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Labor Markets in the Digital Economy: Modeling Employment from the Bottom-Up

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5.1 Introduction

The effects upon labor markets of changes in the digital economy are poorly understood because analyses at the appropriate levels of jobs within specified sectors has been inadequately studied. Contrasting popular views can be characterized as either neo-Luddite—technology destroys employment or at least meaningful work, or techno-utopian—unemployment will be eliminated by massive demand for a wide variety of high-quality work. Despite a constant flow of expert reports promoting each of these positions, I will show here how a bottom-up accounting of both job destruction and job creation provides a much more accurate assessment of the effects of investment in the digital economy. While the effect differs very significantly from sector to sector and place to place, overall we see very modest but constant growth in most places where investments in the digital economy are robust.

This is important both for the general understanding of the effects of the digital economy and for our ability to be specific about the impacts of investments of certain kinds upon local economies. The problem of making

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sense of employment effects is shrouded by controversy about job creation and job losses. On the one side, we aspire to find opportunities to alleviate unnecessary unemployment and to find good quality jobs for all those who have invested in attaining skills. On the other side, we feel compelled to find ways to drive productivity growth even where firms are unable to increase output proportionately while simultaneously employing more staff.

From either position, it is important to have a clear idea of labor market skills requirements for the sake of education and training policies, if only to make sense of the constant refrain coming from employers and amplified by researchers who perennially claim that the labor market is desperately in need of hundreds of thousands of newly skilled workers. There is a constant refrain of laments about skills shortages that goes back decades.[1] What, exactly, the labor market was missing changed constantly, so the supposed dearth of hardware designers of the past was displaced by frenzied demands that hundreds of thousands of software engineers be trained, followed by confident predictions that the economy's potential for growth is hampered by the lack of sufficient data analysts, etc. These claims are all belied by two clear trends: The number of digital economy workers is only gradually rising, and unemployment among information and communications skilled workers is almost constantly half of overall unemployment in OECD economies. All the while the overall unemployment rate fluctuates very significantly within about 20-year periods.

So, we see a simple contrast between our ambition to solve unemployment problems while we promote productivity growth and "modernization" which at the firm level often means displacing large numbers of lesser skilled workers with either smaller numbers of higher skilled workers or better technologies, or both.

Most of the discussion to date about the effects of the digital economy has been based on one of two different kinds of analysis. There are those, such as Robert Gordon and John van Reenan, who start from the productivity growth trends in the macroeconomy and project broad labor futures, and there are those, such as Eric Brynjolfsson and Andrew McAfee (2011), who start from the affordances of the technology and imagine what work might be. The first of these either concludes that the growth in demand for knowledge workers will be so great as to provide unlimited high-quality employment. Or, as Robert Gordon does, regards the recent boom in productivity to be anomalous in historical trends and forecasts slow growth with no significant employment consequences.[2] Those who focus on technology's affordances similarly split between optimists who believe that the promise of each new technology boom in the digital economy, currently big data analytics and the "internet of things", will soak up unemployment.[3] Or they become pessimists, such as Brynjolfsson, who write about the robotics of the near future, both physical and virtual, that will displace vast swathes of meaningful work.

The work I report on here, based on four studies on labor market effects of information and communication technologies (ICT)[4] takes a very different approach. While my interests are, similarly, on the character of work and the large-scale effects of ICT upon employment trends, I start from two solid pillars to model trends. The first is rooted in the existing long-term technology investments and policy commitments, seen in governments, large firms, and social trends. These include the manner in which smartphone industries work, investments in smart energy and the shift currently underway in areas we see such as in the fintech firms and in logistics, retailing, and interconnections. The second concerns the specifics of job creation and displacement; i.e., the ways in which tasks are performed, the people employed to perform them, the cost of engaging such employees, and, crucially, the effects that has on the labor market more generally. I also make use, in a distinctly conservative manner, of employment multipliers. While this remains a somewhat controversial technique, it has been used in studies both in the econometric literature on labor markets (Etro 2009)[5] and in the applied and policy literature (Kapstein 2008).[6]

5.2 Methodology and Hypotheses

The starting point of this analysis is the relationship between investments and the character of specific tasks. The input is the presumed spending, by governments or private sector investors, in known digital economy organizations. From this, we can get a first estimate of job creation and displacement. We must take into account the technologies themselves to capture the real changes that are likely to have effects upon organizational productivity, including details of what components are used, how production speed might be affected, whether production processes including tasks such as producing lines of code are enhanced, etc. This bottom-up approach emphasizes the specificity of what firms are doing, their labor market catchment and other features of their location and takes us beyond NIC categories and associated labor statistics. This is because among the key factors determining the effects of investments are the extent to which intermediate markets are filled by domestic suppliers as opposed to imports, the extent to which national procurement policies might affect local sourcing, and which industrial policies are likely to have effect, especially with regard to incentives offered to specific sectors or for certain categories of investment as has long been the case with R&D spending.

In summary, our analysis takes a bottom-up approach that focuses on industry sector level within national contexts. While we use some survey results to help in estimating trends in ICT staff redeployment[7] and evidence about national procurement and infrastructure development priorities, most of the evidence comes from data about labor market composition in relation to product and services development trends.

Sources include national statistical bodies and industry association data, International Labour Organization and International Telecommunications Union statistics, evidence about the productivity of key choices such as in-house versus cloud-based activities, and descriptions of job types and industry structure. In these ways, we can build a rounded picture of the character of the labor market, the distribution of activity between large versus small and medium firms, the effects of trade on the capacity of the domestic industry to respond, and related features of the employment landscape. The strengths and weaknesses of each of these sources of evidence are specified below, within the context of each of the four main studies reported.

Study topic	Research questions	Sectors	Evidence
UK recovery	What effect will accelerated spending on digital economy projects have on employment?	Broadband upgrading; intelligent transport systems; smart energy networks	Domestic market capabilities; industry structure; multiplier effects; labor market data
Modelling the cloud (1)	How do existing cloud services trends in exemplary sectors affect job losses and gains in Germany, Italy, Britain & the USA?	Aerospace; smartphone services	Sectoral features & trends; domestic conditions for cloud utilization
Modelling the cloud (2)	How might projected trends in cloud services affect the Turkish labor market and what does that indicate about emerging economy contexts?	Automotive manufacturing; smartphone services	Sectoral features & trends; domestic conditions for cloud utilization

Study topic	Research questions	Sectors	Evidence
Digital London	What characterizes and explains London's tech/info labor market since the financial crisis of 2008?	All areas of info/tech employment; special focus on big data & fintech jobs	Job advertisements; geographically linked labor market data

Four employment effects studies

While each of the main studies referred to addresses specific research questions concerning the conditions of labor markets for specific sectors in particular countries, in general, we are able to address four main issues. (1) The first addresses the question that, given existing investment intentions, how can an accelerated timescale boost sustainable employment? (2) The second tests the assumption that domestic capabilities along with sourcing policies make significant differences in labor trends. (3) Next, we test the extent to which different technologies respond differently because of mix of job type. (4) Finally, we account for the distribution of effects between large versus small and medium size firms.[8]

All of these concerns cut across each of the four studies under consideration, which are presented in chronological order. In the final section, we will consider what the syntheses of these findings reveal. The first is a study of UK investment effects in broadband upgrading, intelligent transport systems, and smart energy technologies. The second and third address questions about the employment effects of cloud computing trends in international comparison, taking into account both manufacturing and services sector effects. The fourth uses technology and information sector employment data for London in a study that allows for direct contrasts with that in New York and the San Francisco/Silicon Valley regions.

5.3 UK Investment in Recovery[9]

In order to study the impact of certain kinds of digital economy investments in the UK, we selected three cases that fit the main criteria of being potentially high impact infrastructure developments that had long been identified as public policy priorities. The fact that they had been seen as important areas for development meant that there were few policy or planning restrictions to worry about; these were not "pie-in-the-sky" ambitions but gradual, if significant, extensions of existing transportation, energy, and broadband policies. The three specific cases were in intelligent transportation systems, smart energy technologies, and broadband upgrade. For each of these, we postulated £5 billion of spending spread over around three years.

Our research questions were threefold:

1. Given existing investment intentions, what affect will accelerated timescales have on sustainable employment?
2. To what extent do domestic capabilities and sourcing practices make a significant difference?
3. To what extent do differences among investments in different technologies affect the mix of job types?

The first of these was intended to address whether short-term boosts to employment are more or less likely to be sustainable where digital investments are made as opposed to other, known ephemeral effects of literally "shovel-ready" construction projects.[10] As was pointed out repeatedly during the initial discussions of the so-called "Obama stimulus plan", unemployment can most quickly be ameliorated by providing infrastructure construction jobs where no significant preparation is needed, as would be the case with road resurfacing or bridge repairs.

The second focused on production and trade data and concerned the capacity of domestic producers to fulfill the requirements of the stated scale of expansion.

We were able to calculate the specific domestic employment effects taking into account the time periods of the projects, the existing trade patterns, and the extent to which the intermediate markets for components used in, for example smart energy meters, is well developed. This requires a rather detailed analysis of the content of the technologies and an assessment of the qualities of the related software industries, component manufacturing, and the ability to deploy such products and services quickly.

The third question is addressed in part by considering the multiplier effects of investment in particular kinds of jobs. This takes into account, for example, the differences between construction work, which has high employment multiples because of the knock-on effects for materials and machinery suppliers, and software development, which has rather minimal multiplier effects that take into account only what happens with, for example, office space and supplies and directly related services (such as lunch restaurants).

Since the analysis closely parallels a slightly earlier study of the employment effects in the United States (Atkinson et al. 2009), our findings show interesting contrasts in some specific areas. One is that the domestic capabilities in the UK are surprisingly good, with significant capabilities not only in electricity grid production but also in its ability to produce smart meters. Similarly, for intelligent transport systems, UK small and medium businesses are well placed to take advantage of the considerable investment necessary for infrastructure construction including physical networks installed in roadways as well as the production of electronics for vehicles. The comparison with regard to broadband networks, where much of the technology is likely to be imported from either the United States or China, shows less of a disproportionate effect on small and medium sized enterprises but a significant employment effect overall, especially for the larger firms that dominate the telecommunications sector.

The overall effects, as seen in Table 5.1, are revealed to be even more distinct when comparing sectors, as Tables 5.2 and 5.3 show. Since the structures of the industries in terms of the split between large and smaller firms differs, and since the investments imply differing levels of investment in jobs that are associated with high versus low employment multipliers, the contrast is important. We will return to this later when we consider how policy priorities, for the types as well as locations of jobs created, might be made.

Table 5.1 Estimates of UK jobs created or retained by investment in network infrastructures for 1 year

ICT investment	Investment	Total jobs	Small business jobs
Broadband networks	£5 billion	280,500	94,000
ITS	£5 billion	188,500	120,000
Smart power grid	£5 billion	231,000	146,000
Total	£15 billion	700,000	360,000

Table 5.2 UK jobs created or retained for 1 year by a £5 billion broadband investment

Job type	Total jobs	Small business jobs
Direct	76,500	22,500
Indirect and induced	134,500	37,000
Network effect	69,500	34,500
Total jobs	280,500	94,000

Table 5.3 UK jobs created or retained for 1 year by a £5 billion its investment

Job type	Total jobs	Small business jobs
Direct	62,500	44,000
Indirect and induced	79,000	53,000
Network effect	47,000	23,000
Total jobs	188,500	120,000

This study demonstrated the differential effects of spending on different digital economy sectors and the differences one might expect among direct and indirect job creation. It is also clear that while some jobs are quickly created because of the direct effect of employment practices, others lag until, for example, materials purchases are placed. Construction jobs, which account for a considerable proportion of any infrastructure upgrading project, occur early in planning and fade quickly, while many indirectly stimulated jobs appear later and some are sustained.

5.4 Employment Effects of Cloud Services

The second and third studies were conducted using a very similar methodology but focusing not on the broad effects of single, large investments but rather on one set of digital economy services. To understand what impact the move to cloud computing might have, one needs again to consider the relationship between investment trends as well as the specifics of job characteristics for those engaged in various aspects of cloud services work. This includes the work of those developing, marketing and implementing new software for such services, but also crucially the production and maintenance of data centers. In addition, the new skills needed by the users of such services are going to require hiring as the relevant tasks shift from the in-house provision of data analysis to the utilization of outputs provided by cloud services providers. The major consideration in this analysis, however, is that we can also closely estimate the unemployment effects of cloud services as users divest themselves of hardware and staff formerly devoted to providing in-house services. We were strongly influenced in estimating the number of people likely to be made unemployed by this shift by the results of an interview-based survey of chief information officers and other executives of large enterprises in many countries (referred to in footnote 8, above). The majority of respondents claimed that they would take advantage of most of the productivity gains associated with cloud services not by letting their skilled ICT employees go, but rather by redeploying them. While we estimate that there will be some unemployment generated, overall if the rate of spending on cloud services continues as per the current trend, the effect is positive, if modest.

Our research questions were again threefold:

1. Given existing investment intentions, what affect will the growth of cloud services have on sustainable employment?
2. To what extent do sectoral distinctions make a significant difference?

3. What effects might we expect from changes in policies such as those that concern transborder data flow and energy pricing?

For the first of these studies, focusing on employment effects in the UK, USA, Germany, and Italy, we chose three sectors, aerospace (exemplifying mature manufacturing), smartphone services (exemplifying cloud-based business), and mobile operators (an element of infrastructure effects). The second focused only on Turkey, which allowed us to delve deeper into policy effects as well as showed some interesting distinctions relevant for emerging market conditions. That study repeated the focus on smartphone services and mobile operators, but substituted automobile manufacturing for aerospace. For both studies, we used industry and company sources for both suppliers of cloud services as well as customers to understand spending and investment trends, and disaggregated the elements of each industry that utilize cloud services.[11]

Our methodology again rested on a mix of analyses of domestic information and communication technology capabilities and trends, education as it affects both management and the technical workforce, and energy policy. Once again we used our own large-scale interview evidence of large enterprise chief information officers to gauge employers' intentions with regard to the redeployment versus reduction of staffing (Table 5.4, Fig. 5.1).

We repeated this form of analysis for each of the specific configurations of technology under analysis. Taking into account the cost breakdown of data centers, we were able to estimate the cloud jobs of different components for each of the sectors assessed. For the smartphone service sector, this added up to considerable growth during the period 2010–2014, from under 20,000 jobs to almost 55,000 (Table 5.5).

Table 5.4 Jobs

	2010 IT Jobs (direct, indirect, and induced)	2014 IT Jobs (direct, indirect, and induced)	2010 Direct cloud jobs	2014 Direct cloud jobs
US Aerospace	112,000	128,000	1760	2770
US SPS	84,000	148,000	2060	5210
UK Aerospace	11,200	12,100	210	320
UK SPS	5890	13,990	200	870
Ger Aerospace	16,200	17,800	290	420
Ger SPS	8840	16,840	230	800
It Aerospace	3560	3900	60	100
It SPS	6950	12,730	200	700

SPS smartphone services

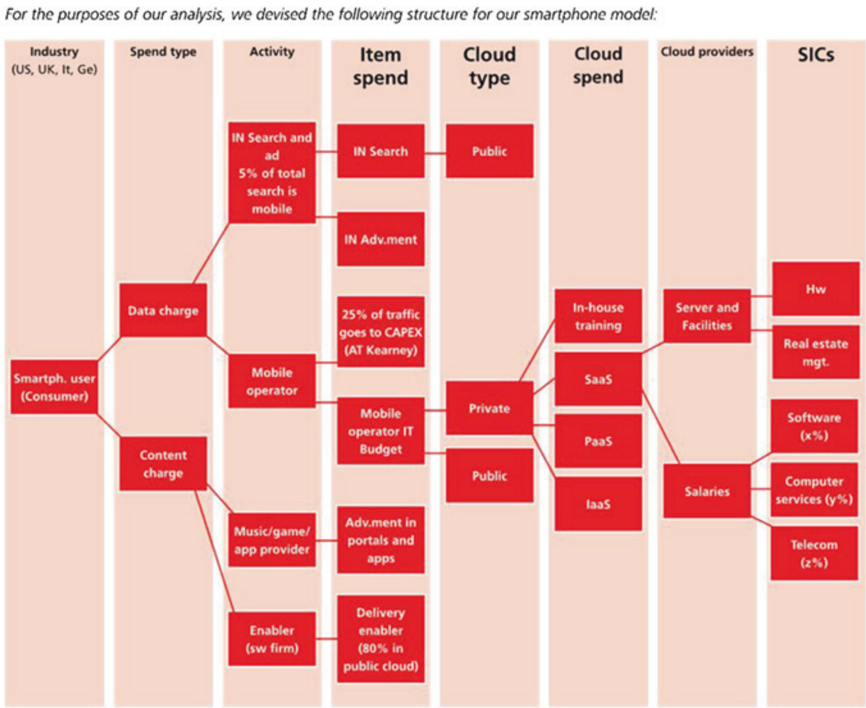

Fig. 5.1 Smartphone model (*Note* the figure is a simplified view whereas in the model all item spends are broken down and analysed into cloud type and eventually SICs)

Table 5.5 Overview of the US smartphone service sector (*Sources* Juniper Research, AT Kearney, HSBC, IDC, Corporate reports (2011))

United States	2010	2014	Cloud Jobs 2014
Smartphone service turn-over	$27.8bn	$46.5bn	54,500
Data revenues (non-messaging)	$27bn	$42.5bn	31,400
Enterprise Applications	$248m	$1.2bn	6770
Consumer Applications (subs)	$23m	$478m	2720
Consumer Apps (advertisement)	$16m	$138m	790
Mobile Search (advertisement)	$503m	$2.25bn	12,780
Related US cloud jobs	19,600	54,500	
SME Cloud spending as share of (total)			
Public cloud	55%	63%	
Private cloud	22%	27%	

A similar growth trend can be seen for the US aerospace sector, but with the important difference in the structure of the industry where growth as a result of small- and medium-sized enterprise spending on cloud services accounting for a much higher proportion of the smartphone services business (because of the large number of apps developers engaged), versus the large firm-dominated character of the aerospace sector (Table 5.6).

The pattern is similar in the UK, with a slightly larger proportion of the industry structure comprised of SMEs, but because of the different weightings placed on segments of the industry, slightly different growth rates, also (Table 5.7).

A much larger difference in the share of spending on cloud services from aerospace SMEs is apparent in the UK industry, indicative of a much higher reliance on a more diversified supply chain there than in the United States (Tables 5.8, 5.9, 5.10).

Table 5.6 Overview of the US aerospace sector

	2010	2014
Aerospace service revenues	$210bn	$241bn
Total induced, indirect, and direct jobs	15,400	24,200
SME Cloud spending as share of (total)		
Public cloud	7%	8%
Private cloud	3%	4%

Table 5.7 UK (*Sources* Juniper Research, AT Kearney, HSBC, IDC, Corporate reports (2011))

UK	2010	2014	Cloud jobs 2014
Smartphone service turn-over	£1.6bn ($2.5bn)	£3.9bn ($6.1bn)	4040
Data revenues (non-messaging)	£1.5bn	£3.3bn	2144
Enterprise Applications	£47m	£235m	787
Consumer Applications (subs)	£2.8m	£73m	246
Consumer Apps (advertisement)	£2.2m	£21m	72
Mobile Search (advertisement)	£26m	£236m	791
Total induced, indirect, and direct jobs	900	4040	
SME Cloud spending as share of (total)			
Public cloud	57%	63%	
Private cloud	27%	33%	

Table 5.8 UK

UK	2010	2014
Aerospace revenues	£22.2bn ($34.7bn)	£24.3bn ($37.8bn)
Total induced, indirect, and direct jobs	880	1340
SME Cloud spending as share of (total)		
Public cloud	30%	33%
Private cloud	16%	18%

Table 5.9 Germany

Panel A			
Data center cost breakdown	Public cloud (%)	Private cloud (%)	Internal data center (%)
Unit costs (per M $)			
Facilities/infrastructure	29.2	21.9	15.8
IT hardware (annualized)	42.1	31.7	22.8
Software	0.0	2.8	2.5
Electricity costs	17.7	20.7	28.6
Network fees	1.8	1.4	1.0
Property taxes	2.7	2.0	1.4
Staff	6.5	19.4	27.9
IT administrators	1.8	15.9	25.3
Facilities site management	1.8	1.4	1.0
Maintenance	0.9	0.7	0.5
Janitorial and landscaping	0.6	0.5	0.3
Security	1.4	1.0	0.7

Panel B			
Germany	2010	2014	Related jobs 2014
GER smartphone service turn-over	€3.1bn ($4.3bn)	€4.8bn ($6.5bn)	4840
Data revenues (non-messaging)	€2.2bn	€4.2bn	2520
Enterprise applications	€57m	€266m	970
Consumer applications (subs)	€3.3m	€83m	300
Consumer apps (advertisement)	€2.6m	€24m	90
Mobile search (advertisement)	€30m	€267m	970
Total induced, indirect, and direct jobs	1273	4840	
SME cloud spending as share of (total)			
Public cloud	54%	62%	
Private cloud	25%	32%	

Panel C		
Germany	2010	2014
Aerospace revenues	€24.7bn ($34bn)	€27.2bn ($37.6bn)
Total induced, indirect, and direct jobs	1490	2100
SME cloud spending as share of (total)		
Public cloud	5%	6%
Private cloud	2%	3%

Panel A: Germany has relatively higher electricity costs and lower staffing costs than the UK and the USA
Panel B: *Sources* Juniper Research, AT Kearney, HSBC, IDC, Corporate reports (2011)

Table 5.10 Italy

Panel A

Data center cost breakdown	Public cloud (%)	Private cloud (%)	Internal data center (%)
Unit costs (per M $)			
Facilities/infrastructure	27.9	20.9	15.0
IT hardware (annualized)	40.3	30.2	21.7
Software	0.0	2.7	2.4
Electricity costs	21.9	26.4	34.8
Network fees	1.8	1.3	0.9
Property taxes	2.5	1.9	1.4
Staff	5.6	16.6	23.8
IT administrators	1.9	16.9	27.0
Facilities site management	2.0	1.5	1.1
Maintenance	1.0	0.7	0.5
Janitorial and landscaping	0.7	0.5	0.4
Security	1.5	1.1	0.8

Panel B

Italy	2010	2014	Related Jobs 2014
GER smartphone service turn-over	€2.1bn ($2.9bn)	€3.9bn ($5.4bn)	3450
Data revenues (non-messaging)	€2bn	€3.37bn	1790
Enterprise applications	€40m	€199m	600
Consumer applications (subs)	€2.4m	€62m	190
Consumer apps (advertisement)	€1.9m	€18m	60
Mobile search (advertisement)	€31m	€277m	820
Total induced, indirect, and direct jobs	937	3450	
SME cloud spending as share of (total)			
Public cloud	54%	63%	
Private cloud	25%	33%	

Panel C

Italy	2010	2014
Aerospace revenues	€8bn ($11bn)	€8.8bn ($12.2bn)
Total induced, indirect, and direct jobs	280	380
SME cloud spending as share of (total)		
Public cloud	30%	32%
Private cloud	16%	18%

Panel A: Italian firms have the highest costs for electricity and the lowest overall cost for staff in the study

Panel B: Modeling—Smartphone services. *Sources* Juniper Research, AT Kearney, HSBC, IDC, Corporate reports (2011)

Panel C: Modeling—Aerospace. The profile of the Italian aerospace industry is similar to the UK with a strong impact from SMEs, but the sector is relatively smaller compared to the overall economy

5.5 Findings of Cloud Studies

The analysis of these cloud studies demonstrates the high degree of variability among countries based on the following three key factors. One is the fact that the choice of location of cloud services is strongly affected by energy prices and the propensity to use offshore facilities has both direct and indirect employment effects. Just as with the stimulus studies where the capacity of the domestic economy to meet forecast demand without great reliance on imports affects employment rates, the siting of data centers especially makes a difference on short-term employment for associated construction, equipping, and enhancing infrastructure.

A second finding is the very large discrepancy between sectors. This was anticipated and affected our choice of the mix of mature manufacturing, new services and infrastructure sectors, but even so the extent is such that it makes it all but senseless to generalize about the whole of an economy across many sectors. The factors that we took into consideration about growth rates based on analyses (some informed by surveys) of replacement cycles of service contracts as well as goods, and of redeployment as opposed to decrease in staffing, have direct consequences that differ by sector for employment trends.

Finally, we see that the direct positive employment effects are not dramatic except for those businesses that were founded on or later became dependent on cloud services. While all sectors pushed short-term employment through pressure to construct data centers, the longer term effects are easy to exaggerate. While we can show that they are in every case studied positive, and so contradict pessimistic speculations about the negative employment effects of new productivity-enhancing technologies, the scale is modest.

There is much literature already debunking the exaggerated claims that there is extensive pent-up demand for skilled labor,[12] nevertheless there remains much policy pressure to prioritize STEM education.[13] Especially considering the propensity to redeploy skilled staff, and a modest trend toward accepting that some more in-house training is worth spending on, there is some danger of accepting such exaggerations without taking into account the real capacity of these sectors to absorb available labor.

5.6 Digital London

The fourth study on employment effects started with a geographical question about the difference between London's growing rate of employment in technology and information jobs and trends in New York City and the San

Francisco/Silicon Valley regions. In contrast to the long-standing presence of a large and dynamic labor force in Northern California, London has grown dramatically only in recent years. In particular, growth in technology and information jobs constituted the major source of employment recovery following the financial crisis of 2008 and it changed the character of central London in important ways.

In the preceding studies of New York and San Francisco, my coauthor, Michael Mandel,[14] used a new method of analyzing job advertising data, along with census and industry sources, to locate jobs in two categories of jobs. The first of these we refer to as the "narrow" definition of technology and information jobs and identifies technicians and those doing work directly engaged in new technology applications to the business. The second, "broad", definition takes into account jobs associated with the new businesses that might not be directly technical but include design and marketing, support tasks and other jobs that would not exist but for the presence of the new technology workers.

We also considered the role of municipal and regional policies to take into account effects that might have come from direct subsidies or other market-distorting factors. In repositioning the methodology from the United States we needed to take into account differences in practice, such as local patterns of job advertising (we noted that advertisements tend to be listed considerably longer for the same jobs in the UK than in the United States).

For this study, the key starting point was to determine a workable definition of the tech/info sector and to do so for the UK in a way that would be sufficiently close to the US employment. The narrow definition is limited to one standard industrial category. For the UK, we included the Census Office's information and communications sector (SIC J): Which is constituted of publishing, software publishing (including games); motion picture, video, sound recording, and television program production; radio and television broadcasting; telecommunications (wired and wireless); computer programming and software development; computer consultancy; data processing and hosting; web portals; news agencies and other information service activities.[15]

The analysis of employment using the narrow definition is compared with the definition of the "expanded" info/tech sector. For the UK, this adds standard industrial code "M" (professional, scientific, and technical activities), in comparison with the addition for the US comparisons with NAICS 54 and 55 (professional, scientific, and technical services; management of companies and enterprises) (Table 5.11).

Table 5.11 What's driving London's growth?

	Numbers of jobs, 2013 (thousands)	Numbers of new jobs created, 2009–2013 (thousands)	Shares of total new jobs in London 2009–2013
Tech/info	382	39	8
Expended tech/info	1.088	143	30
Other industries	4.228	330	70

Note Expanded tech info includes tech/info, as noted in appendix
Data Office for National Statistics, South Mountain Economics LLC

When we compare the narrow with the expanded growth, we can see that in the four years following the 2008 financial crisis, fully 30% of all new jobs created in London are accounted for by tech/info (expanded) employment. Given the diversity of the London economy, this is highly disproportionate and reason to claim that the sector was heavily responsible for growth, especially in skilled and highly paid jobs.

However, not only is growth impressive for London, taken together, London, New York City, and San Francisco accounted for 41% of job growth in the combined US–UK tech–info sector 2009–2013. In that sense, London mirrors New York and San Francisco in that the growing tech/info sectors were a lifeline during the economic downturn from 2009. From that year, the tech/info sector grew 11% to 382,000 workers, a rate that was three times that of the previous four years. When taken together with kindred jobs, the "expanded" tech/info sector increased by 15% versus 8% for the rest of the London economy.

These years of growth created London as a major hub for big data with approximately 54,000 specialist workers within 25 miles of London.[16]

On a slightly smaller scale, but constituting the largest concentration in the world, fintech jobs employed approximately 44,000 workers within 25 miles of London, just slightly surpassing New York City, where 43,000 were employed in fintech. The significance of the link with the financial sector is particularly clear when seen in contrast to the San Francisco-Silicon Valley area, where there are 11,000 fintech workers.

The research not only reveals details about the scale and location of employment, it also holds implications, especially through comparative analysis, about why it has grown as it has, and how to keep it. There are, of course, several reasons for London's tech/info boom, and they resemble the reasons for the recent growth spurts in San Francisco and New York City. In part, this is a sort of organic growth with which tech companies share talent, ideas, products, and a labor market of well-educated workers. There are many talented programmers and designers, and many of them have been long employed in the local media firms and large, older tech companies. Most significantly, the customers of these goods and services are local in very long established sectors including publishing, the arts, advertising, education, and the public sector. There are also complementary industries, such as finance, media, and fashion that contribute to the growth of interlinked markets.

The presence of a reasonably well-installed infrastructure was also important for London, where the East End and Silicon Roundabout had appealing office space and good transportation and broadband connections. The local government contributed, as in the case of New York City, not through direct subsidies of great size, but through low-cost catalysts including concerted efforts to build up the image of London as a vibrant hub. There was a conscious effort to create a tech community through the formation of the Mayor's Tech City UK and related promotional and educational activities. These practices catalyzed a virtuous circle: Policy helped create clear guideposts for attracting start-ups, which generated more excitement, energy, and growth. This form of boosterism from municipal government was common to both London and New York, where Mayor Michael Bloomberg set a style similar to that adapted by Mayor Boris Johnson to put tech entrepreneurs at ease (Figs. 5.2, 5.3).

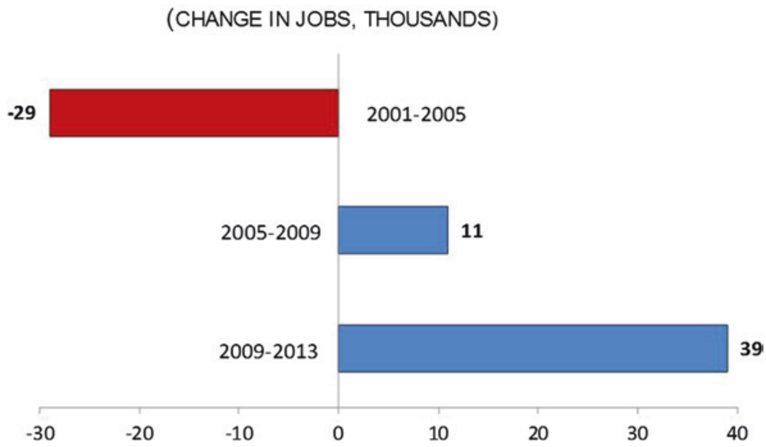

Fig. 5.2 London: Accelerating tech/info growth

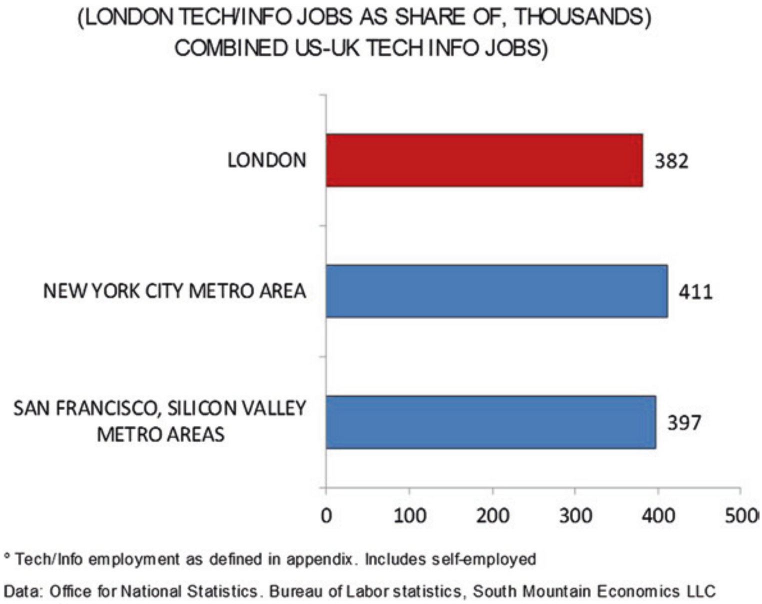

Fig. 5.3 Global digital city: London gains ground

5.7 Synthesis

At the beginning, I raised four questions that these studies shed light on. (1) Given known investment intentions, how can an accelerated timescale boost sustainable employment? (2) To what extent do domestic capabilities along with sourcing policies make significant differences in labor trends? (3) To what extent do different technologies respond differently because of mix of job type. (4) Finally, we account for the distribution of effects between large versus small and medium size firms.

All four of these studies give evidence of employment gains from the digital economy, and not only in jobs where digital skills are paramount. The knock-on effects, as assessed through multipliers, show how unskilled jobs as well as jobs in associated, non-digital economy positions are affected. Since we have taken into account both job losses and job gains, we can have a fairly good sense that productivity gains are not going to reduce total employment. We can also see that despite the promise of cloud services to reduce in-house employment in data management, so long as the domestic economy has some capability to contribute to the provision of cloud services, total employment will not be reduced. The gains for cloud services, however, are very small and contingent on the domestic economic climate for the key inputs into running data centers and associated services: low energy costs and capable manpower.

The study of tech/info employment in London sheds light on two different trends. The first is that factors accelerating the growth of the digital economy are highly concentrated geographically and rest on the interrelationships among well-entrenched sectors (government, education, health care, media, retail, entertainment, and especially financial services) and the particular technological tools and trends currently driving growth (e.g., big data and fintech). The study also shows the significance of local factors such as municipal policies related to infrastructure and boosterism and other forms of "nudge" inducements.

These studies are significant for our understanding of the digital economy because they show how the focus on the character of the technology can make a difference to our analysis of the labor market trends. Not only do different areas of technology require different skills, they are differently entrenched into the broader economy in their own ways. Technologies in mature manufacturing industries, such as aerospace and automobile manufacturing, change more slowly and employment growth has smaller knock-on effects than those in new sectors, such as smartphone services. New technologies of cloud computing will reduce and redeploy in-house information management workers but the total effects, even when taking a conservative view of the productivity gains, is unlikely to reduce total employment of technically skilled people.

The policy implications of these studies are extensive. Contrary to both optimistic and pessimistic positions, we see a modest growth in most areas of digital economy employment. While it is not nearly large enough to solve the persistent unemployment problems of some economies, such as Italy and Turkey, it is significant in local areas, as can be seen by the dramatic boost to London's labor market brought on by the rise of "digital London". The fact that employment grows as we have described also raises many questions about the common, often shrill, warnings about massive skills shortages in the labor market. Where we have used salary data, we have not seen significant wage pressure in areas where we might have expected to note the effects of job-seekers applying strong bargaining power. Employers may claim that they cannot hire the people that they want, but they grow in any case, perhaps reluctantly resorting to investing in employee skills acquisition along the way.

The studies show some surprising results. Trade data and industry structure evidence indicate that the UK economy is more capable to meet the expectations of digital economy requirements in areas such as smart metering and intelligent transport systems infrastructure than might have been expected. Their reliance on imports may be less than sometimes assumed, and so fewer of the jobs generated by such spending will be created abroad. Another surprise was the strong effect that policies regarding restricting the export of data and on energy pricing have on the ability of cloud services to generate domestic employment. Especially given that, in theory, cloud services are highly portable, the ability to avoid exporting all new employment opportunities rests on the local economy's ability to achieve growth in those sectors that benefit from the new digital services as well as the providers of those services who rely upon data centers and skilled staff.

Notes

1. We have a right to be particularly cynical about employers' claims that the labor market is massively devoid of skilled workers because they have an interest in ensuring that in the long run, skills shortages cannot be used to create wage squeezes that drive up their salary bills. It is also apparent that the economy usually makes due with the labor force it has and still leaves some capable skilled workers unemployed or underemployed.
2. See the debate as expressed by Salzman, Hal, Daniel Kuehn, and B. Lindsay Lowell (2013), "Guestworkers in the High-Skill U.S. Labor Market, An Analysis of Supply, Employment, and Wage Trends," Economic Policy Institute, http://www.epi.org/files/2013/bp359-guestworkers-high-skill-labor-market-analysis.pdf; see also: Lazonick, William (2009), Sustainable Prosperity in the New Economy? Business Organization and High-Tech Employment in the United States. Kalamazoo, MI: Upjohn Institute of Employment Research.
3. Michael Mandel of the Progressive Policy Institute, who counts himself an optimist, is one of the few who use careful methodology to assess the employment effects of the digital economy to show how and where job creation can be found. His focus on the growth of fulfillment centers shows how low paid retail jobs has been multiplied by higher paid e-commerce related workers: http://www.progressivepolicy.org/blog/evolution-not-revolution-retail-apocalypse.
4. "The UK's Digital Road to Recovery" following the parallel US "stimulus" study by ITIF (supported by IBM funding 2009).
   "*Modeling the Cloud; employment effects in two exemplary sectors in the US, UK, Germany & Italy*," which adjusted the ITIF model for a bottom-up analysis of labor changes from investments in specific technologies (supported by Microsoft funding 2012).

"Modeling the Cloud for Turkey," which applied to specific national conditions (Microsoft funding 2013).
"London: Digital City on the Rise" w/Michael Mandel paralleling his NYC and San Francisco studies (Bloomberg Philanthropies funding 2014).

5. Etro, F. (2009), "The Economics of Cloud Computing on Business Creation, Employment and Output in Europe," *Review of Business and Economics* 2: 179–208.
6. It has also been used, more controversially, to inflate the economic effects of certain policies. An example of that which is directly relevant to this work is the report by NESTA (2010) which used distinctly nonconservative multipliers to imply that employment effects of broadband investment can be huge—on the order of ten times my estimates. Kapstein has used this approach most convincingly in a series of reports on the economic impact of foreign direct investment, for example, Kapstein, E. (2008), "Measuring Unilever's Economic Footprint: The Case of South Africa," Unilever.
7. In a related study, we surveyed chief information officers or related executives in large enterprises in seven countries about, among other things, their intentions to redeploy or reduce staff as a consequence of new productivity-enhancing methods including cloud computing services, outsourcing opportunities, etc., Liebenau and Karrberg (2008), "Enterprise Efficiency in the Use of ICT in China, France, Germany, Great Britain, India, Japan & the USA," LSE Enterprise (with funding from Dell), https://www.researchgate.net/publication/277188210_Enterprise_efficiency_in_the_use_of_ICT_in_China_France_Germany_Great_Britain_India_Japan_the_USA_first_interim_report_on_LSE-Dell_research.
8. We assume that the short-term effects on the proportion of small versus large firms stay constant, i.e., that there is no special boost for SMEs.
9. Independent research conducted with ITIF using IBM funding and mainly UK statistical sources, ILU and OECD employment data, industry and company-level data on tasks, pay, and firm capabilities.
10. J.M. Keynes is said to have pointed out, probably factiously, that the most straightforward way to boost employment is to dig holes and fill them in again, an observation that perhaps influenced some "stimulus spending" advisors to focus especially on infrastructure construction or maintenance projects at the expense of less immediately efficacious job creation in new industry development activities.
11. Both studies were independent research supported by Microsoft funding and based on national statistical sources, ILU, OECD employment data, industry and company-level data on tasks, pay, firm capabilities, etc.
12. See for example, Lowell, B. Lindsay, and Hal Salzman (2007), "Into the Eye of the Storm: Assessing the Evidence on Science and Engineering Education, Quality, and Workforce Demand," Research Report, Urban Institute, http://www.urban.org/publications/411562.html.

13. Atkinson, Robert D., and Merrilea Mayo (2010), "Refueling the U.S. Innovation Economy: Fresh Approaches to Science, Technology, Engineering and Mathematics (STEM) Education," Washington, DC, ITIF. However, consider the oversupply of STEM skilled youth in some countries, notably South Korea, this concern is not fanciful.
14. Mandel, Michael (2014), "San Francisco and the Tech-Info Boom: Making the Transition to a Balanced and Growing Economy," South Mountain Economics. https://southmountaineconomics.files.wordpress.com/2014/05/sf-techinfo-study.pdf; Mandel, Michael (2013), "Building a Digital City: The Growth and Impact of New York City's Tech/Information Sector," South Mountain Economics. https://southmountaineconomics.files.wordpress.com/2013/09/building-a-digital-city1.pdf.
15. While there is a large degree of overlap with the comparable list for the United States under the category "information" (NAICS 51), that list consists of: publishing; software publishing; motion picture and sound recording; radio, television, and cable broadcasting; telecommunications (wired and wireless); data processing and hosting; internet publishing and broadcasting and web search portals, news syndicates, and other information services. This is combined with the category "computer systems design and related services" (NAICS 5415): custom computer programming services; computer systems design services; computer facilities management services.
16. This compares with New York City which has slightly more big data workers (approx. 57,000), but both are significantly behind the San Francisco-Silicon Valley region where 98,000 work in big data. Presumably, they are engaged in the large social media, advertising and online commerce activities concentrated in California.

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