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**Trends Analysis**

# Future Shocks and Shifts: Challenges for the Global Workforce and Skills Development

**OECD EDUCATION 2030**
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# FUTURE SHOCKS AND SHIFTS: CHALLENGES FOR THE GLOBAL WORKFORCE AND SKILLS DEVELOPMENT

**Key messages**

1. This report presents evidence on the expanding scope of automation. After three decades of a secular decline in middle-income jobs, the bulk of low-skilled and low-income workers are now for the first time susceptible to computerization. Meanwhile, skilled jobs remain relatively resilient to recent trends in technology. In particular, workers with extraordinary social and creative skills will still remain in the workforce in 2030.

2. As technology replaces old work, new jobs are being created. Occupations such as nanotechnology engineers, solar energy engineers, web developers, and biostatisticians, have all recently emerged. To adapt, the workforce of 2030 will require more technical skills, such as the ability to design and develop new theories that form the basis for advancements in a discipline, and applications.

3. While more investment in digital skills will be needed, a combination of skillsets that make workers adaptable to technological change will be even more important. In particular, educational efforts should focus on fusion skills—that is, the combination of creative, entrepreneurial and technical skills—allowing workers to shift into new occupations as they emerge.

4. The recent surge in income inequality has led to inequality of opportunity. Investments to broadly improve skills development for children at an early stage are thus not only likely to pay long-term dividends in terms of productivity gains, but would also contribute to a more equal distribution of skills, in turn making incomes more uniform and boosting upward mobility. In particular, as socio-emotional and cognitive skills reinforce each other and shape children’s future skills development, investments in such skills during the school years will be of crucial importance.

5. Demographic shifts are fundamentally changing the demand for skills. A shrinking workforce and an aging population will require increasing adaptability for people to be able to work later in life. The ability to constantly acquire new skills and knowledge provides a central challenge for the workforce.

6. Aging populations will also make socio-emotional skills such as caring, sociability and respect more important. A wide range of emerging occupations, including acute care nurses, informatics nurse specialists, geneticists and hospitalists, speak to the growing demand for such skills.

7. We find that younger workers are more likely to be observed in new work and tend to cluster in skilled cities. On average, cities with a younger workforce are also more innovative. If fewer people work, the workforce will have to become even more innovative to avoid stagnation. Teaching entrepreneurial skills will be essential to avoid stagnation.

## 1. Introduction

8. The global economy is arguably currently going through more rapid change than at any other time since the Industrial Revolution.[1] New technologies are being adopted faster than they have in the past: while it took 119 years for the spindle to diffuse outside Europe, for example, the Internet has spread across the globe in only seven years.[2] At the same time, surging carbon emissions are putting pressure on nations and their workforces to innovate and develop new and cheaper sources of clean energy. The polarization of labor markets has made industrial economies more unequal, not just in terms of outcomes, but has also contributed to growing inequality of opportunity. Urbanization in general, and the clustering of talent in skilled cities in particular, has further exacerbated this trend, making entire cities and regions obsolete while boosting innovation and incomes in skilled locations. Meanwhile, aging populations and a shrinking labor force in the industrial world will put pressure on workers to become more productive, while increasing the demand for health care and the retraining of workers later in life. In this paper, we examine how these trends will transform today's workforce up until 2030, and the skills workers will have to acquire in order to adapt.

9. The remainder of this paper is structured as follows. First, we examine how technology is transforming the occupational structure of labor markets. Doing so, we identify the types of skills that are unlikely to be replaced by technologies before 2030, and the types of new jobs and skills we expect will emerge. Second, we analyze the implications of recent technology shocks for trends in inequality. Building on past studies showing that investment in human capital is an important force of convergence[3], we identify skills that are essential to combat the surge in inequality. Third, we consider the impact of demographic shifts and urbanization on the workforce. In particular, we explore the implications of an aging population and the clustering of young workers in skilled cities. Finally, we derive some conclusions and implications for policy.

## 2. Digital Disruption: The Future of Technology and Skills

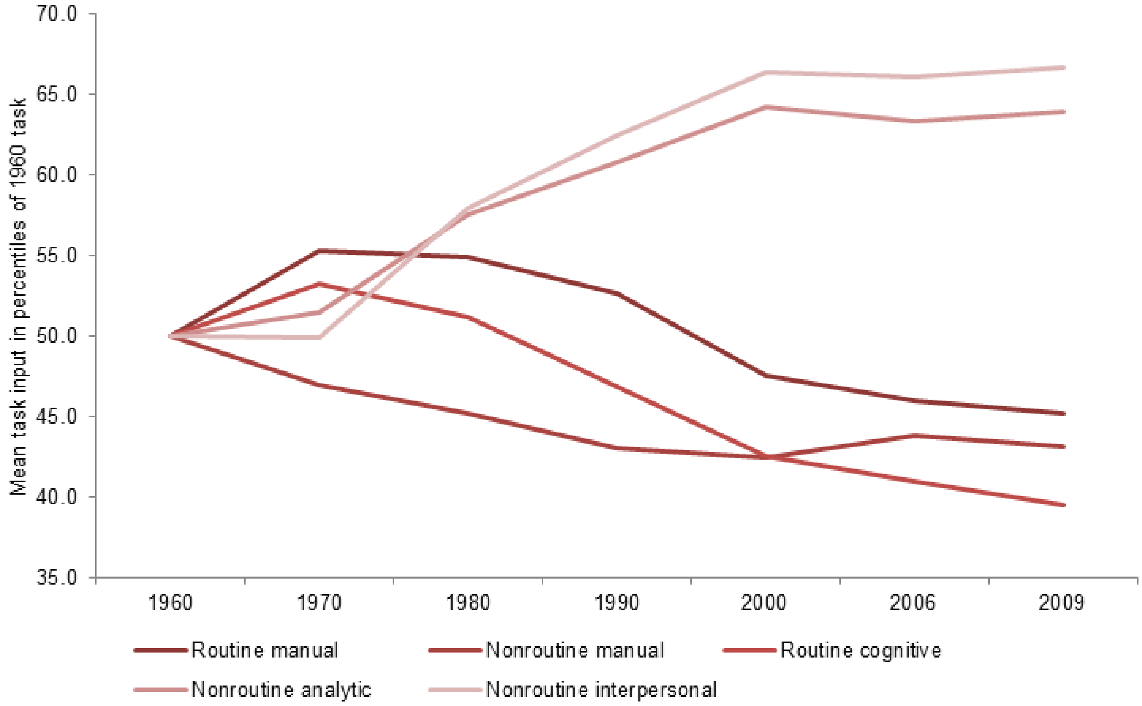
### *2.1 Skills in an Age of Computers*

10. Over recent decades, computer-controlled equipment has replaced workers in a wide range of jobs that consisting of routine work—that is, tasks that follow well-defined procedures that can easily be expressed in computer code. As shown in Figure 2.1, most routine work such as repetitive calculating, typing or sorting, as well as production tasks that revolve around performing repetitive motions, have been automated away since the early 1980s. At the same time, starting in the late 1970s, the demand for non-routine interpersonal and analytical skills increased dramatically. The explanation is straightforward: as computer technologies have displaced labor in routine tasks, they have also created new employment opportunities for workers with non-routine social and cognitive abilities.

[1] Frey & Osborne (2015).
[2] Comin and Hobjin (2010).
[3] Glaeser et al. (2004).

**Figure 1. The task content of employment**

1960 - 2009




*Notes*: This figure shows how the task composition performed by US workers has changed between 1960 and 2009.
*Sources*: OECD (2013) and Autor & Price (2013).

11. The scope of automation has however recently expanded, and will inevitably continue to expand. By turning complex tasks into well-defined problems, many tasks that we used to characterize as non-routine are today automatable. A decade ago, for example, Frank Levy and Richard Murnane predicted that mimicking the subtleties of human perception—a then non-routine task—would be nearly impossible, so that a computer would never be able to navigate a car without human input.[4] Yet in 2011, Google proved the feasibility of automated vehicles and today major car manufacturers such as GM and Toyota have built near-autonomous vehicles that are still improving by the day.

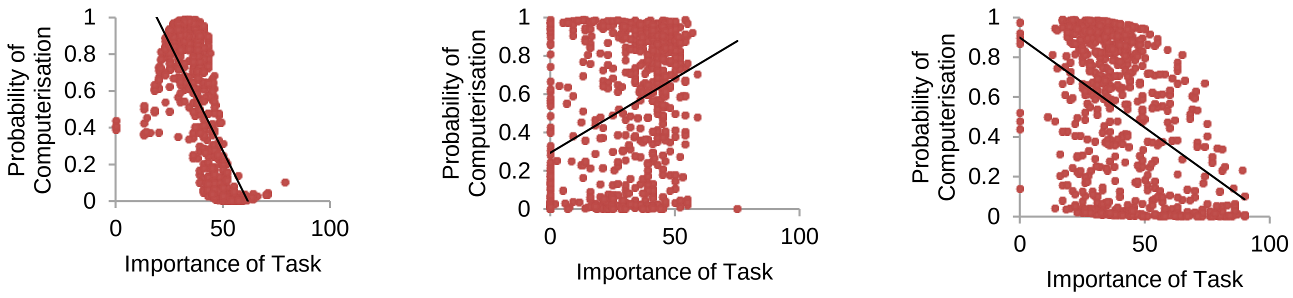
12. This is not an isolated example. In a wide range of industries, technological breakthroughs are already pervasively transforming labor markets. Take the example of health care where IBM's Watson computer has been retrained as a doctor. With access to two million pages of text from medical journals, 600,000 medical evidence reports and 1.5 million clinical trials and patient records, Watson can reference a patient's symptoms against her genetics and medical history to identify the treatment with the highest probability of success.[5] Following these developments, a computer was recently able to identify potential

4 Levy & Murnane (2004).
5 Cohn (2013).

drug candidates and identify those that potentially can treat diseases.[6] Furthermore, while a human chemist can screen some 10-20 chemicals in a year, a computer can screen 10,000 in a single day.

13. Advances in additive manufacturing, biotech and nanotechnology will similarly transform a wide range of processes in development, design and production. Meanwhile, commercial service robots are becoming better at performing complex tasks in commercial cleaning, health care and food preparation, and are already able to perform simpler household services.[7] Many workers in administrative and office support occupations will also be made redundant as algorithms become more efficient at handling tasks that revolve around accessing or storing information. Finally, a wide range of jobs in transportation and logistics are at risk, reflecting the development of autonomous vehicles and cheaper sensors. Taken together, such advances will profoundly affect the demand for skills by 2030.

**Figure 2. What tasks are susceptible to computerisation?**




(a) Originality (b) Manual dexterity (c) Assisting and caring for others

*Notes*: These figures show how the probability that an occupation susceptible to computerisation over the next two decades against the importance of different types of tasks for 702 US occupations.[8]
*Source*: Frey & Osborne (2013).

14. The implications of recent trends in technology are shown by Frey & Osborne (2013) predicting that 47% of US jobs are at "high risk" of automation over the next decade or two.[9] A similar share of jobs is at risk in other industrial economies, although poorer countries are generally more exposed due to their relatively high shares of employment in low-skill jobs.[10] The critical question is therefore: what type of skills will still be in demand by 2030? The study conducted by Frey& Osborne (2013) sheds some light on this. Workers in jobs that require originality—that is, "the ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem"—are substantially less

6 Williams (2015).

7 Robotics-VO (2013); MGI (2013).

8 This includes occupations in Management, Business, and Financial; Computer, Engineering, and Science; Education, Legal, Community Service, Arts, and Media; Healthcare Practitioners and Technical; Service and Sales; Office and Administrative Support; Farming, Fishing, and Forestry; Construction and Extraction; Installation, Maintenance, and Repair, Production; Transportation and Material Moving.

9 Frey & Osborne (2013).

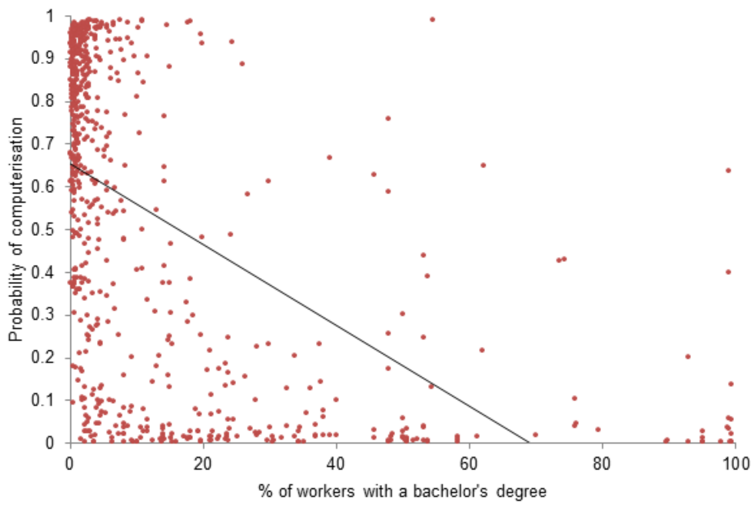
10 See, for example, Bowles (2014) that apply the estimates of Frey & Osborne (2013) to employment data for the EU28.

likely to see themselves replaced by computer-controlled equipment, reflecting the current limitations of automation (Figure 2.2a). Art Directors, Fashion Designers and Microbiologists are thus unlikely to be out of work soon. Furthermore, although a wide range of low-skill production, sales and service jobs are likely to be displaced, some relatively simple tasks, such as assisting and caring for others, are unlikely to be automated (Figure 2.2c), while workers that perform tasks that require manual dexterity, such as iron and steel workers or aircraft mechanics, are more likely to be displaced (Figure 2.2b). In other words, although computers are making inroads to domains previously confined to human workers, they are unlikely to replace jobs that require complex social interactions, such as persuasion and negotiation, as well as creative work involving the creation of new ideas and knowledge of human heuristics. Thus, in order to adapt to recent trends in technology workers will have to acquire creative and social skills.

### *2.2 Technology and Skills in 2030: A Digital Divide?*

15. While the past three decades have witnessed a decline in mid-skill jobs, computer technologies are most likely to displace low-skill jobs over the next decade. As shown in Figure 2.3, occupations where most workers do not have a bachelor's degree are substantially more likely to be automated. The implications of this shift will be profound: as many of the safe havens for low-skill workers are likely to disappear, a broad educational upgrading of the workforce will be essential by 2030.

**Figure 3. Educated workers are less likely to be displaced**

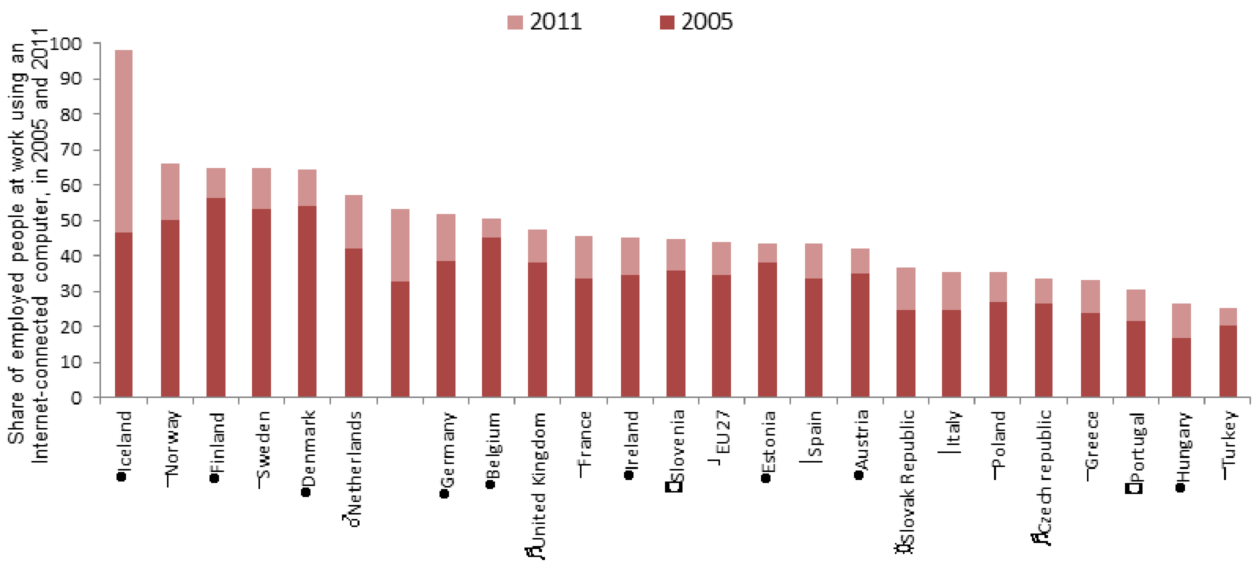



*Notes*: This figure shows the probability that an occupation will be feasible to computerise within the next two decades against the share of workers with a bachelor's degree in 702 US occupations.[11]
*Source*: Frey & Osborne (2013).

[11] This includes occupations in Management, Business, and Financial; Computer, Engineering, and Science; Education, Legal, Community Service, Arts, and Media; Healthcare Practitioners and Technical; Service and Sales; Office and Administrative Support; Farming, Fishing, and Forestry; Construction and Extraction; Installation, Maintenance, and Repair, Production; Transportation and Material Moving.

16. In particular, as digital technologies are adopted in the workplace, acquiring and maintaining a portfolio of digital skills will become increasingly important for the vast majority of workers (Figure 2.4). A crucial task for governments across the OECD is therefore to meet the growing demand for digital or ICT-related skills. Since the IT revolution of the 1990s, most OECD countries have witnessed the share of ICT employment increase, with some exceptions, including Austria, Ireland and the US.[12] Predictions by the OECD further suggest that employment in ICT industries will continue to increase as advances in 'smart-grid' technology reshapes the management of energy systems, infrastructure and transportation.[13] According to the European Commission, the demand for workers with specialist digital skills is already growing by about 4% each year.[14]

**Figure 4. Digital technology is becoming increasingly common in the workplace**

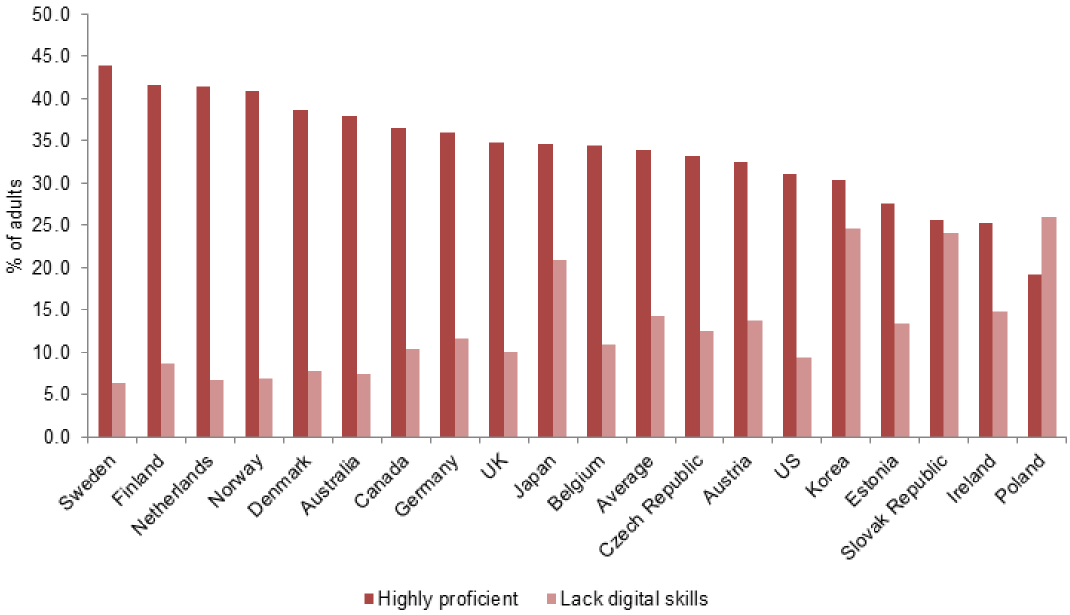



*Notes*: This figure shows the share of employed people at work using an Internet-connected computer, in 2005 and 2011.
*Source:* OECD (2013c).

17. While the demand for digital skills is projected to increase by 2030, there are signs that there will be a shortage of such skills. According to a recent Capgemini survey as many as 77% of firms consider the lack of digital skills a barrier to their digital transformation, and by 2020 there may be as much as 900,000 vacancies in ICT jobs according to estimates by the European Commission.[15] Globally, according to the most recent Manpower Talent Shortage Survey, specialist ICT workers—particularly programmers and developers—are some of the hardest jobs to find suitable employees for.[16]

[12] OECD (2015a).
[13] OECD (2013b).
[14] European Commission (2014).
[15] Capgemini (2013).
16 Manpower (2014).

**Figure 5. Digital skills vary widely across countries**




*Notes*: This figure shows the % of adults in the OECD's Survey of Adult Skills that were highly proficient at problem solving in technology-rich environments (scored at Level 2 and 3) and the percentage that lacked digital skills (failed the ICT core test).
*Source*: OECD (2013a).

18. At the same time, however, many OECD countries have seen the share of graduates in science, technology, engineering and mathematics (STEM) fields stagnate or decline. Although ICT industries employ a third of all business sector researchers, less than 3% of tertiary graduates are in the field of computer sciences.[17] In 2013, more than 60% of European workers reported that their digital skills were insufficient to apply for a new job.[18] A non-negligible share of workers even lack the most basic digital skills: 4.9% of workers in the OECD's Survey of Adult Skills failed to perform fundamental tasks such as scrolling through a web page or using a mouse, although there are substantial cross-country differences (Figure 2.4). In Italy, Korea and Spain nearly one in four adults fail to perform such elementary digital tasks, while less than 7% of Norwegians or Swedes lack basic digital skills.[19]

19. For workers without these basic digital skills, such as the ability to use standard computer software, navigate the internet and conduct basic programming, it will be difficult to adapt to the rapid pace of change. Over the past three years, about 30% of workers in the OECD report that new processes or technologies were introduced at their workplaces.[20] As the workplace continues to undergo substantial restructuring in response to new technologies becoming available, many skills will rapidly become outdated. For example, coding skills tend to be made obsolete only in a few years' time, and according to a recent study by European Centre for the Development of Vocational Training, 16% of workers in

17 OECD (2014a).
18 OECD (2014a).
19 OECD (2013a).
20 OECD (2013a).

Germany, Hungary, the Netherlands and Finland have seen their skills made obsolete in the last two years: digital and ICT-related skills were also identified as critical skill sets that are particularly rapidly outdated.[21]

20. Thus, to remain competitive, workers will constantly need to acquire new skills, requiring flexibility, an attitude towards life-long and life-wide learning, and curiosity. Modular approaches to education that allow workers to constantly update their digital skills portfolio will be crucial to meet the rising demand by 2030. At the same time, workers would do well in not acquiring to narrow skill sets that will eventually become obsolete. While ICT specialists will be needed, a combination of skillsets that make workers adaptable to technological change will be even more important. As we will argue throughout this paper, educational efforts should to focus on fusion skills—that is, the combination of creative, entrepreneurial and technical skills—allowing workers to shift into new occupations as they emerge.

### *2.3 New and Emerging Occupations*

21. A central concern is whether new job creation will be sufficient to replace the many employment opportunities that have recently disappeared. ICT employment in the OECD, for example, has yet to recover to its 2001 peak of 4.1% of total employment.[22] Although high-tech employment has grown and spread across Europe over the past decade, only about 10% of workers in the EU-27 are employed in high-tech industries.[23]

22. Job creation in new occupations and industries has been even sparser: according to our estimates about 0.5% of US workers are employed in tech industries that have been created since the turn of the century.[24] While Kodak employed some 145,000 workers at its peak, with many more employed indirectly as subcontractors and retailers; Instagram employed 15 people in 2010 and was acquired by Facebook for $1 billion two years later. One explanation for the sluggish rate of job creation is the low investment demand associated with tech startups: in the digital economy only few workers are needed to build up the capital that allows companies to reach global markets.[25]

23. Nevertheless, computer technologies have created a wide range of new occupations in the past. Following the Computer Revolution of the 1980s, about 1,500 new job titles appeared in the US labor market, many resulting directly from new technologies: jobs such as web designers, database administrators and software engineers, for example, were created as a direct result of the introduction and diffusion of the personal computer and the World Wide Web. [26] More recently, several new job titles have also emerged as a result of advances in nanotechnology, medicine and robotics (Table 2.1). Furthermore, advances in green technology has increased the demand for chemical engineers, electricians and zoologist, and created a range of entirely new occupations, including biomass plant technicians, carbon trading analysts and solar photovoltaic installers.

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21 Cedefop (2012).
22 OECD (2014a).
23 Goos et al. (2013).
24 Berger & Frey (2014b).
25 Frey (2015a).
26 Lin (2011).

**Figure 6. Examples of New and Emerging Jobs**

| Occupation | Description | Examples of Skills | Examples of Knowledge | Example of Attitudes and Values |
|---|---|---|---|---|
| Robotics Engineers | Research, design, develop, or test robotic applications. | Critical Thinking; Complex Problem Solving, Quality Control Analysis. | Engineering and Technology, Robotics, Design. | Exploration; precision; observation |
| Biostatisticians | Develop and apply biostatistical theory and methods to the study of life sciences. | Inductive Reasoning, Oral Expression; Mathematical Reasoning. | Mathematics, English Language, Education and Training. | Project/program management, execution, inquisitiveness. |
| Fuel Cell Engineers | Design, evaluate, modify, or construct fuel cell components or systems for transportation, stationary, or portable applications. | Judgment and Decision Making, Writing, Critical Thinking. | Physics, Mathematics, Chemistry. | Focus, reliability; feedback. |
| Solar Sales Representatives and Assessors | Contact new or existing customers to determine their Solar equipment needs, Suggest Systems or equipment, or estimate costs. | Active Listening, Persuasion, Social Perceptiveness. | Sales and Marketing, Engineering and Technology; Customer and Personal Service. | Accountability; focus, results orientation. |
| Video Game Designers | Design core features of video games. Specify innovative game and role-play mechanics, Story lines, and character biographies. Create and maintain design documentation. Guide and collaborate with production staff to produce games as designed. | Programming, Critical Thinking, Complex Problem Solving. | Design; Communications and Media, Psychology. | Inquisitiveness, playfulness, passion. |

*Source*: O*NET (http://www.onetonline.org/find/bright?b=3&g=Go)

24. Thus, most new jobs have one thing in common: they are substantially more skilled than jobs of the past. While this is a trend that has been going on for several decades (Figure 2.1), many new jobs now even require an advanced degree.[27] Among Biostatisticians 48% of the workers surveyed responded that their job required at least a doctoral degree. In addition, many of these jobs also require both creative and technical skills. Core work activities for a Robotics Engineer, for example, include thinking creatively and two central skill requirements are critical thinking and complex problem solving.

## 3. Mind the Gap: The Future of Inequality

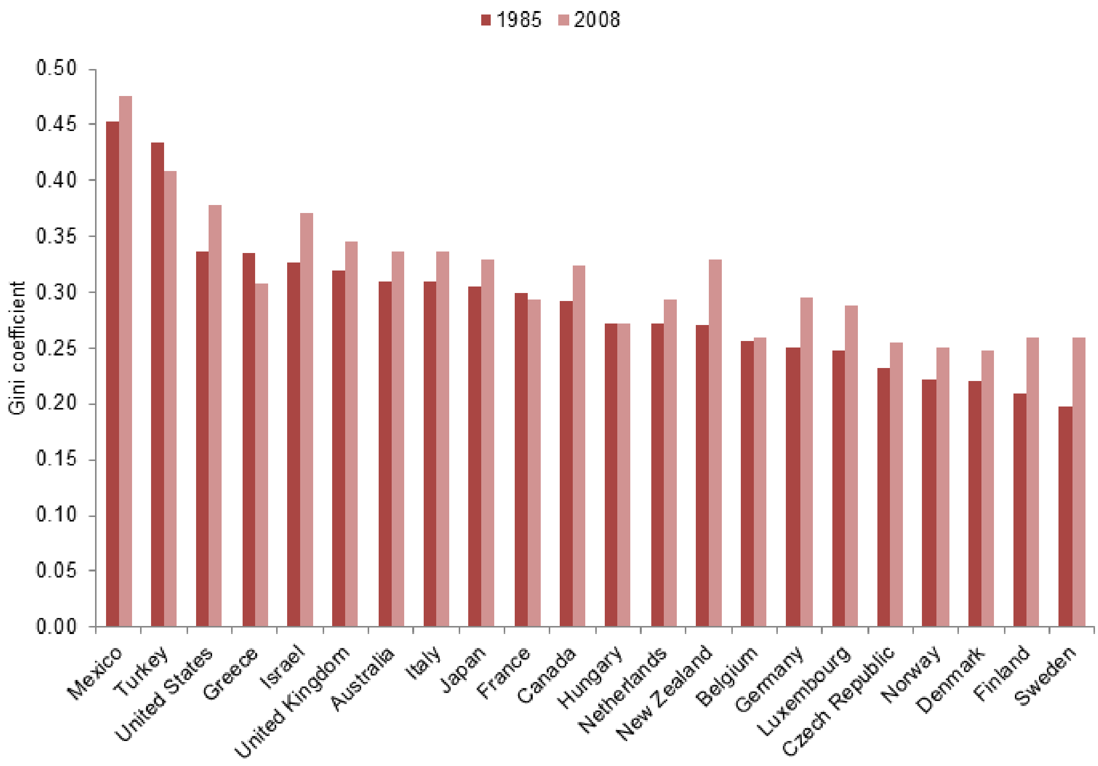
### *3.1 Inequality Among the 99%*

25. In tandem with rapid technological progress, most OECD countries have experienced a rise in income inequality (Figure 3.1).[28] In particular, as the price of computing has fallen, problem-solving skills—where college educated workers have a comparative advantage—have become relatively more productive, explaining the growing return to education. In the US, for example, the college premium

27 Berger & Frey (2014a). In addition, studies have shown that almost the entire increase in the return to education reflect an increase in returns to cognitive skills (Ingram & Neuman 2006).
28 Acemoglu (2002); Goldin & Katz (2009).

started increasing in the late 1970s around the same time as the personal computer was introduced: about two-thirds of the increase in wage inequality is explained by higher returns to education.[29]

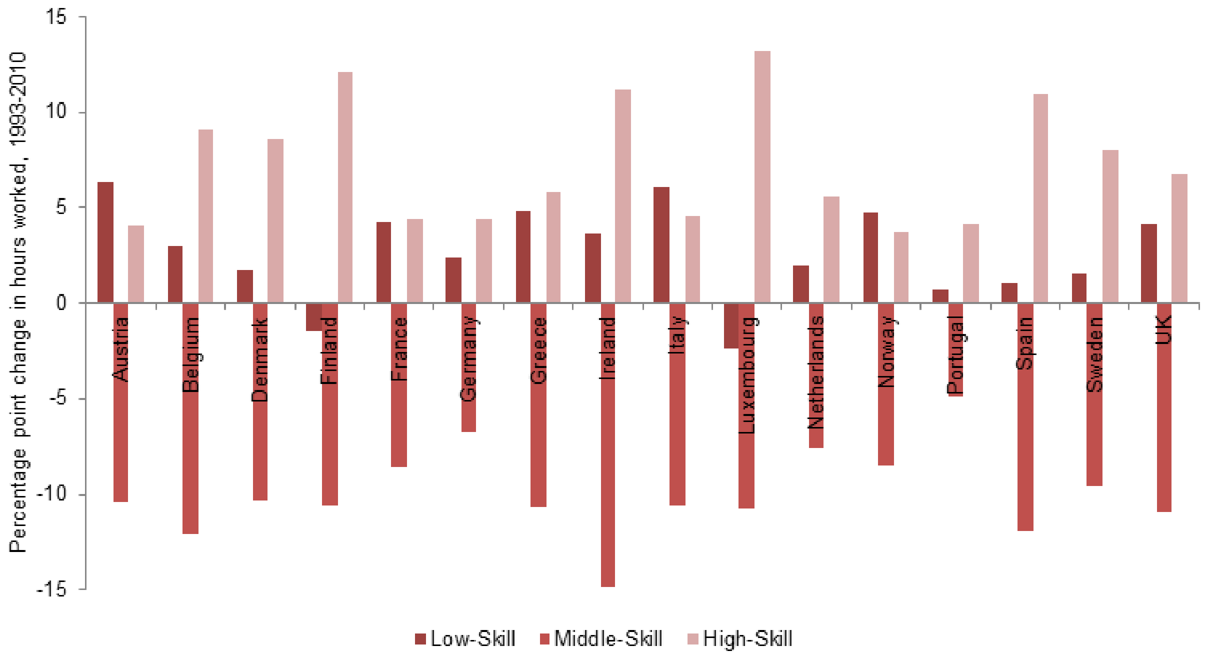
**Figure 7. Inequality has increased in most OECD countries**




*Source*: OECD (2013c).

29 Nevertheless, skill premiums vary substantially across countries. While the Czech Republic and Sweden has a premium below 13%; Germany, Spain and the United Kingdom exhibit premiums of more than 20% (Autor, 2014).

**Figure 8. European labor markets have polarized**




*Notes*: This figure shows percentage point changes in hours worked in low-, mid- and high-skill occupations in 16 European countries between 1993 and 2010.
*Source:* Goos et al. (2014).

26. Although skill-biased technological change can explain the growing demand for educated workers, it is silent on an important feature of most labor markets in the OECD: job polarization. As has been persuasively shown by Autor et al. (2003), however, computer technologies have also displaced workers in a wide range of routine work, including many clerking and manufacturing jobs—work that is typically concentrated at the middle of the income distribution. Accompanied with employment growth both at the top and bottom of the skill and income distribution, the automation of routine work has contributed to a hollowing-out of labor markets across the industrial world.[30] As documented in Figure 3.2, the share of hours worked in middle-income occupations has declined in all 16 European countries between 1993 and 2010, while jobs at the top and bottom of the wage distribution have experienced rapid employment growth. Furthermore, studies of the US, Japan and Europe show that industries that implemented ICT also shifted the demand from middle-educated workers to skilled workers, with technology accounting for about a quarter of these shifts.[31]

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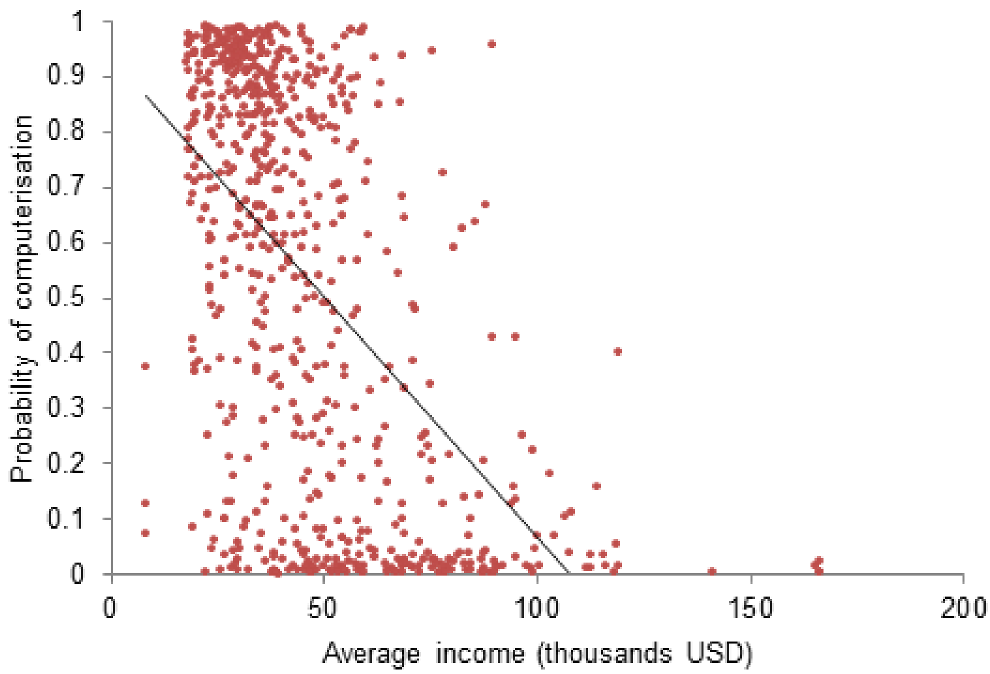
30 Autor et al. (2003); Goos & Manning (2007); Goos et al. (2009); Autor & Dorn (2013).
31 Michaels et al. (2014).

**Figure 9. Low-income jobs are more likely to be computerised**




*Source:* Frey & Osborne (2013)

27. The future of income inequality will thus largely be determined by the direction of technological change. As low-income and low-skill workers are now for the first time at risk of automation (Figures 2.3 and 3.3), while new and emerging occupations are largely confined to skilled workers, the recent surge in inequality is likely to further be exacerbated. To avoid such an outcome, governments will need to manage the reallocation of workers from existing low- and middle-skilled jobs to relatively skilled emerging occupations. Unless investments are made into skills development to allow workers to shift into new employment opportunities, income inequality among the 99% is likely to continue to increase through 2030, as an increasing scope of low-skilled jobs are at risk of being displaced.

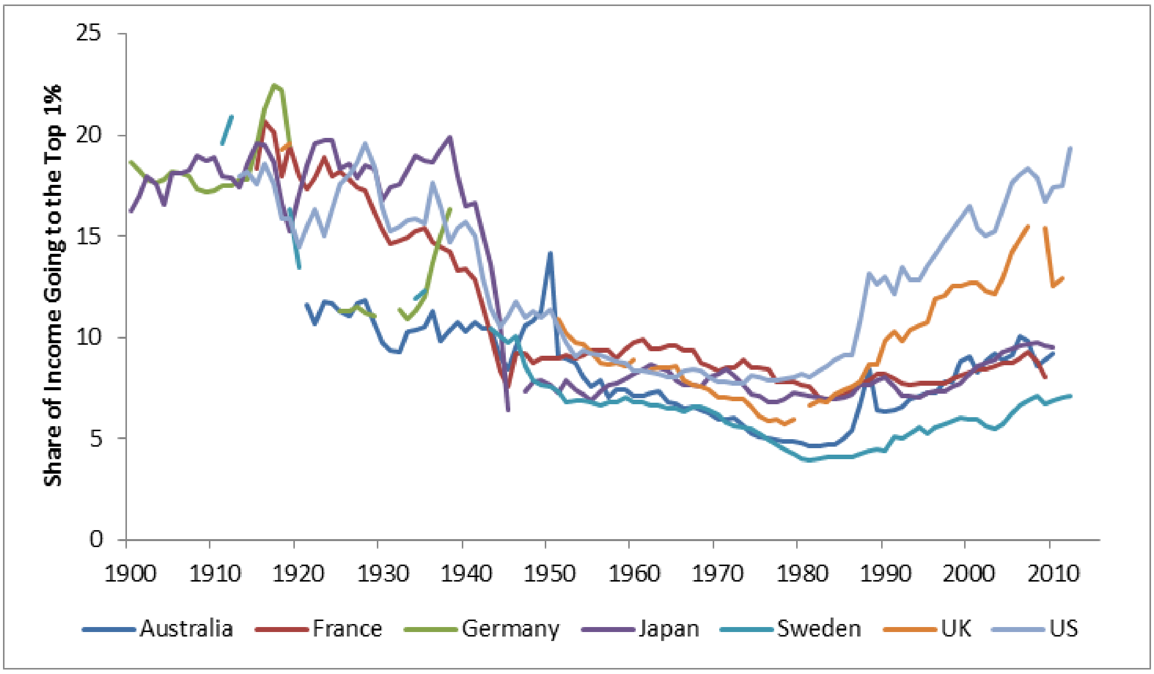
### *3.2 The Top 1% and the Labor Share of Income*

28. The top-1% has become the theme of the 21st century.[32] While the first half of the 20th century witnessed a sharp decline in the share of GDP accruing to the top-1%, the convergence between the top-1% and the 99% came to a halt during the 1950s (Figure 3.4). More recently, this process reversed with an increasing fraction of incomes accruing to the top-1%. In virtually all countries, the top-1% income share has increased dramatically since the early 1980s, coinciding with the liberalization of financial markets, a decline in marginal tax rates, as well as the dawn of the computer revolution. In the United States this trend

32 Piketty (2014).

has been the most pronounced: between the late 1970s and 2012, the top percentile of US households more than doubled their share of national income from 10.0% to 22.5%.[33]

**Figure 10. The top 1%**




*Source:* Alvaredo, F., A. B. Atkinson, T. Piketty and E. Saez, The World Top Incomes Database, http://topincomes.g-mond.parisschoolofeconomics.eu/. Accessed: 2015-03-19. Data excludes capital gains and is measured as a percentage of total income.

29. While the impact of technology on inequality among the 99% is evident, the link between technology and the concentration of income among the 1% is less clear. A commonly held view however is that globalization and technological advances together have created a 'winner-take-all' economy, where reduced barriers to trade and an increasingly digitized economy allows leading firms and entrepreneurs to capture the entire market. For example, as has been pointed out by Brynjolfsson et al. (2014): "digital copies can be made at virtually zero cost and transmitted anywhere in the world almost instantaneously, each an exact replica of the original." This feature of the digital economy, allows companies like Twitch, a live streaming video platform, to employ some 170 workers, while serving the world market.

30. At the same time, a growing body of work has pointed at digital technologies as a key driver behind the declining labor share of GDP across the industrial world.[34] Crucially, as companies are becoming increasingly automated, gains in productivity have not translated into wage growth, but have shifted incomes from labor to owners of capital. According to a recent study, 42 out of the 59 countries examined experienced a decline in the share of GDP accruing to labor over recent decades, mainly as a

33 Autor (2014).

34 Furthermore, between 2000 and 2011, revenues of internet firms in the OECD grew by 30%; while employment expanded by 15% (OECD, 2013b).

result of cheaper technologies becoming available[35] Estimates by the OECD even suggests about 80% of the drop in the labor share is accounted for by reductions in the price of computerized equipment and robots, creating incentives for firms to replace workers with machines.[36]

31. As incomes have been shifted from workers to capital owners, wealth inequality has also soared. In the US, for example, the wealth share of the 160,000 families that constitute the top 0.1% more than tripled between 1979 and 2012, from 7% to 22%.[37] Similarly, over the past decade, the combined net worth of the 400 richest Americans has more than doubled, from $2.5 to $5.7 trillion, according to Forbes Magazine. As the price of robots is expected to decline further, there are good reasons to believe that the labor share of GDP will continue to fall over the decades leading up to 2030. Thus, in the absence of other shocks or policy interventions, owners of capital are likely to capture a growing share of GDP.

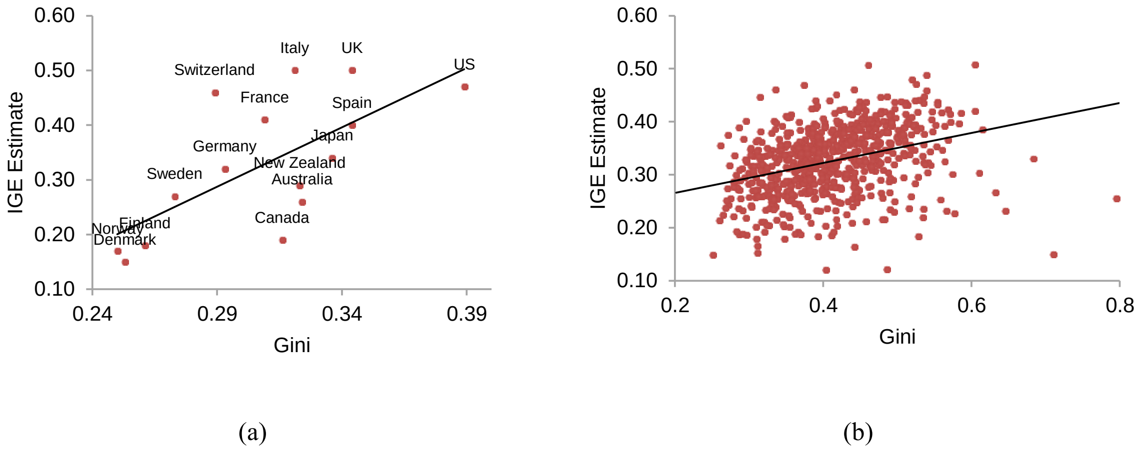
32. Nevertheless, while digital technologies are likely to continue substituting for an even broader range of workers, technological progress may also help boost the labor share of GDP as workers acquire skills that are complementary to the technologies that are being developed. For example, while registered nurses in the United States earn on average 66,220 USD per year, informatics nurse specialists, focused on the design and implementation of computerized health care systems, earn 81,190 USD annually. Investments into skills that complement the arrival of new digital technologies may not only reduce inequality among the 99%, but could also help boost wages and increase the labor share of GDP.

### *3.3 Inequality and Opportunity: The Impact on Social Mobility*

33. The hollowing-out of labor markets and the potential future displacement of low-skilled workers are fueling an already growing concern that as societies become more unequal, there will be less opportunity for the children of low- and middle skilled workers advance up the economic ladder. A well-documented fact is that more unequal countries also tend to be less upwardly mobile, a relationship that has become known as "the Great Gatsby Curve" (Figure 3.5a). In other words, the correlation between parental and child outcomes—a common measure of intergenerational mobility—is on average higher in more unequal countries. To be sure, countries like Denmark and the United States are fundamentally different on various dimensions, meaning that such a correlation can be driven by some omitted third factor that may in turn affect mobility rates. Nevertheless, as shown in Figure 3.5b, the same relationship also exists *within* countries: in the Unites States there is a strong negative link between inequality and mobility across local labor markets, suggesting that also the cross-country data is likely to reflect causal forces.

35 Karabarbounis & Neiman (2013).
36 The Economist (2013).
37 Saez & Zucman, (2014).

**Figure 11. Upward mobility decreases as inequality increases**

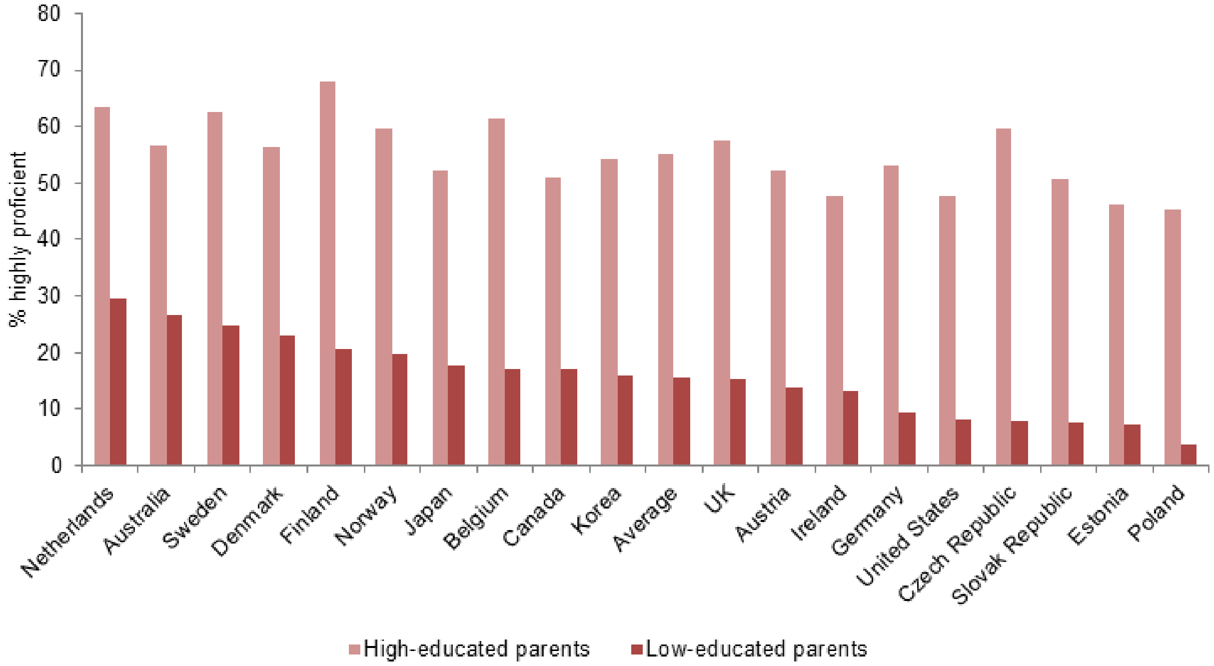



*Notes*: Panel a shows mobility measures (IGE estimates) and Gini coefficients (at disposable income, post taxes and transfers) for a number of OECD countries; panel b shows similar mobility measures and Gini coefficients for 741 local labor markets ("Commuting Zones") in the US.
*Sources:* OECD, Corak (2013), Chetty et al. (2014).

34. As has been extensively documented, however, much of the surge in income inequality stems from the increasing returns to education. This, in turn, has implications for social mobility. Evidence from the OECD's Survey of Adult Skills unambiguously shows that adults from socio-economically disadvantaged backgrounds have lower skills proficiency, and that parental education is a key predictor of a child's skills (Figure 3.6). Thus, countries with higher returns to education also exhibit higher lower rates of mobility, since educational attainment is often sticky across generations.[38] Investments to broadly improve skills development for children at an early stage are thus not only likely to pay long-term dividends in terms of productivity gains, but would also contribute to a more equal distribution of skills, in turn equalizing incomes and boosting upward mobility. For example, studies have shown that the return to a one standard deviation in numeracy skills is associated with a 12-15% increase in wages in the Nordic countries; the equivalent figure is 28% in the US.[39] At the same time, the Nordic countries have among the highest mobility rates whereas children's outcomes in the US to a larger extent are determined by parental outcomes (Figure 3.5a).[40]

38 Autor (2014).
39 Hanushek et al. (2013).
40 Hanushek et al. (2013).

**Figure 12. Individuals with low-educated parents have lower problem-solving skills**




*Notes*: This figure shows the percentage of adults that were highly proficient (scored at Level 2 or 3) in problem solving skills in technology-rich environments. Adults to low-educated parents are defined as those were neither parent has attained upper secondary education; high-educated parents correspond to adults to parents where at least one has attended tertiary education.
*Source:* OECD (2013a).

35. As many elementary occupations, that have previously provided a stepping-stone to more well-paid work, have disappeared over recent decades, and a growing share of low-skilled workers are now susceptible to automation, a central challenge for many workers will be to upgrade their skills---including skills such as creative thinking, social perceptiveness, negotiation, persuasion, the ability to care for others, and depth of perception---allowing them to transition into meaningful and better-paying jobs that are less susceptible to computerisation. Investments to broadly improve the skills of the workforce are thus not only likely to pay long-term dividends in terms of productivity gains, but would also contribute a more equal distribution of skills, in turn equalizing incomes and boosting upward mobility. This is supported by evidence showing that those least well-off have a higher probability of experiencing upward mobility in places that invest in schooling.[41] In particular, as socio-emotional skills among children shape their future development of cognitive skills, investments in such skills during the school years will be of crucial importance (see Table 3.1 for examples of associated social and emotional skills that will be required).[42]

41 Chetty et al. (2014).
42 See Cunha & Heckman (2008), Cunha et al. (2012) and OECD (2015b).

**Table 13. Emerging Skills**

| Skill | Description of skill | Examples of Knowledge | Examples of Attitudes and Values | Examples of Occupations |
|---|---|---|---|---|
| Assisting and Caring for Others | Providing personal assistance, medical attention, emotional support, or other personal care to others such as coworkers, customers, or patients. | Biology; Medicine and Dentistry; Therapy and Counselling | Care; Kindness; Respect for others | Hospitalists; Music Therapists; Psychiatrists |
| Persuasion | Persuading others to change their minds or behaviour. | Communications and Media; Psychology; Sales and Marketing | Determination; Energy; Interconnectedness | Arbitrators; Mediators; Sales Engineers |
| Social Perceptiveness | Being aware of others' reactions and understanding why they react as they do. | Administration and Management; Customer and Personal Service; Psychology | Compassion; Decency; Insight | Clergy; Clinical Psychologists; Psychiatrists |

*Source:* O*NET (http://www.onetonline.org/find/bright?b=3&g=Go).

## 4. Demographic Shifts: The Future of Populations

### *4.1 A Declining Population: Dividend or Deficit?*

36. One of the major achievements of the twentieth century has been the substantial increases in life expectancy across the industrial world. Improvements in nutrition, disease prevention and medicine allow individuals to live substantially longer, healthier and more fulfilling lives. Over the next decades, new technological advances are likely to increase life expectancy even further, to above 100 years in many OECD countries.[43]

37. Longer life spans have also contributed to the growth of the world's population, increasing from about 1.7 to 6 billion over the course of the twentieth century. In the twentieth century, however, declining fertility means that the industrial world is entering a period of stagnating and even declining populations.[44] Crucially, recent declines in fertility largely stem from more women acquiring an education, in turn increasing the female labor force participation, although cultural shifts in the desired number of children and better access to contraceptives provide additional important explanatory factors. While the average number of children born per woman (aged 15 to 49) was 2.8 across the OECD in 1970, the equivalent figure is now 1.7.[45] Today, nearly all OECD countries have total fertility rates below 2.1—that is, the rate needed to sustain a stable population. According to UN projections, most industrial countries are also expected to exhibit fertility rates below-replacement levels over the forthcoming decades, although there are substantial differences across regions. In Europe, fertility rates are projected to increase from 1.6 to 1.7

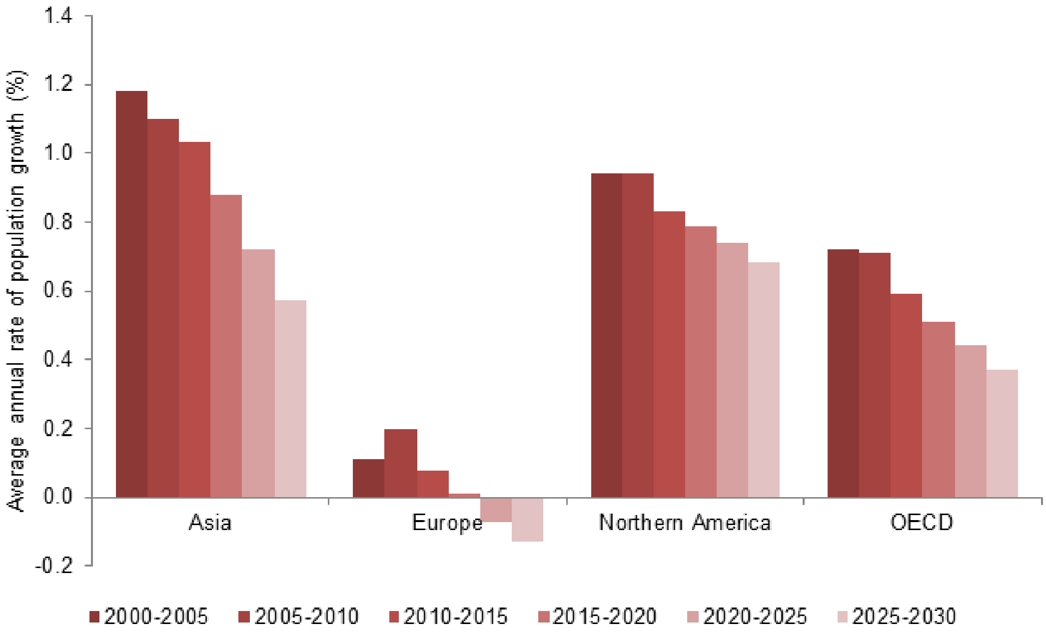
43 Vaupel (2010).

44 While whether a decline in populations is desirable or not is still being intensely debated, the world population is set to peak between 9 and 10 billion by 2050 (Goldin, 2014).

45 OECD (2014b).

by 2030; in Asia, they are expected to fall from 2.1 to 2.0; whereas in the US, they are projected to remain at 2.0.[46]

**Figure 14. UN Population Growth Forecasts**



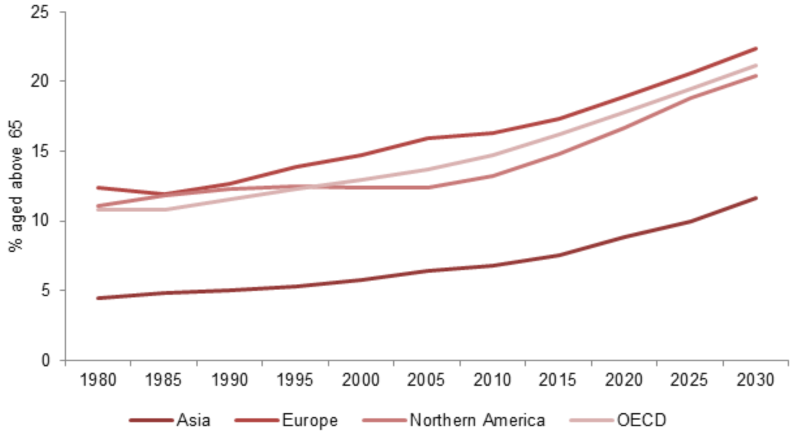

*Source:* UN (2012).

38. This tendency means that populations will stabilize and eventually decline. The European population is projected to fall from about 743 million today, to 736 million by 2030, and the population of Japan is already in decline.[47] In the OECD as a whole, the population is expected to increase only slightly, from about 1.28 to 1.37 billion over the same period. Most population growth is thus expected to come from the developing world, boosting the world's population from about 7.3 to 8.4 billion.

46 UN (2012).
47 UN (2012).

**Figure 15. Average Population age**

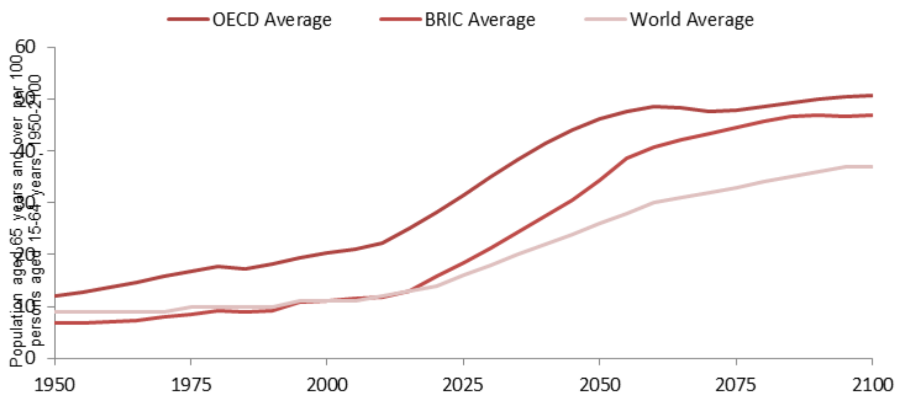
1980 - 2030




*Source:* Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2012 Revision, http://esa.un.org/unpd/wpp/index.htm Medium variant.

39. As population growth tapers off in the industrial world, the age composition of nations and regions will change dramatically: the median age in Europe, for example, is projected to increase from 41.4 to 44.7. Similarly, in Asia and Northern America, the median age is expected to increase from 30.2 to 35.4, and 37.9 to 39.8, respectively. [48] In tandem with this trend, the share of people aged above 65 will increase substantially: in the OECD, one in five people will be 65 or older by 2030 (Figure 4.2). Accordingly, nearly every industrial country will experience increases in the elderly dependency ratio by 2030 (Figure 4.3), with considerable effects on growth and the skills of the workforce.

**Figure 16. Elderly dependency ratios will increase by 2030**




*Source:* OECD (2013c).

48 UN (2012).

40. In particular, as populations' age, the demand for health care will continue to increase. This is not least reflected in the wide range of new and emerging health care-related occupations (Table 4.1), requiring socio-emotional skills such as caring, sociability and respect as well as scientific skills:[49] while acute care nurses and hospitalists require a higher degree of social perceptiveness to understand emotional patterns and interact with patients, geneticists and pathologists require a higher degree of knowledge about science and critical thinking. Furthermore, even in health care, digital skills are becoming more important: informatics nurse specialists, for example, focus on the design and implementation of computerized health care systems, requiring being able to work with computers.

**Table 17. Aging and emerging occupations in health care**

| Occupation | Description | Examples of Skills | Example of Knowledge | Example of Attitudes and Values |
|---|---|---|---|---|
| Acute Care Nurses | Provide advanced nursing care for patients with acute conditions such as heart attacks, respiratory distress: syndrome or shock. May care for pre- and post/ operative patients or perform advanced, invasive diagnostic or therapeutic procedures. | Service Orientation; Social Perceptiveness | Medicine and Dentistry, Psychology; English Language. | Respect for others; patience; sensibility. |
| Hospitalists | Provide inpatient care predominantly in settings such as medical wards, acute care units, intensive care units, rehabilitation centres, or emergency rooms. Manage and coordinate patient care throughout treatment. | Service Orientation; Social Perceptiveness | Biology; Customer and Personal Service; Biology. | Care; kindness; compassion. |
| Geneticists | Research and study the inheritance of traits at the molecular, organism or population level. May evaluate or treat patients with genetic disorders. | Critical Thinking; Science. | Chemistry; Mathematics; Biology. | Diligence; focus; exploration. |
| Pathologists | Diagnose presence and stage of diseases using laboratory techniques and patient specimens. Study the nature, cause, and development of diseases. May perform autopsies. | Complex Problem Solving; Science | Medicine and Dentistry; Administration and Management; Computers and Electronics. | Precision dealing with ambiguity; accountability. |
| Neurologists | Diagnose, treat, and help prevent diseases and disorders of the nervous system. | Complex Problem Solving; Social Perceptiveness | Psychology; Therapy and Counselling. | Goal-orientation; exploration; commitment. |
| Informatics Nurse Specialist | Apply knowledge of nursing and informatics to assist in the design, development, and ongoing modification of computerized health care systems. May educate staff and assist in problem solving to promote the implementation of the health care system. | Systems Analysis; Critical Thinking. | Customer and Personal Service; Medicine and Dentistry; Education and Training. | Feedback; Project/program management; cooperation. |

*Source*: O*NET (http://www.onetonline.org/find/bright?b=3&g=Go).

## 4.2 Populations and the Workforce: Implications for Growth and Skills

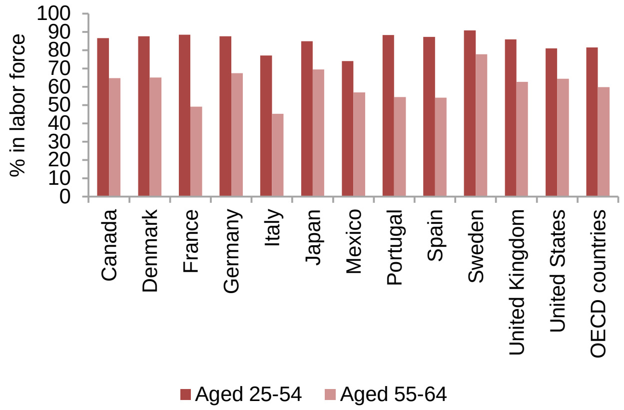
41. As people grow older they are also more likely to drop out of the labor force. Across the OECD the average labor force participation rate for those aged 25-54 is 81.5%, but only 59.7% among individuals aged 55-64 (Figure 4.4a). Thus, an aging population will reduce the number of productive workers in the

49 OECD (2015b).

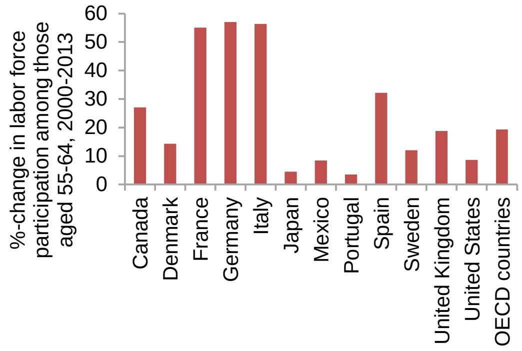
economy, as long as the current age of retirement remains. To counter this trend a wide range of skills will be required, including flexibility, life-long and life-wide learning, determination, entrepreneurial ability and curiosity.

42. Crucially, educated workers are substantially more likely to remain active in the labor market later in life, reflecting both their higher opportunity costs of leaving work and better health. In Europe, for example, 50% of workers aged 60-64 with a degree remain in the labor force, whereas only 25% of low-skilled workers are still in employment. Past studies further suggest that about half of the increase (from 35 to 44%) in US labor force participation among those aged 60-74 over the past 25 years is the result of rising educational attainment among older workers.[50] Although there is substantial variation in labor force participation among older workers across economies (Figure 4.4b), this is a trend that is prevalent in many countries.

**Figure 18. Older workers are less likely to participate in the labor force**




(a)




(b)

*Source:* OECD (http://stats.oecd.org/Index.aspx?DatasetCode=LFS_SEXAGE_I_R).

43. The implications of these demographic shifts are potentially severe: a shrinking labor force will mechanically reduce economic growth unless it is offset by productivity gains among younger workers that remain in the labor force. Had the projected population changes through 2050 occurred between 1960 and 2005, for example, the average annual growth rate for the OECD country would have been 0.7% lower (2.1% rather than 2.8%).[51] Other estimates suggest that Japan's shrinking workforce has reduced average annual GDP growth by roughly 0.6 percentage points, and in Germany growth has been 0.5 percentage points slower as a result.[52]

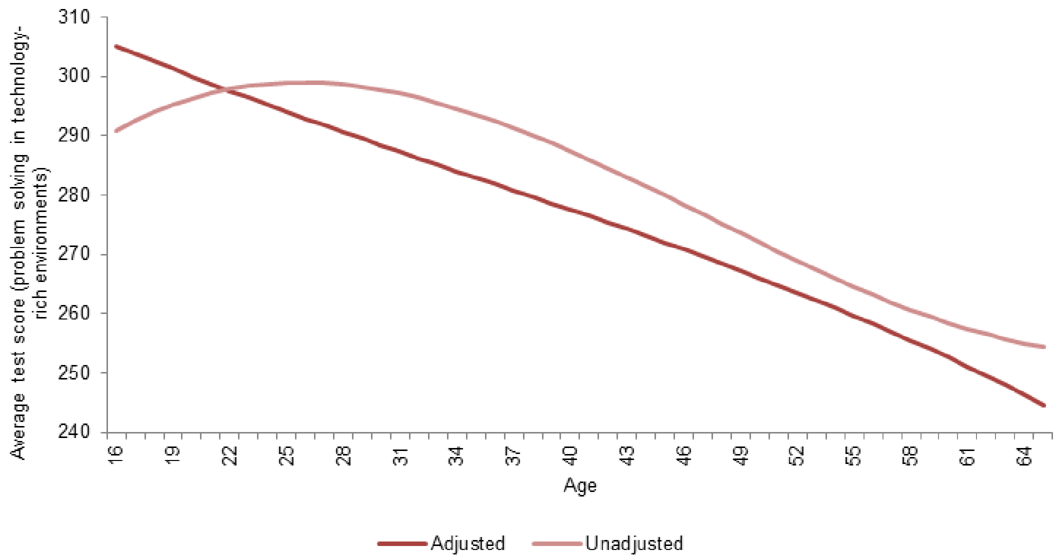
44. Alarmist views of the economic impact of population aging are however based on the assumption that age-specific behavior will remain constant over time, which is problematic since individuals may

50 Burtless (2013).
51 Bloom et al. (2011).
52 The Economist (2014).

adapt to further increases in life expectancy. Investing in an education is more attractive the longer that investment pays off and looking forward to a larger share of their life in retirement, workers may adapt by saving more during their active working lives. More fundamentally, these demographic projections are uncertain themselves: according to the UNs predictions for 2030, the world population may be anything between 7.9 and 8.9 billion.

45. At the same time, it is important not to understate the challenge ahead. In essence, governments will be faced with three main options to mitigate the effects of aging populations by 2030: harnessing the skills of older workers, encouraging immigration, attract more women into the labor force, and embracing automation. Although immigration option may offset age imbalances in the labor force it is unlikely to bridge the skills gap: immigrants have substantially lower proficiency on average, even when adjusting for a number of other factors.[53] Furthermore, immigration will require the workforce to develop entirely new skills. In particular, a recent UNESCO report has pointed at the importance of promoting skills such as tolerance, knowledge of other cultures and empathy,, to create a better understanding for people from different backgrounds.[54] Similarly, Delors (1996) points towards the importance of learning to live together by developing "an understanding of others and their history, traditions and spiritual values and, on this basis, creating a new spirit which, guided by recognition of our growing interdependence and common analysis of these risks and challenges of the future, would induce people to implement common projects or to manage the inevitable conflicts in an intelligent and peaceful way."

**Figure 19. Problem-solving skills decline with age**




53 OECD Skills Outlook (2013).
54 UNESCO (2014).

*Notes:* The adjusted series take account for educational attainment and foreign-language.
*Source:* OECD (2013a).

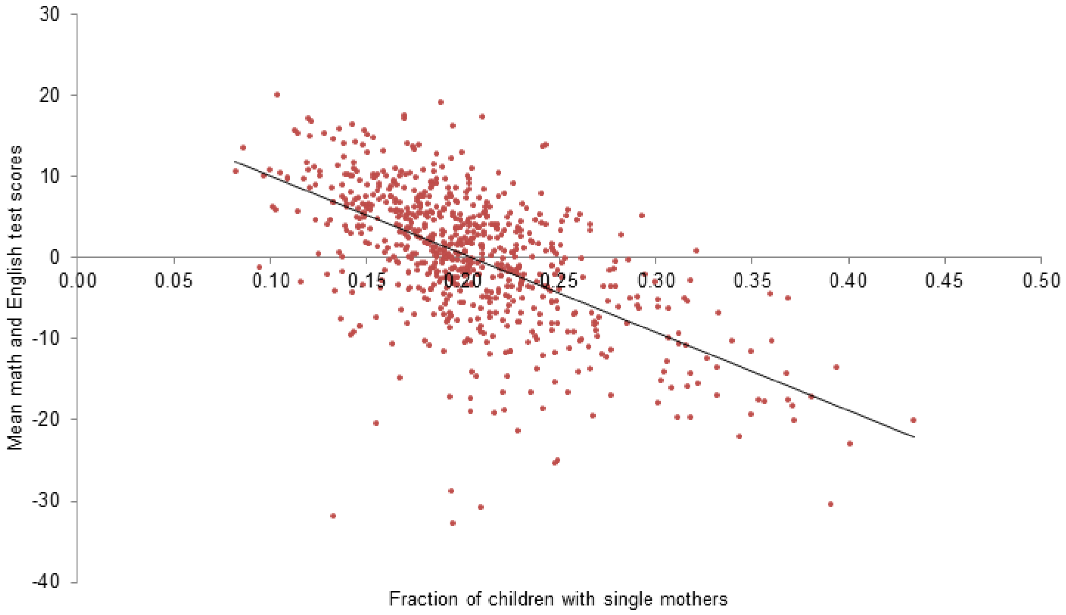
46. Thus, some substantial skill upgrading of the workforce will be required to adapt to these demographic shifts. In particular, as populations gradually age, providing opportunities for upgrading or re-skilling later in life will become increasingly important. Older workers are typically less proficient than their younger counterparts, reflecting a lack of opportunities to maintain, refine and update skills over their careers as well as biological aging. Problem-solving skills, for example, peak around the age of 30 and decline thereafter (Figure 4.4).[55] In addition, as digital skills are becoming increasingly important, a key concern is that older workers use digital technologies substantially less and will require more intensive training to maintain their employability. With a larger share of older workers in the labor force, flexible and skills-orientated learning must therefore be made available to workers throughout their careers. Fortunately, digital technologies can also help transform education to expand the opportunities for aging workers to maintain and upgrade their skills. Distance learning and massive open online courses (MOOCs) promises a flexible and cheaper way for workers to learn; in 2013, 9.3% of the Internet users in the OECD took part of an online course.[56] Approaches to distance learning will also become more important, as exemplified by the emerging occupation of Distance Learning Coordinators that train instructors in the use of distance learning applications.

47. Furthermore, the expanding scope of automation can help offset some of the decline in population growth as computers are now able to perform many tasks that have previously been confined to human [labor]. At the same time, low- and mid-skilled workers will have to reallocate to jobs that are less susceptible to automation. Countries that successfully upskill their workforce, making their skills complementary to digital technologies, will also experience further productivity gains as a result. Job automation and upgrading/re-skilling thus need to go hand-in-hand.

48. Other demographic shifts will also have an effect on the skills of the workforce. Over the past four decades, marriage rates have plummeted from about eight per 1000 people to five, divorce rates have tripled since 1980, and 15% of children now live in single-parent households (OECD 2011, Families in 2030). As evidence from the PISA shows that students from single-parent families perform substantially worse relative to other students, this provides a challenge for skills development. Similarly, across local labor markets in the US, there is a considerable negative relationship between average test scores and the stability of family structures, proxied by the fraction of children living with single mothers (Figure 4.5). Investing in developing skills among the most disadvantaged would thus likely yield large benefits, both in terms of individual welfare and economic growth.

55 Yet, differences in skills proficiency between the old and young differ widely between countries, suggesting a scope for policy makers (OECD 2013a).
56 OECD (2014a).

**Figure 20. Test scores are lower in places with weaker family structures**



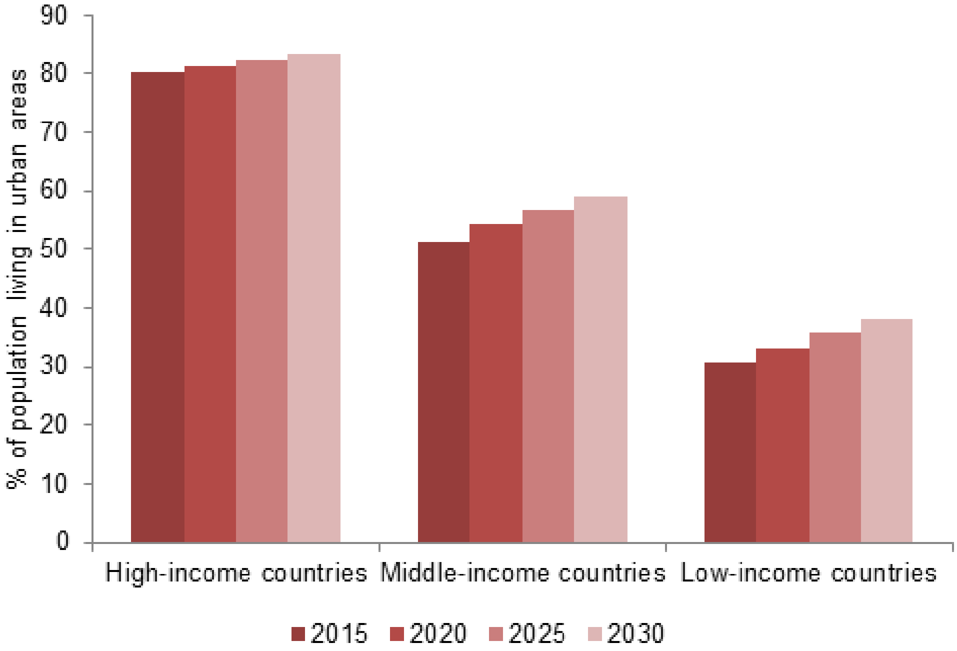

*Notes:* Test scores correspond to mean test scores in English and math adjusted for differences in household income per capita.
*Source:* Chetty et al. (2014).

### *4.3 Urbanization and Innovation*

49. As famously proposed by Lucas (1988), cities across the industrial world provide "the engines of growth". Despite recent claims that the death of distance facilitated by improvements in information and communications technology would make geography less important, leading to the decline of cities, the opposite has happed.[57] Today, a larger population of the world's population is living in cities than a decade ago—a trend that is likely to continue. According to projections by the UN, the share of the population living in urban areas is expected to even further across high-, middle- as and low-income countries over the forthcoming decades (Figure 4.6).

57 Glaeser (1998).

**Figure 21. Urbanization is increasing everywhere by 2030**

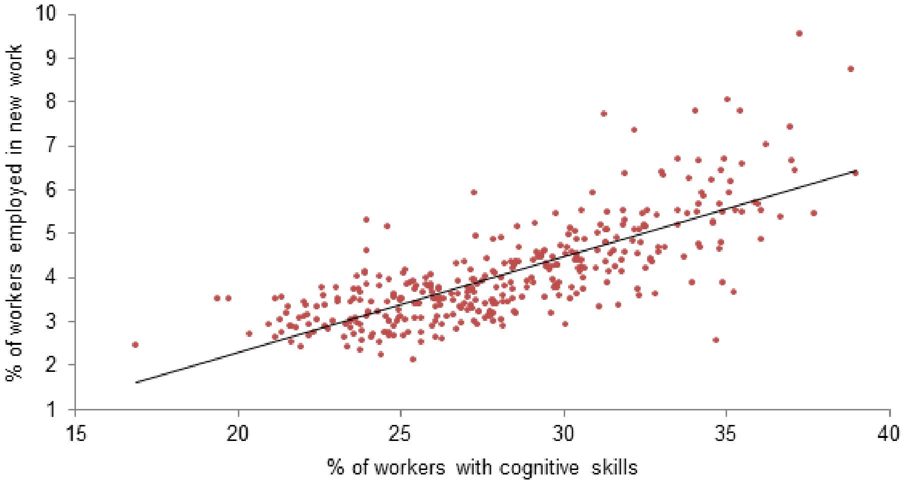



*Notes:* Percentage of the population that lives in urban areas.
*Source: United Nations, Department of Economic and Social Affairs, Population Division (2014).*

50. This concentration of economic activity, following the migration from rural areas to cities, posts important challenges for societies. At a time when growth rates across nations are converging, disparities within countries are growing, both in terms of education and incomes:[58] while computer technologies have made the skills that are prevalent in many rural areas and older manufacturing cities redundant, the shift towards technology industries, where knowledge transmission is particularly important, has made new occupations and industries cluster in skilled cities. For example, the continuous renewal of clusters like Silicon Valley, which has attracted the higher share of new industries since the turn of the century, is largely the result of workers frequently switching jobs, leading to the creation of new companies and industries. While some older cities such as Boston and London have also successfully managed this renewal process to become innovation hubs, many places have experienced declines both in relative and absolute terms: Detroit, Liverpool and Bremen are today all smaller cities than they once were.

58 Berry & Glaeser (2005).

**Figure 22. New jobs are created in cities with cognitive skills**

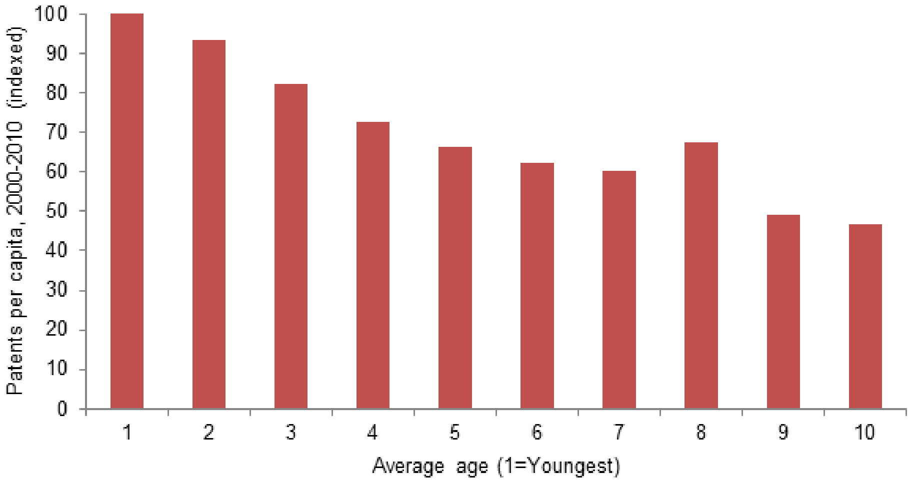



*Notes:* This figure shows the percentage of workers in US cities that were employed in jobs that appeared for the first time between 1990 and 2000, and the percentage of workers with cognitive skills.
*Source:* Berger & Frey (2014a).

51. Importantly, a city's ability to reinvent itself is determined by its resilience to the arrival of new technologies and its capacity to innovate, which in turn is a function of the skills of its workers.[59] In particular, over recent decades, cities' with more cognitive skills have been better at incorporating new technologies into new types of jobs (Figure 4.7; see Table 4.2 for examples of such skills), reflecting the rising importance of such skills in advanced economies (Figure 2.1). Because skill levels differ widely within countries, however, the future prospects of reinvention across cities. For example, differences in education between certain cities with the US are larger than differences in average educational levels between the US and developing countries such as India or Peru.[60] Furthermore, as older workers are less likely to transition into new occupations and industries, which tend to cluster in skilled cities, an age divide across location is likely to emerge, leading to a decline in the technological dynamism of aging cities.[61] As shown in Figure 4.8, patenting rates in US cities with the youngest populations are more than twice as high as those in the oldest cities.

59 Saiz & Glaeser (2003); Frey (2014).
60 Moretti (2014).
61 Lin (2011); Berger & Frey (2014a).

**Figure 23. Younger cities are more innovative**




*Notes:* This figure shows the average number of patents issued per capita by the USPTO between 2000 and 2010 by average age of 741 local labor markets in the US.
*Source:* See Berger & Frey (2014b).

52. Thus, inequality across cities is likely to continue growing, unless action is taken to upskill/re-skill aging populations, and efforts are made to support the diffusion of cognitive skills across cities and regions. At the same time, the clustering of entrepreneurs and educated workers in skilled cities is still likely to continue being the main driver of innovation and new job creation over the next decades, leading to further increases in property prices in prime locations. While rising costs of land and housing reflect productive advantages, finding ways to curb price increases that keep workers and entrepreneurs out are crucial. The easiest way to meet such a challenge would be to increase the supply of housing in skilled cities, which could have substantial effects on national growth rates: recent evidence suggests that housing constraints lowered US output by some 13 percent between 1964 and 2009.[62] Expanding the supply of housing, in places where skilled workers cluster, would make cognitive skills, such as complex problem solving and critical thinking, more productive, while facilitating spillovers to less skilled workers.

62 Hsieh & Moretti (2014).

**Figure 24. Emerging Skills**

| Skill | Description of Skill | Examples of Knowledge | Examples of Attitudes and Values | Examples of Occupations |
|---|---|---|---|---|
| Active Learning | Understanding the implications of new information for both current and future problem-solving and decision-making. | English Language; Education and Training; Psychology | Engagement; Patience; Self-direction | Astronomers; Biochemists and Biophysicists; Teachers |
| Complex Problem Solving | Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions. | Design; Engineering and Technology; Mathematics | Execution; Exploration; Flexibility | Chief Executives; Physicists; Surgeons |
| Critical Thinking | Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems. | English Language; Mathematics; Philosophy | Open-mindedness; Inquisitiveness; Vision | Anesthesiologists; Judges, Magistrate Judges, and Magistrates; Mathematical Technicians |

*Source:* O*NET (http://www.onetonline.org/find/bright?b=3&g=Go).

53. Over the next decades skilled cities will remain the driver of innovation and the creation of new occupations and industries. Over the long-run, this is also likely to benefit other cities and regions: gradually, as the new work becomes "old" work, it tends to diffuse to other locations. In other words, while we expect that new types of work will be concentrated to skilled cities, where entrepreneurs, innovators and early adopters experiment with new technologies,[63] other regions will benefit as new work migrates from skilled locations.[64] In the United Kingdom, for example, new job creation is initially overwhelmingly concentrated to Central London but also benefits neighboring regions as it diffuses over time.[65] Regional development strategies that aim at breaking up existing clusters to smoothen new job creation are thus likely to be counterproductive. Instead, investments in transportation and communications technology that facilitate the diffusion of innovations and skills across locations, including disadvantaged areas, are more likely to help. Furthermore, supporting links between local universities and businesses can be of crucial importance: since William Hewlett and David Packard, two Stanford students, formed Hewlett-Packard (HP) in 1938, Stanford alumni alone have created some 39,900 companies and about 5.4 million jobs.[66] Although it is notoriously difficult to replicate successful clusters, governments should focus on supporting skills development locally by investing in skills associated with complex problem solving; science, mathematical reasoning, creative thinking entrepreneurial ability and curiosity, while building the infrastructure to support the diffusion of knowledge and skills across locations.

## 5. Conclusions: Entering an Age of Secular Stagnation?

54. In this paper, we examine how future shifts and shocks will transform the workforce and with it the demand for skills. Our findings build on a growing body of research, suggesting that the global

63 Lin (2011); Berry and Glaeser (2005); Glaeser et al. (2012).
64 Duranton and Puga (2001).
65 Frey (2015b).
66 Eesley and Miller (2012).

workforce is facing several transformative challenges. The expanding scope of automation is reducing the demand for labor in several domains, while making the skills of many workers redundant, contributing to the recent surge in inequality. Digital technologies are less capital-absorbing relative to innovations of the past, leading to a reduced investment demand and sluggish job creation.[67] Together with the concentration of incomes among individuals with lower marginal propensities to spend, an aging population and a shrinking labor force are likely to reduce demand even further, potentially leading to a period of secular stagnation.

55. With the right policies such an outcome can be avoided. Most importantly, public investment is needed for new job creation and skills. By upskilling the workforce, gains in productivity could offset the decline in growth associated with a shrinking labor force, while making workers less vulnerable to automation. Furthermore, the diffusion of skills and knowledge provides the most important force of convergence, thereby reducing inequality and potentially boosting spending. In particular, investments hard skills such as science and mathematics, theoretical reasoning and computer programming will be essential, but also a wide range of social and emotional skills, including creative thinking, social intelligence and curiosity.

56. While it is notoriously difficult to predict the type of jobs that will be emerge in the future, the skills requirements of new and emerging occupations are suggestive of the type of skills that will be needed. Occupations such as nanotechnology engineers, solar energy engineers, web developers, and biostatisticians, all involve complex problem solving and creative thinking. Furthermore, with an aging population the demand for care will continues to increase. Related skills, such as assisting and caring for others as well as social perceptiveness and emotional intelligence, will thus become more important. As recent research suggests that computer technologies are least likely to substitute for creative and social skills, there is a strong case for investing not only in technical skills. In fact, most future challenges are likely to require fusion skills---that is, a combination of entrepreneurial, creative and technical skills.

67 Frey (2015a).

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