

HUMAN CAPITAL: DISRUPTION, OPPORTUNITY AND RESILIENCE IN LONDON'S WORKFORCE

*Benjamin Kulka
Richard Brown*

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Foreword

Caroline Artis. London Senior Partner, EY

London is one of the world's most attractive, dynamic and powerful cities, with an incredible mix of commerce, culture and people. With an economy generating around £400 billion every year in economic activity, it has rightly established itself as a leading global city in a league of its own.

But whilst London has proved astonishingly resilient over recent decades, as it has adapted to deindustrialisation, the transformation of financial and business services, cultural resurgence and the growth of the global city economy, we cannot ignore that the world is changing.

We are living in an era that combines unprecedented change with limitless opportunity. The nature of work is evolving fast, new generations are now dominating the workforce and we are being forced to be more innovative, more agile, more collaborative and more everything.

This report considers some of the factors that are likely to disrupt London's economy and its 5.8 million workers over the coming decades. It explores how three 'disruptive' factors – automation, migration and low pay – act as potential challenges and disruptors to London's economy and labour market.

Adapting to these challenges requires changes to current ways of working for people, businesses and government. It recognises that many employers are already seeking to adapt to the changing paradigms of work, but the disruption of business models is hardly new.

What is considered new ground is how technological change is creating new enterprise and employment opportunities. London's well-qualified workforce, its areas of economic specialism and its global character should enable the city to take advantage of these opportunities.

The second part of this report looks at London's resilience and capacity to make the most of these opportunities. A new focus on cognitive skills, but also creative problem solving and social skills, will

be required to enable Londoners to benefit from the advantages offered by disruptive developments.

It also considers the implications for policy and regulation, particularly in the context of a post-Brexit immigration strategy, which will be critical in helping London to attract and retain the skills necessary to capitalise on the opportunities unlocked by technological change.

This report undertakes a fresh approach to the possibilities and opportunities to arise from this decade of disruption, along with data analysis to support the evidence that will ensure London remains resilient and prosperous in the decades to come.

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Summary

London's economy has been on a roll in recent decades, establishing the city as a leading global centre for finance and business services, cultural industries, higher education and tech. But times are changing: the growth of automation, Brexit and wage pressures are three factors with potential to shake up London's labour market.

This report undertakes fresh analysis of data on London's workforce, skills and specialisms in order to consider which jobs and businesses will be most affected. It also reviews the factors that will help the capital adapt to change, and considers the implications for businesses and policymakers.

Automation is expected to affect more and more jobs in coming decades...

- Machine learning and mobile robotics are enabling the automation of ever more complex tasks, though the human skills of creativity, dexterity and social intelligence remain more challenging.
- The cost of robots is falling, by around 10 per cent each year.
- The impacts of technological change on work are uncertain, but estimates suggest that between 10 and 47 per cent of current jobs in high-income countries could be automated over the next 20 years.

...and in London, automation combines with other disruptive factors.

- Reduced access to European labour following Brexit could pose a particular challenge in a city where 15 per cent of workers come from other European countries.
- Pressure on wages resulting from national policy and rising costs within London may be amplified

by labour shortages, creating more pressure for automation.

London's workers and employers are expected to face a perfect storm of disruption...

- Around one-third of London's jobs could be automated.
- The impact is likely to be greatest for low- and medium-skilled workers in secretarial, administrative, sales and routine trade jobs.
- Their occupational makeup means that wholesale and retail, transportation and storage, and accommodation and food – together accounting for around one million jobs in London – are the sectors most likely to be affected.
- Automation in some of these sectors (such as accommodation, food and retail) may be accelerated by wage pressures and labour shortages.

...but London is also well placed to weather the storm.

- Jobs in retail and food service in the capital are often more specialised than in the UK as a whole, with more focus on personal service and less capacity for automation.
- New jobs are likely to be created in finance, IT, education, manufacturing, and health – some of which are London specialisms.
- London's workers are better qualified: 53 per cent have degrees compared with 31 per cent in the rest of the UK, suggesting a greater capacity to adapt to change (though international comparisons are less favourable).

- London’s “global city” clusters offer high productivity and a concentration of higher-skilled functions, suggesting sectoral strength and resilience.

Businesses are already working to capture opportunities and ready themselves for change...

- Diversified, artisanal and bespoke products are offered to increasingly discerning consumers.
- Business services are “moving up the value chain” – offering specialised consultancy services rather than the routine services that are already being automated.
- As routine cognitive work is automated, employers are seeking staff with adaptable, creative and people-focused skills.

...but policymakers should also think radically about how to respond.

- Education and skills policy should increasingly focus on developing cognitive skills and the capacity to learn, not just delivering vocational and academic qualifications.
- Immigration policy must reflect the need to secure and retain the skills necessary to grasp the new opportunities emerging from technological, social and demographic change.
- Regulatory systems need to be progressive – capable of making London a centre for the development and adoption of new technology, while safeguarding worker and consumer interests.

Introduction

London's economy has been transformed, and is the dynamo of growth in the UK, though inequality and poverty persist in the capital. This report looks at how automation and other factors may combine to disrupt London's economy in coming years, and at how London's workforce will be able to adapt to change.

Disruption and transformation are nothing new for London. In the past 70 years, the city has been transformed from a declining imperial capital to one of a handful of “global cities” – command and control centres where the global movement of capital, goods and information is managed and organised.¹

After rapid deindustrialisation and the decline of dock-based industries, London found a new role as a global financial capital following the deregulatory “big bang” of 1987, and as a global cultural and educational centre in the following years. Population decline in the post-war years – driven by public policy and a flight to the suburbs – slowed in the 1980s before reversing in the early 1990s. As a result, by early 2015 London’s population had exceeded its pre-war total of 8.6 million people.

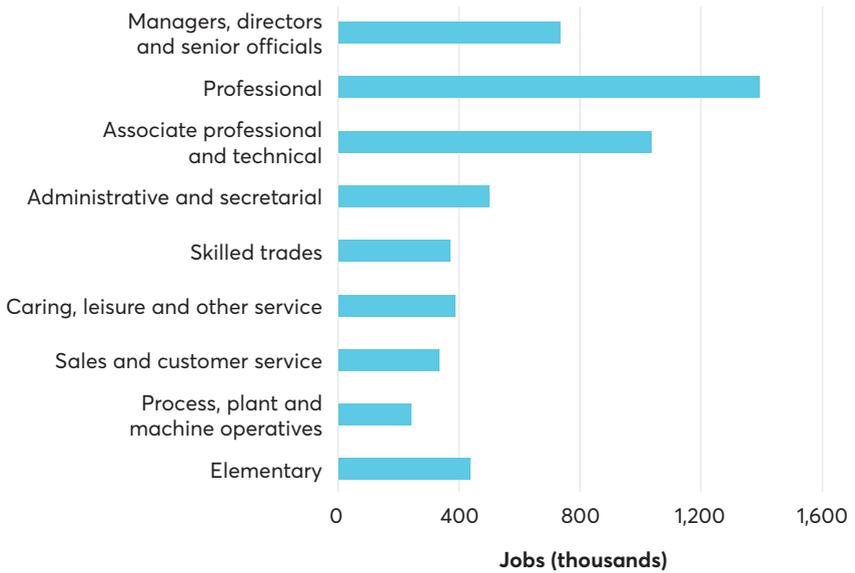
Today, London has around 5.8 million workers – one-sixth of the UK total – and generates around £400 billion every year in economic activity.²

Figure 1 shows the sectors and occupations that make up London’s economy today.

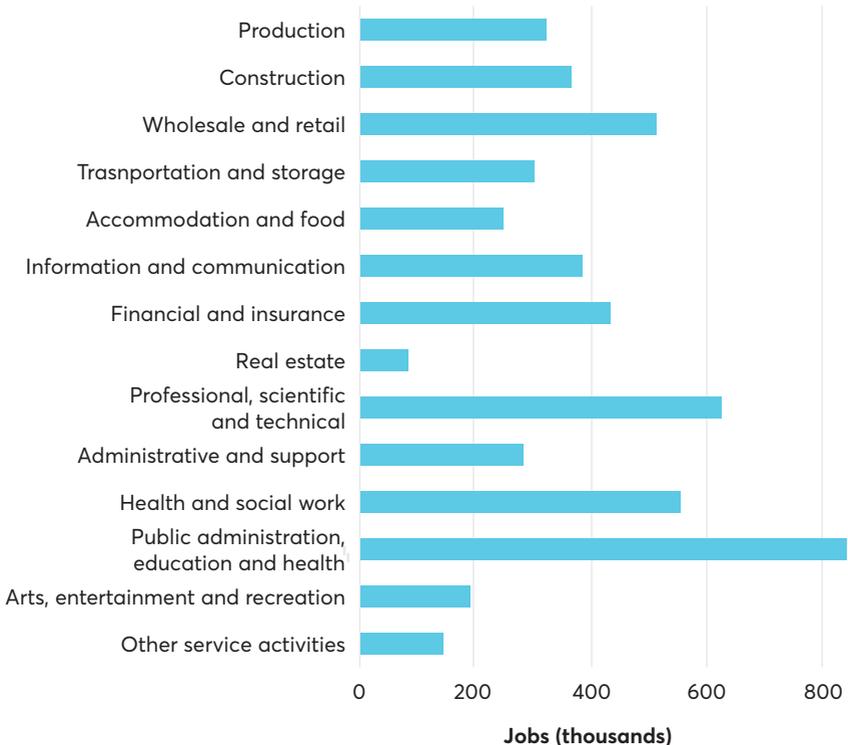
London has proved resilient to setbacks such as the financial crisis of the late 2000s, and has continued to grow despite the uncertainties following the EU referendum in 2016. Nonetheless, the economy has not worked for everyone, and London still has one of the highest regional unemployment rates in the UK as well as high rates of in-work poverty and child poverty – reflecting the impact of London’s cost of living even upon those in employment.

Our report examines some of the factors likely to transform London’s economy in coming years, focusing on automation – sometimes heralded as the catalyst for a new industrial revolution – but also on some of the other factors that may combine to intensify or mitigate automation’s effects.

Figure 1: London's employment by occupation, 2016



London's employment by sector, 2016



For several indicators in this report, 'Production' represents manufacturing, which still has a significant presence in London, with less significant primary industries such as agriculture, mining and quarrying.

Source: ONS Annual Population Survey 2017

Against this backdrop, our report examines some of the factors likely to transform London’s economy in coming years, focusing on automation – sometimes heralded as the catalyst for a new industrial revolution – but also on some of the other factors that may combine to intensify or mitigate automation’s effects. It looks at the potential impact on the workforce in different sectors; the opportunities that will arise from the changes; the factors that will help workers and employers to weather the storm and take advantage of these opportunities; and what government agencies and employers can do now to ensure resilience, prosperity and fairness in the decades to come.

Research has consisted of desk-based research, including fresh analysis of bespoke data provided to Centre for London by the Office for National Statistics (ONS). The team also held two roundtables to discuss findings with business leaders from the finance, real estate, hospitality, transport, retail and business service sectors.

Chapter 1 discusses three disrupting factors (automation, Brexit and low pay) as well as three potentially mitigating ones (new job creation, skills and cluster strength). Chapter 2 shows the impact that each of these factors is expected to have on different industries in London. Chapter 3 summarises the findings and discusses implications for businesses, for workers and for public policy.

Throughout this report we have used a orange, yellow, green traffic light system to indicate which sectors are at high, medium and low risk of disruption over the next 20 years. For mitigation, orange indicates low potential for mitigation, yellow indicates medium potential and green indicates high potential. This has been developed to give an easily-digestible overview of findings.

Disruption		Mitigation	
	Low		Low
	Medium		Medium
	High		High

1. Measuring disruption, opportunity and resilience

This chapter examines some of the factors that are likely to change London's economy and jobs base over the coming decades. It explores how three "disruptive" factors – automation, migration and low pay – may affect sectoral employment. However, it also looks at the opportunities created, London's adaptability and at the strength of its sectoral clusters. The next chapter draws these findings together to take an overview of the challenges and opportunities for different sectors.

Automation

As the second machine age unfolds, the scope of technology – and of tasks that can be automated – is expanding rapidly, provoking both utopian and dystopian debates about the ‘end of work’. In thinking about the growth of automation, a two-by-two matrix can be used to map “routine” and “non-routine” roles onto the distinction between “cognitive” (knowledge work) and “manual” (physical labour) tasks.³

	Routine	Non-routine
Manual	Assembly line work	Domestic plumbing
Cognitive	Bookkeeping	Programming

Source: Derived from Autor, Levy and Murnane.⁴

Automation to date has largely been confined to routine manual tasks, and to cognitive tasks involving activities for which machines can be programmed using simple “If A, Then B” algorithms. The limits of automation were set by the potential of a task to be broken up into rule-based elements, the possible complexity of these rules, and the availability of data. “Non-routine” tasks like handwriting interpretation, which requires judgement and the ability to spot patterns in order to cope with almost limitless variations, were resistant to such approaches.

Big data – the production and analysis of large data sets – and improved pattern recognition technology has made such tasks much more well defined as problems, and more capable of automation. Additionally, machine learning allows a computer to take on elements of non-routine cognitive work, like programming itself (once a human has set parameters and specifications) or writing financial journalism stories based on company accounts.

The potential impact of these advances is significant for productivity, employment and daily life. Research by economist Carl Benedikt Frey and machine learning researcher Michael Osborne⁵ suggests that about 47 per

cent of US employment may be susceptible to substitution by technology in the next 20 years.

However, technological change does not operate in isolation, but interacts with other factors that influence the decisions of businesses and investors. Wage costs, labour availability, the price of technology, commercial viability, consumer preferences and regulatory frameworks all play a part. Wage rises in one sector can encourage automation, but the movement of displaced workers may reduce wages and thereby discourage automation in other sectors. Similarly, the deployment of ride-sharing services and autonomous vehicles is dependent not solely on technical feasibility and economic viability but ultimately also on regulatory approval. And if the business case for the capital outlay involved in automation does not stack up, the decision to invest will be deferred, particularly in times of economic uncertainty.

These advances could lead to fundamental changes in the types of tasks that can be automated, with machines becoming capable of undertaking complex cognitive tasks as efficiently as human workers – if not more so. Technology now offers:

- **Scalability and pattern recognition:** machine-learning algorithms are better able to store, process and analyse complex data sets. For example, Frey and Osborne cite Symantec’s Clearwell system, which “uses language analysis to identify general concepts in documents, can present the results graphically, and proved capable of analysing and sorting more than 570,000 documents in two days”⁶ – far more quickly and efficiently than the junior lawyers and paralegals who would have previously undertaken this task.
- **Reduced bias:** human decisions are subject to biases and the influence of conditions that should not be relevant to the decision. Frey and Osborne mention research by Danziger et al. that showed

judges being more generous in their rulings following a lunch break. An algorithm, by contrast, is designed to “ruthlessly satisfy the small range of tasks it is given”. This does assume, of course, that no biases are programmed in either intentionally or unintentionally. In the financial sector, for example, artificial intelligence algorithms can access and process more press releases and financial announcements than a human trader, and thus react faster – though automated trading has been blamed for moments of extreme volatility in the markets.

Automation is also extending to non-routine manual tasks. In the past, industrial robots have taken over many routine manual tasks, but now the scope of mobile robotics is being extended by three factors:

- 1—Machine vision allows robots to recognise irregular layouts. This is necessary for (relatively) autonomous orientation and locomotion in unstructured, “messy” places such as roads, construction sites and homes – as opposed to the more predictable layout of a warehouse or factory floor.
- 2—High-precision dexterity, enabling more complex and delicate manual tasks to be undertaken (for instance in plant operations).
- 3—Prices, which are falling by 10 per cent annually, both for programming and installation costs and for the cost of the robot itself.⁷

Nonetheless, significant constraints remain, at least in the immediate future. Frey and Osborne suggest that over the next two decades the susceptibility of occupations to automation will be determined by the extent to which they involve the following tasks, which

are considered “engineering bottlenecks” and render automation less likely:

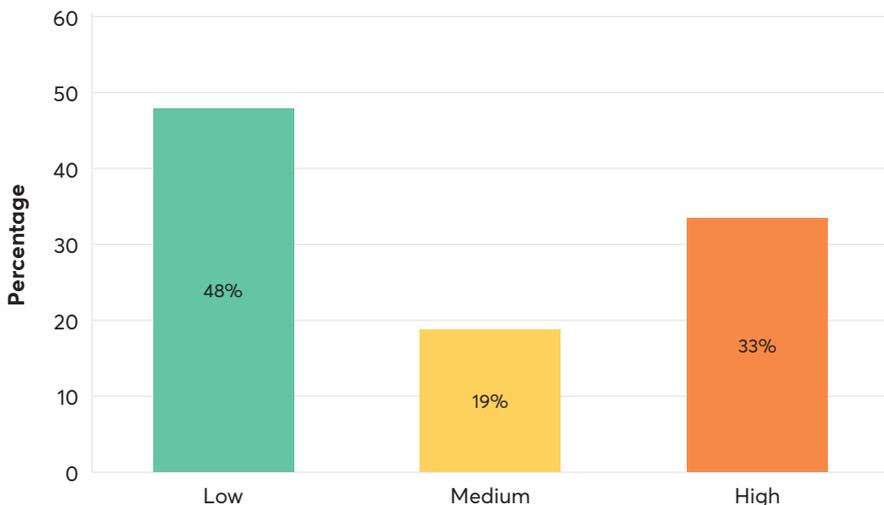
- **Perception and manipulation tasks:** while machine vision is improving, it is not yet capable of working in the most complex and cluttered contexts – for example in cardiovascular surgery.
- **Creative intelligence tasks:** the ability to bring to life ideas or artefacts that are “novel and valuable”, as well as creating “unfamiliar combinations of familiar ideas” in ways that require a “rich store of knowledge”.
- **Social intelligence tasks:** these involve social perceptiveness (being aware of others’ reactions and understanding the reasons for them), negotiation (reconciling differences), care, and persuasion (changing other people’s minds or behaviour).

This report uses Frey and Osborne’s methodology, recoding US occupational classifications to their UK equivalents, and then applying these to London’s workforce, using ONS data that shows employment by occupation (SOC 2010) and by industry (SIC 2007). This enables analysis of London’s economy on the basis of the occupational structure of different industrial sectors.

Figure 2 summarises the proportion of jobs in London that have the potential to be automated in the next 20 years, based on the occupational structure of the workforce. It divides jobs into those that have high (greater than 70 per cent), medium (30-70 per cent) and low (less than 30 per cent) potential for automation within the next 20 years.

The research found that almost exactly one-third of London jobs (33 per cent) are in occupations with a high potential for automation in the next 20 years.

Figure 2: Share of jobs in London with low, medium and high automation potential



Source: Centre for London calculations based on ONS and Frey and Osborne, 2013

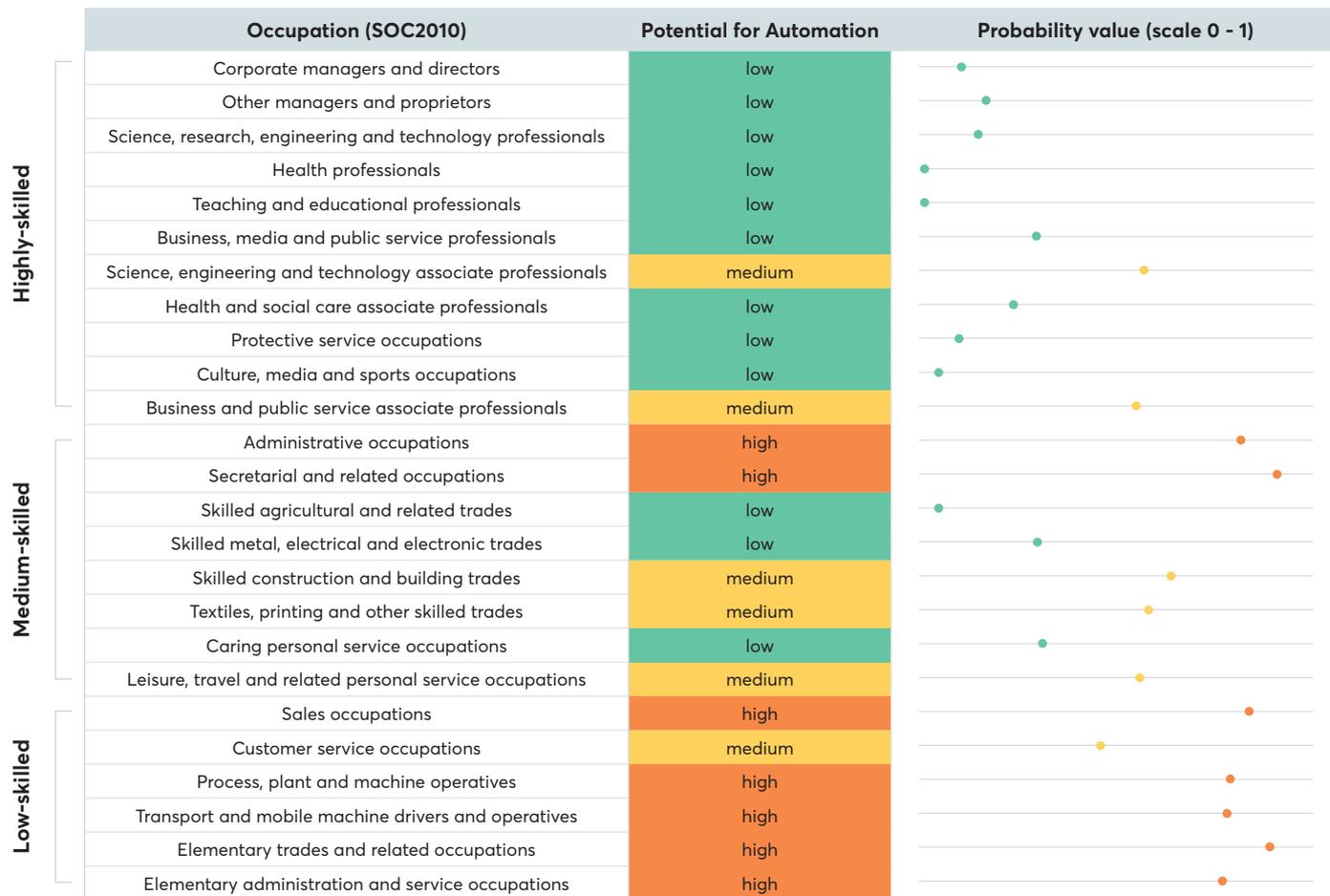
Around one in five (19 per cent) have medium potential, and just under half (48 per cent) are in low-potential occupations. This report talks of “potential” rather than “probability” to reflect the fact that many other discretionary or external factors – such as employer preferences, regulations and wage levels – will determine whether any specific job is actually automated or not.

Table 1 shows the values for the individual occupations, grouped by skill level, that underpin these findings. A number at or near 1 shows an occupation for which all tasks are likely to be automatable in the next 10-20 years. A value nearer zero indicates that the role will be much less susceptible to automation over the same timescale.

High-skilled occupations are the least likely to be automated. There are some notable exceptions, including business and public service professionals.

These are associated with a medium probability for automation overall, reflecting significant variation

Table 1: Automation potential for occupational groups in London



Source: Centre for London calculations based on ONS and Frey and Osborne, 2013

within the category. Paralegals and legal assistants, for example are more susceptible to automation (reflecting the routine nature of much of their work) while many other occupations – e.g. public relations professionals – are less susceptible.

Middle-skilled occupations show a more mixed picture: administrative and secretarial occupations are associated with some of the highest potential for automation. However, care occupations have relatively low potential, as they encompass social intelligence and dexterity tasks.

Lower-skilled occupations have the highest potential for automation, reflecting a low degree of engineering bottlenecks in their respective activities.

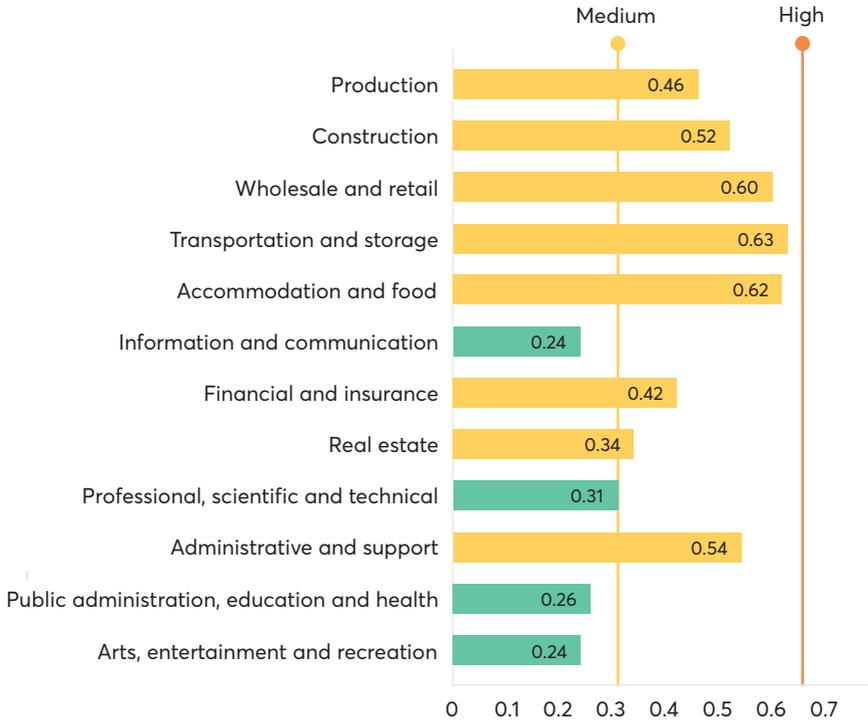
The findings for sales occupations may look anomalous, given the social skills involved. However, the sales category includes some highly automatable tasks (such as till operation); other customer service occupations have less potential for automation. The assessment also works on the basis of what could be automated, so may not fully take into account the social intelligence that is valued but perhaps not strictly required in some roles.

Combining this assessment of the automation potential of different occupations with data on the makeup of different industries' workforce in London enables an assessment of the automation potential of different economic sectors (Figures 3 and 4). Where the weighted probability is lower than 0.33, the industry concerned is shown in green; where it is between 0.33 and 0.66 it is shown in yellow, and where it is above 0.66 it is shown in orange. No sector shows a high automation potential overall on this metric, reflecting the mix of occupations found in most sectors in London – though it is the globally specialised sectors such as finance, information and communications, and arts and entertainment that have lowest potential.

These sectors also show the most marked difference

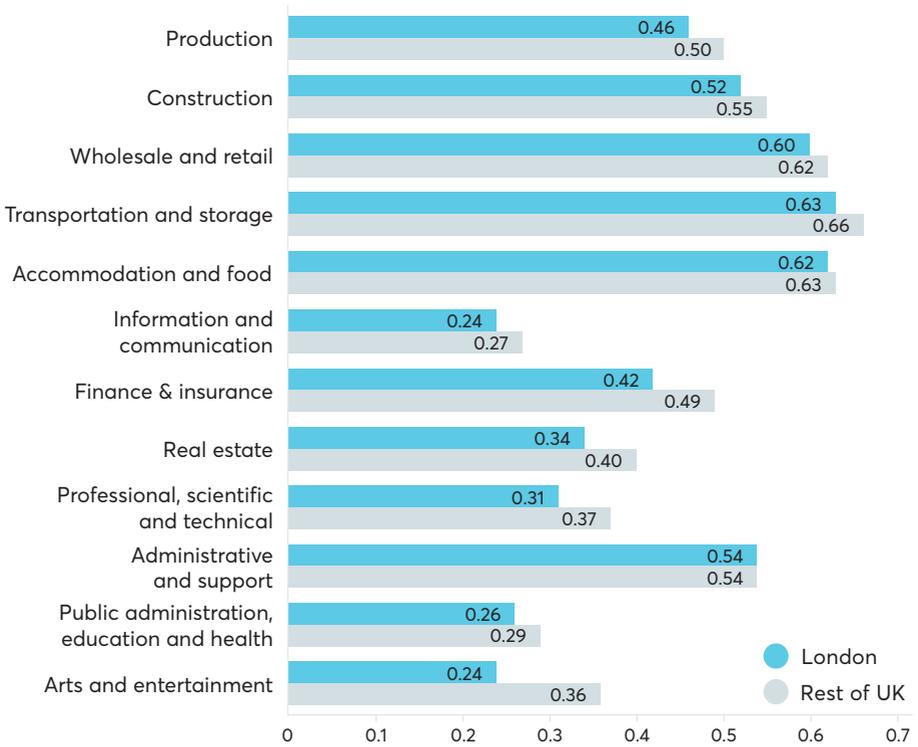
from the UK as a whole – though London has a lower potential for automation in most sectors owing to its higher proportion of managers, professionals and other roles that involve creativity and social intelligence (Figure 4).

Figure 3: Automation potential in London, per industry



Source: Centre for London calculations based on ONS Annual Population Survey 2014-16; Frey and Osborne 2013

Figure 4: Automation potential by industrial sector in London and UK

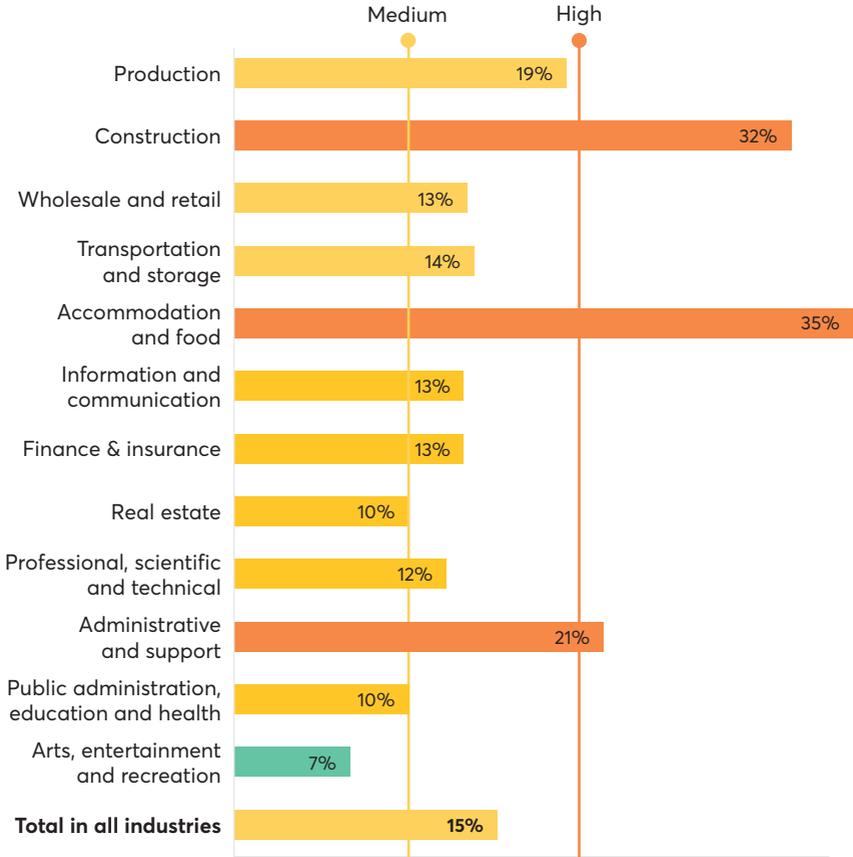


Source: Centre for London calculations based on ONS Annual Population Survey 2014-16; Frey and Osborne 2013

Migration

While automation’s impact will be universal, the impact of Brexit will be specific to the UK and particularly to London. With almost 37 per cent of its population born overseas,⁸ London is one of the most mixed cities in the world, its cosmopolitanism both reinforcing and mirroring its economic position as a leading global city of the 21st century. 15 per cent of the workforce are overseas EU/EEA citizens, ranging from 5 per cent in public administration to 35 per cent in accommodation and food services (Figure 5). While we do not yet know the likely shape of a Brexit immigration policy, the expectation is that immigration controls will be tightened.

Figure 5: Foreign EU/EEA workers as share of workforce, by industry



Source: ONS Annual Population Survey, 2016

While the government has emphasised that they wish European workers currently in the UK to be able to remain, there is significant churn in the EU workforce, with 10,000 to 50,000 workers leaving each year, as discussed in Centre for London’s *Open City* report.⁹ Future restrictions on freedom of movement could make it harder to replace these workers, particularly in low- to medium-skilled sectors where work permits may be harder to come by. In anticipation of Brexit, there is already a slowdown in European workers arriving in London for work,¹⁰ and recent ONS data suggested

that net immigration to London is also falling (though it remains positive).

It is worth noting that the three sectors most dependent on EU workers – construction, accommodation and food, and administrative and support services – are also among those with the highest potential for automation.

These sectors also offer relatively low pay and often have comparatively informal recruitment processes: consequently, they may find it more difficult to adapt to any new work permit regimes requiring minimum pay levels and applications in advance of arrival in the UK. This in turn may strengthen the business case for deployment of automation.

Low Pay

Low pay is a big challenge for London’s workforce today, pushing many working people into poverty, but measures to tackle it could accelerate the process of automation. Without cheap labour, businesses may rethink their operating model and the business case for automation may be strengthened.

Low pay can be defined in a number of ways. The Resolution Foundation uses two-thirds of median wages as a benchmark,¹¹ while the government’s “National Living Wage” – the national minimum wage – uses 60 per cent of median pay. It was set at £7.50 per hour in 2016/17, and is expected to rise to around £9 per hour by 2020.

Centre for London has argued for a separate minimum wage for London, around 20 per cent higher than the national rate. This would suggest a minimum wage of around £9 per hour today.¹² Other measures, such as the voluntary Living Wage promoted by Citizens UK, focus on the costs of living, and have different rates for London and the UK. The current calculations are shown in Table 2.

Figure 6 shows gross hourly pay rates in London for the 10 per cent lowest-paid and 25 per cent lowest-paid workers. As the graph indicates, the National

Living Wage, which applies to workers aged 25 and over, affects relatively few London sectors. However, several service sectors – retail, accommodation, food, administration and personal social services – have around 10 per cent of workers paid at or below this threshold (many of whom may be under 25). As the rate rises – it will be around four per cent higher from April 2018 – it will “bite” for more and more workers in these sectors. Recent media reports suggest that it is already having an effect on employment levels.¹³

Table 2: Wage rates

Pollutant	London	UK
66 per cent of median pay	11.05	8.32
National Living Wage	7.50	7.50
Living Wage	10.20	8.75

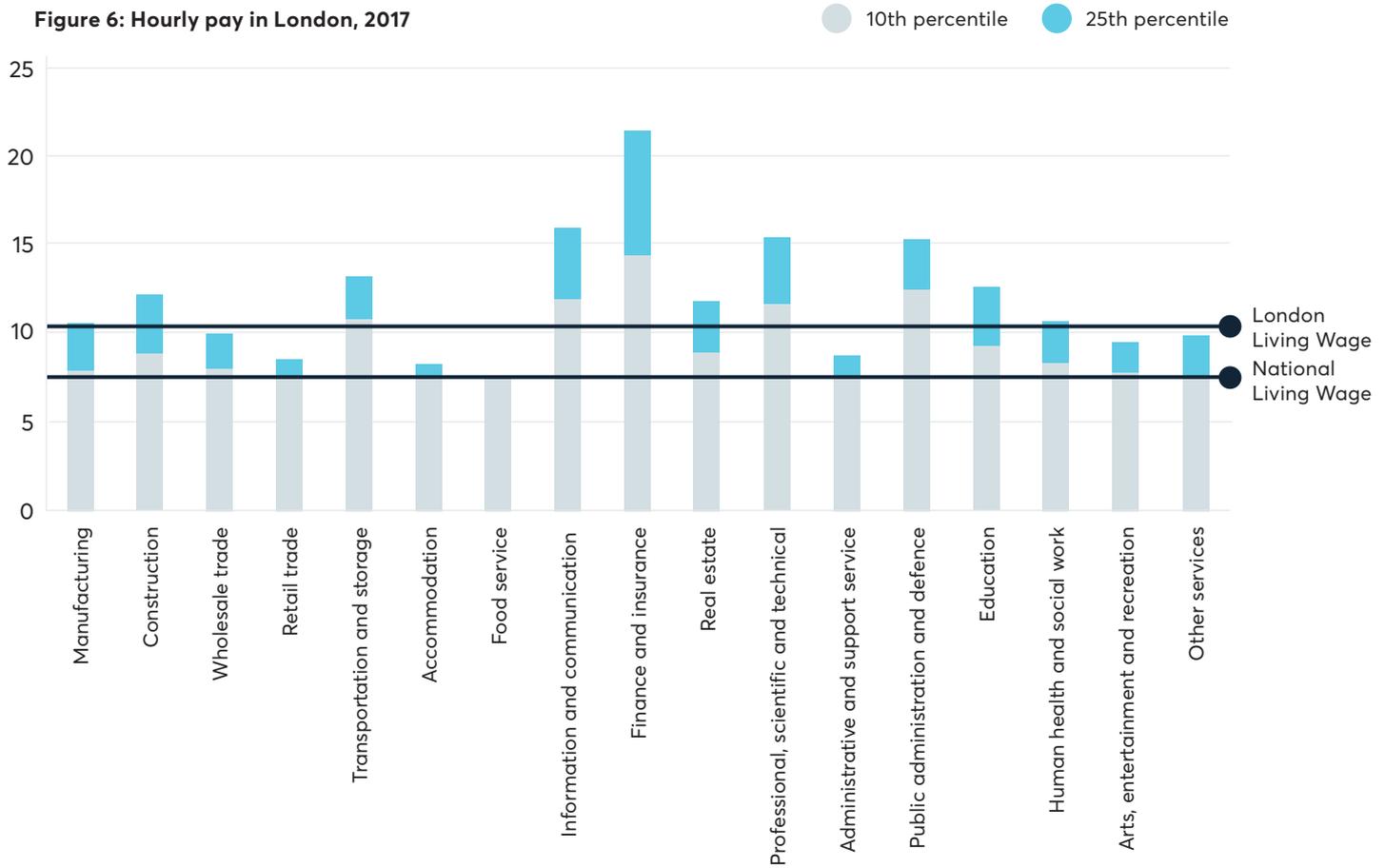
Source: ONS Annual Survey of Hours and Earnings 2017; Resolution Foundation

Many more workers are paid at or below the London Living Wage; in most sectors at least 25 per cent of workers are paid near or below this rate. If Brexit restrictions on immigration lead to labour shortages in these sectors, pressure for higher pay is likely to grow (though wages have remained stagnant in recent years – at a time of nearly full employment – suggesting that this is not guaranteed).

If wages rise as a result of labour shortages and policy interventions, this may in turn strengthen the business case for investment in automation as a substitute for more expensive labour.

As recent research analysis from the Institute of Fiscal Studies has indicated, the National Living Wage will rise to a point at which it is expected to affect employment levels. Some mid-level sectors are actually

Figure 6: Hourly pay in London, 2017



Source: ONS Annual Survey of Hours and Earnings, 2017

more routine and more easily automated than lower-skilled roles, so wage pressure in these sectors may lead to even swifter adoption of automation¹⁴ (though London may be less rapidly affected than the rest of the UK as wage rates are higher to start with).

The timeframe for Frey and Osborne's projections is 20 years. While Brexit negotiations are still underway at the time of writing, it is likely that the UK will leave the European Union within that timescale. Net migration has fallen since the referendum in 2016, while official figures put unemployment levels in London at 4.9 per cent – their lowest level since 1992.¹⁵ Therefore, it may be that labour shortages begin to bite in some sectors before automation is technically and commercially feasible. The shortfall would most likely lead to wage inflation, and possibly price inflation where labour is a major element of costs. While this would offer low-paid workers a very welcome relief in terms of their living standards, it might at the same time further strengthen the case for and accelerate automation.

Automation has the potential to act as a significant disruptor to London's economy, with Brexit and regulatory pressure on wages strengthening its impact. Together, these factors may dramatically change the employment profile of some sectors, encouraging and enabling management to substitute robots and algorithms for workers.

Adapting to these challenges will require changes to the way people, businesses, and the government conduct their affairs. But technological change will create new enterprise and employment opportunities too.

Opportunities and resilience

Disruptive change presents challenges, but also offers opportunities. London's economy has shown itself to be resilient and adaptable to technological and economic change over time, so it should be well placed to adapt to new circumstances. This section will look at the opportunities for job creation, the skills profile of the capital's workers, and how clustering and specialisation might provide resilience in the face of the challenges discussed above.

Job Creation

Technological change will create new jobs as well as replacing labour by automating existing jobs. New jobs will emerge in professions involved in the process of automation and digitalisation itself (for example in coding and development); from additional demand for services that are made more productive (such as financial advice); and from new products and services that are enabled by automation and increases in productivity (e.g. demand-responsive mass transit systems).

Research undertaken by Nesta¹⁶ offers some insight into occupations that may experience increased demand as a result of the need for higher-order cognitive skills, interpersonal skills, and system skills. This research is based on the needs of automation processes themselves, as well as other trends such as urbanisation, demographic change, mitigation of climate change, socioeconomic inequality, political uncertainty and globalisation.

The authors of the report offer their assessment of the probability of increased demand for 92 different occupations as a result of these trends (1 being the highest possible probability value and 0 the lowest). This analysis suggests that sports and fitness occupations have the highest probability of increased demand in the future (0.745): in contrast, elementary storage occupations have a probability of only 0.061 for increased demand – the lowest value of all occupations (see Tables 3 and 4).

Table 3: Occupations with a high probability of higher future demand

Top 15 future demand occupations	Probability of higher demand
Sports and fitness	0.745
Health, social services managers and directors	0.700
Food preparation and hospitality trades	0.699
Natural and social science professionals	0.694
Therapy professionals	0.689
Managers and proprietors in health and care services	0.681
Teaching and educational professionals	0.666
Design	0.659
Managers and proprietors in hospitality and leisure services	0.659
Health professionals	0.646
Conservation and environment professionals	0.638
Engineering professionals	0.637
Artistic, literary and media	0.633
Chief executives and senior officials	0.633
Nursing and midwifery professionals	0.626

Table 4: Occupations with a low probability of higher future demand

Bottom 15 future demand occupations	Probability of higher demand
Sales Assistants and Retail Cashiers	0.289
Customer Service Managers and Supervisors	0.284
Customer Service Occupations	0.280
Elementary Administration Occupations	0.268
Elementary Agricultural Occupations	0.266
Elementary Process Plant Occupations	0.260
Other Administrative Occupations	0.244
Plant and Machine Operatives	0.241
Process Operatives	0.230
Printing Trades	0.218
Metal Forming, Welding and Related Trades	0.210
Mobile Machine Drivers and Operatives	0.192
Assemblers and Routine Operatives	0.164
Elementary Sales Occupations	0.102
Elementary Storage Occupations	0.061

Source: Centre for London calculations based on NESTA, 2017 and ONS Annual Population Survey, 2017

Table 5: Probability of higher future demand by occupation in London

	Occupations	Probability of higher demand	Probability value (scale 0 to 1)
Highly-skilled	Corporate managers and directors	high	0.95
	Other managers and proprietors	high	0.85
	Science, research, engineering and technology professionals	high	0.85
	Health professionals	high	0.85
	Teaching and educational professionals	high	0.90
	Business, media and public service professionals	high	0.80
	Science, engineering and technology associate professionals	high	0.75
	Health and social care associate professionals	high	0.80
	Protective service occupations	high	0.80
	Culture, media and sports occupations	high	0.85
	Business and public service associate professionals	high	0.80
Medium-skilled	Administrative occupations	medium	0.55
	Secretarial and related occupations	medium	0.55
	Skilled agricultural and related trades	high	0.80
	Skilled metal, electrical and electronic trades	medium	0.65
	Skilled construction and building trades	medium	0.60
	Textiles, printing and other skilled trades	high	0.85
	Caring personal service occupations	medium	0.65
	Leisure, travel and related personal service occupations	high	0.80
Low-skilled	Sales occupations	medium	0.55
	Customer service occupations	low	0.45
	Process, plant and machine operatives	medium	0.55
	Transport and mobile machine drivers and operatives	medium	0.55
	medium	medium	0.60
	Elementary administration and service occupations	medium	0.55

Source: Centre for London calculations based on NESTA, 2017 and ONS Annual Population Survey, 2017

Table 6: Probability of higher future demand in London, by industry

Industry	Probability of higher demand	Probability value (scale 0 to 1)
Manufacturing	high	
Construction	medium	
Wholesale and retail	medium	
Transportation and storage	medium	
Accommodation and food	medium	
Information and communication	high	
Financial and insurance	high	
Real estate	medium	
Professional, scientific and technical	medium	
Administrative and support	medium	
Public administration, education and health	high	
Arts, entertainment and recreation	medium	
Other service activities	medium	

Source: Centre for London calculations based on NESTA, 2017 and ONS Annual Population Survey, 2017

Table 5 uses this analysis to indicate the probability of increased demand at a two-digit SOC code level, weighted to reflect the composition of these occupational categories in London. All higher-skilled managerial, professional and associate professional occupations have a high probability of higher demand (> 0.5) – especially those requiring social and analytical skills such as teaching, health and science professionals. The middle-skilled occupations offer a mixed picture with some skilled manual trades and leisure-related personal services expected to see higher demand, while for the remaining occupational categories the probability is medium. Sales and customer service, process and transport operatives, and elementary occupations are associated with a medium-to-low probability of higher future demand.

As with the Frey and Osborne analysis of potential for automation, we have used these occupational data to show potential for job growth by industry (Table 6). Information and communication, financial and insurance, public administration, education and health, and (surprisingly) manufacturing are associated with a probability of increased future demand of 0.5 or greater, while all other sectors are below this threshold. The result for manufacturing might reflect the greater role of research and development in this sector in London, and the relatively specialised and skilled profile of the industry in the capital. The lowest values and therefore the lowest probability of increased future demand are in retail, and transportation and storage.

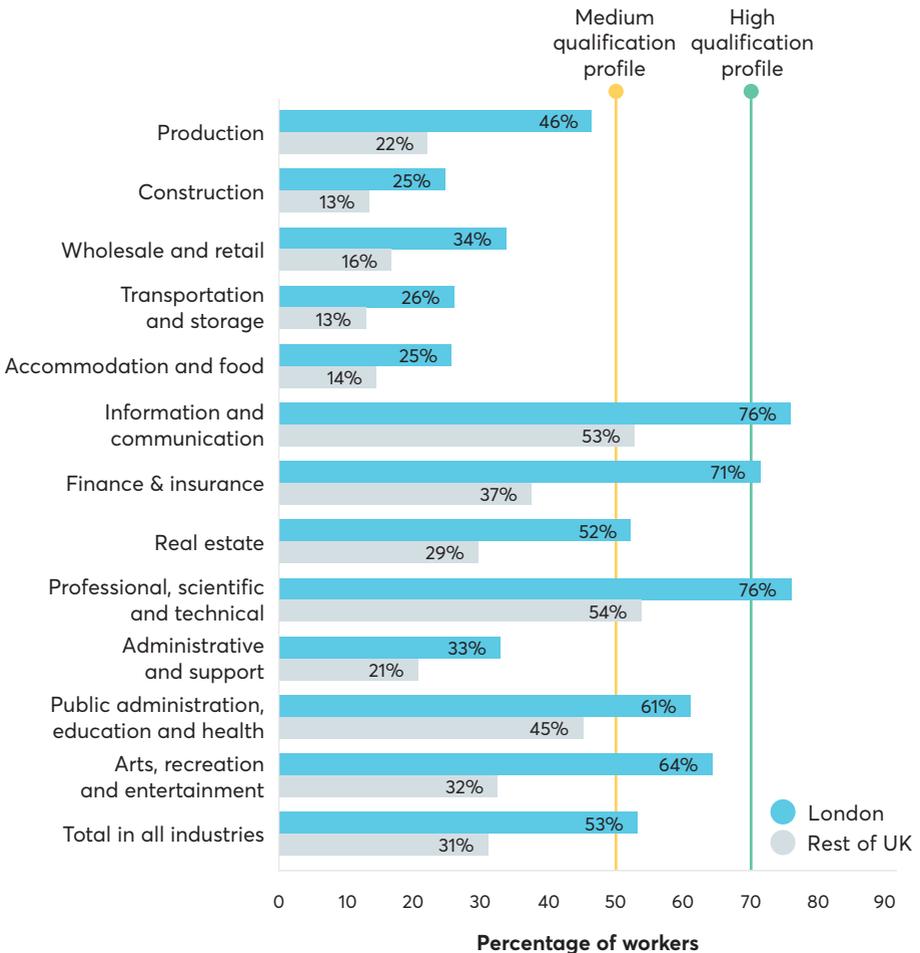
Skills and qualifications

All other things being equal, a more skilled workforce would be expected to be more resilient to changing circumstances, having the intellectual capacity to learn new skills and adapt existing skills to the changing demands of the workplace.¹⁷

We can assess skills by reference to formal qualifications – GCSEs, A Levels, vocational qualifications, diplomas and degrees. London's workforce is well qualified in these terms compared to the rest

of the UK (see Figure 7). More than half (53 per cent) of London workers have a degree, compared to 31 per cent for the rest of the UK. The contrast is particularly strong in sectors where London has a strong concentration and higher productivity (see next section) – for instance in finance and insurance, where 71 per cent of the workforce in London is educated to degree level compared to 37 per cent for the rest of the UK. This suggests that workers in London will be more capable of taking advantage

Figure 7: Proportion of workforce educated to degree level or above, 2016

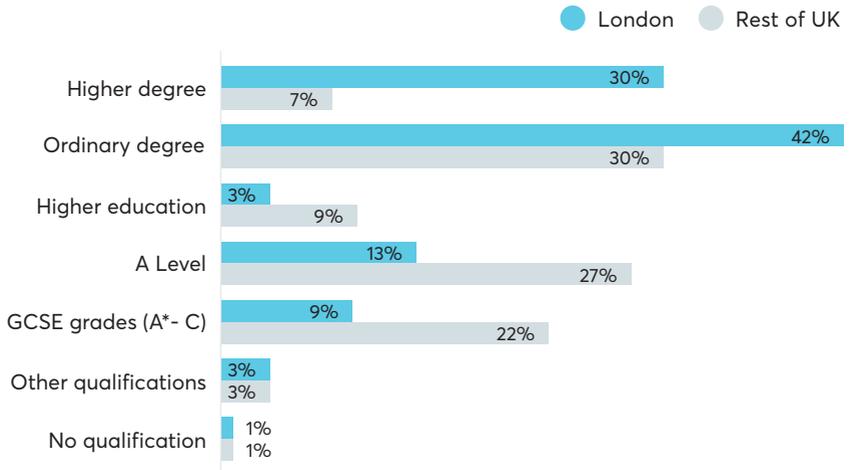


Source: ONS Annual Population Survey, 2017

of new opportunities and adapting to economic and technological change.

The difference between London and the UK becomes even more pronounced when disaggregating qualification levels further for particular industries. Figure 8 charts the educational attainment of workers in the finance and insurance sector. Almost one-third of financial sector workers in London hold postgraduate qualifications, compared to seven per cent of those in the rest of the UK.

Figure 8: Educational attainment of finance and insurance workers, 2016



Source: ONS Annual Population Survey, 2017

However, it is also worth asking whether these formal qualifications needed for jobs today reflect the skills needed to thrive in tomorrow’s workplaces, and adapt to the challenges of automation and digitalisation. Many young people currently attending primary and secondary school may acquire specific skills for traditional middle- and low-skilled occupations – only to see these jobs disappear over the next 20 years.

As we do not know precisely which occupations will be affected and when, “meta-learning” – the ability to learn and adapt through a working lifetime of more than 40 years – becomes as important as specific skills.

Cognitive skills – information processing capabilities such as numeracy and literacy – are crucial for meta-learning. These form the basis for acquiring occupation-specific skills or functional skills in further and higher education and later in life.

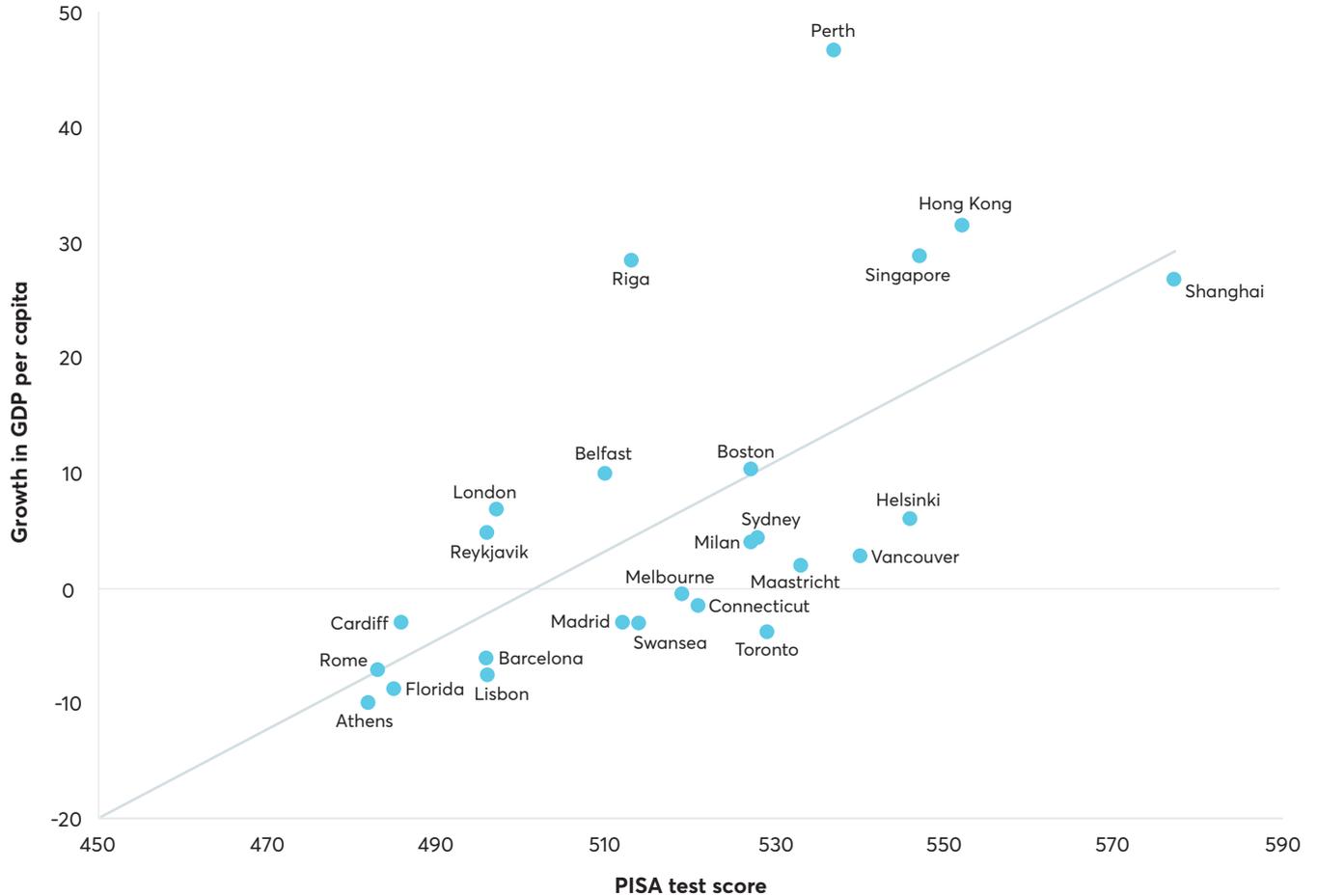
A growing body of research suggests that cognitive skills matter more than formal qualifications. Research on standardised international tests in high-income OECD member countries comparing cognitive skills suggested that the attainment of formal qualifications “has very little impact on growth if it does not have substantial association with a better cognitive skills score”.¹⁸

The OECD Programme for International Student Assessment (PISA) – which tests mathematics, science and reading skills among 15-year-olds – indicates that London does not compare particularly well with other city regions, including Hong Kong, Boston, Singapore, Vancouver and Shanghai.¹⁹ Furthermore, comparing per capita growth rates with attainment demonstrates a fairly strong association between these two variables (Figure 9), including between cities in the same country, though London has a high level of GDP growth compared to other cities with similar PISA scores.

Data on adult skills derived from the OECD Programme for the International Assessment of Adult Competencies (PIAAC) – which tests numeracy and literacy skills among adults – also indicates a stagnation of cognitive skills in the UK between the younger and the older generations.²¹ In contrast to almost all other OECD countries, the younger generations of 16-24 and 25-34 year-olds do not have better literacy and numeracy skills than the 55-64 year olds, despite being much more likely to have attended upper secondary schools and university. In the same study, London working-age residents performed just below the English average (see Figure 10) – roughly in line with the city’s overall deprivation profile.

So, while London’s population appears to be doing well when looking at educational attainment from a formal qualifications perspective, the city’s performance – compared to global competitors – in relation to

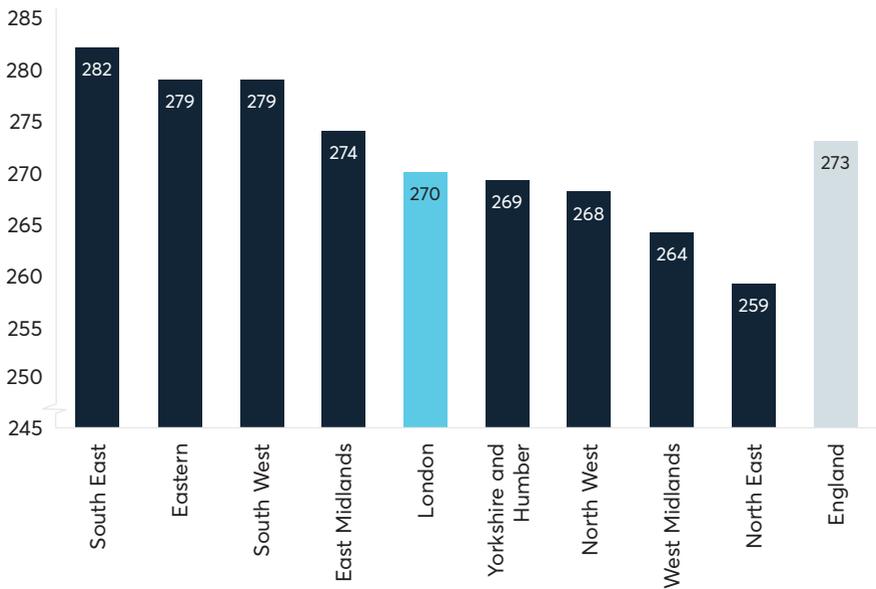
Figure 9: OECD PISA science scores (2009-12) compared to GDP per capita growth rates (2004-12)



Source: Centre for London calculations based on OECD, International Monetary Fund, and UCL Institute of Education analyses.²⁰

standardised tests of cognitive skills is far less impressive. While the OECD PISA and PIAAC data is based on residence rather than workplace (thereby reflecting patterns of disadvantage among London residents as well as workforce skills), these findings suggest that London cannot afford to be complacent in terms of its skills profile.

Figure 10: Average PIAAC scores in literacy, numeracy and problem-solving by region, 2012



Source: OECD, PIAAC 2013, UK Department of Education

Cluster strength

A further source of resilience should stem from the structure of London's economy, the sectors that the city specialises in, and the extent to which these sectors demonstrate clustering (or "agglomeration") that will make them relatively resilient to change.

Table 7 shows the industries in which London's economic output (Gross Value Added) is concentrated compared to those of the UK as a whole; it also shows the industries where London has a greater proportion of

Table 7: Index of specialisation for economic output / managers and professionals

Industry	Economic output	Managers and professionals
Manufacturing	0.3	1.2
Construction	0.7	1.2
Wholesale and motor trades	0.7	1.4
Retail	0.7	1.5
Transportation and storage	1.0	1.3
Accommodation and food	1.0	1.1
Information and communication	1.7	1.7
Financial and insurance activities	2.2	1.5
Real estate	1.1	1.3
Professional, scientific and technical	1.5	1.3
Administrative and support	1.2	1.3
Public administration	0.7	1.2
Education	0.8	1.4
Human health and social work	0.7	1.1
Arts, entertainment and recreation	1.3	1.3
Other service activities	0.9	1.3

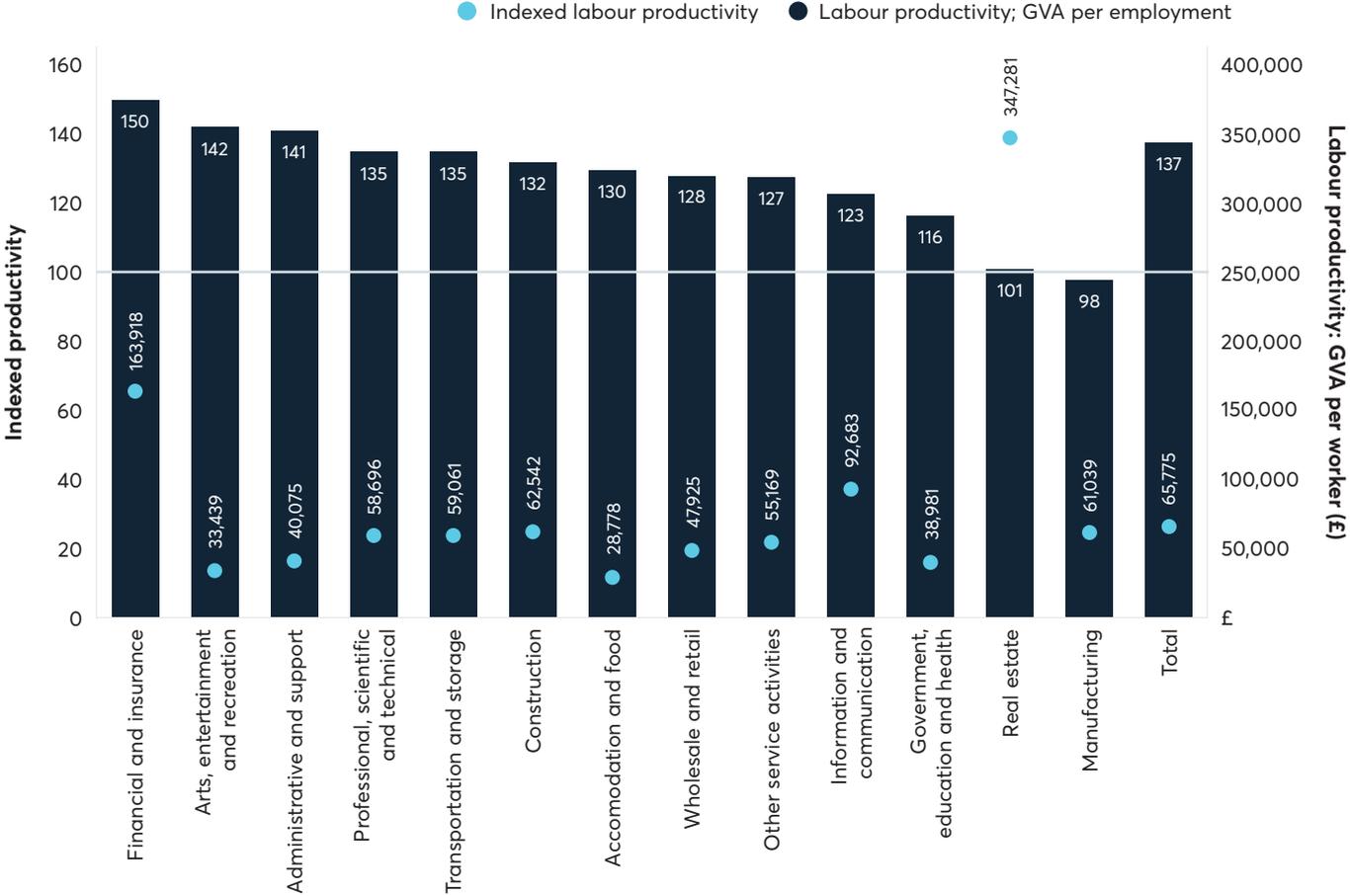
Source: Centre for London calculations based on ONS and Oxford Economics data

managers and professionals. A value above 1 means that London has relatively more economic output, or more managers and professionals, when compared to the UK as a whole in that industry; a value below 1 means that London's relative share of the same is lesser than the UK.

The match is not precise, but London's global city functions – information and communication, financial and insurance services, arts, entertainment and recreation, and professional and technical services – are areas of significant specialism. These industries, which employ 1.8 million people and have accounted for nearly half London's net job growth since 2000, are also sectors with a high share of managerial and professional staff (whose jobs are relatively resilient to automation owing to the creative and social intelligence skills required).

Firms in London are also more productive. Figure 11 shows London's sector labour productivity as Gross

Figure 11: Labour productivity (GVA per worker) in London compared to UK (UK=100), 2016



Source: Centre for London calculations based on ONS and Oxford Economics data

Value Added per worker on the right-hand scale, indexed to the respective values for the UK as a whole on the left-hand scale (where a value of 100 means that London has the same productivity rate as the UK as a whole). Except for manufacturing, every sector either matches (in the case of real estate) or is more productive in London than in the UK as a whole. In the case of the finance and insurance sector, London is 50 per cent more productive.

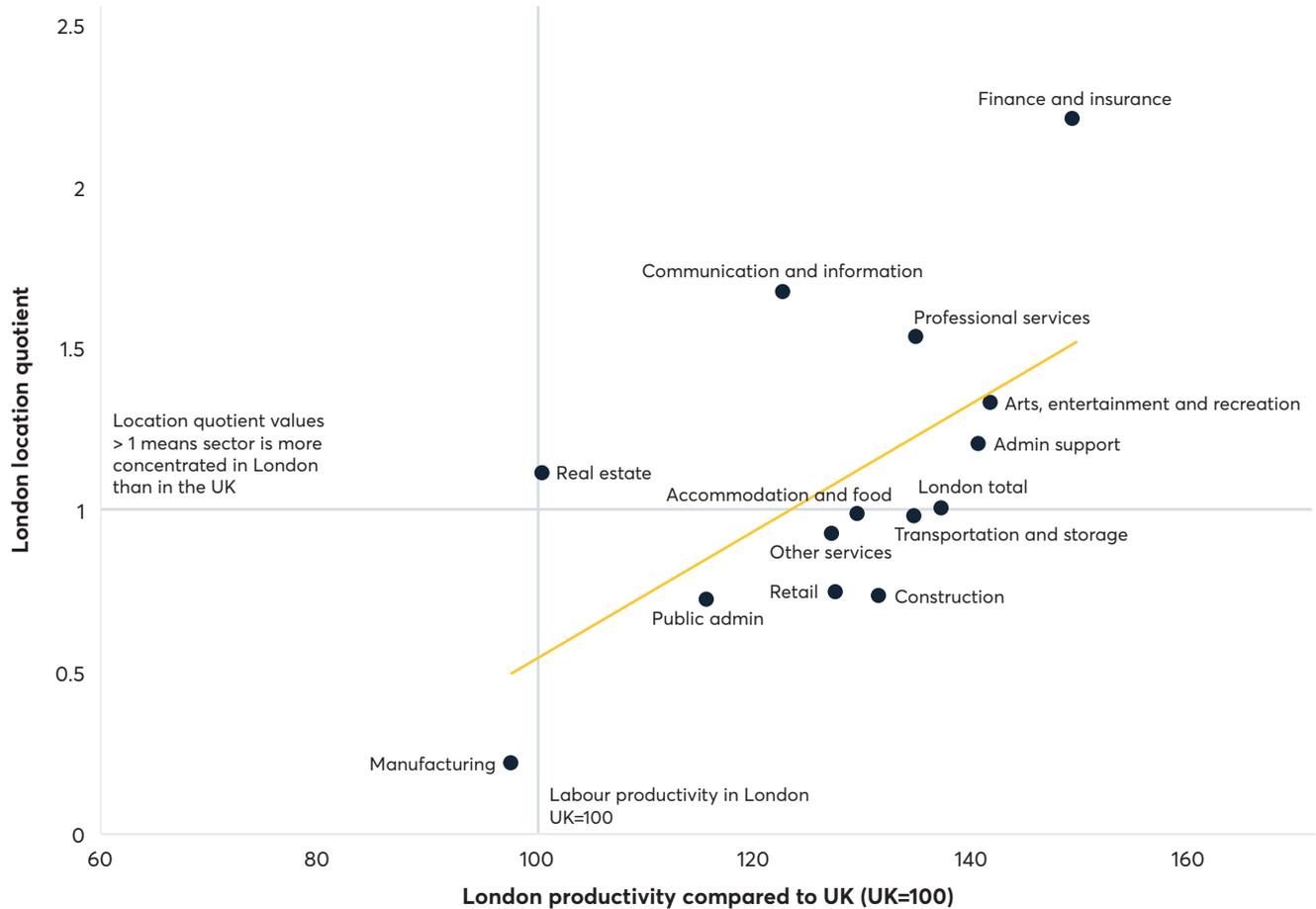
Figure 12 brings these two datasets together to compare the sectors in which London's economic output is concentrated with their relative labour productivity. As the chart shows, it is the same suite of "world city" functions that are both concentrated in London and more productive in London than in the UK as a whole.

These data suggest that London's specialist sectors are benefiting from agglomeration economies. These make firms in some sectors more efficient and productive because they can "share, match and learn" with others: companies may draw on the same well-stocked talent pool to match their staffing needs, learn and innovate through personal networks, observe the competition, and even share infrastructure.²² This is confirmed by other research that suggests that agglomeration works much more powerfully for sectors such as professional, scientific and technical services than for wholesale and retail.²³

In summary, London specialises in sectors that are highly productive, and which have a high proportion of workers in managerial and professional functions. These jobs are less likely to be automated, and London's relative productivity suggests that an agglomeration "stickiness" will preserve critical mass in the capital, notwithstanding the regulatory and market access challenges posed by Brexit.

That said, London also retains some economic diversity—although financial services dominate, they have not been London's fastest-growing sector in recent years – providing further resilience against the sudden decline of one sector.

Figure 12: London's specialisations and productivity compared, 2016



Source: Centre for London calculations based on ONS and Oxford Economics data

2.

Sector analysis

This chapter draws together the findings to give an overview of the potential scale of change and opportunity facing different industrial sectors.

Table 8 summarises the potential for disruption and mitigation in different industrial sectors in London. Orange indicates high potential for disruption, yellow medium and green low. For mitigation, orange indicates low potential for mitigation, yellow medium and green high. In summary, it shows:

- The potential for automation, based on Frey and Osborne’s occupational analysis, translated to the London workforce.
- The level of reliance on EU labour, which may be disrupted by the impact of Brexit.
- The exposure of low-waged sectors to changes in regulation or market conditions.
- The potential for growth in demand for particular occupations unlocked by automation and other factors.
- The existing skills levels, and the flexibility they represent.
- The strength of clusters in London, and the resilience to economic change that these embody.

There are a number of sectors which seem to face particularly intense disruption: **construction, retail, accommodation and food, and administrative and support services** are all relatively poorly paid and highly dependent on a migrant workforce – as well as offering high potential for automation. As Brexit approaches and pressure on pay mounts, it is relatively likely that automation will become more widespread in these areas – at least for those tasks where no “engineering bottlenecks” (the need for advanced dexterity, creative intelligence and social intelligence) are present. On occasion, this may require redefinition of tasks – for example, separating the manufacture of standardised housing units or components from their assembly on

Table 8: Potential disruptions and mitigatory factors in London, by sector

Industry sector	Disruptions		
	Automation	Migration	Wage
Manufacturing/production	High	Low	Low
Construction	High	High	Low
Wholesale and retail	High	Low	High
Transportation and storage	High	Low	Medium
Accommodation and food	High	High	High
Information and communication	Medium	Low	Medium
Financial and insurance	High	Low	Medium
Real estate	High	Medium	High
Professional, scientific and technical	Medium	Low	Medium
Administrative and support	High	High	High
Public administration, education and health	Medium	Low	Medium
Arts, entertainment and recreation	Medium	Medium	High

Industry sector	Mitigation		
	Demand	Skills	Cluster
Manufacturing/production	Medium	High	High
Construction	High	High	High
Wholesale and retail	High	High	High
Transportation and storage	High	High	High
Accommodation and food	High	High	High
Information and communication	Medium	Medium	Medium
Financial and insurance	Medium	Medium	Medium
Real estate	High	High	High
Professional, scientific and technical	High	Medium	Medium
Administrative and support	High	High	Medium
Public administration, education and health	Medium	Low	Low
Arts, entertainment and recreation	High	High	Medium

Source: Centre for London calculations based on OECD, International Monetary Fund, and UCL Institute of Education analyses.²⁰

complex and cluttered building sites. In construction, the issue may become acute more quickly, as the workforce is relatively aged: across the UK, around 20 per cent of construction workers are aged over 55.²⁴

That said, each of these sectors exhibits considerable variety within London, which cannot always be picked up through use of standardised statistics. While basic retail and food service functions are already being automated – as automatic tills and Internet shopping grow – London has a considerable concentration of specialist, often high-end traders and restaurants, where serving staff and shop assistants will not be as easily replaced as in fast-food chains, supermarkets or high street outlets.

In London's shops and restaurants, relatively high qualification levels may be attributable not only to graduates "trading down", but also the nature of work within the capital.

In other sectors, such as **arts, entertainment and recreation, and financial, professional and technical services**, the immediate potential for automation seems lower, while the potential for job growth seems higher and agglomeration effects seem more pronounced. However, there may be significant change within these sectors as more routine tasks are automated, enabling higher productivity and a shift of workforce to higher value-adding activities.

A special note of caution should be sounded with the **financial and insurance** sector. While the overall automation potential for people working in this sector is medium, some underlying occupations (especially associate professional roles) might be much more exposed, as future demand shifts to tech occupations rather than traditional finance professional roles. In 2000, more than 600 cash equity traders worked at Goldman Sachs's New York headquarters. These have since been replaced by automated programs supported by 200 computer engineers – and two equity traders. This may turn out to affect other activities in investment banking too: Goldman has identified 146 steps taken

in any initial public offering of shares, and “many are begging to be automated.”²⁵

Many **transport** occupations are associated with a particularly high risk of automation. At the same time, many jobs in this sector are relatively well paid and open to those who did not pursue further or higher education having left school. A sharp decrease in demand for these workers – if the speed of automation is as great as many expect it to be – may create a challenge on a similar scale to the decline of manufacturing employment in previous decades.

It is also worth bearing in mind that these disruption and mitigation factors have interdependencies, not only within but also between sectors. The interdependencies become clear when looking at the relationship between immigration, wages and automation. For example, higher barriers to immigration will reduce labour supply (particularly in low-wage occupations), potentially leading to higher wages (despite mixed results in research on this topic).²⁶ This might in turn encourage investment in capital to automate these jobs, but displaced workers moving to other sectors might then drive down wages there.

Conclusion and implications

Political and technological change are likely to transform London's economy in coming years. Businesses are already responding to these changes, and the economy as a whole is well-positioned to respond. But policy makers will need to focus on skills and automation, to avoid lower-skilled workers being marginalised by change.

London has proved astonishingly resilient in recent decades: it has adapted well to deindustrialisation, has led the transformation of financial and business services, has undergone a cultural resurgence, and is a primary hub for the global city economy.

This report's analysis indicates that London's economy will face significant disruption in coming years, as political and technological change combine to accelerate automation in many London sectors. But it also indicates that the city has the resilience and adaptability to thrive in a transformed economy.

Some sectors in London face big challenges. Sectors such as construction and administrative services are both highly automatable and highly dependent on EU labour. Wholesale and retail are less reliant on overseas labour, but more likely to face rising wage costs in coming years. Other areas, like the fast-growing accommodation and food sector, face all three disruptive factors. London's occupational and industrial structure means that it is slightly less prone to automation than the rest of the UK, which presents challenges in itself given the widespread concern about the UK economy being "unbalanced".

From many perspectives, automation should be welcomed: it has the potential to improve productivity, create new economic opportunities and free workers from the drudgery of routine production.

London's well-qualified workforce, its areas of economic specialisation and its global character should enable the city to take advantage of many of the opportunities that disruption may bring. Many employers are already seeking to adapt to the changing paradigms of work.

But we should not ignore the potentially negative impact, particularly on lower-skilled workers, who

could see significant losses of employment and earning potential. Supporting these workers and equipping them with the resilience and adaptability to grasp new opportunities will be essential for both fairness and prosperity in the London of the future.

Implications for businesses

Changing business models are not new. Of the 500 companies listed in the Forbes Fortune 500 index in 1995, only around 230 remained in the index in 2010.²⁷ In this respect, the impact of automation for incumbent businesses may not be significantly different from the impact of previous waves of change. But three factors suggest it could be different this time:

- **First, the structure of sectors is changing.** Many tech startups require high up-front investment in fixed costs (such as platform development and marketing), but then have very low marginal costs of scaling up the service: a new user to a ride-sharing app costs the company next to nothing, leading to significant returns to scale. Furthermore, many of these services require a large number of users to work effectively – think of Facebook, Uber and LinkedIn. A ride-sharing app with few users would not attract many drivers. These specific qualities of many digital services are often leading to concentration in one or a few firms, supported by the patient capital that will enable them to build critical mass.
- **Second, this has locational implications.** Much of the surplus value created by growth of such companies will accrue at their headquarters – which may be in Silicon Valley – rather than at a branch office. London has done well in developing its own thriving tech sector, and has proven an attractive location for regional head offices – but it will need to work to create and retain critical mass and to be aware of the potential impacts of regulatory changes.

- **Third, while automation will create new jobs, there is a difference in scale from their industrial era predecessors.** Digital businesses need fewer employees to generate a large turnover than traditional industry often required. In 1962, when their annual sales surpassed \$1 billion, Kodak Eastman employed 75,000 people in production sites across the world. When Facebook passed \$8 billion, today's equivalent of this threshold, it employed only around 6,300 people.²⁸

As part of the research for this project, we held two roundtable discussions with business leaders in transport, catering, business services, financial services, and recruitment. The paragraphs below set out some of the emerging responses to the challenges discussed.

Diversifying products

Many businesses are reacting to these challenges by increasing variety in their range of products and services. Consumers are more demanding, forming discrete "taste tribes" or lifestyle groups, and creating markets for bespoke products – from artisanal coffees and specialist exercise classes to new social networks. Firms are reacting to this by offering more product variety and personalisation. This diversification creates a degree of resilience to automation: instead of standardising products and services to be produced at scale by machines, high-specification products can be designed and tailored to meet the needs of a very diverse customer base, and are then produced using a range of artisanal and highly automated technologies.

Moving up the value chain

Firms are also seeking to confront the challenges that new entrants might bring to their business, and to shift their focus as they adopt new technologies. In our roundtables, participants referred to this as “moving up the value chain”. Routine brokerage, transactional or information services – such as property search, audit and legal research – can be replaced by more tailored consultancy support, responding to client needs more precisely and holistically, and adding more value as a result.

Smaller can be nimbler

Many businesses are benefiting from automation – even if they are not operating at scales where in-house or on-site automation would be economically or technically feasible. Restaurants are using more outsourced food preparation, enabling efficiencies in staffing and space requirements on-site. Off-site precision manufacture using a mix of automated and manual processes is already taking place in construction, enabling developers to buy more or less completed products rather than having to project-manage the range of contractors involved in traditional construction.

From deep knowledge to broad skills

With this increase in product and service differentiation, the need arises for a redesign of product, production methods, and the occupations involved. As many of the activities within traditional occupations are automated, employers will focus on abilities that are specific to humans, including social intelligence, creative intelligence and high manual dexterity in unstructured environments.

This may mean less focus on the traditional “deep” expertise of professional specialisations – detailed

legal knowledge, or surveying and engineering skills – and more focus on broader transferable skills such as interpersonal relations, creative-problem solving, and project management. This in turn has implications for recruitment and professional development, and even for the traditional conception of “the professions”.

Implications for workers

Automation and other factors seem set to benefit educated workers – or those with specific dexterity and social skills. Three potential lessons can be drawn:

1—First, meta-learning abilities will be very important as they add resilience to people’s working life. They enable workers to develop an understanding of their own resources, skills, weaknesses, and external opportunities in the labour market. They also promote people’s ability to direct their own learning, take advantage of new opportunities, and adapt to changes in the labour market over time.

2—Secondly, social and creative intelligence will be in high demand. This is a result not only of how difficult these skills are to automate, but also of changes in business models – from sale of expertise and access to markets to value-adding consultancy and differentiation of products to satisfy diverse clients and consumers.

3—Third, it appears that routine cognitive work will be in lower demand: advances in artificial intelligence, especially around data mining, will render many of the activities automatable.

Career choices also matter. There is nothing wrong in training for a specific trade or profession, as long as there is also an expectation of change. The secretarial and administrative occupations that looked like solid middle-class employment 50 years ago are rapidly disappearing, and bookkeeping and accountancy jobs may follow them.

At the same time, demand for personal fitness instructors, care workers and designers may grow. It would be rash to predict with any confidence how the labour market will change over a working lifetime, so we will all need to be ready to continue learning and adapting.

Implications for policy

Skills

While automation may affect more middle-class administrative and associate professional occupations, the workers likely to be most negatively affected are those in the lowest-paid, lowest-skilled and most precarious jobs. High qualification profiles in London should help ensure adaptability, but the previous discussion of skills levels indicates that further attention should be paid to cognitive skills and ways of learning, as well as to academic attainment.

As noted above, technological change does not just impact the **level** but also the **type** of skills needed. Frey and Osborne argue that

*“as technology races ahead, low-skill workers will reallocate to tasks that are non-susceptible to computerisation – i.e., tasks requiring creative and social intelligence. For workers to win the race, however, they will have to acquire creative and social skills.”*²⁹

There also seems to be a greater role for more generic and transferable skills: some of the businesses we spoke to suggested that automation meant their skills needs were changing. Rather than needing specialist professionals with deep knowledge of their subject (from law to coding), their services required people with skills such as “project management” or “customer service”. These were often the skills they found were in shortest supply.

A new focus on cognitive skills, creative problem solving and social skills will be required to enable Londoners to benefit from the advantages offered

as London's economy changes. Improvements in the education and skills system will enable London to capture opportunities arising from automation and mitigate difficulties stemming from tighter controls on international migration.

As cognitive skills have been shown to be particularly associated with economic growth, the question remains: what enables a country or city to develop a high cognitive skills base? Research indicates that one factor distinguishing high-performing countries in international school education studies is the recruitment of top graduates into the teaching profession. In Singapore, Korea and Finland teachers are recruited from the top one-third of graduates measured by performance.³⁰ In the UK, however, with a formidable teacher shortage looming, especially in outer London, recruiting top graduates into the profession appears to be a particular challenge.

Social inclusion

In the past, the fruits of the huge productivity increases experienced since the advent of the Industrial Revolution were shared between employers and workers – especially during the height of mass production before 1973. However, in the second machine age, Brynjolfsson and McAfee argue, the growth in productivity has been decoupled from jobs and income. And this divergence has its roots not in tax codes or labour law, but in the “very nature of the digital economy, in which a set of goods and services can be provided to an infinite number of additional customers, all at the same time, at a cost that is often close to zero”.³¹

Productivity may continue to grow, therefore, but its fruits may not be shared widely, particularly with workers who struggle to adapt to changing economic circumstances. Therefore, in the longer term, more radical solutions may need to be debated and considered. These might include rethinking the working week or providing a universal basic income for a world where automation leads to lower employment levels.

Immigration

As many economic sectors in London are highly dependent on immigration, positive immigration strategies will be critical in helping London attract and retain the skills necessary to capitalise on the opportunities unlocked by technological change.

Regulation

Besides labour costs and management practices, regulation is one of the major factors determining the scope and extent of adoption of technology by businesses. In sectors such as transport, debates about the extent to which public authorities should seek to constrain growth of new technology-enabled services are already intense.

Setting out a clear framework for regulation of innovative sectors that intelligently balances the interests of innovators, consumers and workers will be essential if London is to be at the forefront of innovation – and the economic and employment growth that this unlocks.

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London is a leading global centre for finance and business services, cultural industries, higher education and tech, and an economic dynamo within the UK. But times are changing: the growth of automation, Brexit and wage pressures are set to shake up labour markets in London and beyond. How will London fare against this backdrop of disruptive change? Human Capital brings together data on these factors, and on the skills and specialisms that could give Londoners resilience in uncertain times, and enable them to capture new opportunities.

Looking at the impact on different sectors and occupational groups, the report highlights the ways in which businesses are already adapting to change, identifies implications for policy on skills, immigration and regulation, and looks at what longer-term action might be needed to ensure fairness and prosperity.

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