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Decomposing UK aggregate labour productivity and growth: 1998-2013 using the ONS business structure database data

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ABSTRACT

This study provides a comprehensive analysis of UK labour productivity patterns and contributing factors over the 1997-2013 period. Based on the ONS Business Structure Database (BSD), we present a full picture of the UK firms' productivity patterns in the whole economy over the examined period and in particular during the "Great Recession", at aggregate level, sector level, and among heterogeneous groups. We observe significant business demographic changes underlying UK aggregate productivity change, featuring an increasing number of small businesses especially single-employee firms, less entrants and more exits and discuss the implications of these changes in explaining the productivity decline. When differentiating firm growth types, we find "Growth heroes" and "Decline by efficiency loss" firms over-contribute to aggregate labour productivity compared to their weight in the business population. In contrast, an already large group of 'Decline by contraction' firms surged over the recent recession and under-contribute to aggregate labour productivity. We highlight that *within* firm productivity improvement has been mainly responsible for aggregate productivity changes in the UK while resource allocation on average played a limited role in driving the aggregate productivity change.

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1. INTRODUCTION

This research contributes to the ongoing discussions and debates on the UK productivity puzzle. During the recent 'Great Recession' the UK experienced a dramatic labour productivity decline. Above all the slow rate of recovery has been unprecedented and exceptionally sluggish by international standards (Weale, 2014). The implication of the decline and slow recovery of productivity growth is important not just for the short term, but also impacts long run labour productivity, even if productivity growth returns to the pre-crisis level (Outlton and Sebastiá-Barriel, 2013). There are also worries of a possible structural change to the economy shifting production and employment permanently to less productive sectors. In addition, the productivity problem may lead to an impaired ability to generate income for government expenditure, hence the ability to relieve government debts (Pryce, 2015) and for monetary policy (Bank of England, 2014). The upshot is that the productivity puzzle is a major part of what we need to understand to ensure and sustain growth.

Due to its importance, the UK productivity puzzle has generated great interest among policy makers and researchers recently. Key findings and debates keep emerging. To date there is still a heated debate on what may underlie Britain's stall in productivity and what measures may revitalise it. While some of the existing empirical work provides established facts about the weak aggregate productivity growth and the slow recovery, the search for possible explanations continue. Overall, although we know much more about what may explain the puzzle (see our critical review in the following section), many questions remain unanswered, uncertified and hence need to be further investigated.

In particular, firm heterogeneity as the well-understood prevalent phenomenon that plays an important role in firm growth is yet to receive sufficient attention in this line of research. Firms in different sectors, of different size and age, showing difference growth patterns may react to a crisis differently and hence end up with different performance trajectories. Assuming all firms as homogenous and trying to identify some common

factors that explain the reasons behind the productivity puzzle is likely to produce weak and mixed results.

Further to this point, most of the existing studies tend to focus on large firms in the economy and overlook the role of small businesses. There are several justifiable reasons for making this choice, in particular large firms make up the mainstay of the economy in several measures, and the classic mainstream literature has focused on these big firms. Also, data are much more available and generally of better quality for larger firms. However, the explosion of new research conducted on small business and entrepreneurship in recent decades has demonstrated the key role of small businesses in the economy, in generating growth, conducting R&D and innovation, and disproportionally creating many jobs (Acs, 1992; Anyadike-Danes et al., 2009). This adds extra reasons to investigate the welfare of small businesses over the recession period because they are more sensitive to uncertainty, demand shocks and credit constraints (Vivek and Ye, 2015). Yet we know very little about what the young and small companies have experienced, how they performed and how they contributed to the aggregate productivity decline.

Therefore, the objective of this research is to enhance our understanding of labour productivity changes over the 1997-2013 period. By conducting an in-depth analysis of UK firm productivity growth patterns, we identify the contributions of different types of heterogeneous firms to aggregate labour productivity in the UK. Revealing these patterns helps us to shed light on the complete picture of UK firm growth dynamics and reflect on several explanations so far proposed for the UK productivity puzzle. Surrounding the central question of identifying the aggregate productivity contribution, we focus on the productivity improvements among surviving firms and resource allocation factors among heterogeneous firms, such as firms showing different growth types and firms of different size and age. We use the ONS Business Structure Database (BSD), due to its extensive coverage of the firm-level business population, and apply the Melitz and Polanec (2012) aggregate productivity and growth decomposition methodology to document in detail the productivity patterns of UK firms

over the examined period, at aggregate level, sector level and among specific groups.

As a brief preview, we find that the recent "Great Recession" exhibited a steeper decline and longer recovery in the output market than the labour market. Significant changes in business demography underlie UK aggregate productivity change, including an increasing number of small businesses, especially single-employee firms, more exits and less entrants[1]. As we show, these demographic changes provide important clues to explain the recent productivity weakness. In particular, the share of single-employee firms increases considerably relative to small firms with more than one employee and medium sized firms, while their average productivity is lower and declining over time, which reduces overall average productivity. Together with the evidence of a small resource allocation effect, whereby resources are allocated from lower to higher productivity firms, this raises concerns about the increasing self-employment in the UK over the recession that tends to be low-paid and low-productive jobs (Martin and Rowthorn, 2012). Overall this builds on the existing evidence that UK has a relatively high number of start-ups, but it is the quality of the start-ups that is to be improved in terms of their survival and growth potential (Roper and Hart, 2013; and Criscuolo and Menon, 2014).

We categorise firms into five growth types and find the varying firm growth patterns are behind aggregate productivity changes. Several interesting phenomena emerge such as resilient "Growth heroes", "Decline by efficiency loss" firms and a large chunk of 'Decline by contraction' firms which may help understand several hypotheses on the productivity puzzle.

We demonstrate that firms showing productivity growth can be quite heterogeneous – "Fake growth" firms are in fact the least productive firms among all contracting in both employment and revenue. In contrast firms showing productivity growth are not necessarily less productive firms – "Decline by efficiency loss" firms are on average relatively productive and

[1] The definitions of entry and exit are discussed in detail in Section 3.2.

over-contribute to aggregate labour productivity compared to their weights in the business population.

In particular, the small percentage of "Growth heroes", not only show impressive employment and turnover growth over the whole examined period, leading to above average labour productivity growth, but also disproportionally contribute to aggregate labour productivity. These Growth heroes tend to be SMEs, but not single-employee firms, foreign-owned and located in the London area, and have more presence in Professional Service sectors and Manufacturing sectors.

In contrast, an already large group of 'Decline by contraction' firms surged in number during the recent recession and under-contribute to aggregate labour productivity. Understanding the driving forces and barriers of these growth types will help understand several hypotheses on the productivity puzzle.

Our evidence suggests that *within* firms' productivity improvement has been mainly responsible for aggregate productivity changes in the UK, especially among large firms, while resource allocation on average played a very limited role in driving aggregate productivity change. In addition, the total contribution of resource allocation was small and the pictures for heterogeneous groups of firms vary.

The following content is structured as follows. Section 2 offers a critical overview of the background literature on firm productivity, the recent productivity puzzle debates and small business growth. We explain our data and methodology in Section 3. Section 4 sets the scene by documenting the growth trends and patterns in the examined period, while Section 5 reports the main findings of the aggregate labour productivity decomposition. We then discuss the main findings in light of the existing literature and on-going discussions as well as suggest further research to be done, in Section 6. Section 7 concludes.

2. BACKGROUND LITERATURE

2.1 Why productivity matters?

Raising productivity is crucial to prosperity. At the macroeconomic level, productivity measured by total factor productivity (TFP) is a well-understood source of long-run economic growth (Hall and Jones, 1999; Bartelsman and Doms, 2000), and the main driver of global inequality (Hall and Jones, 1999; Hsieh and Klenow, 2009). Today there are still many heated discussions on the productivity differences of comparable countries and the extent to which productivity differences explain these nations' economic growth[2].

At the microeconomic level, productivity is an unfailing predictor of firms' survival and post-entry growth (Farinãs and Ruano, 2005). Much has been learned about the channels through which productivity may determine firms' strategic choices of international trade (Greenaway and Kneller 2007), outward investment (Harris and Robinson, 2003) and capability to innovate (Hall, 2011) (see a recent review in Syverson 2011). As Paul Krugman asserts, "productivity isn't everything but in the long run it is almost everything" (Krugman, 1994).

There is a clear aggregate productivity growth gap between Europe and the US (Van Ark et al. 2008), and within Europe the UK lags behind major economies such as Germany and France (ONS, 2012; 2014). Answers to the question as to why the gaps exist and how to close them are still being sought.

2.2 UK Productivity: the puzzle and the debate

The UK has experienced particularly weak labour productivity growth since the recent financial crisis in 2008. Various estimates of the counterfactual

[2] For example, it is noted that the UK's overall productivity is lower than Germany and France (ONS, 2014), and some attribute the differences to the size of the medium-sized enterprises (Grant Thorton, 2012). Another example is the debate on productivity and middle-income trap (Eichengreen et al., 2011) among fast growing emerging economies.

level of productivity have been put forward, and despite the differences, indicate both an unprecedented long decline in the aggregate productivity of the economy itself and an alarming decline relative to its peers in the developed world.[3]

In addition, growth has not returned to where it was before the crisis by 2013. In normal recessions any loss in productivity is quickly recovered as employment is cut back faster than output declines, and growth during recovery is at or above trend (Pryce, 2015). But this was not the case this time; it has been an extraordinary flat period for productivity change over a very long time (Haldane, 2014).

The implication of the decline and slow recovery of productivity growth is not just for the short term, but impacts long run labour productivity, even if productivity growth returns to the pre-crisis level (Outlton and Sebastiá-Barriel, 2013). The importance of understanding the puzzle has generated great interest among policy makers and researchers. To date there is still a heated debate on what may underline Britain's stall in productivity and what measures may revitalise it. Several recent studies summarise well the possible explanations of the puzzle, and we only reflect on them briefly below.

2.2.1 Demand side of problems and global impact

Weakened demand as the result of the initial recession exacerbated the crisis in the UK following the initial breakout. Over time, weakened demand depressed the economy's productive capacity through cuts in investment and depressed technological progress (Pryce, 2015). Some commentators attribute it to weakened consumer confidence, intensified by government

[3] Barnett et al (2014) raised the productivity puzzle of the UK economy that weak labour productivity growth since crisis, a 14% below pre-crisis level. The recent update (Haldane, 2014) suggests that based on 2014 Q2 figure, GDP per hour worked was broadly unchanged and that leaves it around 15% below its pre-crisis trend level. Bryson and Forth (2015) estimate labour productivity was 15-16% lower than the pre-crisis trend level. ONS (2014) highlight a productivity gap of around 6% between the UK and the rest of the G7.

austerity. Martin and Rowthorn (2013) interpret the post-2007 productivity shortfall as being caused by a persistent effective demand failure.

But the opposite view suggests that domestic demand problems may play an important role in the actual recession and the subsequent stagnation, but not enough to explain the prolonged period of reduced productivity growth. Based on business survey data, the Bank of England (2014) eliminate the possibility of cyclical explanation for the fall in productivity and find little evidence of spare capacity and demand shortfall.

Undeniably in the globalised world that we are in now, the weak global demand particularly from the Eurozone and Japan, has been a major contributor to of firms' output falls. Recent research suggests that the transmission mechanisms include trade, finance and uncertainty (Chowla et al., 2014).

It is worth noting that the demand weakness may underlie other important and damaging issues, although the effects are far from being clear. For example, demand problems may discourage bank lending and hence firms may be unable to fund capital investment. Similarly, investors may respond to control risk by not investing in innovation and productivity-improving mechanisms. But the effects can be different where firms are forced to explore something different or even become innovative facing the changed markets.

2.2.2 Measurement issues

The low levels of productivity could be due to the overestimation of past productivity as a result of measurement issues in employment and output. If in the past productivity was over estimated, the lower figures now reflect the return to normal. Barnett et al (2014) argue that this could explain up to 4 per cent (one quarter) of the productivity shortfall since the beginning of the recession. Outlton and Sebastiá-Barriel (2013) argue that 4-16 per cent of the productivity shortfall was due to measurement issues. However, investigating the importance of the measurement issues is not easy as data are not sufficient to construct longitudinal series of capital stock and the

adopted methodologies of calculating productivity vary among the existing studies. Given the absence of complete and high quality data, this is an issue that cannot be easily verified and remedied.

In addition, several sectors are identified as having experienced a specific growth trajectory, such as oil, gas, and finance sectors, so that past GDP growth might be inflated. The role of intangible assets in generating output is also discussed but can not fully explain the productivity puzzle (Goodridge, et al 2015).

Overall, these issues point in the direction of conducting studies at disaggregated levels over a long period of time, using large samples and consistent statistical instruments to construct comparable statistics. In this study, we employ BSD data precisely for this reason (which is discussed below in the Data section).

2.2.3 Financial constraints

Given the prominent presence of the financial sector in the UK economy, many researchers have speculated on the role of the troubled finance sector in driving the productivity puzzle. This could happen in several ways. The first is through restricted bank lending that would have impacts on start-ups, scaling up and the survival chance of existing companies, as well as on improving within firm productivity through intensifying the capital-labour ratio. However, although there is evidence to suggest that both the availability and cost of bank credit were adversely affected by the onset of recession (Riley et al, 2014a), the significance of credit constraints in driving productivity weakness, is not clear given that bank loans only provide a small proportion of finance, and UK companies were cash rich prior to the crisis (Bryson and Forth, 2015). Overall, what matters more is likely to be the uncertainty the banking and financial crisis induced among investors (Bloom, 2009). That implies that the finance problem is a demand problem as much as a supply one.

Secondly, there is speculation that over the crisis period, UK banks have been more forgiving and tolerated underperforming companies to survive,

which potentially led to less exits and hence low productivity (Pessoa and Van Reenen, 2014; Bryson and Forth, 2015). There is little evidence though to support this view. Arrowsmith et al (2013) find that the benefit of forbearance was mainly within the real estate sector. Overall, the role of restricted bank lending in explaining the productivity puzzle is still unclear and likely to be limited.

2.2.4 Labour market factors

Companies reserved labour as output fell in recession, when facing uncertain demand, in order to avoid the costs of firing and then re-hiring (Martin and Rowthorn, 2012). In this scenario, workers accept reduced hours to work, pay freezes or even pay reductions to retain their jobs. This "labour hoarding" hypothesis was put forward with the supportive statistics of low levels of employment contraction during the crisis (Butcher and Bursnall, 2013; Barnett et al 2014). The flexibility of the labour market in the UK has been argued to facilitate this phenomenon (Bryson and Forth, 2015). Further, there are more employees working part-time by a reduction in the average working hours by full-time employees (Bell and Blanchflower, 2015). The recent Labour Force Survey also shows that UK self-employment has grown sharply.

It has become more apparent that the falling real wages might have played a role in triggering the lack of response to output decline in the labour market. Real wage growth in Britain started to decrease in the early 2000s, before the recession (Gregg et al 2014). The evidence also suggests that real wage decline occurs within the same work force on a year-on-year basis and not due to the changing composition of workforce (Blundell et al 2014). As such, labour was made relatively cheap for employers, hence there was stronger incentive to substitute labour for capital (Bryson and Forth 2015), and delay upgrading capital-intensive assets which would enhance productivity. Although real wage and labour hoarding appear to share a strong movement, there is so far no robust evidence to prove the causal relationship.

So the reasons behind labour hoarding are not yet clear and most of the

arguments are largely speculative. Some alternative explanations are suggested, including that companies retained skilled labour as a result of learning lessons from the previous recession (Barnett et al 2014b), and skilled labour building up intangible capital which is not measured (Goodridge et al 2013).

Labour hoarding is more common in continental Europe such as Germany, compared to the US companies which tend to shed labour fast at the first sign of trouble (Dietz et al., 2010). Small size family firms could be more likely to retain labour and these are more likely to be in some sectors than others. This suggests that corporate culture could play a role in this business behaviour, as well as firm heterogeneity, although there is little evidence on this so far.

Seeing the evidence of the robust hiring rate in the labour market during the recovery periods (Barnett et al 2014b), one would dispute labour hoarding as the main explanation of the productivity puzzle. Also, the UK labour market has seen increased flexibility with the decline in unionisation. It is unclear how much labour market flexibility may underline the firm labour using decision. Hence overall, labour hoarding as an explanation of the productivity puzzle is likely to exist but only to a certain extent.

2.2.5 Self-employment

Job creation has been prolific in the labour market during this recession. With around half a million jobs lost in the public sector since 2010 as part of the austerity program, the private sector has added 1.7 million jobs between 2012 and 2015 (Pryce, 2015). However, Martin and Rowthorn (2012) suggest that this trend may have encouraged the private sector to create low-productivity jobs. The explanation proposed is that many jobs created or – safe-guarded - over this period were part-time, zero-hour contract jobs and self-employment with lower pay, less training provided and poor skill utilisation. [4]

[4] Martin and Rowthorn (2012) suggest that both the output per head and the output per hour work have seen decreasing.

Self-employment is a particularly relevant issue here, as it represents one-third of the increased employment in the UK in the recession (Martin and Rowthorn, 2012). Self-employment jobs are generally low paid jobs, and even less well paid over the crisis. There is very little research done on their productivity per se but there are some concerns that they produce very little output (Martin and Rowthorn, 2012). The Bank of England estimated that assuming the self-employed produce no output at all would explain some 2 per cent of the current gap in productivity levels with respect to the pre-crisis trend (Barnett et al., 2014).

Overall, this is clearly an under-researched area as there are multiple and complicated issues at play on which our knowledge is limited, including public finance, entrepreneurial ambition, start-up conditions, and skill upgrading and productivity enhancement among this particular type of business organization.

2.2.6 Capital shallowing

Related to the real wage decline, the capital shallowing hypothesis is proposed to explain the productivity puzzle; as the relative cost of labour and capital drops, the capital-labour ratio declines. Unfortunately this is a difficult assertion to test empirically, even though we observe a reduced real wage and increased cost of capital (Broadbent, 2012; Pessoa and Van Reenen, 2013). Because the availability of good-quality data on capital per worker has historically been limited in the UK, researchers have often compiled their own series, leading to different views on the changing role of capital in the economy (Bryson and Forth, 2015).

Recent studies along this line suggest conflicting results of how much capital shallowing played a role in leading to the productivity puzzle (for example, Pessoa and Van Reenen, 2013; Oulton 2013; Field and Franklin, 2014; and Harris and Moffat, 2014). To date, more studies do not support the capital shallowing hypothesis than do. Some recent work seems to conclude that the productivity puzzle appears primarily to be a puzzle about

the slowdown in TFP growth (Goodridge et al 2015; Connors and Franklin, 2015).

2.2.7 *Capital misallocation effects*

Related to the changes in business demography and reduced investment in the economy is the view of the damaging effects of impaired capital reallocation on productivity. Several studies point out that the financial crisis has resulted in a misallocation of capital to less productive firmsmany of which are small but not productive (IFS, 2013; Bank of England, 2014). Consistent with what has been argued above for the reasons behind the changing business demographics, the lower wage and low interest rates on the one hand maintained low costs of survival, and uncertainty and restricted access to finance on the other dampened incentives to invest in innovation and discouraged entry.

There are also doubts about the view of capital misallocation. For example, firms hire both high and low skilled labour (IFS 2013, Philpot, 2014). Capital use per hour worked increased over the crisis (Oulton 2015; Oulton and Willis 2014). Doubts were also raised elsewhere (Riley et al 2014a). Overall from the different views, what seems to be consistent is the view that the key explanations of the recent productivity weakness need to be able to explain the weakness of productivity within companies (Riley, Bondibene and Yong, 2014).

2.3 Small business productivity

2.3.1 High growth patterns in small business

High growth firms (HGFs), or high impact firms, even though occasionally being defined differently, are a very small number of small businesses that create a disproportionately large number of new jobs across countries (OECD, 2002; Anyadike-Danes, et al, 2013). In light of the on-going debate about the average productivity lag in Europe compared with the US, policy-makers are hopeful that one of the ways to alleviate the gap is to support and fund innovative and rapidly growing businesses (Bravo-Biosca 2010a). Identifying and supporting these high growth businesses is another

opportunity for public policy to encourage productivity and economic growth in the UK economy.

Given that small businesses represent a high proportion of all high growth firms, Du and Yama (2014)[5] reveal the causal link between high growth in sales and total factor productivity growth. They demonstrate that firms in both the manufacturing and services sector in the UK are more likely to become high growth (in sales) firms when they exhibit higher TFP growth. In addition, firms that have had HGF experience tend to enjoy faster productivity growth following the high growth episodes. Put differently, high growth is a self-reinforcing process, where more productive firms are more likely to accomplish high growth status and in turn high growth achievers are more likely to achieve higher productivity growth. The policy implications of our findings are reassuring. Appropriately designed measures and instruments to stimulate high growth are expected to deliver more than just short-term sales boosts. These findings suggest that (successful) high growth-stimulating policies may have a positive side effect in that productivity is stimulated as well.

2.3.2 Productivity, firm size and employment creation

Statistically speaking, labour productivity is negatively associated with employment size simply because employment is the denominator in the calculation of labour productivity. However, the relationship between productivity and employment size is all but clear.

Generally, entrants' productivity levels differ by cohorts; they tend to be more productive than the entrants in the previous cohorts, but are on average less productive than incumbents. There is evidence that productivity levels converge between different age cohorts after five to ten years. [6] We expect that small businesses, if they survive the start-up period, become more productive over time but the productivity growth

[5] The earlier version of the paper was a NESTA funded research project, published as a NESTA working paper at http://www.nesta.org.uk/publications/high-growth-firms-and-productivity-evidence-united-kingdom.
[6] This is based on US plant level empirical findings (Jensen, McGuckin and Stiroh, 2001).

decreases by age and size (Jensen et al 2001). During the start-up period, productivity is a crucial determinant of survival (Farinãs and Ruano, 2005 among others), partly because new firms tend to realize their actual productivity level only after observing their performance in the industry (Taymaz 2002). During the period of productivity catch-up with incumbents, new firms may experience much higher productivity growth than incumbents (Taymaz 2002), which may also drive high growth episodes in sales or employment (Du and Temouri, 2014). The evidence seems to suggest that firms' productivity level is an important factor upon which they make decisions about operation sales. More productive firms are more likely to be able to expand in size.

However, there are reasons to expect productivity to be negatively associated with firm size. Firm size, as a result of the expansion of firms' operating scale, is also affected by other factors. A debate of policy relevance related to this discussion is the size distortion and firm productivity distribution. Government policy and regulation affect a firm's decision of whether or not to invest and where to invest (for example, capital vs labour), which is also the decision of whether to expand in employment size or capital accumulation.[7] These decisions could affect a firm's productivity level and the productivity distribution. For example, many governments around the world are keen to promote small businesses in the economies through creating better business environments, improving resource access and markets. Small businesses may be incentivized to create more jobs to meet certain criteria of receiving preferential treatment.

Further, there is also an argument that the extent of "creative destruction" in the UK in recent years is low, with too few bad businesses going under and being replaced by dynamic, high-productivity start-ups (Smith, 2014). This may have been facilitated by the current banking system.

Thirdly, in a time of crisis and uncertainty, firms may prefer to recruit workers, that can be shed if demand falls short, rather than make the

[7] Layard and Nickell (1999) discuss the importance of labour laws for unemployment and productivity.

bigger and less reversible commitment to new investment. Uncertainty plays an important role in this process (Bond et al 2004), but there may be other factors contributing to low investment rates. There is evidence that Britain's low productivity in relation to Germany and France is in large part due to lower levels of investment in this country (Crafts and O'Mahony, 2001; Broadberry and O'Mahony, 2004). This tendency may contribute to a lower productivity level and increased job creation. In these circumstances, job creation is likely to be associated with lower productivity.

There are also circumstances in which firms may resist creating jobs but this does not imply productivity increases. In the discussions around the issues related to labour market regulations, for example the employment caps in the US and France (Garicano et al., 2013), managers are confronted with legislation that introduces a cost of acquiring a size that is beyond a certain threshold; they then choose to stay below the threshold and remain at an inefficiently small size. Consequently, there are large welfare losses as a result of the interaction between regulation and downwardly rigid real wages caused by such a regulation. Along the same line, Bravo-Biosca et al (2014) study the effects of labour market regulation, bankruptcy legislation, financial market development and R&D support policies on a firm growth distribution using cross-country data over a relatively short period (2002-05). The results show that financial development, higher banking competition and better contract enforcement are associated with a more dynamic growth distribution, with a lower share of stable firms and higher shares of growing and shrinking firms, and with a more rapid expansion and contraction at the extremes of the growth distribution. Stringent employment protection legislation and generous R&D fiscal incentives are associated with a less dynamic firm growth distribution, with more stable firms and fewer growing and shrinking firms.

2.3.3 Technology and innovation

The theoretical and empirical literature on firm productivity identify that the levers that managers can use to improve business performance and productivity include managerial practice and talent, employee and input quality, information technology, R&D, product innovation, organizational

structure and learning by doing (Syverson 2011). However, the relative importance of these determinants may differ considerably among small businesses. Most predominantly, innovation could be more crucial for small firms compared to large ones, as the latter could undertake a wider range of activities to achieve economies of scale which may not be of an innovative nature. The recent evidence suggests that small firms differ in the benefits of openness in innovation compared to medium and large ones (Vahter et al., 2013). Small firms can benefit disproportionately from adopting open innovation approaches but they reach the benefits of this approach at lower levels than medium and larger firms making the choice of innovation partner critical.

Relatively productivity improvement due to learning-by-doing is more relevant to large firms than smaller firms. According to Acemoglu et al (2014), focusing on IT-using **(**rather than IT-producing**)** industries, the evidence for faster productivity growth in more IT-intensive industries is somewhat mixed and depends on the measure of IT intensity used.

2.3.4 International context

This is an area in which the evidence of small businesses challenges classic economic theories (such as Melitz, 1993). The widely acclaimed prediction is that firms self-select into export markets due to productivity superiority. However, some firms, often called born-global firms, seem to enter export markets early in their lifecycle, and tend to be heavily involved in international activities virtually from formation[8]. Although there is no study on the link between initial productivity and internationalization among these firms, many characteristics they share, such as leveraging advanced information and communications technology (ICT), superior product quality, focusing on product differentiation (Tanev, 2012), may indicate they are

[8] Although not numerous, born-global firms may be important: evidence for the UK suggests that while they account for only around 2% of firms in the marketable goods and services sector, they are much more likely to innovate and perform R&D than non-exporters, and tend to be more productive than non-exporters. They also tend to be concentrated in high technology sectors (BIS, 2010 'Internationalisation of Innovative and High Growth Firms', Economics Paper No 5,op. cit. pp 21-22).

born productive.

What we know about small businesses' productivity is limited, but it is clearly crucial to understanding national businesses productivity. There are only two ways to improve a country's aggregate productivity, either by improving an average firm's productivity, or reallocating resources from less productive firms to more productive ones. Therefore, we need to build a comprehensive knowledge stock based on systematic and rigorous evidence on the two areas:

i. How to make small businesses on average more productive – by understanding the productivity growth drivers and barriers?

Given that entry patterns differ before and after the recent economic crisis (Anyadike-Danes & Hart, 2015), it is useful to investigate what caused the differences and how start-up conditions affect productivity growth (and survival) post-entry. We also need to understand better the role of innovation and technology in small businesses.

ii. How to allocate resources to more productive firms, and to do this, we need to understand the contribution of small businesses to aggregate productivity?

We need to know how important the small business population is not only in creating jobs but also in contributing to aggregate productivity. We need to start investigating the resource allocation effects of promoting small businesses to start up, to grow and to exit. Hence the link between productivity growth and job creation needs a more careful examination.

3. DATA AND OUR APPROACH

3.1 Data

The dataset used in the analysis is the ONS Business Structure Database (BSD). This is derived from the Inter Departmental Business Register (IDBR) and holds information on all firms registered for VAT and/or PAYE in the UK. The BSD is the most comprehensive dataset in terms of

business coverage in the UK, storing information on employees, turnover, age, sector and geography. The BSD represents a snapshot of the IDBR taken each year in March and contains over two million records; however the data it holds are sourced from the VAT and PAYE records of firms as well as from other ONS business surveys, such as Business Register and Employment Survey (BRES) and the Annual Business Survey (ABS), and thus the time period of coverage is not consistent for all firms. Due to the manner in which the BSD is updated and the timing of the snapshot, we estimate that lag on the BSD turnover data to be approximately 2 years.[9]

3.2 Define entry and exit

In order to undertake the productivity analysis over the 1997-2013 period, a longitudinal version of the BSD was created in which the individual annual BSD datasets were linked together keeping only relevant variables. As the version of the BSD that is accessible to researchers is a relatively unclean version, there are many instances of missing employment or turnover observations for firms that are supposedly alive and active. To correct for this an Entry/firm creation variable was created in the first year that the firm records employees and turnover and where the firm is recorded as being active. Similarly, an Exit variable was created the first year the firm's employee or turnover is recorded as zero or missing, and where the firm is recorded as being inactive, having been active the previous year. Those for whom an entry and exit year could not be established by this method (i.e. never record employees or turnover) were dropped. This longitudinal dataset was used in the productivity analysis. The inclusion of dual SIC 2003 and SIC 2007 coding on the dataset from 2007 onwards was used to run the SIC 2007 series back to 1997. Where there were SIC 2003 codes, prior to 2007, which had no SIC 2007 equivalent on the dataset, an ONS

[9] This issue was discussed at an IDBR/BSD user group meeting organised by BIS in October 2014. The minutes from the meeting suggest that researchers using BSD could be using data in summer 2015 that relates to mostly 2012 activity. The problem occurs for both employment and turnover, but is more serious for the latter. However, given that there is no accurate estimate of the possible delay in reporting, nor is there official documents to give guidance of the adjustments, we use and interpret the figures in BSD as they are given.

lookup table was used to obtain the correct 2007 equivalent. Furthermore, the turnover data was deflated using a derived deflator based on 2-digit SIC (2007) GVA data sourced from ONS, using the GDP (o) low level aggregates series[10].

The data used in the analysis covers the partial private sector, which is all firms except those in SIC (2007) Sections O (Public Administration and Defense), P (Education) and Q (Human Health and Social Work Activities), SIC (2007) Section A (Agriculture), B (Mining), D&E (Energy and Water), K (Finance and Insurance) and L (Real Estate). These particular sectors were excluded in order to provide results which are comparable to other recent similar studies, for example, the recent work by the Bank of England (Barnett et al., 2014), who have also used the BSD, but have calculated measures of labour productivity using GVA per employee. In addition, we further exclude outliers in the top and bottom 1% in terms of labour productivity (log of turnover per employee). To undertake a sensitivity analysis we will redo the analysis on another subset of the data which includes some of the sectors we have excluded here.

3.3 Define firm size and age

Rather than just focusing on firms as a single group, we differentiate firms by size and age bands. In addition to the usual classification of SMEs (firms with 1-249 employees) and large firms (firms with 250+ employees), we separately consider single employee firms that, according to the recent statistics, have risen noticeably in the business population over the crisis period. Our interest is to investigate whether there are any signs of falling productivity in each category, particularly among single employee firms, in order to reflect on the recent argument of the rising amount of low productivity jobs in the UK (Martin and Rowthorn, 2012).

[10] It was difficult to find a suitable price index that covers the period of interest (1997-2013) and is at a detailed enough level to correctly deflate the turnover series. Using 2 digit SIC could be argued as being too general but it is quite likely that even within 5 digit SIC codes that prices for firms will differ, and will depend on costs and demand for the product.

3.4 Categorising firm growth types

The change in aggregate labour productivity is driven by the change in individual firm labour productivity. We use the change in firm employment and turnover to classify the change in firm labour productivity into five categories shown in the following table. Three categories exhibit productivity growth, namely Fake Growth. Growth Hero and Jobless Growth, and two productivity decline, Decline by Efficiency Loss and Decline by Contraction.

<table>
<tr><th>Labour productivity growth</th><th>Labour productivity decline</th></tr>
<tr><td><u>Fake growth</u>
Positive productivity growth, whereby productivity increases through a contraction in employment (dy=0>dE); or where the contraction in employment is faster than the contraction in turnover (dE<dY<0).</td><td rowspan="2"><u>Decline by efficiency loss</u>
Negative productivity growth, whereby turnover decreases but employment grows (dY≤0<dE) or where employment and turnover grow but employment growth outpaces turnover growth (0<dY<dE).</td></tr>
<tr><td><u>Growth hero</u>
Positive productivity growth, whereby turnover and employment both grow, the growth in turnover faster than employment (dY>dE>0).</td></tr>
<tr><td><u>Jobless growth</u>
Positive productivity growth, whereby turnover increases with either no employment growth, or with employment contraction (dY>dE≤0).</td><td><u>Decline by contraction</u>
Negative productivity growth, whereby turnover and employment both decrease but turnover contracts more than employment (dY<dE≤0).</td></tr>
</table>

Note: Y denotes turnover, and E denotes employment, d is the rate of change.

It is worth noting that these groups contain survivors and exits as the growth records are compared on a yearly basis. Therefore, there are two additional groups that constitute the remaining firms in the business population, a) entrants and b) survivors with missing previous employment and turnover data. As entrants are new in a particular year they have no previous employment or turnover levels and so a growth figure cannot be calculated; likewise for those survivors whose previous data are missing (this arises due to previous data points being removed as outliers). We therefore exclude these two types of firm when assessing the contribution

to aggregate productivity growth. [11]

3.5 Measuring firm level productivity and decomposing aggregate productivity: methodology

Melitz and Polanec (2012) show that the aggregate productivity between any two consecutive periods can be written as a function of the aggregate share and productivity of continuing survivors (i.e. Φ_{St}), exiting firms (i.e. Φ_{Xt}) and entrants (i.e.Φ_{Et}). In particular, at the start of period *t=1* and in the next period *t=2* the aggregate productivity can be written respectively as:

$$\Phi_1 = w_{S1}\underbrace{\sum_{i\in S}\left(\frac{s_{i1}^k}{w_{S1}}\right)\phi_{i1}}_{\Phi_{S1}} + w_{X1}\underbrace{\sum_{i\in X}\left(\frac{s_{i1}^k}{w_{X1}}\right)\phi_{i1}}_{\Phi_{X1}}$$
$$\Phi_2 = w_{S2}\underbrace{\sum_{i\in S}\left(\frac{s_{i2}^k}{w_{S2}}\right)\phi_{i2}}_{\Phi_{S2}} + w_{E2}\underbrace{\sum_{i\in E}\left(\frac{s_{i2}^k}{w_{E2}}\right)\phi_{i2}}_{\Phi_{E2}} \quad (2)$$

where $w_{ht} = \sum_{i\in h} s_{it}^k \Big/ \sum_i s_{it}^k$, $h = S, X, E$ denotes the set of firms which belong to the survivors (S), the exit firms (X) and the new entry (E) in the economy. This means that for any consecutive periods, the aggregate productivity in period 1 consists of the weighted average productivity of the survivors and the exits, while that of period 2 consists of the weighted average productivity of the survivors and entrants, where the survivor set of in the both periods are common.

For surviving firms, their productivity can be further decomposed into an average productivity term (or technical efficiency) and an allocation term. The *average-productivity* term is the unweighted mean of labour productivity of all the surviving firms $\overline{\phi_{St}} = \sum \overline{\phi_{it}}/N_{St}$ where i $\in S$ and N_{St} denotes the total number of surviving firms at time *t*. It measures the unweighted average contribution of individual surviving firm's productivity to

[11] This result in on average an exclusion of 16% of the total population in any year, which ranges annually from 14-20%.

aggregate productivity. The *allocation* term corresponds to the sample size-productivity covariance, which is expressed as $cov(s_{it}^{k}, \phi_{it}) = \sum_{i \in S}\left(\frac{s_{it}^{k}}{w_{St}} - \frac{1}{N_{St}}\right)(\phi_{it} - \overline{\phi_{St}})$. In other words, the allocation term is the mean of the multiplication terms of the differences between a surviving firm's actual share in the economy and the hypothetical average share in the economy (i.e. if resources were allocated randomly by a perfect market mechanism) and the differences between the firm's TFP and the average TFP level of the surviving firms. This means that Equation (2) can be re-written as:

$$\Phi_1 = w_{S1}\overline{\phi_{S1}} + w_{S1}\sum_{i \in S} cov(s_{i1}^{k}, \phi_{i1}) + w_{X1}\Phi_{X1}$$
$$\Phi_2 = w_{S2}\overline{\phi_{S2}} + w_{S2}\sum_{i \in S} cov(s_{i2}^{k}, \phi_{i2}) + w_{E2}\Phi_{E2} \quad (3)$$

The formulas above describe the contribution of average technology of the surviving firms, resource reallocation among surviving firms, and of exit and entry to aggregate productivity.

Unlike the resource allocation measure in Foster et al. (2001) who report the inter-relationship between the market share and productivity of individual firms when compared to itself over time, the measure for resource allocation in equation (3) captures the joint cross-sectional distribution of market share and productivity that compares the individual labour productivity with the average of all the surviving firms, which provides greater insight into aggregate productivity variation (Melitz and Polanc, 2012).

Understanding the components in equation (3) helps to shed light on the important contributing factors to the static aggregate labour productivity in the UK. However, to gain knowledge about the dynamic development of the aggregate productivity, we need to study its changes over time. Given equation (3) above, Melitz and Polanec (2012) show that the changes in aggregate productivity between time *t=1* and *t=2* can be written as:

$$\Delta\Phi_t = \underbrace{\overline{\Phi_{S2}} - \overline{\Phi_{S1}}}_{\text{Labour productivity improvement}} + \underbrace{\left[\sum_{i\in S} cov(s_{i2}^k, \phi_{i2}) - \sum_{i\in S} cov(s_{i1}^k, \phi_{i1})\right]}_{\text{Resource allocation of survivor}} + \underbrace{w_{X1}[\Phi_{S1} - \Phi_{X1}]}_{\text{Gains from exit}} + \underbrace{w_{E2}[\Phi_{E2} - \Phi_{S2}]}_{\text{Gains from entry}}, \quad (4)$$

where the first term, technical progress, represents the aggregate productivity growth due to the average productivity improvements of the survivors, while the second term represents the improvements due to the resource allocation among survivors; the third term represents the gains in labour productivity growth by firm exits and the last term represents the gains from the entrants. The last three terms together indicate the total resource allocation effects in the aggregate productivity growth.

As shown in Equation (4), the contribution of exiting firms to aggregate productivity growth is compared to surviving firms at time *t=1*, while the contribution of entering firms to aggregate productivity growth is compared to surviving firms at time *t=2*. This sets Melitz and Polanec (2012) method apart from the earlier decomposition methods by Baily et al. (1992), Grilliches and Regev (1995) and Foster et al. (2001), where the exits and entrants are compared to average productivity of all firms between the two periods. Melitz and Polanec (2012) show the contribution for exiting and entering firms in their method is constructed on a more rational "counterfactual" case, where the aggregate productivity gain are derived from comparing exiting and entering firms with their surviving peers in the same periods.

In addition to understand the impact of new entry and exit on aggregate productivity growth, we are also interested in the contribution of surviving firms of different life stages on aggregate productivity growth, so we divide the firms into three groups based on the number of years since they had their first employee. More specifically, we define a firm to be a new firm if it had its first employee in the past year, a firm to be a young firm if it had its first employee between 1 and 5 years ago and a firm to be a mature firm if it had its first employee more than 5 years ago.

4. UK LABOUR PRODUCTIVITY TRENDS AND PATTERNS

4.1 Aggregate employment, turnover and average labour productivity in the UK

Table 1 presents the summary statistics, as derived from the BSD, for the partial private sector removing the top and bottom 1 percent observations in terms of labour productivity. Although the BSD has data available from 1997, the starting year selected for the analysis here is 1998, to allow for survivors and entrants to be identified.

The change in the levels and growth of employment, turnover and the calculated labour productivity listed in Table 1 are depicted in Figures 1-3. Overall, we see the labour market recovered more quickly than the output market while going through the recent financial crisis. More specifically, employment in the UK (amongst employer-enterprises) rose on aggregate by 1.3 million, or 9%, over the 1998 – 2013 period. The pattern of growth was quite volatile (Figure 1); most of the increase in employment occurred up to 2002, followed by a period of relative stability until the peak of 2008. The Great Recession was characterised by a sharp drop in employment of around 5% starting in 2008 till 2012[12]. By 2013 employment had recovered nearly to pre-recession levels and growth was positive again.

Unlike employment, aggregate turnover followed a steadier rate of growth, in real terms, with annual changes typically between 0 and 2% over the 1998-2013 period (Figure 2). The pronounced drop in turnover of around 4% between 2007-2009 was followed by some degree of recovery, and then a further drop of around 5% between 2009 and 2012. This means that over the whole financial crisis period turnover dropped by 9% overall. As with employment growth, turnover growth returned to a positive state by

[12] The interpretation of the timing could be different if one takes into consideration the possible BSD statistics' lag as mentioned in footnote 10.

2012, but turnover levels have not returned to the level experienced prior to 2007.

An important observation when comparing the employment and turnover patterns is the following. There was one deep drop in employment growth over the recession but two drops in turnover growth. Reflecting on the recent discussions on the productivity puzzle, scholars argue that the labour market has responded rather differently from previous recessions in that the labour market recovered quicker than turnover. That forms part of the UK productivity puzzle (Bryson and Forth, 2015). It is useful to note that turnover had a small recovery in 2010 but employment did not. [13] That explains why the labour market response to the recession was perceived as less prolonged.

The trends in aggregate and average labour productivity are shown in Figure 3. The former is calculated as the sum of turnover per year divided by the sum of employees; the latter is calculated as mean turnover per employee per firm per year. While the aggregate shows a flat trend over the period, average labour productivity follows a generally decreasing trend with the 2013 figure around 23% lower than that in 1998, in real terms. As we will show in the rest of the analysis, the difference in the two series is due to the changing business demographic characteristics. For example, the share of exit increased and that of entry firms decreased over the crisis period (see Section 4.3 below); single-employee firms represent an ever-increasing share of firms in the economy however their average labour productivity has declined over time; reducing the overall average[14] (see Section 4.5 below).

Focusing on aggregate labour productivity, we see a generally positive picture until 2007, with some negative growth around the early part of the decade. It appears from the data that the recent crisis period is represented

[13] It is worth noting that based on BSD data, we do not find that the employment level went back and exceeded its pre-recession level in 2012, as reported in Bryson and Forth (2015).
[14] The share of single-employee firms in the economy increases from 33% in 1998 to 45% in 2013 (source: BSD).

by two separate dips, 2007-09 and 2010-2012. In the first period the drop in growth is around 3%[15] and the second period saw a drop around 5%. By 2013 productivity growth returns towards zero, with the average productivity level stagnating at around £115,000. It is noteworthy that a similar drop in aggregate productivity growth also happened in the early 2000s when aggregate productivity growth dropped by about 4%.

4.2 Industrial sector differences

Comparing the above to other broad sectors we find similar patterns in average labour productivity for almost all sectors, i.e. that of a continual decline. The manufacturing sector experienced a consistent decline in employment over the entire period from 1998-2013, with an overall 19% decrease from 4.1m employees in 1998 to 2.2m in 2013. Turnover was also characterised by an overall decrease, falling by 16% in real terms from £403bn in 2008 to £367bn in 2013. The 12% decline in turnover over the 2010-11 period, coupled with a drop in employment of half that, resulted in an overall drop in productivity of around 5% in 2010-11 and 8% the following year (see Figure 4), the apparent productivity puzzle thus due to a combination of lost employment and lost markets.

Employment in the construction sector was generally positive until 2009; thereafter it suffered a large loss, with a drop of around 11% between 2009 and 2011. In contrast, turnover was on a downward slope during most of the period, with considerable annual decreases throughout. In 2010-11 alone turnover fell by 12%, resulting in a similar decrease in productivity.

Since the onset of the recession other sectors, including Wholesale and Retail, Transport, Accommodation, Arts and Other Services followed a similar decrease in average labour productivity (Figure 4). Sectors which bucked the trend include the Information and Communication and Professional Services sectors. The former of these, which covers information technology, software, radio, TV and telecommunications

[15] This is less than what is as reported in Barnett et al. (2014) for the 2007-09 period.

experienced almost flat growth since the recession whilst Professional Services is the only sector to have shown an increase, which was the result of an increase in employment levels coupled with an even higher increase in turnover levels.

4.3 Industrial Dynamics

The economy is made up in any year, of firms that are continuers (or survivors), new entrants and exiting firms. As per Table 1 the shares of continuing firms in the economy remained stable throughout the 1998-2013 periods at around 76%, even during the recession. However, the composition of the industrial dynamics, made up of entrants and exiting firms, changed somewhat during this period; the share of exiting firms rose from an average of 8% between 1998 and 2007 to 11% between 2008 and 2012 whilst there was a coinciding drop in the share of entrants, from 16% on average, to 13% in the latter period. This finding is perhaps not surprising given that new firms might have found it too risky to enter the market or too challenging to borrow to start up during the recession, whilst existing firms may have suffered a drop in demand and could not survive falls in demand and increased competition.

The share of continuing firms was consistent throughout the entire period for the broad sectors too, although there were differences across sectors in their contribution to the total (Figure 5). Continuing firms accounted for just 72% of firms on average in the Information and Communication, and Accommodation sectors but 80% or more of the total in the Manufacturing; Wholesale and Retail; Arts and Other Services.

The general trends of decreasing entry rate and increasing exit rate can also been seen across sectors (Figure 6 and Figure 7). There are clear differences in the composition across sectors from entrants and exiting firms. Typically entrants accounted for around 15% of all firms, on average over the entire period, although this ranged from 9% of manufacturing firms to 18% in Professional Services (Figure 6). Exiting firms accounted for 9% of firms in any one year on average; with the range narrower than that for entrants, at 7%-12% (Figure 7). Higher entry and exit rates were observed

amongst the service sectors indicating higher levels of churn than for Manufacturing.

Alongside these compositional differences, the effects of the recession were manifested differently by sector. The Manufacturing and Wholesale and Retail sectors showed little change in the makeup of firms prior to and post 2008 compared to Construction, Transport, Information and Communication, and Professional Services. These sectors appear to have been affected by the recession to a greater degree, with Construction hit particularly badly; exiting firms contributing an average 7% of firms during 1998-2007 rising to 11% during 2008-13, with a corresponding fall in entrants from 17% to 13%.

The timing of such changes to the makeup of firms appeared, for the most part, to occur during the 2008-09 period. However for other sectors, particularly Accommodation, Arts and Other Services, the drop-off in entrants appeared earlier, occurring during the 2007-08 period for the former and from 2004 for the latter two sectors.

4.4 Firms of different growth types

We next look more closely at the growth types of continuing firms over the period, which amount to around 84% of the whole business population. Figure 8 displays the five types of labour productivity growth or decline that firms experienced. Overall, on average at least half of the business population displays negative productivity growth (based on the sum of the numbers of firms in the two types of productivity decline). In difficult times such as the recent economic crisis period, there can be a higher share of such firms than usual. For example, 2002 and 2009 seem to be the worst – 60% of the surviving business population showing labour productivity decline.

Looking into detailed growth types, the share of ‘Jobless growth’ firms, i.e. those that experience real labour productivity growth without hiring more employment, that usually make up two fifths of the economy, drops to around one third during the recent recession. This could be an important

explanation of the overall economy's decreased labour productivity given the group's large contribution to the economy. In the other words, there are fewer becoming-more-efficient firms in the economy.

Another notable change during the recessionary period is the surge of firms that 'Decline by contraction'. These are the firms that experience negative productivity growth due to both revenue decrease and labour contraction, with revenue contracting more than employment. The share of this group in the economy is significant, usually accounting for at least one third and peaking at 47% in 2011; this could be an important explanation of the overall economy's underperformance. The fact that this group started to revert to pre-crisis trends in 2012 may suggest it was mainly due to the overall demand shock during the recession period. This also indicates the significance of potential labour hoarding.

Firms of 'Decline by efficiency loss' show an increasing presence during the crisis period; these are firms that experience negative productivity growth due to efficiency loss. This arises when firms have employment and output increases but where employment growth outpaces output growth. This group is relatively small (generally around 10% of firms) however their share increased to 15% by 2013. Clearly these firms were unlikely to be labour hoarding. It could be the case that the upscaling firms were caught up with unexpected demand shocks, although we need to be cautious when characterising these firms, for they might also have taken the opportunity of the crisis period, when asset prices are low, to accumulate productive capacity.

Focusing on those firms that display positive labour productivity growth, we observe that those with 'Fake growth' and those labelled 'Growth heroes' are fairly stable over the period. The most desirable group, 'Growth heroes' (which amount to around 4% of all surviving firms) has not experienced much volatility over the crisis period which shows strong resilience. Although this group is not equal to high growth firms, it is still a very interesting phenomenon that a small proportion of firms seem immune to the recession and grows strongly.

We further summarise firm characteristics by growth type in Table 2. We first note that all growth types are similarly represented across age groups, so age alone cannot characterise growth types. There appear to be some pattern of firm growth types by size. For example, there is no single employee firm in the category of Growth heroes, the majority of which are SMEs (2-249 employees here). Similarly, almost all firms showing "Decline by efficiency" are SMEs (98.9%). Consistent with the declining productivity records of single employee firms we show in the following section, 46% of firms that show "Decline by contraction" are single employee firms. This is consistent with our observation that single employee firms have become on average less productive over time (more discussion in Section 4.5). In addition, by comparing the group composition of growth types across sectors, we see a pattern of the sectors that experience more decline or growth relatively. For example, there are more Growth heroes and Jobless growth firms in Professional Service sectors and in manufacturing sectors than average. The percentage of Decline by contraction firms from the Construction sector seems the highest among other growth types. We also find that 18% of Growth heroes are based in London, more than anywhere in the country. In addition, 13% of Growth heroes are not UK-owned, highest among all other growth types. Turning to the variables that determine productivity formation, we note that Growth heroes show impressive records of both employment growth (29%) and turnover growth (44%) over the whole period, which lead to the average labour productivity growth of 23%.

Figure 9 displays the growth types for the manufacturing sector. This picture is largely consistent national aggregates. Over the crisis period it is clear that the share of firms with negative productivity growth has increased to account for more than half of all firms. The dominance of these negative productivity firms explains the poor performance of the Manufacturing sector, particularly as firms that 'Decline by contraction' i.e. those with decreasing output and employment, where the fall in output is greater than the employment contraction, or where there is output fall without a change in employee numbers, accounts for the largest share of such firms. Of the positive growth firms those labelled 'Growth hero' are squeezed somewhat

over the financial crisis but these are a small group representing less than 5% of firms. The biggest drop in the share of firms with positive growth is in the 'Jobless growth' firms; prior to the crisis these firms account for around 40% of firms dropping to around 30% thereafter. These are firms with positive growth due to output expansion and either lower or no employment growth, and their contraction in numbers, which has remained at the lower rate even in 2013 is a worry.

4.5 Firms of different size and age

4.5.1 Firm size

Turning to the patterns of firm size and age, we convert our raw data into indices relative to 2011[16]. Figure 10 displays the business demography changes in share of firms by size group, employment, turnover and labour productivity for firms of different sizes. First of all, in terms of the number of firms, SMEs (<249 employees) remain dominant in their presence in the business landscape, while the share of large firms (250+ employees) has fallen from 0.5% to 0.3% of the business population. There are also clear trends among SMEs themselves, in that the share of single-employee firms increases considerably relative to non-single employee SMEs. Compared to 1998 when single employee firms represented 33% of the business population, there are over 45% in 2013 with a noticeable surge occurring around 2008.

Consistent with the number of businesses, single employee firms have been growing at a faster rate in terms of employment and revenue than other firms over the entire period, with their 2013 rates moving towards their pre-recession peaks. Both non-single employee SMEs and large firms experience a drop in employment during the crisis period, and do not show the same pattern of recovery.

[16] 2011 is chosen as it reflects the deflator series provided by the ONS, and enables comparisons to be made against other productivity series, such as that shown in Harari (2015).

Despite the above growth trends for single employee firms, labour productivity follows a different growth trajectory (Figure 10). It appears that average labour productivity for single-employee firms (and by definition aggregate labour productivity) decreases over the entire period. Other small and medium-sized firms also show a decrease in average labour productivity, although to a lesser extent. In contrast, average labour productivity for the largest firms increases over the period. However, given the small number of these firms in the economy, their impact is not reflected in the overall average productivity trend.

Given the difference in average productivity growth above, Figure 11 contrasts labour productivity performance by size for the four largest sectors in the economy in 2013: Professional Services, Wholesale and Retail, Construction, and Information and Communication. Contrasts can be seen by size both within and across sectors. Professional services, which accounts for around 30% of all firms, saw an overall decrease in average productivity for the smallest size groups; the largest having relatively flat growth over the period. However, growth flat-lined for all three sizes between 2010-13. Average labour productivity levels for the Wholesale and Retail sector, which account for around one fifth of firms, also saw divergent trends between the size-bands. Labour productivity for the single-employee firms has been on a downward trend since 1998; for other SMEs average labour productivity also decreased overall, although it remained pretty stable from the start of the decade until the crisis. In contrast the average labour productivity of larger firms barely changed. The Construction sector followed a similar trend; average labour productivity for the smallest groups of firms decreased by around 60% overall whilst that for larger firms remained relatively unchanged. Information and Communication bucked the trend with the average labour productivity of the smallest firms remaining mostly flat, with the exception of a temporary increased blip around 2007; in contrast the largest firms saw an increase in average productivity over the entire period.

4.5.2 Firm age

Due to the way in which we have constructed entry and exit on the BSD (i.e. presence of employees and turnover), the first year in which an entry can be observed is 1998. We have generated age based on a firm's entry date, and have separated it into three categories, entrants aged 0; young firms aged 1-5 and mature firms aged 6+; thus as 1998 is the earliest entry year observed then the first year a mature firm can be observed is 2004.

Figure 12 presents the trends in employment, turnover and labour productivity by firm age from 2004 onwards. Given that every additional year results in an increase in the number of firms in each age group (as age 0 firms move into age 1-5, and age 5 move into 6+), as well as a net change in the employment and turnover of incumbent firms, the employment and turnover figures are standardised by firm to remove the effects of firms' movements through age group categories. A noticeable feature is the drop in the share of new entrant firms, particularly between 2008-12, and the subsequent knock-on effect on the share of 1-5 year old firms. For the youngest groups of firms the turnover and employment series follow the same trend; both decreasing over the entire period whilst the older firms see an overall small increase, although peaking around 2008. For all age groups both aggregate and average labour productivity fell over the period, with two drops particularly noticeable in the average labour productivity of young firms.

Figure 13 displays the labour productivity trends for the four largest sectors. The Wholesale and Retail and Construction sectors show the least divergence between their respective age groups, with all following the same broad downward trend. In contrast both the Professional Services and Information and Communication sectors display rather different trends by age group although the latter sector shows some convergence since the recession. Notably, the only increase in average labour productivity since the most recent 2012-13 period has been in Professional Services and has been driven by young firms, aged 1-4.

5. AGGREGATE LABOUR PRODUCTIVITY DECOMPOSITION RESULTS

We next apply Melitz and Polanec (2012) decomposition methods to aggregate labour productivity and its growth and report the findings below.

5.1 Aggregate labour productivity level decomposition

From the aggregate picture, we first observe a general upward trend in aggregate labour productivity over the whole course to 2013 (see Table 3 and Figure 14). There are periods of decreasing aggregate labour productivity, and clearly the recent financial crisis period was not the only one.[17] Since the outset of the recent financial crisis, there have been two drops in aggregate labour productivity, neither was as deep as the one around 2000, but has noticeably lasted longer.

The second observation is that aggregate labour productivity follows the trend of average labour productivity of surviving firms. This is known as within firm effects. On average, the pattern of surviving firms' labour productivity profile dominates the pattern of aggregate labour productivity by about 95.8%. This is consistent with what has been found previously (Disney et al 2003; Barnett et al 2014).

Third, while the past decade saw an overall uptrend of aggregate labour productivity, the average labour productivity of surviving firms has in fact decreased compared to the starting point, indicating the weakness of within firm productivity.

The components of resource allocation are illustrated in Figure 15. On average across the whole period of examination, resource allocation between surviving firms contributes to the aggregate labour productivity level by about 0.1%. However, this masks a clearly increasing trend over time – resource allocation among surviving firms has been steadily

[17] The previous recession was around 1999-2001 presumably due to the dot com bubble.

increasing, with a few flattening episodes, particularly at the beginning of the crisis between 2007-2009. It contributes to the aggregate labour productivity level by 2.6% in 2013, and reaches the highest level of 2.9% in 2012. This reflects the cleansing effects and functioning market mechanism of labour reallocation effects in the economy.

The overall trend in the resource allocation contribution of entrants and exits to aggregate productivity is one of slight decline. On average, exits contribute about 3.4% to aggregate productivity and entrants contribute about 0.8%. Because firms' contributions are weighted by their presence in the economy, the decreased contribution is either due to lower weights of these two groups in the economy (less firms in these groups than previously), or a worsened average labour productivity level of each group (the average labour productivity is lower). We note that the resource allocation contribution of exits is more volatile than entrants with big dips easily detected. We also find that the share of exits has increased while entry has decreased over the crisis period. This makes sense in that over recessionary periods more firms than usual exit the market and some of them may not be the least productive ones hence their exits register a negative contribution to the aggregate productivity level, largely because the exits during the recession period were not the least productive firms.

We also notice that during the recent recession the decline in entrants' contribution to resource allocation happened earlier than that of exits. This could be due to existing businesses managing to hang on for a while before closing down while entrants might have experienced difficulties straight away and hence been deterred from entry. Certainly, the number of entrants in the economy dropped over the crisis period, with the numbers entering between 2009 and 2011 down by around one quarter, on average, from the 2007 figure. These aspects reflect the selection and competition effects of the industrial dynamics.

5.2 Aggregate labour productivity growth decomposition

Turning to labour productivity growth, we observe that while it is mostly positive the annual changes are relatively small, with the exception of the

deep drops in 2000, 2008 and 2011 (see Table 4 and Figure 16). The recent crisis is marked by a particularly deep drop that was perceived to be exceptionally long.

Consistent with the finding in the aggregate labour productivity level decomposition, it appears that the contribution to aggregate labour productivity growth by the labour productivity improvement of surviving firms has been quite volatile over time and overall, as seen in the previous section, drives the trend in aggregate labour productivity growth.

Despite this, the total reallocation effects act as the driving force of aggregate labour productivity, particularly in the recession periods. These effects come with delays in time (about a year). This is not surprising given that resource reallocation reflects to some extent the feedback effect of market conditions. Summarising the annual results into three-year periods, as reported in Table 4, we find some evidence of deteriorating resource misallocation among surviving firms as found in Barnett et al (2014). However, the most noticeable worsening effects were in fact within firm productivity decline. Resource misallocation effects due to exiting firms have also deteriorated but resource misallocation effects due to entrants have improved. Given that there are less entrants over the recession period, this improvement is mainly attributed to the average higher productive level of the entrants.

5.3 Aggregate labour productivity level and growth decomposition by sector

Figure 17 depicts aggregate labour productivity and its decomposition by sectors. While nationwide productivity has stagnated, the experience varied considerably by sectors. First of all, there are notable differences in the labour productivity trends over time amongst sectors particularly since the recession. The most obvious decline is seen in Manufacturing, although there are also decreases in Transport, Construction and Other Services. Professional Services is distinguished as the only sector to show a noticeable upswing since the recession, this may reflect an underlying industrial structural transformation within the service sectors. The sector-

level aggregate labour productivity stays close to the labour productivity of surviving firms and for most sectors the two series are indistinguishable, suggesting the small contribution of resource allocation overall.

Turning to the contribution of resource allocation effects in more details (Figure 18), we note that the rank of the contribution to aggregate labour productivity in the economy is consistent across sectors, and consistent with the national picture (as in Figure 15). Not surprisingly entrants play a more important role in driving aggregate labour productivity growth than exits, and the smallest contribution is from resource allocation among surviving firms. There is great heterogeneity among sectors, in both the levels of the contribution of resource allocation and in their dynamic trends. For example, the Manufacturing sector saw diminishing contributions from entry and exit over time, converging with slightly improved resource allocation among surviving firms. Similar trends can be found in the Wholesale and Retail sector, Transport and Information and Communication sectors. We also notice that resource allocation among surviving firms in Professional Services decreased over time and has been consistently negative while resource allocation effects through entry and exit are stronger than any other sectors.

The sectors where the contribution of entrants fell in the crisis period are Construction, Accommodation (slightly), Information and Communication and Professional Services, and Other Services although most of them recovered recently. This could be due to either less entry or lower productivity level entry. We can confirm that there were noticeably less entrants over the period for all sectors, whilst the average productivity levels for Construction, Accommodation and Other Service sectors all decreased since 2008. This further reflects that service sectors were hit harder in the crisis.

Mirroring entry effects, Information and Communication and Other Services also have a high contribution from exits in the early to mid-2000s period and are quite volatile. A noticeable change is also observed in Construction particularly since the crisis. Towards the end of the series, the contribution from entry and exit has reversed and exits contribute more than entrants. A

greater contribution among survivors reallocating resources and a lower contribution from entry reflect the structural changes that occurred in this sector during the crisis period.

Focusing on the overall Manufacturing sector, the pattern of aggregate labour productivity growth is quite volatile and, as stated above in the aggregate picture, is mainly driven by the performance of survivors. While aggregate labour productivity growth has remained below zero throughout the whole period, it is clear that there has been a big drop in aggregate labour productivity among surviving firms since 2008 but the recovery has been steady since 2010. Figure 19 shows that in fact growth is almost exclusively accounted for by the within firm productivity improvement of survivors. The contribution from resource allocation has generally been positive and has been relatively stable in size.

Although the contribution of overall resource allocation was quite stable over time, it hides an underlying picture of change (see Figure 20). The most dominant source of resource allocation is due to the resource allocation of surviving firms; this was particularly pronounced in 2002, 2006-07 and 2012. Interestingly, exits also contribute positively to resource allocation in most of years; and the line appears to be flat over the recent recession compared to the 2002-3 recession. This implies that more firms died over the period and they tended to be unproductive firms. The contribution of entry has also tumbled during the recent recession, reflecting the lower share of entrants discussed earlier. The contrast between these two factors shows that the mechanism of resource reallocation has worked well with cleansing effects and the main issue lies on the entry side.

Aggregate labour productivity growth in Construction has moved around the zero line and in good times the Construction sector benefits and in bad times it suffers. It is also clear that since 1999 this sector has experienced its largest ever drop in growth in the recent recession (Figure 21). Although starting to recover since 2011, aggregate labour productivity growth has not quite returned to its pre-crisis level until 2013. Again, the growth has been driven almost entirely by within firm productivity improvement. Since

2009 the contribution from resource allocation has been close to zero but there is also an upward trend, indicating improvement in overall resource allocation.

The detailed picture of the resource allocation contribution of the components shows that resource reallocation among surviving firms has been making a positive contribution, and during the crisis, despite the volatility, made a significant contribution (Figure 22). This could happen through mergers and acquisition and reflect cleansing effects. The overall trend of the contribution of entry and exit is upward, suggesting that improvement in resource allocation has taken place over the whole period. But still it is worth noting that both entry and exit effects make negative contributions to aggregate labour productivity growth, except recently where exit effects have been positive and have overtaken resource allocation in surviving firms. The negative contribution of exits contrasts with the national picture and the Manufacturing sector, and highlights the relatively poor resource allocation of the Construction sector.

Compared to the above two sectors, reallocation through entry and exit plays a greater role in labour productivity growth in the Professional Services sector. The contribution from both has been generally positive, with exit accounting for a larger share than entry, since 2007, suggesting that the recession resulted in the exit of the least productive firms. Labour productivity growth in this sector has remained positive since 2007, although quite volatile. Notably the sector has had increasing productivity growth since 2011 and is the only sector to do so.

5.4 Aggregate labour productivity level and growth decomposition: by growth types

Next we look into the productivity contribution from firms by growth types. Table 5 reports detailed results. For each type of growth pattern, we discuss the average labour productivity level of these firms; their contribution to aggregate productivity in percentage terms (as illustrated in Figure 25); the level of the resource allocation of these firms, the contribution of resource allocation in aggregate productivity (as illustrated

in Figure 26), and finally their overall contribution in terms of both the average productivity level and resource allocation.

Interesting contrasts can be seen in the level of labour productivity among the three groups that show productivity growth, labelled 'Fake growth', 'Growth heroes' and 'Jobless growth'. Although seemingly growing, the 'Fake growth' group is the least productive, not only among growing firms but also among all types of growth patterns. Its productivity level is just a little above the entry group, which is normally less productive than incumbents.

While 'Growth heroes' on average are not as productive as 'Jobless growth' firms, they create employment. The 'Jobless growth' is also the most volatile of the three positive growth groups, and much more adversely affected by the recessions. Relatively, the 'Growth hero' group shows more resilience and a quicker recovery from the recession.

Firms that experience 'Decline by efficiency loss' have the second highest labour productivity level while 'Decline by contraction' also show decent labour productivity records. This perhaps reflects the difficulties that many productive firms experience over the crisis period.

We break down the contribution of each group to national aggregate productivity by summing up the two contributing components of average labour productivity of the group and the resource allocation factor (see Figures 25 and 26). The group of 'Growth heroes' contributes disproportionally to aggregate labour productivity. On average this group contribute about 15% of national aggregate labour productivity, triple their weight in the business population, 4-5%. Compared with other groups, this is the most desirable pattern from the policy-making point of view. Although the overall contribution of these firms dropped slightly over the financial crisis period, by 2013, the level had recovered and exceeded the pre-crisis period. This again shows strong resilience and the capability of recovery.

'Decline by efficiency loss' is the only other group that over-contribute to aggregate productivity. On average this group contribute about 30% of the

national aggregate labour productivity, more than twice their weight in the business population, at 13%. The contribution to aggregate productivity has increased steadily over the recession years except the one year drop in 2010, which was driven by a mixture of an increased number of firms in this group and improved average productive performance. A sensible interpretation is that these are on average good firms that experienced a demand shock during the crisis but did not decrease employment corresponding to the revenue dip. When the business environment improves, they are likely to get back on track fairly quickly. Hence this pattern may imply some degree of labour hoarding among these firms. In addition, the resource allocation effects in this group have been positive and very small in magnitude, indicating negligible labour reallocation and exit effects among these firms. Again given that they are likely to experience short-term difficulties, these results are not surprising.

The 'Decline by contraction' group contributes the least to the aggregate productivity relative to their presence in the economy. On average this group contribute about 20% to national aggregate labour productivity, while their weight in the business population is above 40%. The positive contribution of allocation effects contribute more to this group than it does to the others, indicating that restructuring by expansion or contraction as well as exits in this groups of firms have driven up aggregate productivity. This again suggests resource reallocation that has cleansing effects.

We next discuss the decomposition results within each group. Bear in mind the way we define the growth types implies that each group includes survivors and exiting firms. Hence it is not a surprise that within firm labour productivity improvement is mainly responsible for the contribution made to aggregate labour productivity growth for all groups. For most of the groups resource reallocation effects are negligible (Figures 27 and 28).

Overall, comparing groups in parallel, the most positive resource allocation contribution by surviving firms to aggregate productivity happened among 'Decline by contraction' and 'Growth hero' groups, suggesting that the restructuring by expansion or contraction and exits in these two groups of firms have driven up aggregate productivity. For the 'Fake growth' and

'Jobless growth' groups, resource allocation effects are minimal, but stable over time. Surviving firms of 'Decline by efficiency loss' see a clear decreasing trend in resource allocation effects over time, with the series moving towards the zero line, suggesting (a very small degree of) deteriorating allocation of resources among these firms as discussed above.

5.5 Aggregate labour productivity level and growth decomposition: by firm size

Figure 29 reveals obvious contrasts where we report on the aggregate labour productivity level decomposition results by size band. Overall single employee firms are the least productive, whilst the most productive ones are the largest firms. Again surviving firms' average labour productivity drives the aggregate labour productivity for firms of all sizes, but we also observe that the distance between the line representing the weighted average labour productivity of surviving firms and aggregate labour productivity is largest among SMEs (2-249 employees). This means that the contribution of resource reallocation is more important for SMEs than others. This is hardly surprising as industrial dynamics itself are more relevant to smaller firms, given that firms' death rates drop considerably once past a threshold.

Next we decompose aggregate labour productivity growth for each firm size group and investigate the growth contribution in more detail. Figures 30 - 35 report these results. Overall, all three size bands experienced dips over the crisis period, with SMEs experiencing the deepest drop (Figure 32). In contrast single employee firms' aggregate productivity growth has been mostly negative with the level remaining largely unchanged (Figure 30). Aggregate labour productivity growth amongst the single-employee firms is almost entirely driven by the average level of within-firm productivity growth, while resource allocation effects are trivial. Nonetheless, Figure 31 shows that these small resource allocation effects have been driven up by exits, which surged during the recession period. This suggests that many more unproductive single employee firms died during difficult times and

that improved the overall productivity growth of this type of firm. The entrants' contribution slightly improved, because although there have been more entrants, they were on average less productive (as in Figure 10).

Labour productivity growth for those with 2-249 employees has been relatively volatile over the entire period but aggregate productivity growth has not fallen below zero even during the most recent recession. Unlike that of single employee firms, the aggregate productivity of this group was not entirely driven by survivors' average productivity growth as resource allocation also played a more important role than for other size bands. Resource allocation amongst SMEs has been improving since 2005 and contributed an even higher share during the recession period, with exit contributing more than entry, suggesting some cleansing effects (Figure 32).

Labour productivity growth amongst the largest firms (250+ employees) has also been volatile, and was particularly affected by the recent recession. There was a very deep drop in productivity growth around 2008 and a less severe one in 2012. Whilst within firm productivity growth has been responsible for this growth, there was also a significant contribution from resource allocation during 2007. Resource reallocation from less productive to more productive firms has improved the aggregate productivity growth performance (Figure 33). Clearly, for large firms, within firm productivity improvement is responsible for driving aggregate productivity growth which tumbled by 1.5% over 2008-2009, bounced back until 2012 and dropped again.

5.6 Aggregate labour productivity level and growth decomposition: firm age

Firms were split into young (age 1-5) and mature firms (aged 6+) by age, with entrants (age 0) categorised separately in the initial analysis. As with smaller size bands above, for young firms we would expect to see higher aggregate labour productivity as age increases. Indeed Figure 35 shows a large gap in labour productivity between young firms and entrants. Interestingly we also observe different trends in productivity between young

firms and mature firms; the aggregate productivity level of young firms has been largely steady but dropped slightly since the recent recession, while mature firms have shown an upward increasingly more productive performance at aggregate level over time. For all age groups the resource allocation effects are relatively low.

When we focus on the three types of resource allocation from 2004 onwards we see that the positive aggregate productivity growth of these young firms drops below zero when entering 2007, and only recovers to above zero after 2012 (Figure 36). This is also consistent with the aggregate picture for SMEs, where their aggregate productivity suffered considerably. It is important to note that within firm productivity growth has mainly been responsible for the changes in aggregate productivity growth – suggesting that young firms on average have become less productive. In addition, resource allocation among surviving firms also contributes less and less to aggregate productivity growth over time, and at the same time resource allocation by exits contributes increasingly more to aggregate productivity growth (Figure 37). Given that the relative contribution was the opposite just prior to the recession, these results imply that the effects of the crisis on resource reallocation among young firms was more death and difficulties in upscaling.

The picture for mature firms is different. Aggregate productivity growth has been improving and shows strong resilience during the recession (Figure 38), which is almost entirely driven by within firm productivity growth, while resource allocation does little. As with younger firms since 2005 exits have increasingly contributed to aggregate productivity growth suggesting cleansing effects (Figure 39). Resource allocation among surviving firms has suffered over the recession but recovered well in 2009, which is clearly highlighting the better position that older productive firms may enjoy in acquiring resources to grow and the flexibility of downsizing when needed.

5.7 Aggregate labour productivity level decomposition: firm age and size

Given that there are differences between small firms and young firms, we

further examine the subsamples of firms by age and size-band. Figure 40 shows that aggregate labour productivity among entrants, in all sizes, is almost identical. However the labour productivity levels of firms aged of 1-5 years shows differences, with SMEs showing the most significant growth in labour productivity before levelling off, which is expected. A similar picture can be seen for the mature firm groups, again SME mature firms showing the most significant growth in labour productivity levels compared to single employee firms and large mature firms. The difference between the two is that the growth trajectory for mature firms was more resilient over the recession. The commonality of all these patterns is that within firm productivity is the main driver of the aggregate picture.

6. DISCUSSION AND POLICY IMPLICATIONS

Before we set out to discuss what we find in this research, it is important to point out the characteristics of the dataset we employ and its limitations. The entire analysis has been conducted using BSD data that covers the whole business population in the UK[18]. This is an important feature to bear in mind when reading the results. Using this data allows us to represent the productivity patterns of the whole UK economy in detail over the examined period, and relatively accurately estimate the contribution of each heterogeneous firm group in leading to or preventing aggregate productivity growth. However, the population coverage of the data comes with a price, namely limited information. We are unable to construct firms' capital stock, hence total factor productivity. Little can be said about firms' capital-labour ratio and technology adoption, which is important for firm total factor productivity improvements. As a result, our research does not shed light on the arguments about capital shallowing or measurement issues around capital.

Evaluating the UK's productivity trends, this study yields the following observations. There are periods of decreasing aggregate labour

[18] The dataset covers the business population that is registered for VAT and/or PAYE, hence 99% of business activity (turnover). There are a further 3m businesses in the UK composed of the self-employed and sole traders etc. that have no employees and who fall below the VAT threshold.

productivity in recent history, and clearly the recent financial crisis period was not the only one. Since the outset of the recent financial crisis, the data show two drops in aggregate labour productivity, none of which was as deep as the one around the early 2000s, however the period spanning the two drops was longer than the previous recession. The large drop in employment was on the path of recovery in 2010, while the output market (turnover) did not follow the same pattern. Clearly the labour market recovered from the recession more quickly than turnover, resulting in weak labour productivity.

We also find considerable sectoral differences with regards to productivity trends and growth during the recent recession. The Manufacturing and Construction sectors suffered the largest declines in aggregate labour productivity while Wholesale and Retail, Transport, Accommodation, Arts, Other Services, and the Information and Communication sectors suffered less. The Professional Services sector has been exceptional and in fact experienced positive growth.

Importantly, this research highlights that there were significant business demography changes underlying the UK aggregate productivity change. First of all, this change is characterised by an increasing number of small businesses in the business population especially single-employee firms whose share increased considerably relative to non-single employee small firms and medium sized firms. Compared to 1998 when single employee firms represented 33% of the business population, there were over 45% in 2013 with a noticeable surge occurring around 2008. However their average productivity was lower and declined over time, which reduced the overall average productivity. Given that the resource allocation effect was tiny, it is evidence for the arguments against increasing self-employment in the UK over the recession (Martin and Rowthorn, 2012) as they tend to be low-paid and low-productive jobs. Although this study does not provide direct evidence of why this type of firm is less productive, we could find clues from the existing literature explaining the importance of economies of scale, and other size-related determinants of productivity (see our literature review in Section 2.3). In addition, recent research suggests that

entrepreneurs run by households tend to avoid external finance and hence are likely to experience growth traps (Mwaura and Carter, 2015). It implies concerns over their long run growth perspective.

Overall, we also know little of whether these issues are particularly acute over the recession period, as we observe that the decreasing trend of labour productivity started much earlier than the recent recession. This is clearly an under-researched area as to how finance, entrepreneurial ambition, start-up conditions, and skill shortage and technology adoption may determine this type of business organizations' productivity and growth trajectory, hence warrants further research.

Secondly, the composition of industrial dynamics, made up of entrants and exiting firms, changed during the recession period. The share of exiting firms rose from an average of 8% between 1998 and 2007 to 11% between 2008 and 2012 whilst there was a coinciding drop in the share of entrants, from 16% on average, to 13% in the latter period. Given that exiting firms are on average less productive firms their exit reflects cleansing effects. This is unless excessive exits happen, which did not seem to be the case. We also find that exits register a negative contribution to the aggregate productivity level, largely because the exits during the recession period were not the least productive firms. Entrants are on average less productive, hence less entrants are unlikely to drag aggregate productivity growth down. The concern though is the impact on the longer term business environment, investment and innovation.

Moreover, we find that heterogeneous firm growth types lie behind aggregate productivity changes. First, during the recession, about 60% of all firms showed productivity decline rather than growth. A small percentage of 'Growth hero' firms, around 4% of all surviving firms, showed impressive records of both employment growth (29%) and turnover growth (44%) over the whole examined period, leading to the average labour productivity growth of 23%. They also showed resilience against the recession in terms of being less affected and recovering more quickly, and disproportionally contribute more to aggregate labour productivity, showing trends of further improvements. On average this group contribute about

15% of national aggregate labour productivity, triple of their weight in the business population, 4-5%. Our analysis reveals that both young and mature firms can be growth heroes but there is no single-employee firm among this type. These firms are more likely to be SMEs, foreign-owned and located in the London area. However, beyond these crude statistics, we unfortunately know little about these firms in terms of what drive their impressive growth. This is an area that deserves more research attention.

'Decline by efficiency loss' firms increased by 5% over the recession, but also over-contribute to aggregate productivity, with their contribution of 30% of national aggregate labour productivity twice as much as their weight in the business population, 13%. We consider that these firms experienced temporary difficulties due to a demand shock during the crisis but did not decrease employment corresponding to their revenue dip. When the business environment improves, they are likely to get back on track fairly quickly. Similarly, one third of the economy, the 'Jobless growth' firms, considered as becoming-more-efficient firms in the economy, have decreased in number in the recession. For this reason, we find little cleansing effects among this group of firms. It will be interesting to understand the reasons behind the efficiency loss. Given that these relatively highly productive firms seem to show employment growth as the same time as their revenue increases, it would be useful to investigate if these firms have opened up productive capacity or accumulated capacity by taking advantage of business opportunity during the recession.

'Decline by contraction' firms, accounting for one third of the population, surged in the crisis. This most likely demonstrates the overall economy's underperformance due to weak demand. They have been improving their resource allocative efficiency since 2009, showing 'cleansing effects'.

The results for the "Fake growth" group demonstrate that firms showing productivity growth can be quite heterogeneous – this type of firm is the least productive and in fact contracting in both employment and revenue.

Our evidence further confirms that within firms' productivity improvement is mainly responsible for aggregate productivity. Aggregate labour

productivity follows the trend of average labour productivity of surviving firms at aggregate level and in almost all our split-sample examinations. This is particularly the case for large firms. This has important implications on the future direction of research – to understand better the channels through which firms improve productivity, with or without resource allocation within firms, through adjusting the capital-labour ratio, investing in productivity-enhancing process and product innovation, or internationalisation, for example. We need to understand why this process has slowed down so dramatically over the recession in particular and what can be done.

Associated with the last point, resource allocation had a rather limited role in leading to the productivity decline. Although the overall trends of the resource allocation contribution of entrants and exits to aggregate productivity declined, resource allocation among surviving firms has been steadily increasing with a few flattening episodes at the national level and in some key sectors. In addition, the total contribution of resource allocation was small and the pictures for heterogeneous groups of firms vary. For example, resource allocation is seen as playing a more important role in raising aggregate productivity among small and young firms but not among large firms. Hence we cannot conclude on the deteriorating resource misallocation among UK firms, in contrast to what's reported elsewhere. However, we argue that at the aggregate level, the market mechanisms of creative destruction through entry and exit were less effective over the recession period.

7. CONCLUSION

This study provides a comprehensive analysis of UK labour productivity patterns and contributing factors over the 1997-2013 period. Firm level population data from the ONS Business Structure Database (BSD) allow us to build a full representation of the productivity patterns of UK firms in the whole economy over the examined period, at aggregate level, sector level, and among heterogeneous groups.

We document the patterns of the output market and labour market

response to the “Great Recession”. We highlight significant business demographic changes underlying UK aggregate productivity change, featuring an increasing number of small businesses especially single-employee firms, more exits and less entrants and discuss the implications of these changes in explaining the productivity decline. Further, we define firm growth types and investigate their contributions to the aggregate productivity changes. In particular, “Growth heroes” and “Decline by efficiency loss” firms over-contribute to aggregate labour productivity compared to their weight in the business population. In contrast, an already large chunk of ‘Decline by contraction’ firms surged over the recent recession and under-contribute to aggregate labour productivity. Understanding the driving forces and barriers of these growth types will help understand several hypotheses on the productivity puzzle. We confirm the previous finding that within firms’ productivity improvement has been mainly responsible for aggregate productivity changes in the UK and discuss the implications. Finally we argue that resource allocation on average played a very limited role in driving the aggregate productivity change.

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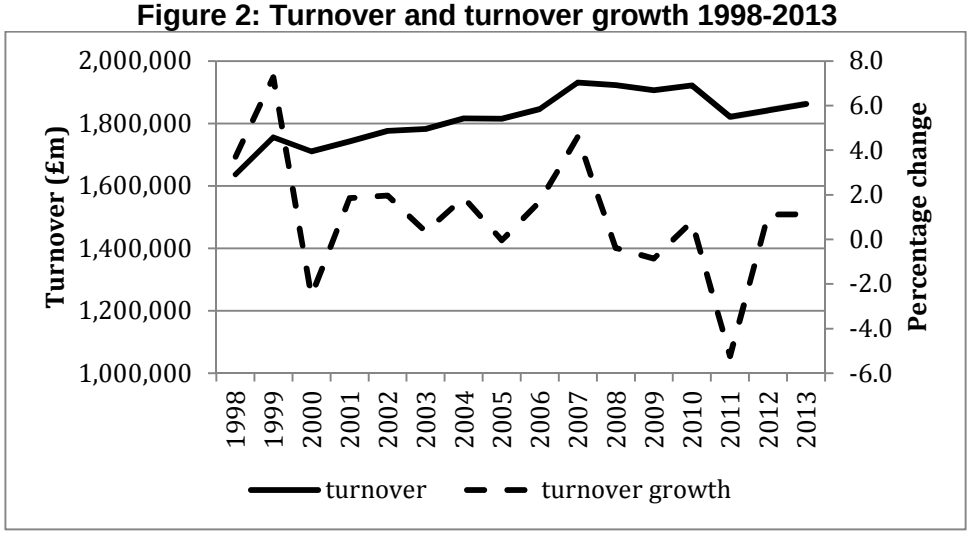
Figure 1: Employment and employment growth 1998-2013

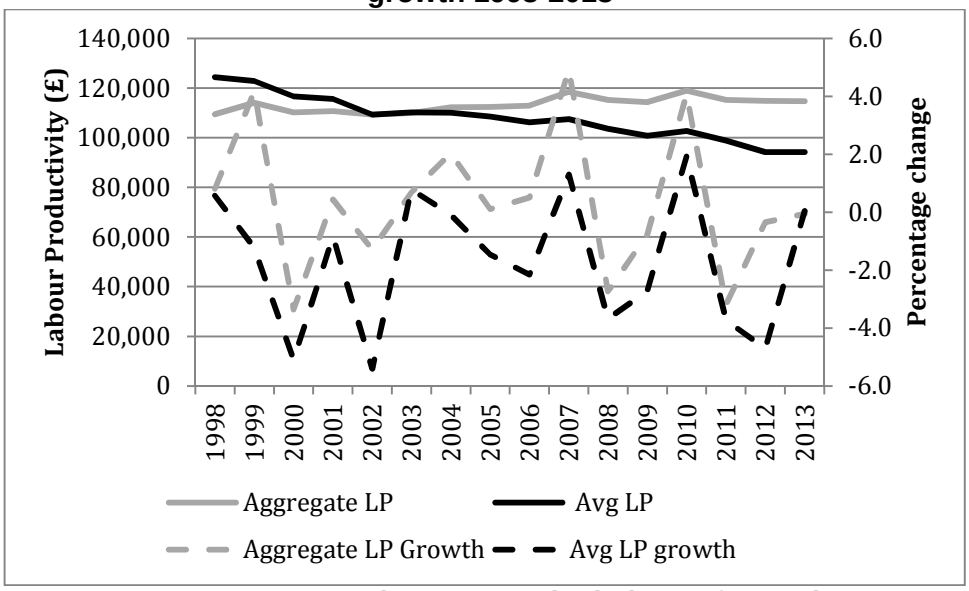
Source: Authors own calculations of BSD data

Figure 2: Turnover and turnover growth 1998-2013



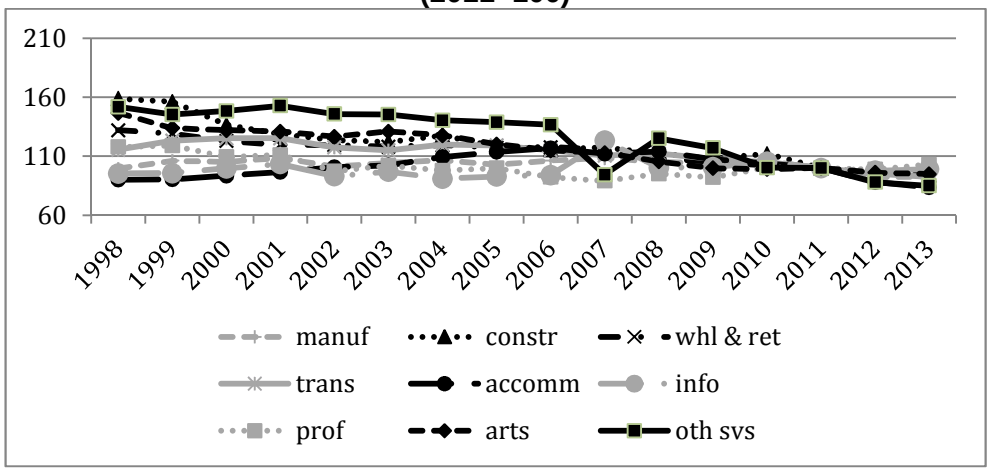
Source: Authors own calculations of BSD data

Figure 3: Aggregate and Average Labour Productivity level and growth 1998-2013



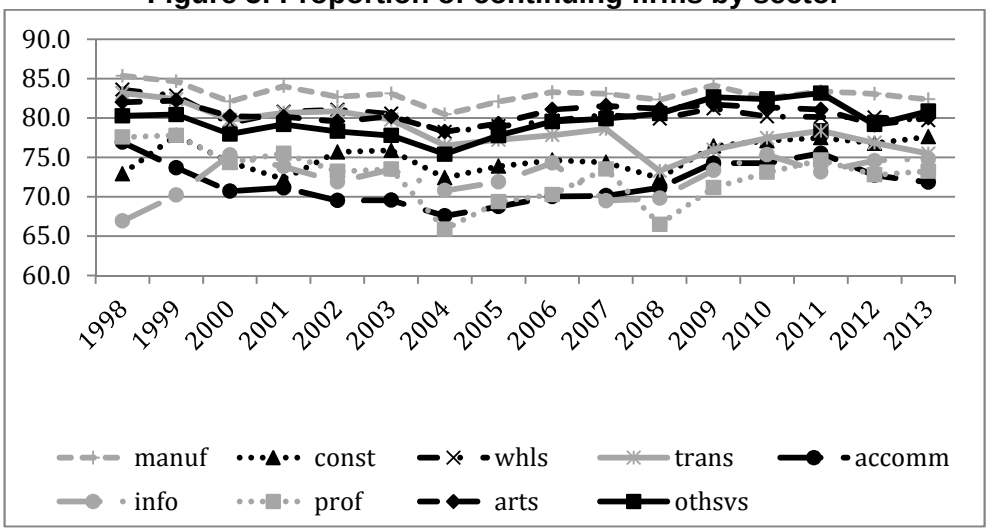
Source: Authors own calculations of BSD data

Figure 4: Index of labour productivity change by sector 1998-2013 (2011=100)



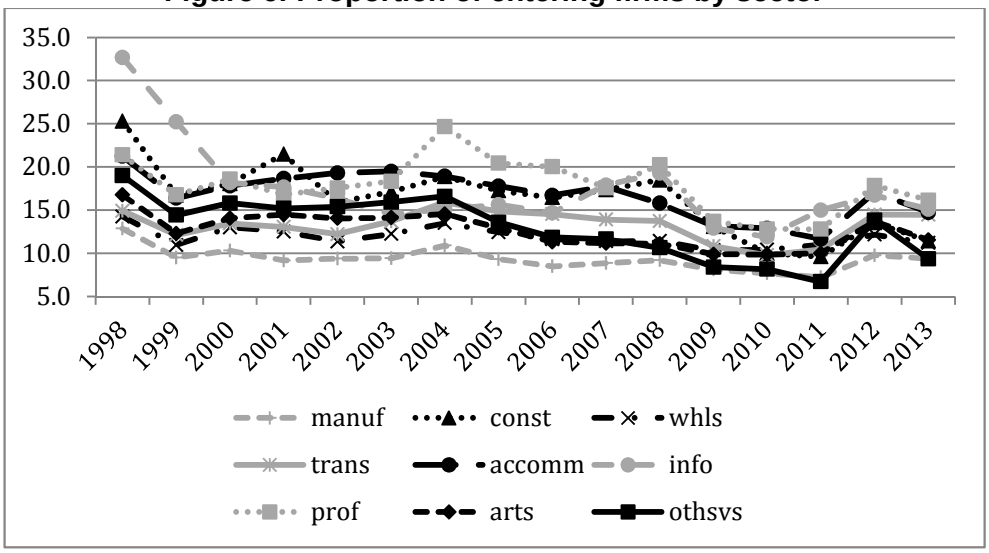
Source: Authors own calculations of BSD data

Figure 5: Proportion of continuing firms by sector



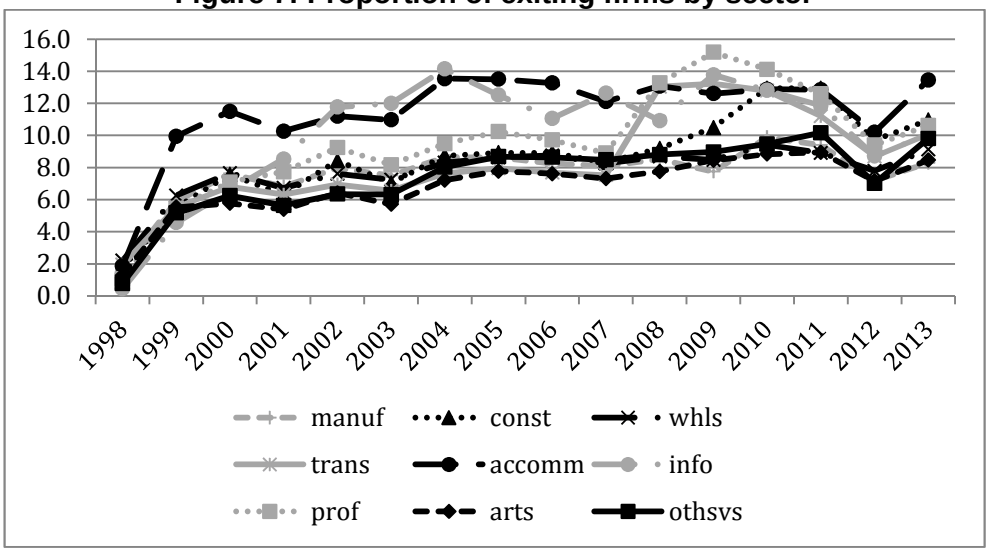
Source: Authors own calculations of BSD data

Figure 6: Proportion of entering firms by sector



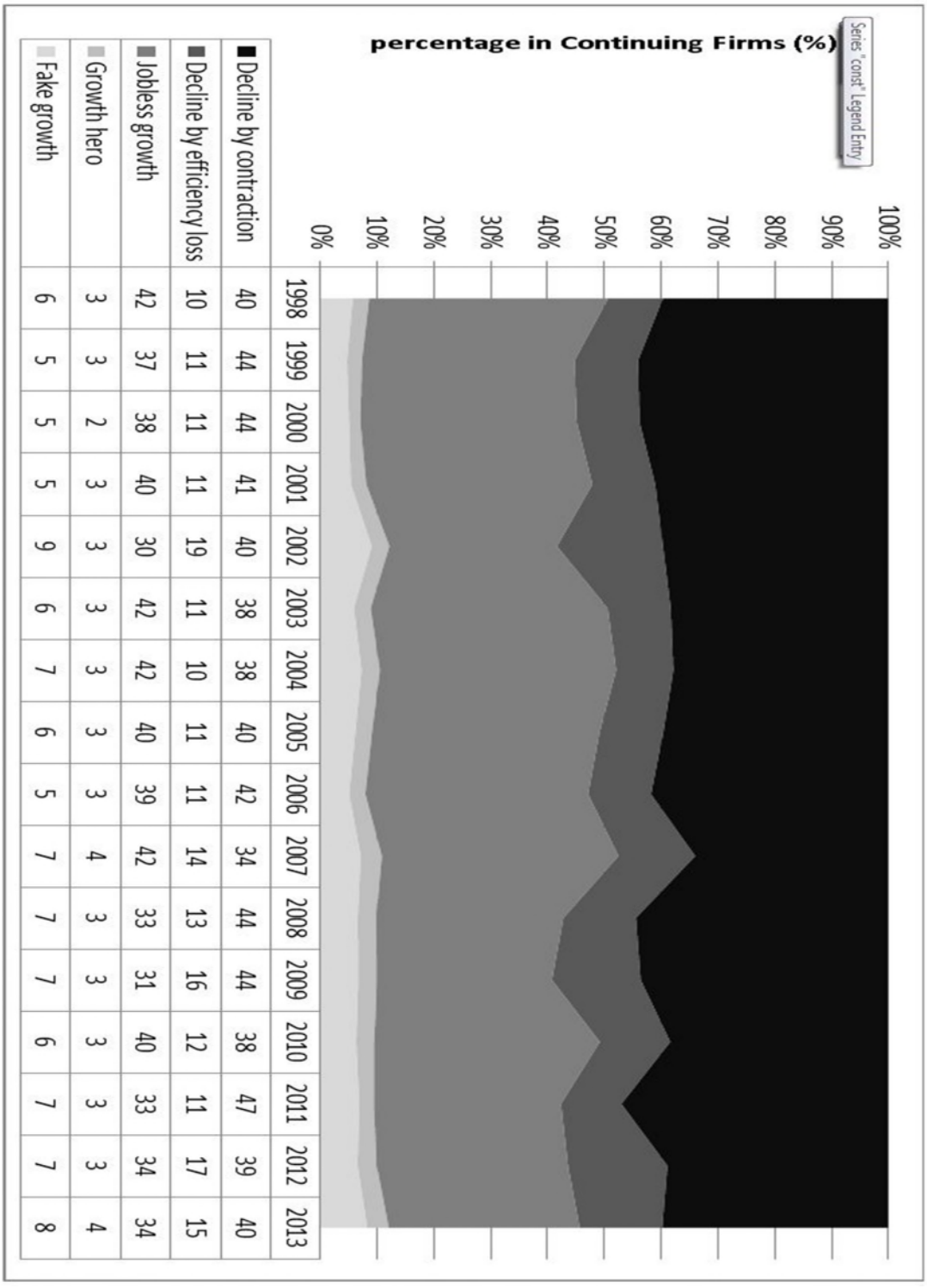
Source: Authors own calculations of BSD data

Figure 7: Proportion of exiting firms by sector



Source: Authors own calculations of BSD data

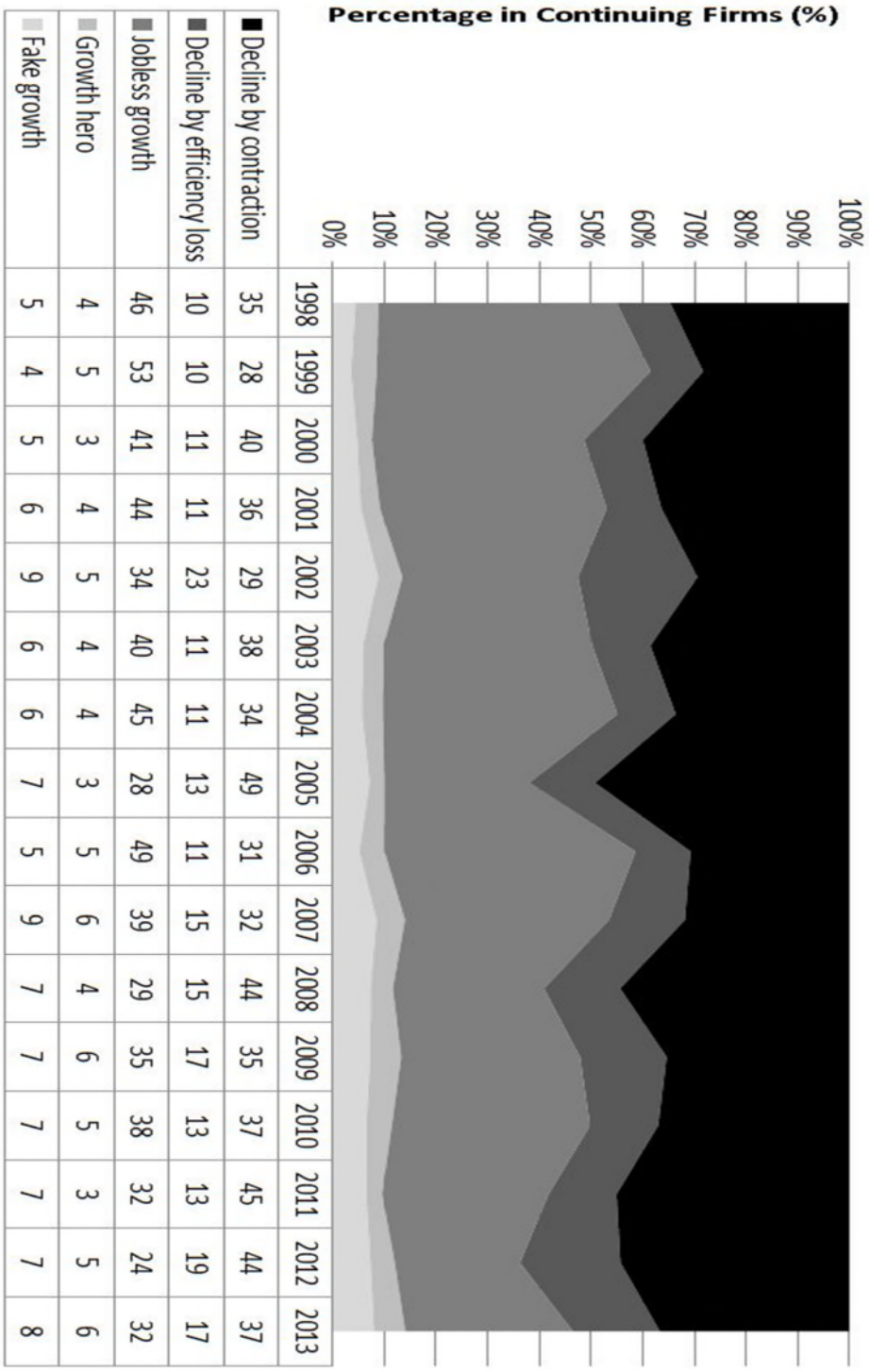
Figure 8: Share of Continuing Firms in the Economy by Growth Patterns over 1998-2013: All Industries



	Decline by contraction	Decline by efficiency loss	Jobless growth	Growth hero	Fake growth
1998	40	10	42	3	6
1999	44	11	37	3	5
2000	44	11	38	2	5
2001	41	11	40	3	5
2002	40	19	30	3	9
2003	38	11	42	3	6
2004	38	10	42	3	7
2005	40	11	40	3	6
2006	42	11	39	3	5
2007	34	14	42	4	7
2008	44	13	33	3	7
2009	44	16	31	3	7
2010	38	12	40	3	6
2011	47	11	33	3	7
2012	39	17	34	3	7
2013	40	15	34	4	8

Source: Authors own calculations of BSD data

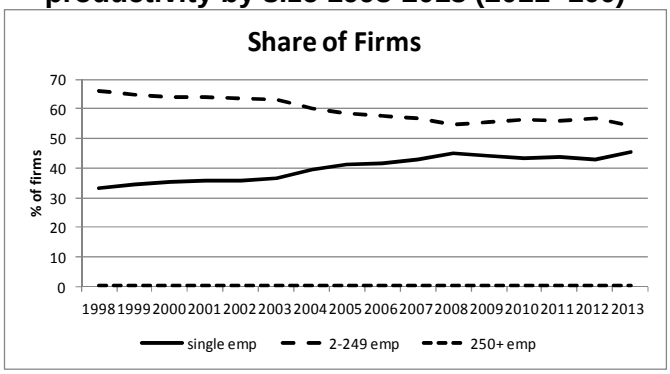
Figure 9: Share of Continuing Firms in the Economy by Growth Patterns over 1998-2013: Manufacturing

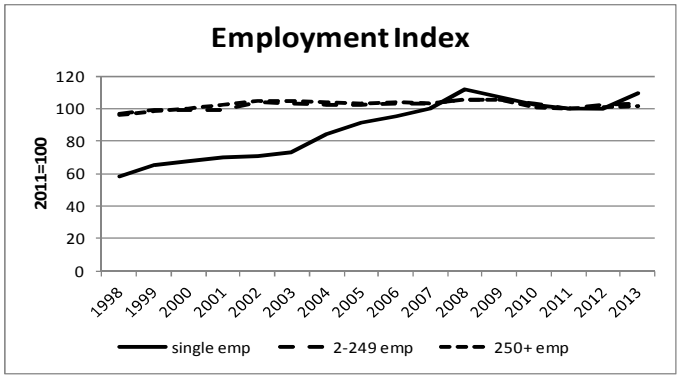


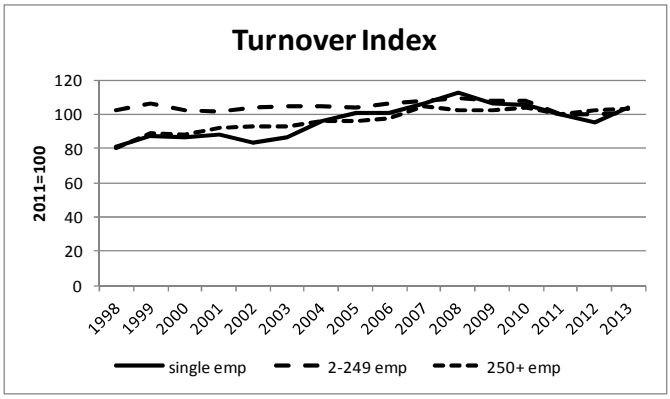
	Decline by contraction	Decline by efficiency loss	Jobless growth	Growth hero	Fake growth
1998	35	10	46	4	5
1999	28	10	53	5	4
2000	40	11	41	3	5
2001	36	11	44	4	6
2002	29	23	34	5	9
2003	38	11	40	4	6
2004	34	11	45	4	6
2005	49	13	28	3	7
2006	31	11	49	5	5
2007	32	15	39	6	9
2008	44	15	29	4	7
2009	35	17	35	6	7
2010	37	13	38	5	7
2011	45	13	32	3	7
2012	44	19	24	5	7
2013	37	17	32	6	8

Source: Authors own calculations of BSD data

Figure 10: Trends in firm share, employment, turnover and labour productivity by size 1998-2013 (2011=100)







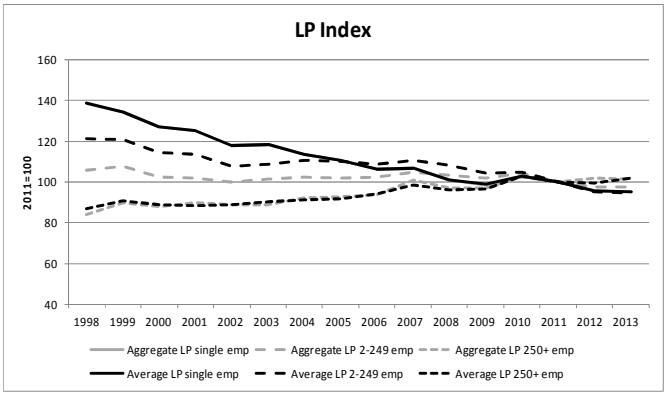


Figure 11: Trends in labour productivity by size & selected sector 1998-2013 (2011=100)

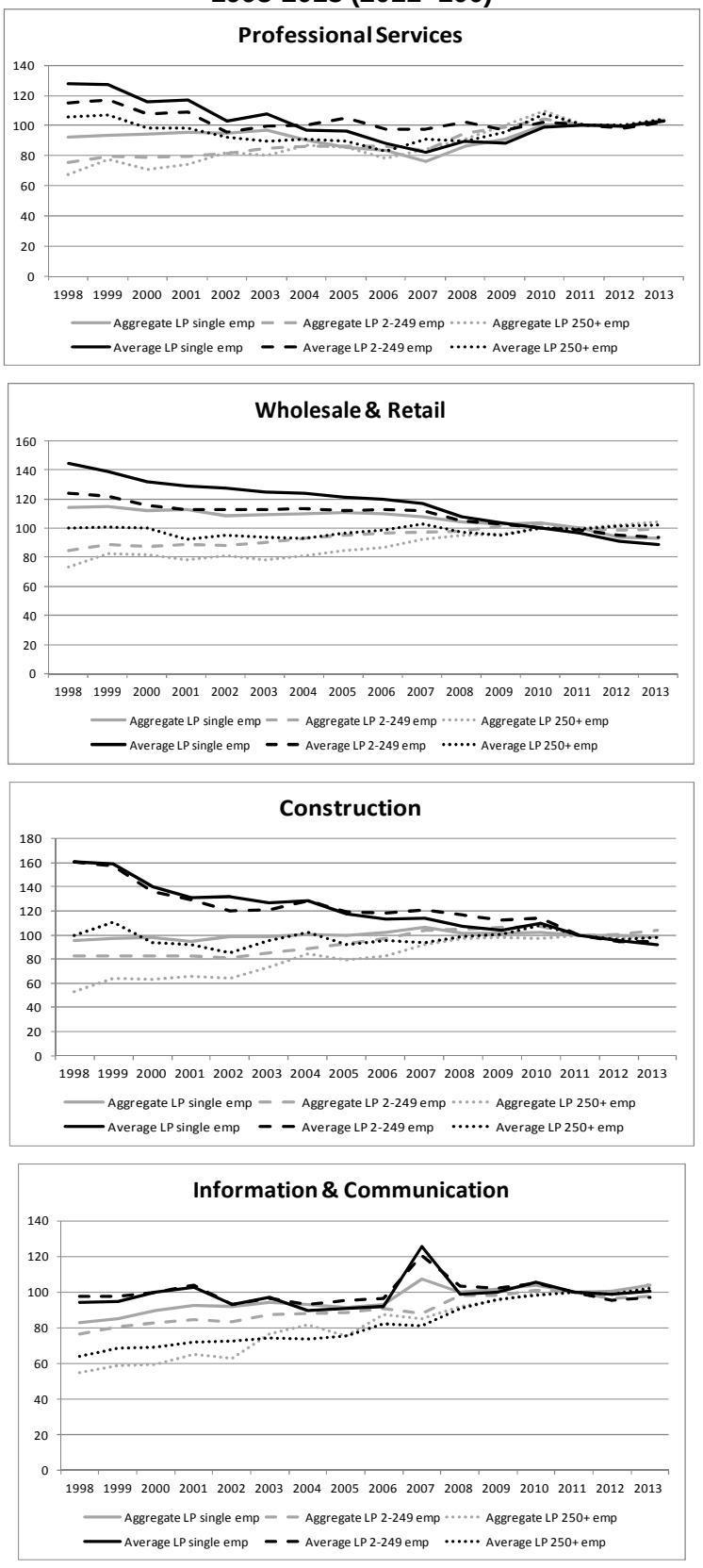
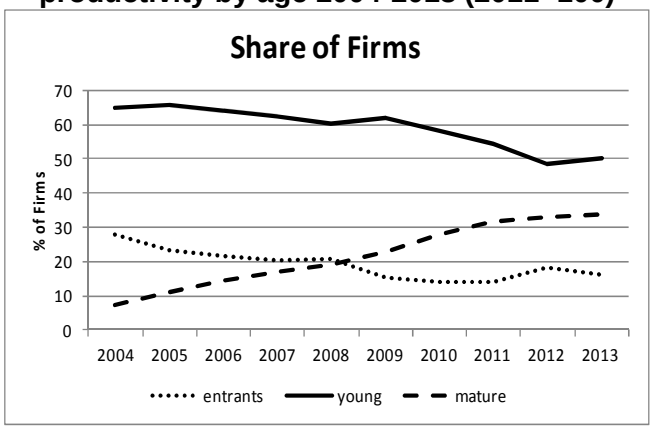
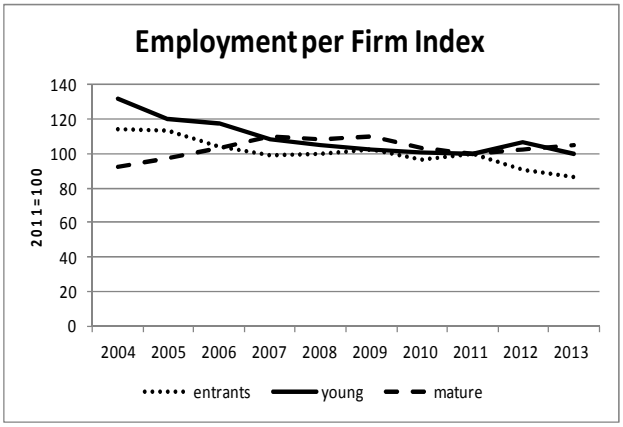
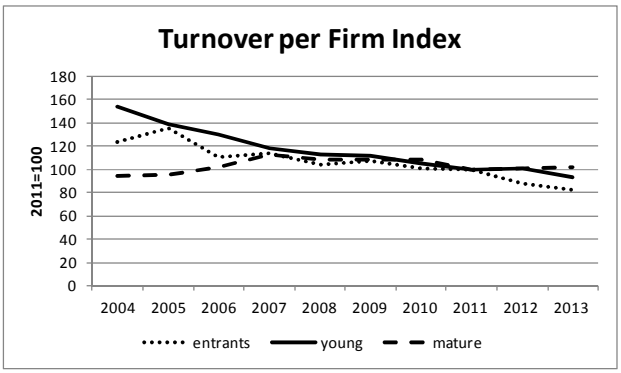


Figure 12: Trends in firm share, employment, turnover and labour productivity by age 2004-2013 (2011=100)







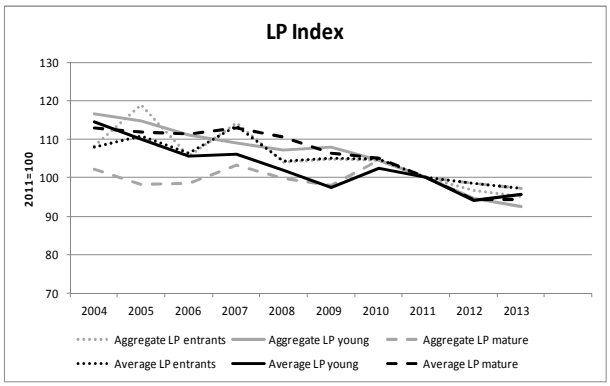


Figure 13: Trends in labour productivity by age & selected sector 2004-2013 (Index 2011=100)

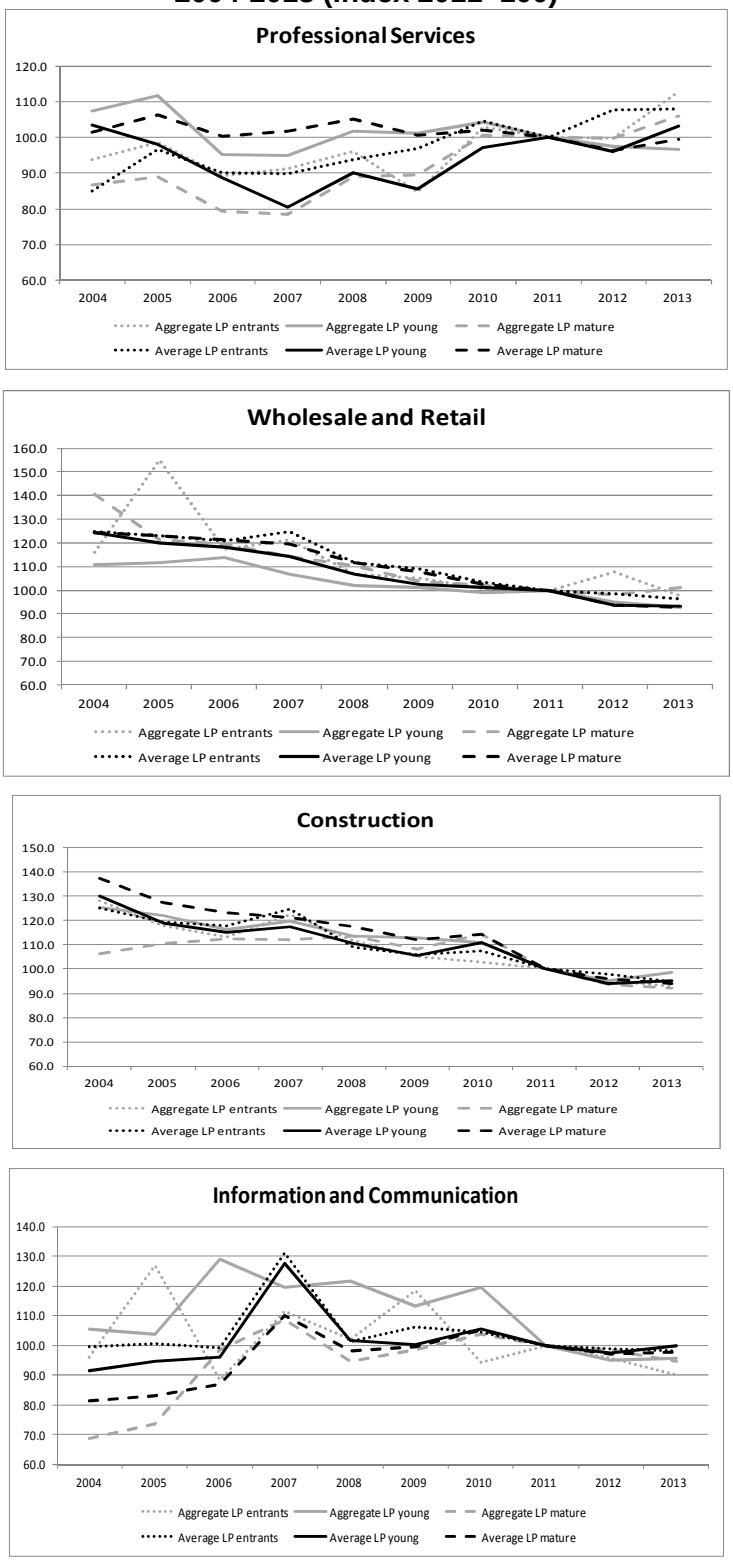


Figure 14: Aggregate Labour Productivity 1998-2013 (log of £000s)

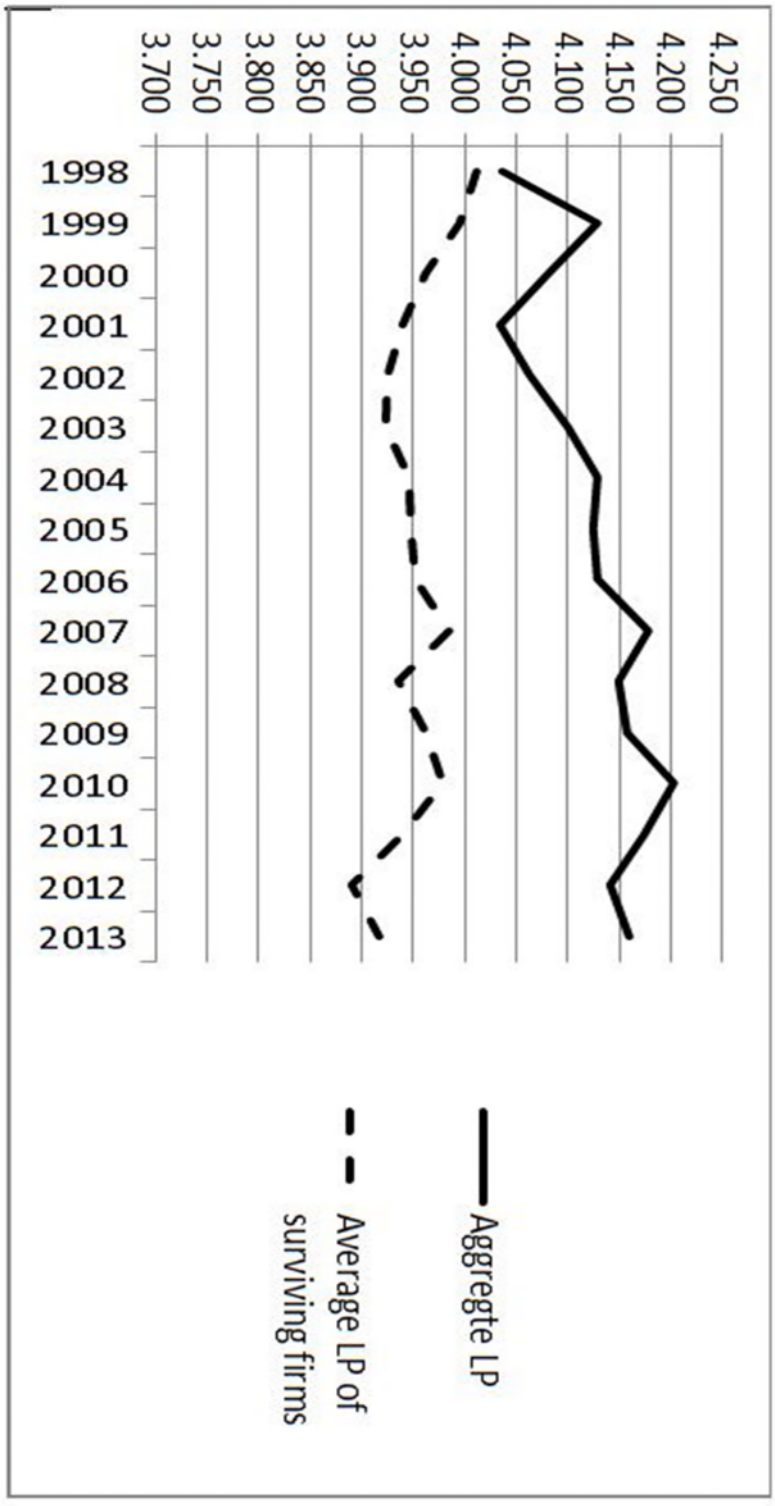


Figure 15: Labour Productivity of Entrants and Exits and Resource Allocation of Surviving Firms 1998 – 2013

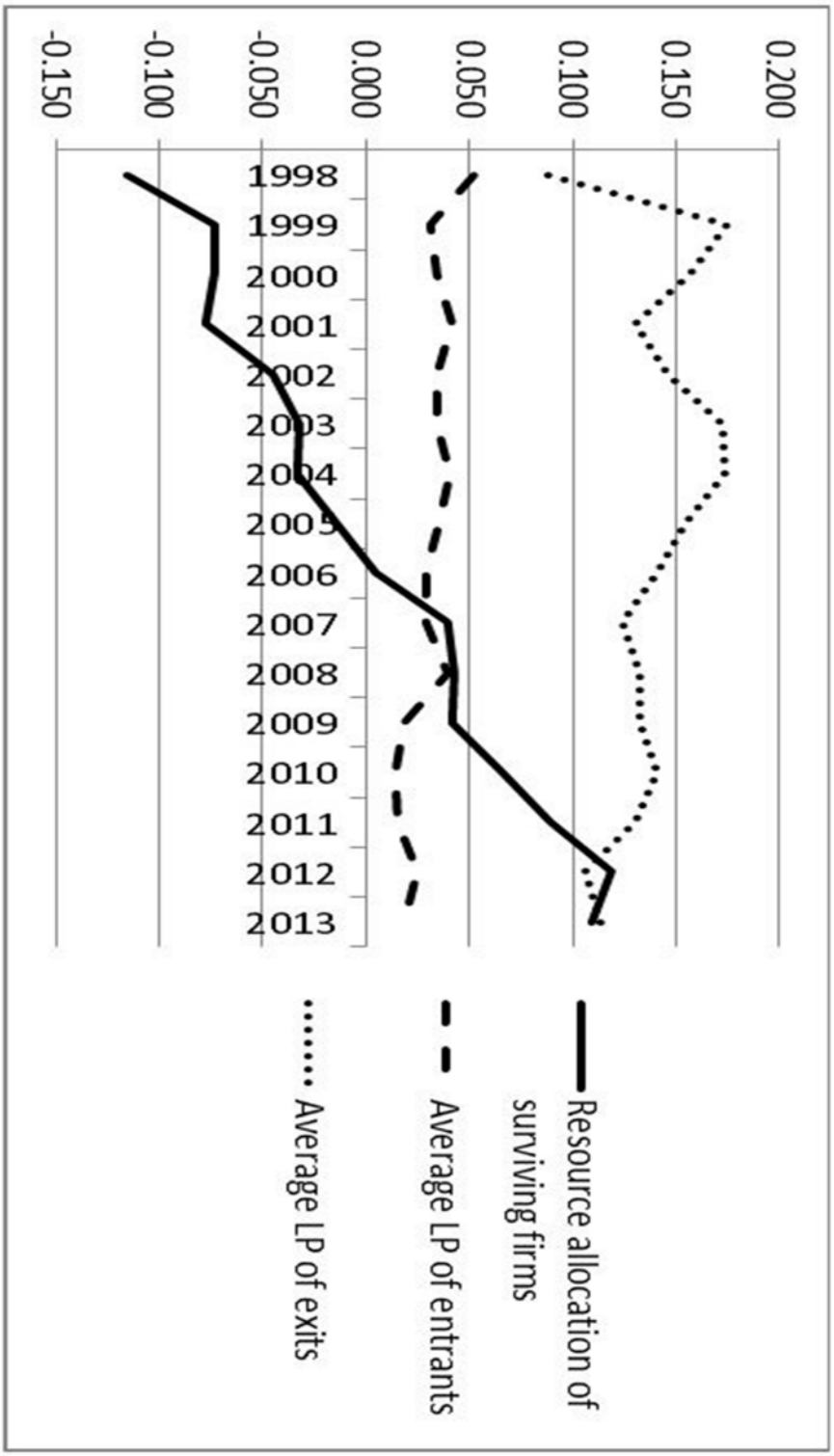


Figure 16: Decomposition of Aggregate Labour Productivity Growth: within firm productivity growth and resource allocation, Whole Economy

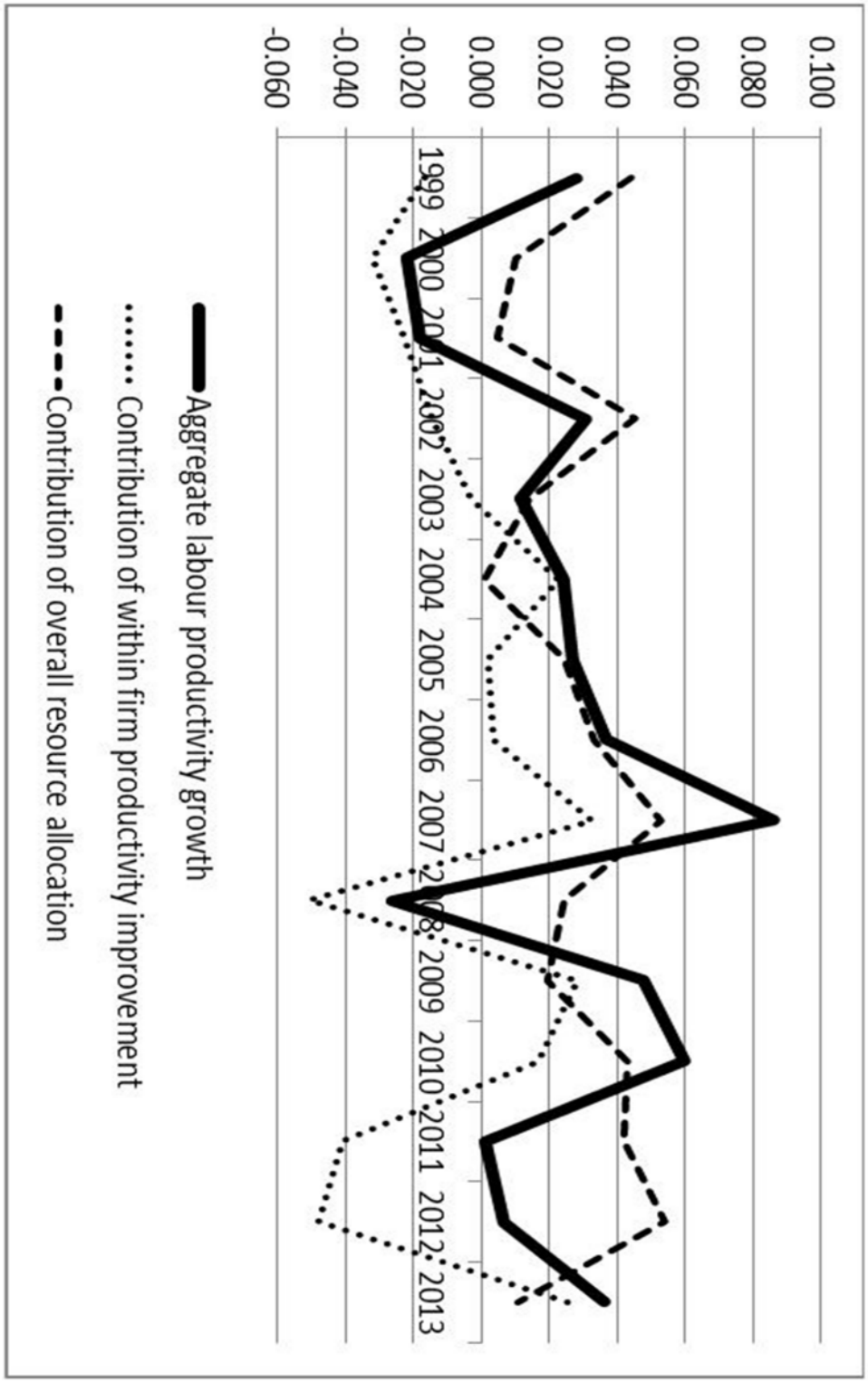


Figure 17: Aggregate productivity Decomposition by Sector (I): Contribution of Average productivity

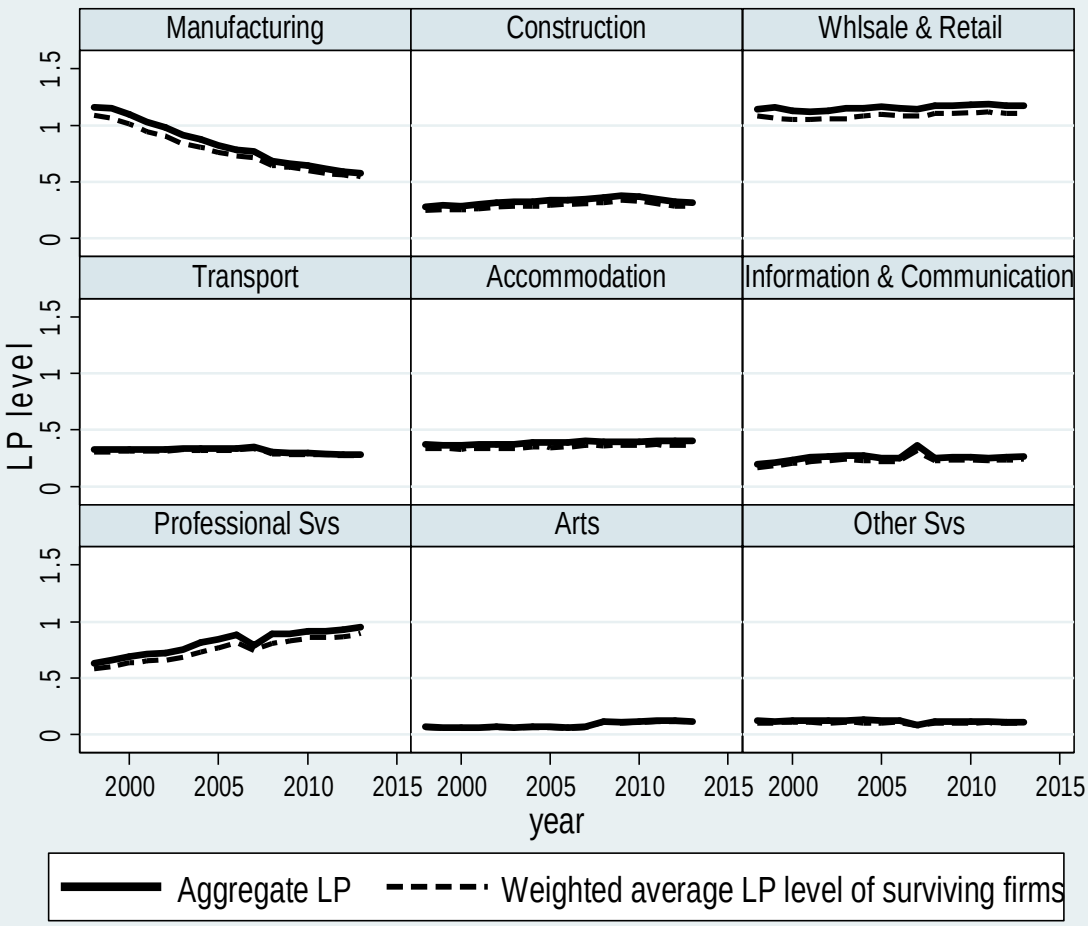


Figure 18: Aggregate productivity Decomposition by Sector (II): Contribution of Survivors, Entrants and Exits

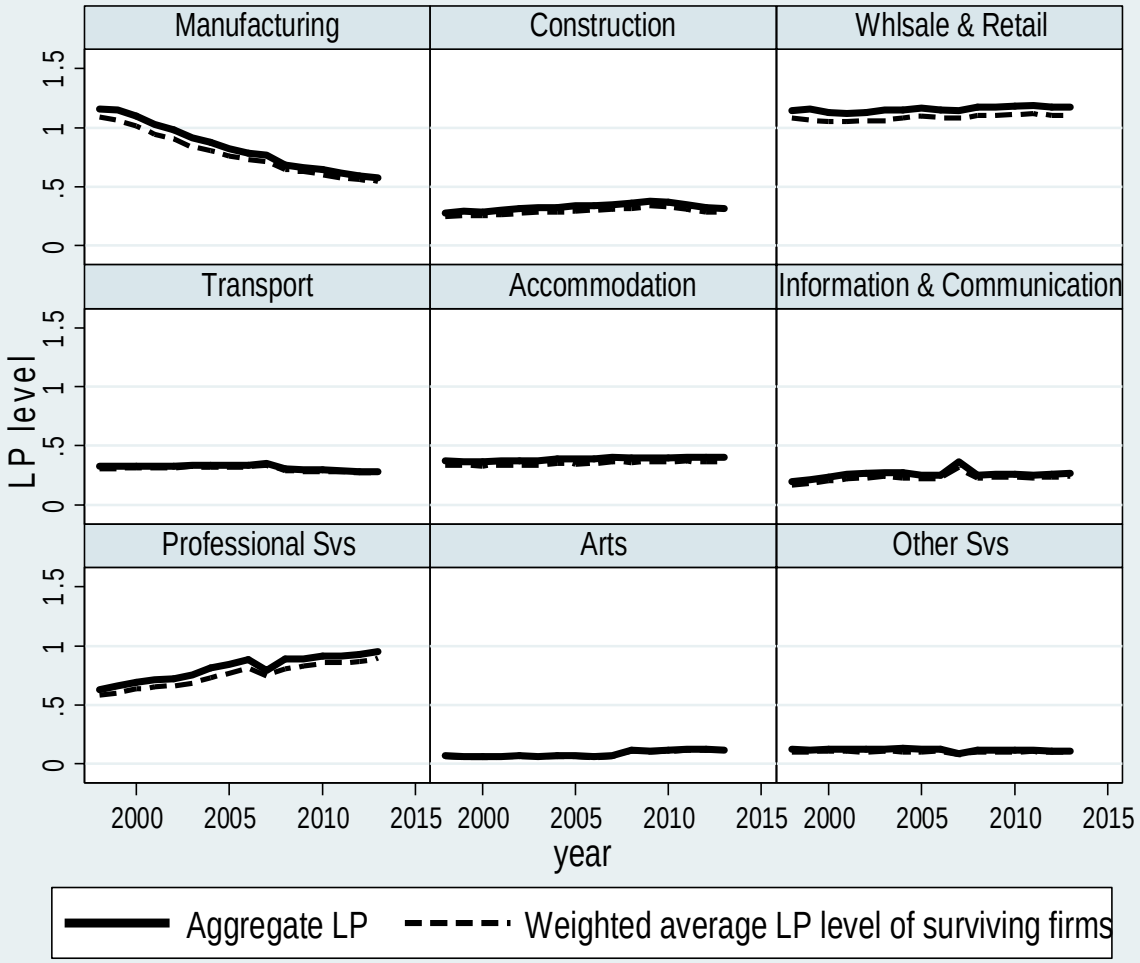


Figure 19: Decomposition of Aggregate Labour Productivity Growth: within firm productivity growth and resource allocation, Manufacturing

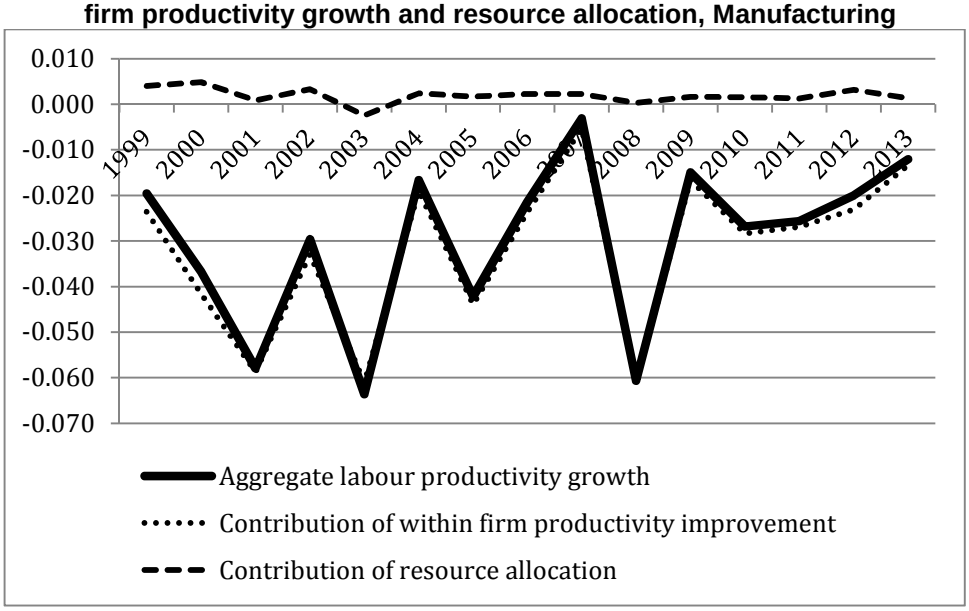


Figure 20: Decomposition of Aggregate Labour Productivity Growth: three ways of resource allocation, Manufacturing

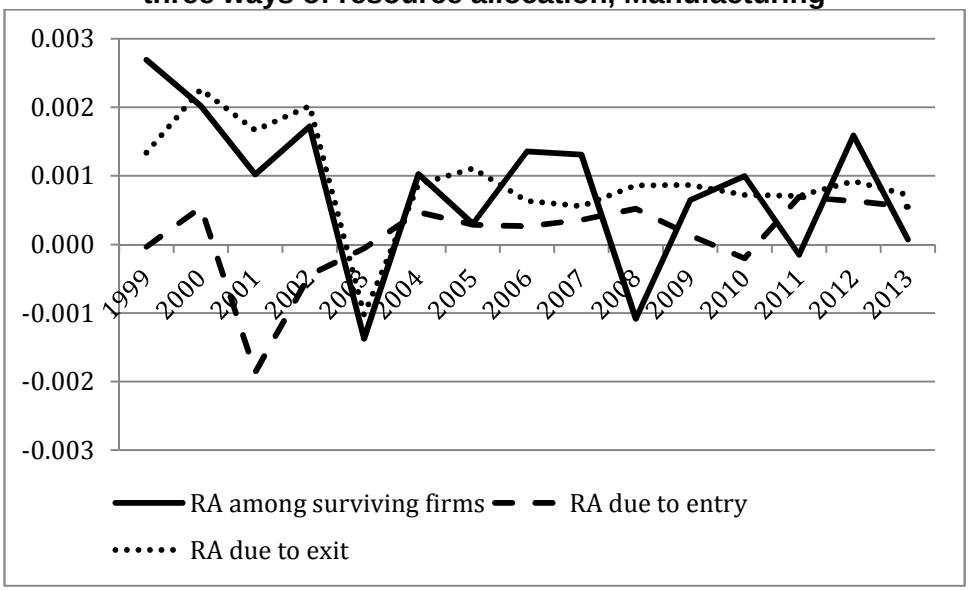


Figure 21: Decomposition of Aggregate Labour Productivity Growth: within firm productivity growth and resource allocation, Construction

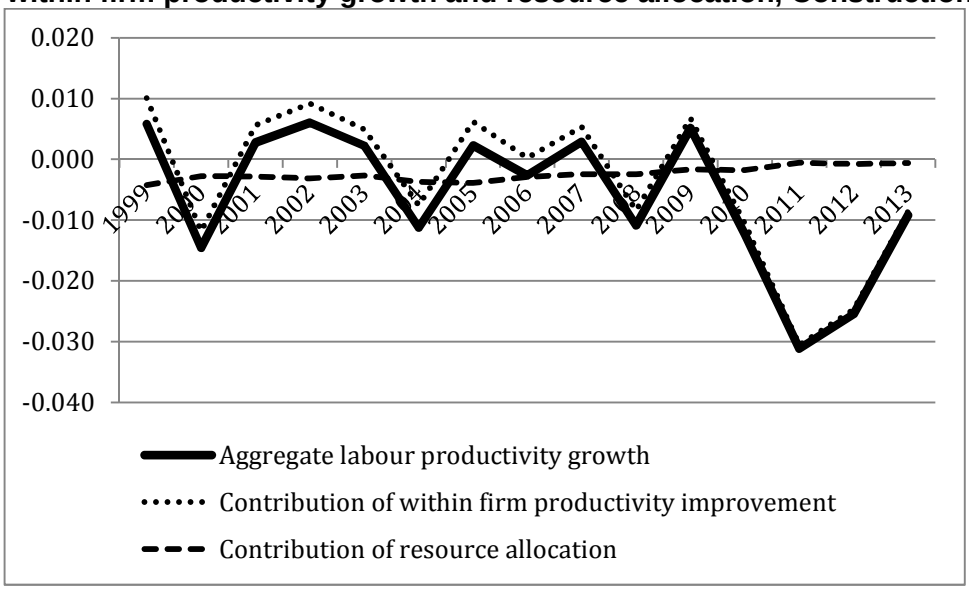


Figure 22: Decomposition of Aggregate Labour Productivity Growth: three ways of resource allocation, Construction

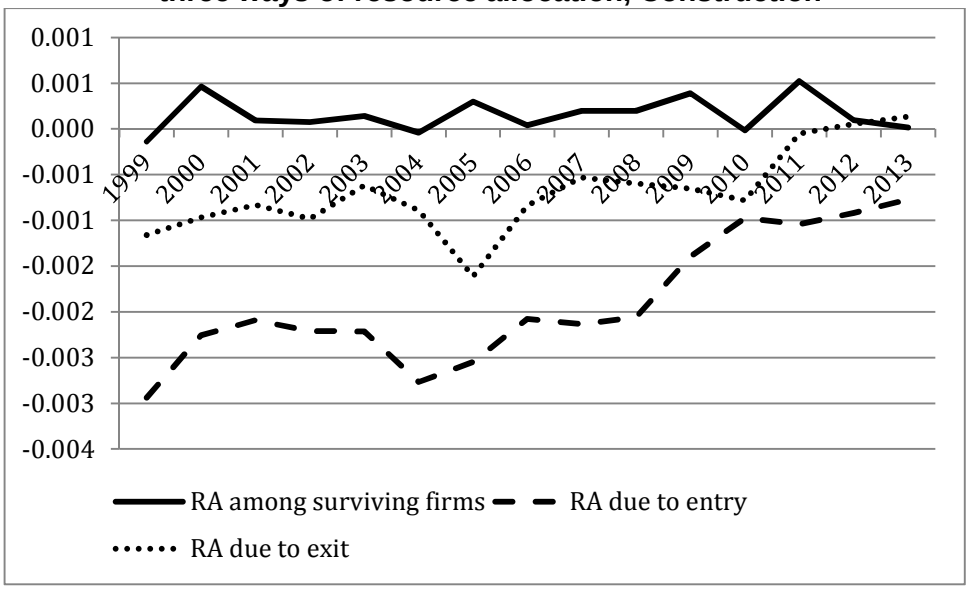


Figure 23: Decomposition of Aggregate Labour Productivity Growth: within firm productivity growth and resource allocation, Professional Services

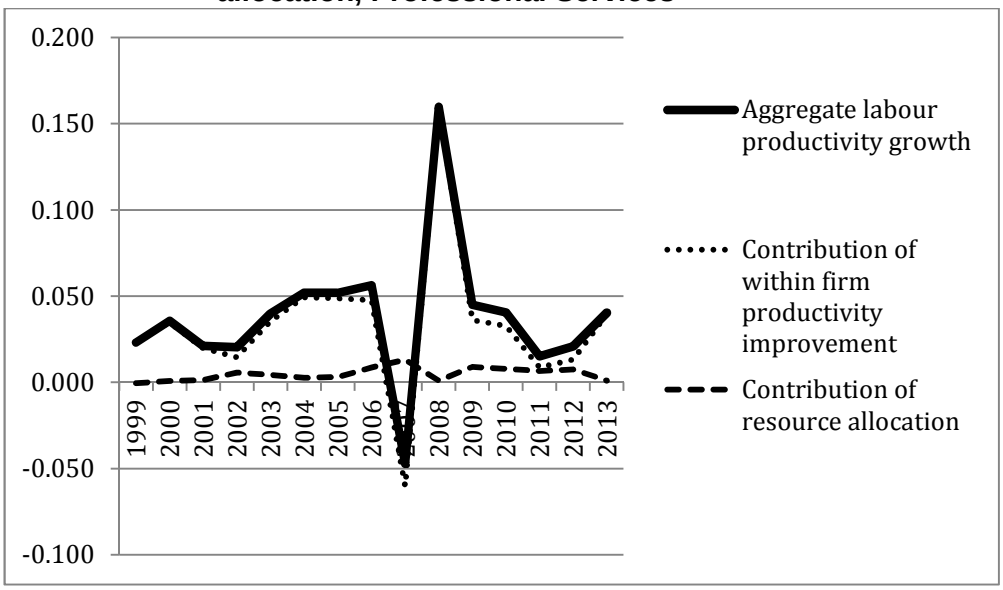


Figure 24: Decomposition of Aggregate Labour Productivity Growth: three ways of resource allocation, Professional Services

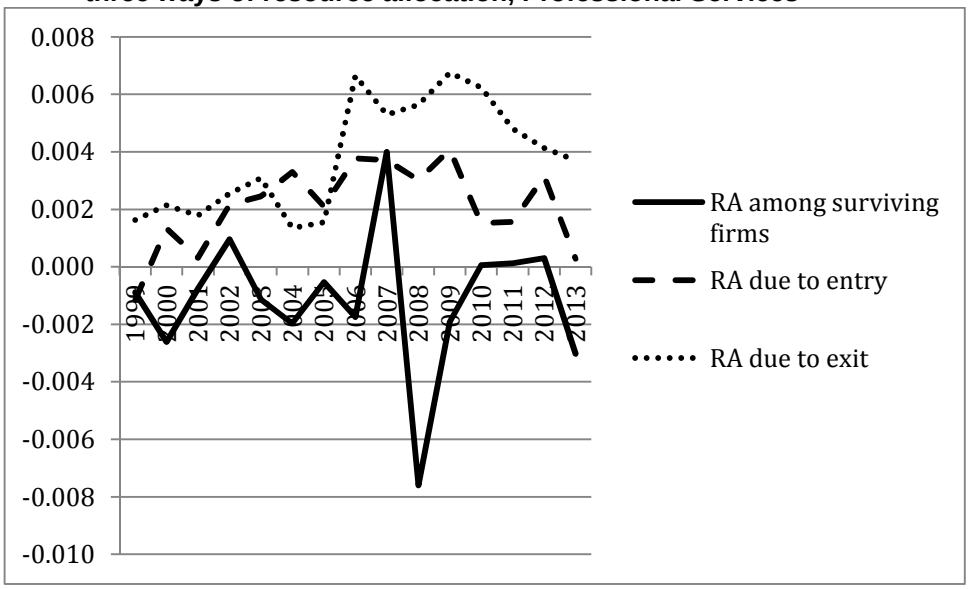
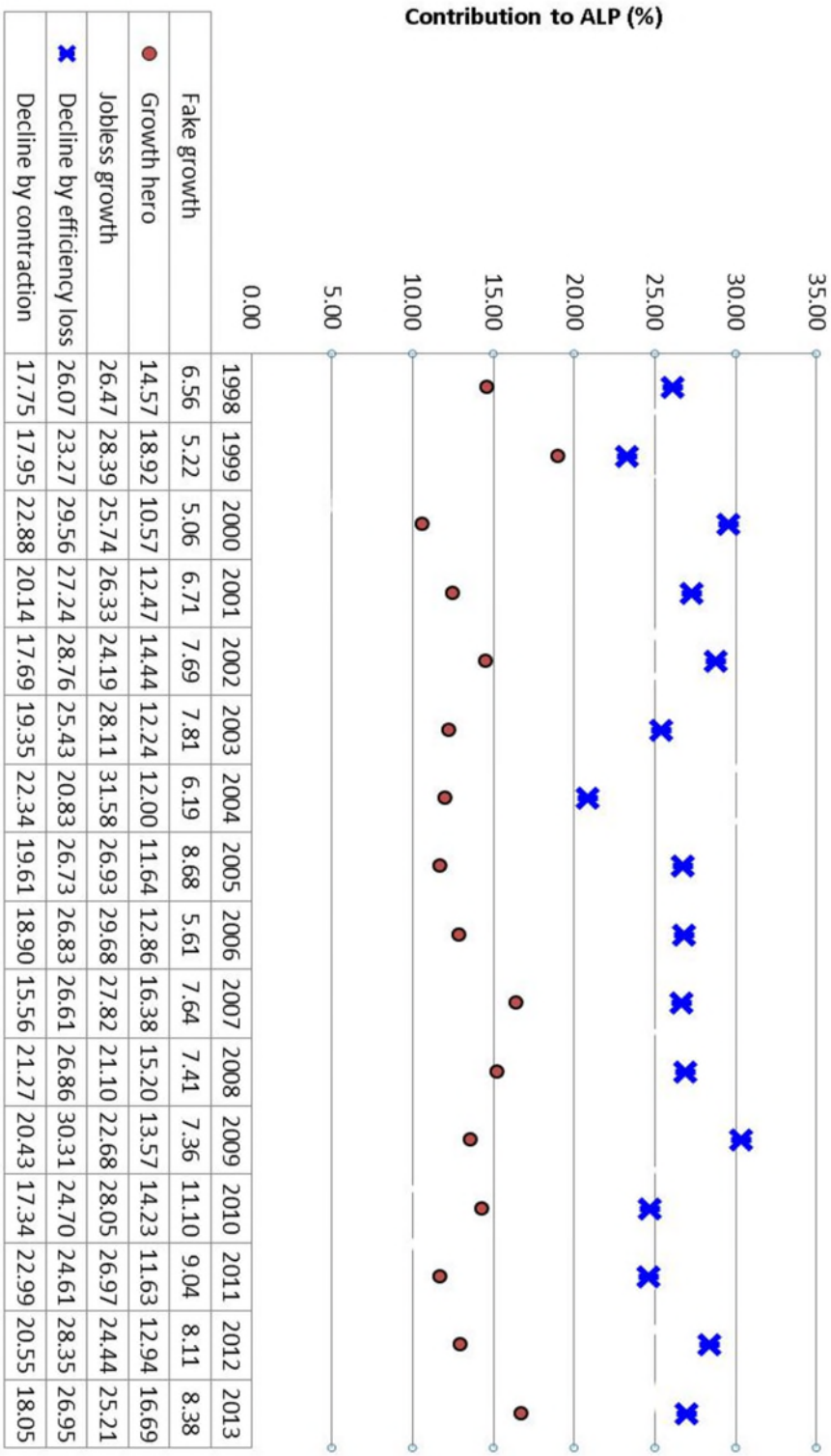
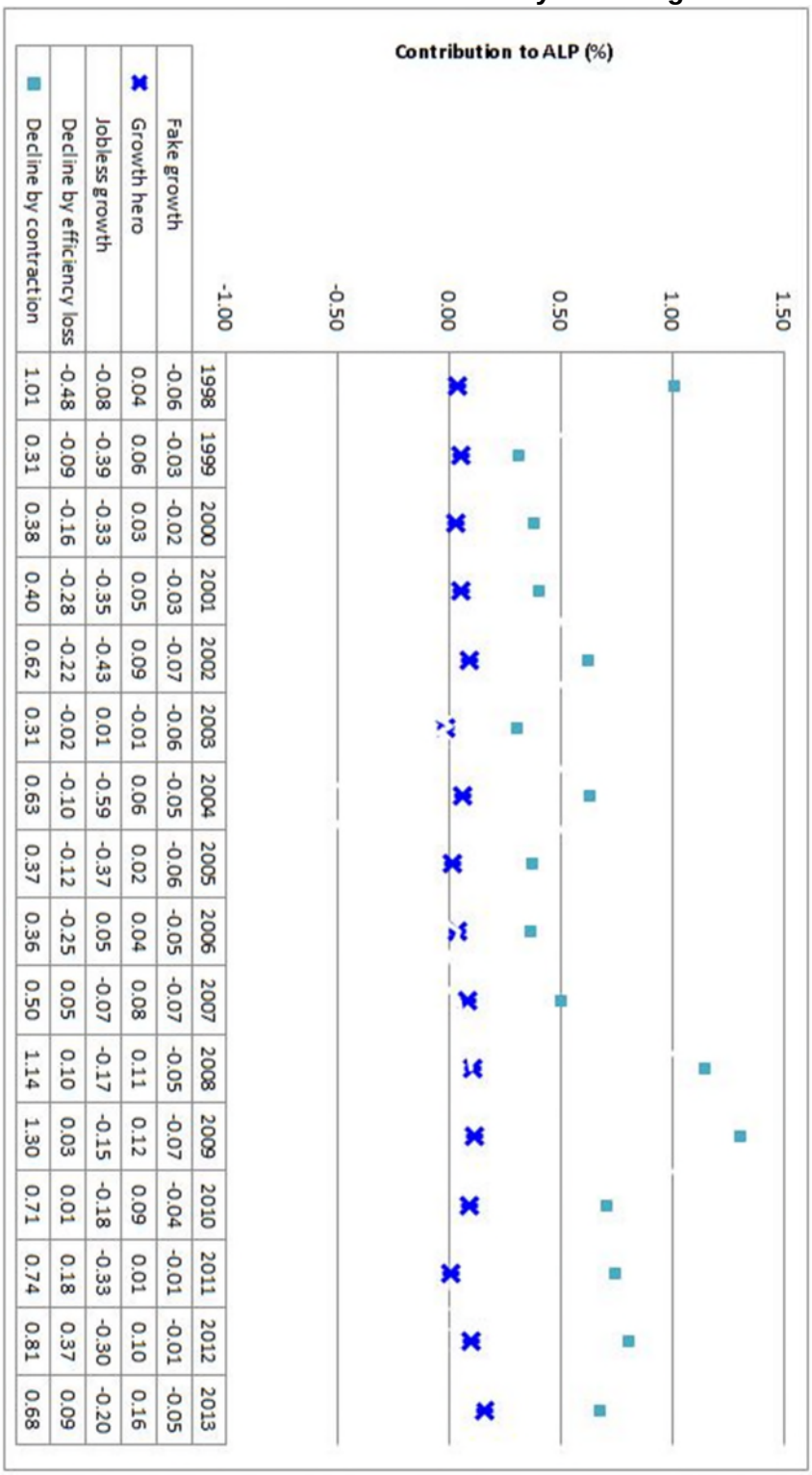


Figure 25: Aggregate Labour Productivity decomposition by firm growth patterns



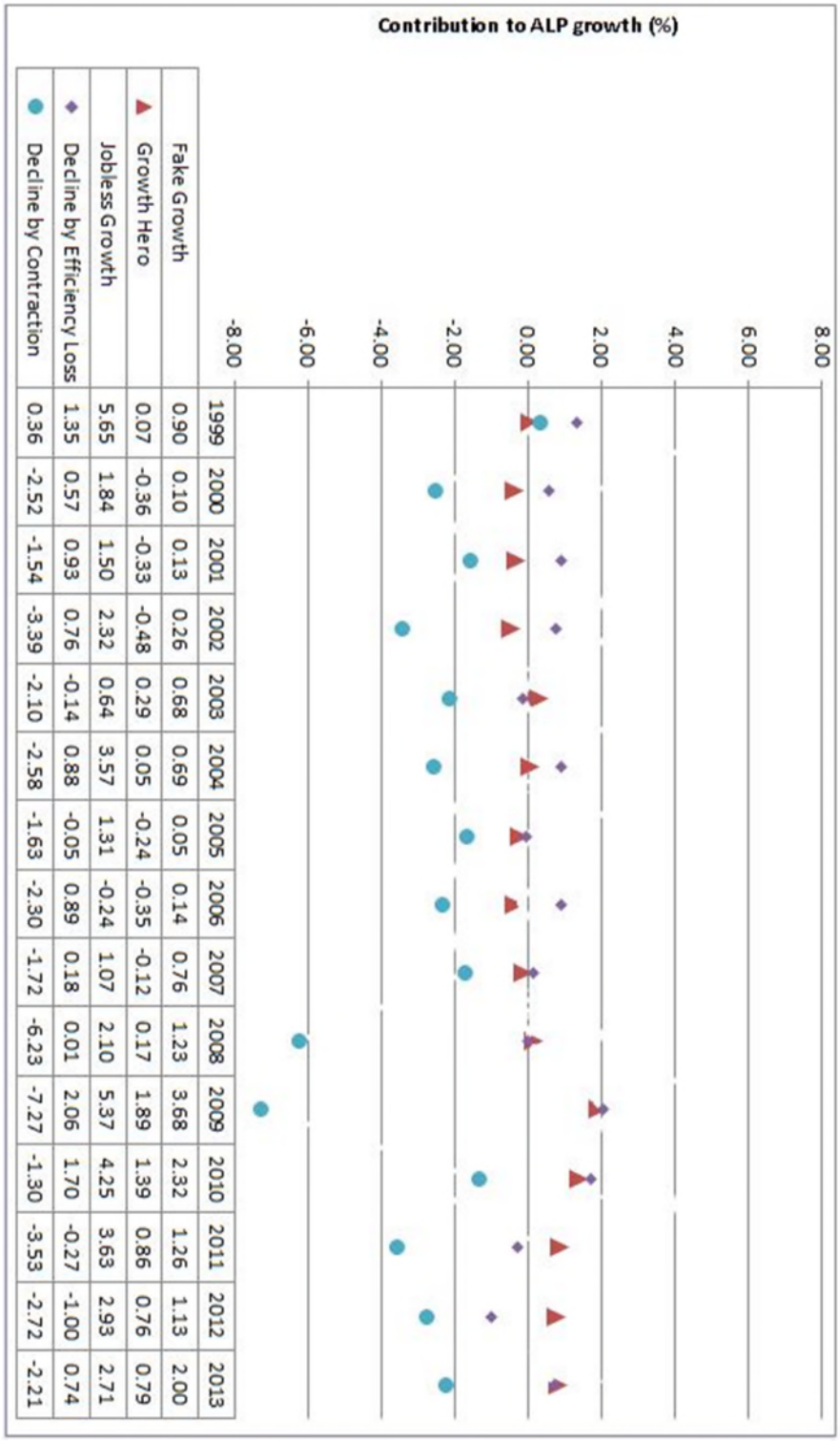
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fake growth	6.56	5.22	5.06	6.71	7.69	7.81	6.19	8.68	5.61	7.64	7.41	7.36	11.10	9.04	8.11	8.38
Growth hero	14.57	18.92	10.57	12.47	14.44	12.24	12.00	11.64	12.86	16.38	15.20	13.57	14.23	11.63	12.94	16.69
Jobless growth	26.47	28.39	25.74	26.33	24.19	28.11	31.58	26.93	29.68	27.82	21.10	22.68	28.05	26.97	24.44	25.21
Decline by efficiency loss	26.07	23.27	29.56	27.24	28.76	25.43	20.83	26.73	26.83	26.61	26.86	30.31	24.70	24.61	28.35	26.95
Decline by contraction	17.75	17.95	22.88	20.14	17.69	19.35	22.34	19.61	18.90	15.56	21.27	20.43	17.34	22.99	20.55	18.05

Figure 26: Aggregate Labour productivity decomposition: contribution of resource allocation by surviving firms



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fake growth	-0.06	-0.03	-0.02	-0.03	-0.07	-0.06	-0.05	-0.06	-0.05	-0.07	-0.05	-0.07	-0.04	-0.01	-0.01	-0.05
Growth hero	0.04	0.06	0.03	0.05	0.09	-0.01	0.06	0.02	0.04	0.08	0.11	0.12	0.09	0.01	0.10	0.16
Jobless growth	-0.08	-0.39	-0.33	-0.35	-0.43	0.01	-0.59	-0.37	0.05	-0.07	-0.17	-0.15	-0.18	-0.33	-0.30	-0.20
Decline by efficiency loss	-0.48	-0.09	-0.16	-0.28	-0.22	-0.02	-0.10	-0.12	-0.25	0.05	0.10	0.03	0.01	0.18	0.37	0.09
Decline by contraction	1.01	0.31	0.38	0.40	0.62	0.31	0.63	0.37	0.36	0.50	1.14	1.30	0.71	0.74	0.81	0.68

Figure 27: Decomposition of aggregate labour productivity growth: contribution from resource allocation of surviving firms



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fake Growth	0.90	0.10	0.13	0.26	0.68	0.69	0.05	0.14	0.76	1.23	3.68	2.32	1.26	1.13	2.00
▲ Growth Hero	0.07	-0.36	-0.33	-0.48	0.29	0.05	-0.24	-0.35	-0.12	0.17	1.89	1.39	0.86	0.76	0.79
Jobless Growth	5.65	1.84	1.50	2.32	0.64	3.57	1.31	-0.24	1.07	2.10	5.37	4.25	3.63	2.93	2.71
◆ Decline by Efficiency Loss	1.35	0.57	0.93	0.76	-0.14	0.88	-0.05	0.89	0.18	0.01	2.06	1.70	-0.27	-1.00	0.74
● Decline by Contraction	0.36	-2.52	-1.54	-3.39	-2.10	-2.58	-1.63	-2.30	-1.72	-6.23	-7.27	-1.30	-3.53	-2.72	-2.21

Figure 28: Aggregate labour productivity by firm size

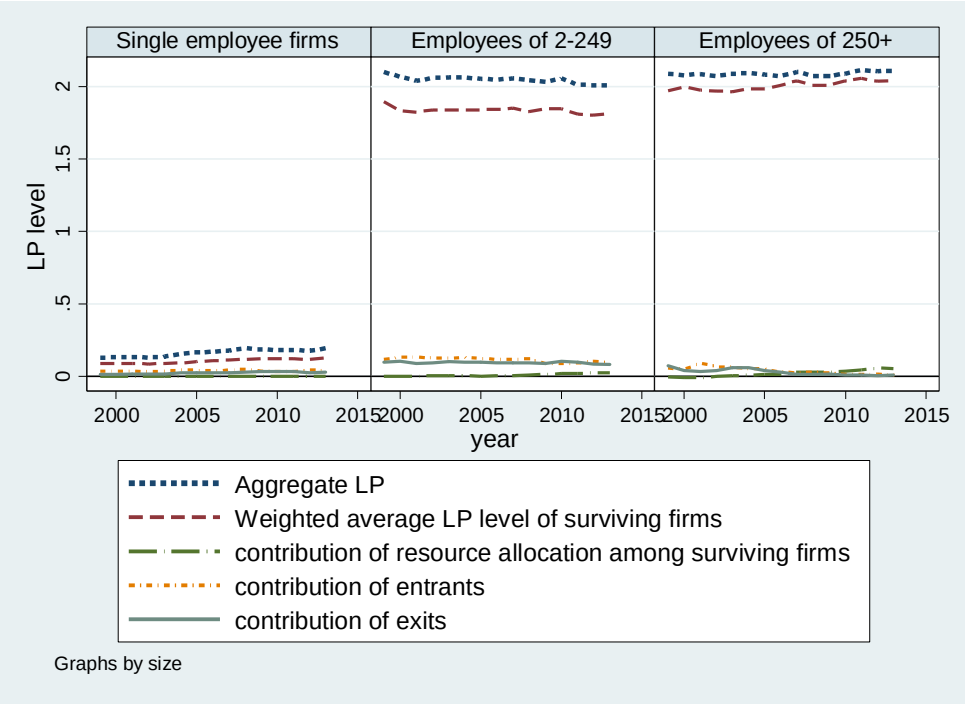


Figure 29: Decomposition of aggregate labour productivity growth: within firm productivity growth and resource allocation - single-employee firms

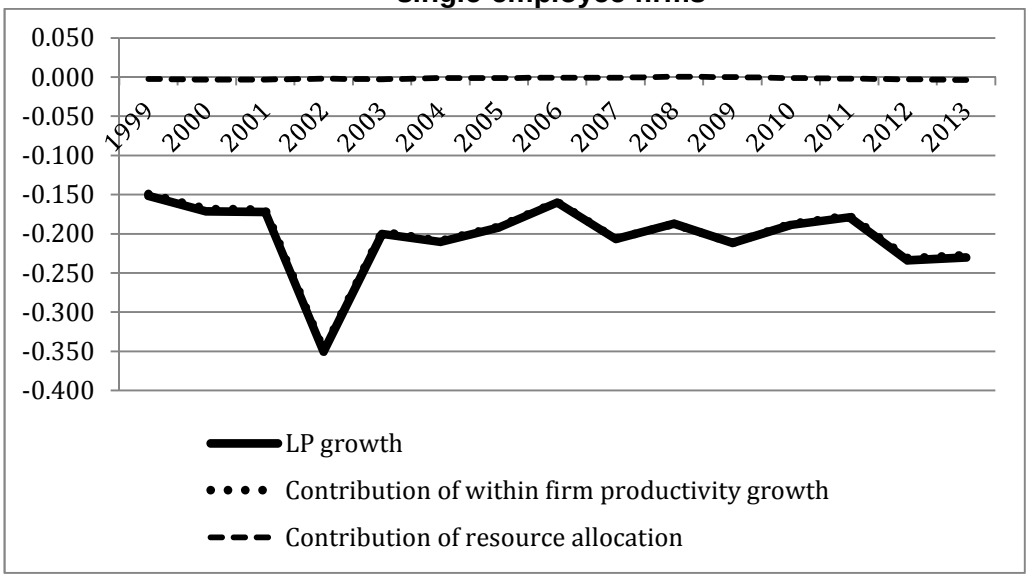


Figure 30: Decomposition of aggregate labour productivity growth: three ways of resource allocation – single-employee firms

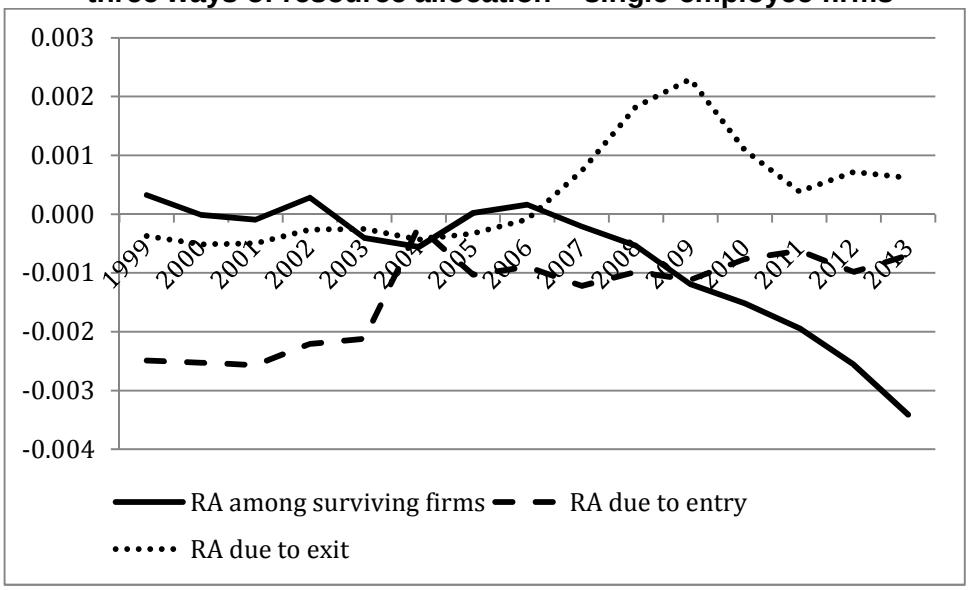


Figure 31: Decomposition of aggregate labour productivity growth: within firm productivity growth and resource allocation - 2-249 employee firms

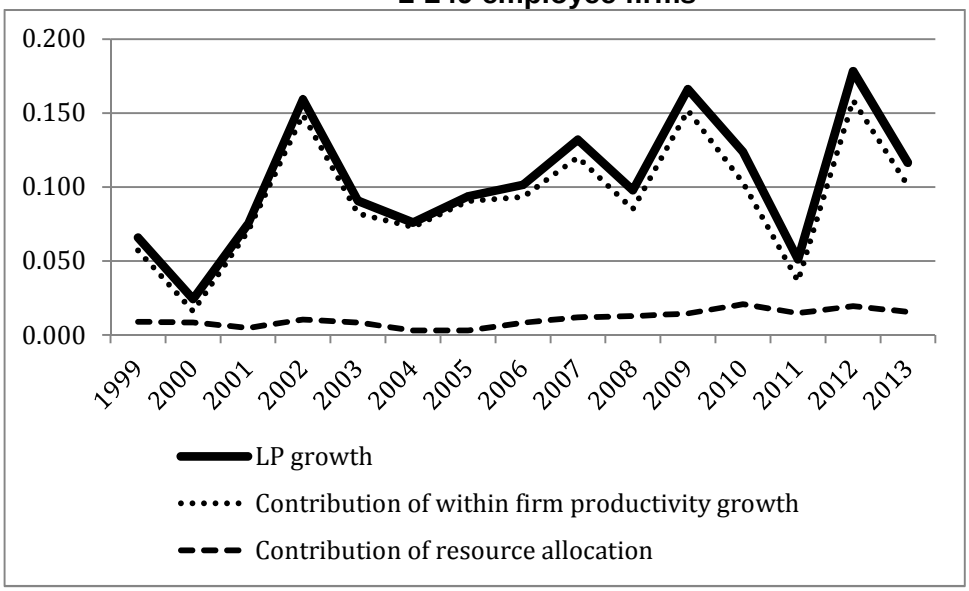


Figure 32: Decomposition of Aggregate Labour Productivity Growth: three ways of resource allocation – 2-249 employee firms

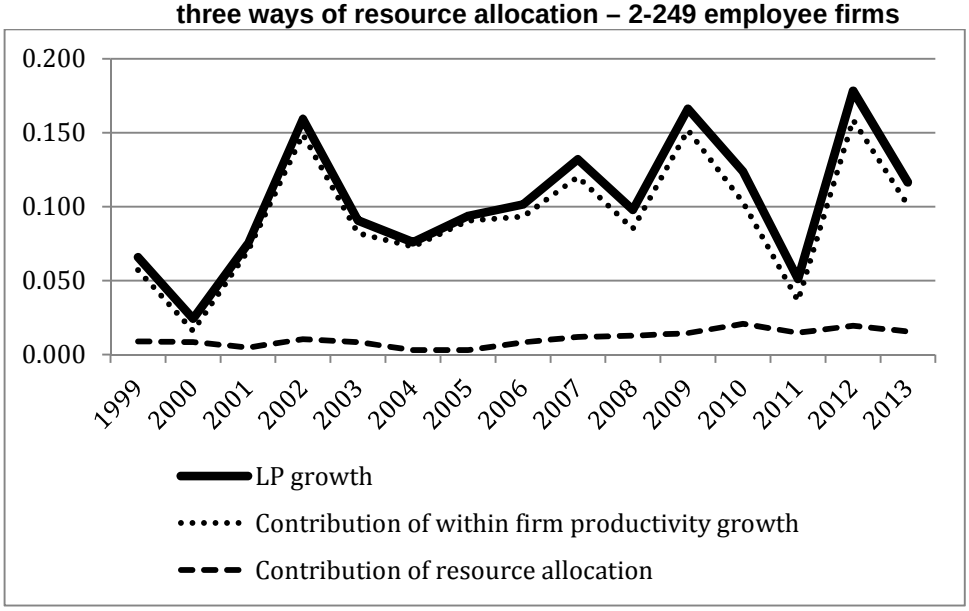


Figure 33: Decomposition of Aggregate TFP Growth: within firm productivity growth and resource allocation - 250+ Employee Firms

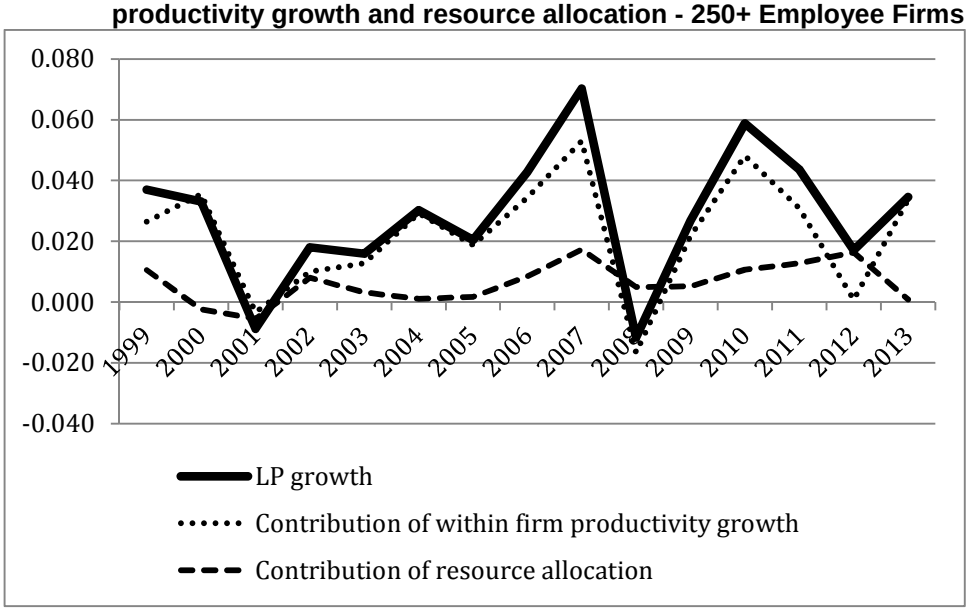


Figure 34: Decomposition of Aggregate Labour Productivity Growth: three ways of resource allocation – 250+ Employee Firms

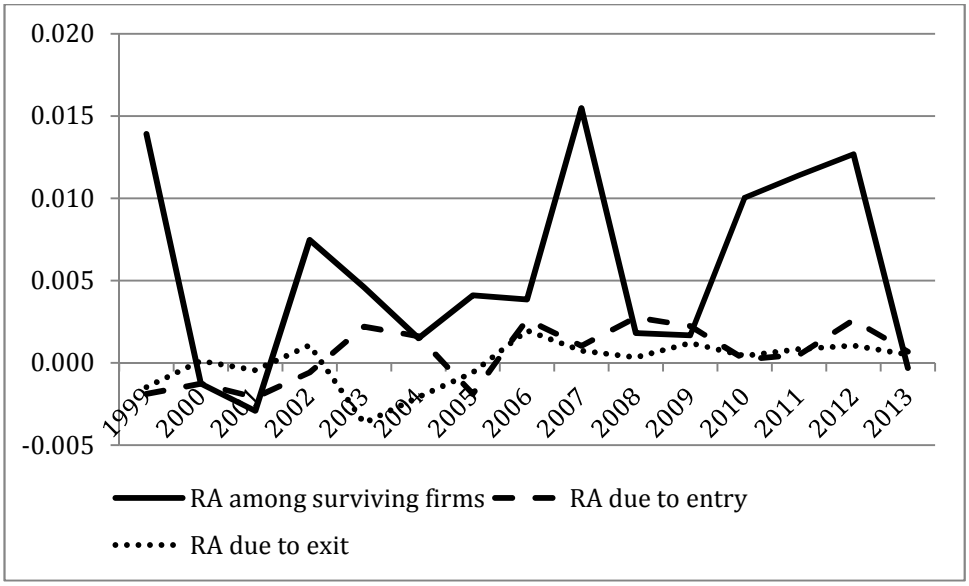


Figure 35: Aggregate Labour Productivity by Firm Age

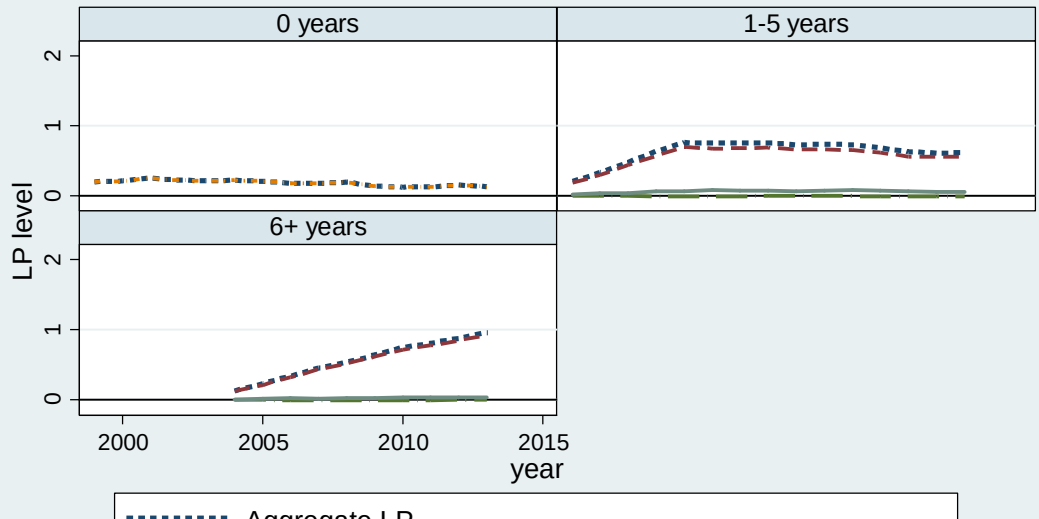


Figure 36: Decomposition of Aggregate Labour Productivity Growth: within firm productivity growth and resource allocation, Young Firms (1-5 years)

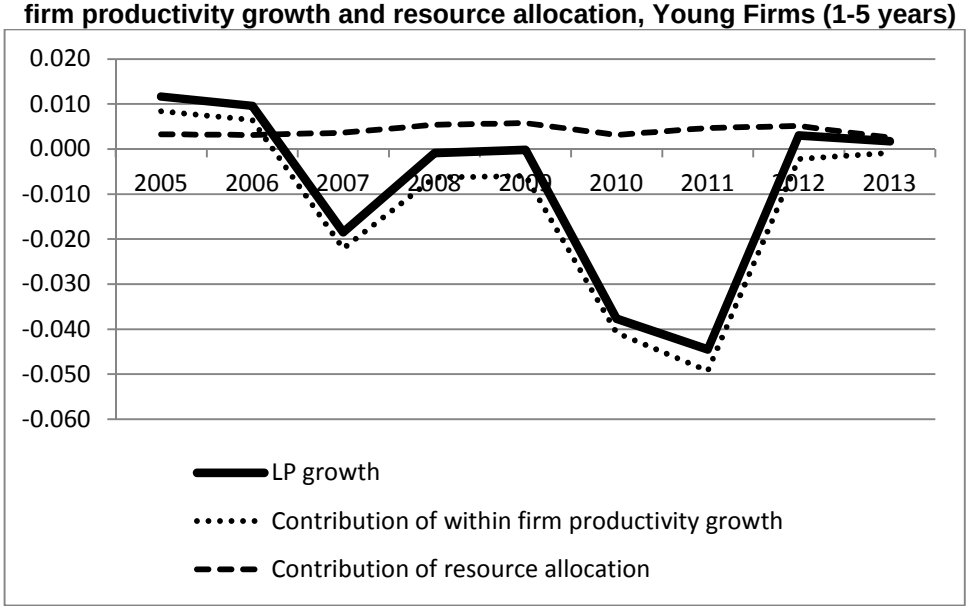


Figure 37: Decomposition of Aggregate Labour Productivity Growth: three ways of resource allocation – Young Firms

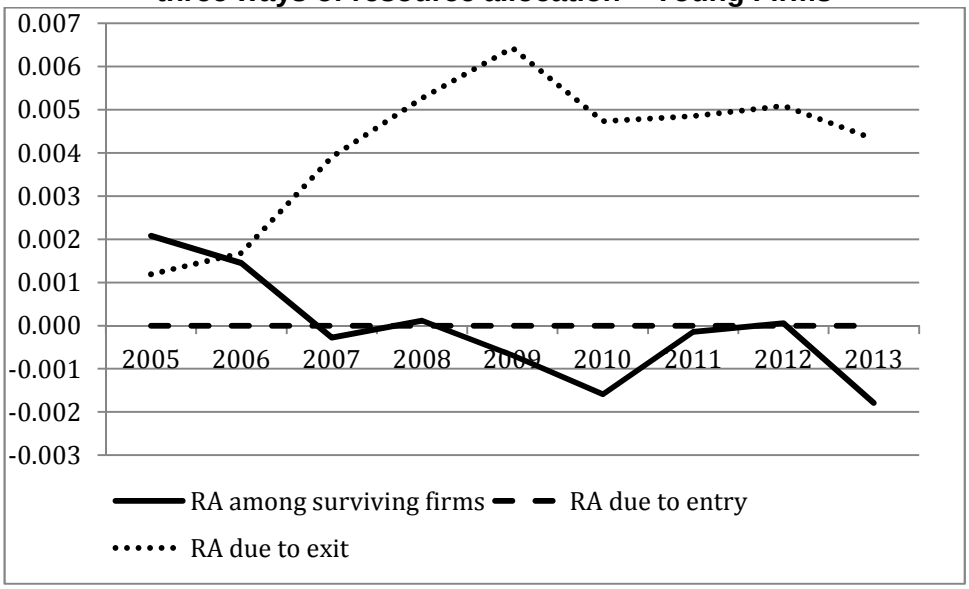


Figure 38: Decomposition of Aggregate Labour Productivity Growth: within firm productivity growth and resource allocation, Mature Firms (6+ years)

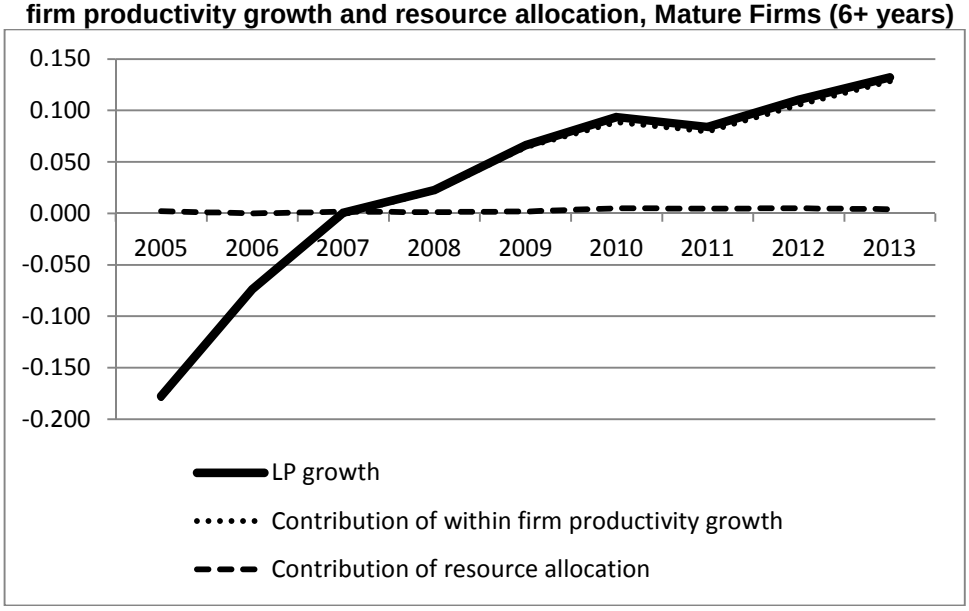


Figure 39: Decomposition of Aggregate Labour Productivity Growth: three ways of resource allocation –Mature Firms

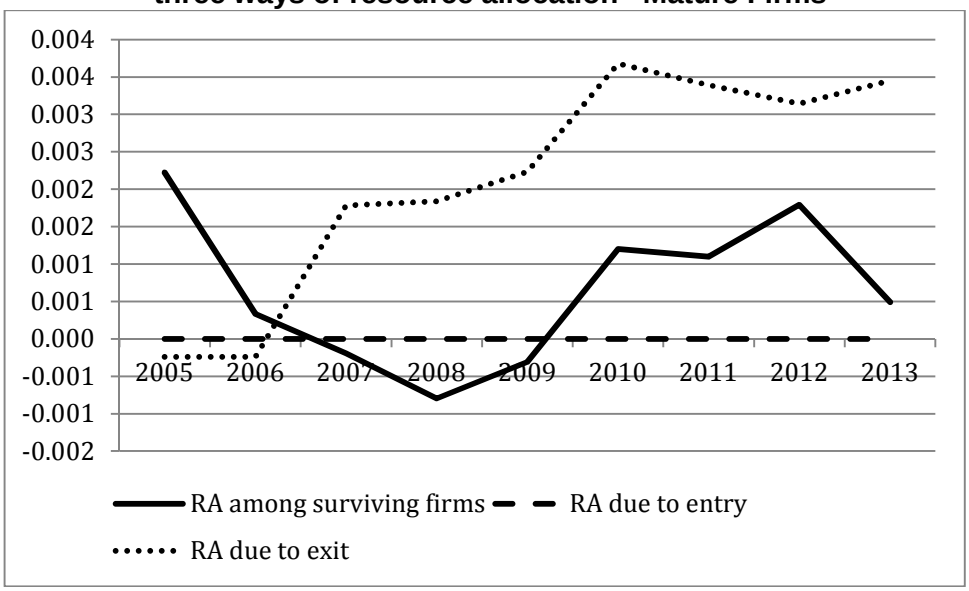


Figure 40: Aggregate Labour Productivity by Firm Age and Size: contribution from survivors and resource allocation

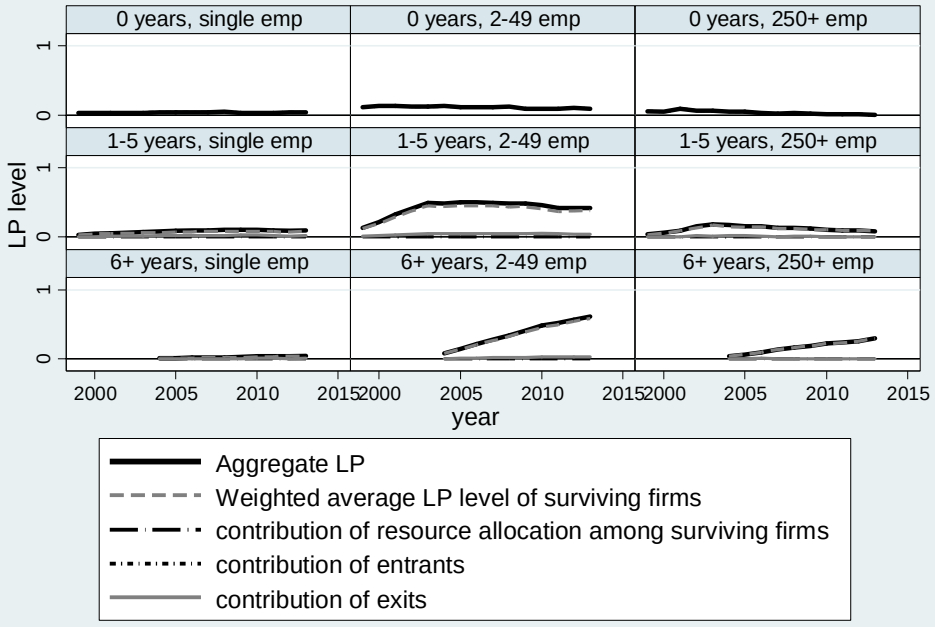


Table 1: Summary Statistics

	No. of obs.	Employees	Turnover	Mean Labour productivity	Continuers	Exiting firms	Entrants
			£m	£	%	%	%
1998	1,164,453	14,949,270	1,636,220	124,360	78.9	1.6	19.6
1999	1,248,509	15,394,700	1,755,226	122,825	79.0	6.1	15.0
2000	1,272,837	15,523,620	1,710,501	116,567	76.7	7.6	15.7
2001	1,302,136	15,741,610	1,742,071	115,588	77.1	7.3	15.6
2002	1,313,938	16,263,310	1,776,382	109,339	76.4	8.8	14.8
2003	1,331,633	16,208,810	1,782,465	110,197	76.5	8.2	15.3
2004	1,413,511	16,182,590	1,815,749	110,091	72.5	9.7	17.8
2005	1,463,620	16,159,370	1,814,986	108,481	74.2	9.9	16.0
2006	1,509,144	16,351,150	1,845,721	106,140	75.1	9.6	15.3
2007	1,541,055	16,299,900	1,930,519	107,524	75.3	9.5	15.2
2008	1,645,884	16,692,450	1,923,034	103,566	73.1	10.9	16.1
2009	1,611,758	16,678,190	1,906,539	100,747	76.3	11.7	11.9
2010	1,565,945	16,154,250	1,921,903	102,699	76.9	12.1	11.0
2011	1,518,596	15,809,750	1,821,060	98,860	77.5	11.4	11.2
2012	1,551,291	16,040,640	1,841,237	94,217	76.3	8.8	14.9
2013	1,598,065	16,233,340	1,862,177	94,252	76.4	10.3	13.3

Source: Authors own calculations of BSD data, based on our working data, i.e. the partial private sector excluding outliers (see more discussions in 3.5)

Note: Turnover and productivity are deflated using an implied 2-digit SIC07 GVA deflator (2011=100), as sourced from the ONS. Turnover is given in pounds million; productivity represents the mean value and is given in actual pounds.

Table 2: Firm characteristics of growth type

	Fake growth		Growth hero		Jobless growth		Decline by efficiency loss		Decline by contraction		Total	
N	1,263,686		593,036		7,172,205		2,471,821		7,902,814		19,403,562	
	mean (sd)		mean (sd)		mean (sd)		mean (sd)		mean (sd)		mean (sd)	
By productivity formation												
Employees	14.279	(375.525)	57.311	(1245.002)	9.131	(245.95)	28.792	(742.155)	6.625	(205.885)	12.423	(407.997)
Turnover (000s)	1599.541	(47181.1)	6775.019	(147464.1)	1076.845	(34759.78)	2543.399	(78140.01)	604.6674	(20639.64)	1279.554	(46998.52)
Labour Prod (000s)	130.604	(126.582)	125.278	(127.46)	124.332	(128.364)	84.721	(83.833)	91.21	(96.427)	106.233	(112.404)
Emp growth	-1.231	(8.484)	0.291	(0.194)	-0.084	(0.517)	0.4	(0.202)	-0.062	(4.344)	-0.076	(3.549)
Turnover growth	-0.372	(3.36)	0.443	(0.232)	0.168	(0.185)	-0.048	(1.225)	-0.763	(11.161)	-0.265	(7.202)
Labour Prod growth	0.286	(0.205)	0.226	(0.224)	0.197	(0.207)	-1.04	(2.871)	-0.57	(3.006)	-0.266	(2.229)
By age												
Young	0.73	(0.444)	0.77	(0.421)	0.771	(0.42)	0.763	(0.426)	0.776	(0.417)	0.769	(0.421)
Mature	0.27	(0.444)	0.23	(0.421)	0.229	(0.42)	0.237	(0.426)	0.224	(0.417)	0.231	(0.421)
By size												
Single employee	0.348	(0.476)	0	(0)	0.421	(0.494)	0	(0)	0.46	(0.498)	0.366	(0.482)
2-249 employees	0.646	(0.478)	0.974	(0.158)	0.576	(0.494)	0.989	(0.106)	0.539	(0.498)	0.63	(0.483)
250+ employees	0.006	(0.075)	0.026	(0.158)	0.003	(0.054)	0.011	(0.106)	0.002	(0.041)	0.004	(0.066)

Table 2: Firm characteristics of growth type – Continued

By sector										
Manufacturing	0.095	(0.294)	0.14	(0.347)	0.101	(0.302)	0.104	(0.305)	0.088	(0.283)	0.097	(0.296)
Construction	0.106	(0.307)	0.125	(0.331)	0.121	(0.327)	0.121	(0.326)	0.146	(0.353)	0.131	(0.337)
Wholesale & Retail	0.218	(0.413)	0.178	(0.382)	0.188	(0.391)	0.225	(0.418)	0.209	(0.407)	0.203	(0.402)
Transport	0.043	(0.203)	0.047	(0.212)	0.05	(0.217)	0.049	(0.216)	0.04	(0.196)	0.045	(0.207)
Accommodation	0.191	(0.393)	0.063	(0.243)	0.07	(0.255)	0.131	(0.338)	0.087	(0.281)	0.092	(0.289)
Information	0.058	(0.235)	0.091	(0.288)	0.115	(0.319)	0.068	(0.252)	0.103	(0.303)	0.099	(0.299)
Prof Svs	0.194	(0.395)	0.272	(0.445)	0.283	(0.451)	0.211	(0.408)	0.24	(0.427)	0.25	(0.433)
Arts	0.023	(0.148)	0.021	(0.142)	0.018	(0.132)	0.022	(0.148)	0.022	(0.146)	0.02	(0.142)
Oth Svs	0.072	(0.259)	0.064	(0.244)	0.054	(0.225)	0.069	(0.253)	0.066	(0.248)	0.062	(0.241)
By location												
NE	0.031	(0.172)	0.029	(0.166)	0.027	(0.162)	0.03	(0.169)	0.027	(0.161)	0.028	(0.164)
NW	0.107	(0.309)	0.1	(0.301)	0.103	(0.304)	0.103	(0.303)	0.106	(0.308)	0.104	(0.306)
Merseyside	0.001	(0.039)	0.001	(0.038)	0.002	(0.041)	0.001	(0.035)	0.002	(0.043)	0.002	(0.041)
Yorkshire & Humber	0.076	(0.265)	0.075	(0.263)	0.071	(0.256)	0.075	(0.263)	0.071	(0.257)	0.072	(0.258)
East Midlands	0.069	(0.254)	0.07	(0.254)	0.066	(0.248)	0.069	(0.254)	0.065	(0.247)	0.066	(0.249)
West Midlands	0.085	(0.278)	0.082	(0.275)	0.082	(0.274)	0.083	(0.277)	0.082	(0.274)	0.082	(0.275)
East of England	0.095	(0.294)	0.097	(0.296)	0.102	(0.302)	0.099	(0.298)	0.1	(0.3)	0.1	(0.3)
London	0.159	(0.366)	0.182	(0.386)	0.165	(0.371)	0.158	(0.365)	0.169	(0.375)	0.166	(0.372)
SE	0.151	(0.358)	0.158	(0.364)	0.171	(0.377)	0.156	(0.362)	0.169	(0.375)	0.167	(0.373)
SW	0.088	(0.284)	0.084	(0.278)	0.086	(0.281)	0.09	(0.287)	0.084	(0.277)	0.086	(0.28)
Wales	0.043	(0.202)	0.036	(0.187)	0.037	(0.189)	0.041	(0.198)	0.037	(0.19)	0.038	(0.191)
Scotland	0.071	(0.257)	0.065	(0.246)	0.066	(0.248)	0.071	(0.256)	0.066	(0.248)	0.067	(0.25)
NI	0.024	(0.152)	0.021	(0.144)	0.022	(0.147)	0.025	(0.156)	0.021	(0.143)	0.022	(0.147)
By ownership												
UK-owned	0.937	(0.242)	0.873	(0.333)	0.948	(0.221)	0.929	(0.256)	0.956	(0.205)	0.946	(0.226)

Source: Authors own calculations of BSD data, based on our working data. The groups classified here contain survivors and exits as the growth records are compared on a yearly basis, hence including an average 84% of the whole population (also see more discussion in Section 3.4.

Note: This table provides the summary statistics (mean and standard deviation) for the five growth types. Group compositions, i.e. percentages of firms in total, are reported, except the first panel (By productivity formation).

Table 3: Decomposition of aggregate Labour Productivity: the whole economy

	Aggregate LP	Labour Productivity decomposition			
		Average LP of surviving firms	Resource allocation of surviving firms	Average LP of the exits	Average LP of the entrants
	Φ_t	$w_S\overline{\phi_{St}}$	$w_S\Sigma cov(s_{it}, \phi_{it})$	$w_{Xt}\Phi_{Xt}$	$w_{Et}\Phi_{Et}$
	(1)	(2)	(3)	(4)	(5)
1998	4.037	4.012 (99.4%)	-0.116 (-2.9%)	0.089 (2.2%)	0.052 (1.3%)
1999	4.128	3.995 (96.8%	-0.074 (-1.8%)	0.175 (4.2%)	0.032 (0.8%)
2000	4.083	3.963 (97.1%)	-0.073 (-1.8%)	0.157 (3.9%)	0.035 (0.8%)
2001	4.035	3.941 (97.7%)	-0.078 (-1.9%)	0.130 (3.2%)	0.042 (1.0%)
2002	4.062	3.926 (96.6%)	-0.044 (-1.1%)	0.146 (3.6%)	0.035 (0.9%)
2003	4.100	3.924 (95.7%)	-0.032 (-0.8%)	0.173 (4.2%)	0.035 (0.9%)
2004	4.129	3.947 (95.6%)	-0.033 (-0.8%)	0.174 (4.2%)	0.041 (1.0%)
2005	4.125	3.949 (95.7%)	-0.014 (-0.3%)	0.154 (3.7%)	0.035 (0.9%)
2006	4.128	3.953 (95.7%)	0.005 (0.1%)	0.141 (3.4%)	0.029 (0.7%)
2007	4.178	3.986 (95.4%)	0.040 (1.0%)	0.124 (3.0%)	0.029 (0.7%)
2008	4.151	3.935 (94.8%)	0.043 (1.0%)	0.133 (3.2%)	0.040 (1.0%)
2009	4.157	3.963 (95.3%)	0.042 (1.0%)	0.133 (3.2%)	0.019 (0.5%)
2010	4.202	3.980 (94.7%)	0.066 (1.6%)	0.141 (3.3%)	0.015 (0.4%)
2011	4.175	3.939 (94.4%)	0.089 (2.1%)	0.130 (3.1%)	0.016 (0.4%)
2012	4.142	3.892 (94.0%)	0.119 (2.9%)	0.106 (2.6%)	0.025 (0.6%)
2013	4.159	3.917 (94.2%)	0.109 (2.6%)	0.113 (2.7%)	0.019 (0.5%)
All	***4.124***	***3.951 (95.8%)***	***0.003(0.1%)***	***0.139 (0.8%)***	***0.031 (3.4%)***

Note: From authors' own calculation, and the components are defined as in equation (3), the percentage of the contribution of each components in aggregate labour productivity are also calculated and reported in the parentheses. The weight is calculated based on employees.

Table 4: Decomposition of aggregate Labour Productivity growth: the whole economy

	Aggregate labour Productivity growth decomposition						
		i. Labour productivity improvement of surviving firms	ii.+iii.+iv. Total resource allocation effects	Among which:			
	Aggregate LP growth $\Delta\Phi_t$ =i.+ii.+iii.+iv.	$\overline{\Phi_{S2}} - \overline{\Phi_{S1}}$		ii. Improvement in resource allocation among surviving firms $\sum_{i\in S} cov(s_{i2}^k, \phi_i$ $- \sum_{i\in S} cov(s_{i1}^k,$	iii.+iv. Improvement of net entry and Exit	iii. Improvement in exit $w_{X1}[\Phi_{S1} - \Phi_{X1}]$	iv. Improvement in entry $w_{E2}[\Phi_{E2} - \Phi_{S2}]$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1999-2001 average	-0.004	-0.024	0.020	0.013	0.007	0.003	0.004
2002-2004 average	0.022	0.002	0.020	0.015	0.005	0.002	0.003
2005-2007 average	0.050	0.013	0.037	0.025	0.013	0.005	0.007
2008-2010 average	0.027	-0.002	0.029	0.009	0.020	0.010	0.011
2011-2013 average	0.015	-0.021	0.036	0.014	0.021	0.010	0.012
All year average	*0.022*	*-0.006*	*0.028*	*0.015*	*0.013*	*0.006*	*0.007*

Note: From authors' own calculation, and the components are defined as in equation (4). The weight is calculated based on value-added.

Table 5: Contribution to aggregate labour productivity by growth types

Year	Aggregate LP	Fake Growth					Growth Hero					Jobless Growth				
		Average LP	% in Agg LP	Research Allocation	% in Agg LP	Total % in Agg LP	Average LP	% in Agg LP	Research Allocation	% in Agg LP	Total % in Agg LP	Average LP	% in Agg LP	Research Allocation	% in Agg LP	Total % in Agg LP
1998	4.3715	0.287	*0.07*	-0.0024	*-0.0006*	***0.07***	0.637	*0.15*	0.0016	*0.000*	***0.15***	1.1572	*0.26*	-0.0036	*-0.001*	***0.26***
1999	4.3811	0.2288	*0.05*	-0.0014	*-0.0003*	***0.05***	0.829	*0.19*	0.0024	*0.001*	***0.19***	1.2436	*0.28*	-0.0172	*-0.004*	***0.28***
2000	4.289	0.217	*0.05*	-0.001	*-0.0002*	***0.05***	0.4535	*0.11*	0.0013	*0.000*	***0.11***	1.1039	*0.26*	-0.0143	*-0.003*	***0.25***
2001	4.2988	0.2884	*0.07*	-0.0015	*-0.0003*	***0.07***	0.536	*0.12*	0.0022	*0.001*	***0.13***	1.1317	*0.26*	-0.015	*-0.004*	***0.26***
2002	4.3123	0.3317	*0.08*	-0.0029	*-0.0007*	***0.08***	0.6229	*0.14*	0.0038	*0.001*	***0.15***	1.0431	*0.24*	-0.0184	*-0.004*	***0.24***
2003	4.313	0.3367	*0.08*	-0.0024	*-0.0006*	***0.08***	0.5279	*0.12*	-0.0004	*0.000*	***0.12***	1.2125	*0.28*	0.0003	*0.000*	***0.28***
2004	4.3201	0.2673	*0.06*	-0.0023	*-0.0005*	***0.06***	0.5183	*0.12*	0.0026	*0.001*	***0.12***	1.3643	*0.32*	-0.0255	*-0.006*	***0.31***
2005	4.3051	0.3735	*0.09*	-0.0025	*-0.0006*	***0.09***	0.5013	*0.12*	0.0008	*0.000*	***0.12***	1.1594	*0.27*	-0.0159	*-0.004*	***0.27***
2006	4.2859	0.2404	*0.06*	-0.0021	*-0.0005*	***0.06***	0.5512	*0.13*	0.0017	*0.000*	***0.13***	1.272	*0.30*	0.0021	*0.001*	***0.30***
2007	4.3353	0.3312	*0.08*	-0.0029	*-0.0007*	***0.08***	0.7101	*0.16*	0.0036	*0.001*	***0.16***	1.2062	*0.28*	-0.0032	*-0.001*	***0.28***
2008	4.3101	0.3194	*0.07*	-0.0023	*-0.0005*	***0.07***	0.655	*0.15*	0.0048	*0.001*	***0.15***	0.9093	*0.21*	-0.0074	*-0.002*	***0.21***
2009	4.2844	0.3152	*0.07*	-0.0029	*-0.0007*	***0.07***	0.5814	*0.14*	0.0049	*0.001*	***0.14***	0.9718	*0.23*	-0.0066	*-0.002*	***0.23***
2010	4.2901	0.4761	*0.11*	-0.0019	*-0.0004*	***0.11***	0.6105	*0.14*	0.004	*0.001*	***0.14***	1.2034	*0.28*	-0.0077	*-0.002*	***0.28***
2011	4.2418	0.3834	*0.09*	-0.0005	*-0.0001*	***0.09***	0.4935	*0.12*	0.0006	*0.000*	***0.12***	1.1442	*0.27*	-0.0141	*-0.003*	***0.27***
2012	4.2131	0.3418	*0.08*	-0.0003	*-0.0001*	***0.08***	0.545	*0.13*	0.0042	*0.001*	***0.13***	1.0296	*0.24*	-0.0125	*-0.003*	***0.24***
2013	4.2089	0.3529	*0.08*	-0.02	*-0.0005*	***0.08***	0.7024	*0.17*	0.0067	*0.002*	***0.17***	1.0612	*0.25*	-0.0085	*-0.002*	***0.25***

Table 5: Contribution to aggregate labour productivity by growth types- Continued

Year	Decline by Efficiency Loss					Decline by Contraction					Entrants	
	Average LP	% in Agg LP	Resource Allocation	% in Agg LP	Total % in Agg LP	Average LP	% in Agg LP	Resource Allocation	% in Agg LP	Total % in Agg LP	Average LP	Total % in Agg LP
1998	1.1399	0.26	-0.021	-0.005	**0.26**	0.7758	0.18	0.0443	0.01	**0.19**	0.2568	0.06
1999	1.0194	0.23	-0.004	-0.001	**0.23**	0.7863	0.18	0.0136	0.00	**0.18**	0.2011	0.05
2000	1.2679	0.30	-0.0071	-0.002	**0.29**	0.9814	0.23	0.0164	0.00	**0.23**	0.2118	0.05
2001	1.1709	0.27	-0.0119	-0.003	**0.27**	0.8659	0.20	0.0172	0.00	**0.21**	0.2557	0.06
2002	1.2404	0.29	-0.0094	-0.002	**0.29**	0.7627	0.18	0.0269	0.01	**0.18**	0.2221	0.05
2003	1.0967	0.25	-0.001	0.000	**0.25**	0.8346	0.19	0.0133	0.00	**0.20**	0.2181	0.05
2004	0.8997	0.21	-0.0045	-0.001	**0.21**	0.9652	0.22	0.0271	0.01	**0.23**	0.2217	0.05
2005	1.151	0.27	-0.0051	-0.001	**0.27**	0.8443	0.20	0.0161	0.00	**0.20**	0.2093	0.05
2006	1.15	0.27	-0.0107	-0.003	**0.27**	0.81	0.19	0.0155	0.00	**0.19**	0.1814	0.04
2007	1.1536	0.27	0.002	0.001	**0.27**	0.6747	0.16	0.0218	0.01	**0.16**	0.1787	0.04
2008	1.1576	0.27	0.0042	0.001	**0.27**	0.9166	0.21	0.0493	0.01	**0.22**	0.1954	0.05
2009	1.2985	0.30	0.0013	0.000	**0.3**	0.8754	0.20	0.0558	0.01	**0.22**	0.1451	0.03
2010	1.0596	0.25	0.0006	0.000	**0.25**	0.7439	0.17	0.0304	0.01	**0.18**	0.1273	0.03
2011	1.0437	0.25	0.0077	0.002	**0.25**	0.9751	0.23	0.0316	0.01	**0.24**	0.1311	0.03
2012	1.1943	0.28	0.0156	0.004	**0.29**	0.8657	0.21	0.0339	0.01	**0.21**	0.1579	0.04
2013	1.1343	0.27	0.0038	0.001	**0.27**	0.7599	0.18	0.0284	0.01	**0.19**	0.1363	0.03

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