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Sources of labour productivity growth at sector level in Britain, after 2007: a firm level analysis

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Abstract

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Contents

Abstract

This study analyses the importance of the distribution and re-distribution of resources across firms for sector level labour productivity levels and growth over the period 1998-2013. Using a representative data set of UK businesses we consider labour productivity in 20 market sectors, offering a comprehensive picture of the relationship between firm growth dynamics and sectoral productivity performance.

A simple measure of allocative efficiency suggests that on average 1998-2013 market sector labour productivity was around a fifth higher than it would have been if firms' market shares were randomly allocated within sectors; this measure is highly sensitive to a number of methodological choices. Compositional changes in the business population (firm entry, firm exit, and changes in market shares between incumbent firms) contributed substantially to labour productivity growth, adding on average around 3 to 4 per cent to labour productivity every three years. The magnitude of this contribution depends on the particular decomposition method used.

The aggregate figures mask substantial variation across detailed sectors. Nevertheless, there are also important commonalities. In the vast majority of sectors the covariance between firm size and labour productivity is positive, i.e. more productive firms tend to be larger than less productive firms, and compositional changes in the business population add to labour productivity growth. In most sectors allocative efficiency increased following the financial crisis and the slowdown in labour productivity growth was predominantly driven by productivity weakness within incumbent firms. But, there are also some signs that the economy got worse at reallocating resources to the highest productivity businesses in many sectors as the economy moved from recession into stagnation.

There are differences across sectors in the extent to which composition effects add to labour productivity growth. However, in terms of understanding sectoral differences in growth, it is more important to understand why productivity within continuing firms grows more quickly in some sectors than in others. Most of the variation in sectoral labour productivity growth performance arises due to differences in within firm growth performance rather than differences in the contributions of market share shifts.

Key findings

This study analyses the importance of resource allocation and reallocation for sectoral labour productivity levels and growth 1998-2013. We calculate the Olley-Pakes measure of allocative efficiency for different sectors and time periods, illustrating how this measure of allocative efficiency has changed since the financial crisis. We analyse the contributions to sector level labour productivity growth arising from compositional changes in the business population (firm entry, firm exit, and changes in market shares between incumbent firms) and from productivity growth within incumbent firms.

Estimates of the Olley-Pakes covariance term between firm size and labour productivity levels within sectors suggest that ***on average 1998-2013 market sector labour productivity was around a fifth higher than it would have been if firms' market shares were randomly allocated within industries***; but note that this estimate is very sensitive to methodological choices. This measure of allocative efficiency was higher in the manufacturing sector than in the construction and services sectors, possibly reflecting a correlation between capital intensity and size.

There is significant variation across disaggregate sectors in allocative efficiency within both manufacturing and services; ***a quarter of the variation across sectors in log labour productivity 1998-2013 arises due to variation in allocative efficiency***. But, there are also significant commonalities. ***In the vast majority of sectors***, all nine disaggregate manufacturing sectors that we consider and in nine of ten service sectors, ***labour productivity is higher than it would be if instead employment was randomly distributed across firms***.

Looking at patterns over time we find that after 2007 allocative efficiency was generally higher than or similar to that in previous years. For the market sector as a whole allocative efficiency was on average higher after 2007 than before. The increase in allocative efficiency after the financial crisis was a phenomenon that was observed within most subsectors of both manufacturing and services. In manufacturing this may partly have reflected pre-crisis trends.

Looking at the contributions of resource reallocation to productivity growth, distinguishing the separate contributions of entry, exit and resource reallocation between incumbent firms, we find that ***resource reallocation contributed on average 3 to 4 percentage points to 3-year productivity changes***. The magnitude of these contributions depends on the decomposition method used.

Average productivity growth was generally higher in manufacturing than for the market sector as a whole. This appears to have been because the within firm contribution to aggregate labour productivity growth was higher in manufacturing than in the rest of the economy, i.e. labour productivity grows faster within manufacturing firms than within firms in other sectors. Indeed, looking at more detailed sectors, the ***sectoral variation in labour productivity growth primarily***

reflects sectoral variation in the contribution of labour productivity growth within continuing firms.

After the financial crisis sector level labour productivity growth was significantly weaker in most disaggregate manufacturing and service sectors we consider. We also find that the ***contributions of compositional effects*** to labour productivity growth were generally positive in these sectors. But, ***were less than they had been prior to the recession in many sectors***. While this contributed to the weakness of sector level labour productivity growth after the financial crisis relative to its pre-crisis trend, ***in most sectors the majority of productivity weakness was accounted for by the fall in labour productivity growth within incumbent firms relative to the situation before 2008***.

1. Introduction

The distribution of resources across more and less productive firms has a direct bearing on aggregate productivity levels, if for no other reason than arithmetically. A simple summary measure of the productivity or efficiency gain associated with the allocation of resources across firms is provided by the Olley-Pakes (1996) (OP) covariance term between firms' market shares and their productivity levels within industries. It essentially measures the gain (or loss) in aggregate productivity relative to a benchmark where market shares are randomly distributed across firms within industries, and is thought to provide a relatively robust measure of the impact of distortions to resource allocation on aggregate labour productivity levels (Bartelsman, Haltiwanger & Scarpetta, 2013).

Changes in the OP covariance term over time provide one indicator of the contribution of changes in the efficiency of resource allocation to productivity growth. More often studies of productivity growth gauge the importance of external restructuring, i.e. changes in the allocation of resources across firms, by considering explicitly the contributions to productivity growth of entering and exiting firms and of changes in firms' market shares (see e.g. Foster, Haltiwanger & Krizan, 2001; Baily, Bartelsman & Haltiwanger, 2001; Melitz & Polanec, 2015). Analysing labour productivity and TFP growth in this way, Disney, Haskel & Heden (2003) find that external restructuring (i.e. the net effect of firm entry and exit and changes in market shares of surviving firms) accounted for around 50% of labour productivity growth in British manufacturing from 1980 to 1992. More recently, Riley, Rosazza Bondibene & Young (2014, 2015) and Barnett *et al.* (2014) examine the sources of labour productivity growth in the UK market sector before and after the financial crisis. These studies suggest that the majority of productivity weakness since the crisis occurred within incumbent firms, but also suggest there is some evidence that the productivity contributions of external restructuring were dampened after the financial crisis.

This study contributes to the evidence base, analysing the contribution of allocative efficiency to differences in labour productivity levels across sectors and time as well as the contributions to sector level labour productivity growth arising from compositional changes in the business population (firm entry, firm exit, and changes in market shares between incumbent firms) and from productivity growth within incumbent firms. There is no reason to expect that the effects of recession and subsequent recovery have played out uniformly across disaggregate sectors. We compare the recessionary and post-recession periods 2007-13, when UK labour productivity growth stagnated, with the period before, when UK labour productivity growth was relatively strong. We build on the sectoral analysis of labour productivity in Mason, Robinson & Rosazza Bondibene (2014), which covers the period before the financial crisis, updating this analysis to 2013 using the methods described there and alternate methods described in Riley *et al.* (2014,

2015). We do not explore the reasons for differences in the sources of sectoral growth and how these changed during and after recession. Our objective is first and foremost to document the sources of sectoral growth over this period. However, this exercise does shed some light on the potential foundations of recent productivity weakness. We return to this in the conclusion section of the paper.

The report is structured as follows. Section 2 describes the decomposition methodologies that we use to analyse the sources of growth. Section 3 details the ARD (Annual Respondents Database) data that we use and highlights some of the issues that arise in using and interpreting the data. Section 4 then reports results from the decomposition of sectoral labour productivity levels and Section 5 the results from the decomposition of sectoral labour productivity growth. Section 6 summarises and draws some conclusions.

2. Methodology

There are a number of empirical approaches to the decomposition of productivity levels and growth rates available in the literature. These enable us to explore the extent to which specific groups of firms contribute to productivity performance over time at both sectoral and aggregate economy levels. Firms are typically identified as those that enter, those that exit and continuing firms in the market.

As in Mason *et al.* (2014) we first explore developments in the efficiency of resource allocation or "allocative efficiency" as measured by the Olley-Pakes (OP) covariance term between firm size and productivity within sectors (Olley & Pakes, 1996). This is simply calculated as the difference between the employment share-weighted sum of firms' (log) labour productivity within the sector and the simple average of (log) labour productivity across firms within the sector. Bartelsman, Haltiwanger & Scarpetta (2013) suggest this is a reasonably robust measure of allocative efficiency that can be interpreted as the %difference in sector level productivity due to the non-random distribution of market shares across firms within the sector. Examining changes in this term across time gives us an indication of how changes in the efficiency of resource allocation may have affected productivity growth.

Next we turn to the decomposition of sector level labour productivity growth. The starting point for the analysis in Mason *et al.* (2014) and many other studies is the widely used Foster, Haltiwanger & Krizan (2001) decomposition (hereafter FHK). But, as discussed in Melitz & Polanec (2015) (hereafter MP), the treatment of entering firms in the FHK decomposition is problematic in that the productivity contribution of such firms is benchmarked against incumbent firms at an altogether different point in time. For this reason Mason *et al.* (2014) also consider the dynamic Olley-Pakes decomposition introduced by MP. Riley *et al.* (2014, 2015)

suggest the FHK decomposition (and the oft used decomposition proposed by Griliches & Regev, 1995) may be particularly misleading when productivity growth moves between growth and stagnation phases and will tend to exaggerate changes in the productivity growth contribution of resource reallocation between such phases.[1] The MP decomposition provides an alternative, but is perhaps not very robust in small samples and leads to some disjuncture between the treatment of resource allocation at the intensive (market share changes amongst incumbents) and extensive (entry and exit) margins. Therefore they use a decomposition method first proposed by Diewert & Fox (2010) (hereafter DF), which is essentially a hybrid of the extended Griliches & Regev (1995) decomposition reported in Baily, Bartelman & Haltiwanger (2001) and the MP decomposition, retaining attractive features of both. Our main results in this report are based on the DF decomposition, but we report sensitivity analysis based on the MP, GR and FHK decompositions.

We write aggregate labour productivity at time t (Π_t) as a weighted average of the level of labour productivity of individual firms (π_{it}):

(1) $$\Pi_t = \sum_i s_{it}\pi_{it}$$

where weights s_{it} measure firm i's market share at time t, $s_{it} \geq 0$ and $\sum_i s_{it} = 1$. We use employment shares to measure market shares so that Π_t equals the ratio of aggregate gross value added (or output) to aggregate employment, equivalent to the measurement of labour productivity at the aggregate sector level. Continuing firm i's share of the market of continuing firms is written as $s_{Cit} = \frac{s_{it}}{\sum_{i\in C} s_{it}}$, where $\sum_{i\in C} s_{Cit} = 1$. We then decompose the change in aggregate sector level labour productivity between time t-k and time t as:

(2) $$\begin{aligned}\Delta\Pi_t = &\sum_{i\in C} \bar{s}_{Ci}\Delta\pi_{it} \\ &+ \sum_{i\in C} \Delta s_{Cit}(\bar{\pi}_i - \bar{\Pi}_C) \\ &+ \sum_{i\in N} s_{it}(\pi_{it} - \Pi_{Ct}) \\ &- \sum_{i\in X} s_{i,t-k}(\pi_{i,t-k} - \Pi_{C,t-k})\end{aligned}$$

[1] In the FHK and GR decompositions the contribution of net entry is biased upwards (downwards) when productivity is generally rising (falling) over time. This is because the productivity level of entrants is compared to that of other firms at an earlier point in time (making entrants appear relatively productive when productivity is rising and relatively unproductive when productivity is falling) and, in the GR decomposition, because the productivity level of exitors is compared to that of other firms at a later point in time (making exitors appear relatively unproductive when productivity is rising and relatively productive when productivity is falling). Thus, when productivity growth slows these decompositions will automatically generate a fall in the productivity growth contribution of net entrants unrelated to any genuine change in the efficiency of resource allocation.

where a bar above a variable denotes an average across time *t* and time *t-k*, and where $\Pi_{Ct} = \sum_{i \in C} s_{Cit} \pi_{it}$ is the share weighted average of labour productivity for continuing firms only, equivalent to aggregate labour productivity for this subset of firms. In (2) the first sum is the within component and the second sum the between component, which is positive if firms that are on average more (less) productive over the two periods (time *t* and time *t-k*) gain (lose) market share. The last two sums in (2) measure the productivity contributions from entry and exit respectively. The contribution to aggregate productivity growth of entrants (exitors) is positive if their productivity exceeds (is less than) the average productivity at time *t* of incumbents (at time *t-k* of survivors). The MP, FHK and GR decompositions are discussed extensively elsewhere. Formulas are provided in appendix A of this report.

The firm-level productivity measure used in the growth decomposition literature is usually a log rather than a levels measure. We use a levels measure of productivity for two reasons. First, gross value added may be zero or negative and the characteristics of such firms change during recession. Second, the levels measures of firms' productivity map directly onto sector level productivity, providing a straightforward link between productivity changes at the firm and sector levels. Following Baily, Bartelsman & Haltiwanger (2001) we convert the decompositions into percentage changes by dividing all terms in equation (2) by sector level productivity at time *t-k*. (The OP covariance term is calculated using log labour productivity.)

We assess three year changes in labour productivity, dividing the available sample into three pre-recession periods and two post-crisis periods. Broad sector results are calculated by aggregating up the disaggregate sector results using sector employment shares.[2]

3. Data

The main data source we use for the decomposition analysis is the Annual Respondents Database (ARD), which pulls together information from the Inter-Departmental Business Register (IDBR), Annual Business Inquiry, Annual Business Survey and the Business Register Employment Survey (BRES). The ARD holds information on the nature of production in British establishments and is essentially a census of larger establishments and a stratified random sample of establishments with less than 250 employees. Details of the ARD data can be found in Bovill (2012). Here we describe issues that are particularly relevant in the current context.

[2] Note that this means our measures of three year changes in labour productivity for broad sector groups do not take into account changes in labour productivity that arise because of shifts in employment between sub-sectors.

Unit of analysis

There are four levels at which it is possible to analyse the data: the holding company, enterprise, reporting and plant levels. We undertake our analysis at the level of the reporting unit, which is the sampling unit. This is similar to the unit of analysis used in Disney *et al.* (2003), Barnett *et al.* (2014) and Riley *et al.* (2015). Harris & Moffat (2013) undertake their analysis at the level of the plant (the local unit). Others have decomposed productivity at the level of the enterprise (Riley *et al.*, 2014; Mason *et al.*, 2014), typically considered the smallest legally independent unit. In the vast majority of cases plants, reporting units, enterprises and holding companies are one and the same. But, for larger firms there are differences. These differences need to be borne in mind when comparing results across studies and in considering what is actually being measured. For example, productivity growth due to reallocation between plants may occur within multi-plant reporting units or enterprises. Also, measures of entry and exit will differ in what they capture at different levels of analysis. ONS has advised that plant identifiers remain the same when plants are bought and sold. In contrast, reporting unit and enterprise identifiers might change with ownership changes. Because these identifiers are used to measure entry and exit, entry and exit of plants will reflect genuine births and deaths, where entry and exit of reporting units and enterprises might reflect genuine market entry or exit, but might also reflect mergers and acquisitions that appear as changes within and between continuing plants or holding companies.[3] There are valid reasons for using each of these units of analysis. Here we use the reporting unit which we refer to as the firm or establishment throughout; we note some unreported sensitivity analysis of the OP covariance using enterprises.

Sampling issues and population weighting

The sampling frame for the ARD is the IDBR, a list of all incorporated businesses and other businesses registered for tax purposes. The ARD includes basic information (e.g. industry, ownership structure, and indicative employment) for all establishments in the sampling frame. These population data allow us to determine entry and exit, which cannot be calculated from the surveyed sample alone (Disney *et al.*, 2003), and allow us to calculate grossing weights. We follow the advice in ONS (2002) and use the ratio of population to survey aggregates (we use employment) within sampling strata as grossing weights. Sampling strata are defined in terms of industry, employment size groups and region. We ignore regions due to small cell sizes. Extreme grossing weights due to small cell sizes are eliminated by further aggregation.

[3] How this then affects the productivity growth contributions of entry and exit will also depend on how M&A firms affect the relative productivity of entrants and exitors.

In the dynamic decomposition analysis we have three categories of firm: continuers, exits and entrants. In carrying out the decompositions we weight up the data separately for each of these three categories of firm. This allows us take into account differential sampling probabilities in the longitudinal versus the cross section data. Grossing factors need to be larger for continuers than for the other categories of firm within the same cross-sectional sample stratification cell, because the probability of being observed in the longitudinal data is much smaller than the probability of being observed in the cross-section. Weighting the data in this way also allows us to replicate market shares in the IDBR. For continuing firms we average grossing weights over time (over the start and end period of the decomposition) so that productivity and market share changes for these firms do not reflect changes in grossing weights.

Sampling probabilities in the ARD are decreasing in size of firm. For larger firms the ARD is a census, although response rates mean that in practice we do not have information for all larger firms. For the smallest firms (employing less than 10 employees) the probability of appearing in the survey is just 1%. This means that the probability of observing these micro firms in the longitudinal sample (continuer sample) is only 1 in 10,000. We return to the issue of micro firms below.

Industrial classification issues

The ARD covers businesses in the non-financial non-agricultural market sectors. The ARD includes partial coverage of the agricultural sector (we exclude these businesses) as well as businesses in "non-market" service sectors such as education, health and social work. We exclude businesses in these latter sectors where inputs and outputs are thought not to be directly comparable, making productivity analysis difficult to undertake. We also exclude businesses in the mining and quarrying, and utilities sectors (typically very large businesses with erratic patterns of output) and in the real estate sector, where output mostly reflects imputed housing rents.

Data are available for these market sectors 1997-2013 and for manufacturing back to 1974. There are a couple of important changes in the ARD data over the sample period that we analyse. From 1997 to 2008 the ARD includes the ABI-1 (Annual Business Inquiry-1), a survey of employment, and the ABI-2 (Annual Business Inquiry-2), a survey of financial information. In 2009 the ABI-2 was replaced by the ABS and the ABI-1 was replaced by BRES. This introduces some discontinuities in the data, which we minimise by grossing the data to the underlying sampling frame, which did not change, and by using the measure of employment that is available in the IDBR, as discussed below.

Before 2008 industry was coded to the UK Standard Industrial Classification (SIC) 2003. From 2008 onwards this changed to SIC 2007. We use a look-up table between industry classifications

available from Companies House and supplement this with information from ONS on the correlation between classifications to generate sector definitions that can be used before and after 2007. To maintain broad continuity in the sectors that we analyse this requires us to drop a few 3-digit sectors. Because of significant differences between SIC 2003 and SIC 2007 there remains some discontinuity in sector definitions before and after 2008.

We define 20 sectors informed by the sectors defined in Mason *et al.* (2015). These broadly correspond to sections of SIC 2007 and in manufacturing and the wholesale & retail trade to divisions or groups of divisions within sections. In the dynamic decompositions firms that change their industry over time are classified according to their starting industry.

Measuring labour productivity and market shares

We measure labour productivity as the ratio of gross value added at factor cost to employment (as in Mason *et al.*, 2014). The ARD financial information is published in current values. GVA deflators published by the ONS are used to construct real values; these are available at the 2- and sometimes the 3-digit sector level. Market shares are defined in terms of employment as is standard in decompositions of labour productivity; this ensures that the firm level data can be aggregated to industry level labour productivity.

The ARD includes a number of employment measures. We use the indicative employment information available in the IDBR as we do not have a consistent series of year average or point in time employment estimates for surveyed businesses.[4] For those years where we are able to make the comparison this indicative employment measure correlates reasonably with the point in time measure of employment that we observe for surveyed businesses, but less so in the earlier years of the survey and for smaller firms in particular. For these reasons, and because the longitudinal data is not representative of very small firms, we highlight how the results can differ when we exclude micro firms. Throughout we exclude establishments with less than two persons employed.[5]

[4] The IDBR employment measure is used, for example, in Mason *et al.* (2014) and is discussed in Evans & Welpton (2009). Discontinuities in alternative measures of employment in the data we use occur in 2006, 2008 and with the introduction of BRES in 2009. We discuss some sensitivity analysis using survey (ABI/BRES) measures of employment.

[5] In the data we use, discrepancies in outcomes based on different measures of employment are particularly pronounced for this group.

4. Decompositions of labour productivity levels

We first explore a well-known measure of allocative efficiency, the OP covariance term between size and labour productivity within an industry. This provides a measure of the gain (or loss) in sector level labour productivity compared to a situation where size was distributed randomly across firms with different labour productivity levels within sectors (Bartelsman *et al.*, 2013).

4.1 Broad sector groups

We find that the OP covariance term averaged 20 log points over the period 1998-2013 in the UK market sector, suggesting that UK market sector labour productivity was significantly higher than it would have been if firm size was random (within industries).[6] Note that the precise magnitude of this measure of allocative efficiency can vary substantially depending on the initial level of sectoral disaggregation used (compare Tables 5.1 and 5.3 in Mason *et al.*, 2014) and other assumptions made in compiling the data. When we exclude micro firms from the analysis the OP covariance term is around 10 log points on average over this period.[7] Measured allocative efficiency is higher when we include micro firms because on average micro firms are less productive than larger firms, and, by definition, they are smaller.

In Figure 4.1.1 we illustrate the OP covariance term on average over three year periods: 1999-2001, 2002-2004, 2005-2007, 2008-2010 and 2011-2013. We illustrate this for the market sector as a whole (please see definition used here in section 3) and for the three broad sector groups this comprises: manufacturing, construction and market services. While for the market sector as a whole the OP covariance term is around 20 log points, there is significant variation across broad sectors. In particular, the manufacturing sector has a much higher OP term than construction or services. This may reflect the capital intensity of manufacturing production relative to other sectors and a positive correlation between capital intensity and size. The OP covariance term is on average twice as high in manufacturing compared to services.[8] When, as

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[6] Results throughout this paper are obtained by decomposing productivity within 31 sub-sectors and then aggregating up to broad sector level, or to the 20 detailed industries that we consider, using employment shares. The aggregate figures are therefore fully consistent with the results shown for more detailed sectors.

[7] This is broadly consistent with the findings in Mason *et al.* (2014), despite differences in methodology. They find an OP covariance term of 19 log points on average 1998-2007. Over the same time period the OP covariance term excluding micro establishments in this paper averages 10 log points.

[8] ONS estimates in Franklin & Field (2013) suggest that the OP covariance term is significantly higher in manufacturing compared to market services. Indeed, their estimates suggest that the OP term is negative in services.

in Figure 4.1.2, we exclude the very smallest firms, differences across sectors are much less pronounced, but allocative efficiency is still higher in manufacturing than in services, on average over the time period shown.

Looking at how the OP covariance term has changed over time, both Figures 4.1.1 and 4.1.2 suggest the OP covariance term was higher on average 2008-2013 than on average in the 6 years before. In Figure 4.1.1, where we include micro firms, this is evident in manufacturing, construction and market services. When we exclude micro firms, as in Figure 4.1.2, the increase in allocative efficiency after the financial crisis (compared to the 6 years before) is much less evident in market services and therefore in the market sector as a whole.[9] However, whether or not we include micro firms, there is no suggestion that allocative efficiency should have worsened since 2007.

In Figure 4.1.1 the OP covariance term is higher 2008-2013 than on average over all the previous years in our sample. In contrast, Figure 4.1.2, where we exclude micro firms, suggests that the OP covariance term was highest 1999-2001, falling sharply thereafter because of a reduction in measured allocative efficiency in services. This drop in allocative efficiency is however not a widespread phenomenon within services, arising primarily because of a very sharp drop in the estimated OP covariance term in the retail sector. This is consistent with the findings of Mason *et al.* (2014).[10]

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[9] Franklin & Field (2013) find that the OP covariance term increased by 13 to 15 log points in manufacturing between 2002-2007 and 2008-2010. In market services the increase was negligible. These patterns over time and across sectors are broadly consistent with the findings here.

[10] We report further sensitivity testing in Appendix B. First, in Figure B.1, we show the OP covariance term when we include establishments with one person employed. The increase in allocative efficiency over time is more pronounced in this case, but this may partly reflect measurement error. We also show the market sector OP term derived when the data is weighted to the population of firms and when it is not. The profile over time is sensitive to population weighting. The unweighted estimates show a drop in allocative efficiency between the years around the turn of the century and thereafter, which is not apparent when the data are population weighted. The unweighted results are in this respect similar to the weighted results excluding micro firms. This may reflect the fact that there are relatively few micro firms in the sample relative to their numbers in the population. Finally, we illustrate the OP term when we use survey (ABI/BRES) employment rather than IDBR employment where possible (we still use IDBR employment where survey employment is missing, i.e. for the majority of observations after 2007). In this case the OP measure is a little higher than in our main results pre-crisis. Post-crisis it is similar to the case where we use IDBR employment because BRES employment is available for relatively few firms in the ABS. These inconsistencies over time make it difficult to interpret changes over time in the OP measure based on survey employment. Additional sensitivity testing (not shown) used the enterprise data rather than the establishment

4.2 Disaggregate sectors

The broad sector results discussed in the previous section mask considerable variation in allocative efficiency between more detailed sectors. In Table 4.2.1 we report the weighted mean and standard deviation of the OP covariance term across 20 detailed sectors. On average over the period 1999-2013 the OP covariance term has a mean of 20½ log points and has a standard deviation of 22 log points.[11] The weighted standard deviation of the OP covariance term is higher across the service sectors than across the manufacturing sectors in our sample, also when measured relative to the mean, implying even greater variation in allocative efficiency within market services than within manufacturing. Variation in the OP term explains around a quarter of the (unweighted) variation in log labour productivity (average 1999-2013) across 20 sectors.

The trends in the OP covariance term for broad sector groups discussed in section 4.1 may reflect changes in allocative efficiency within disaggregate sectors as well as changes in the size of disaggregate sectors within the broad sector group. Table 4.2.1 also shows the OP covariance term calculated when sector shares are held constant over time. Differences in the profile over time between the mean allocative efficiency measure and the mean calculated with fixed sector shares reflect changes over time in sectoral employment shares. The two profiles are very similar so that the majority of the change in allocative efficiency for broad sectors arises as a consequence of changes within detailed sectors rather than as a consequence of sectoral shifts.

In Figures 4.2.1 and 4.2.2 we illustrate the OP covariance term for disaggregate sectors within manufacturing, including and excluding micro firms respectively. Consistent with Table 4.2.1 these illustrate significant differences between disaggregate sectors in allocative efficiency within manufacturing. In Figure 4.2.1 we see that the OP covariance term is significantly higher in the Food, beverages, tobacco sector, the Coke & petrol, chemicals, pharmaceuticals sector and the Transport equipment sector than in other sectors. When we exclude micro firms the OP covariance terms are much smaller (as in the case for the manufacturing sector as a whole) and there are less dramatic differences in measured allocative efficiency across sectors. Still, the same three sectors stand out as having relatively high allocative efficiency. In all 9 disaggregate sectors labour productivity is higher than it would be if employment shares were randomly distributed across firms.

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data. We found that the OP term is relatively independent of the unit of analysis (enterprise or establishment).

[11] Minor differences in log point averages to those implied by Figure 4.1.1 arise because of slightly different sector weights used in deriving the employment share weighted average across sectors.

In Figures 4.2.3 and 4.2.4 we turn to market services sectors. In all but the Administration & Support sector the OP covariance term between size and labour productivity is positive on average 1999-2013 (it is negative in some sectors for some sub-periods shown). This means that in most sectors, the covariance between market share (measured as employment share) and labour productivity levels within the sector contributed towards higher sector productivity. In the Administration & Support sector it would appear that labour productivity would be higher were more resources diverted from larger to smaller establishments. The Information & Communication sector is characterised by a relatively high covariance between size and labour productivity compared to all other sectors.

As mentioned above, the majority of change in allocative efficiency after 2007 arises because of changes within rather than between detailed sectors. In Figures 4.2.5 and 4.2.6 we illustrate the change in allocative efficiency after the financial crisis within disaggregate manufacturing sectors. We show the change in the OP covariance term between 2008-2010 and 2002-2007 and the change in the OP covariance term between 2011-2013 and 2002-2007, including and excluding micro firms respectively. In Figures 4.2.7 and 4.2.8 we show the same changes within disaggregate service sectors.

Looking first at disaggregate manufacturing sectors in Figures 4.2.5 and 4.2.6 we see that the increase in allocative efficiency within the manufacturing sector as a whole after the financial crisis was a phenomenon that was observed within most subsectors of manufacturing. The OP covariance term was higher on average in both 2008-2010 and 2011-2013 than on average over the period 2002-2007 in all sectors; when excluding micro firms in all but the Coke & petrol, chemicals, pharmaceuticals sector and the Rubber & plastics, Non-metallic mineral products sectors; two sectors that were already characterised by a relatively high correlation between size and labour productivity. It is difficult to say whether this increase in allocative efficiency after the financial crisis within disaggregate sectors reflected an increase in efficiency related to the fact that there was a recession, or whether this simply reflected the continuation of a trend that started before the crisis.

The relatively flat profile of the OP covariance term 2002-2013 for the service sector as a whole (when we exclude micro firms, Figure 4.1.2) reflects off-setting trends in the Retail sector versus other sectors. In the service sectors that we examine, Figure 4.2.7 and Figure 4.2.8 show that in all but the Retail sector the OP covariance term was higher (or at least as high) on average 2008-2010 and 2011-2013 as on average 2002-2007.

5. Decompositions of labour productivity growth

The previous section illustrated trends and differences across sectors in allocative efficiency as measured by the OP covariance term. Changes over time in the OP covariance term can be used to gauge the contributions of changes in allocative efficiency to productivity growth. If anything the data in the previous section suggests that allocative efficiency was higher during and after the recession than in the years leading up to the recession. These patterns differed across disaggregate sectors.

In this section we look at the contributions of resource reallocation to productivity growth, distinguishing the separate contributions of entry, exit and shifts in market share between incumbent firms over three-year periods (1998-2001, 2001-2004, 2004-2007, 2007-2010, 2010-2013) in different sectors.

5.1 Broad sector groups

In Figure 5.1.1 we illustrate how 3-year changes in UK market sector labour productivity can be accounted for by the separate contributions of within establishment productivity growth and compositional effects (entry, exit, and shifts in market share between incumbent firms). Resource reallocation contributed on average 4.7 percentage points to the 3-year productivity changes considered before the financial crisis, and a little less (4.1 percentage points) after the financial crisis. The large differences in productivity growth before and after the crisis can be accounted for by the reduction in the contribution to aggregate labour productivity growth of labour productivity growth within firms, as pointed out in Riley *et al.* (2014, 2015). Before the crisis, the reallocation of employment shares between incumbent firms accounted for around 70% of the 4.7 percentage point contribution of resource reallocation to aggregate productivity growth. Entry added around 1 percentage point and exit added around ½ percentage points to labour productivity every three years. After the recession market share shifts between incumbent firms contributed less to labour productivity growth and entry became a drag on growth (2010-2013). The reduced contribution to growth of entry and employment shifts between incumbent firms was partially offset by an increase in the growth contribution of exitors; exitors accounted for more than half the contribution of resource reallocation to aggregate labour productivity growth in the market sector after 2007.[12]

[12] In Appendix Figure B.2 we show results excluding establishments with less than 10 employees; these are similar to those in Figure 5.1.1. Appendix Figure B.3 shows the decomposition when we hold sector shares constant over each three year growth period. This gives a near identical picture to that in Figure 5.1.1.

In Figure 5.1.2 we look at the manufacturing sector. Average labour productivity growth before the recession was higher in manufacturing than for the market sector as a whole. This appears mostly to have been because the within firm contribution to aggregate labour productivity growth was higher in manufacturing than in the rest of the economy. The contribution of resource allocation in manufacturing was similar to that of the market sector as a whole, adding on average 5 percentage points to 3-year labour productivity change. This contribution reduced after the financial crisis, with resource allocation adding only 2.2 percentage points to 3-year labour productivity change in manufacturing on average after the crisis (average 2007-2010 and 2010-2013), because of a reduction in the contribution of market share changes between incumbent firms and the contribution of entering firms.

The sources of growth in the construction sector (see Figure 5.1.3) appear to be quite different to the market sector taken as a whole. Within firm shifts in productivity tend to reduce aggregate labour productivity growth in the construction sector. On average over the period shown 3-year changes in construction sector labour productivity were nevertheless positive. This can be attributed entirely to the reallocation of resources across firms. The contribution of market share shifts between incumbent firms to construction sector labour productivity growth was positive in all 3-year periods considered and was on average the largest source of growth in the sector. Entry effects were a significant source of growth before the recession. Since the recession the contribution of firm exit has been more important.

The contributions to labour productivity growth in the service sector (see Figure 5.1.4) very much mimic what we observe for the market sector as a whole, which is dominated by the service sector.

5.2 Disaggregate sectors

We report the contributions of entry, exit, market share shifts between incumbent firms and within firm productivity changes to 3-year labour productivity changes in 9 disaggregate manufacturing sectors and 10 disaggregate service sectors. In Tables 5.2.1 and 5.2.2 we show these on average before the recession (average of 3-year changes 2001-2004 and 2004-2007) and on average after the financial crisis (average of 3-year changes 2007-2010 and 2010-2013). We also show the *difference* to the pre-crisis period in growth contributions arising from within firm shifts and compositional effects on average after the financial crisis, 2007-2010, and 2010-2013. Results for each 3-year change are shown in Tables 5.2.3 and 5.2.4. Note that the detailed sector productivity profiles implied by these tables may differ substantially from those reported elsewhere. This is well-known (Franklin & Murphy, 2014) and partly because sample sizes get smaller when we analyse the data in more detail, something that is particularly pertinent to the longitudinal data. For these reasons the disaggregated sector results are less robust than those that we can generate for broader sectors.

Before the recession the contribution of resource reallocation to labour productivity growth in manufacturing was positive in all but the Food, beverages, tobacco sector, where on average over the two pre-recession periods 2001-2004 and 2004-2007 compositional effects reduced 3-year labour productivity growth by a little more than 2 percentage points (see Table 5.2.1). The contribution of compositional effects was greatest in the Textile & leather products sector and the Coke & petrol, chemicals, pharmaceuticals sector where compositional effects added 9 and 10 percentage points to 3-year labour productivity growth on average pre-recession, respectively. In 4 of 9 manufacturing sectors compositional effects accounted for more than half of 3-year labour productivity changes before the recession. Although compositional effects are important for sectoral labour productivity growth, the variation across sectors in these contributions explains less than a fifth of the variance in sectoral labour productivity growth (on average 2001-2013).

The weakness of compositional effects in the Food, beverages, tobacco sector before the recession was due to the contribution of market share shifts between incumbent firms appearing particularly weak in this sector. The contribution of market share shifts between incumbent firms was an important source of growth in all other sectors, adding between 1 and 6 percentage points to 3-year labour productivity growth before the recession. In the Textile & leather products and Transport equipment sectors the relatively large contributions of compositional effects to sector level productivity growth arose because of the significant contribution of exit (low productivity firms leaving the market). In the six years before the recession exit effects were on average positive in all sectors except the Coke & petrol, chemicals, pharmaceuticals sector. Over the same period entering firms reduced labour productivity growth (evaluated over 3 years) in four of the manufacturing sectors shown (entrants are typically less capital intensive than incumbents and have more scope for learning).

After 2007 sector level labour productivity growth was significantly weaker in all disaggregate manufacturing sectors shown in Table 5.2.1 (comparing 2007-2013 with 2001-2007), except the Transport equipment sector. The contributions of compositional effects to labour productivity growth were positive in all but the Transport equipment sector. But, were less than they had been prior to the recession in almost all sectors (the exceptions was the Food, beverages, tobacco sector).[13] While this contributed to the weakness of sector level labour productivity

[13] This is in contrast to the stable pattern of (rather than falling) *growth* in the OP covariance coefficient in manufacturing (on average before and after the recession) shown in the previous section. Note that, in addition to differences in what changes in the OP covariance term and compositional effects measure, the OP covariance term is estimated on a sample that includes many more small firms.

growth after the financial crisis relative to its pre-crisis trend, in 6 out of the 9 manufacturing sectors most of this weakness was accounted for by the fall in labour productivity growth within incumbent firms. This was evident both 2007-2010 and 2010-2013. In the data we use labour productivity growth was less 2010-2013 than 2007-2010 in all but the Basic metals & fabricated metals and Transport equipment sectors. Overall, the change in manufacturing labour productivity was similar 2010-2013 and 2007-2010 (see Figure 5.1.2).

Turning to disaggregate service sectors in Table 5.2.2 we see that before the recession the contribution of resource reallocation to labour productivity growth was positive in all sectors except Professional & Scientific services, adding 2 to 8 percentage points to 3-year changes in labour productivity on average 2001-2007 and accounting for the majority of labour productivity growth in 4 of 10 service sectors. Sectoral variation in the contribution of resource reallocation accounted for a quarter of the sectoral variation in labour productivity growth (and only a tenth of the sectoral variation in labour productivity growth averaged over time).

Market share shifts between incumbent firms were typically the most significant cause of this contribution, with entry being relatively more important in the Information & Communication, Professional & Scientific and Administration & Support sectors. The growth contribution of net entry (entry less exit) was negative in the Wholesale, Arts & Entertainment and Other Services sectors; the growth contribution of net entry was positive elsewhere.

After the recession sector level labour productivity growth in these data was significantly weaker in all disaggregate service sectors shown in Table 5.2.2 except the Transport & Storage sector. The contributions of compositional effects to labour productivity growth were positive in all services sectors, except Other Services, but were smaller in magnitude than they were prior to the crisis in 5 out of 10 sectors. In 8 out of 10 service sectors the majority of post-crisis labour productivity stagnation was accounted for by the fall in labour productivity growth within incumbent firms relative to the situation before 2008; evident in both 2007-2010 and 2010-2013. Overall service sector labour productivity growth remained weak relative to the pre-crisis trend (see Figure 5.1.4) in 2010-2013, albeit slightly stronger than 2007-2010. This pattern of a pick-up in growth in 2010-2013 was evident in most sectors, except the Wholesale and the Admin & Support sectors. In 2010-2013 compositional effects added less to service sector growth than in 2007-2010 in 6 of 10 service sectors.

5.3 Alternative decomposition methods

In Figures 5.3.1-5.3.3 we show the sources of manufacturing sector labour productivity growth using alternative productivity growth decompositions (MP, GR and FHK decompositions). These

figures should be compared to our main results for manufacturing in Figure 5.1.2.[14] These alternative decomposition methods suggest that compositional effects were equally or more important in accounting for growth before the financial crisis than our main results suggest. The MP decomposition is perhaps most different, suggesting that compositional effects added on average 7.5 percentage points to 3-year labour productivity growth in manufacturing before the crisis (in contrast to our main results, which suggest a contribution of around 5 percentage points). This arises because of a much larger contribution from market share shifts between incumbent firms (entry and exit contributions are per definition no different to our main results) than in our main results. The GR and FHK decompositions show slightly larger contributions from net entry for the reasons discussed in the methodology section. For these same reasons the GR and FHK decompositions shown here suggest that the contribution of compositional effects to the stagnation in manufacturing productivity after 2007 was more significant than our main results suggest.

In Figures 5.3.4-5.3.6 we show the sources of service sector labour productivity growth using the same three alternative productivity growth decompositions. These figures should be compared to our main results for services in Figure 5.1.4. A few things stand out. First, the sources of service sector growth as characterised by the MP decomposition are more variable across time periods than those that can be obtained by other decompositions. Second, the contribution of compositional changes to labour productivity growth in market services using the FHK decomposition are on average much smaller than calculated using other methods.[15] The FHK decomposition suggests that before the recession most labour productivity growth in the service sector was due to labour productivity changes within firms (similar to the findings of Mason *et al.*, 2014).[16] All decomposition methods suggest that the contribution of resource allocation

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[14] The FHK decomposition includes an additional term (the third sum in (A3), the "cross" firm component), which captures the covariance between changes in market shares and changes in productivity amongst continuing firms. Following Disney *et al.* (2003) and Harris & Moffat (2013) we include this term too as restructuring that is external to the firm, i.e. due to market activity rather than due to productivity changes internal to the firm.

[15] That is, unless we exclude the “cross” firm component from compositional changes in the FHK decomposition.

[16] The within component is also more important, regardless of decomposition technique, when we use the alternative employment measure that utilises both the survey and sampling frame employment measures in the ARD (see Appendix Figure B.4). Note that the correlation across the 20 sectors we examine, between the components of growth derived using sampling frame employment (shown in Tables 5.2.3 and 5.2.4) and the components of growth derived using the alternative employment measure, is around 2/3 for each the between and within components and close to 1 for each the entry and exit components (less in earlier years).

(entry, exit and market share shifts between incumbent firms) was similar or slightly less on average after the crisis than before; slightly less 2010-2013.

In Table 5.3.1 we report the correlation across the 20 sectors in our analysis of the growth components from the MP, GR and FHK decompositions with the growth components from the DF decomposition, which we use to calculate our main results. As shown there the GR and DF growth components are highly correlated across sectors. The entry and exit components of the MP decomposition are perfectly correlated with the equivalent DF components (by definition). But, the correlation of the MP and DF between and within components for incumbent firms is much weaker; differences are most apparent in the between component and are likely to arise in part due to the sensitivity of the MP decomposition in small samples. The growth components of the FHK decomposition are reasonably highly correlated with the DF components across sectors. Again it is the between component where the correlation is weakest.

6. Conclusion

This report assesses the importance of compositional changes in the UK business population for sector level labour productivity growth 1998-2013. It also provides measures of the importance of allocative efficiency for labour productivity levels. The analysis here builds on and updates the analysis in Mason *et al.* (2014), which considered sources of sector level labour productivity growth 1998-2007. Compared to other recent papers for the UK, we provide a more sectorally disaggregated breakdown for the period after the financial crisis.

There are a number of components to our analysis. The first analytical strand considers the static decomposition of labour productivity levels. We calculate the Olley-Pakes measure of allocative efficiency for 20 sectors over different time periods and find a positive correlation between labour productivity and firms' market (employment) share in most sectors and time periods, the magnitude of which varies significantly across sectors. The variance in the OP term accounts for around a quarter of the variance in log labour productivity across sectors. Our results also suggest that allocative efficiency in the UK market sector was higher, or no less, after the financial crisis than before. An increase in allocative efficiency after the financial crisis was observed within many subsectors.

Examining dynamic decompositions we find, in line with a number of the plant level studies for the UK and other countries, that much of labour productivity growth is the result of the reallocation that takes place within and between continuing firms rather than as a result of entry and exit of firms. We find that the combined effect of compositional changes (market share changes, entry and exit) is non-negligible, adding on average over the sample period 3 to 4 percentage points to 3-year labour productivity growth. This result depends on the choice of

decomposition method. The oft used FHK decomposition could suggest the importance of compositional effects for labour productivity growth is less.

We find that resource reallocation plays an important role for sectoral labour productivity growth in most of the 20 disaggregate sectors that we analyse, but to differing degrees. Compositional effects supported sectoral labour productivity growth both before and after the financial crisis, but a little less after 2007 than before, particularly after 2010. Our results suggest that the recession led to a widespread fall in sectoral labour productivity growth which occurred first and foremost within surviving firms within sectors.

Our analysis emphasises the importance, in arithmetic terms, of compositional effects in determining both aggregate and sectoral labour productivity performance. It suggests that aggregate patterns mask considerable variation in allocative efficiency and the sources of growth across different sectors, the reasons for which we do not explore in this paper. Yet, the variation across sectors in the contribution of compositional effects accounts for less than a fifth of the variation in labour productivity growth across sectors (averaged over time). Hence, in seeking to explain sectoral differences in labour productivity growth one must look elsewhere.

Our analysis also points to some important commonalities across sectors. In particular, the tendency for higher productivity firms to have higher market (employment) share is evident in almost all sectors and time periods. Furthermore, allocative efficiency generally added more to labour productivity levels on average over the period after the financial crisis than over the period before. In other words, in most sectors the allocation of resources across firms would appear to have been at least as efficient, i.e. productivity enhancing, during the recession and stagnation as it was before. Another common observation across sectors is that compositional effects tend to add to labour productivity growth (evaluated over 3 year periods). This was also the case after 2007, albeit a bit less than before. We find that labour productivity growth both 2007-2010 and 2010-2013 was low relative to its pre-crisis trend in almost all sectors. Partly this was because resource reallocation provided less of a boost to labour productivity, particularly in manufacturing and retail, but in the majority of sectors characterised by productivity weakness this was more to do with productivity weakness within firms.

In considering the underlying causes of the "productivity puzzle" in the UK, the analysis presented in this paper suggests that any explanation or set of explanations needs to be consistent with a very broad-based shift in productivity within firms within relatively detailed and disparate sector groups. While there are differences across sectors in the extent to which productivity can be regarded as weak post crisis, there is nevertheless a relatively clear general

trend across sectors.[17] Note also that the results for the aggregate market sector in this paper are not due to shifts in employment towards low productivity sectors, but arise because of trends in the sources of growth within detailed sectors.[18]

One of the prominent and popular explanations for UK productivity weakness is the idea that the allocation of resources has become less efficient since the financial crisis.[19] But the evidence for this is scarce. While, we find some evidence that the contributions of compositional effects to labour productivity growth weakened 2010-2013 in many of the sectors we consider, neither the sectoral OP covariance terms nor the productivity contributions of compositional effects within detailed sectors point to UK productivity stagnation associated with a substantial drop in the efficiency of resource allocation.[20] These findings do not categorically prove that the financial crisis did not affect the efficiency of resource reallocation. This is because we do not have a clear counterfactual against which to compare outcomes. For example, it is unclear whether we should have expected an increase in the contributions of resource reallocation associated with the economic downturn, or whether we should have seen a reduction in these contributions due to heightened uncertainty.

The analysis in this paper uses information available in the ARD. We highlight a number of data issues and methodological choices involved in working with the data, which mean that caution is required when comparing results over time and across studies. We find that patterns in labour productivity for broad sectors prove similar to those implied by other sources, but the detailed sector productivity patterns generated here may differ more substantially from those implied by alternate data sources and whether using the cross-sectional or longitudinal aspects of the data. Inherently, results for a particular detailed sector are likely less robust than for more aggregated sectors. Furthermore, as is the case in most uses of firm level data, we do not have detailed information on firm level prices. This means that real labour productivity is measured with error

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[17] Note we do not include the financial or mining sectors in our analysis, which are considered to contribute disproportionately to UK productivity weakness relative to trend (see e.g. Goodridge *et al.*, 2015).

[18] We do not account for the reallocation of labour between sectors. Goodridge *et al.* (2015) find that the gap between post-crisis labour productivity and the trend implied by pre-crisis productivity growth would have been even (slightly) larger were it not for between sector shifts in employment. Barnett *et al.* (2014) find that in terms of the productivity puzzle reallocation between sectors explains very little. Data sources and sector coverage differ in these studies.

[19] *Fixing the foundations: Creating a more prosperous nation.* HMT. July 2015.

[20] The analysis in this paper does not allow us to draw conclusions about the relative contribution to the productivity puzzle of capital shallowing versus TFP changes.

across individual firms, which may affect the relative contributions of continuing firms, entrants and exitors.[21]

These caveats aside, the analysis here illustrates the importance of allocative efficiency in determining aggregate productivity levels and the importance of firm growth dynamics for aggregate labour productivity growth in the UK over the last 15 years. The magnitudes of these effects are material in most sectors. However, in terms of understanding sectoral differences in growth, it is more important to understand why productivity within continuing firms grows more quickly in some sectors than in others. Most of the variation in sectoral labour productivity growth performance arises due to differences in within firm growth performance rather than differences in the contributions of market share shifts.

[21] As highlighted in Barnett *et al.* (2014) and by others, industry level deflators may understate the level of labour productivity in young firms relative to older firms because younger firms tend to offer lower prices. This may affect the evaluation of the contributions of firm entry to sector level labour productivity growth.

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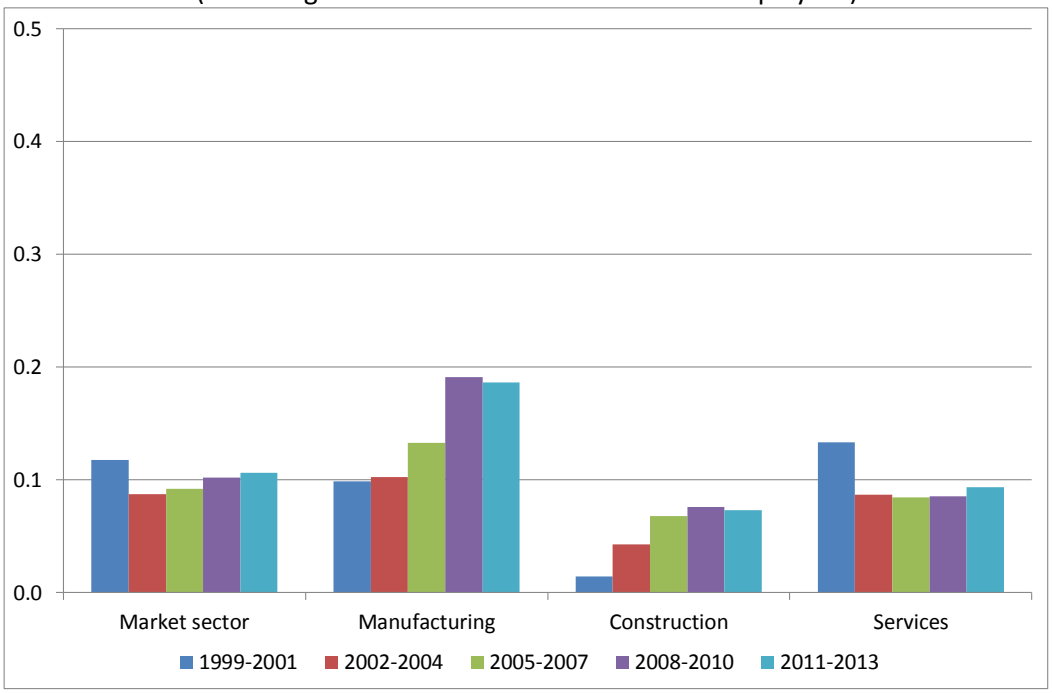
Figures

Figure 4.1.1 Olley-Pakes covariance term between employment share and labour productivity

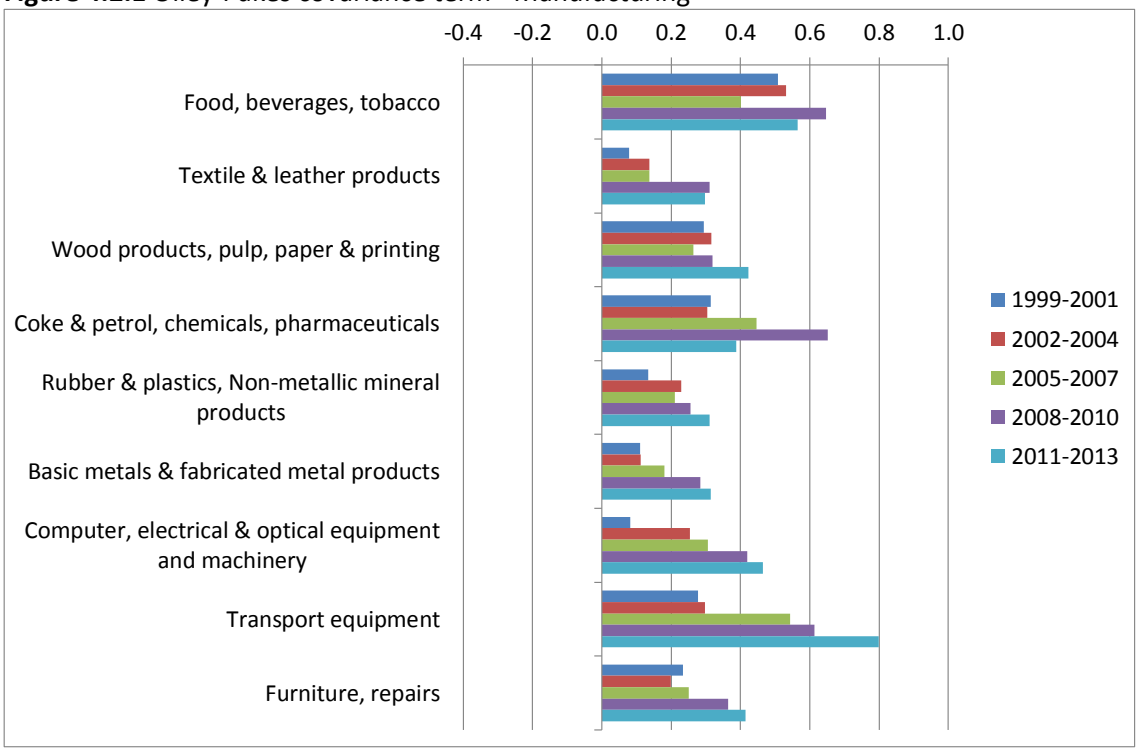
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. Financial services and real estate excluded. Market sector as measured here includes manufacturing, construction and services less financial services and real estate. British establishments with two or more persons employed.

Figure 4.1.2 Olley-Pakes covariance term between employment share and labour productivity (excluding establishments with less than 10 employees)



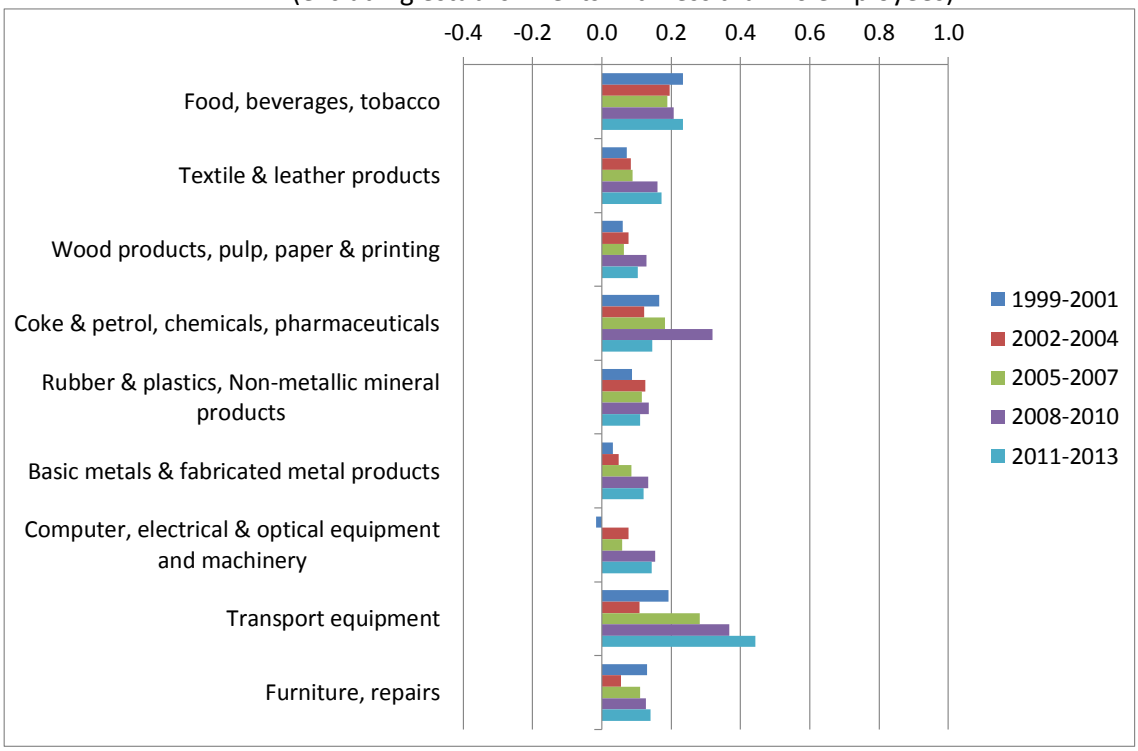
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. Financial services and real estate excluded. Market sector as measured here includes manufacturing, construction and services less financial services and real estate. British establishments with 10 or more persons employed.

Figure 4.2.1 Olley-Pakes covariance term - Manufacturing



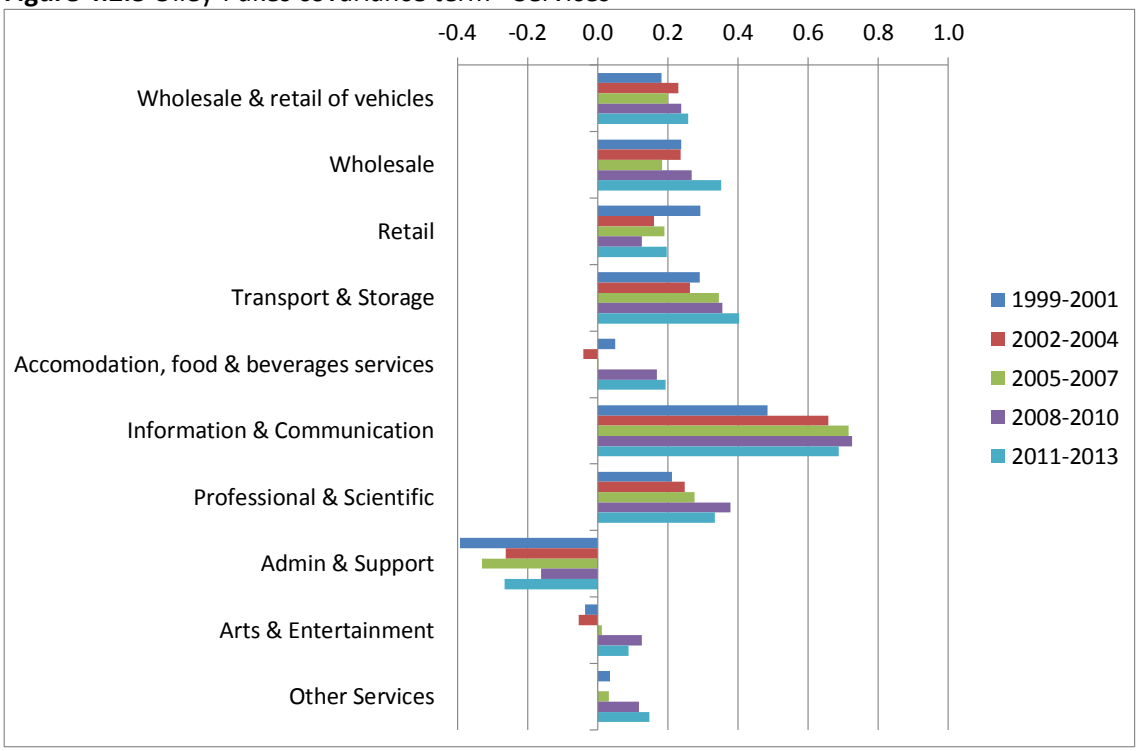
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. British establishments with two or more persons employed.

Figure 4.2.2 Olley-Pakes covariance term - Manufacturing
(excluding establishments with less than 10 employees)



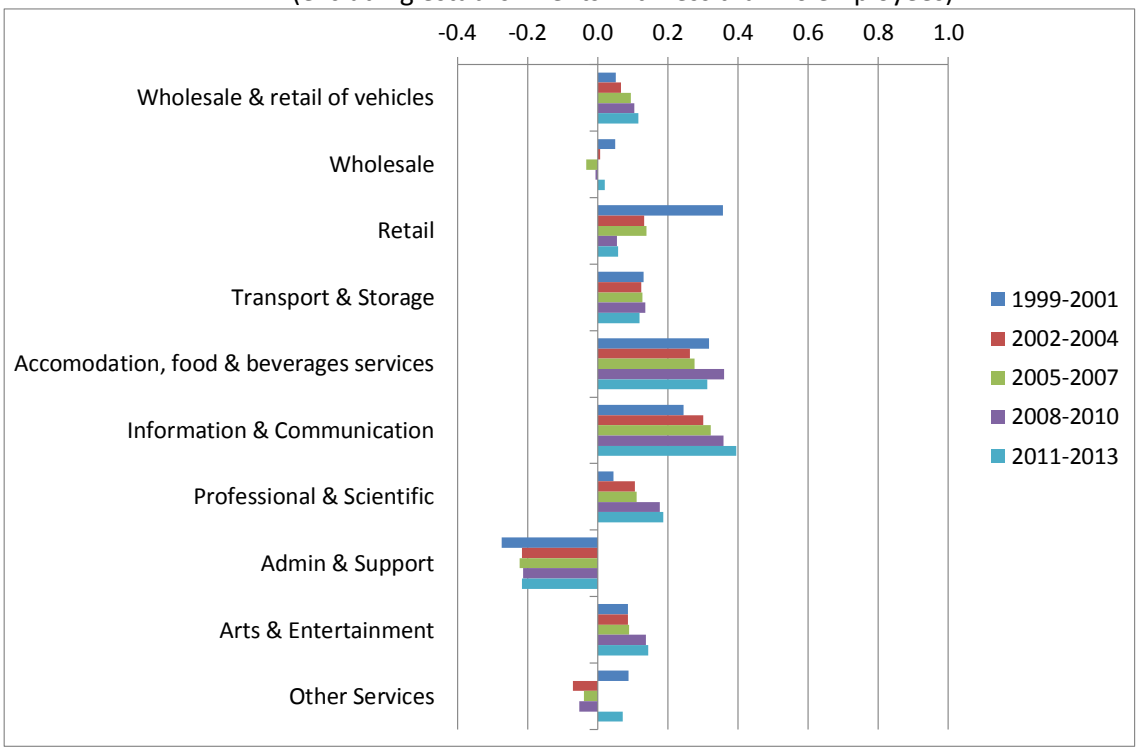
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. British establishments with 10 or more persons employed.

Figure 4.2.3 Olley-Pakes covariance term - Services



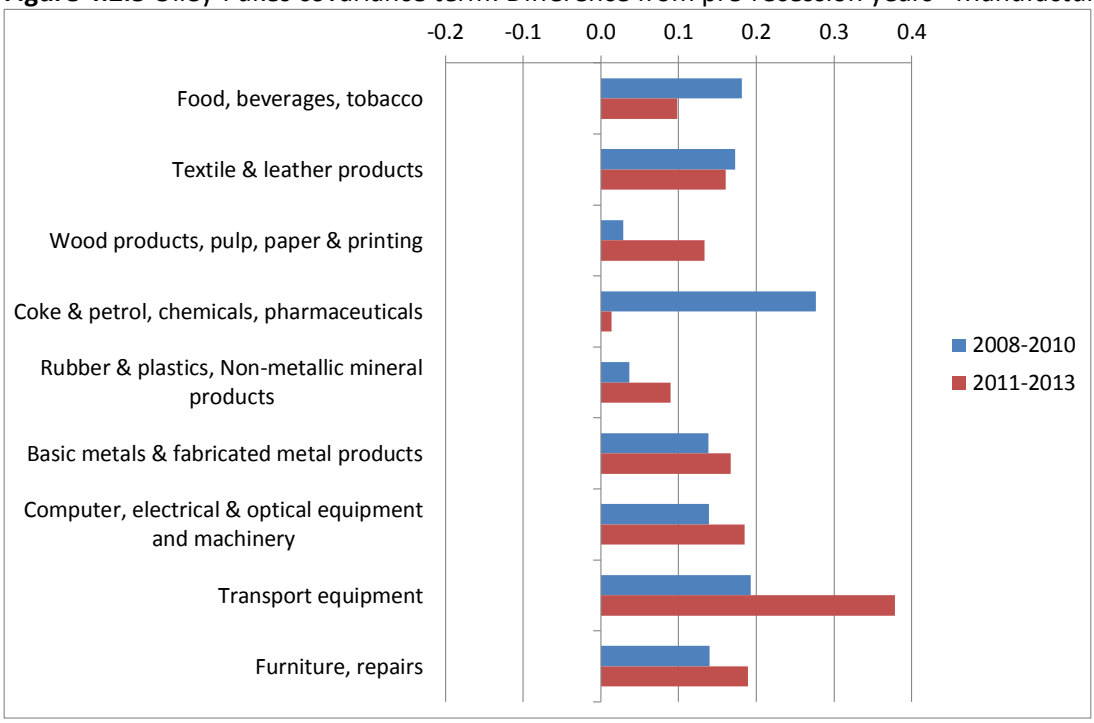
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. British establishments with two or more persons employed.

Figure 4.2.4 Olley-Pakes covariance term - Services
(excluding establishments with less than 10 employees)



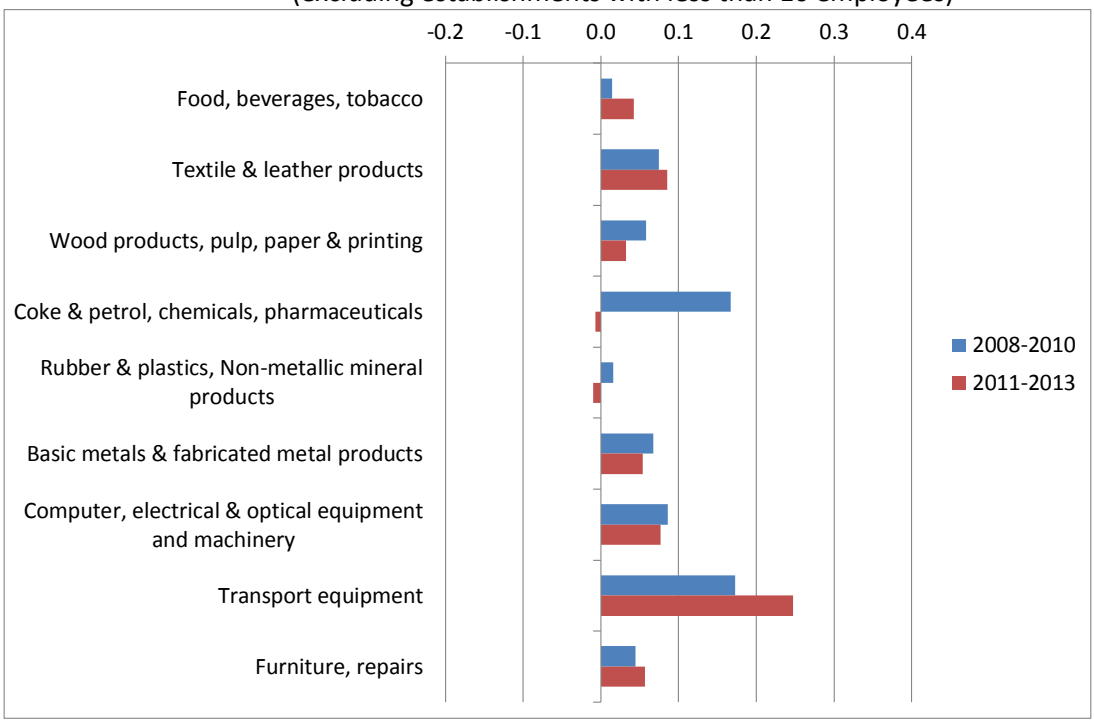
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. British establishments with 10 or more persons employed.

Figure 4.2.5 Olley-Pakes covariance term: Difference from pre-recession years - Manufacturing



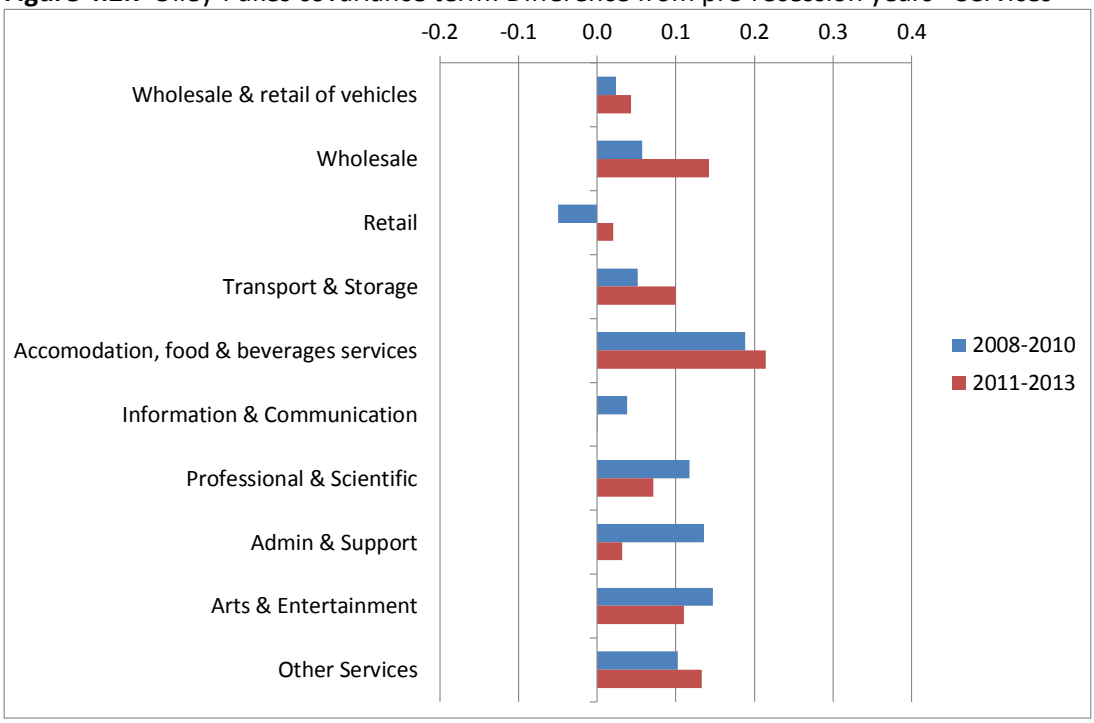
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. British establishments with two or more persons employed. Change is difference from average 2002-2007.

Figure 4.2.6 Olley-Pakes covariance term: Difference from pre-recession years - Manufacturing (excluding establishments with less than 10 employees)



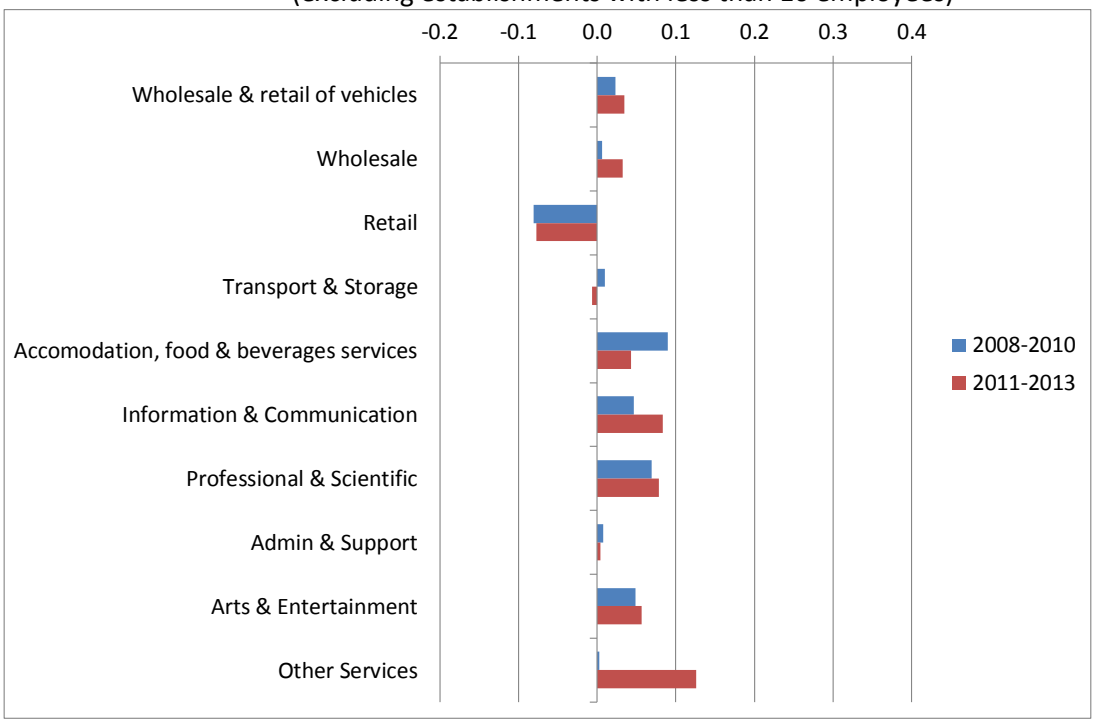
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. British establishments with 10 or more persons employed. Change is difference from average 2002-2007.

Figure 4.2.7 Olley-Pakes covariance term: Difference from pre-recession years - Services



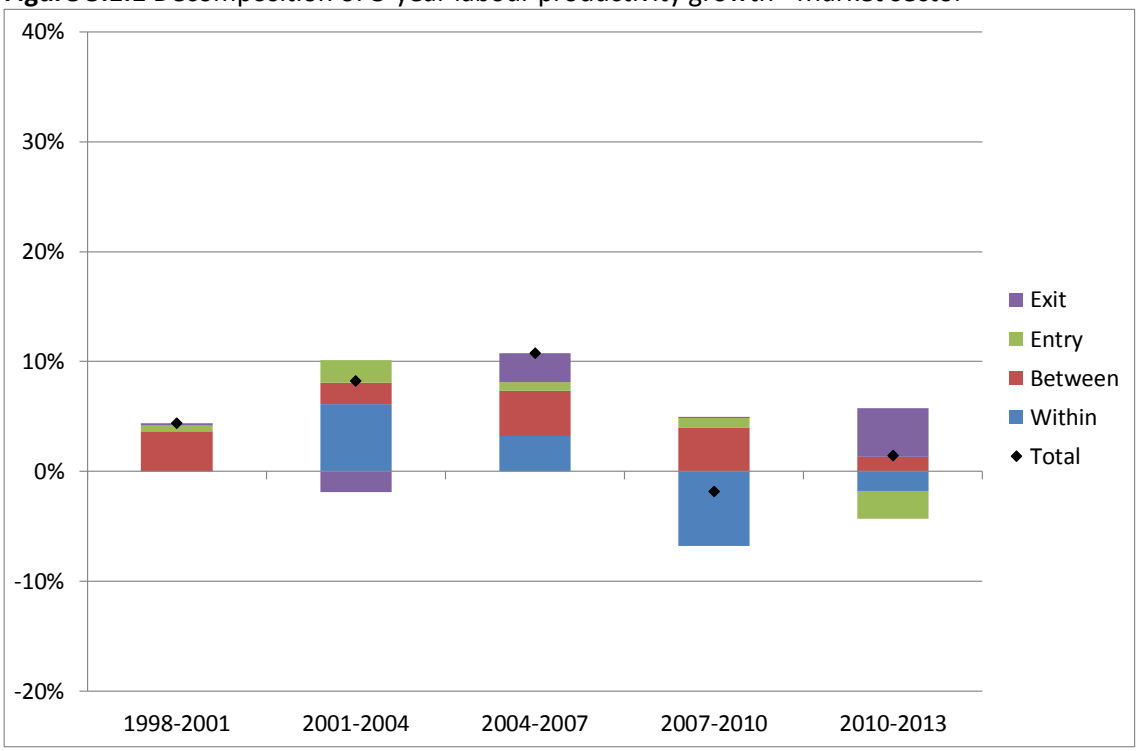
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. British establishments with two or more persons employed. Change is difference from average 2002-2007.

Figure 4.2.8 Olley-Pakes covariance term: Difference from pre-recession years - Services (excluding establishments with less than 10 employees)



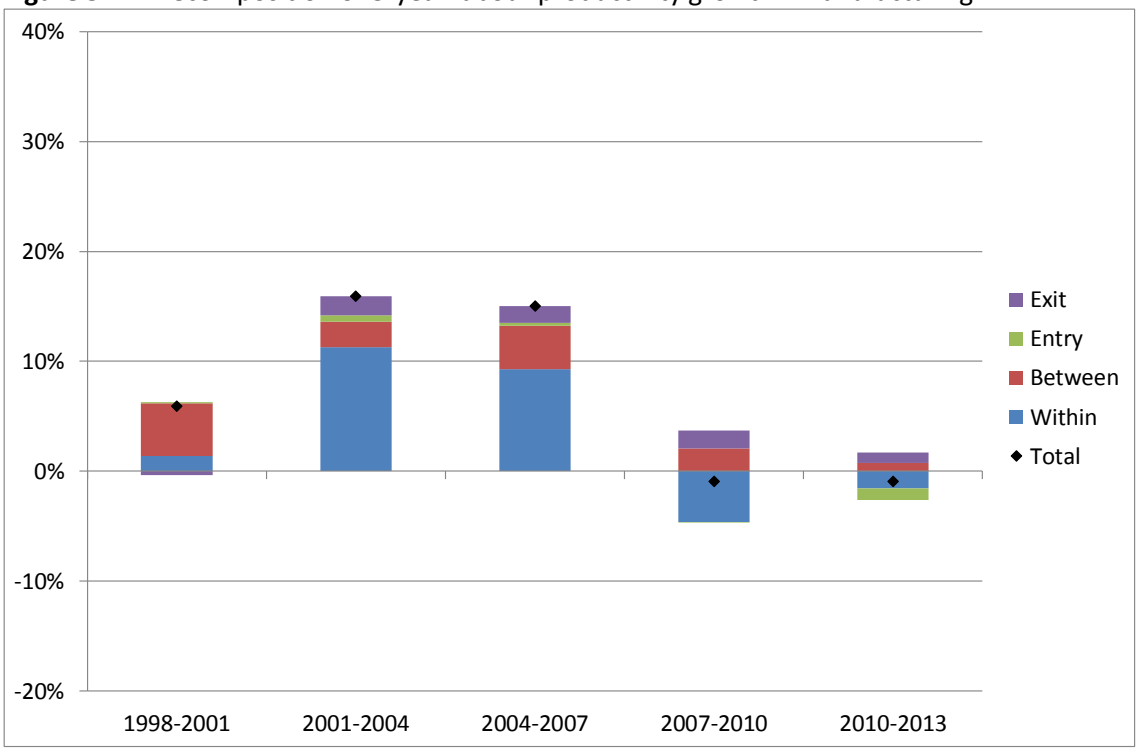
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. British establishments with 10 or more persons employed. Change is difference from average 2002-2007.

Figure 5.1.1 Decomposition of 3-year labour productivity growth - Market sector



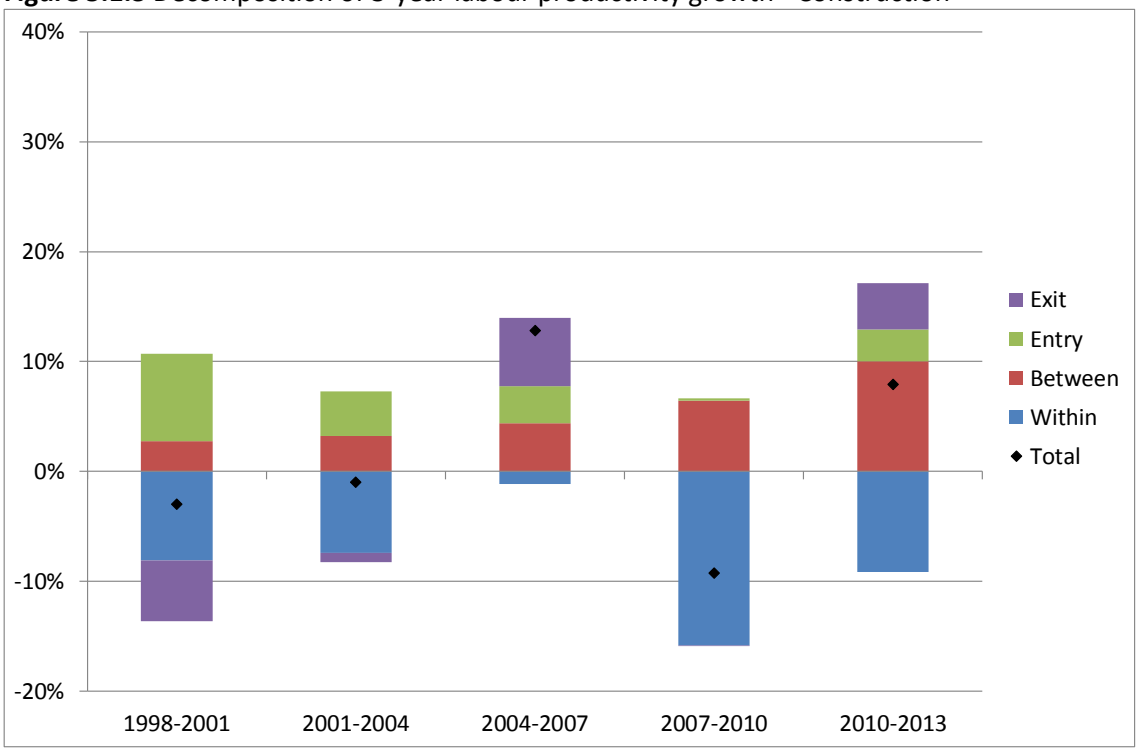
Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. Market sector as measured here includes manufacturing, construction and services less financial services and real estate. British establishments with two or more persons employed.

Figure 5.1.2 Decomposition of 3-year labour productivity growth - Manufacturing



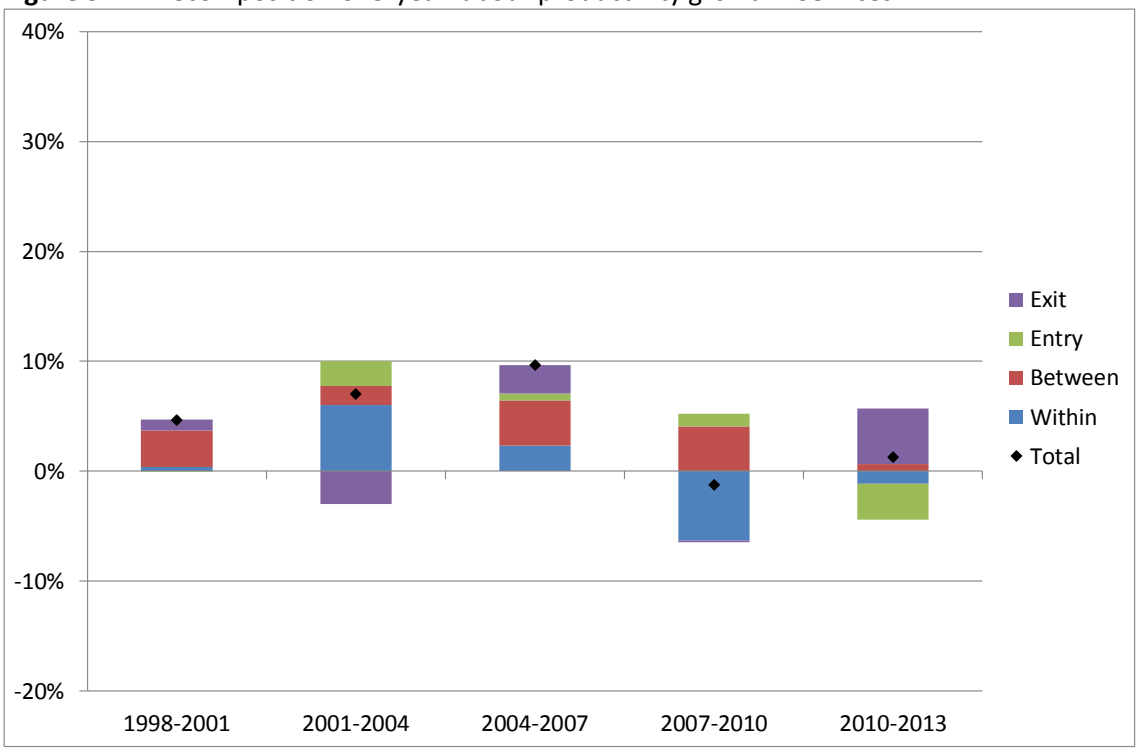
Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. British establishments with two or more persons employed.

Figure 5.1.3 Decomposition of 3-year labour productivity growth - Construction



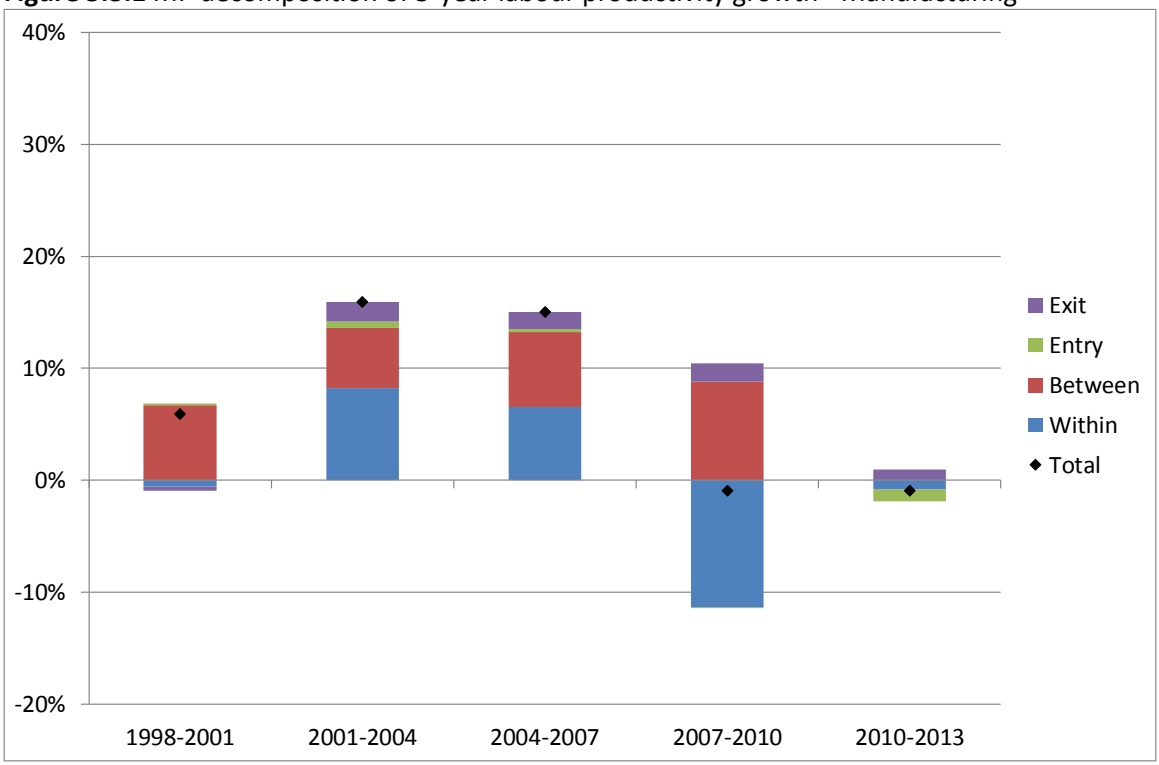
Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. British establishments with 10 or more persons employed.

Figure 5.1.4 Decomposition of 3-year labour productivity growth - Services



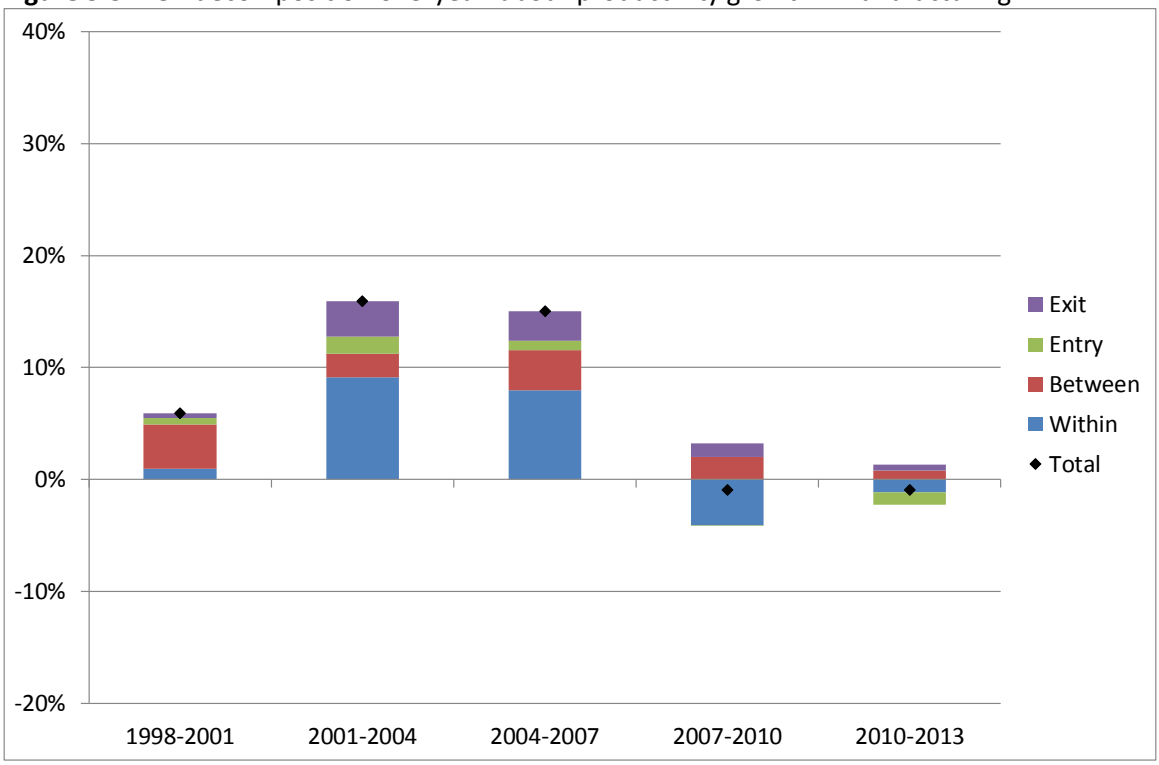
Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. Financial services and real estate excluded. British establishments with two or more persons employed.

Figure 5.3.1 MP decomposition of 3-year labour productivity growth - Manufacturing



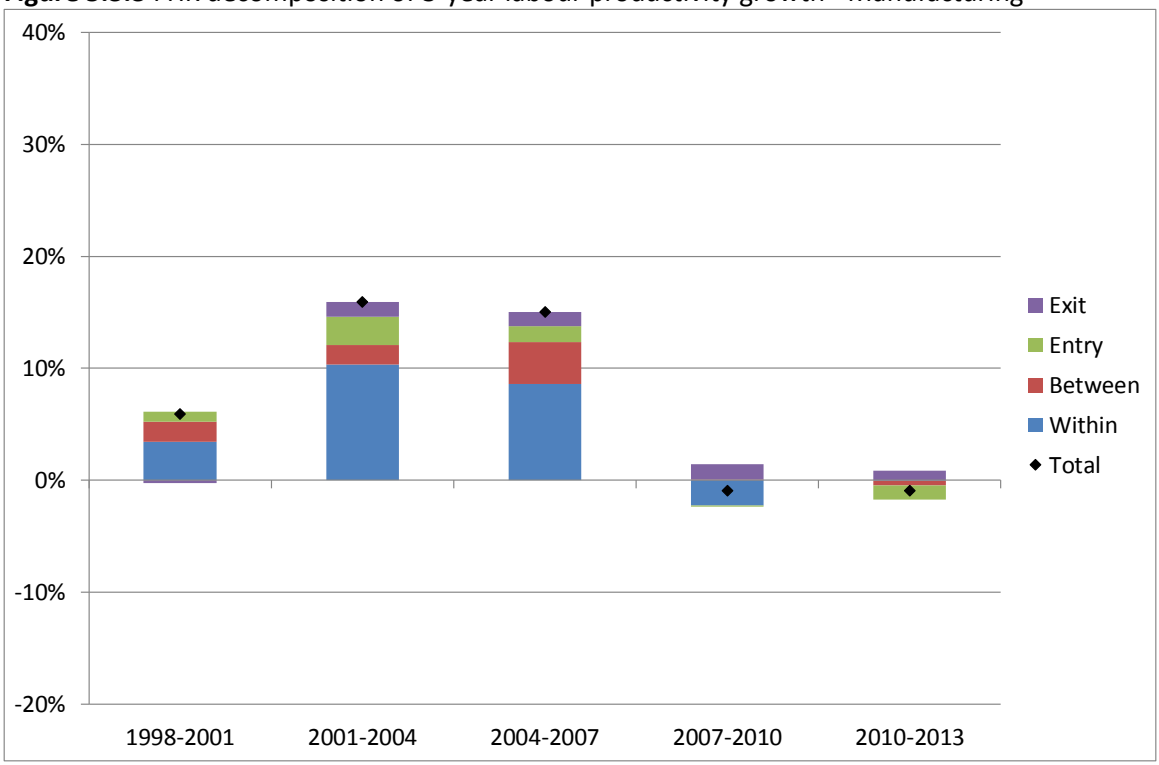
Source: ARD, ONS. Authors' calculations.
Note: British establishments with two or more persons employed.

Figure 5.3.2 GR decomposition of 3-year labour productivity growth - Manufacturing



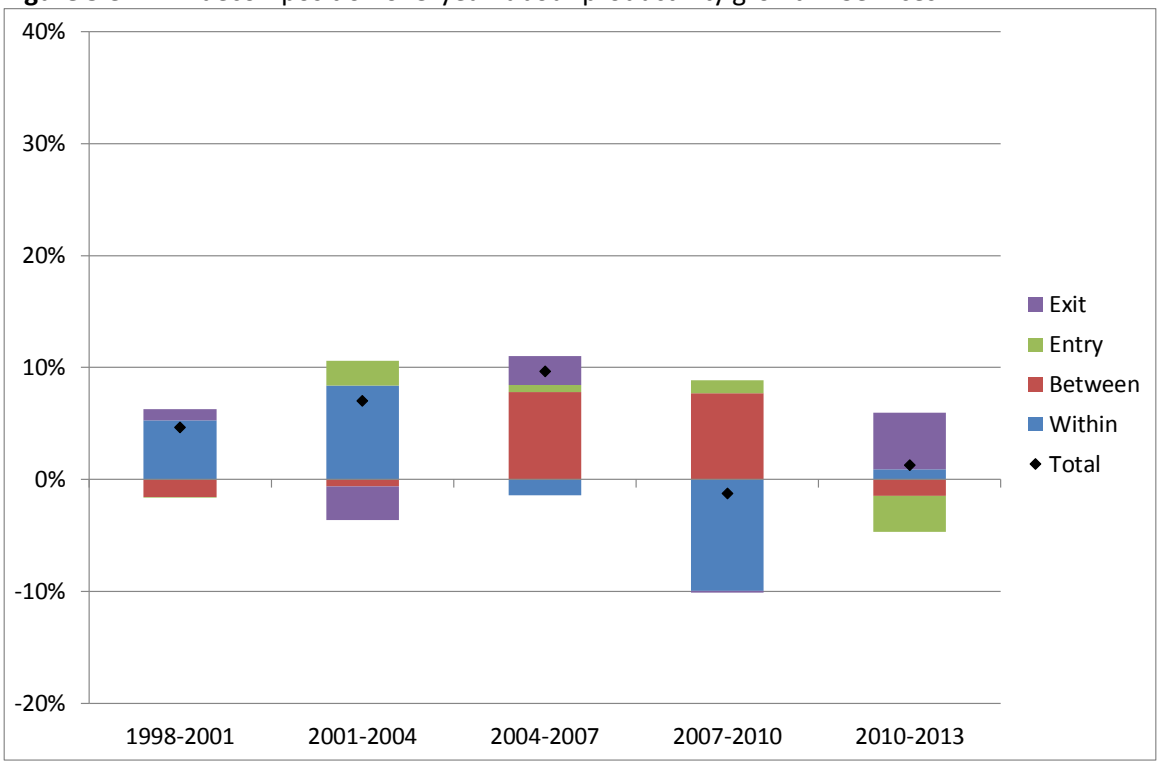
Source: ARD, ONS. Authors' calculations.
Note: British establishments with two or more persons employed.

Figure 5.3.3 FHK decomposition of 3-year labour productivity growth - Manufacturing



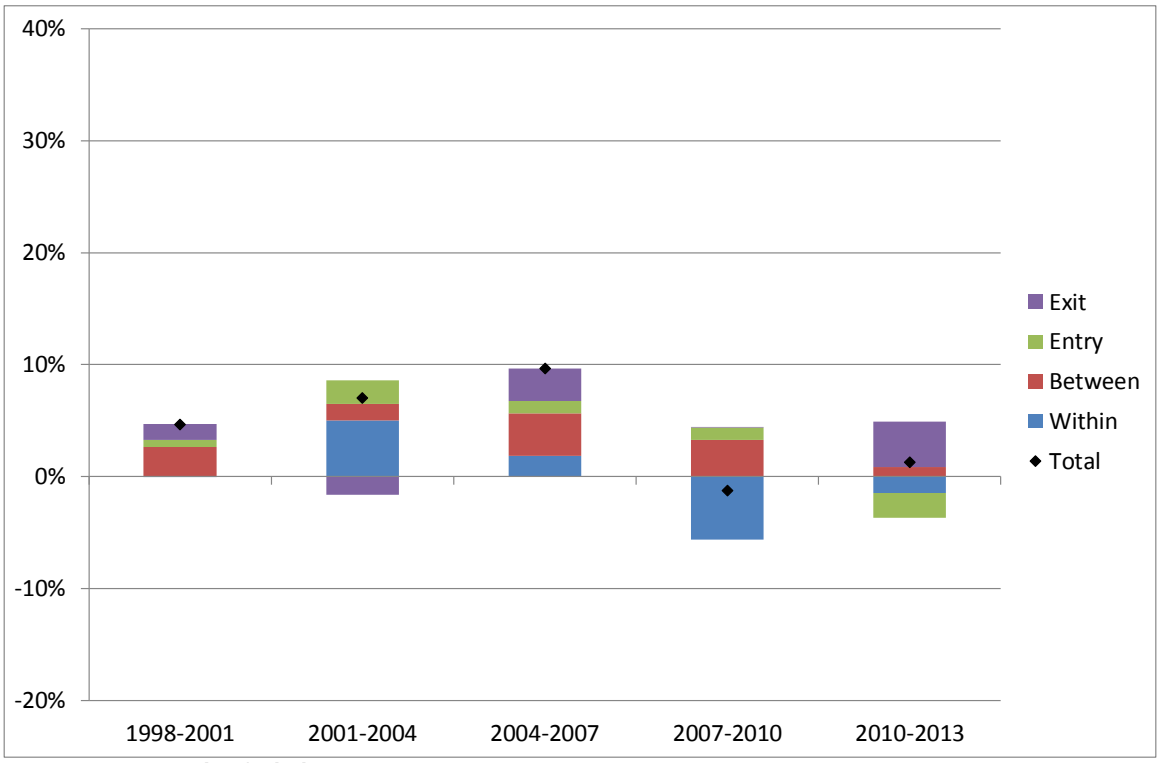
Source: ARD, ONS. Authors' calculations.
Note: British establishments with two or more persons employed.

Figure 5.3.4 MP decomposition of 3-year labour productivity growth - Services



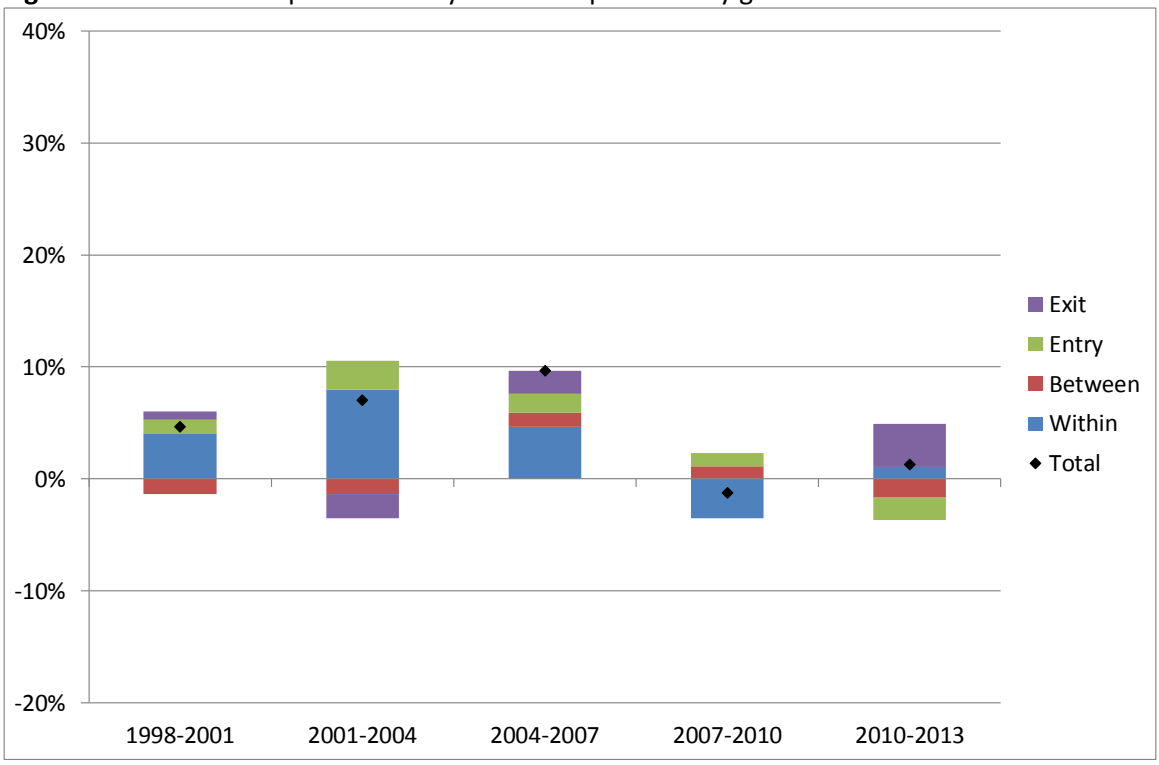
Source: ARD, ONS. Authors' calculations.
Note: Financial services and real estate excluded. British establishments with two or more persons employed.

Figure 5.3.5 GR decomposition of 3-year labour productivity growth - Services



Source: ARD, ONS. Authors' calculations.
Note: Financial services and real estate excluded. British establishments with two or more persons employed.

Figure 5.3.6 FHK decomposition of 3-year labour productivity growth - Services



Source: ARD, ONS. Authors' calculations.
Note: Financial services and real estate excluded. British establishments with two or more persons employed.

Tables

Table 4.2.1 Olley-Pakes covariance term - Distribution across detailed sectors

	1999-2001	2002-2004	2005-2007	2008-2010	2011-2013
Market sector					
Mean	0.166	0.166	0.188	0.246	0.267
Std Dev	0.213	0.213	0.232	0.214	0.246
assuming constant sector shares					
Mean	0.161	0.167	0.187	0.255	0.275
Std Dev	0.223	0.212	0.236	0.215	0.235
Manufacturing					
Mean	0.217	0.274	0.311	0.437	0.459
Std Dev	0.142	0.123	0.117	0.152	0.149
assuming constant sector shares					
Mean	0.226	0.275	0.309	0.433	0.454
Std Dev	0.144	0.125	0.118	0.150	0.146
Services					
Mean	0.151	0.136	0.155	0.208	0.227
Std Dev	0.240	0.232	0.251	0.215	0.253
assuming constant sector shares					
Mean	0.148	0.141	0.152	0.212	0.226
Std Dev	0.246	0.230	0.257	0.217	0.241

Source: ARD, ONS. Authors' calculations.
Note: Means and standard deviations (weighted by sector employment shares) calculated across 9 manufacturing sectors and 10 service sectors. Market sector includes manufacturing and service sectors as well as construction. Where we assume constant sector shares sector shares are calculated as an average 1998-2013. Mean (*not* assuming constant sector shares) differs slightly from that reported in Figure 4.1.1 due to differences in the sector weights used there.

Table 5.2.1 Decomposition of 3-year labour productivity growth before and after 2007 - Manufacturing sectors

3-year changes*		Food, beverages, tobacco	Textile & leather products	Wood products, pulp, paper & printing	Coke & petrol, chemicals, pharmaceuticals	Rubber & plastics; Non-metallic mineral products	Basic metals & fabricated metal products	Computer, electrical & optical equipment and machinery	Transport equipment	Furniture, repairs
2001-2007	Within	0.139	0.086	0.006	0.060	0.000	0.093	0.205	0.155	0.067
	Between	-0.010	0.039	0.012	0.017	0.057	0.041	0.041	0.050	0.044
	Entry	-0.020	-0.009	0.020	0.084	-0.003	0.004	0.001	-0.014	0.007
	Exit	0.006	0.063	0.006	-0.001	0.018	0.027	0.003	0.044	0.007
	Compositional	-0.024	0.093	0.037	0.101	0.072	0.072	0.045	0.080	0.058
	Total	0.115	0.179	0.043	0.160	0.072	0.165	0.249	0.234	0.125
2007-2013	Within	-0.065	-0.014	-0.179	-0.020	-0.032	-0.176	-0.005	0.272	-0.034
	Between	0.007	0.014	0.015	0.020	0.011	0.019	0.028	0.004	0.003
	Entry	-0.019	0.024	-0.002	-0.016	-0.002	0.002	0.005	-0.024	-0.008
	Exit	0.036	-0.024	0.020	0.006	0.009	0.015	0.011	-0.003	0.018
	Compositional	0.023	0.014	0.032	0.011	0.018	0.035	0.044	-0.023	0.014
	Total	-0.042	0.000	-0.147	-0.009	-0.014	-0.140	0.039	0.249	-0.020
Difference from 2001-2007										
2007-2013	Within	-0.204	-0.100	-0.185	-0.080	-0.032	-0.268	-0.210	0.118	-0.101
	Compositional	0.048	-0.079	-0.005	-0.090	-0.053	-0.037	-0.001	-0.103	-0.044
	Total	-0.157	-0.179	-0.190	-0.170	-0.086	-0.305	-0.211	0.015	-0.145
2007-2010	Within	-0.132	-0.085	-0.123	-0.045	-0.007	-0.305	-0.214	-0.172	-0.080
	Compositional	0.014	-0.033	0.016	-0.089	-0.021	-0.007	0.010	-0.083	0.006
	Total	-0.119	-0.117	-0.108	-0.134	-0.028	-0.312	-0.205	-0.255	-0.073
2010-2013	Within	-0.276	-0.116	-0.247	-0.115	-0.058	-0.231	-0.205	0.407	-0.122
	Compositional	0.081	-0.126	-0.026	-0.091	-0.086	-0.067	-0.012	-0.122	-0.094
	Total	-0.195	-0.241	-0.273	-0.206	-0.144	-0.298	-0.217	0.285	-0.216

*3-year changes 2001-2007 include 2001-2004, 2004-2007. 3-year changes 2007-2013 include 2007-2010, 2010-2013.
Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. British establishments with two or more persons employed.

Table 5.2.2 Decomposition of 3-year labour productivity growth before and after 2007 - Service sectors

3-year changes*		Wholesale & retail of vehicles	Wholesale	Retail	Transport & Storage	Accomodation, food & beverages services	Information & Communication	Professional & Scientific	Admin & Support	Arts & Entertainment	Other Services
2001-2007	Within	-0.019	0.071	0.019	0.023	0.014	0.114	0.106	0.033	0.099	-0.126
	Between	0.041	0.048	0.043	0.049	0.028	-0.026	-0.010	0.023	0.053	0.047
	Entry	0.006	0.007	0.004	-0.015	0.006	0.033	0.009	0.071	-0.005	0.019
	Exit	0.002	-0.026	0.031	0.018	0.009	0.026	-0.009	-0.070	0.000	-0.034
	Compositional	0.049	0.029	0.078	0.051	0.043	0.034	-0.010	0.024	0.047	0.032
	Total	0.029	0.099	0.097	0.074	0.057	0.147	0.096	0.057	0.146	-0.095
2007-2013	Within	-0.053	-0.105	-0.044	0.035	-0.047	0.003	0.058	-0.030	-0.111	-0.130
	Between	0.003	-0.004	0.017	0.109	0.002	0.037	0.052	-0.009	0.007	0.033
	Entry	-0.021	-0.004	0.002	-0.079	-0.060	-0.020	-0.047	0.080	0.023	-0.067
	Exit	0.066	0.028	0.024	0.066	0.077	0.021	0.024	-0.045	0.017	0.021
	Compositional	0.048	0.019	0.042	0.096	0.019	0.038	0.029	0.026	0.047	-0.014
	Total	-0.005	-0.085	-0.002	0.131	-0.028	0.041	0.087	-0.005	-0.064	-0.144
Difference from 2001-2007											
2007-2013	Within	-0.034	-0.176	-0.063	0.012	-0.061	-0.111	-0.047	-0.063	-0.209	-0.004
	Compositional	-0.001	-0.009	-0.035	0.045	-0.024	0.004	0.038	0.002	0.000	-0.045
	Total	-0.035	-0.185	-0.099	0.057	-0.085	-0.107	-0.009	-0.061	-0.210	-0.049
2007-2010	Within	0.040	-0.137	-0.142	-0.079	-0.076	-0.141	-0.175	0.013	-0.292	0.012
	Compositional	-0.100	-0.020	-0.021	0.133	-0.024	0.010	0.060	0.023	-0.020	-0.085
	Total	-0.060	-0.157	-0.163	0.053	-0.100	-0.131	-0.115	0.036	-0.311	-0.073
2010-2013	Within	-0.108	-0.214	0.015	0.103	-0.045	-0.080	0.081	-0.139	-0.127	-0.020
	Compositional	0.098	0.001	-0.050	-0.042	-0.025	-0.003	0.017	-0.019	0.019	-0.006
	Total	-0.010	-0.213	-0.035	0.061	-0.070	-0.082	0.098	-0.159	-0.108	-0.026

*3-year changes 2001-2007 include 2001-2004, 2004-2007. 3-year changes 2007-2013 include 2007-2010, 2010-2013.
Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. British establishments with two or more persons employed.

Table 5.2.3 Decomposition of 3-year labour productivity growth - Manufacturing sectors

		Food, beverages, tobacco	Textile & leather products	Wood products, pulp, paper & printing	Coke & petrol, chemicals, pharmaceuticals	Rubber & plastics; Non-metallic mineral products	Basic metals & fabricated metal products	Computer, electrical & optical equipment and machinery	Transport equipment	Furniture, repairs
1998-2001	Within	0.018	-0.009	0.030	-0.026	0.048	-0.083	0.051	0.070	0.009
	Between	-0.001	0.037	0.034	0.063	0.028	0.060	0.034	0.158	0.039
	Entry	-0.001	-0.026	0.017	0.021	0.001	-0.001	0.029	-0.058	0.001
	Exit	0.017	0.074	0.005	-0.017	0.017	0.024	-0.004	-0.182	0.044
	Total	0.033	0.076	0.086	0.041	0.093	0.000	0.110	-0.012	0.093
2001-2004	Within	0.140	0.151	0.030	0.160	0.018	0.046	0.236	0.128	0.039
	Between	-0.012	0.039	0.019	0.010	0.029	0.022	0.032	0.055	0.024
	Entry	-0.023	-0.017	0.022	0.111	0.011	0.002	-0.006	-0.017	0.014
	Exit	-0.022	0.075	0.004	-0.003	0.025	0.032	0.013	0.050	0.012
	Total	0.083	0.248	0.075	0.278	0.083	0.102	0.276	0.216	0.089
2004-2007	Within	0.139	0.021	-0.018	-0.040	-0.017	0.140	0.173	0.181	0.096
	Between	-0.008	0.038	0.005	0.023	0.084	0.061	0.050	0.046	0.063
	Entry	-0.017	0.000	0.017	0.058	-0.016	0.006	0.007	-0.012	-0.001
	Exit	0.033	0.052	0.007	0.002	0.011	0.022	-0.008	0.037	0.003
	Total	0.147	0.111	0.012	0.043	0.061	0.228	0.223	0.252	0.161
2007-2010	Within	0.007	0.001	-0.117	0.015	-0.006	-0.213	-0.010	-0.017	-0.013
	Between	-0.011	0.024	0.028	0.028	0.018	0.030	0.040	-0.005	0.042
	Entry	-0.028	-0.003	0.001	0.004	0.019	0.011	0.016	-0.025	0.006
	Exit	0.028	0.040	0.023	-0.021	0.014	0.025	-0.001	0.026	0.016
	Total	-0.004	0.062	-0.064	0.027	0.044	-0.147	0.045	-0.021	0.052
2010-2013	Within	-0.137	-0.030	-0.241	-0.055	-0.058	-0.139	0.000	0.561	-0.055
	Between	0.024	0.005	0.001	0.012	0.004	0.007	0.015	0.013	-0.037
	Entry	-0.011	0.050	-0.006	-0.036	-0.022	-0.008	-0.005	-0.023	-0.021
	Exit	0.044	-0.088	0.016	0.034	0.004	0.006	0.023	-0.032	0.021
	Total	-0.080	-0.062	-0.230	-0.045	-0.072	-0.133	0.033	0.519	-0.091

Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. British establishments with two or more persons employed.

Table 5.2.4 Decomposition of 3-year labour productivity growth - Service sectors

		Wholesale & retail of vehicles	Wholesale	Retail	Transport & Storage	Accomodation, food & beverages services	Information & Communication	Professional & Scientific	Admin & Support	Arts & Entertainment	Other Services
1998-2001	Within	0.005	-0.219	0.058	-0.056	-0.073	0.085	0.102	0.235	0.072	-0.104
	Between	0.062	0.013	0.030	-0.012	0.096	0.010	0.053	0.008	0.126	0.138
	Entry	0.014	0.007	-0.022	-0.028	0.020	-0.052	-0.034	0.080	0.000	-0.061
	Exit	0.022	-0.002	0.034	-0.009	0.048	0.001	0.010	-0.030	-0.024	0.118
	Total	0.103	-0.202	0.101	-0.104	0.090	0.045	0.131	0.293	0.174	0.092
2001-2004	Within	0.081	0.103	0.070	0.083	0.039	0.100	0.004	0.010	0.176	-0.014
	Between	0.043	0.033	0.037	0.013	0.019	0.003	-0.015	0.009	0.028	-0.041
	Entry	0.005	0.020	0.018	-0.026	0.027	0.097	0.027	0.042	-0.054	0.073
	Exit	-0.023	-0.063	0.010	0.010	-0.021	-0.012	-0.024	-0.137	0.001	-0.064
	Total	0.107	0.092	0.135	0.080	0.064	0.188	-0.007	-0.075	0.150	-0.045
2004-2007	Within	-0.119	0.038	-0.032	-0.038	-0.012	0.127	0.207	0.055	0.022	-0.239
	Between	0.038	0.063	0.049	0.085	0.036	-0.054	-0.005	0.036	0.078	0.135
	Entry	0.007	-0.005	-0.011	-0.005	-0.014	-0.031	-0.009	0.100	0.043	-0.036
	Exit	0.026	0.011	0.051	0.025	0.039	0.065	0.005	-0.003	-0.001	-0.005
	Total	-0.048	0.107	0.058	0.067	0.050	0.106	0.198	0.189	0.142	-0.144
2007-2010	Within	0.021	-0.066	-0.123	-0.057	-0.062	-0.028	-0.070	0.046	-0.193	-0.114
	Between	-0.061	-0.021	0.027	0.197	0.018	0.069	0.076	0.017	0.003	-0.002
	Entry	-0.038	0.005	0.008	0.004	-0.035	-0.014	-0.036	0.139	-0.001	-0.050
	Exit	0.048	0.024	0.022	-0.018	0.036	-0.011	0.010	-0.108	0.025	-0.001
	Total	-0.030	-0.057	-0.066	0.127	-0.043	0.017	-0.020	0.093	-0.166	-0.167
2010-2013	Within	-0.128	-0.144	0.034	0.126	-0.031	0.034	0.186	-0.107	-0.028	-0.146
	Between	0.066	0.013	0.006	0.022	-0.015	0.005	0.028	-0.034	0.011	0.067
	Entry	-0.003	-0.013	-0.005	-0.163	-0.084	-0.026	-0.058	0.021	0.047	-0.084
	Exit	0.084	0.031	0.026	0.150	0.117	0.052	0.037	0.018	0.009	0.042
	Total	0.019	-0.114	0.062	0.135	-0.013	0.065	0.193	-0.102	0.038	-0.121

Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. British establishments with two or more persons employed.

Table 5.3.1 Correlation across 20 sectors of growth components from different decompositions with growth components from the DF decomposition

		Within	Between	Entry	Exit
MP	1998-2001	0.656	0.282	1.000	1.000
	2001-2004	0.651	0.295	1.000	1.000
	2004-2007	0.917	0.572	1.000	1.000
	2007-2010	0.622	0.573	1.000	1.000
	2010-2013	0.838	0.530	1.000	1.000
GR	1998-2001	0.993	0.975	0.935	0.973
	2001-2004	0.998	0.987	0.962	0.974
	2004-2007	0.997	0.991	0.983	0.878
	2007-2010	0.998	0.997	0.991	0.945
	2010-2013	0.996	0.995	0.967	0.968
FHK	1998-2001	0.958	0.735	0.824	0.996
	2001-2004	0.947	0.799	0.878	0.998
	2004-2007	0.971	0.711	0.940	0.995
	2007-2010	0.982	0.968	0.970	0.997
	2010-2013	0.982	0.689	0.897	0.990

Source: ARD, ONS. Authors' calculations.
Note: Market sector. British establishments with two or more persons employed.

APPENDIX A: Dynamic decomposition methods

The MP decomposition:

(A1)
$$\Delta\Pi_t = \frac{1}{1-\overline{cov}_C}\sum_{i\in C}\frac{1}{n_C}\Delta\pi_{it} + \frac{\overline{\Pi}_C}{1-\overline{cov}_C}\Delta cov_{Ct} + \sum_{i\in N} s_{it}(\pi_{it} - \Pi_{Ct}) - \sum_{i\in X} s_{i,t-k}(\pi_{i,t-k} - \Pi_{C,t-k}) \quad \text{(MP)}$$

where n_C denotes the number of continuing firms and

$cov_{Ct} = \frac{1}{\Pi_{Ct}}\sum_{i\in C}\left(s_{Cit} - \frac{1}{n_C}\right)(\pi_{it} - \sum_{i\in C}\frac{1}{n_C}\pi_{it})$.[22]

The GR decomposition:

(A2)
$$\Delta\Pi_t = \sum_{i\in C}\overline{s}_i\Delta\pi_{it} + \sum_{i\in C}\Delta s_{it}(\overline{\pi}_i - \overline{\Pi}) + \sum_{i\in N} s_{it}(\pi_{it} - \overline{\Pi}) - \sum_{i\in X} s_{i,t-k}(\pi_{i,t-k} - \overline{\Pi}) \quad \text{(GR)}$$

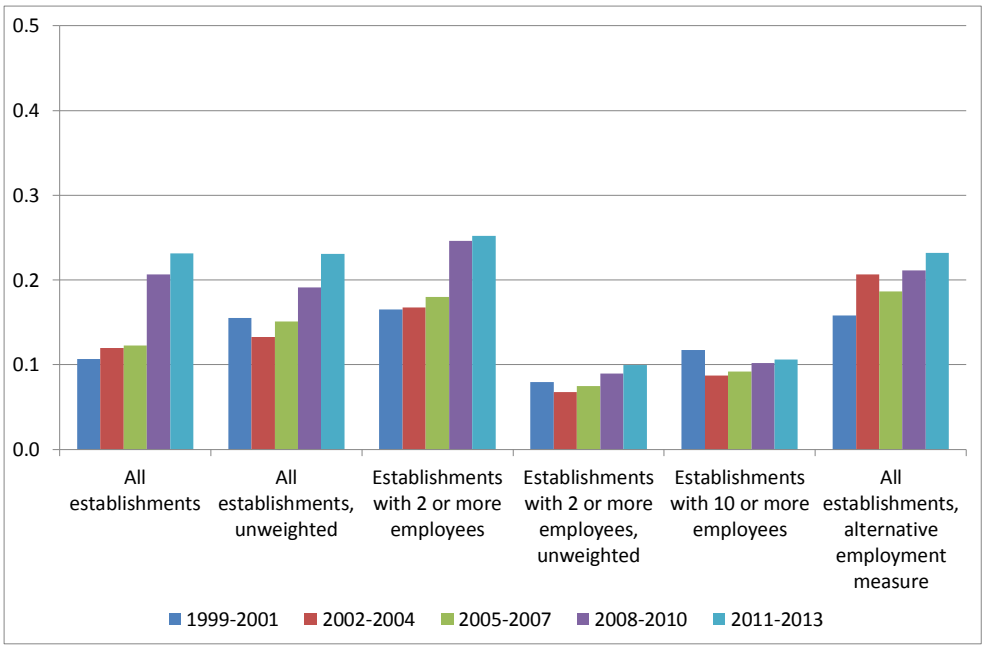
The FHK decomposition:

(A3)
$$\Delta\Pi_t = \sum_{i\in C} s_{i,t-k}\Delta\pi_{it} + \sum_{i\in C}\Delta s_{it}(\pi_{i,t-k} - \Pi_{t-k}) + \sum_{i\in C}\Delta s_{it}\Delta\pi_{it} + \sum_{i\in N} s_{it}(\pi_{it} - \Pi_{t-k}) - \sum_{i\in X} s_{i,t-k}(\pi_{i,t-k} - \Pi_{t-k}) \quad \text{(FHK)}$$

[22] The MP decomposition shown here is for the case where productivity is measured in levels rather than in logs, because our main results consider the levels case.

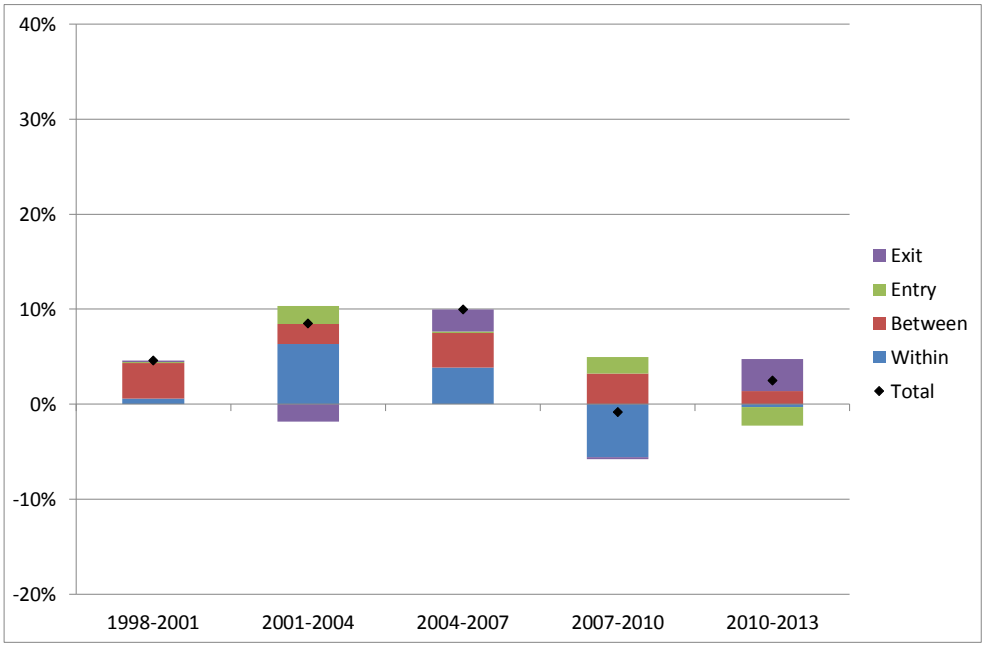
APPENDIX B: Additional figures and tables

Figure B.1 Olley-Pakes covariance term between employment share and labour productivity (different populations, population weighting schemes and employment measures)



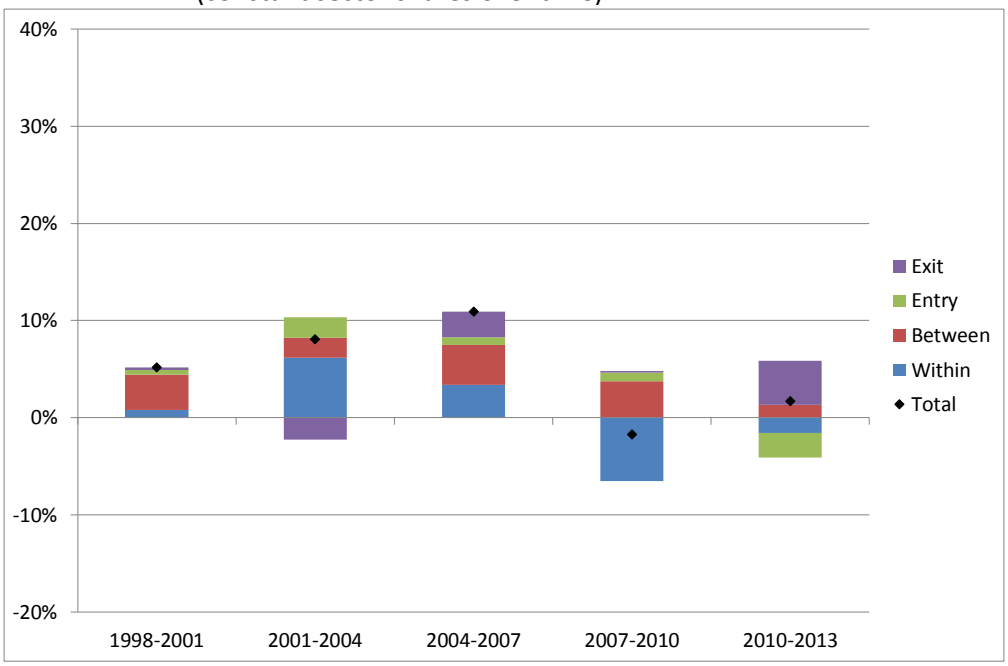
Source: ARD, ONS. Authors' calculations.
Note: Olley-Pakes measure of allocative efficiency. Financial services and real estate excluded. Market sector as measured here includes manufacturing, construction and services less financial services and real estate. British establishments. Alternative employment measure utilises both the survey and sampling frame employment measures in the ARD.

Figure B.2 Decomposition of 3-year labour productivity growth - Market sector (excluding establishments with less than 10 employees)



Source: ARD, ONS. Authors' calculations.
Note: Diewert-Fox decomposition of labour productivity growth. Market sector as measured here includes manufacturing, construction and services less financial services and real estate. British establishments with 10 or more persons employed.

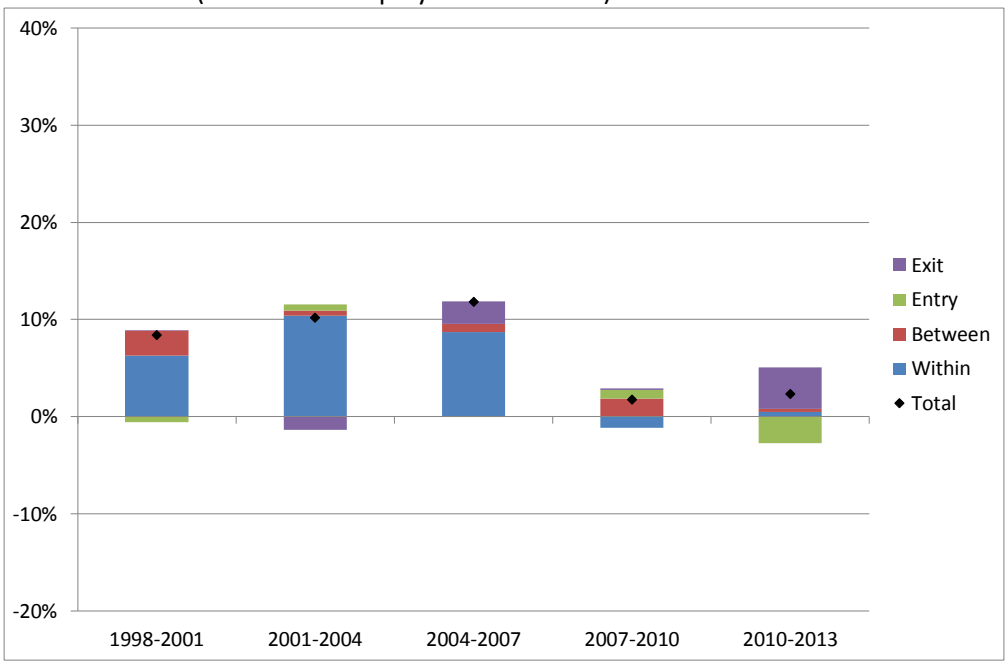
Figure B.3 Decomposition of 3-year labour productivity growth - Market sector (constant sector shares over time)



Source: ARD, ONS. Authors' calculations.

Note: Diewert-Fox decomposition of labour productivity growth. Market sector as measured here includes manufacturing, construction and services less financial services and real estate. British establishments with two or more persons employed. Aggregated from 20 sector decompositions using average sector shares 1998-2013.

Figure B.4 Decomposition of 3-year labour productivity growth - Market sector (alternative employment measure)



Source: ARD, ONS. Authors' calculations.

Note: Diewert-Fox decomposition of labour productivity growth. Market sector as measured here includes manufacturing, construction and services less financial services and real estate. British establishments with 10 or more persons employed. Alternative employment measure utilises both the survey and sampling frame employment measures in the ARD.