

4 – New job creation in the UK: which regions will benefit most from the digital revolution?¹

Key points

- The digital revolution has both created and displaced many types of jobs since 1990. In this article, we focus on the new types of jobs created and assess how this has affected total national and regional employment in the UK since 2004. We highlight the key role of London as an incubator for the digital revolution, but also find some signs of catch up in other regions such as the North, Wales and Northern Ireland.
- We examined new job titles that emerged only after 1990 and found that 5.5% of the UK workforce had shifted into these new types of jobs by 2004. But by 2014 the proportion of workers in these new types of jobs had risen only slightly further to around 6%. Eight of the ten occupational categories in which these new job titles arose were related to computers, so this can largely be linked to the digital revolution.
- London has been the greatest motor of the creation of new types of jobs, outperforming the rest of the UK economy: for example, the proportion of total employment in new types of jobs in Central London was 8.6% in 2004, increasing to 9.8% in 2014.
- But we also find some evidence of regional convergence over the past decade. While London continues to lead in terms of the proportion of workers in new types of jobs, regions like Yorkshire, Tyne & Wear, Wales and Northern Ireland with low initial employment shares in new types of jobs in 2004 experienced higher growth rates of these new job types on average between 2004 and 2014.
- Our findings suggest that new types of jobs (linked mainly but not only to the digital revolution) initially appeared in areas like London where entrepreneurs, innovative firms and skilled workers were concentrated and then gradually diffused to other regions. These other regions will continue to catch up unless London's pace of new job creation is higher than the rate of regional diffusion.
- Projecting patterns in total regional employment growth over the next decade, we find that total employment in Central London could grow by around 25% between 2014 and 2024, but this would be down from around 35% total employment growth over the past ten years.
- By contrast, employment growth rates over the next decade in regions like West Yorkshire, Greater Manchester, the West Midlands, Scotland and the rest of the South East are projected to see some acceleration in job creation relative to the past decade as the digital revolution continues to diffuse.
- Future UK and London governments need to make sure that the city's growth potential is not constrained by the supply of housing and transport infrastructure. But it also needs to support the diffusion of digital job creation to other UK regions by boosting transport links outside London, supporting leading regional universities, and building skills, which we find to be a key driver of economic success for cities.

4.1 Introduction

Over the last hundred years, technological change² has fundamentally transformed labour markets in most industrial nations. In recent decades, the arrival of new digital technologies has displaced a wide range of routine work, including the jobs of bookkeepers, assembly workers, cashiers and telephone operators.³ At the same time, the appearance of more than 1,500 new occupational titles in official classifications since the computer revolution of the 1980s, suggests that a host of new occupations have emerged.⁴ In the United States, around 4.4% of total employment in 2000 was in types of jobs that did not exist in 1990.⁵

Many new occupations are directly related to the arrival of the personal computer (PC) in the 1980s and the subsequent internet (or 'digital') revolution that has rolled out since the early 1990s. Table 4.1 shows the detailed occupational categories with the highest proportions of new types of jobs between 1990 and 2010. 8 of the 10 occupational categories with the highest fractions of new job titles since 1990 were directly related to computer technologies.⁶ This also explains the high proportions of new job types in professional and technical occupations as shown in Figure 4.1.

1 This article was written by Dr Carl Benedikt Frey, Oxford Martin Programme on Technology and Employment, University of Oxford, and John Hawksworth, chief economist at PwC.

2 For more insights on this general phenomenon, please see PwC's megatrends and World in Beta websites at: <http://www.pwc.co.uk/issues/megatrends/index.jhtml> and <http://www.worldinbeta.com/>

3 Autor and Dorn (2013).

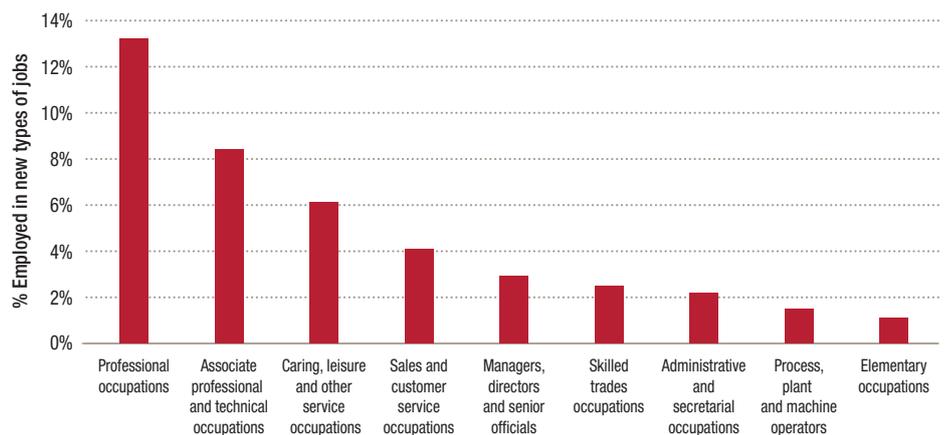
As computer technologies disrupt the world of work, making some occupations redundant in the process⁷, the key challenge for governments is to help support the shift of workers into new and emerging employment opportunities. A concern is therefore that the companies leading the digital age have created relatively few new jobs compared to the giants of the early computer revolution: while IBM and Dell still employed around 430,000 and around 110,000 workers respectively in 2013, Facebook’s global headcount reached only 7,185 in that year. We turn next to examining the broader implications of this trend for the UK economy.

Table 4.1: Top 10 occupational categories in 2010 with the highest proportions of new job types that did not exist in 1990

Category	New job types (%)
Computer Software Engineers	80.0
Database Administrators	78.6
Network and Computer Systems Administrators	78.1
Computer and Information Systems Managers	76.5
Computer Support Specialists	71.4
Computer Programmers	59.1
Miscellaneous Personal Appearance Workers	50.0
Logisticians	50.0
Computer Hardware Engineers	50.0
Physical Therapists	50.0

Source: Lin (2011); calculations by Carl Frey using methodology described in the technical appendix. These proportions are derived from US data, but should be broadly similar for the UK in the same occupational categories, which is what we assume in the rest of this analysis.

Figure 4.1: Proportion of new job types by broad occupational category in 2010



Source: Calculations by Carl Frey based on methodology in technical appendix

⁴ Berger and Frey (2014a); Lin (2011).

⁵ Lin (2011).

⁶ Interestingly the other occupations with a high proportion of new types of work were in the personal care area (i.e. physical therapists and beauticians), which is one where computers cannot easily replace humans. This general area also sees relatively high levels of new work at the broad occupational level, as shown in Figure 4.1.

⁷ This will also change the nature of work for others, as discussed, for example, in PwC’s report on the Future of Work (2014b):

<http://www.pwc.com/gx/en/managing-tomorrows-people/future-of-work/journey-to-2022.jhtml>

4.2 New job creation in the UK economy

The UK labour market has witnessed a structural transformation since the early 1990s. In 2004, 5.5% of the UK workforce was already employed in occupations that did not exist in 1990 (see Technical Appendix A for details of the methodology and data used to produce this and other estimates in this section of the article). By 2014 the share of UK workers employed in these new types of occupations had grown further, but only relatively slowly, to around 6% (Figure 4.2).

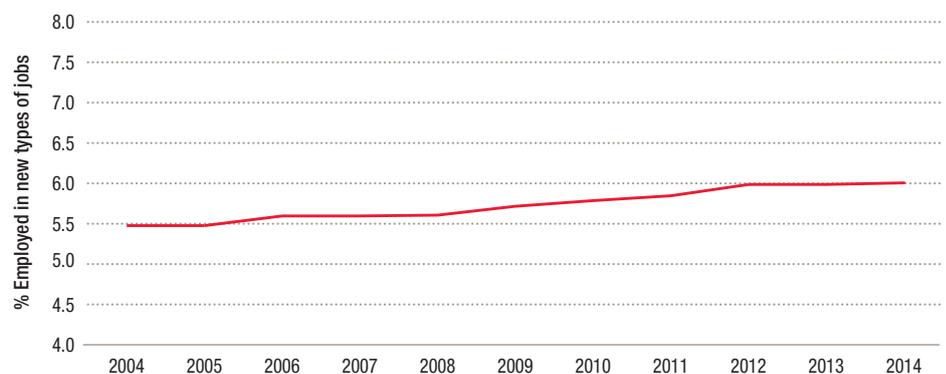
While we are unable to make cross-country comparisons due to lack of fully consistent data, our findings for the UK seem to largely reflect previous findings for the US. According to an earlier estimate around 4.4% of the US workforce in 2000 was employed in occupations that did not exist in 1990.⁸ This implies a broadly similar rate of increase over ten years in the US to the rise from zero⁹ to 5.5% over the 14 years to 2004 in the UK.

Furthermore, just as more recent rates of new job type creation in the UK have been relatively modest as shown in Figure 4.2, the US economy has witnessed a decline in some indicators of technological dynamism. In particular, the falling pace of job reallocation—the process by which workers move from contracting companies to expanding ones—has induced concern about the future of jobs.¹⁰ The slowdown in the rate of creation of new types of jobs in the UK over the last decade thus seems to reflect a broader tendency of digital technologies to create fewer jobs than the technologies of earlier computer revolutions.

It is important to note that this cannot be explained just as a cyclical phenomenon given that the period from 2004 to 2014 that is shown in Figure 4.2 probably covers close to a full economic cycle, with a relative strong period in 2004-7, then a deep recession in 2008-9 and a gradual recovery thereafter, picking up pace in 2013-14. Instead, there seem to be a more structural factor at work in the digital revolution directly creating a smaller number of jobs than earlier technological revolutions.

However, there may still be large indirect job creation effects as the extra wealth generated by the digital revolution filters down through the economy and the new technology increases the productivity of many existing occupations.

Figure 4.2: Proportion of employment in new types of jobs in the UK economy, 2004-2014



Source: ONS Labour Force Survey; calculations by Carl Frey using methodology described in the technical appendix

8 Lin (2011).

9 By definition, the proportion of workers in types of jobs that did not exist in 1990 would be zero in that year.

10 Decker et al. (2014).

The regional perspective

Nearly all UK regions have increased their employment in new types of jobs over the past decade. Nevertheless, London stands out relative to other regions, mainly due to its relatively high initial share of new work. In 2004, the share of employment in new work varied between 4.1% in Rest of Northern Region to 8.2% in Central London (Figure 4.3). Outside Central London, the creation of new types of jobs is somewhat more concentrated in surrounding areas, including Inner and Outer London as well as the South East, although other regional rates do not vary that much as Figure 4.3 shows.

The patterns observed in 2004 have largely remained in place since then. Central London has seen a further rise in the share of workers in new types of jobs over the past decade, reaching 9.8% in 2014. Inner London and the South East also experienced increases in new types of jobs, but we find that Outer London is falling slightly behind. By 2014, all regions had seen their share of new types of jobs increase, with the exception of Rest of Yorkshire & Humberside, which witnessed a small decline from 4.8% to 4.6%. In contrast, South Yorkshire substantially increased the share of its workers in new job types between 2004 and 2014, growing from 4.5% to 5.5%, suggesting some possible displacement of new jobs across the region.

Figure 4.3: Proportion of workers in new types of jobs in UK regions, 2004 and 2014



Source: ONS Labour Force Survey; calculations by Carl Frey using methodology described in technical appendix

4.3 Evidence of regional convergence, 2004-2014

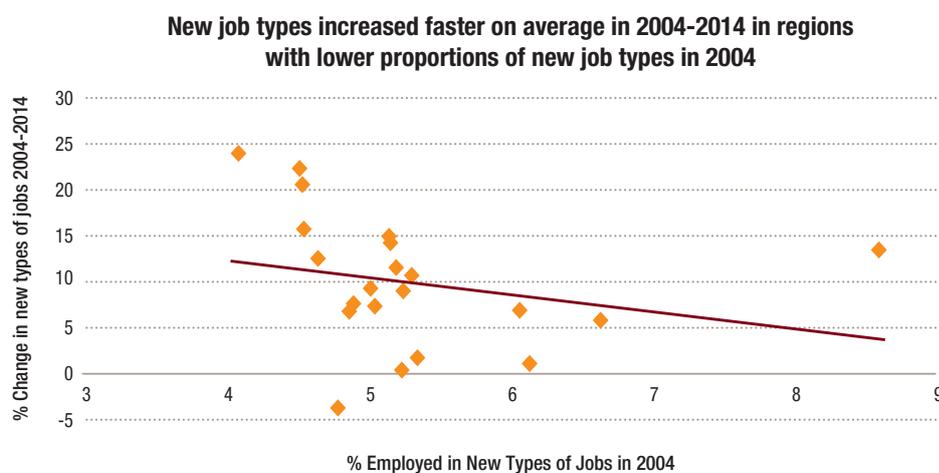
Despite the fact that Central London and surrounding regions still had higher proportions of workers in new types of jobs in 2014, the share of new jobs across UK regions converged over the past decade. As shown in Figure 4.4, regions with the lowest employment shares in new types of jobs in 2004 saw these shares increase the fastest over the next ten years, especially if one excludes Central London. The Rest of Northern region, with the lowest initial share of new work, experienced the fastest growth in new work over the past decade: the region increased its employment in new types of jobs by around 24%, closely followed by South Yorkshire (23%) and Tyne & Wear (21%).

These findings resonate with previous research showing that since the advent of the computer revolution new types of work have emerged more strongly in the most skilled cities.¹¹ Gradually, however, as the new work becomes “old” work, it diffuses to other cities and regions. Thus, new job creation in the digital area tends to be concentrated in cities like London, Oxford and Cambridge with a large pool of skilled workers, where entrepreneurs, innovators and early adopters experiment with new technologies.¹² Only after production processes have become more standardized does it tend to be widely adopted elsewhere.¹³

In other words, convergence occurs if the diffusion of “old” work takes place at a faster pace than new job creation. In line with the general trend of a slowdown in the creation of new work between 2004 and 2014, our findings suggest that the diffusion process took place at a relatively fast rate. Accordingly, regional convergence is not necessarily good news. As London remains the early adopter of the UK economy, the apparent slowdown in new digital job creation in London may imply a subsequent slowdown across other regions over the next decade.

These findings are interesting and surprising, given that the perception would be that in other high value added services e.g. financial and business services, the agglomeration economies pushing towards existing clusters would still be predominant. This seems, however, to be less true in digital sectors where economies of scale (and indeed physical location) may be less important and so activity can diffuse more widely across the country.

Figure 4.4: Regional convergence across UK, 2004-14



Source: ONS Labour Force Survey; calculations by Carl Frey using methodology in technical appendix

11 Berger and Frey (2014a).

12 Lin (2011); Berry and Glaeser (2005); Glaeser et al. (2012).

13 Duranton and Puga (2001).

4.4 Projected employment growth across UK regions, 2014-2024

Using data on employment growth by region between 2004 and 2014 from the ONS and the share of new types of jobs in each region in 2004, we estimate a simple ordinary least squares (OLS) regression where we examine the statistical relationship between new work creation and employment growth. Details are provided in Technical Appendix 4B, but we focus here on the key conclusions.

The main findings are that the share of new types of jobs in 2004 is a statistically significant predictor of subsequent total employment growth in a region. In fact, we find that differences in the share of new types of jobs can

explain about 50 percent of the variation in employment growth across UK regions over the last decade. Using this estimated relationship, we can also make illustrative projections of employment growth over the next 10 years, based on each region's share of workers in new types of jobs in 2014.¹⁴

According to our illustrative projections (Figure 4.5), Central London seems likely to experience the fastest employment growth (of around 25%) over the next decade, though this would be markedly less than the 35% total growth rate over the past decade. This is followed by Inner London (around 12.5% but also decreasing relative to the past decade), the Rest of the South East (10% and rising) and Outer London (9% and rising). Our estimates also show, however, that some regions

outside London and the South East show accelerating employment growth over the next decade as compared to the previous decade. These include West Yorkshire (perhaps reflecting the influence of Leeds), Greater Manchester, the West Midlands and Merseyside. Northern Ireland, by contrast, sees some 'reversion to the mean' in its projected employment growth.

Our projections are subject to many uncertainties, but they generally support the view that skilled cities like London, Oxford, Cambridge, Leeds, Manchester and Edinburgh will continue to be key motors of jobs growth, both in digital areas and more generally across the economy. This is consistent with the findings of other previous PwC research.¹⁵

Figure 4.5: Projected employment growth across UK regions, 2014-24, as compared to past decade



Source: ONS Labour Force Survey; calculations by Carl Frey

14 These projections are calibrated based on the top-down assumption that total UK employment will grow at an annual rate of 0.7% over the next decade, based on trends in working age population growth and employment rates. The projection does not take explicit account of the potentially expanding scope of job automation (Frey and Osborne, 2013) or other factors, which is why we describe them as only being illustrative.

15 PwC Good Growth for Cities (2014).

4.5 Fostering new job creation: Implications for policy

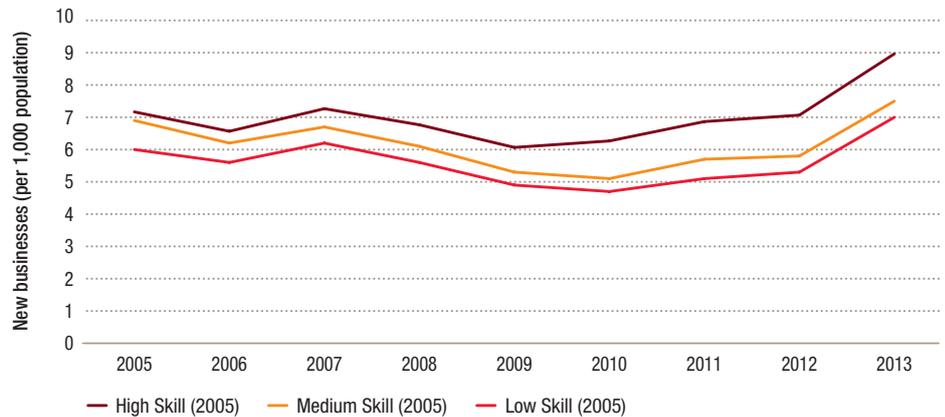
In terms of new job creation, London has been the largest single regional motor of the UK economy. While other regions are catching-up, as new work diffuses from London across the UK, our findings imply that new work initially clusters to take advantage of knowledge flows across companies and industries. Our findings speak to a growing body of research showing that new occupations and industries emerge in skilled cities.¹⁶ Larger pools of skilled workers attract start-ups and knowledgeable workers are more adaptable to technological change.

This is also confirmed by new PwC research for this report. As shown in Figure 4.6, high skill cities (as measured by the proportion of those aged 25-64 with education levels of NVQ3 or above) in the UK have systematically outperformed other cities in terms of new business creation since 2005.

Furthermore, UK cities with a high fraction of skilled workers in 2005 experienced much lower levels of unemployment increase during the recession and subsequently up to 2013 (Figure 4.7) according to other recent PwC research for this report. Skilled workers seem to be more able to shift into new types of work, though the educational measure used here may not pick up all of this effect, which could be more specifically related to levels of cognitive skills that are particularly important in digital sectors and other professional and technical occupations.

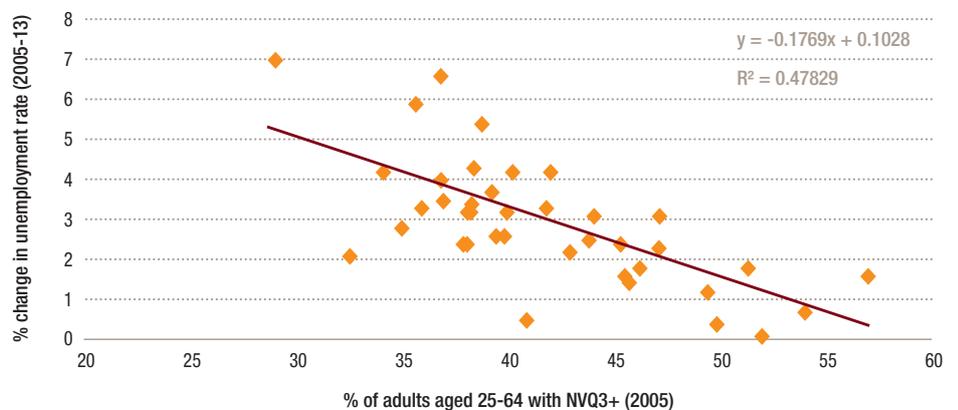
Taken together, these findings have important implications for new job creation in the UK. As the largest

Figure 4.6: New business creation according to average education levels in UK cities



Source: PwC analysis of ONS data

Figure 4.7: Unemployment changes by city in 2005-13 relative to initial education levels



Source: PwC analysis of ONS data

proportion of new work is initially created in London, and then diffuses throughout the UK economy, policies to support further growth of London are important. At the same time, there is a need to support further other clusters of skilled occupations and industries

elsewhere in the UK, as many LEPs and the City region devolution programme have sought to do in recent years.¹⁷

Instead the role of policy should be to create and maintain the soft and hard infrastructure that facilitates job

¹⁶ Berger and Frey (2014a; 2014b); Duranton and Puga (2001); Lin (2011).

¹⁷ The gains from creating strong industry clusters outside London are discussed further in McKinsey and Centre for Cities (July 2014) *Industrial Revolutions* and also by Sentance (2014).

creation and regional diffusion. Universities can play a vital role in fostering new job creation. Since Fredrick Terman, the dean of Stanford's Engineering School, encouraged two of his students, William Hewlett and David Packard, to found Hewlett-Packard (HP) in 1938, Stanford alumni alone have created 39,900 companies and about 5.4 million jobs.¹⁸ London's leading position in new work is similarly likely to be associated with its universities. According to QS World University Ranking, 4 of the top 10 universities for computer science and information systems in the UK are located in London. The other top 10 ranked universities outside London include the University of Southampton, Cambridge, Oxford, Birmingham, Manchester and Edinburgh. The latter three are outside the South East and could provide useful hubs for future development of digital hubs in the Midlands, the North West and Scotland.¹⁹

As the dissemination of knowledge and skills provides the most important force of convergence, investing in education is therefore crucial for regions to catch up and remain resilient to technological change.²⁰ Policy focused on promoting further investment in education and collaboration between universities and digital businesses across regions would help to make regions more adaptable and receptive to the arrival of new technologies.

Second, there is a need to provide the hard infrastructure to facilitate the diffusion of new work across regions, while making sure that the growth of London is not constrained by the supply of housing and transport. According to our estimates, employment in Central London could grow by a further 25% over the next decade. Crucially, as skilled cities are becoming

more attractive, rising house prices makes them less affordable places to live²¹. This has implications particularly for low-income workers, who can often not afford to move or travel to places where new employment opportunities are being created.²² Furthermore, housing constraints in London can also provide constraints on growth for the UK economy as a whole. For example, a recent study estimates output in the United States was 13 percent below its potential over recent decades as a result of insufficient housing in skilled cities.²³

To avoid such an outcome, investment in improving the connectivity between places will be essential to make sure that new job creation continues to thrive in London, while diffusing faster to other regions. In particular, there should be increased attention to building affordable housing outside the city, with faster, less congested commuting links to central London. Doing so will be vital to avoid holding back the growth prospects of the city. In addition, other key cities such as Manchester, Leeds and Liverpool also need improved transport links to support their growth and deliver the government's vision of a new 'Northern powerhouse'.

4.6 Summary and conclusions

Between 2004 and 2014, UK regions showed some convergence in terms of the pace with which they were creating new types of jobs that did not exist in 1990, notably but not only in the digital area. This convergence, however, reflects a general slowdown in the creation of new types of jobs over the past decade: a tendency that is not particular to the UK economy. In the United States, for example, rates of technology-related new job creation have declined over the past

decade, speaking to a growing concern that the digital age of the 21st century has created relatively few employment opportunities compared to earlier waves of new technology, including the personal computer revolution of the 1980s.

Central London continues to lead other UK regions with a share of almost 10% of its workforce in 2014 in new types of jobs that did not exist back in 1990, relative to a UK average rate of around 6%. Our findings support the general trend of new types of jobs clustering in skilled cities, including not just London but also places like Oxford, Cambridge, Manchester and Edinburgh.

Our illustrative model projections suggest that total employment in Central London could grow by around a quarter over the next decade, although this would be slower than the 35% growth rate seen over the past decade. A key task for future UK and London governments will be to make sure that the city's growth potential is not constrained by lagging housing and transport infrastructure.

At same time, our projections do suggest an acceleration of employment growth in some regions outside London, including Greater Manchester, West Yorkshire, the West Midlands and Merseyside. This is encouraging, and reflects our expectation that there will be a continued diffusion of the digital revolution (and other technological advances) across the UK over the next decade. However, this does require increased investment in transport connectivity in these regions, as well as the development of regional clusters around high quality regional universities. Only in this way will the full potential benefits of digital be felt across the country.

18 Easley and Miller (2012).

19 As discussed also in Sentance (2014)

20 Piketty (2014).

21 See, for example, the discussion in PwC's last Good Growth for Cities report (2014a).

22 Anderson et al. (2014).

23 Moretti and Chang-Tai Hsieh (2014).

Technical Appendix A

Data and Methodology

To identify the appearance of new types of jobs, we used revisions of the Alphabetical Index of Occupations, maintained by the US Census Bureau. Each index (1990, 2000, and 2010) reports approximately 30,000 occupational titles that are used to identify US census respondents' occupation. Importantly, these indexes are periodically updated to reflect the appearance of new types of jobs in the labour market. New job titles reflect, for example, the appearance of new technologies (e.g. solar PV installer) or shifts in consumer demand (e.g. sommelier), capturing how the labour market is restructured over time.

We created an algorithm that isolates job titles in the 2010 edition for which there is no match in the 2000 edition. Manually, we then compared each new job title to exclude titles that are simply relabelled, reclassified, separated into multiple categories (e.g. bank cashiers with and without an associate degree) or residual titles (e.g. life scientists\ not specified). We mapped each title that appeared for the first time between 2000 and 2010 to their corresponding US detailed occupational category using crosswalks from the US Census Bureau. To this we add the number of new job titles that appeared between 1990 and 2000, taken from earlier research by Jeffrey Lin (Philadelphia Federal Reserve, 2011).

For each occupational category, we calculated the number of new job titles that appeared between 1990 and 2010. Over this period, 948 new occupational titles appeared (relative to a total number of 30,800 titles in 2010). We then normalised the number of new titles by the number of total titles per occupation in 2010, so that we obtain the fraction of new titles for 469 US detailed occupations (that is, the probability that a worker is employed in new types of jobs). For example, in detailed occupation 104 (Computer Support Specialists), 71% of the occupational titles in 2010 appeared for the first time over the period between 1990 and 2010²⁴.

To map US occupations to their UK counterparts, we began by mapping US occupations to their corresponding ISCO88 codes, again relying on crosswalks from the US Census Bureau. We then used crosswalks provided by the ONS that maps UK SOC 2000 codes to ISCO88 codes. In cases where UK SOC 2000 occupations consist of several ISCO88 codes, we took a simple arithmetic average. From 2011 and onwards, the U.K. occupational data is reported using UK 2010 SOC codes. We therefore used crosswalks to map ISCO88 codes to ISCO08 codes from the ILO that in turn are mapped to UK 2010 SOC occupations using a crosswalk from the ONS that matches ISCO08 codes to their UK 2010 SOC counterparts.

Using data on employed persons aged above 16 by region of work from the ONS, we merged the fraction of new types of jobs per UK occupation to each region, for all occupations for which the ONS provide employment figures. Note that because the ONS reports employment figures using SOC 2000 codes for the period 2004-2010 and SOC 2010 codes for 2011-2014, levels of new job types per region are not strictly comparable between these periods, but we have spliced the data together in a way that minimises inconsistencies over time (as can be seen from the relatively smooth time series between 2010 and 2011 in Figure 4.2).

24 When considering data for 2014 in the UK, we are therefore ignoring new job titles that appeared after 2010, since there is no detailed data available on these more recent new job types emerging between 2010 and 2014.

Technical Appendix B

Regression Analysis

We estimated a simple ordinary least squares (OLS) regression where total regional employment growth between 2004 and 2014 was the outcome (dependent variable) and the fraction of new types of jobs in 2004 in each region was the explanatory variable (Table 4.2 and Figure 4.8).

We found that the proportion of new types of jobs is a highly statistically significant predictor of subsequent employment growth (p-value=0.00) by region. The R-squared of the regression is 52%, meaning that about half of the variation in total employment growth across UK regions in 2004-14 can be accounted for by differences in the initial level of new types of jobs in the workforce in 2004.

We then fed into this estimated model our data on the proportion of workers in each region in new types of jobs in 2014 and used this to project how total regional employment growth might vary over the coming ten years. However, since these estimates are based on a small sample of regions these results should be interpreted with care. They can only be considered illustrative of potential broad trends rather than being regarded as precise forecasts.

Table 4.2: New Work and Employment Growth in UK Regions, 2014-2024

Outcome: Empl. Growth 2004-2014 (%)	Coef.	Std. Err.	P>t	[95% Conf. Interval]	
New Work 2004 (%)	6.10	1.35	0.00	3.28	8.92
Constant	-25.28	7.20	0.00	-40.36	-10.21
Number of observations				21	
R-squared				0.52	

Source: ONS Labour Force Survey; calculations by Carl Frey

Figure 4.8: Relationship between proportion of workers in new types of jobs in 2004 and subsequent total regional employment growth in 2004-14



Source: ONS Labour Force Survey; analysis by Carl Frey

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