level. To do this we calculate the correlation between growth in the Inputs measure in one link and growth in the Outputs measure in the same and following links. Correlations give a general indication of whether increases (decreases) in the growth rate of the Inputs measure are contemporaneous with or are followed by increases (decreases) in growth rate of the Outputs measure.

Table 7 shows the correlations between the growth in the Inputs measure (rows) and the growth in the Outputs measure (columns). For contemporaneous growth (main diagonal of the table), we see that the

Table 6: Descriptive Statistics for the Growth Rates of the Productivity Measure. Unchanged Trusts

	L1	L2	L3	L4	L5
Number of Unchanged Trusts	151	151	151	151	151
Min	-25.24	-51.41	-24.05	-27.50	-25.70
25th Percentile	-8.20	-1.08	-1.00	-5.50	-3.76
Median	-5.15	3.59	2.63	1.09	-0.16
75th Percentile	-1.17	7.48	6.47	6.91	3.64
Max	30.81	29.45	66.32	44.52	43.95
Mean	-4.57	2.12	3.84	1.05	0.42
Standard Deviation	6.69	10.84	11.20	9.91	8.51

correlation between the growth of Inputs and Outputs measures vary between 3% and 72% (note that 72% is much higher than any other correlation in the main diagonal, the other four are below 13%). For growth lagged by one link (cells next to the diagonal) the correlations vary between -6 % and +7%, and for longer lags (further to the right of the diagonal) they vary between -13% and +12%. The table offers no evidence of growth in the Inputs measure preceding that of the Outputs measure as off-diagonal correlations are small.

Table 7: Correlation between Growth in the Inputs and Outputs Measures

		Growth in Outputs				
		L1	L2	L3	L4	L5
Growth in Inputs	L1	0.1275	0.0659	-0.1316	-0.0046	0.1181
	L2		0.0825	0.0391	0.0975	0.0069
	L3			0.7242	-0.0594	0.0582
	L4				0.1013	0.0679
	L5					0.0290

4.2.3. Growth in hospital Trust's Productivity Measure

In this section we first determine how persistent the relative growth of the Productivity measure is by counting the number of times each *unchanged* Trust is in a given quartile of growth (Section 4.2.3.1). Second, we calculate the transition probabilities of moving from one quartile of growth in Productivity measure in link t to the same or a different quartile in link $t+1$ (Section 4.2.3.2). Lastly, we calculate the growth rate of the Productivity measure over the whole period of analysis (referred to as *'overall growth'*) and compare the Trusts' positioning in a quartile using their overall growth rate with their positioning in a quartile using the growth rates of Productivity measure in each link (Section 4.2.3.3).

Quartiles are defined by the minimum, 25th percentile, median, 75th percentile and maximum as reported in Table 6, with Q1 being the quartile between the minimum and the 25th percentile and Q4 the quartile between the 75th percentile and the maximum.

Changes in how Capital is measured and recorded in Financial accounts may artificially impact on the growth of the Inputs measure and thus the Productivity measure, by introducing unexplained and

irreconcilable noise (Section 4.1). Therefore, as a sensitivity analysis, we limit the Inputs to NHS Labour, defined as direct Labour and Agency expenditure, and produce a growth series for the growth in the Labour Productivity measure. Descriptive statistics and selected results for this series, for *unchanged Trusts* only, are reported in Appendix H.

4.2.3.1 Persistence Over Time in the Relative Position of a Trust based on its Productivity Measure

Table 8 shows how many times Trusts are in the same quartile. Since the analysis considers five links (08/09-09/10, 09/10-10/11, ..., 12/13-13/14), a Trust can at most be in the same quartile five times. Rows represent the growth quartiles for the growth in the Productivity measure and the columns the number of links; so, if growth is persistent, we would observe a large number of Trusts in the same link three or more times, that is a large number of Trusts in the last three columns.

Table 8: Persistence Trust Rank Quartile Over Time

	Number of Links				
	1	2	3	4	5
Lowest Growth - Q1	67	38	13	2	0
Q2	56	38	15	2	0
Q3	53	44	15	1	0
Highest Growth - Q4	64	49	8	1	0

There are no Trusts that remain in the highest growth quartile (Q4) of the Productivity measure throughout the whole time period covered by our study. That is, no Trust is among those growing faster in all five links. This finding suggests a lack of persistence in the relative positioning of Trusts' growth.

4.2.3.2 Transition Probabilities

Table 9 shows the probabilities, as percentages, of moving between quartiles of the Productivity growth measure for the unchanged Trusts. Rows reflect the initial (link t) quartile, and the columns reflect the final (link $t+1$) quartile.[11,12] The first row of Table 9 shows that 21% of Trusts that had the lowest values of growth in their Productivity measure (Q1) in one link are also among those with the lowest growth (Q1) in the following link; 14% of Trusts have a growth rate lower than the median growth (Q2) in the following link; 25% of Trusts have a growth rate higher than the median (Q3) in the following link; and 40% of Trusts are among those with the highest growth (Q4) in the following link.

Further, we consider whether the probability of remaining in the same growth quartile depends on the Trusts' initial position. In particular, we are interested in whether Trusts with measured Productivity growth in either Q1 or Q4 move more frequently to a central quartile (Q2 or Q3) in a subsequent period rather than remaining in an extreme quartile (Q1 or Q4). This type of pattern is generally referred to in the literature as regression to the mean.

[11] For an alternative grouping based on absolute levels rather than relative position of the growth of Productivity measure , see Appendix F.

[12] The number of Trusts that remain in the same or change Productivity growth measure quartile from one link to the next, considering all Trusts common to both links, can be found in Appendix D.

Table 9: Transition Probabilities

		Quartile in link $t+1$			
		Q1	Q2	Q3	Q4
Quartile in link t	Lowest Growth - Q1	21.05	14.47	25.00	39.48
	Q2	24.32	29.05	26.35	20.28
	Q3	23.03	25.66	26.32	24.99
	Highest Growth - Q4	32.24	28.95	23.03	15.78

Our results show that the Q1-Q1 ($p_{11} = 21.05$) and Q4-Q4 ($p_{44} = 15.78$) probabilities are smaller than Q2-Q2 ($p_{22} = 29.05$) and Q3-Q3 ($p_{33} = 26.32$), which indicates that being in the extremes in two consecutive links is less likely than being in 'the middle' for two consecutive links. However, the most likely quartile to be in following an extreme (Q1 or Q4) is the opposite extreme: the probability of moving from Q1 to Q4 is 39.48% and the probability of moving from Q4 to Q1 is 32.24%.

Even when we exclude Trusts with 'extreme growth'[13] in either the Outputs or the Inputs measure, we find similar transition probabilities.[14] This suggests that the pattern of change in the growth of Trusts' Productivity measures follow a random draw more closely than being persistent over time. A stronger tendency to move from one extreme to another might also be due to Trust level changes in how data is recorded. See Table 10.

Table 10: Transition Probabilities. Excluding Trusts with Extreme Growth in Outputs and/or Inputs Measures

		Quartile in link $t+1$			
		Q1	Q2	Q3	Q4
Quartile in link t	Lowest Growth - Q1	21.09	18.75	24.22	35.94
	Q2	25.00	26.56	25.78	22.66
	Q3	20.31	25.00	26.56	28.13
	Highest Growth - Q4	32.58	28.79	22.73	15.91

4.2.3.3 Overall Growth vs. Link Growth of a Trust's Productivity Measure

Table 11 shows the descriptive statistics of the growth in the Productivity measure for the unchanged Trusts both for each link (columns L1 to L5 are those reported in Table 6 and the chain index summarising the overall change from a Trust's growth in Productivity measure from 2008/09 to 2013/14.[15]

From Table 11 we see that the overall growth indicated in the Productivity measure is on average positive, that the distribution is not symmetric (mean and median do not coincide) and that there are more Trusts with negative overall growth than Trusts with positive overall growth (median is also negative). This can also be seen in Figure 4. Table 10 and Figure 4 suggest that despite the presence of some outliers in

[13] For a definition of 'extreme growth' see Section 4.1.
[14] After eliminating Trusts with 'extreme growth', we are left with 129 Trusts.
[15] For the growth in Productivity measure in each link we also calculate the average (and its confidence interval) for each Trust, see Appendix G.

growth for individual links, discussed in Section 4.1, overall growth appears to have a distribution close to normal. Taken at face value, this suggests variation in overall growth might be used as a signal for good and bad practice. However, results presented in Section 4.2.3.2 on transition probabilities of individual Trusts show a less stable pattern, where remaining in the same quartile of growth performance is less likely than moving to another quartile in the next and following links. This highlights the importance of understanding the patterns of growth which lay behind the overall growth measure.

Table 11: Descriptive Statistics for the Growth Rates of the Productivity Measure. Unchanged Trusts

	L1	L2	L3	L4	L5	08/09 - 13/14
Number of Unchanged Trusts	151	151	151	151	151	151
Min	-25.24	-51.41	-24.05	-27.50	-25.70	-31.63
25th Percentile	-8.20	-1.08	-1.00	-5.50	-3.76	-8.79
Median	-5.15	3.59	2.63	1.09	-0.16	-1.34
75th Percentile	-1.17	7.48	6.47	6.91	3.64	8.83
Max	30.81	29.45	66.32	44.52	43.95	67.16
Mean	-4.57	2.12	3.84	1.05	0.42	1.41
Standard Deviation	6.69	10.84	11.20	9.91	8.51	14.90

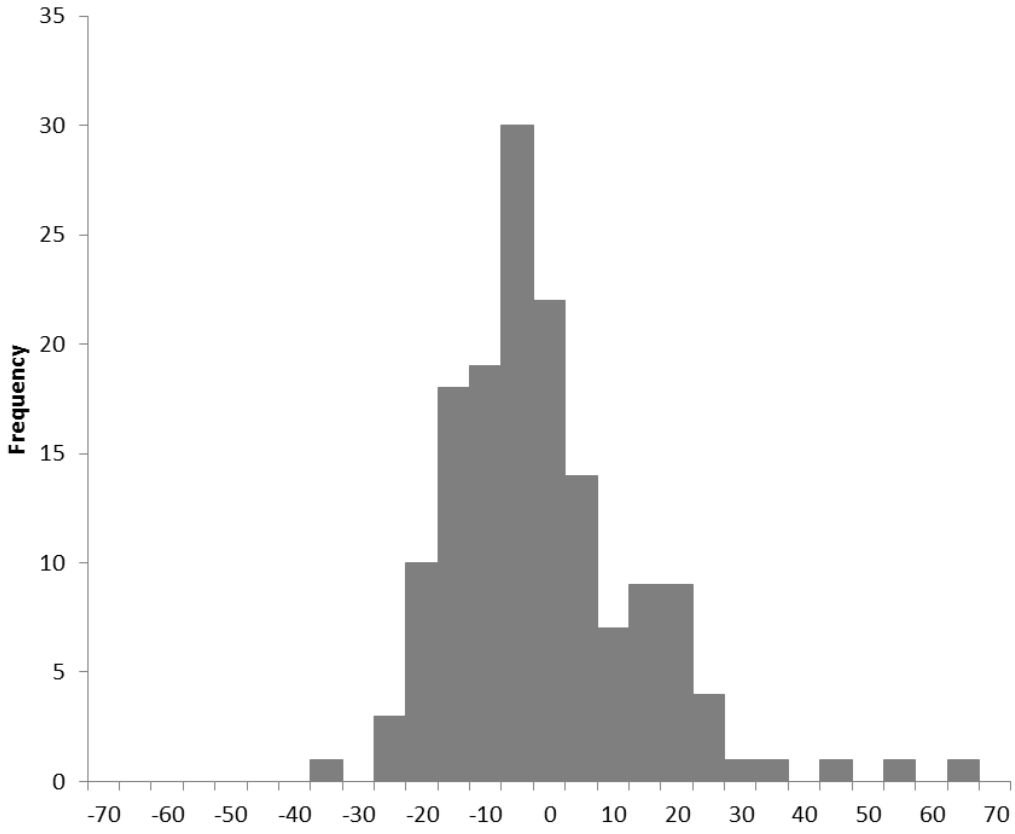

Figure 4: Distribution of Overall Growth of the Productivity Measure. Unchanged Trusts
Note that the bins are labelled using the upper limit of the interval they represent, e.g. the bin labelled '0' corresponds to the interval [-5, 0)

Table 12 shows the relationship between the relative growth of the productivity measure over the whole period (rows) and measured growth in each link (columns). For each quartile of overall growth, we count

the number of times Trusts are in different quartiles in the different links. For example, the first row shows that Trusts with the lowest overall growth are most frequently among those with the lowest growth in individual links. Further, these providers have growth under the median (Q1 and Q2) more frequently than over the median (Q3 and Q4). Note that the rows add up to five (the number of links) times the number of Trusts in that quartile. Table12 reflects the pattern of growth observed for single Trusts within the study period covered in these analyses. This table shows that the overall relative position (row) does not always coincide with the relative position in the different links (column). Only for Q1 and Q4 the main diagonal contains the majority of observations in the row.

Table 12: Growth Quartiles for Overall Growth and Growth in Links of the Productivity Measure

		Growth in Links			
		Q1	Q2	Q3	Q4
Overall Growth	Lowest Growth - Q1	75	45	31	39
	Q2	59	48	38	40
	Q3	33	60	60	37
	Highest Growth - Q4	23	32	61	74

Figure 5 shows how the Productivity of each Trust changes over time, it fixes the initial Productivity *level* of every Trust to be 100 and uses the measured growth in Productivity for each link to calculate their Productivity in each of the following financial years. This figure indicates a high degree of variation in growth levels over time for individual Trusts, rather than a smooth growth path. Even for Trusts with extreme (more than 3 s.d. away form the mean) overall growth (darker thicker lines), we see that their growth is not the result of consistently high growth but of one or two periods of very high growth.

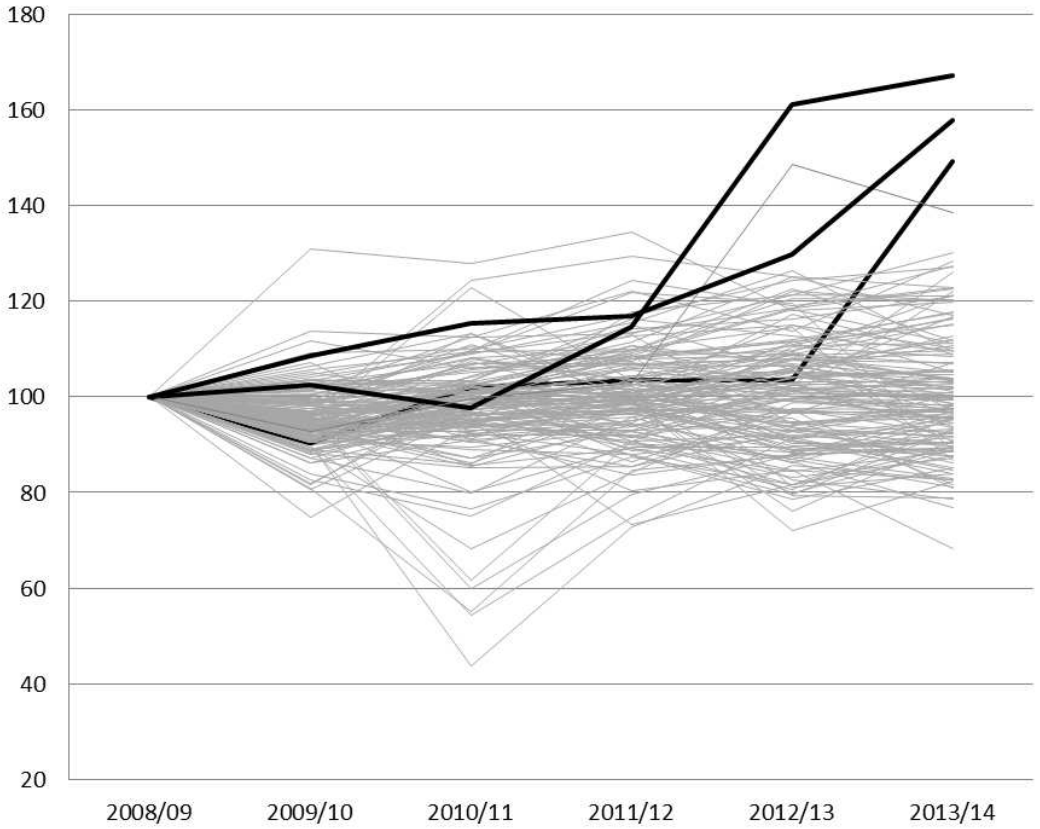

Figure 5: Productivity Levels (2008/09 = 100). Unchanged Trusts

5. Discussion

This study investigates growth in hospital Trusts' Productivity in the Acute care sector of the English NHS. It extends previous work investigating hospital Trusts' productivity levels (Aragón Aragón et al. 2015; Castelli et al. 2015) by using a growth measure previously constructed and used to analyse the National Productivity of the English NHS (Dawson et al. 2005). A major advantage of measuring Productivity in terms of growth over levels is that characteristics such as hospital size and patient case-mix, which are generally stable over time but differ by Trust, have no impact on the measure. Our principal research question is whether there is persistence in the Trusts' Productivity growth measure over time, which might be used to identify exemplars of good practice that other hospitals could emulate.

The time period covered by our study, 2008/09 to 2013/14, is one that has been characterised by one of the greatest re-configurations of the English NHS in recent times, with the abolition of Primary Care Trusts (PCTs) and Strategic Health Authorities (SHAs) and the creation of new purchasing bodies of health care services in the form of Clinical Commissioning Groups (CCGs). From the findings of Bojke et al. (2016), we know that the turbulence affecting the organisational structure of the NHS in England may have negatively impacted on the consistency and reliability of data reported by hospital Trusts both in terms of volume of the Outputs produced and Inputs used. Moreover, expenditure data on Inputs, in particular Capital inputs, have been found to have undergone large changes from one financial year to the next, the cause of which we have not always been able to identify.

Overall, we believe that inconsistency in the data, whether due to the structural changes in the organisation of the NHS, to changes in the reporting practices of hospital Trusts or both, will have influenced the results found in our study.

Using available data on Trusts' Outputs and Inputs and the method developed by Dawson et al. (2005) to measure the National Productivity of the English NHS, we find a considerable degree of variation in the Productivity growth rates of hospital Trusts'. Focusing on hospital Trusts that do not undergo structural change (mergers, take overs or closure) during our study period, we find an inter-quartile range of growth in Productivity measure of around six percentage points in each pair of adjacent years. The full range of growth figures for the same group of hospital Trusts is greater than 50 percentage points in each pair of years. This finding concurs with previous work on levels of hospital Trusts' Productivity, where marked variation was also found, even after accounting for a range of hospital characteristics (Aragón Aragón et al. 2015; Castelli et al. 2015).

Further, we find that the ordering of hospital Trusts using our measure of Productivity growth varies considerably over time. No hospital remains in the same quartile of growth throughout the study period and only six out of 151 Trusts remain in the same quartile in four out of five adjacent pairs of years. Similarly, in considering transition probabilities in adjacent links, we find the chance of appearing in a quartile is similar to a random draw. We therefore do not find evidence to identify a set of hospital Trusts which can be confidently described as being exemplars of good practice.

These results suggest either that Trusts' Productivity growth is not systematic or that the data observed are noisy. If the latter is true, it is important to consider where such noise is concentrated.

With regard to Outputs, a particular feature of NHS provision is frequent structural change. Examples in our study period include the recoding of Mental Health activity and the gradual removal of primarily community care provision by Primary Care Trusts (PCTs), which was either incorporated by existing

Acute Trusts or taken over by newly established Community Care Trusts. Such changes can impact both on the activity that hospital Trusts do and how they record it. For example, absorbing community care activity, previously provided by a PCT, represents a considerable change in the day-to-day work of a hospital and the staff employed.

Concerning Inputs, the most likely source of noise comes from the recording of Capital. It is not surprising that variations in accounting practices may generate substantial uncertainty in capturing the contribution of Capital in the Inputs growth measure and hence in the Productivity growth measure. This severely constrains the ability to draw meaningful comparisons across hospital Trusts. Therefore, as a sensitivity check, we limit our measure of Inputs to include only NHS and Agency staff (the growth in the former calculated using the direct method, whilst the other uses deflated expenditure data). Growth in the Labour Productivity measure for each hospital Trust does not, however, yield a more informative conclusion. While a Labour Productivity measure series may be subject to smaller fluctuations, using this measure does not change our main finding of a lack of persistence in relative growth over time for individual Trusts. Further, health care technology, which impacts on the use of Capital, has and continues to have great importance in the treatment of patients. Limiting analysis to Labour Productivity could penalise providers which have heavily invested in Capital, where that investment proves beneficial to Productivity in the long run.

Critically, the previously described issues in how Outputs and Inputs are recorded and/or categorised over time may be a source of variation which, unlike stable Output (Input) characteristics, are not removed when measuring growth.

In taking an established methodology for measuring Productivity growth at the national level and using this to consider growth at hospital Trust level, this study shows that beneath a relatively stable series of overall growth (Bojke et al. 2016) there is substantial variation between providers in points of time and in growth over time. This raises two important questions: how much of the observed fluctuation in the Productivity growth measure is ‘true change’ (directly or indirectly driven by how patients are treated) and how much is noise (made up of local shocks such as major investments in Capital or changes in measurement practice or changes in data consistency and reliability)?

We conclude that great caution is needed in interpreting growth in Productivity measures at hospital Trust level given current available data and methods of measurement. The methods used in this study, albeit established, have been developed to calculate a national index of health system Productivity growth and may not be sensitive enough to capture the same measure at the local (Trust) level. Our findings suggest that there is a need to develop a new approach of calculating hospital level growth in Productivity, better suited to dealing with inevitable variations at the local level.

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A. Settings

Table A.1 shows the number of Trusts report activity in each of the settings considered in each link. Please note that in link L3 (2010/11 - 2011/12) Community Mental Health is not included because this setting was affected by a complete overhaul in 2011/12, which resulted in the incomparability of mental health activity in the two financial years.

Table A.1: Settings considered in each Link

	Setting Code*	L1	L2	L3	L4	L5
Number of Trusts		166	166	164	160	161
Inpatients	IP	166	166	164	160	161
Outpatients	OP	166	166	164	160	160
A&E	AE	152	152	151	147	147
Chemo/Radiotherapy & High Cost Drugs	CRD	164	164	161	159	160
Community Care	CC	152	149	147	143	144
Community Mental Health	CMH	26	24	–	27	26
Diagnostic Tests	DT	150	150	154	151	150
Radiology	RAD	164	165	162	159	159
Rehabilitation	REHAB	85	86	96	92	97
Renal Dialysis	RD	65	67	61	64	62
Specialist Services	SPEC	163	163	161	157	157
Other	OTHER	154	154	153	151	143

* They will be used in Appendix B.

B. Contribution to Growth

First, we consider all Trusts together in each link, i.e. as if they were all one unit that has as Outputs the sum of all Outputs produced by all Trusts and as Inputs the sum of all the Inputs of each of the Trusts. Table B.1 shows how much each type of Output, i.e. each one of the settings, grows in each link and how much it contributes to the growth of Outputs in that link; similarly, Table B.2 shows how much each type of Input, Labour (from ESR), Agency, Intermediates and Capital, grows in each link and how much it contributes to the growth of Inputs in that link.

Table B.1: Contribution to Outputs Growth

Type of Output	Output specific growth rate	Share of total Outputs*	Share of Output growth
	2008/09 - 2009/10		
IP	0.87%	55.42%	55.90%
OP	8.72%	19.64%	21.35%
AE	3.64%	4.30%	4.46%
CRD	14.99%	4.40%	5.06%
CC	8.38%	1.31%	1.42%
CMH	12.34%	0.15%	0.17%
DT	5.84%	1.95%	2.06%
RAD	3.51%	2.28%	2.36%
REHAB	1.98%	1.02%	1.04%
RD	1.16%	1.40%	1.42%
SPEC	5.48%	7.37%	7.78%
OTHER	-1.51%	0.75%	0.74%
Outputs growth			**3.76%**
	2009/10 - 2010/11		
IP	3.18%	54.52%	56.25%
OP	2.84%	19.98%	20.54%
AE	4.91%	4.40%	4.61%
CRD	19.59%	5.10%	6.10%
CC	21.65%	1.38%	1.68%
CMH	5.85%	0.16%	0.17%
DT	5.24%	1.98%	2.08%
RAD	2.88%	2.21%	2.28%
REHAB	1.05%	0.96%	0.97%
RD	-2.53%	1.35%	1.32%
SPEC	2.56%	7.30%	7.48%
OTHER	6.61%	0.67%	0.72%
Outputs growth			**4.20%**

Table B.1: (continued)

Type of Output	Output specific growth rate	Share of total Outputs*	Share of Output growth
2010/11 - 2011/12			
IP	3.39%	54.17%	56.00%
OP	1.79%	20.03%	20.38%
AE	7.99%	4.50%	4.86%
CRD	19.28%	5.45%	6.51%
CC	149.92%	1.69%	4.22%
DT	19.12%	2.01%	2.40%
RAD	-1.74%	2.07%	2.03%
REHAB	33.46%	0.99%	1.32%
RD	-0.19%	1.31%	1.30%
SPEC	0.53%	7.08%	7.12%
OTHER	11.26%	0.71%	0.78%
Outputs growth			**6.93%**
2011/12 - 2012/13			
IP	10.84%	52.31%	57.98%
OP	1.91%	18.97%	19.34%
AE	4.14%	4.54%	4.73%
CRD	5.92%	5.85%	6.20%
CC	5.95%	4.09%	4.33%
CMH	10.68%	0.24%	0.26%
DT	2.54%	2.17%	2.22%
RAD	11.01%	1.94%	2.15%
REHAB	-4.98%	1.18%	1.12%
RD	0.46%	1.24%	1.25%
SPEC	2.13%	6.72%	6.86%
OTHER	0.48%	0.74%	0.74%
Outputs growth			**7.20%**
2012/13 - 2013/14			
IP	1.91%	48.71%	49.64%
OP	7.13%	20.22%	21.66%
AE	7.47%	4.95%	5.32%
CRD	10.99%	6.47%	7.18%
CC	13.74%	4.55%	5.18%
CMH	-20.11%	0.32%	0.25%
DT	15.67%	2.28%	2.63%
RAD	7.35%	2.10%	2.26%
REHAB	14.83%	1.18%	1.36%
RD	0.28%	1.30%	1.30%
SPEC	3.53%	7.15%	7.40%
OTHER	-12.60%	0.78%	0.68%
Outputs growth			**4.86%**

* Calculated using expenditure in first year of the link, e.g. in Link 1 (2008/09 - 2009/10) the shares are calculated using the expenditure for 2008/09.

Table B.2: Contribution to Inputs Growth

Type of Input	Input specific growth rate	Share of total Inputs*	Share of Input growth
	2008/09 - 2009/10		
Direct Labour (from ESR)	4.12%	61.64%	64.19%
Agency	26.56%	2.48%	3.14%
Intermediates	31.42%	13.86%	18.22%
Capital	6.60%	22.01%	23.46%
Inputs growth			**9.01%**
	2009/10 - 2010/11		
Direct Labour (from ESR)	2.70%	59.44%	61.04%
Agency	0.70%	2.76%	2.78%
Intermediates	-6.36%	16.52%	15.47%
Capital	9.11%	21.28%	23.22%
Inputs growth			**2.51%**
	2010/11 - 2011/12		
Direct Labour (from ESR)	3.88%	60.54%	62.89%
Agency	-5.94%	2.64%	2.48%
Intermediates	2.91%	14.73%	15.16%
Capital	11.23%	22.10%	24.58%
Inputs growth			**5.10%**
	2011/12 - 2012/13		
Direct Labour (from ESR)	2.75%	55.34%	56.86%
Agency	28.12%	2.13%	2.72%
Intermediates	8.11%	16.74%	18.09%
Capital	15.36%	25.80%	29.76%
Inputs growth			**7.44%**
	2012/13 - 2013/14		
Direct Labour (from ESR)	1.93%	53.62%	54.66%
Agency	27.95%	2.55%	3.26%
Intermediates	8.82%	16.57%	18.03%
Capital	8.59%	27.26%	29.61%
Inputs growth			**5.55%**

* Calculated using expenditure in first year of the link, e.g. in Link 1 (2008/09 - 2009/10) the shares are calculated using the expenditure for 2008/09.

Second, we show how much each type of Output (Input) contributes to each Trust's Output (Input) growth measure. Figures B.1 and B.2 show box plots (created using Stata 13 (StataCorp. 2013) command $\mathrm{graph\ box}$) for each type of Output[16] and Input, respectively in each link. The box represents the values between the 25th and 75th percentile, with the median marked as a horizontal line crossing the box. The whiskers mark the 'adjacent values' (see `http://www.stata.com/manuals13/g-2graphbox.pdf` for its definition) and the symbols (dots, triangles, etc.) show the values outside the 'adjacent values'. Therefore,

[16] For Outputs we plot only the settings that represent more than 4% of the overall activity in at least one link.

longer whiskers and/or symbols further away from the box indicate that there is greater dispersion in how much that type of Output (Input) contributes to the measure of growth in each Trust.

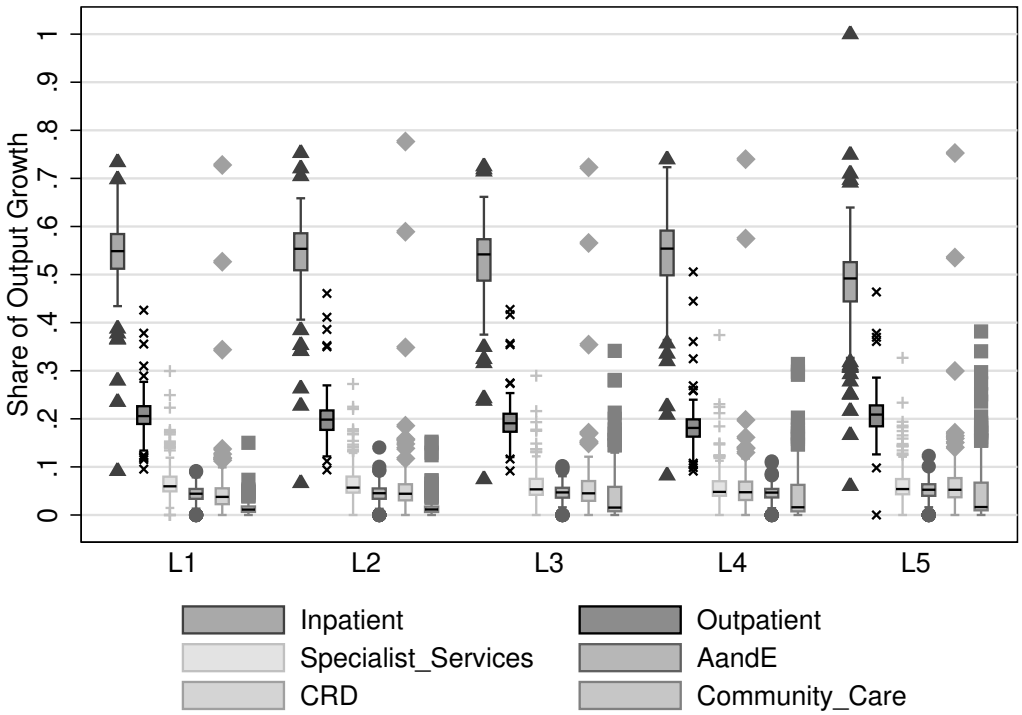

Figure B.1: Main Contributions to Output Growth, by Trust over the five Links

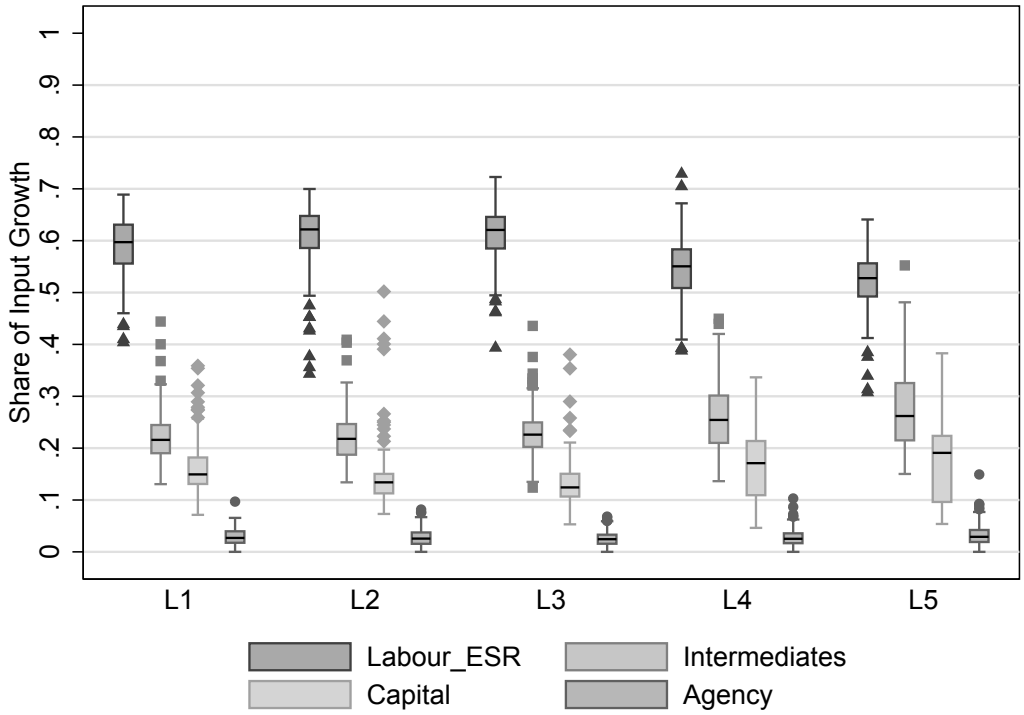

Figure B.2: Contribution to Input Growth, by Trust over the five Links

C. Mergers and Closures

Table C.1: Mergers

Financial Year	Merging Trusts	Merged Trusts
2008/09	N/A	
2009/10	· Queen Elizabeth Hospital NHS Trust (RG2), Bromley Hospitals NHS Trust (RG3) and Queen Mary's Sidcup NHS Trust (RGZ)	· South London Healthcare NHS Trust (RYQ)
	· Worthing and Southlands Hospitals NHS Trust (RPL) and Royal West Sussex NHS Trust (RPR)	· Western Sussex Hospitals NHS Trust (RYR)
2010/11	No Mergers	
2011/12	· Nuffield Orthopaedic Centre NHS Trust (RBF) and Oxford Radcliffe Hospital NHS Trust (RTH)	· Oxford University Hospitals NHS Trust (RTH)
	· Winchester and Eastleigh Healthcare NHS Trust (RN1) and Basingstoke and North Hampshire NHS FT (RN5)	· Hampshire Hospitals NHS FT (RN5)
2012/13	· York Teaching Hospital NHS FT (RCB) and Scarborough and North East Yorkshire NHS Trust (RCC)	· York Teaching Hospital NHS FT (RCB)
	· Trafford Healthcare NHS Trust (RM4) and Central Manchester and Manchester Children's University Hospitals NHS FT (RW3)	· Central Manchester and Manchester Children's University Hospitals NHS FT (RW3)
	· Barts and the London NHS Trust (RNJ), Whipps Cross University Hospital NHS Trust (RGC) and Newham University Hospital NHS Trust (RNH)	· Barts Health NHS Trust (R1H)
2013/14	No Mergers	

Table C.2: Closures

Financial Year	Closing Trusts	Trusts Taking Over Activity
2013/14	· South London Healthcare NHS Trust (RYQ)	· King's College Hospital NHS Foundation Trust (RJZ), Lewisham and Greenwich NHS Trust (RJ2) and Oxleas NHS Foundation Trust (RPG - community trust)

D. Cross Tabulations

The following Tables show the number of Trusts in each quartile of the growth distribution in different pairs of links for the growth in Outputs, Inputs and Productivity measures. As before, Q1 corresponds to the quartile with the lowest growth and Q4 to the one with the highest growth. The growth rates of the earliest link are reported in the rows and the growth rates in the latest link in the columns. Since the number of Trusts changes over time due to mergers, each table includes a note indicating the total number of Trusts and the number of Trusts in each quartile of growth. Only Trusts which are unchanged over the three years covered by the two links compared are included in the relevant Table.

Table D.1 shows the number of Trusts in each quartile of the growth distribution in 2008/09-2009/10 (L1) and 2009/10-2010/11 (L2), for the Inputs, Outputs and Productivity measures.

Table D.1: Growth in 2008/09-2009/10 (L1) and 2009/10-2010/11 (L2)

		Inputs				*Outputs*				*Productivity*			
		Growth in L2				Growth in L2				Growth in L2			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Growth in L1	Lowest - Q1	9	9	13	11	12	10	10	10	11	2	8	21
	Q2	6	11	12	12	7	12	13	9	8	12	10	11
	Q3	5	11	13	12	11	12	8	10	8	14	12	7
	Highest - Q4	22	10	3	7	12	7	10	13	15	13	11	3

Note: There are 166 Trusts, 42 in Q1, 41 in Q2, 41 in Q3 and 42 in Q4.

Table D.2 shows the number of Trusts in each quartile or the growth distribution in 2009/10-2010/11 (L2) and 2010/11-2011/12 (L3), for the Inputs, Outputs and Productivity measures.

Table D.2: Growth in 2009/10-2010/11 (L2) and 2010/11-2011/12 (L3)

		Inputs				*Outputs*				*Productivity*			
		Growth in L3				Growth in L3				Growth in L3			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Growth in L2	Lowest - Q1	14	7	7	13	6	10	15	10	4	6	10	21
	Q2	7	10	12	11	12	10	9	9	12	10	13	5
	Q3	6	18	10	6	13	10	7	10	9	12	11	8
	Highest - Q4	14	5	11	11	10	10	9	12	16	12	6	7

Note: There are 162 Trusts, 41 in Q1, 40 in Q2, 40 in Q3 and 41 in Q4.

Table D.3 shows the number of Trusts in each quartile or the growth distribution in 2010/11-2011/12 (L3) and 2011/12-2012/13 (L4), for the Inputs, Outputs and Productivity measures.

Table D.3: Growth in 2010/11-2011/12 (L3) and 2011/12-2012/13 (L4)

		Inputs				*Outputs*				*Productivity*			
		Growth in L4				Growth in L4				Growth in L4			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Growth in L3	Lowest - Q1	7	14	11	7	8	11	11	9	9	10	9	11
	Q2	12	11	8	8	8	10	11	10	10	8	9	12
	Q3	9	9	12	9	8	12	9	10	7	9	13	10
	Highest - Q4	11	5	8	16	15	6	8	11	13	12	8	7

Note: There are 157 Trusts, 39 in Q1, 39 in Q2, 39 in Q3 and 40 in Q4.

Table D.4 shows the number of Trusts in each quartile or the growth distribution in 2011/12-2012/13 (L4) and 2012/13-2013/14 (L5), for the Inputs, Outputs and Productivity measures.

Table D.4: Growth in 2011/12-2012/13 (L4) and 2012/13-2013/14 (L5)

		Inputs				*Outputs*				*Productivity*			
		Growth in L5				Growth in L5				Growth in L5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Growth in L4	Lowest - Q1	8	9	14	9	8	8	11	13	8	5	13	14
	Q2	5	10	15	10	13	13	8	6	10	16	6	8
	Q3	13	11	6	10	9	12	9	10	11	7	9	13
	Highest - Q4	14	10	5	11	10	7	12	11	11	12	12	5

Note: There are 160 Trusts, 40 in each quartile.

E. Growth in the Trust's Productivity Measure in Adjacent Links

The following plots show the growth in Trusts' Productivity measure in two adjacent links, e.g. 2011/12-2012/13 and 2012/13-2013/14, with the oldest link on the horizontal axis and the most recent link on the vertical axis. All of them have been scaled so that the units of the axes are standard deviations and the origin corresponds to the mean in each link. Thus, a Trust with average growth on both links will be on the origin of the plot.

If the growth in the Productivity measures were persistent over time, we would expect to see a positive trend in the plots. The plots below show either no or a negative trend.

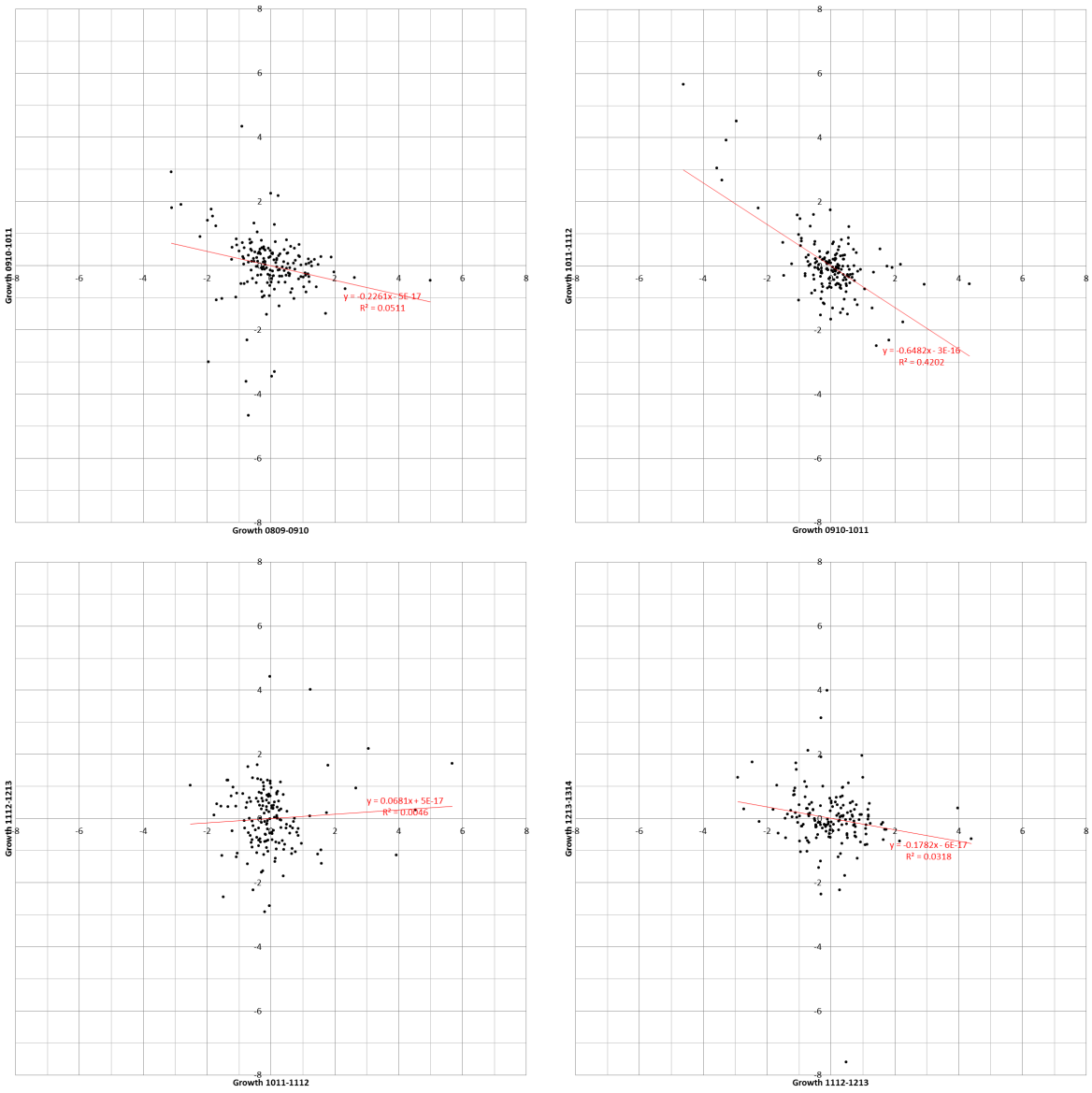

Figure E.1: Growth in Trusts' Productivity Measures across links

F. Growth Intervals

In the main text we used relative growth (quartiles) to observe whether the growth in the Productivity measure was persistent across pairs of links. In this section we explore an alternative grouping of Trusts based on fixed intervals instead of measured growth in productivity. Note that in this case the number of Trusts is not stable over time, both because of mergers occurring in any link, but also because the number of Trusts in each interval will not be by definition constant (unlike quartiles that have one quarter of the Trusts in each group). Only Trusts which are unchanged over the three years covered by the links compared are included in each relevant Table.

We divide the growth rates in the Productivity measure in each link into four intervals $(-\infty, -5)$, $[-5, 0)$, $[0, +5)$ and $[+5, +\infty)$ and compare each Trust's growth rate with its growth rate in the following link. We then summarise this information into tables that have a row for each interval in one link and a column for each interval in the following link.

Table F.1 shows the percentage of Trusts in each interval of growth in 2008/09-2009/10 (L1) and 2009/10-2010/11 (L2). Therefore, the first row tells us that most of the Trusts with a growth rate below -5% in L1 have a growth rate above +5% in L2 and that only around a quarter of them (13.79% +12.64%) have negative growth in L2.

Table F.1: Growth of Productivity Measure in 2008/09-2009/10 (L1) and 2009/10-2010/11 (L2)

		Growth in L2			
		$(-\infty, -5)$	$[-5, 0)$	$[0, +5)$	$[+5, +\infty)$
Growth in L1	$(-\infty, -5)$	13.79	12.64	21.84	51.73
	$[-5, 0)$	13.33	20.00	31.11	35.56
	$[0, +5)$	8.00	28.00	36.00	28.00
	$[+5, +\infty)$	22.22	33.33	22.22	22.23

Note: There are 166 Trusts common to the two links, in L1 87 had growth in the interval $(-\infty, -5)$, 45 in $[-5, 0)$, 25 in $[0, +5)$ and 9 in $[+5, +\infty)$.

Tables F.2, F.3 and F.4 show the percentage of Trusts in each growth group of of the Productivity measure in 2009/10-2010/11 (L2) and 2010/11-2011/12 (L3). In 2010/11-2011/12 (L3) and 2011/12-2012/13 (L4) and in 2011/12-2012/13 (L4) and 2012/13-2013/14 (L5), respectively.

F.1. Transition Probabilities between Growth Intervals

Table F.5 shows the probabilities, as percentages, of moving between growth rate intervals for the subset of Trusts that are not affected by mergers or closures. Rows reflect the initial (link t) interval, and the columns reflect the final (link $t + 1$) interval. The first row of Table F.5 shows that 15% of Trusts that have a value of growth of their Productivity measure under -5% in one link are also among those with the lowest growth in the following link; 11% of Trusts have a growth rate between -5% and 0% in the following link; 28% of Trusts have a growth rate between 0% and 5% in the following link; and 46% of Trusts have a growth rate above 5% in the following link.

Table F.2: Growth of Productivity Measure in 2009/10-2010/11 (L2) and 2010/11-2011/12 (L3)

		Growth in L3			
		$(-\infty,-5)$	$[-5,0)$	$[0,+5)$	$[+5,+\infty)$
Growth in L2	$(-\infty,-5)$	4.55	0.00	22.73	72.72
	$[-5,0)$	13.33	16.67	40.00	30.00
	$[0,+5)$	9.30	18.60	37.21	34.898
	$[+5,+\infty)$	16.42	26.87	34.33	22.38

Note: There are 162 Trusts common to the two links, in L2 22 had growth in the interval $(-\infty,-5)$, 30 in $[-5,0)$, 43 in $[0,+5)$ and 67 in $[+5,+\infty)$.

Table F.3: Growth of Productivity Measure in 2010/11-2011/12 (L3) and 2011/12-2012/13 (L4)

		Growth in L4			
		$(-\infty,-5)$	$[-5,0)$	$[0,+5)$	$[+5,+\infty)$
Growth in L3	$(-\infty,-5)$	21.05	10.53	26.32	42.10
	$[-5,0)$	28.57	21.43	10.71	39.29
	$[0,+5)$	23.21	17.86	25.00	33.93
	$[+5,+\infty)$	31.48	16.67	29.63	22.22

Note: There are 157 Trusts common to the two links, in L3 19 had growth in the interval $(-\infty,-5)$, 28 in $[-5,0)$, 56 in $[0,+5)$ and 54 in $[+5,+\infty)$.

Table F.4: Growth of Productivity Measure in 2011/12-2012/13 (L4) and 2012/13-2013/14 (L5)

		Growth in L5			
		$(-\infty,-5)$	$[-5,0)$	$[0,+5)$	$[+5,+\infty)$
Growth in L4	$(-\infty,-5)$	16.67	14.29	38.10	30.94
	$[-5,0)$	18.52	55.56	11.11	14.81
	$[0,+5)$	17.95	33.33	23.08	25.64
	$[+5,+\infty)$	28.85	32.69	26.92	11.54

Note: There are 160 Trusts common to the two links, in L3 42 had growth in the interval $(-\infty,-5)$, 27 in $[-5,0)$, 39 in $[0,+5)$ and 52 in $[+5,+\infty)$.

Table F.5: Transition Probabilities for Growth Intervals

		Interval in link $t+1$			
		$(-\infty,-5)$	$[-5,0)$	$[0,+5)$	$[+5,+\infty)$
Interval in link t	$(-\infty,-5)$	15.00	11.25	28.13	45.62
	$[-5,0)$	18.85	27.87	23.77	29.51
	$[0,+5)$	16.45	23.03	29.61	30.91
	$[+5,+\infty)$	25.29	23.53	31.18	20.00

G. Growth of the Productivity Measure. Unchanged Trusts

For each Trust we observe growth rates of the Productivity measure in five links; we use these to calculate the average growth rate and its confidence interval (CI), for each Trust. Figure G.1 shows the average growth of the Productivity measure for each Trust (dot) and its confidence interval (lines). Trusts are ordered from left to right in ascending order of their average growth rate; only six Trusts have an average value of growth of their Productivity measures over the five links with a CI which does not include zero (bigger, darker dots).

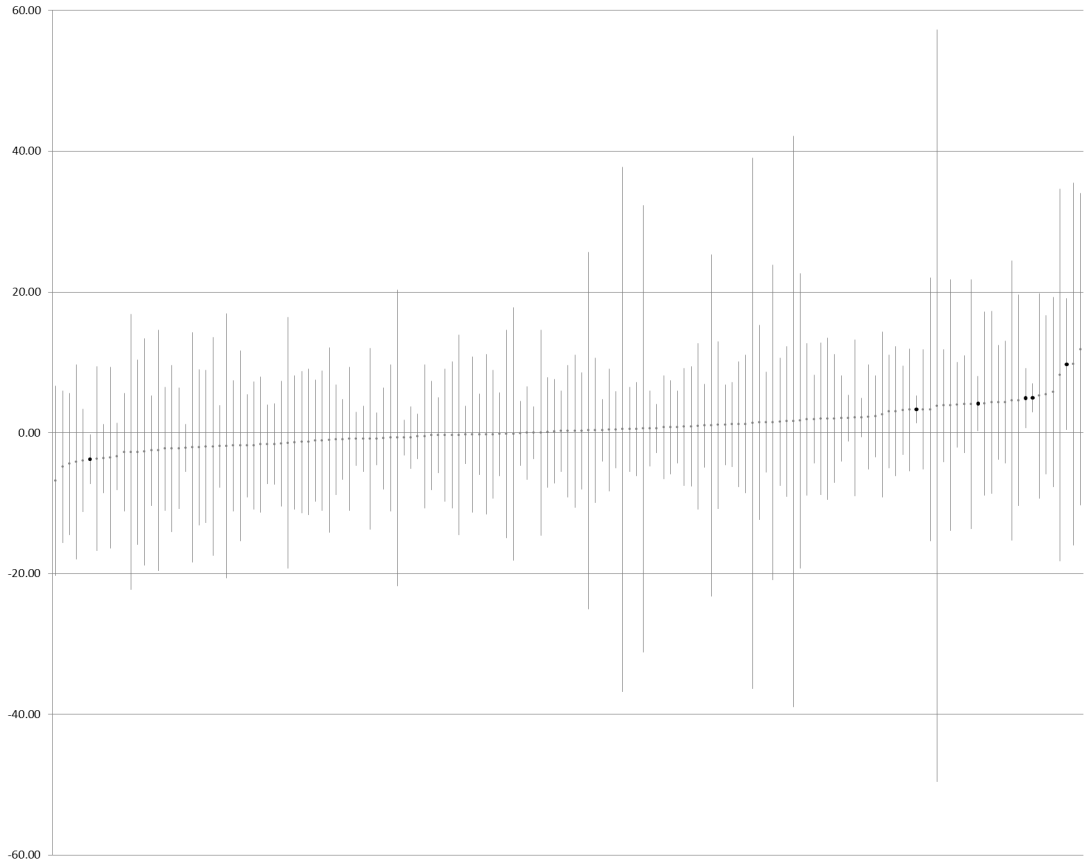

Figure G.1: Average Growth in Productivity Measure, and its CI, over the five Links

H. Labour Productivity Measure

In this section we focus our attention on Labour Productivity only. The Labour Productivity measure considers only Direct Labour, i.e. NHS Staff, and expenditure on Agency Staff.

Figure H.1 shows the relationship between the two definitions of Inputs (Labour (Direct Labour + Agency) and All Inputs), where the horizontal axes depicts the value of All Inputs and the vertical axes that of Labour Inputs only (in pounds of each year). In this context the line of best fit represents the best estimate of a fixed proportion of Labour in All Inputs. The figures suggest that the proportion of Labour in Total Inputs is frequently similar across Trusts, with the exception of larger Trusts (those with higher levels of Inputs) for which the estimates are less precise. This might reflect the greater opportunity for larger Trusts to invest more heavily in capital (buildings or medical equipment).

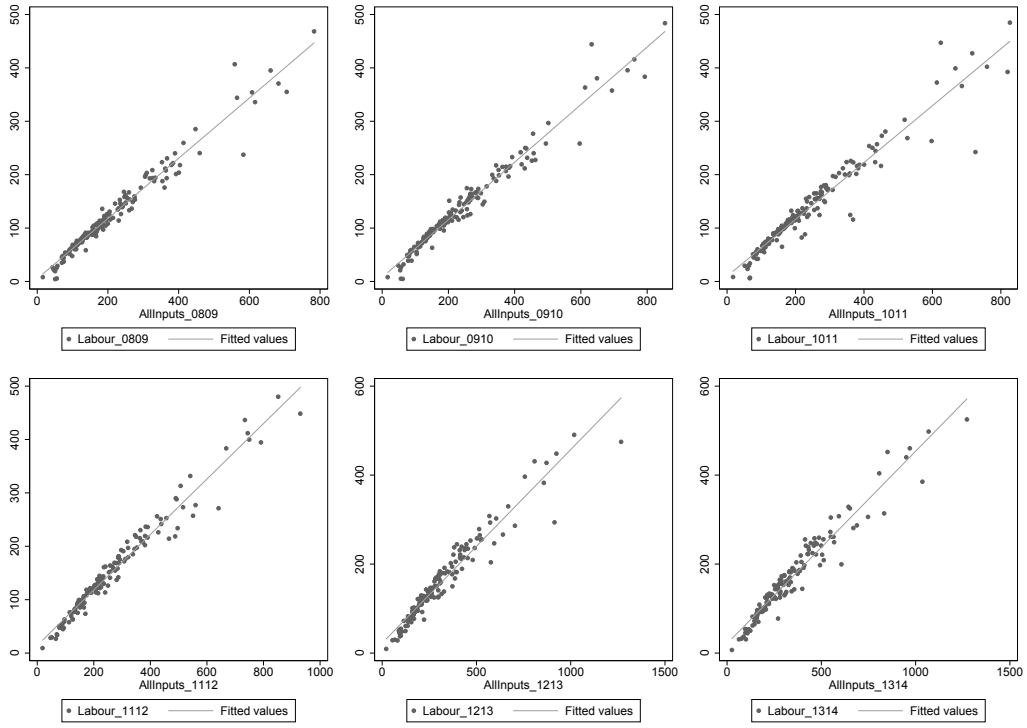

Figure H.1: All Inputs - Labour (Direct Labour + Agency) Inputs

Similarly to All Inputs (Section 3.4), we check for the temporal correlation of the Labour Inputs measure. Figure H.2 shows scatterplots with the value of Labour (Direct Labour + Agency) Input in a financial year on the horizontal axis and the value of Labour Input in the following financial year on the vertical axis (both expressed in Pounds of the same year). The plots all show high and consistent inter-temporal correlation in Labour Input. Compared to All Inputs (Figure 3), there is an increase in variation in links 2009/10-10/11 and 2010/11-11/12. Greater stability is to be expected when considering only Labour Input as its greatest component, NHS Staff, is measured directly and thus should be less noisy. Also, Labour input is less likely to change dramatically from one year to the next, except for expenditure on Agency Staff, which by definition varies according to the use of extra staff needed in any single financial year. We find in fact some variation in links 2009/10-10/11 and 2010/11-11/12 which, as discussed in Section 3.4, may be due to the need to employ additional staff in response to the structural changes occurring in those years.

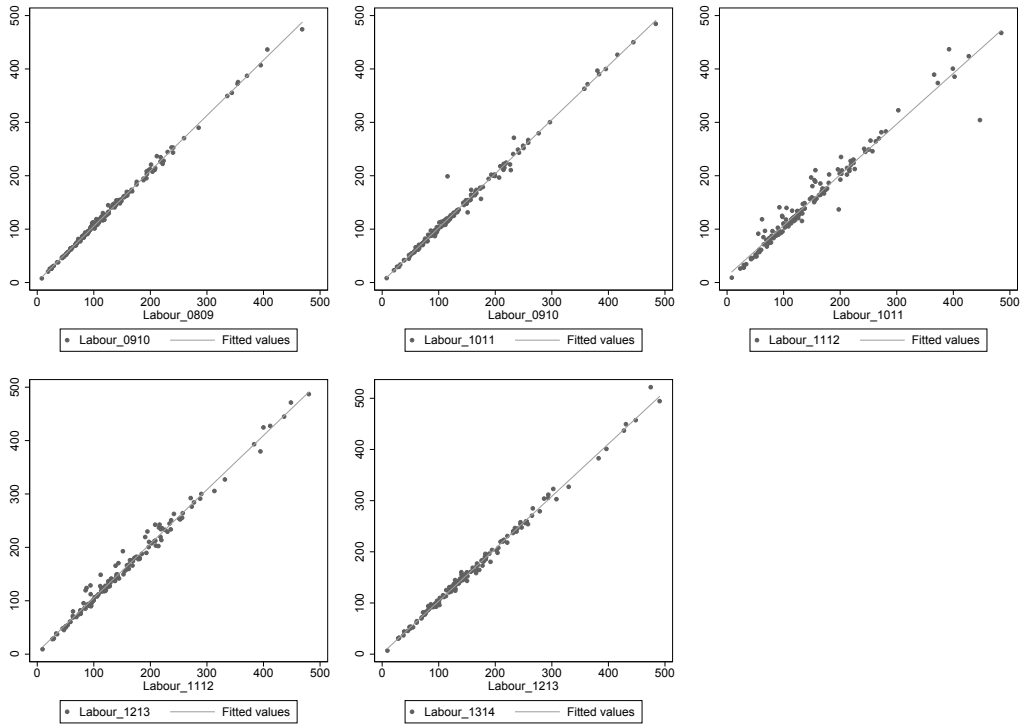

Figure H.2: Labour (Direct Labour + Agency) Inputs

In Table H.1 we show the descriptive statistics for the growth in the Labour Input measure for each link.[17] Comparing these results with those obtained for All Inputs (Table 5), we find that when considering Labour alone, the dispersion in the growth distribution is reduced (interquantile range and difference between minimum and maximum are smaller). This is expected given that Direct Labour and Agency represent a great proportion of total Inputs (see Appendix B). It also supports our previous findings that the most common source of extreme growth in the All Inputs measure comes from Capital Inputs.

Table H.1: Descriptive Statistics for Labour (Direct Labour + Agency) Growth Rates. Unchanged Trusts

	L1	L2	L3	L4	L5
Number of Unchanged Trusts	151	151	151	151	151
Min	-2.28	-12.84	-31.92	-5.45	-23.08
25th Percentile	3.34	0.64	-0.05	0.48	1.26
Median	5.16	2.36	2.53	2.96	3.31
75th Percentile	7.26	4.00	7.34	6.00	5.90
Max	19.49	72.84	91.41	42.51	16.44
Mean	5.72	2.98	5.53	4.90	3.63
Standard Deviation	3.63	6.96	13.17	8.00	4.52

[17] Please note that some Trusts report zero Agency staff expenditure in some years. If a Trust reports zero expenditure in one of the two financial years considered in one link, the growth in that particular link corresponds to that of Direct Labour only. This is the case for Trusts RRJ in 09/10-10/11, RJC in 10/11-11/12, and RN5 in 11/12-12/13 and 12/13-13/14.

Descriptive statistics for the growth in the Labour Productivity (LP) measure in each link and the overall growth of the LP measure are presented in Table H.2. Comparing these results with those in Table 11 for the growth in the Total Factor Productivity (TFP) measure, we find a reduction in the dispersion of the distribution of the growth in the Labour Productivity measures. The comparison also highlights higher median and mean LP growth than TFP growth. However, the correlation between the two measures of growth in Productivity, TFP and LP, is high, ranging between 55% and 82% for individual links, and it is 79% when considering overall growth (i.e. growth over the period 2008/09 - 2013/14).

Table H.2: Descriptive Statistics for Labour Productivity Measure Growth Rates. Unchanged Trusts

	L1	L2	L3	L4	L5	08/09 - 13/14
Number of Unchanged Trusts	151	151	151	151	151	151
Min	-16.01	-38.88	-15.55	-31.80	-32.97	-24.35
25th Percentile	-4.65	-1.76	-1.85	-3.00	-1.95	-4.99
Median	-2.22	1.73	2.16	1.96	1.08	3.47
75th Percentile	0.70	4.06	6.49	6.86	4.52	10.73
Max	33.44	25.30	46.82	55.59	44.97	68.88
Mean	-1.57	1.38	2.89	1.68	1.82	5.80
Standard Deviation	6.09	6.66	8.95	10.24	7.59	16.03

Table H.3 shows the transition probabilities based on the LP measure. As in Table 9 for TFP, the probabilities of moving from one extreme of the distribution to the other (Q1 to Q4 or viceversa) are the highest. In the main diagonal we see that staying in the extremes (Q1 or Q4) is less likely than staying in the middle (Q2 or Q3).

Table H.3: Transition Probabilities - Labour Productivity Measure

		Quartile in link $t+1$			
		Q1	Q2	Q3	Q4
Quartile in link t	Lowest Growth - Q1	24.34	20.39	23.68	31.58
	Q2	22.97	27.03	23.65	26.35
	Q3	25.00	25.66	26.97	22.37
	Highest Growth - Q4	28.29	25.00	26.32	20.39