

Business Growth and Innovation

The wider impact of rapidly-growing firms in UK city-regions

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Foreword

Thriving businesses are vital to the UK's economic recovery. Businesspeople, investors and policymakers agree that they create jobs, wealth and wider prosperity.

If government is to create the right conditions for businesses to grow, it must understand how this growth happens and what lies behind it.

This report examines business growth in UK cities, considering the wider benefits of growth businesses and the relationship between growth and innovation. It demonstrates the importance of innovation to business growth, as well as the considerable socio-economic benefits of high-growth businesses. Not only do they employ a significant number of people, but they also drive the employment of the businesses that surround them. Hence, this report is the counterpart to *Measuring Business Growth*, which considers instead the direct contribution to employment made by UK high-growth firms.

This work has significant implications for the direction of economic policy. It shows that enabling innovation is good for growth, and that high-growth businesses make a disproportionate contribution to job creation and prosperity.

We believe that this report will be a powerful contribution to the debate on how to foster economic growth. As ever, I welcome your views.

Stian Westlake

Executive Director of Policy and Research, NESTA

October, 2009

NESTA is the National Endowment for Science, Technology and the Arts.

Our aim is to transform the UK's capacity for innovation. We invest in early-stage companies, inform innovation policy and encourage a culture that helps innovation to flourish.

Executive summary

Countries prosper when their businesses thrive, which is why governments encourage entrepreneurship and support small firms

The UK's long-term economic growth is underpinned by the vitality of its businesses. A dynamic business sector, where new firms continuously enter the market, grow in size and displace weak firms, is the best guarantee of the UK's future economic performance.

For these reasons the UK government encourages entrepreneurship and provides a range of help for small and medium-sized enterprises (SMEs). This includes grants for business investment and research and development, advice and co-funding for development of export capability, small loan guarantees and venture capital schemes.

But our knowledge regarding UK businesses' growth is limited

Despite the interest in fast-growing firms, not much is currently known about how businesses grow in the UK and what the impact on economic performance is.

We aim to help fill this gap. First, we examine the wider impact of fast-growing firms on economic and social outcomes in 45 UK city-regions, which account for just under 80 per cent of total UK employment. Specifically, we use econometric techniques to find out what happens to regional performance if firm growth involves a small minority of outstanding performers rather than modest average growth by the majority of firms in the region.

Second, we study the causal relationship between businesses' growth and their innovation activities. We use firm-level data from the Business Structure Database and the Community Innovation Survey and ask whether innovation drives growth, and whether faster growth subsequently leads to higher spending on innovation.

And to complete the picture, *Measuring Business Growth*,¹ a separate NESTA report, provides a comprehensive study of business growth in the UK, focusing particularly on high-growth firms, their distribution across sectors and regions, and examining their direct contribution to job creation.

Not all businesses have the same impact on the UK's prosperity

Both new entrants and SMEs play an important role in UK's economy. But many new firms do not survive and many small firms remain small for long periods of time. Our analysis shows that a small minority of high-growth firms does most to boost the economy and employment in UK city-regions, and to drive innovation.

High-growth firms are defined by the OECD as those with ten or more employees that have recorded average annual growth rates of 20 per cent or more (in employment or sales) over a three-year period. In terms of employment growth, there were just under 11,500 such firms in the UK in 2005, representing 6 per cent of all firms with ten or more employees. This is above-average compared to other OECD countries for which such data are available.²

1. Anyadike-Danes, M., Bonner, K., Hart, M. And Mason, C. (2009) 'Measuring Business Growth: High-growth firms and their contribution to employment in the UK.' London: NESTA.

In the UK, newer firms are more likely than older firms to surpass this high-growth threshold though as many as half the firms in this category are at least ten years old. Moreover, high-growth firms are found in all sectors of the economy, not just in high-tech sectors, as is commonly assumed.

High-growth firms contribute to economic performance in several ways

High-growth firms have a direct impact on national economic performance through their own employment, innovation and productivity growth. But they also have wider effects on economic and social outcomes. We identify three main effects of this kind:

1. The positive impact of high-growth firms on productivity as the resources of displaced weaker firms are reallocated to stronger firms. This process also encourages greater innovation and efficiency in surviving firms.
2. The spillover effects of rapid firm growth on the growth of other firms as well as on regional economic and social outcomes, such as employment and inactivity rates.
3. Positive effects on overall innovative activity, since high-growth firms are disproportionately innovative.

High-growth firms generate spillovers in their regions

Our new analysis of UK city-region data finds evidence that not only do high-growth firms create jobs, but they do so over and above their direct effect on employment. If two city-regions have the same average level of firm growth, the one with a greater proportion of high-growth firms (and by implication a greater proportion of lower-growth or declining companies too) will generate more jobs. Specifically, a 5 percentage point rise in the share of employment accounted for by high-growth firms typically leads to a 1 percentage point increase in employment rates in a city-region, even assuming the same average firm growth. High-growth firms also help to reduce inactivity and dependency rates in city-regions.

High-growth firms are major innovators

The ability of high-growth firms to outperform others derives in large part from their greater levels of successful innovation.³ We find that innovative firms grow twice as fast, both in employment and sales, as firms that fail to innovate. This reflects earlier investment by fast-growing firms in innovative resources and in development of innovation-related capabilities.

For instance, firms that had introduced a product innovation in 2002-04 experienced a 4.4 per cent average employment growth rate between 2004-07, in contrast to the 2 per cent average growth displayed by non-innovators. And the figures are 10 per cent and 5.8 per cent respectively if we consider sales growth. Looking at it the other way around, high-growth firms' propensity to innovate in the prior period was 6 percentage points higher than for slower-growing firms.

Innovation drives growth

But we cannot necessarily infer from simple correlations that innovation is the driver of growth. To explore this issue further, we carried out multivariate analysis which showed that more innovative firms do indeed grow faster (as measured by the percentage of sales coming from new products, a common measure of innovation success). This effect is more marked the faster a company is growing. A high-growth firm that sees a 10 percentage point increase in the share of sales from new products adds almost 1.5 percentage points to its employment growth rate.

Investment in innovation continues after an initial period of strong growth

Our analysis suggests that the relationship between firm growth and innovation also works the other way around. We find evidence that high-growth firms continue to invest in innovative activity after their initial period of growth, whereas slower-growing firms are less likely to invest more in innovation. This is another reason why high-growth firms contribute disproportionately to innovative activity in the economy.

2. See Ibid.

3. Regardless of the definition of innovative firms that we choose (i.e. product innovator, process innovator or wider innovator).

Implications for policymakers

1. **Focus on the firms with the potential for significant growth**

The UK has successfully nurtured many small firms. There are many subsistence entrepreneurs, who happily continue to earn a modest income and employ a limited number of people. Policymakers have traditionally focused on the number rather than the quality of small firms. But to achieve greater economic prosperity and higher rates of employment, this research shows that it is important to focus on those firms with the greatest potential to grow.

2. **Don't rule out existing businesses**

Young firms are more likely to grow fast, but still only a small proportion of new firms succeed in achieving high-growth status. At the same time mature firms constitute a large proportion of high-growth firms (even though the vast majority of older firms do not grow much at all). So support for small and medium-sized firms would probably best be targeted at firms which have demonstrated some capacity or ambition to grow, regardless of their age.

3. **Encourage innovation, and make sure the necessary finance is available**

The links between innovation and growth suggest that supporting innovation is a crucial channel to foster business growth. Therefore, it is important to continue improving the availability of finance for growing innovative firms.

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Part 1: Overview

The growth of firms is dear to the hearts of policymakers in market economies. In recent decades differences between countries in patterns of firm growth have been linked to relative national economic performance, not just in new job creation (Birch, 1981, 1987) but also in improved productivity (Bartelsman, Scarpetta and Schivardi, 2005).

Productivity growth can be decomposed between the effects of the reallocation of resources within firms (for instance, through internal reorganisation) and between firms (as a result of entry, growth and exit). But this restructuring process is inhibited if highly productive firms' growth is constrained, so that they fail to replace low-productivity firms. And this failure is relatively more frequent across Europe than in the USA (Bartelsman *et al.*, 2005). There is therefore a keen interest in learning more about the policy and institutional settings which help create the most favourable conditions for firms to prosper and grow.

Why pay attention to high-growth firms?

The role of creative destruction in fostering growth has captured the interest of policymakers in the UK and other European countries. This in part results from the desire in these countries to emulate the US in breeding innovative new firms that grow quickly into world leaders in their fields (such as Microsoft, Cisco, Google, Starbucks and FedEx). Particular attention is paid to the performance of so-called 'gazelle', 'high-growth' or 'high impact' firms which show above-average growth in employment or sales over several years (Ahmad and Gonnard, 2006; Hözl and Friesenbichler, 2008). High-growth firms are therefore seen as major contributors to the process of creative destruction, driving productivity growth and the economic performance of nations.

Definitions of high-growth firms and gazelles vary. Some authors define them solely in terms of growth rates while others also emphasise either their age or size. For example, OECD (2008) defines gazelles as a sub-set of high-growth firms born five years or less before the end of a three-year observation period. By contrast, Hözl and Friesenbichler (2008) define gazelles as high-growth firms with fewer than 250 employees. In this report we adopt the OECD definition of 'high-growth' status, namely, that firms have recorded average annual growth rates of 20 per cent or higher (in employment or in sales) in a recent three-year period, regardless of their age.

Policymakers in the UK and elsewhere have developed, with more or less success, a variety of government support programmes to facilitate the emergence of these 'exceptional' firms. They are often focused on new-start firms and small and medium-sized enterprises (SMEs), since they are expected to make substantial contributions to product innovation and to help "[displace] old products and practices with better, more efficient ones" (BERR, 2008b: 7). Programmes in the UK include grants for business investment and research and development, venture capital schemes, advice and co-funding for development of export capability and a number of other services (BERR, 2008a).

These business support programmes attempt to strike a delicate balance. On the one hand, they support new entrants in the hope that they will expand, challenge and replace incumbent firms. On the other hand, they also support established businesses which vary greatly in their growth prospects. In consequence, there is an on-going debate about which kind of businesses (if any) the government should

support. A key choice for policymakers is whether to try to help a wide cross-section of businesses or whether to target only those firms that have the potential to achieve high levels of growth. Both these approaches have pros and cons, and the arguments about them concern, in particular, the feasibility of a targeted approach, the cost-effectiveness of different types of intervention and the impact of firm growth on wider economic performance. Ultimately, the choice to target (or not target) high-growth firms needs to be informed by empirical evidence.

Do high-growth firms have strong effects on socio-economic outcomes?

We do not really know much about high-growth firms in the UK, but this is changing quickly. The recent availability of a newly developed business demography database has provided the opportunity to study high-growth firms and their impact on economic performance.⁴

As a result of this, NESTA is now publishing two complementary reports that shed some light on the role of high-growth firms in the UK. The first one provides the first comprehensive study of high-growth firms in the UK.⁵ It maps their distribution across sectors and regions, and examines their direct contribution to employment creation.

The second one is this report, which focuses primarily on the indirect contribution of high-growth firms to wider economic performance and social welfare, and compares it to that made by other, slower-growing firms in the economy. By doing so, we aim to provide evidence on whether a targeting approach to business support policy would – subject to feasibility – also be desirable.

In order to assess the impact of firm growth on economic and social outcomes, we need to take explicit account of externalities arising from this process, that is, the costs and benefits of firm growth which ‘spill over’ onto third parties. These accrue to consumers, workers, regions and other firms as a result of the investments in resources and capability development made by growing firms. Examples include the build-up of local skill supplies and business services, and the intensification of supply-chain linkages and relationships between firms and local universities and research institutions.

High-growth firms are also likely to contribute disproportionately to innovation activities, in the form of distinctive new products, processes

or forms of work organisation. The practices that have helped them achieve above-average growth rates provide learning opportunities for other firms in the same area, which can then choose to adopt the most successful of them.

Consequently, the goals of this report are two-fold. First, we examine the effects on social and economic outcomes if growth involves a small minority of outstanding performers (i.e. a few high-growth firms) rather than a strong average growth performance by firms in general. In other words, we study the relationship between the ‘skewness’ of the distribution of firm growth rates and socio-economic outcomes in different regions of the UK, such as employment, inactivity and dependency rates. Second, we present new analyses of the links between high-growth firms and innovation in the UK, drawing on data for services, utilities and construction firms as well as for firms in manufacturing.

Structure of the report

Our findings are presented as follows: Part 2 briefly summarises the main characteristics of high-growth firms in the UK. Part 3 presents new evidence on the effects of spillovers from firm growth onto social and economic outcomes in UK city-regions. Part 4 assesses the links between firm growth and innovation in the UK. Part 5 summarises our main conclusions regarding the impact of growing firms on economic and social outcomes.

4. Business Structure Database (BSD), Office for National Statistics.

5. Anyadike-Danes, M., Bonner, K., Hart, M. And Mason, C. (2009) ‘Measuring Business Growth: High-growth firms and their contribution to employment in the UK.’ London: NESTA.

Part 2: Characteristics of high-growth firms

6. Anyadike-Danes, M., Bonner, K., Hart, M. And Mason, C. (2009) 'Measuring Business Growth: High-growth firms and their contribution to employment in the UK.' London: NESTA.
7. The reason for excluding firms born in the first year of each time period is that it is impossible to take account of how long each newborn firm was active during this first year.
8. The BSD is an experimental database constructed by the ONS by utilising the snapshots of the Inter-Departmental Business Register each year to construct a panel dataset. Further details are available in the BSD User Guide (Version 1, May 2006).
9. Average annual growth in variables of interest such as employment (N) is computed as follows:

$$\sqrt[i]{\frac{N_t}{N_{t-i}}} - 1$$
 where i = the number of years in each time period.
10. Firm age is here calculated following Anyadike-Danes *et al.* (2009) by using the presence or absence of employees in the period 1997-2002 to derive the age of the business. This criterion reflects the fact that 1997 is the starting year for the Business Structure Database.

We focus on firms exceeding 20 per cent annual growth over three years

Measuring Business Growth,⁶ the new NESTA report being published in parallel with this one, provides a comprehensive study of high-growth firms in the UK and its regions. Here we provide a quick review of the main characteristics of high-growth firms to provide perspective for the analysis that we undertake.

Definitions of 'high-growth firms' are typically based on either threshold measures (growth rates above a certain percentage level) or relative measures (e.g. firms in the upper decile of growth rates of a given population of firms). We adopt the threshold measure proposed in the EUROSTAT-OECD Business Demography Manual:

All enterprises with average annualised growth greater than 20 per cent over a three year period, and with ten or more employees in the beginning of the observation period, should be considered as high-growth enterprises. Growth can be measured by the number of employees or by turnover.

Thus we focus on survivor firms with ten or more employees over selected time periods ending in 2005. We classify firms into groups based on their initial size at the start of each period and exclude firms which started in the first year of each time period.⁷

We first consider the main characteristics of high-growth firms in the UK by reporting analyses based on the Business Structure Database (BSD) which effectively covers all known firms in the UK (as recorded on the Inter-Departmental Business Register).⁹ As shown in Figure 1, just over two-thirds of firms

with ten or more employees recorded negative or minimal growth in employment between 2002 and 2005.¹⁰ Some 11,369 firms (about 6 per cent of the total) achieved the high-growth threshold of 20 per cent or higher average growth in employment during this period. This proportion rises to 12 per cent if growth is measured in terms of turnover (annual sales) and 17 per cent if growth in average turnover per employee is considered.

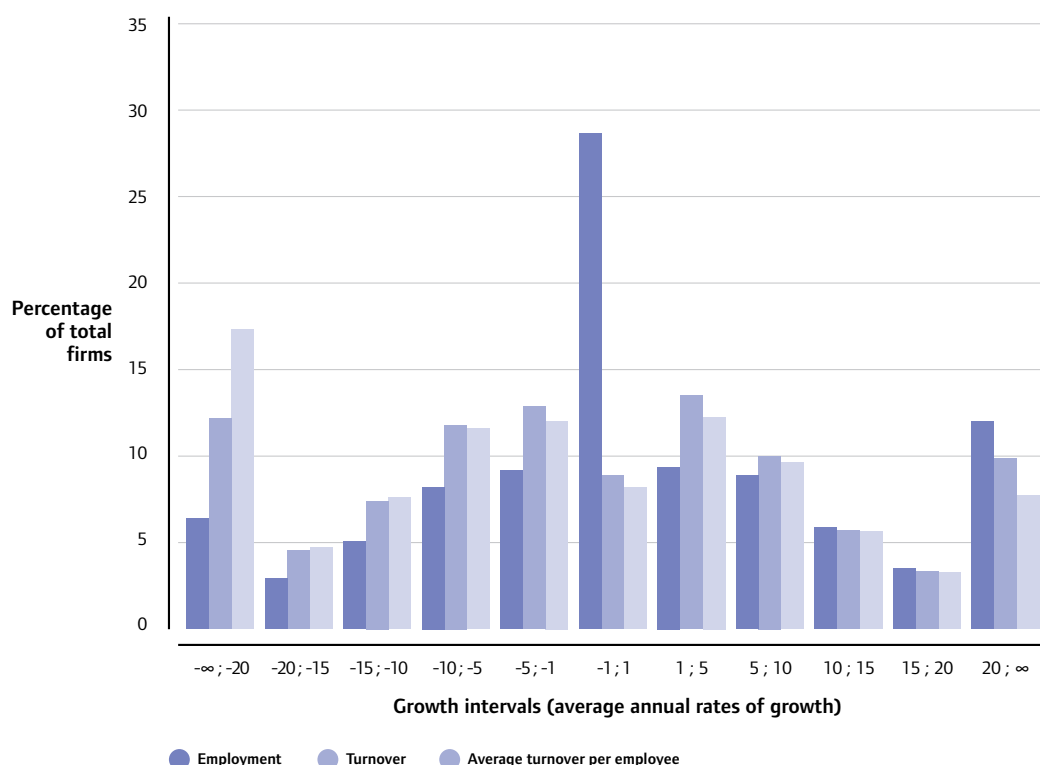
However, a large majority of the 30,828 firms achieving high-growth status in terms of average turnover per employee (TPE) between 2002 and 2005 did so in part by cutting back on employment. Some 71 per cent of these high-growth TPE firms recorded negative growth in employment over this period while a further 14 per cent recorded no growth in employment. In all, only 4,642 firms (2.6 per cent of all firms with ten or more employees) surpassed the high-growth TPE threshold whilst increasing employment.

A firm's age is more important to its growth than its size

Looking at the results for 2002-05 in detail, business service firms are strikingly over-represented on all three high-growth measures while manufacturing firms are under-represented (Table 1). It is notable that the distribution of high-growth firms by size bracket on all three measures is not much different from the overall size-distribution of firms with ten or more employees.

By contrast, there is much more variation by age of firm with relatively young firms (those less than five years old) being over-represented on all three high-growth measures.¹¹ However, most high-growth firms are still aged more than five years.

Figure 1: Distribution of firms by growth interval, Business Structure Database, average annual rates of growth in employment, turnover and average turnover per employee (firms with ten or more employees),¹² 2002–05 (n = 178188)



Source: Derived from Business Structure Database.

For instance, old firms (aged ten or more) still represent 50 per cent of high-growth firms in terms of employment growth and 53 per cent in average turnover per employee (Table 1). Put another way, these mature firms are under-represented among high-growth firms but, because they account for a large majority of all firms with ten or more employees, high-growth firms in older age brackets constitute a sizeable proportion of all high-growth firms.¹¹

This strong relationship between growth and age for surviving firms is consistent

with other evidence for the UK (Dunne and Hughes, 1994; Storey, 1989). It also finds echoes in international studies reviewed by Henrekson and Johansson (2008:15) who find ‘unambiguous’ evidence of high-growth firms being younger than other firms while, in contrast, the relationship between size and high-growth is less clearcut. Coad (2007: 18–19) concludes that, with a few exceptions, “the negative dependence of growth rate on age appears to be a robust feature of industrial dynamics”.¹³

11. Note that these UK findings are not directly comparable with recent US results showing that ‘high-impact’ firms have an average age of 25 years old (Acs, Parsons and Tracy, 2008). Acs *et al.* define ‘high-impact’ firms as those whose sales have at least doubled over a four-year period and in which an employment growth quantifier (defined as the product of a firm’s absolute change and percent change in employment, expressed as a decimal) is two or greater over the same period. Their notes on scope and methodology make clear that their sample of firms has limited coverage of firms aged less than five years. In addition, estimates of average firm age may be biased upwards by the inclusion of some very old firms. However, it is worth noting that the average age of high-impact firms in the Acs *et al.* study is still lower than that of low-impact firms.

12. Note that the distribution of firms by growth intervals changes markedly if firms with fewer than ten employees are included in the analysis. For example, Anyadike-Danes *et al.* (2009) find that, when all firms with at least one employee are included, some 61 per cent of firms fall into the central growth interval for employment between 2002–05 (i.e. those with average annual growth rates ranging from -1 per cent to +1 per cent).

13. Exploratory probit regressions on BSD data show that, after controlling for starting size, sector and technology level, the probability of firms aged two years achieving growth rates in employment of 20 per cent or more is significantly greater than the probability of firms aged four years or more doing so (Appendix Table A1).

Table 1: High-growth firms employing ten or more employees, Business Structure Database, 2002–05, analysed by size group, age group, sector and technology group

	High-growth firms (20% or higher average annual rates of growth)			Total firms in BSD
	Employment	Turnover	Turnover per employee	All firms (%)
Firms in high-growth category analysed by size group and age group (%)				
Size group (employees):				
10-19	53	51	53	52
20-49	28	29	28	30
50-99	10	10	10	9
100-249	5	6	5	5
250-499	2	2	2	2
500-999	1	1	1	1
1000-plus	1	1	1	1
Total	100	100	100	100
n	11,369	21,657	30,828	178,188
Age in 2002:				
1 year old (new-start)	8	11	9	4
2 years	8	9	8	4
3 years	7	7	6	4
4 years	8	6	6	4
5 years or more	70	67	70	83
Total	100	100	100	100
Firms in high-growth category analysed by sector and technology group (%)				
Sector:				
Manufacturing	15	18	18	23
Other production	<1	<1	<1	<1
Construction	10	10	9	9
Retail and wholesale	21	17	18	22
Hotels and catering	9	8	12	9
Transport and communications	6	6	5	5
Financial services	3	3	2	2
Business services	27	31	27	22
Other private services	8	7	8	8
Total	100	100	100	100

	High-growth firms (20% or higher average annual rates of growth)			Total firms in BSD
	Employment	Turnover	Turnover per employee	All firms (%)

Firms in high-growth category analysed by size group and age group (%)

Technology group:

High-tech	7	8	7	6
Medium- or low-tech	93	92	93	94
Total	100	100	100	100

Notes: See notes to Figure 1. Percentage column totals may not sum to 100 due to rounding.

High-tech sectors are defined as follows (SIC codes): 64.20; 72.20; 72.30; Telecommunication, Computer Programming and Software Service Industries; 72.40; 72.60; 73.10; Data Processing, Misc. Computer Services, R&D in Natural Sciences and Engineering; 30.01; 30.02; 32.20; 32.30; Office Equipment; Computers and other Information Processing Equipment; Television and Radio Transmitters and Apparatus for Line Telephony and Line Telegraphy; Television and Radio Receivers, Sound or Video Recording and Reproducing Apparatus; 33.20; 33.30; 33.40 Electronic Instruments and Appliances for Measuring, Checking (except Industrial Process Control); Electronic Industrial Process Control Equipment; Optical Instruments; Photographic Equipment; 24.41; 24.42; 33.10 Pharmaceutical Products and Preparations; Medical and Life Sciences Surgical Equipment and Orthopaedic Appliances; 24.16; 24.17; 31.10; Plastics and Synthetic Rubber in Primary Form; Electric Manufacturing; 31.20; 32.10; 35.30. Motors, Generators and Transformers; Electricity Distribution and Control Apparatus; Electronic Valves, Tubes and other Components; Aircraft and Spacecraft Manufacturing.

Source: Derived from Business Structure Database.

Part 3: The wider impact of high-growth firms

3.1 The effects of high-growth firms on aggregate economic performance

We now consider the extent to which firm growth makes an impact on economic and social outcomes over and above the direct effects of the fast-growing firms themselves. It is well understood that high-growth firms help improve productivity within their sectors by promoting more rapid churn (entry/exit) and resource reallocation between firms. At the same time, this external restructuring within sectors helps to raise multi-factor productivity growth within individual firms by inducing internal restructuring (Disney, Haskel and Heden, 2003; Aghion, Blundell, Griffith, Howitt and Prantl, 2007).

But high-growth firms' contribution to the UK economy goes beyond that. For instance, existing research on the wider effects of rapidly-growing firms highlights their contribution to the development of local resources which help improve the productivity of other local firms, including those in different sectors. Examples include the build-up of local skills and business services, the intensification of supply-chain linkages and relationships between firms and local universities and research institutions. To the extent that the benefits of such developments are available to other firms at little or no cost to themselves, they may be regarded as 'spillovers' from the activities of rapidly-growing firms (Harris and Robinson, 2004; Crespi, Criscuolo, Haskel and Slaughter, 2008). Therefore, our focus is on the effects of spillovers from growing firms on wider economic and social outcomes, not just the effects of spillovers on the growth of other firms.

Growth spillovers in cities and regions

Many high-growth firms operate on a national or international scale and do not confine their important supply-chain or innovation-related interactions to specific geographical regions. However, focussing on economic and social outcomes at regional level provides a fruitful way of examining some of the spillover effects from firm growth in which we are interested, such as the development of the localised resources which underlie both intra-industry and inter-industry spillovers.

The benefits of regional-level analysis for investigation of spillovers are shown by Glaeser *et al.*'s (1992) study of 170 US cities, which suggests that industries grow slower in cities in which they have the most employees. This supports an argument that city diversity promotes growth as knowledge and ideas spread between sectors. Glaeser *et al.* also find evidence of urbanisation externalities (spin-offs or side effects), deriving from the impact of industrial growth on local payrolls and thus local demand for a wide range of goods and services (although there are some negative side effects such as overcrowding and growth in pollution).

Clearly, there may be some interdependence between this growth and its positive spillover effects. Growing firms contribute through knowledge, agglomeration¹⁴ and other spillovers to regional economic and social outcomes (for example, productivity levels and aspects of living standards such as employment and wage rates) while being simultaneously affected in their own growth rates by those regional characteristics. To investigate these issues further, we estimate the impact of firm growth on wider economic and social outcomes at regional level for the UK using

14. 'Agglomeration spillovers' here refer to the cost reductions or benefits that firms gain as a result of concentrating or clustering together.

econometric methods which take account of inter-dependence of this kind.

3.2 Spillovers from high-growth firms in UK city-regions

Our analysis uses a new dataset for the 45 UK city-regions which account for just under 80 per cent of total UK employment. City-regions typically comprise large metropolitan areas – or contiguous metropolitan areas – together with their surrounding hinterlands (Scott, 2005). Our own definition of city-regions derives from Robson *et al.* (2006) who used employment, housing, retail and commuting data to identify relatively self-contained city-regions which overlap with the commuting patterns of managers and professionals.

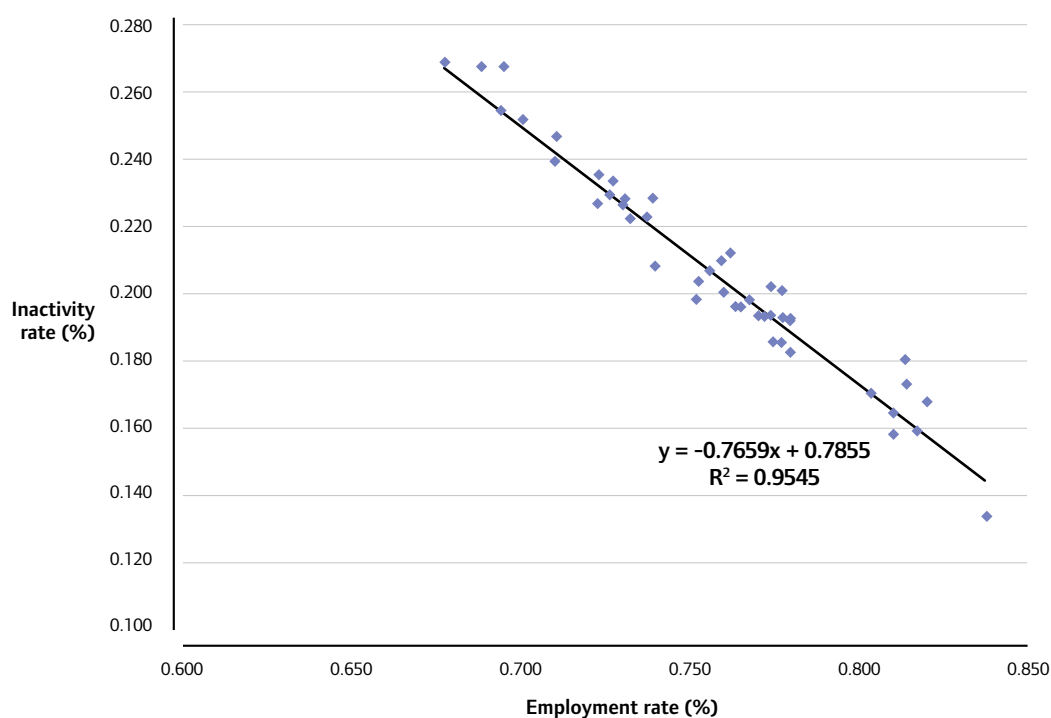
Thus city-regions potentially delineate both labour markets for high-level skills and the geographical boundaries within which extensive face-to-face business interactions and knowledge exchange may take place.

Our city-regions dataset has been built up from Local Authority District (LAD)-level data derived from a number of sources such as NOMIS, the Annual Survey of Hours and Earnings and the Business Structure Database (Appendix Tables A2-4).

The wider economic and social effects of high-growth firms in city-regions are assessed through measures of economic performance, living standards, and social exclusion and hardship. Descriptive statistics indicate that there are marked differences between city-regions in respect of employment and inactivity rates (Figure 2) as well as in median gross hourly pay levels.

Given that high-performing firms may be attracted to locations in areas of high skill density, it seems likely that some regions will benefit more than others from regional agglomeration and other spillovers from firm growth. Thus the concentration of high-growth firms may also contribute to the marginalisation of some regions through reduced labour force participation and pay rates.

Figure 2: Employment and inactivity rates, UK city-regions, 2007



Source: NIESR City-Regions Dataset.

Investigating the impact of high-growth firms on economic performance and living standards

In order to assess the impact of the distribution of firm growth rates at city-region level on wider economic and social outcomes, we test whether these outcomes are more closely linked to a small minority of high-growth firms than they are to moderate performance by 'average' firms. We do so by examining the effects of both the average growth rate achieved by firms in city-regions and the skewness of the growth distribution. Finally, we also examine the impact of new firm start-ups on the same socio-economic outcomes.

We use the following measures to characterise the firm growth distribution and the entry of new firms:

- Mean firm growth rate (employment-weighted)
- Employment share of high-growth firms
- 90th percentile firm growth rate (employment-weighted)
- New-start firms per 1,000 working age population

And we consider three sets of socio-economic outcomes:

1. Measures of economic performance at city-region level:
 - a. Annual growth rate of private sector employment
 - b. Employment rate (employed persons as a proportion of the total working age population, defined as men aged 16-64 and women aged 16-59)
2. Measures of social exclusion at city-region level:
 - a. Inactivity rate (persons neither working nor seeking employment as a proportion of the total working-age population)
 - b. Dependency rate (non-employed persons as a proportion of the total population)
3. Pay at city-region level:
 - a. Median gross hourly pay (2005 prices)

Other variables in the dataset enable us to take account of workforce qualifications, industrial structure, age and size structure of firms and the annual rate of growth in the working-age population. The latter variable captures the net effects of age-related movements into and out of working-age populations as well as net migration in and out of city-regions by working-age people. Finally, in all models except those where the dependent variables are wage-related, we enter the average gross hourly rate of pay as an independent variable, as a rough proxy for average labour productivity. Box 1 provides further details of the empirical models and estimation methods that we use, which also address the problem of simultaneity between firm growth and the other socio-economic variables.

High-growth firms drive employment growth

The results summarised in Table 2 provide strong evidence that high-growth firms have a positive impact on private sector employment growth and employment rates and a negative impact on inactivity and dependency rates. For example, an increase of 5 percentage points (pp) in the employment share of high-growth firms is associated with an increase of 3.5 pp in private sector employment growth rates (Table 2, Panel A, Column 2) and a 1 percentage point increase in employment rates in a city-region (Table 2, Panel B, Column 2). It is notable that these spillover effects derive from high-growth firms but not from firms with average (mean) employment growth.

The effects of new firm start-ups are mixed

Employment rates also benefit from entrepreneurship in the form of new firm start-ups. But our measure of business start-ups is not associated with faster growth in private sector employment or with lower inactivity and dependency rates in UK city-regions. This may reflect the fact that, as other research in German and US regions suggests, new firm start-ups take time to impact on employment growth (Fritsch and Mueller, 2004; Acs and Mueller, 2008). Hence, it is possible that longer lags would capture greater effects of business start-ups on employment growth in UK city-regions.

Pay levels are independent of entry and growth

We do not find any effect of high-growth firms or new firm start-ups on regional pay levels and higher pay rates. This may reflect the net outcome of contending forces in regional labour markets. On the one hand, relatively

low pay may (all else being equal) encourage growth in many types of employment, in particular, of low-skilled workers. On the other hand, rapid firm growth may increase the demand for labour, putting upward pressure on wage rates in some city-regions but also attracting new workers from other regions.

We provide full tables describing the models that we estimate in the Appendix (Tables A5-9). These tables show that several other variables contribute substantially to the explanatory power of our models. For example, the graduate share of employment is strongly positively related to employment rates as is the high-tech share of employment (Table A6). The annual growth rate of the working-age population (which captures differences in age structure and net migration between city-regions) has no significant effects on employment or inactivity rates but is strongly positively associated with dependency rates (Table A8). However, we do not find any significant links between firm growth measures and pay (Table A9).¹⁵

Box 1: Socio-economic outcomes and firm growth at city-region level

In more precise terms, our empirical model takes the form:

$$(1.1) \ SO_{it} = \beta_0 + \beta_1 FG_{it} + \beta_2 X_{it} + \varepsilon_{it}$$

where i denotes city-regions; SO represents a selected socio-economic outcome measure; FG is a measure of firm growth; X is a vector of city-region characteristics which prior research has suggested may affect social and economic outcomes at regional level, for example, workforce skills, industrial structure and pay rates (Overman and Puga, 2002; Badinger and Url, 2002); and ε is an error term.

Analysis of bivariate correlations suggests that our measures of firm growth are likely to have contemporaneous effects on growth rates in private sector employment but lagged effects on socio-economic outcomes such as employment and dependency rates. Accordingly, in the latter cases Equation (1.1) is modified to allow for one-year lagged measures of firm growth (FG_{t-1}) as independent variables. The firm start-up rate is entered as a once-lagged variable in all models, reflecting evidence that any effect it has on employment rates take

time to develop (Fritsch and Mueller, 2004; Acs and Mueller, 2008). Note also that the results shown here make use of employment-weighted versions of firm growth rates; alternative estimates (not shown here) indicate that our main conclusions are not altered if we use unweighted growth rates.

The estimates presented in Table 3.1 are for Fixed Effects (FE) specifications using Instrumental Variable (IV) techniques. FE models make use of time series variation within city-regions but not of cross-sectional variation between city-regions. This ensures the consistency of our estimators by removing city-region specific effects which are correlated with independent variables in our models. IV methods are required to allow for the potential endogeneity (two-way interdependence or reverse causality) of our firm growth indicators. These indicators are instrumented by second lag and rank order versions of themselves. While the rank order terms are still highly correlated with the original firm growth measures, they are purged of 'errors in variables' (measurement error) that might be related to the error terms in the main regressions (Durbin, 1954; Johnston, 1972).

15. This conclusion also applies to estimates (not reported here) in which average pay levels and annual growth rates in median and average hourly pay were taken as dependent variables.

Table 2: Fixed effects instrumental variable estimates of the determinants of socio-economic outcomes at city-region level, 1997-2007

	(1)	(2)	(3)
Dependent variable: (A) Annual rate of growth in private sector employment			
Mean firm employment growth rate (weighted) (t)	0.0004	0.0001	0.0002
	[0.0008]	[0.0008]	[0.0008]
New firm start rate (t-1)	-0.0016	-0.0037	-0.0035
	[0.0030]	[0.0032]	[0.0031]
Employment share of high-growth firms (t)		0.7095***	
		[0.2144]	
90th percentile firm growth rate (weighted) (t)			0.0017**
			[0.0008]
Dependent variable: (B) Employment rate			
Mean firm employment growth rate (weighted) (t-1)	-0.0001	-0.0002	-0.0002
	[0.0003]	[0.0003]	[0.0003]
New firm start rate (t-1)	0.0027*	0.0031**	0.0030**
	[0.0014]	[0.0012]	[0.0012]
Employment share of high-growth firms (t-1)		0.1981***	
		[0.0762]	
90th percentile firm growth rate (weighted) (t-1)			0.0007**
			[0.0003]
Dependent variable: (C) Inactivity rate			
Mean firm employment growth rate (weighted) (t-1)	0.0002	0.0003	0.0003
	[0.0003]	[0.0003]	[0.0003]
New firm start rate (t-1)	-0.0008	-0.0011	-0.001
	[0.0012]	[0.0011]	[0.0011]
Employment share of high-growth firms (t-1)		-0.1470**	
		[0.0629]	
90th percentile firm growth rate (weighted) (t-1)			-0.0005**
			[0.0002]

	(1)	(2)	(3)
Dependent variable: (D) Dependency rate			
Mean firm employment growth rate (weighted) (t-1)	0.0000	0.0000	0.0000
	[0.0003]	[0.0003]	[0.0003]
New firm start rate (t-1)	0.0000	-0.0002	-0.0002
	[0.0012]	[0.0013]	[0.0013]
Employment share of high-growth firms (t-1)		-0.1067**	
		[0.0506]	
90th percentile firm growth rate (weighted) (t-1)			-0.0003*
			[0.0002]
Dependent variable: (E) Median gross hourly pay			
Mean firm employment growth rate (weighted) (t-1)	-0.0003	-0.0001	0.0001
	[0.0051]	[0.0052]	[0.0051]
New firm start rate (t-1)	0.0318*	0.0308	0.0311
	[0.0190]	[0.0193]	[0.0191]
Employment share of high-growth firms (t-1)		-0.4831	
		[0.9659]	
90th percentile firm growth rate (weighted) (t-1)			-0.0017
			[0.0037]

Notes: *** p<0.01, ** p<0.05, * p<0.1

Robust standard errors, shown in brackets, are corrected for clustering of observations at the city-region level. All equations include year dummies and control variables for graduate share of employment; manufacturing, business services, high tech and public sector shares of employment; small firms share of employment; older firms share of employment; and annual growth rate of working-age population. Average gross hourly pay rates are also entered as an independent variable in all models except where the dependent variable is median gross hourly pay. See Appendix Tables A5-9 for details of fixed effects IV specifications and statistical tests for all models.

Part 4: Innovation and firm growth

Innovation is one of the main channels by which growing firms affect wider economic performance. High-growth firms are likely to contribute disproportionately to innovation activity, and thus generate in the process significant spillovers that benefit other firms.

But the relationship between firm growth and innovation is two-way. Investing in innovation is one of the drivers of firm growth, while high-growth firms are also in a better position to innovate. Therefore, we need to address this inter-dependence. But prior to doing so, we briefly review what we know about the drivers of firm growth, and the role that innovation plays in the process.

4.1 Explaining persistent differences in firm growth

Why do some firms perform so much better than others? Resource- and knowledge-based theories of the firm suggest that differences arise because successful firms build up distinctive resources, capabilities and structures over time which:

- i. permit them to offer superior product performance and/or lower prices;
- ii. are difficult and/or costly for other firms to duplicate or imitate.

Here, resources and capabilities are broadly defined to include intangible assets such as skills, tacit knowledge and relationships with external organisations, as well as the tangible assets arising from past investments in capital equipment and new product development. In each sector, those firms which achieve a

position of relatively high profitability will need to continue developing new capabilities to retain those positions. For example, firms which have benefited from a breakthrough new product are under pressure to scale up production in ways that rivals find hard to emulate.

In this context it is hardly surprising that firms grow in different ways. At each point, the opportunities confronting firms – and their ability to respond to them – are shaped by the idiosyncratic and specific nature of their own previous decisions, as well as the resources and capabilities which they have accumulated, and their organisational routines. Thus the present-day options confronting firms reflect their history, that is, they are ‘path dependent’. When seeking to respond to competitive market pressures and opportunities, firms are each typically starting from very different places in terms of the firm-specific knowledge, operational capabilities and dynamic or change capabilities which they have accumulated (Teece, Pisano and Shuen, 1997; Eisenhardt and Martin, 2001; Teece, 2007).

Both mature and new firms are under pressure to innovate

Clearly, these issues arise most strongly in mature firms which may face difficulties in responding to pressures for change while their existing products and routines remain profitable. March (1991) characterises this dilemma in terms of the ‘exploitation’ of existing resources and capabilities versus the need for ‘exploration’ of new technologies, markets and organisational structures. The ability to balance this tension is described as ‘ambidexterity’ by O’Reilly and Tushman (2007) whose review of firm-level studies points to marked differences between firms in the senior

management capabilities needed to adapt to emerging markets and technologies while continuing to make effective use of existing assets (for example, the ability to manage organisational sub-units with very different short-term objectives).¹⁶

By contrast, newer firms are typically small, making their first priority reaching the minimum efficient scale of operations for their sector quickly if they are to stand any chance of competing against incumbent firms (Audretsch, 1995). However, like older firms, they will be aided in achieving rapid growth if they engage in 'innovation' in the broad sense proposed by Schumpeter (1939), that is, if they combine resources in new and better ways than other slower-growing competitor firms.

Mixed evidence on firm growth and innovation

In this context it is surprising that empirical evidence on the relationship between innovation and firm growth has until recently been mixed. While employment growth is usually positively related to product innovations, the effects of process innovations on employment growth are more variable. At the same time there is strong evidence of positive links between innovation and productivity growth at firm level (Ahn, 2002; Lööf and Heshmati, 2006; Parisi, Schiantarelli and Sembenelli, 2006) but researchers often fail to find any clear link between innovation and firm sales growth (Coad, 2007).

One explanation is that investments in different forms of innovation pay off differently and on different timescales for different firms (Coad and Rao, 2008). This reflects both the inherent riskiness of innovation and the different levels of investment by firms in skills and external relationships. But different proxy measures of innovation also have their limitations. Innovation input measures such as R&D spending or R&D employment provide no indication of the effectiveness of firms' innovation activities. They also suffer from the fact that in many sectors innovation is not the result of formal R&D investment for which data are collected. At the same time, innovation output measures such as patents may be poor indicators of the commercial value of the innovations concerned and also tend to be more prevalent in some sectors than others.

4.2 Firm growth and innovation success

We now turn to examine the innovation performance of high-growth firms in the UK. In the process we aim to shed light on the relationship between firm growth and innovation. In particular, we want to disentangle the effect of innovation on growth from the effect of growth on innovation. We focus on the following questions:

1. Does innovation in preceding time periods drive firm growth today? And is the impact the same across firms, or do some firms benefit more from innovation than others?
2. Do high-growth firms contribute disproportionately to aggregate innovative activity in time periods following their rapid growth?

As the previous discussion makes clear, commonly-used innovation measures are far from perfect. But measures of 'innovation success' (e.g. the sales share of new products in a specified time period) are potentially more attractive than innovation input or process measures because they come closer to capturing the commercial potential generated by firms' previous investments in innovation and their development of innovation-related capabilities. Accordingly, we use innovation success measures derived from Community Innovation Survey (CIS) data and firm-level data on employment growth derived from the Business Structure Database (BSD) to address these questions.

Our analysis is based on data for 12,672 firms with ten or more employees in the 2002-04 CIS4 which could be matched against firm-level data in the BSD and of those just under half (6,216) could also be matched against participants in the 2004-06 CIS5.¹⁷

As a starting point for our analysis, Table 3 presents basic summary statistics of innovation activity by high-growth firms compared to other firms which did not achieve the 20 per cent-plus high-growth threshold in employment or turnover. On three different indicators of innovation – new products, new processes and innovations in business structures and practices (as defined in the notes to Table 3) – high-growth firms are significantly more innovative than other firms in the economy (Panel A). For example, some 38 per cent of high-growth firms reported product innovations compared to 33 per cent in non-high-growth firms. Similarly, we can

16. Birkinshaw and Gibson (2004) provide evidence derived from ten multinational firms that the ability to strike a balance between 'adaptability' (e.g. responding to new opportunities) and 'alignment' (e.g. extracting maximum value from existing proprietary assets) is positively associated with corporate performance.

17. Full details of the datasets and matching procedures are available from the authors on request, as is further information on the derivation of measures of innovation success, innovation inputs and related capabilities.

Table 3: Innovation activity (2002-04) and firm growth (2004-07)**(a) Innovation activity, analysed by firm growth status**

	Product innovation (2002-04)	Process innovation (2002-04)	Wider innovation (2002-04)	n
Proportion of firms reporting each type of innovation				
Employment growth (2004-7)				
High-growth firms	0.384	0.279	0.477	1,115
	(0.015)	(0.013)	(0.015)	
Other firms	0.326	0.229	0.365	11,141
	(0.004)	(0.004)	(0.005)	
Turnover growth (2004-07)				
High-growth firms	0.396	0.288	0.481	1,637
	0.012	0.011	(0.012)	
Other firms	0.321	0.225	0.359	10,615
	0.005	0.004	(0.005)	

(b) Annual growth rates, analysed by firm innovation status

Firms engaging in:	Product innovation		Process innovation		Wider innovation	
	Yes	No	Yes	No	Yes	No
Average annual growth rate, 2004-07						
Employment growth, 2004-07						
	4.44	2.02	4.79	2.22	4.15	2.02
	(0.43)	(0.22)	(0.54)	(0.21)	(0.42)	(0.21)
n =	4058	8198	2858	9398	4604	7652
Turnover growth, 2004-07						
	10.09	5.81	11.36	5.97	10.56	5.22
	(0.81)	(0.47)	(1.02)	(0.44)	(0.86)	(0.42)
n =	4056	8196	2856	9396	4601	7651

Sources: Derived from Business Structure Database 2004-07 and Community Innovation Survey 2002-04.

Notes: Standard errors shown in brackets. All differences between sub-sample means shown in the table are statistically significant at the 1% level.

Types of innovation: (a) Product innovation: Introduced new or significantly improved goods or services between 2002-04.

(b) Process innovation: Made use of new or significantly improved processes for producing or supplying goods or services between 2002-04.

(c) Wider innovation: Implemented new or significantly amended forms of corporate strategy, management techniques, organisational structures, or marketing concepts and strategies between 2002-04.

also break the data by innovators vs. non-innovators and look at average annual growth rates in each type of firm. As shown in Table 3, Panel B, average annual growth rates in both employment and sales were significantly higher for innovative firms than for non-innovators.

But many other factors, such as industry and size, could be driving these differences. So next we undertake an econometric analysis to control for these other factors, while also examining the direction of causation. We first estimate an equation taking a measure of innovation success as dependent variable, with measures of firms' investments in

the development of innovation-related capabilities entered as independent variables (see Appendix Table A11). Subsequently, for reasons described in Box 2, the predicted values of innovation success generated by this regression are entered as independent variables in a second equation which estimates the determinants of firm growth over a three-year period subsequent to the recording of innovation success. Our methodology also takes account of the 'survivor bias' arising from the fact that we can only explore the growth rates of firms which have survived until the end of each time period.

Box 2: Empirical models of firm growth and innovation

In order to explore the links between innovation inputs, innovation success and firm growth, we first estimate an equation taking a measure of innovation success as a dependent variable, with measures of firms' investments in the development of innovation-related capabilities in the current year and the previous two years entered as independent variables:

$$(2.1) NPS_{it} = \beta_0 + \beta_1 \sum_j INN_{ijt} + \beta_2 \sum_k X_{ikt} + \varepsilon_{it}$$

where i denotes firms; NPS_{it} is the new products share of turnover in year t ; INN_{ijt} is a vector of j innovation inputs and capabilities developed in the time period $t-2$ to t ; X_{ikt} is a vector of k firm-specific characteristics such as employment size, age, sector, region and geographic market focus; and ε is an error term.

Subsequently, the predicted values of innovation success generated by this regression are entered as independent variables in a second equation which estimates the determinants of firm growth, measured successively as growth in employment and turnover (sales):

$$(2.2) FG_{(t+3)/t} = \beta_0 + \beta_1 NPS_{it} + \beta_2 \sum_k X_{ikt} + v_{it}$$

where $FG_{(t+3)/t}$ is a measure of firm growth between years t and $t+3$, and v is an error term.

By evaluating the relationship between innovative success in year t and firm

growth in a subsequent three-year period, we attempt to control for problems of simultaneity, i.e. two-way interdependence between firm growth and innovation in the same time period. Furthermore, using the predicted value of the dependent variable in the first equation as a regressor in the second equation has the advantage of addressing other concerns about endogeneity (reverse causality) since the predicted values of the innovation success measure are not correlated with the error term in the second equation as might be expected if we used the actual values of this measure.

Equation 2.1 is estimated by Tobit methods which are preferred when the dependent variable is left- and right-censored (as it is in this case, ranging between 0-100). Equation 2.2 is first estimated using Heckman two-step OLS (Ordinary Least Squares) regression methods with firm growth conditioned on a prior selection equation estimating the probability of firm survival from 2004 until 2007. The identifying variables in this selection equation relate to market conditions, namely, the extent to which markets are dominated by established firms and/or are subject to uncertain demand. This produces estimates of the 'average' effect of innovation success on firm growth. Subsequently, we carry out quantile regressions which enable us to explore the relationship between innovation success and firm growth at different points on the firm growth distribution.

Innovation drives firm growth, especially for the best performing firms

We find that companies that have high levels of innovation activity in previous time periods grow faster. Table 4, Panel A shows that, at average levels of firm growth between 2004-07, a 10 percentage point (pp) increase in the

share of sales of new products in 2004 adds 0.7 pp to firms' employment growth rates.

Innovation success increases firm growth, but the effect is not the same for all firms. The best performing firms benefit much more from innovation than the average firm. Estimates

Table 4: Heckman OLS estimates of the determinants of firm employment and turnover growth, 2004-07

Dependent variable	Average annual rate of growth in employment, 2004-07	Average annual rate of growth in turnover, 2004-07
Turnover share of new products, 2004 – predicted value	0.0672*** [0.0121]	0.0640*** [0.0234]
New start	0.9059 [4.1066]	-6.0735 [10.0803]
Age 4-5	-0.3473 [1.8041]	-14.0234*** [4.7005]
Age 6-9	-1.307 [1.5589]	-19.9329*** [4.3465]
Age 10-19	-4.6123*** [1.3859]	-22.9012*** [4.2508]
Age 20+	-4.4005*** [1.3822]	-23.0849*** [4.2666]
Group	2.0270*** [0.5105]	-0.1547 [1.0449]
Wider market focus	-0.4697 [0.4963]	0.6765 [0.9175]
Graduate share	-0.0208 [0.0133]	0.0480* [0.0266]
Observations	12120	12118
Log likelihood	-54441	-62114
Wald chi-square	264.6	175.6

Notes: Robust standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1

Heckman two-step regression estimates of the determinants of continuous measures of firm growth. The predicted value for the turnover share of new products derives from the Tobit equation shown in Appendix Table A11, Column 1. All equations include employment size, sector and regional dummies. The reference category for firm age is 2-3 years. Each equation is conditioned on a prior selection equation as described in Box 2.

Table 5: Simultaneous quantile regression estimates of the determinants of firm employment and turnover growth, 2004-07

Dependent variable	Average annual rate of growth in employment, 2004-07	Average annual rate of growth in turnover, 2004-07
Turnover share of new products – predicted value		
25th percentile	0.0240***	0.0251***
	[0.0084]	[0.0077]
50th percentile	0.0223***	0.0404***
	[0.0049]	[0.0069]
75th percentile	0.0465***	0.0548***
	[0.0091]	[0.0118]
90th percentile	0.0844***	0.0854***
	[0.0171]	[0.0302]
95th percentile	0.1448***	0.1241**
	[0.0362]	[0.0525]
Observations	11709	11707
.25 Pseudo R2	0.0116	0.0116
.50 Pseudo R2	0.0085	0.0137
.75 Pseudo R2	0.0284	0.0330
.90 Pseudo R2	0.0550	0.0556
.95 Pseudo R2	0.0765	0.0884

Notes: Bootstrapped standard errors in brackets (50 replications). *** p<0.01, ** p<0.05, * p<0.1

The predicted value for the turnover share of new products derives from the Tobit equation shown in Appendix Table A11, Column 1. All equations include employment size, sector and regional dummies and control variables for group membership, geographical market focus and graduate share of employment.

18. This result is clearly consistent with that obtained by Coad and Rao (2008).

19. In this alternative model, the analysis is based on the subset of firms which are represented in both CIS4 and CISS. First, innovation success in 2006 (measured by the turnover share of new products) is regressed on firms' investments in innovation inputs and the development of innovation-related capabilities between 2002-04. Subsequently, the predicted value of innovation success derived from this model is entered as an independent variable in models taking firm growth in employment between 2006-08 as dependent variable. These results are available from the authors on request.

based on quantile regression methods suggest that the impact of a 10 pp increase in the share of sales of new products rises to almost a 1.5 pp increase on employment growth rates for the most rapidly-growing firms, represented here by those at the 95th percentile of the firm growth distribution (Table 5).¹⁸ Similar results are obtained when we use a different specification which covers a different time period for firm employment growth (2006-08) and allows for the possibility of longer lags in the effects of innovation investment (between 2002-04) on innovation success in 2006.¹⁹

Younger firms grow faster

These results also provide some insights on some of the other factors that drive growth. In particular, they show that surviving young firms aged between two and three years experience the fastest growth, both in employment and sales. This partly reflects the fact that young firms are typically relatively small and thus are starting from a low employment base. But it is also consistent with expectations that the small minority of young firms that survive their initial few years of existence do so by developing innovative ways of outperforming

their rivals and achieving the minimum efficient scale needed to operate successfully in their industries.

information about the degree of success resulting from external relationships.

Firms that grow fast continue to be more innovative in the future

We have shown that innovation drives growth, so now we ask whether growth also drives innovation. In short, we examine whether high-growth firms contribute disproportionately to aggregate innovative activity in time periods following their rapid growth. If the answer is affirmative, then not only does rapid firm growth depend on innovation but it also contributes to subsequent increases in innovative activity in the economy.

Here we define innovation intensity as the ratio of total expenditures on innovation-related activities to total sales.²⁰ We then estimate the relationship between innovation intensity and a measure of external knowledge sourcing activity in 2002-04 and firm growth in a prior period, namely, 1999-2002. As shown in Table 6, firms that grow in terms of employment go on to experience higher levels of innovation intensity in subsequent periods. And this impact is significantly larger for high-growth firms than for firms in the bottom half of the firm growth distribution.²¹

By contrast, a more nuanced picture emerges if we consider growth in sales. Average turnover growth is not significantly related to future innovation intensity. However, firms in the upper half of the firm sales growth distribution are significantly more likely to report future increases in innovation intensity than firms in the lower quartile of the distribution.

Inter-organisational collaboration in research and knowledge transfer

Turning to another measure of innovative activity – firms' involvement in external knowledge sourcing – we find that this kind of activity is significantly positively related to prior growth in average turnover but there is no clear evidence that this impact is greater for the fastest-growing firms (for example, those at the 95th percentile). Nor is there any discernible impact of employment growth on future external knowledge sourcing (Appendix Table A15). Therefore, high-growth firms do not appear to contribute disproportionately to inter-organisational collaboration in research and knowledge transfer. This is consistent with findings for Northern Continental European countries by Hölzl and Friesenbichler (2008) and may reflect the fact that measures of external collaboration do not convey

20. The activities included in this definition are innovation-related expenditures on internal R&D, acquisition of external R&D, acquisition of machinery, equipment and software, acquisition of external knowledge, training, design and marketing.

21. This conclusion is supported by alternative estimates based on different time periods where we regress innovation intensity in 2004-06 on firm growth in 2001-04 (Appendix Table A14).

Table 6: Tobit estimates of the determinants of innovation intensity at firm level in CIS4 (2002-04)

	(1)	(2)	(3)	(4)
Average employment growth, 1999-2002	1.2683**			
	[0.5501]			
Employment growth, 1999-2002 – 25th-49th percentiles		0.7685**		
		[0.3169]		
Employment growth, 1999-2002 – 50th-74th percentiles		1.0670***		
		[0.2590]		
Employment growth, 1999-2002 – 75th-94th percentiles		1.1476***		
		[0.3455]		
Employment growth, 1999-2002 – 95th-100th percentiles		1.4691**		
		[0.6180]		
Average turnover growth, 1999-2002			0.6109	
			[0.4349]	
Turnover growth, 1999-2002 – 25th-49th percentiles				0.4579
				[0.3056]
Turnover growth, 1999-2002 – 50th-74th percentiles				0.8824***
				[0.3090]
Turnover growth, 1999-2002 – 75th-94th percentiles				1.2317***
				[0.3240]
Turnover growth, 1999-2002 – 95th-100th percentiles				0.6310
				[0.5926]
Observations	9996	9996	9944	9944
Log likelihood	-25971	-25966	-25819	-25813
Pseudo R sqd	0.016	0.0162	0.016	0.0162

Notes: Bootstrapped standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1

Tobit estimates. The dependent variable is the measure of innovation intensity for 2002-04 (CIS4), defined as described in the notes to Table A2. All equations include firm age, employment size, sector and regional dummies and control variables for group membership, geographical market focus and graduate share of employment.

Part 5: Assessment

Taken together, our results suggest that high-growth firms influence national economic performance and social outcomes in several ways:

- The direct effects of individual firms' contributions to employment, output and productivity growth (reflecting their investments in resources and development of capabilities).
- The positive impact of high-growth firms on aggregate productivity growth which occurs by displacing weaker firms and speeding up the reallocation of their resources to stronger firms. This process also encourages greater innovation and efficiency in surviving firms.
- The spillover effects of rapid firm growth on the growth of other firms as well as on regional economic and social outcomes such as employment and inactivity rates.
- Positive effects on overall innovative activity, since high-growth firms are responsible for a disproportionate amount of innovation.

However, the relative importance of these channels is hard to establish since the different effects are often closely related. For example, the greater the aggregated direct effects of firm growth, the more likely national economic performance will benefit from both resource reallocation and spillovers. On the one hand, the higher the proportion of firms in the economy that may be classified as high-growth by some objective criterion, the more likely weak firms are to be squeezed out of their markets and their resources made available to stronger performers. On the other hand, rapid firm growth depends in large part on the development of dynamic capabilities

deriving from investments in skills, knowledge, innovation, external relationships and other intangible assets which research suggests have strong spillover effects on the growth of other firms.

In respect of wider social outcomes, it can be argued that some aspects of rapid firm growth may be at odds with policy objectives to reduce regional disparities within the UK. Given the likelihood that high-performing firms are attracted to areas of high skill density, some regions are more likely than others to benefit from regional agglomeration effects and other spillovers from firm growth, which may result in a widening of regional disparities. However, at national level these developments are clearly offset by the positive impacts of high-growth firms.

To what extent does it matter for economic and social outcomes if firm growth takes the form of a small minority of outstanding performers as compared to, say, a strong average growth performance by firms in general? For wider social outcomes such as employment rates, our evidence shows that the prevalence of high-growth firms has a strong impact over and above the effects of firms expanding at average rates of growth.

In addition, high-growth firms contribute disproportionately to aggregate innovative activity. And innovation itself drives firm growth. We find that the ability of high-growth firms to outperform their rivals typically reflects success in broadly-defined innovation of some kind (for example, new or improved products, processes, routines or service delivery). This relationship is strongest at the upper end of the firm growth distribution. However, average firm growth is also enhanced by prior success in

innovation as a result of innovative investments and the development of innovation-related capabilities.

While many high-growth firms are relatively new, only a small proportion of new firms succeed in achieving high-growth status. At the same time, mature firms constitute a large proportion of high-growth firms but the vast majority of older firms (including smaller ones) do not grow much at all. One implication for policymakers is that industrial support for small and medium-sized firms is probably best targeted, whenever feasible, at firms which have demonstrated some capacity or potential to grow rather than being made available to a broad mass of firms. In this respect it is particularly important for business support policy to focus on ways of improving the availability of finance for rapidly-growing firms to continue to make investments in innovation.

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Appendix tables

Table A1: Determinants of the probability of firms appearing in high-growth intervals for employment and turnover (probit estimates), Business Structure Database, 2002-05, all firms employing ten or more employees – marginal effects

	Employment	Turnover
Size 20-49	-0.0020 [0.0013]	0.0045** [0.0018]
Size 50-99	0.0087*** [0.0021]	0.0150*** [0.0029]
Size 100-249	0.0068** [0.0028]	0.0243*** [0.0039]
Size 250-499	0.0054 [0.0047]	0.0175*** [0.0063]
Size 500-999	0.0176*** [0.0071]	0.0271*** [0.0092]
Size 1,000+	0.0046 [0.0068]	0.0597*** [0.0105]
New start	-0.0042 [0.0030]	0.0455*** [0.0051]
Age-3	0.0002 [0.0032]	-0.0163*** [0.0040]
Age-4	-0.0054* [0.0030]	-0.0389*** [0.0033]
Age-5+	-0.0573*** [0.0034]	-0.1308*** [0.0045]
High-tech	0.0055 [0.0026]	0.0223*** [0.0036]
Observations	178188	178188
Pseudo R-squared	0.0200	0.0416
Sector dummies included	Yes	Yes

Notes: Robust standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1

Probit estimates. Marginal effects are shown for independent variables evaluated at the means of other covariates. Dependent variable = 1 if firm appears in high-growth interval (average annual rates of growth of 20% or higher between 2002-05) for, respectively, employment and turnover; = 0 if not in these categories. The reference categories for size and age dummies are, respectively, size 10-19 and age-2.

Source: Derived from Business Structure Database.

Table A2: UK city-regions

	City-region	Govt Office Region
1	Birmingham/Sandwell/Wolverhampton	West Midlands
2	Bournemouth/Poole	South West
3	Brighton/Hove	South East
4	Bristol/S.Gloucester	South West
5	Cambridge	Eastern
6	Carlisle	North West
7	Chester	Wales
8	Colchester	Eastern
9	Coventry	West Midlands
10	Exeter	South West
11	Greater London	Eastern/London/South East
12	Gloucester/Cheltenham	South West
13	Ipswich	Eastern
14	Kingston upon Hull	Yorkshire & Humber
15	Leeds/Bradford	Yorkshire & Humber
16	Leicester	East Midlands
17	Lincoln	East Midlands
18	Liverpool	North West
19	Luton	Eastern
20	Manchester/Salford/Trafford	North West/East Midlands
21	Middlesbrough/Stockton	North East/Yorkshire & Humber
22	Milton Keynes	South East
23	Newcastle/Gateshead/Sunderland	North East
24	Northampton	East Midlands
25	Norwich	Eastern
26	Nottingham/Derby	East Midlands
27	Oxford	South East
28	Peterborough	Eastern
29	Plymouth	South West
30	Portsmouth/Southampton	South East
31	Preston	North West
32	Reading	South East
33	Sheffield	Yorkshire & Humber/East Midlands

	City-region	Govt Office Region
34	Stoke-on-Trent	West Midlands
35	Swindon	South West
36	Telford and Wrekin	West Midlands
37	Worcester	West Midlands
38	York	Yorkshire & Humber
39	Cardiff	Wales
40	Swansea	Wales
41	Aberdeen	Scotland
42	Dundee	Scotland
43	Edinburgh	Scotland
44	Glasgow	Scotland
45	Belfast	Northern Ireland

Notes: Definitions of English city-regions are derived from Robson *et al.* (2006, Chapter 2, especially Figures 2.8 and 2.9). We are grateful to Brian Robson and colleagues for the use of their LAD (local authority district) mapping to city-regions. Their Table 2.2 identifies 39 'destination nodes' which constitute the nuclei of city-regions in England. We have reduced this total to 38 English city-regions by combining Nottingham and Derby because of the overlap in commuting patterns between these two cities and their surrounding areas. City-regions in Wales, Scotland and Northern Ireland were identified with the aid of information in Belfast City Development Department (2005), Derek Halden Consultancy (2002), Morgan (2006) and Statistics for Wales (2008).

Table A3: City-region variable definitions and data sources**Socio-economic outcomes:**

	Source
Employment rate (= Employed as percentage of population of working age)	NOMIS
Unemployment rate (= Unemployed as percentage of economically active persons [employed + unemployed])	NOMIS
Dependency rate (= Non-employed persons as percentage of total population)	NOMIS
Economic activity rate (= [Employed + unemployed] as percentage of population of working age)	NOMIS
Economic inactivity rate (= Economically inactive as percentage of population of working age)	NOMIS

Firm growth measures:

	Source
Employment share of firms in high-growth employment interval (20 per cent or higher growth per annum) as percentage of total employment	BSD
Mean employment growth rate of firms	BSD
90th percentile employment growth rate of firms	BSD
Annual rate of growth in private sector employment	BSD
Entrepreneurship: new start firms per head of working-age population	BSD/NOMIS

Other city-region characteristics:

	Source
Graduate share of employment (= Holders of NVQ4 or higher qualifications as percentage of workforce)	NOMIS
Manufacturing share of employment	BSD
Business services share of employment	BSD
Public sector share of employment	BSD
High-tech share of employment	BSD
Older firms (aged 20 years or more) share of employment	BSD
Small firms (<100 employees) share of employment	BSD
Median gross hourly pay	ASHE
Average gross hourly pay	ASHE
Annual rate of growth in working-age population	NOMIS

Sources: NOMIS: Official Labour Market Statistics, Office of National Statistics.

BSD: Business Structure Database, Office of National Statistics.

ASHE: Annual Survey of Hours and Earnings.

Table A4: Descriptive statistics for UK city-regions, 1997–2007

	Obs	Mean	Std. Dev.	Min	Max
Employment share of high-growth firms	495	0.082	0.027	0.005	0.197
Mean firm growth rate (employment-weighted)	495	-5.188	3.279	-21.111	0.031
90th percentile firm growth rate (employment-weighted)	495	17.535	4.064	0.000	40.547
New start firms per 1,000 working age population	495	7.193	2.643	2.716	17.613
Annual growth rate of private sector employment	495	0.008	0.087	-0.927	0.979
Employment rate	495	0.753	0.044	0.611	0.853
Inactivity rate	495	0.208	0.035	0.107	0.309
Dependency rate	495	0.543	0.034	0.436	0.655
Median gross hourly pay (2005 prices)	495	8.746	1.227	6.620	13.858
Average gross hourly pay (2005 prices)	495	10.970	1.666	8.022	18.327
Annual growth rate of median gross hourly pay (2005 prices)	495	0.021	0.047	-0.272	0.413
Annual growth rate of average gross hourly pay (2005 prices)	495	0.024	0.046	-0.222	0.340
Annual growth rate of working-age population	450	0.006	0.023	-0.068	0.079
Graduate (NVQ4+) share of employment	495	0.256	0.063	0.122	0.496
Manufacturing share of employment	495	0.156	0.048	0.050	0.294
Business services share of employment	495	0.101	0.028	0.041	0.245
Public sector share of employment	495	0.248	0.049	0.084	0.367
High-tech sectors share of employment	495	0.045	0.022	0.010	0.147
Small firms (<100 employees) share of employment	495	0.587	0.051	0.446	0.749
Older firms (20 years or older) share of employment	495	0.212	0.062	0.065	0.401

Table A5: Fixed effects estimates of the determinants of annual growth rates in private sector employment at city-region level, 1997-2007

	(1) FE	(2) FE IV	(3) FE	(4) FE IV	(5) FE	(6) FE IV
Mean firm employment growth rate (weighted) (t)	0.0012** [0.0006]	0.0004 [0.0008]	0.001 [0.0006]	0.0001 [0.0008]	0.0010* [0.0006]	0.0002 [0.0008]
New firm start rate (t-1)	0.0031*** [0.0011]	-0.0016 [0.0030]	0.0017 [0.0015]	-0.0037 [0.0032]	0.0018 [0.0014]	-0.0035 [0.0031]
Employment share of high-growth firms (t)			0.5140*** [0.1098]	0.7095*** [0.2144]		
90th percentile firm growth rate (weighted) (t)					0.0016*** [0.0005]	0.0017** [0.0008]
Graduate share of employment	0.0823 [0.1087]	0.0246 [0.1498]	0.0801 [0.1002]	0.0208 [0.1397]	0.0865 [0.1051]	0.0227 [0.1470]
Manufacturing share of employment	-0.1103 [0.2135]	-0.3526 [0.2620]	-0.1133 [0.2120]	-0.3392 [0.2665]	-0.1115 [0.2132]	-0.333 [0.2654]
Business services share of employment	0.3833 [0.2905]	0.2641 [0.3067]	0.4626 [0.2899]	0.3804 [0.3285]	0.4275 [0.2824]	0.3168 [0.3033]
Public sector share of employment	0.2605 [0.1842]	0.1415 [0.2195]	0.2158 [0.1709]	0.0742 [0.2207]	0.2287 [0.1757]	0.1145 [0.2196]
Small firms share of employment	0.8868*** [0.1776]	1.1003*** [0.2233]	0.8769*** [0.1743]	1.0968*** [0.2095]	0.8913*** [0.1763]	1.1095*** [0.2157]
Older firms share of employment	-0.3093** [0.1253]	-0.4442*** [0.1561]	-0.2830** [0.1262]	-0.3870** [0.1544]	-0.3003** [0.1261]	-0.4240*** [0.1577]
High-tech sectors share of employment	-0.036 [0.2823]	0.0214 [0.3023]	-0.0694 [0.2700]	-0.0838 [0.2871]	-0.0633 [0.2706]	-0.0296 [0.2903]
Average gross hourly pay	-0.0010 [0.0014]	-0.0007 [0.0015]	-0.0009 [0.0014]	-0.0004 [0.0015]	-0.0009 [0.0013]	-0.0005 [0.0014]
Annual growth rate of working-age population	0.1530 [0.1356]	0.1607 [0.1760]	0.1260 [0.1320]	0.1197 [0.1712]	0.1403 [0.1346]	0.1535 [0.1765]
Observations	403	313	403	313	403	313
R-squared	0.756		0.767		0.761	
F statistic	33.25		36.14		32.64	
Anderson LR statistic		341.8		263.2		327.4
(p-value)		<0.001		<0.001		<0.001
Hansen J statistic		0.405		0.679		1.034
(p-value)		0.817		0.878		0.793

Notes: *** p<0.01, ** p<0.05, * p<0.1

Robust standard errors, shown in brackets, are corrected for clustering of observations at the city-region level. All equations include year dummies. The dependent variable is the annual rate of growth in private sector employment. Two outlying observations have been omitted since the absolute values of the dependent variable in each case were three times greater than those of the next closest observation. For IV specifications the instrumented variables are the mean firm employment growth rate, the new firm start rate, the employment share of high-growth firms and the 90th percentile firm growth rate. The Anderson LR statistic reports a canonical correlations likelihood-ratio test of the null hypothesis that the equation is underidentified. The Hansen J statistic is the appropriate test of overidentifying restrictions in the presence of heteroscedasticity. The null hypothesis is that all instruments are valid.

Table A6: Fixed effects estimates of the determinants of employment rates at city-region level, 1997–2007

	(1) FE	(2) FE IV	(3) FE	(4) FE IV	(5) FE	(6) FE IV
Mean firm employment growth rate (weighted) (t-1)	-0.0001 [0.0003]	-0.0001 [0.0003]	-0.0002 [0.0003]	-0.0002 [0.0003]	-0.0002 [0.0003]	-0.0002 [0.0003]
New firm start rate (t-1)	0.0013 [0.0011]	0.0027* [0.0014]	0.0020* [0.0011]	0.0031** [0.0012]	0.0019* [0.0011]	0.0030** [0.0012]
Employment share of high-growth firms (t-1)			0.2150*** [0.0706]	0.1981*** [0.0762]		
90th percentile firm growth rate (weighted) (t-1)					0.0008*** [0.0002]	0.0007** [0.0003]
Graduate share of employment	0.1444** [0.0641]	0.1425** [0.0711]	0.1594** [0.0617]	0.1574** [0.0689]	0.1530** [0.0640]	0.1526** [0.0714]
Manufacturing share of employment	0.1509 [0.1028]	-0.0328 [0.1088]	0.1614* [0.0957]	-0.0260 [0.1026]	0.1813* [0.0978]	-0.0001 [0.1054]
Business services share of employment	0.0079 [0.2325]	0.0826 [0.2310]	-0.0056 [0.2259]	0.0880 [0.2249]	-0.0282 [0.2290]	0.0639 [0.2276]
Public sector share of employment	0.0624 [0.0833]	0.0087 [0.0770]	0.0437 [0.0804]	-0.0095 [0.0720]	0.0814 [0.0800]	0.0305 [0.0714]
Small firms share of employment	-0.0605 [0.0706]	0.0281 [0.0679]	-0.0438 [0.0732]	0.0510 [0.0710]	-0.0492 [0.0709]	0.0369 [0.0691]
Older firms share of employment	0.0157 [0.0407]	0.046 [0.0331]	0.0072 [0.0356]	0.0421 [0.0320]	0.0232 [0.0343]	0.0558* [0.0323]
High-tech sectors share of employment	0.3971*** [0.1004]	0.4898*** [0.1015]	0.3631*** [0.1055]	0.4368*** [0.1159]	0.3912*** [0.0996]	0.4750*** [0.1073]
Average gross hourly pay	-0.0023* [0.0014]	-0.0030** [0.0014]	-0.002 [0.0012]	-0.0025** [0.0013]	-0.0020 [0.0012]	-0.0027** [0.0013]
Annual growth rate of working-age population	0.0336 [0.0352]	0.0488 [0.0453]	0.032 [0.0362]	0.0438 [0.0467]	0.0314 [0.0362]	0.0479 [0.0454]
Observations	405	315	405	315	405	315
R-squared	0.171	0.168	0.204	0.201	0.199	0.200
F statistic	4.668		5.733		5.816	
Anderson LR statistic		374.3		375.3		374.2
(p-value)		<0.001		<0.001		<0.001
Hansen J statistic		0.548		2.763		2.514
(p-value)		0.760		0.430		0.473

Notes: *** p<0.01, ** p<0.05, * p<0.1

Robust standard errors, shown in brackets, are corrected for clustering of observations at the city-region level. All equations include year dummies. For details of instrumented variables and test statistics, see notes to Table A5.

Table A7: Fixed effects estimates of the determinants of inactivity rates at city-region level, 1997–2007

	(1) FE	(2) FE IV	(3) FE	(4) FE IV	(5) FE	(6) FE IV
Mean firm employment growth rate (weighted) (t-1)	0.0002 [0.0002]	0.0002 [0.0003]	0.0003 [0.0002]	0.0003 [0.0003]	0.0003 [0.0002]	0.0003 [0.0003]
New firm start rate (t-1)	-0.0003 [0.0009]	-0.0008 [0.0012]	-0.0008 [0.0009]	-0.0011 [0.0011]	-0.0007 [0.0009]	-0.001 [0.0011]
Employment share of high-growth firms (t-1)			-0.1612** [0.0608]	-0.1470** [0.0629]		
90th percentile firm growth rate (weighted) (t-1)					-0.0005** [0.0002]	-0.0005** [0.0002]
Graduate share of employment	-0.0662 [0.0518]	-0.0643 [0.0565]	-0.0775 [0.0513]	-0.0754 [0.0552]	-0.0717 [0.0523]	-0.0714 [0.0570]
Manufacturing share of employment	-0.119 [0.0777]	-0.009 [0.0836]	-0.1268* [0.0720]	-0.014 [0.0791]	-0.1380* [0.0755]	-0.0318 [0.0824]
Business services share of employment	0.0437 [0.1662]	0.0152 [0.1833]	0.0538 [0.1610]	0.0112 [0.1790]	0.0663 [0.1633]	0.0283 [0.1799]
Public sector share of employment	0.0131 [0.0635]	0.0294 [0.0623]	0.0271 [0.0611]	0.0428 [0.0580]	0.0011 [0.0616]	0.0140 [0.0594]
Small firms share of employment	0.0426 [0.0641]	0.0059 [0.0596]	0.03 [0.0669]	-0.011 [0.0623]	0.0355 [0.0648]	-0.0003 [0.0607]
Older firms share of employment	-0.0385 [0.0333]	-0.0541* [0.0314]	-0.0321 [0.0294]	-0.0512* [0.0296]	-0.0432 [0.0297]	-0.0609** [0.0297]
High-tech sectors share of employment	-0.1805** [0.0848]	-0.2340** [0.0917]	-0.1551* [0.0846]	-0.1947** [0.0954]	-0.1768** [0.0818]	-0.2236** [0.0908]
Average gross hourly pay	0.0014 [0.0011]	0.0020* [0.0011]	0.0011 [0.0010]	0.0017* [0.0010]	0.0012 [0.0010]	0.0018* [0.0010]
Annual growth rate of working-age population	-0.0054 [0.0328]	-0.0394 [0.0407]	-0.0042 [0.0336]	-0.0357 [0.0418]	-0.004 [0.0335]	-0.0387 [0.0414]
Observations	405	315	405	315	405	315
R-squared	0.092	0.124	0.118	0.154	0.107	0.145
F statistic	2.832		3.591		3.381	
Anderson LR statistic (p-value)		374.3 <0.001		375.3 <0.001		374.2 <0.001
Hansen J statistic (p-value)		0.668 0.716		2.432 0.488		2.207 0.531

Notes: *** p<0.01, ** p<0.05, * p<0.1

Robust standard errors, shown in brackets, are corrected for clustering of observations at the city-region level. All equations include year dummies. For details of instrumented variables and test statistics, see notes to Table A5.

Table A8: Fixed effects estimates of the determinants of dependency rates at city-region level, 1997-2007

	(1) FE	(2) FE IV	(3) FE	(4) FE IV	(5) FE	(6) FE IV
Mean firm employment growth rate (weighted) (t-1)	-0.0001 [0.0002]	0.0000 [0.0003]	0.0000 [0.0002]	0.0000 [0.0003]	0.0000 [0.0002]	0.0000 [0.0003]
New firm start rate (t-1)	-0.0001 [0.0010]	0.0000 [0.0012]	-0.0006 [0.0009]	-0.0002 [0.0013]	-0.0005 [0.0010]	-0.0002 [0.0013]
Employment share of high-growth firms (t-1)			-0.1294** [0.0494]	-0.1067** [0.0506]		
90th percentile firm growth rate (weighted) (t-1)					-0.0004** [0.0002]	-0.0003* [0.0002]
Graduate share of employment	-0.0239 [0.0477]	-0.0518 [0.0429]	-0.0329 [0.0456]	-0.0598 [0.0414]	-0.0281 [0.0471]	-0.0563 [0.0421]
Manufacturing share of employment	-0.0159 [0.0803]	0.0835 [0.0750]	-0.0222 [0.0775]	0.0798 [0.0736]	-0.0306 [0.0806]	0.0685 [0.0762]
Business services share of employment	0.0589 [0.1700]	-0.1267 [0.1668]	0.0671 [0.1671]	-0.1297 [0.1644]	0.0764 [0.1684]	-0.1182 [0.1652]
Public sector share of employment	-0.0361 [0.0737]	-0.0395 [0.0569]	-0.0248 [0.0722]	-0.0298 [0.0551]	-0.0453 [0.0731]	-0.0496 [0.0565]
Small firms share of employment	0.0949 [0.0603]	0.0835 [0.0557]	0.0848 [0.0604]	0.0711 [0.0569]	0.0894 [0.0605]	0.0793 [0.0563]
Older firms share of employment	-0.0019 [0.0336]	-0.005 [0.0295]	0.0032 [0.0314]	-0.0029 [0.0287]	-0.0056 [0.0320]	-0.0095 [0.0296]
High-tech sectors share of employment	-0.2662*** [0.0879]	-0.3625*** [0.0963]	-0.2458** [0.0925]	-0.3341*** [0.1052]	-0.2634*** [0.0892]	-0.3557*** [0.1011]
Average gross hourly pay	0.0018* [0.0011]	0.0018* [0.0010]	0.0016 [0.0010]	0.0016* [0.0009]	0.0016 [0.0010]	0.0017* [0.0010]
Annual growth rate of working-age population	0.2256*** [0.0252]	0.2207*** [0.0304]	0.2266*** [0.0262]	0.2234*** [0.0312]	0.2267*** [0.0259]	0.2211*** [0.0304]
Observations	405	315	405	315	405	315
R-squared	0.248	0.288	0.266	0.302	0.258	0.299
F statistic	22.7		29.56		29.34	
Anderson LR statistic		374.3		375.3		374.2
(p-value)		<0.001		<0.001		<0.001
Hansen J statistic		0.768		2.243		1.714
(p-value)		0.681		0.524		0.634

Notes: *** p<0.01, ** p<0.05, * p<0.1

Robust standard errors, shown in brackets, are corrected for clustering of observations at the city-region level. All equations include year dummies. For details of instrumented variables and test statistics, see notes to Table A5.

Table A9: Fixed effects estimates of the determinants of median gross hourly pay at city-region level, 1997–2007

	(1) FE	(2) FE IV	(3) FE	(4) FE IV	(5) FE	(6) FE IV
Mean firm employment growth rate (weighted) (t-1)	-0.0027 [0.0040]	-0.0003 [0.0051]	-0.0031 [0.0040]	-0.0001 [0.0052]	-0.0029 [0.0039]	0.0001 [0.0051]
New firm start rate (t-1)	0.0052 [0.0104]	0.0318* [0.0190]	0.0079 [0.0115]	0.0308 [0.0193]	0.0061 [0.0118]	0.0311 [0.0191]
Employment share of high-growth firms (t-1)			0.7691 [0.6883]	-0.4831 [0.9659]		
90th percentile firm growth rate (weighted) (t-1)					0.0012 [0.0032]	-0.0017 [0.0037]
Graduate share of employment	1.0962 [0.8280]	1.7323 [1.3446]	1.1498 [0.8230]	1.695 [1.3455]	1.1087 [0.8211]	1.7051 [1.3332]
Manufacturing share of employment	1.5306 [1.2997]	0.0692 [1.6098]	1.568 [1.3089]	0.0528 [1.6094]	1.5745 [1.3430]	-0.0078 [1.6552]
Business services share of employment	-1.376 [2.0415]	-3.7585 [2.8063]	-1.4244 [2.0426]	-3.7716 [2.8246]	-1.4282 [2.0111]	-3.7146 [2.7859]
Public sector share of employment	-0.9546 [1.1240]	-2.8951** [1.3292]	-1.0216 [1.1013]	-2.8507** [1.2954]	-0.9272 [1.1656]	-2.9476** [1.3872]
Small firms share of employment	-0.3024 [1.2390]	-1.5296 [1.3081]	-0.2423 [1.2584]	-1.5844 [1.3426]	-0.286 [1.2645]	-1.5449 [1.3202]
Older firms share of employment	0.7069 [0.6883]	0.9604 [0.6236]	0.6764 [0.6821]	0.9701 [0.6330]	0.7177 [0.6805]	0.9392 [0.6241]
High-tech sectors share of employment	0.9922 [3.9670]	-0.9798 [3.5889]	0.8709 [3.9294]	-0.8513 [3.5992]	0.9837 [3.9534]	-0.9505 [3.5806]
Annual growth rate of working-age population	0.6736*** [0.0571]	0.6845*** [0.0528]	0.6749*** [0.0570]	0.6835*** [0.0528]	0.6741*** [0.0567]	0.6839*** [0.0525]
Observations	405	315	405	315	405	315
R-squared	0.939	0.927	0.939	0.927	0.939	0.927
F statistic	218.2		213.7		209.2	
Anderson LR statistic (p-value)		374.3 <0.001		375.3 <0.001		374.2 <0.001
Hansen J statistic (p-value)		0.581 0.748		0.816 0.846		1.319 0.725

Notes: *** p<0.01, ** p<0.05, * p<0.1

Robust standard errors, shown in brackets, are corrected for clustering of observations at the city-region level. All equations include year dummies. For details of instrumented variables and test statistics, see notes to Table A5.

Table A10: Descriptive statistics for firms with ten or more employees matched between Business Structure Database and Community Innovation Survey 4 (2002-04)

Variable	Obs	Mean	Std. Dev.
Average annual growth rate in employment, 2004-07	12256	2.82	22.82
Average annual growth rate in turnover (sales), 2004-07	12252	7.23	45.84
New products as share of sales, 2004	12672	2.86	10.72
Intensity of innovation spending (% of sales), 2004	12283	3.19	8.56
New start	12672	0.01	0.10
Age 2-3	12672	0.04	0.18
Age 4-5	12672	0.04	0.20
Age 6-9	12672	0.10	0.30
Age 10-19	12672	0.34	0.47
Age 20+	12672	0.47	0.50
Group	12672	0.39	0.49
Wider market focus	12672	0.69	0.46
Graduate share of employment	12672	13.88	23.72
Manufacturing	12672	0.33	0.47
Other production	12672	0.01	0.12
Construction	12672	0.09	0.29
Retail	12672	0.18	0.38
Hotels	12672	0.05	0.22
Transport and communications	12672	0.08	0.27
Financial services	12672	0.04	0.20
Business services	12672	0.22	0.41
Size 10-19	12672	0.26	0.44
Size 20-49	12672	0.25	0.43
Size 50-99	12672	0.15	0.36
Size 100-249	12672	0.11	0.31
Size 250-499	12672	0.10	0.30
Size 500-999	12672	0.05	0.23
Size 1,000+	12672	0.08	0.27

Table A11: Tobit estimates of the determinants of innovation success, 2004

Dependent variables:	Turnover share of new products (%)	Turnover share of new and improved products (%)
Innovation intensity	0.2390***	0.5509***
	[0.0407]	[0.0656]
External information sourcing	0.8794	3.4906***
	[0.6906]	[0.7120]
External partnerships (distance)	1.4518***	0.1569
	[0.3679]	[0.6655]
Organisational innovation	1.7237***	5.2454***
	[0.3975]	[0.6189]
Public support	0.7627**	1.1575**
	[0.3402]	[0.5400]
Wider collaboration	20.7849***	48.0602***
	[0.7464]	[0.9895]
Formal protection	2.3392***	2.3741***
	[0.5667]	[0.7635]
Strategic protection	7.6617***	9.2574***
	[0.5371]	[0.9315]
Financial barriers	0.7139	0.2926
	[0.5253]	[0.7182]
Skill barriers	0.3915	1.0667*
	[0.4557]	[0.5648]
New start	10.3001**	1.9154
	[4.9759]	[8.2184]
Age 4-5	-4.2104	-5.4019
	[3.7765]	[3.8422]
Age 6-9	-6.4431**	-10.4290***
	[3.0223]	[4.0297]
Age 10-19	-7.0189**	-15.1694***
	[2.9659]	[3.2981]
Age 20+	-9.2751***	-19.1984***
	[3.2496]	[3.2211]
Group	1.5184	0.8794
	[1.0679]	[1.2317]

Dependent variables:	Turnover share of new products (%)	Turnover share of new and improved products (%)
Wider market focus	4.2134***	7.6551***
	[1.5284]	[1.9779]
Graduate share	0.1129***	0.1155***
	[0.0190]	[0.0273]
Observations	12114	12114
Log likelihood	-11477	-20210
Pseudo R sqd	0.128	0.136

Notes: Bootstrapped standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

The Tobit estimation procedure is used because the dependent variables are left- and right-censored. Both equations include employment size, sector and regional dummies. The reference category for firm age is 2-3 years. Innovation intensity is defined as the per cent of turnover spent on R&D (intramural plus extramural) and on innovation-related machinery, equipment, software, acquisition of external knowledge, training, design and marketing. For details of the derivation of measures of other innovation-related resources and capabilities, see Appendix Tables A12-13.

Table A12: Measures of innovative effort at firm level derived from the Community Innovation Survey

Variable name	Variable range	Definitions of variables or constituent elements of factor scores
New products	0-100	Turnover share of products new to market
New and improved products	0-100	Turnover share of products either significantly improved, new to enterprise or new to market
Innovation intensity	0-100	Total innovation spending as per cent of turnover in 2004, comprising spending on: R&D (intramural plus extramural) Innovation-related machinery, equipment and software Innovation-related acquisition of external knowledge Innovation-related training Innovation-related design Innovation-related marketing
External information sourcing	Factor score	Market sources – suppliers of equipment, materials, services, or software Market sources – Clients or customers Market sources – Competitors or others enterprises in your industry Market sources – Consultants, commercial labs, or private R&D institutes Institutional sources – Universities or other higher education institutions Institutional sources – Government or public research institutes Conferences, trade fairs, exhibitions Scientific journals and trade/technical publications Professional and industry associations Technical, industry or service standards
External partnerships	Factor score	Types of co-operation partnership and where located Local or Regional within UK/UK national/Other Europe/All other countries Suppliers of equipment, materials, services, or software Clients or customers Competitors or other enterprises in your industry Consultants, commercial labs, or private R&D institutes Universities or other higher education institutions Government or public research institutes
Organisational innovation	Factor score	Major changes in business structure and practices Y/N Implementation of a new or significantly changed corporate strategy Implementation of advanced management techniques within your enterprise, e.g. knowledge management systems, Investors in People Implementation of major changes to your organisational structure, e.g. introduction of cross-functional teams, outsourcing of major business functions. Implementation of changes in marketing concepts or strategies, e.g. packaging or presentational changes to a product to target new markets, new support services to open up new markets.

Variable name	Variable range	Definitions of variables or constituent elements of factor scores
Public support	Factor score	Public support for innovation Y/N Local or regional authorities Central Government or devolved administrations (including their government agencies or ministries) The European Union (EU)
Wider collaboration	Mean of 0-2 scores for collaboration on product and process innovations	How were innovative goods and services developed? 0: Mainly by your enterprise or enterprise group 1: Mainly by your enterprise together with other enterprises or institutions 2: Mainly by other enterprises or institutions How were innovative processes developed? 0: Mainly by your enterprise or enterprise group 1: Mainly by your enterprise together with other enterprises or institutions 2: Mainly by other enterprises or institutions
Formal protection	Factor score	Formal registration of design Trademarks Patents Confidentiality agreements Copyrights
Strategic protection	Factor score	Strategic secrecy Complexity of design Lead-time advantage on competitors
Financial barriers	Factor score	Barriers to innovation activity: Factor not experienced/Low/Medium/High Excessive perceived economic risks Direct innovation costs too high Cost of finance Availability of finance
Skill barriers	0-3 score	Lack of qualified personnel: Factor not experienced/Low/Medium/High
Market domination	0-3 score	Market dominated by established enterprises: Factor not experienced/Low/Medium/High
Uncertain demand	0-3 score	Uncertain demand for innovative goods or services: Factor not experienced/Low/Medium/High
Group	0/1 score	Whether part of group
Wider market focus	0/1 score	Whether market extends beyond local and regional areas
Graduate share	0-100	Percentage of graduates (all disciplines) among workforce
Internal information sources	0-3 score	Importance of internal information sources within enterprise or enterprise group
Process innovator	0/1 score	Introduced at least one new or significantly improved production process

Table A13: Results of factor analysis underlying selected innovation-related measures

Principal-components factor analysis, unrotated					
External information sources	Factor loading	Geographical reach of external partnerships	Factor loading	Organisational innovation	Factor loading
Suppliers	0.717	Suppliers	0.822	Strategic change	0.789
Customers	0.748	Customers	0.834	Management change	0.699
Competitors	0.754	Consumers	0.837	Organisational change	0.793
Consumers	0.677	Universities	0.803	Marketing change	0.735
Universities	0.616	Public labs	0.773		
Public labs	0.658				
Conferences	0.726				
Journals	0.773				
Professional associations	0.797				
Standards	0.792				
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy	0.900	KMO value	0.824	KMO value	0.764
Total explained variance	53.0%	Total explained variance	66.3%	Total explained variance	57.0%

Public support	Factor loading	Financial barriers	Factor loading
Regional government support	0.728	Direct innovation costs	0.836
Central government support	0.779	Cost of finance	0.932
EU support	0.692	Availability of finance	0.893
KMO value	0.617	KMO value	0.685
Total explained variance	53.9%	Total explained variance	78.8%

Table A14: Tobit estimates of the determinants of innovation intensity at firm level in CIS5 (2004-06)

	(1)	(2)	(3)	(4)
Average employment growth, 2001-2004	1.2104**			
	[0.5724]			
Employment growth, 2001-2004 – 25th-49th percentiles		0.5338		
		[0.3437]		
Employment growth, 2001-2004 – 50th-74th percentiles		0.8918***		
		[0.2205]		
Employment growth, 2001-2004 – 75th-94th percentiles		0.2310		
		[0.2647]		
Employment growth, 2001-2004 – 95th-100th percentiles		1.4160***		
		[0.5044]		
Average turnover growth, 2001-2004			0.0439	
			[0.3026]	
Turnover growth, 2001-2004 – 25th-49th percentiles				-0.1495
				[0.2746]
Turnover growth, 2001-2004 – 50th-74th percentiles				-0.0505
				[0.2967]
Turnover growth, 2001-2004 – 75th-94th percentiles				0.2303
				[0.2958]
Turnover growth, 2001-2004 – 95th-100th percentiles				-0.2845
				[0.3859]
Observations	5241	5241	5220	5220
Log likelihood	-13133	-13128	-13070	-13069
Pseudo R sqd	0.012	0.0123	0.0119	0.012

Notes: Bootstrapped standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1

Tobit estimates. The dependent variable is the measure of innovation intensity for 2004-06 (CIS5), defined as described in the notes to Table A11. All equations include firm age, employment size, sector and regional dummies and control variables for group membership, geographical market focus and graduate share of employment.

Table A15: Tobit estimates of external knowledge sourcing scores at firm level in CIS4 (2002-04)

	(1)	(2)	(3)	(4)
Average employment growth, 1999-2002	0.4286			
	[0.4349]			
Employment growth, 1999-2002 – 25th-49th percentiles		0.3579		
		[0.2859]		
Employment growth, 1999-2002 – 50th-74th percentiles		0.8593***		
		[0.2409]		
Employment growth, 1999-2002 – 75th-94th percentiles		0.8769***		
		[0.2453]		
Employment growth, 1999-2002 – 95th-100th percentiles		0.5056		
		[0.3297]		
Average turnover growth, 1999-2002			0.6458**	
			[0.2959]	
Turnover growth, 1999-2002 – 25th-49th percentiles				0.3442
				[0.2300]
Turnover growth, 1999-2002 – 50th-74th percentiles				0.7498***
				[0.2649]
Turnover growth, 1999-2002 – 75th-94th percentiles				0.7792***
				[0.2623]
Turnover growth, 1999-2002 – 95th-100th percentiles				0.6930*
				[0.3820]
Observations	10239	10239	10181	10181
Log likelihood	-31674	-31666	-31486	-31482
Pseudo R sqd	0.0207	0.0209	0.0206	0.0208

Notes: Bootstrapped standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1

The dependent variable is an aggregate external information score derived by summing firms' responses to the CIS on the importance of ten potential information sources, each of which is measured on a 0-3 point scale. All equations include employment size, sector and regional dummies. The reference category for firm age is 2-3 years.

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