The Future of Work

A CQI Quality Futures Report

March 2020

The **Chartered Quality Institute** (CQI) is a global professional body advancing the practice of quality management in all sectors.

Quality Futures is a programme guided by research and the insight of our members and partners. It is focused on prompting debate among practitioners, academics and policymakers on how quality management methods will need to adapt and change in line with the new digital age.

This report highlights the trends that are shaping the future of work and provides considerations for the quality profession.

Version 2 of this report was published with revisions in March 2020.

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01. Preface

Much has been written about the new age of digitalisation – sometimes referred to as the Fourth Industrial Revolution or Industry 4.0 – and the impact of technology on business and society. Some reports paint a horror scenario, forecasting that digitalisation will lead to global mass unemployment as robots and artificial intelligence take over the jobs currently performed by humans. Others take the view that technology will benefit mankind by automating boring, repetitive, and dangerous tasks, and enhancing the capabilities of the human worker.

In order to make sense of the noise, the CQI has prepared this report on the future of work, which is based on recent information published by a wide range of authoritative organisations. The report covers the key drivers for change that have been identified by the CQI's Research Advisory Panel:

» Big data and analytics

» Artificial intelligence and machine learning

» Connectivity, systems integration and the Internet of Things

» Autonomous machines, robotics and additive manufacturing

» Augmented reality

» Cybersecurity

» Demographics

» Trust and transparency

» Corporate social responsibility and sustainability

Our aims are to raise awareness of the effects of digital transformation so that organisations can proactively address these issues in their management strategies, and to outline the implications for the quality management profession so that quality professionals may prepare for the future.

The aim of the report is to enable organisations to understand the areas that will be affected by the digital revolution, so that they can adopt appropriate measures to ensure that they gain maximum benefit from the dramatic changes it will bring.

Alexander Woods, Policy Manager

02. Executive Summary

Digitalisation is unstoppable, and it is happening at a speed we have never seen before. All aspects of society will be affected, and new technologies such as sophisticated sensors, the Internet of Things, robotics, artificial intelligence, and big data will offer endless possibilities to change the way we live, work and communicate.

The term "digital transformation" is widely used, but what does it really mean? In a 2019 article in *Harvard Business Review*, two professors from the business school INSEAD explain it very simply as "adapting an organisation's strategy and structure to capture opportunities enabled by digital technology".[1] However, some companies are struggling to define exactly what actions need to be taken, and which initiatives need to be prioritised.

Some business leaders fear that digital technology will dramatically disrupt their tried-and-tested business models and are therefore hesitant to undertake what they perceive to be a leap into an unknown future. They cling to the old belief of "if it ain't broke, don't fix it". But this is a blinkered approach. New, agile, digital companies will be able to react quickly to customer demands, competition, and rapidly changing markets. "Traditional" companies, founded on bureaucracy, stability and control, will need to become more flexible if they are to survive the digital revolution, because their present management systems will not allow them to adapt to the speed of change. Digital transformation is not about technology, it is about leadership and flexibility. Companies that accept this change will prosper, while those that do not, risk being phased out of the market.

Change does not need to be disruptive – companies can choose evolution rather than revolution. Although it is true that investment in new manufacturing processes, communication systems, and business models will probably be necessary, most companies will be able to take cumulative steps to embrace new technology and use it to serve the needs of their customers.

Well established companies have historically adapted to massive changes, seamlessly incorporating computers, the internet, self-service retail options, card payment systems, and industrial automation into their business models. Digital transformation is in fact just another change, albeit one that is moving very quickly. Corporate behemoths that do nothing and fail to adopt digital tools will be pushed out by more nimble companies that embrace new technology.

However, traditional service providers and retailers have an advantage that the newcomers do not possess: an emotional relationship with their customers. Even though "digital" will eliminate the need for costly infrastructure and provide a plethora of ways to improve customer experience, there will still be a need for "physical". Customers greatly appreciate the opportunity to have face-to-face interaction with representatives of a company, and often show

1. Furr, Nathan and Shipilov, Andrew, "Digital doesn't have to be disruptive", *Harvard Business Review* (July 2019), https://hbr.org/2019/07/digital-doesnt-have-to-be-disruptive

frustration when confronted by a "digital only" option. Companies can leverage a blend of digital and physical to improve efficiency, reduce costs, and provide an enhanced customer experience, while retaining the customer's trust and loyalty.

Many sectors have already been forced to embrace technology and enhance their own core offering to counteract competition from "tech" companies. A well-known example is Uber's impact on the taxi business. Traditional taxi drivers initially tried to prevent Uber from operating in the fear that the company would take away their livelihoods. However, Uber is still providing services despite the worldwide protests. When traditional taxi drivers began incorporating digital options themselves, they were able to compete and even outperform Uber, by offering enhanced services while retaining their hard-earned customer trust and respect.

Leaders need to understand, however, that digital transformation cannot be confined to the domain of IT departments. A new digital mindset needs to be embedded across the whole organisation. There is no silver bullet for digitalisation – companies can follow multiple paths towards the same goal. Business leaders need to adopt a strategy that best suits their organisation and then make sure that everyone buys into it. It will be a long, continuous journey as new technologies are introduced. Companies need to encourage staff to be aware of what digital can offer and be flexible enough to react to an ever-changing environment. Large-scale IT programmes that take months to implement could be out of date before they come online.

The Chartered Quality Institute's Future of Work report provides an in-depth analysis of the numerous facets of the digital revolution, covering the impacts on organisations, society, and the environment, as well as the roles played by crime, cybersecurity, ethics, sustainability, and governments. The report also includes contributions from the CQI Research Advisory Panel, which highlight the opportunities and challenges that specifically face the quality profession in the age of digital transformation.

The report seeks to raise awareness of the areas that will be affected by digitalisation and provide an insight into the steps that companies need to take in order to derive the most benefit from the exciting opportunities it will offer. Attention is also drawn to the challenges that organisations and society as a whole will face, not least the spectre of mass unemployment as the routine tasks of manufacturing and clerical occupations become automated.

We hope that the report will encourage companies to examine their own business models and develop strategies to ensure that they use technology effectively and securely to derive the maximum benefit for their organisations.

03. Context

Civilisation is facing a digital transformation that will change the way we live, work and interact with each other. This digital revolution, sometimes referred to as the Fourth Industrial Revolution, is being spurred by developments in areas such as artificial intelligence, big data, the Internet of Things, nanotechnology, quantum computing, and biotechnology. Innovations in computational design, additive manufacturing, and intelligent automation will expand the productivity of existing workers, automate tasks previously carried out by human workers and create tasks that have never previously been done by humans.

Digital transformation will affect every sector and, if managed correctly, has the possibility to create exciting new opportunities as well as improvements in the job quality and productivity of the existing workforce. Big data – the analysis and quantification of large datasets – will fundamentally change the way that much of the world's commercial enterprise is done.

The financial services sector, utility companies, and other services providers are already investing heavily in humanoid robots, which will eventually deal with most aspects of client services. Industry is investing in physical robots such as drones, underwater robots and exoskeletons: devices that can extend the capacity of the human worker and even perform jobs that have previously been impossible due to the costs and safety risks involved.

The transition will be difficult, however, and it is crucial that all stakeholders from the public and private sectors, the academic world and civil organisations take steps now, rather than wait for events to unfold.
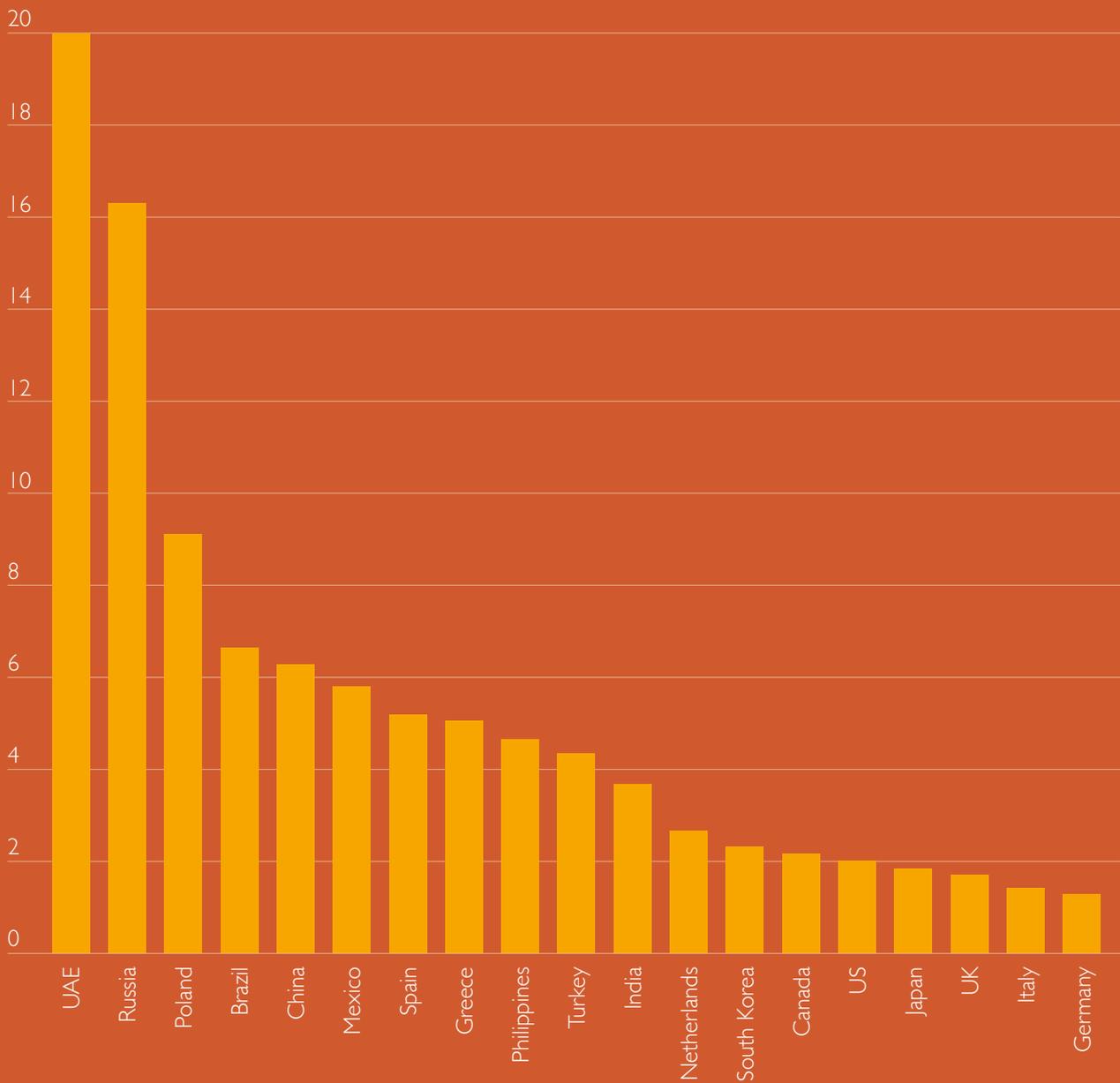
Worryingly, a March 2019 study by Deloitte, entitled "How Leaders are Navigating the Fourth Industrial Revolution"[2], has found that leaders are less prepared than they think. There are signs that executives lack understanding and vision and are therefore failing to define clear strategies. Some managers claim that they are finding themselves overwhelmed by all the different options.

A key problem seems to be the skill gap between leaders, most of whom are over 50 years of age, and Millennials and Generation X who represent most of the workforce today. In Asia, the age of management is even higher, with CEOs often reaching 80+ years of age. There seems to be a tendency among older CEOs, who may be reaching retirement age, to wait for things to evolve, rather than proactively take steps.

2. https://hbr.org/sponsored/2019/03/how-leaders-are-navigating-the-fourth-industrial-revolution

CEO's aged 40 years old or under

% of total country's CEOs, selected countries

Companies with market capitalization above £150 million
Source: FTSE.com

CEO's aged 70 years old or above

% of total country's CEOs, selected countries
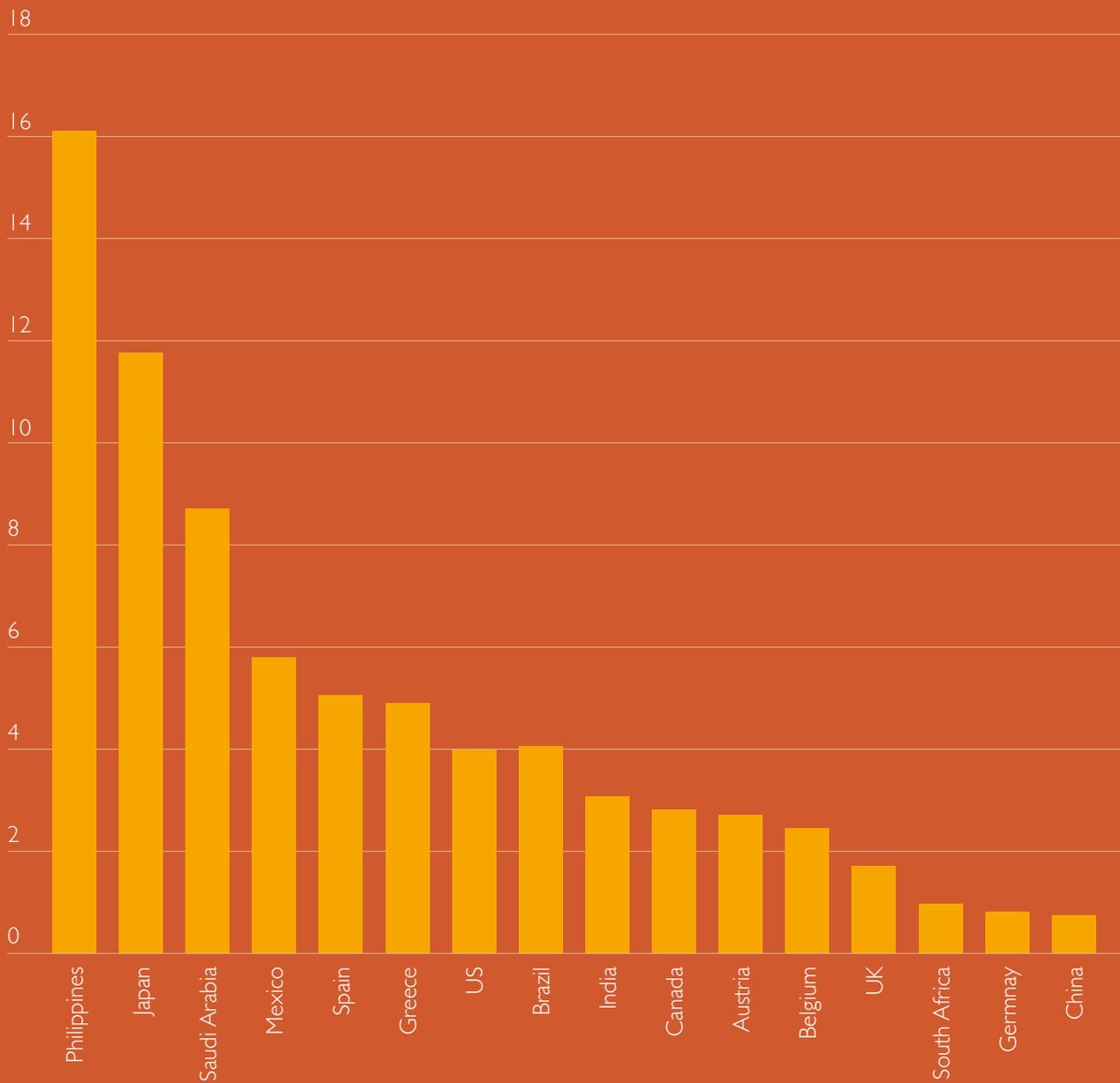
Average age of CEOs

Years, selected countries

65	
60	
55	
50	
45	
40	
35	
30	
25	
20	
15	
10	
5	
0	

Japan · Philippines · South Korea · France · US · Thailand · Mexico · Australia · Malaysia · Indonesia · Germany · UK · Finland · South Africa · China · Russia
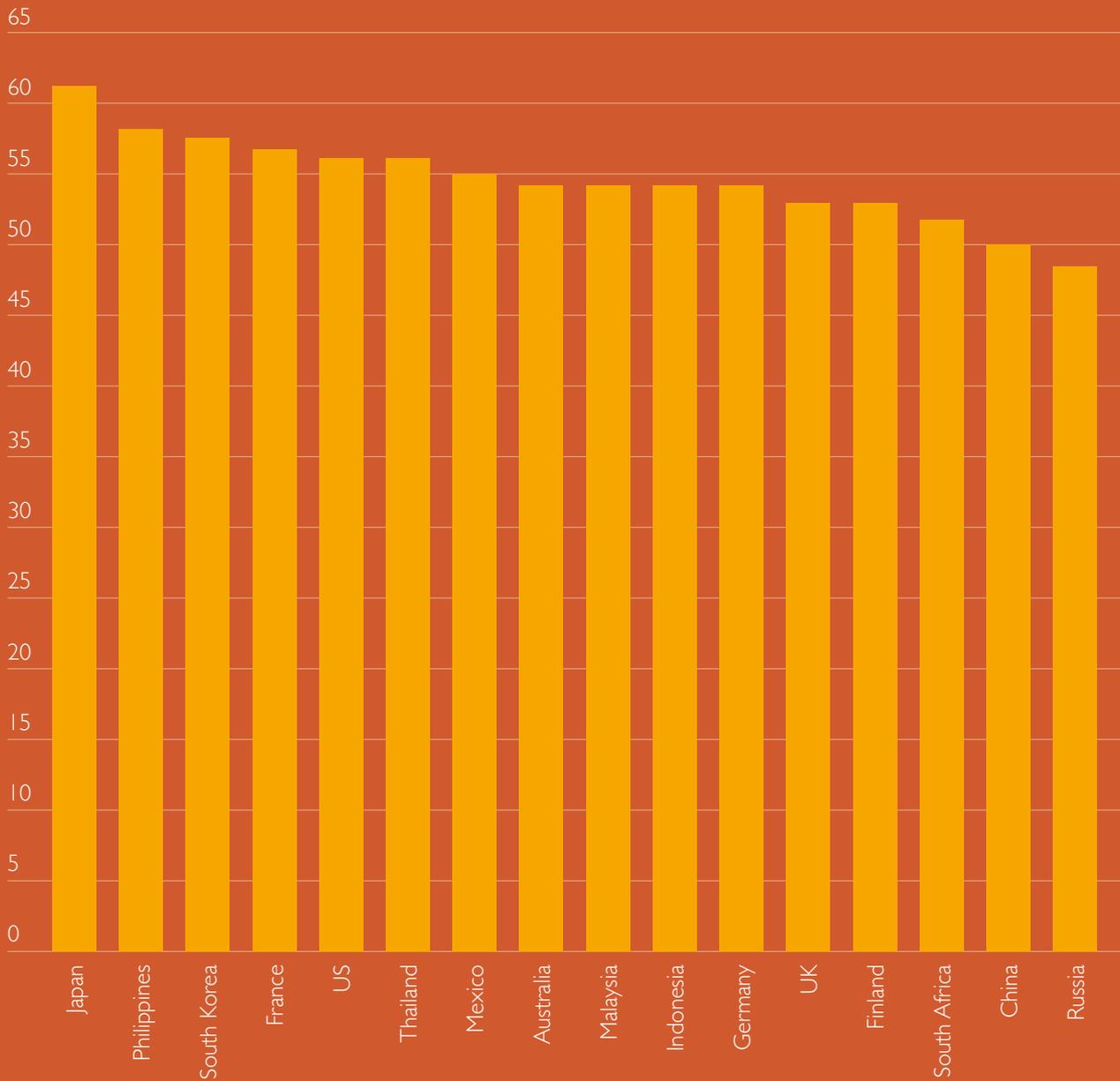
Source: FTSE.com

> **United Airlines faced a storm of online outrage in April 2017 when videos emerged of a Vietnamese-American passenger being forcibly removed from one of its flights. When United's 58-year-old CEO attempted to brazen it out, he showed a total misunderstanding of the power of social media. Within hours, a video clip showing the passenger being dragged down the aisle by aviation security guards had gone viral, Asian passengers had coordinated a boycott of United Airlines and the airline's reputation was in shreds.[3]**

The pace of digital transformation will be rapid, and it will affect every level of business and society. Leaders need to understand the implications of these changes and embrace them if their organisations are to survive. It is a grave mistake to leave digital transformation to the IT department, as the changes will affect every area of business.

Technological advances that will affect business growth between 2018 and 2022

Widely available high-speed mobile internet

Artificial intelligence

Widespread adoption of big data analytics

Cloud technology

The three levels of artificial intelligence

01 Assisted intelligence
» Already available
» Replaces monotonous tasks
» Assembly lines

02 Augmented intelligence
» Emerging today
» Enhances human skills
» Enables activities that were formerly not possible
» Medical surgery, ride-sharing platforms

03 Autonomous intelligence
» Being developed
» Fears that this will cause mass unemployment
» Self-driving vehicles

Digital solutions will open up unthought-of possibilities to increase productivity, while providing an enhanced working environment for employees. Sophisticated IT solutions, which are cheaper and faster than human efforts, will replace physical and knowledge-based tasks. However, there are well-founded fears that this will lead to social polarisation, with highly skilled, highly paid workers reaping the rewards of the digital revolution, leaving the lower skilled, lower paid workforce feeling increasingly excluded from society.

04. Impact on Organisations

4.1 Workforce

Technological advances are making an impact in all countries across the globe, regardless of their state of development. Work will become more entwined with technology, and workers of the future will need to be equipped with the skills to work in technological environments.

As digital technology enables workers to use mobile devices to access and store information, and to communicate seamlessly with each other, organisations will become borderless. Workers are increasingly able to perform their tasks in different locations rather than from a central office. Low-skilled physical jobs will become obsolete, as robotic technology will provide faster and more accurate solutions for tasks such as assembly work and safety inspections.

Workers will need to be flexible and be able to move effortlessly from one task to another. The age of 9-5 work shifts, and the concept of a "job for life" are already becoming obsolete.

There will be an increasing demand for specialists in technology, and highly skilled IT developers will be able to command high salaries. A whole range of new jobs in data analytics, e-commerce, artificial intelligence and machine learning, robotics, process automation, information security, user experience, human-machine interaction, and blockchain will emerge. But these jobs will require a level of cognitive skill that the traditional workforce may not possess.

Companies will need to reskill their workforce as well as take measures to recruit and retain talented staff. Those individuals who can combine creativity, imagination, and innovation with critical thinking will be in high demand. In a 2018 survey by the World Economic Forum, 74 per cent of executives said that the availability of skilled local talent was their main concern when deciding where new jobs should be located.[4]

The new generation of highly skilled professionals will demand more from their professional life than remuneration and benefits. They will want flexibility in their working hours, a balance between their working and personal life, and a comfortable working environment with up-to-date technology. Studies have shown that a healthy balance between work and personal life improves performance. In January 2017, a new French law allowed workers the right to disconnect from their mobile devices outside of office hours. This concept is likely to grow as the new generation of employees rejects the idea of being "on call" 24/7.

Young people are searching out socially responsible employers and are demanding trust and transparency. Companies are finding themselves facing increasing pressure to demonstrate accountability. Those companies that can offer an environment of collaboration as well as additional social and leisure facilities such as childcare, banking facilities, gyms, and transport, will be able to attract a wider range of candidates for the high-tech positions they wish to fill.

4. *The Future of Jobs Report 2018*, Centre for the New Economy and Society, World Economic Forum (2018) http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf

"Companies will need to encourage workers to take part in training courses and provide opportunities for them to widen their skillsets in different technologies."

Lifelong training

The idea of a lifelong career based on the state education system will no longer be sufficient. Workers will need ongoing training throughout their professional lives to be able to adapt to evolving technology. Companies will need to encourage workers to take part in training courses and provide opportunities for them to widen their skillsets in different technologies.

Corporate training programmes can be costly, and it can be difficult to coordinate timetables for the participants and find people to replace them during training hours. Companies should therefore explore the use of virtual reality, which can provide visual training at flexible hours. Virtual reality is also likely to become commonplace for state education.

However, workers may be reluctant to adapt to new methods of working, for fear that their own jobs might eventually become obsolete. Cashiers at supermarkets often criticise automatic checkouts due to fears that their jobs will be at risk.

Recruitment

The hiring of quality candidates for new tech positions in a highly competitive labour market will become a challenge for many companies, and the use of technology will be crucial to help them identify the right candidates among the large number of applicants.

Job aggregators can help with recruitment marketing, and databases with millions of candidates can be accessed for a fee. Aggregators can also be used to check the wages and benefits offered by competitors.

Almost all job applications are now made online and new technologies allow resumes to be screened in a fraction of the time it would take a human recruiter. Chatbots can carry out initial assessments of candidates and schedule interviews. Decisions will increasingly be based on virtual and task-orientated approaches rather than the qualifications of the candidate.

Organisations are increasingly likely to move to a more federated organisational structure, with networks of freelancers and partners, instead of full-time employees.

Multigenerational workforce

The workforce will also become multigenerational as governments increase the age of retirement. Companies will need to provide facilities with this mind and encourage interaction between the different generations. Although older employees may lack the technical skills of their younger colleagues, their in-depth knowledge and experience should be seen as an asset.

Gender gap

Women are often prevented from enjoying the benefits of digitalisation due to lack of education, affordability, and cultural bias. Traditionally, women have been more likely to study humanities and social sciences, rather than the scientific disciplines that are needed for the age of digitalisation. More women are embracing information and communication technologies (ICT), but stereotypes still exist, and need to be addressed if women are to play a full role in the new digital age.[5] There is no reason why women should lag behind their male counterparts in the digital revolution. Although a 2015 study by the OECD Programme for International Student Assessment (PISA), found that boys scored higher marks for individual problem solving, the same study showed that women performed better in all countries for collaborative problem solving – a key requisite to ensure successful digital transformation across all departments.

However, because women do the vast majority of care for children and family members, they are embracing the gig economy, as the flexible working hours allow them to supplement their income, while still taking care of family tasks. Women are increasingly finding work through platforms related to ride-sharing, home decoration, home-sharing services such as Airbnb, and tele-medicine platforms such as DocHERs, which links unemployed or underemployed female doctors to patients who live in rural areas of Pakistan.[6] According to the OECD, women represent a significantly higher proportion of Uber drivers in the US (14%) than traditional taxi drivers (8%). However, this kind of work is often low paid, and flexible working times can lead to longer overall working hours, reducing the amount of quality time spent with the family.

There is also an increase in the number of women starting their own business, which allows them to benefit from the advantages of modern work practices, such as flexible working hours, but with a greater degree of freedom and fewer of the downsides of the gig economy. The number of women-owned businesses has increased nearly 3,000 per cent since 1972, according to a study commissioned by American Express.[7] The report also claims that between 2017 and 2018, women started an average of 1,821 new businesses per day in the US.

5. Debuyser, Claire, Shantyaei, Sanam, Siddiqui, Taha, *Women doctors in Pakistan challenge the status quo*, France24 (22/7/2016) https://www.france24.com/en/20160722-focus-pakistan-female-doctors-docthers-medicine-internet-women

6. *Increase in gender gap in the digital sector – Study on women in the digital age*, European Commission / Iclaves (2018) https://ec.europa.eu/digital-single-market/en/news/increase-gender-gap-digital-sector-study-women-digital-age

7. *The state of women-owned businesses*, American Express (2018) https://about.americanexpress.com/files/doc_library/file/2018-state-of-women-owned-businesses-report.pdf

Benefits of working in the gig economy

%

100	
80	
60	
40	
20	
0	

Flexible hours · Control over earning total · More personal time · Less stress · Opportunity to pursue your interests · Variety of projects and clients · No commute
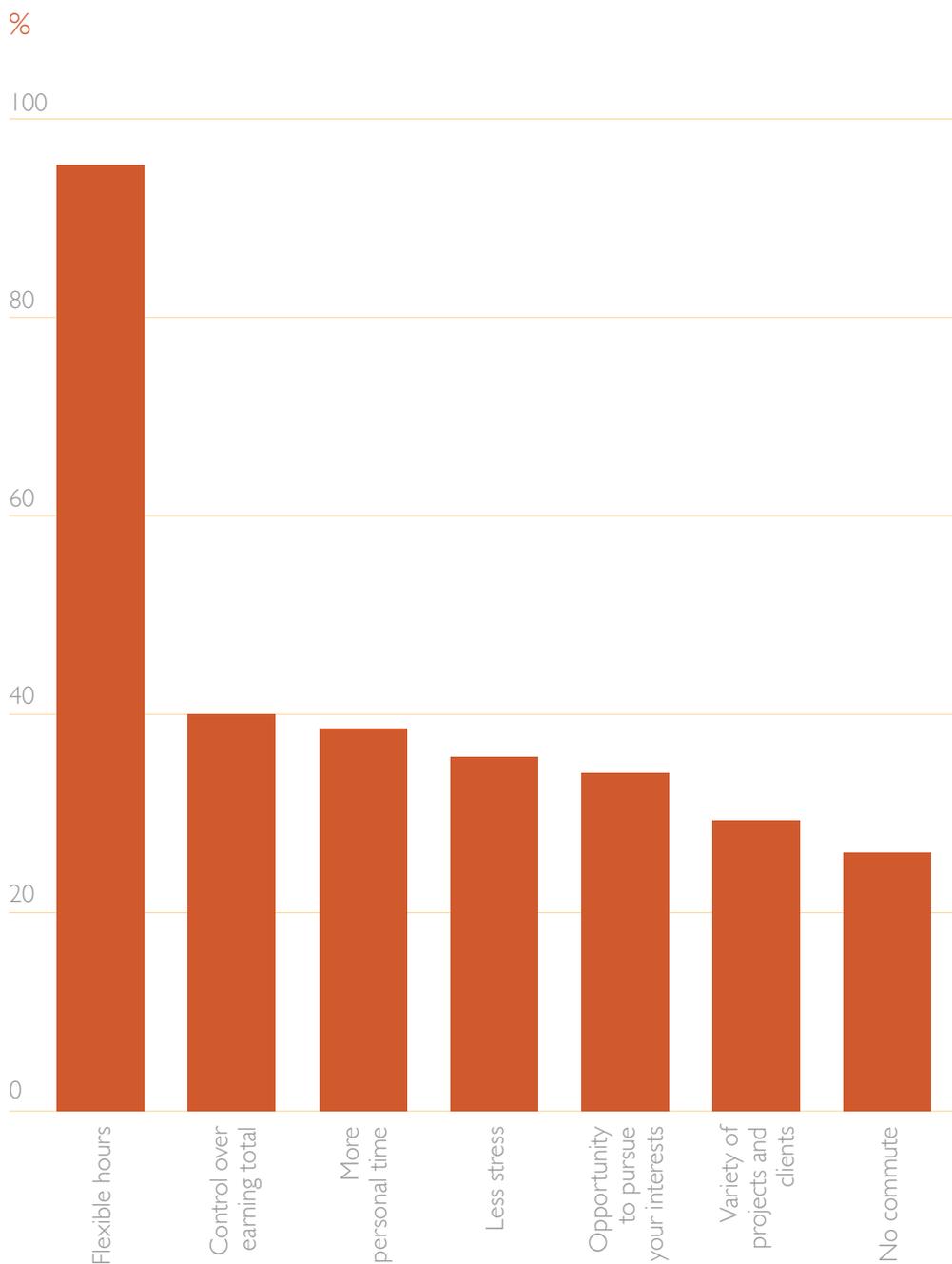
Although the digital world is offering new opportunities for women to widen their employment options, it is worrying to see that gender inequality remains severe. A 2019 survey by Statista, the German statistics company, shows that women are grossly underrepresented at major tech companies.

The Tech World is Still a Man's World

% of female employees in the workforce of major tech companies*
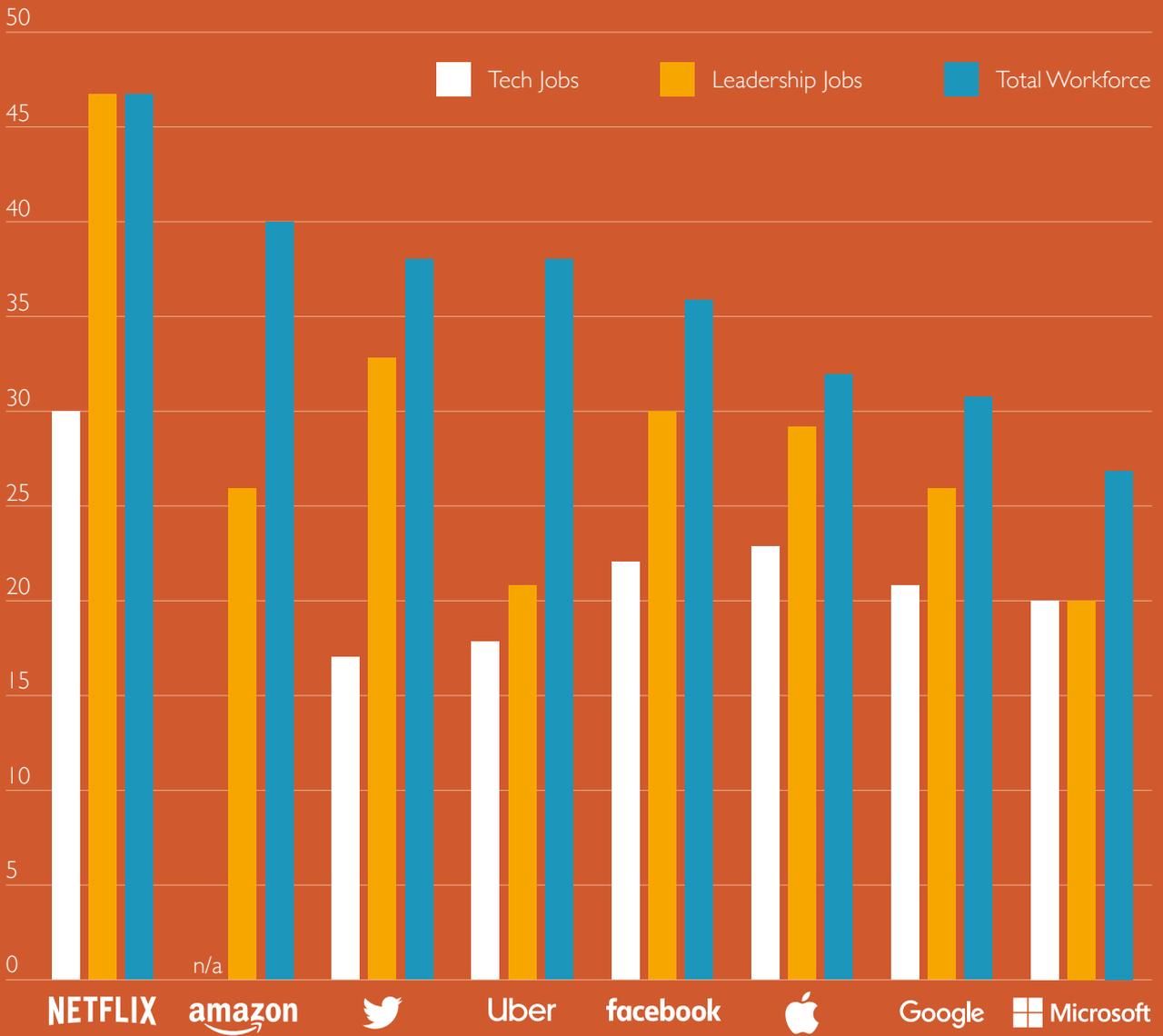
Legend: Tech Jobs (white) · Leadership Jobs (orange) · Total Workforce (blue)

Company	Tech Jobs	Leadership Jobs	Total Workforce
Netflix	29.7	46.3	46.3
Amazon	n/a	25.5	39.7
Twitter	16.5	32.5	37.8
Uber	17.5	20.5	37.8
Facebook	21.7	29.8	35.5
Apple	22.5	29.0	31.5
Google	20.5	25.5	30.5
Microsoft	19.7	19.7	26.5

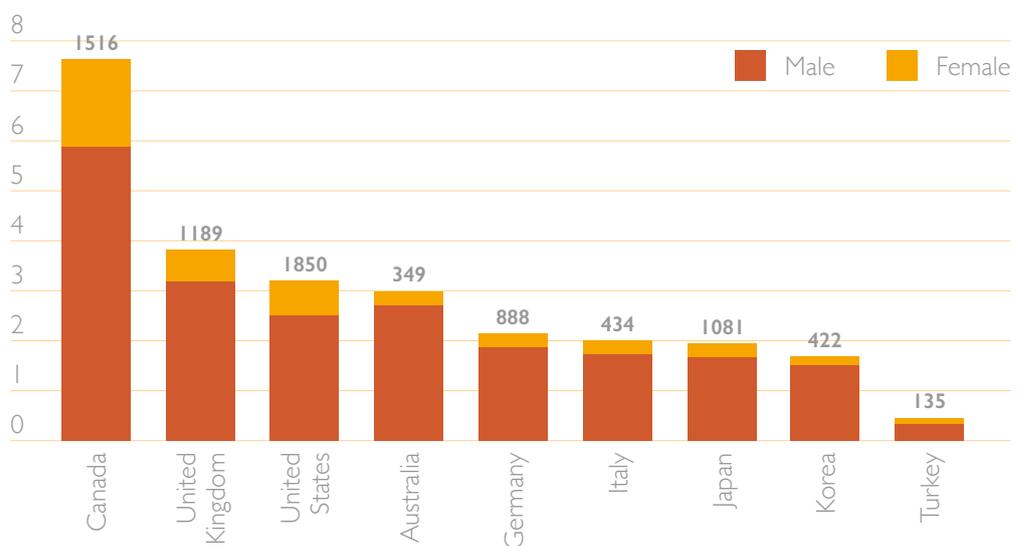The OECD also reports that 327 million fewer women than men have a smartphone and can access the mobile internet, and that men are four times more likely than women to become highly paid ICT specialists.

ICT specialists from selected G20 economies, by gender, 2015
As a % of the total workforce, and total number of ICT specialists (thousands)

In order to narrow the ICT gender gap, and to avoid female workers being relegated to low-paid contract work, women will need to enrol in disciplines such as engineering, mathematics, science, and technology that will allow them to embrace the opportunities offered by the digital world. Organisations have a major role to play here and training for the female workforce should be prioritised.

Workforce challenges:

» Older executives need to accept new flexible working models

» Workers may be reluctant to embrace new technology due to fear of job losses

» Companies need to re-skill their employees and offer ongoing training programmes

» Companies will need to find highly skilled people in a pool of unqualified talent

» Workers must adapt to a multigenerational working environment.

» The female workforce will require additional training in scientific disciplines.

4.2 Workspace

As workers will increasingly work away from a corporate office and use virtual working spaces instead of physical places, there will be a restructuring of real estate. Companies will close physical offices and hot-desking in the remaining ones will become the norm. However, there are reports that hot-desking can make staff feel isolated, and that they resent such working conditions. Companies are advised therefore to avoid a two-tier system, whereby elite employees have permanent workspaces, while lower-skilled staff are relegated to "economy class" flexible seating.

As the workforce becomes more mobile, an office-based computer will no longer be sufficient or even necessary. Companies will need to provide employees with smartphones as well as "wearable" and portable augmented reality (AR) and virtual reality (VR) devices. As more and more workers will perform their tasks remotely, line managers will need to ensure that staff still feel part of a team and that they have the materials and equipment they need. A Deloitte survey of companies located in Switzerland, entitled, "Workplace transformation in the Digital Age,"[8] found that 42 per cent did not provide hardware for their employees to remotely access their systems, and 25 per cent of employees had no mobile access at all to the company's network.

Managers will need to trust their employees to work flexible hours from different locations and set clear guidelines as to the amount of work that needs to be done. Various studies have found that flexible workers resent the idea of being tightly monitored and perform better in an environment of trust.

Employees carrying out analytical tasks often need a quiet environment, free from interruptions, that allows them to concentrate. The increasing importance of such tasks needs to be considered when designing workspaces.

In 2013, researchers from the University of Sydney published a report following a survey of more than 42,000 office workers in Australia, Canada, Finland, and the USA. The report, which incorporated data from the Center of the Built Environment at the University of California, Berkeley, found that employees were frustrated by the uncontrollable noise and loss of privacy in open plan offices.

8. https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/innovation/ch-en-workplace-of-the-future.pdf

Top 5 frustrations employees report having with open plan environments

% dissatisfied

Legend:
- Enclosed Private
- Enclosed Shared
- Cubicles with High Partitions
- Cubicles with Low Partitions
- Open office with no/limited partitions

X-axis categories: Sound Privacy, Temperature, Noise Level, Air Quality, Visual Comfort
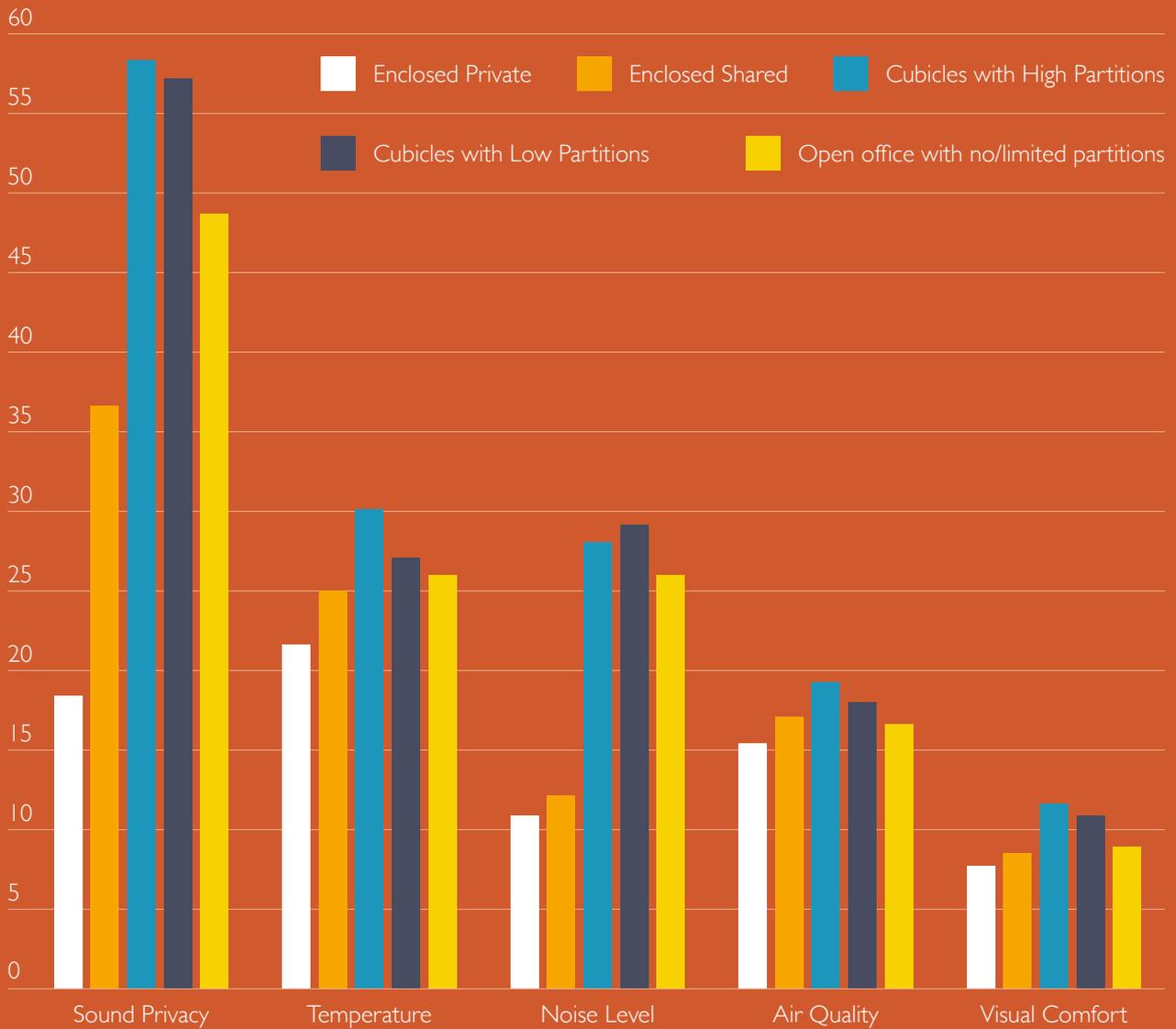
Source: "Workspace satisfaction: The privacy-communication trade-off in open-plan offices", 2013 report by University of Sydney based on the occupant survey database from the Center for the Built Environment, University of California, Berkeley.

"Co-working spaces are becoming popular for employees who cannot work at home but want to reduce the amount of time spent in stressful commuting."

However, collaboration will also be a key aspect of working life and companies will need to provide space for brainstorming and interaction, and invest heavily in virtual conferencing systems, intranet networks, and content-sharing solutions. Here, flexibility is once again key. Instead of a fixed desk, workers will need multifunctional spaces that adapt easily to the task in hand. It is important, however, to engage staff in the planning of new workspaces and allow them to influence the decision-making. If staff are involved at the planning stage, they will more readily accept the changes.

Mobile apps are replacing rigid meeting planners to identify vacant workspaces. Such apps can also be used to find vacant parking places and conference rooms. Sensors can control temperatures and lighting in meeting spaces and indicate whether they have been used – useful information for cleaning purposes and the provision of refreshments.

Co-working spaces are becoming popular for employees who cannot work at home but want to reduce the amount of time spent in stressful commuting. Such spaces can be used by mobile employees such as salespeople or product demonstrators, as well as by external stakeholders.

Smaller companies may find the cost of state-of-the-art communication systems too high and may therefore prefer to switch to subscription-based services – renting assets rather than owning them. The adoption of models such as software-as-a-service (SaaS) and device-as-a-service (DaaS) can free up the workload of the IT department and offer end users a secure and tailored solution.

Workers now expect up-to-date, comfortable facilities and are concerned about the impact of those facilities on the environment. Companies are likely to increase their use of 3D visualisations of workspaces to show impacts of carbon emissions, air quality, and social interaction. In the future, workplaces will even be able to monitor the moods of the people working in them.

4.3 Workflow

Workers are already beginning to base their decisions on automated intelligence and machine learning, but the collaboration between humans and machines will accelerate as the benefits are felt. The International Data Corporation has predicted that by 2023, the productivity of an average worker in a knowledge-intensive sector will increase by 10 per cent through the use of machine learning and cognitive technology.[9]

However, many workers feel that there is a disconnect between IT and core business priorities. IT departments are complaining about the lack of strategy, claiming that they are becoming overwhelmed, as all departments are urgently demanding new software applications, most of which cannot be adapted for use by other departments. The outsourcing of IT solutions to a network of suitable tech partners that maintain and develop them will be common, rather than retaining large corporate IT departments.

According to research commissioned by app technology developer Appian, companies in the US and the EU are failing to provide the IT solutions that have been requested by their different business units. Appian reports that 50 per cent of new applications end in failure. This is because some projects are never started, others are started but not completed, and the ones that are finished often do not provide a solution to the original problem.

9. IDC The Future of Work: A New Business Imperative https://www8.hp.com/h20195/v2/GetPDF.aspx/4AA7-4457EEGB.pdf

% of New Development Requests
By Line of Business by Region
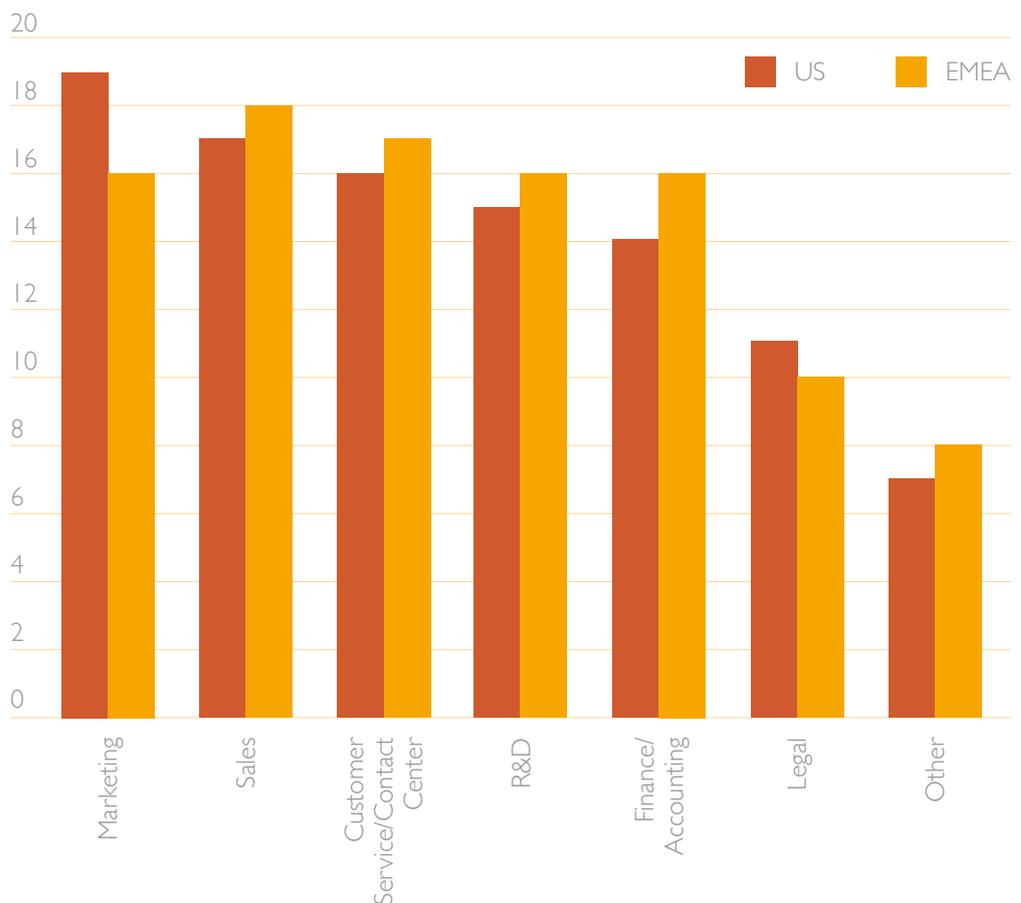
Technical debt

Many companies, through lack of vision, have chosen simple and inexpensive software that has provided a limited solution to an existing problem. These companies are now facing the high costs of "technical debt" as they need to "fix" the systems to incorporate more sophisticated solutions. Although opting for a simple solution can allow a company to get ahead quickly, in the long term this approach can cause the company to be saddled with heavy costs, as the simple solution will not support cutting-edge technology. The costs of "lost opportunity" also need to be factored into technical debt, as companies are unable to update their systems quickly enough to take advantage of new opportunities. Technical debt can accumulate. The technology and marketing company IDG Research estimates that technical debt is currently costing EMEA and US companies around 40 per cent of their development time. Some IT specialists advise the use of low code development – that delivers in less time and with less effort – as a solution to many technical debt problems. However, developers claim that such systems are slower and can eventually lead to more problems than writing in high code.

Sources of Technical Debt by Region
%

Legend: US (orange), EMEA (yellow)

Categories (x-axis):
- IT decision-marking is disconnected from strategic business goals
- On-time market pressure
- Poor and insufficient requirements documentation/ project briefs
- Bad source code/ source code complexity
- Poor testing
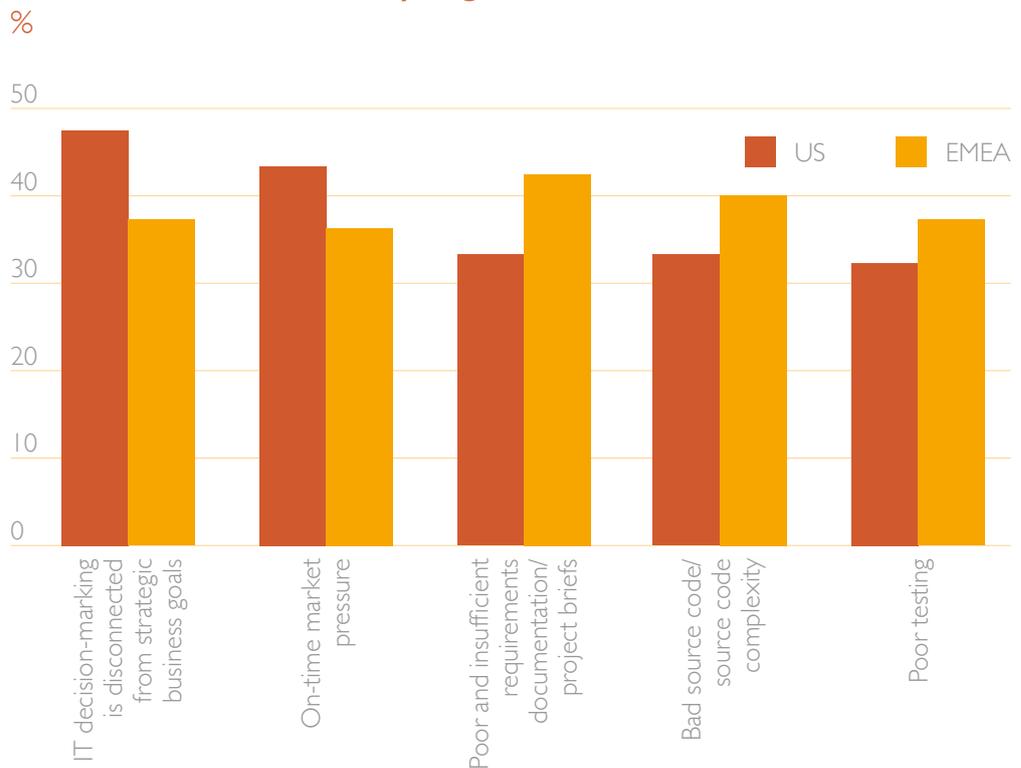
Industry is already using automated processes, but this will increase with the use of robotics and as machines become autonomous. Some of the main technologies that are transforming the workplace are:

Additive manufacturing

Also known as 3D printing, additive manufacturing (AM) will revolutionise production methods. It involves adding materials layer-by-layer to build an object (as opposed to traditional "subtractive" manufacturing (SM), where you begin with a piece of solid material and remove the parts you don't need). AM allows the production of complex parts that are impossible to make by traditional manufacturing methods. It also allows engineers to easily and rapidly produce multiple versions of a single design – unlike in traditional manufacturing, where changing a design can be time-consuming and the costs can be prohibitive.

Some companies have not considered AM as the upfront costs have traditionally been high. However, they are now becoming more affordable, allowing AM to offer a cost-effective alternative to traditional manufacturing. Adding the material you need rather than removing what you don't, can lead to significant reductions in costs for materials, and wastage is sometimes reduced by as much as 90 per cent. Furthermore, remanufacturing using 3D printing enables components that have reached the end of their lives to be replaced, whereas a traditionally manufactured replacement part might be unavailable or costly.

However, 3D printers apparently consume more energy than injection moulding or metal casting[10]. Research into the energy consumption of Bulk Forming, Subtractive, and Additive production processes, carried out by the Department of Mechanical and Aerospace Engineering of Seoul National University, concluded that the Specific Energy Consumption (SEC) of additive processes was 100 times higher than that of conventional bulk-forming manufacturing, while that of subtractive processes was midway between the two. The technology remains young, and improvements will be made to solve the problems of energy consumption, the choice of materials that can be used, toxic emissions, and the complicated operating systems of the machines involved.

Although complex geometric and organic shapes are often only possible by AM, subtractive manufacturing is still the method of choice for industries such as medical and aerospace, and for sectors that require precision engineering or parts that will be subjected to high stress use.

In many sectors, 3D printing will provide countless advantages, but it should be seen as a complement to traditional manufacturing rather than a replacement.

Industrial robots

Industry is investing heavily in physical robotic systems, and there has been a rapid rise in drone applications. In its "Clarity from Above" report,[11] PricewaterhouseCoopers believes that drone solutions could potentially replace USD 127 billion in current business services across a wide variety of industries, and predicts that the main sectors to feel the impact will be construction, agriculture, forestry, utilities, mining, and transportation. The insurance sector is also beginning to use drone inspections for insurance claims.

Drones can dramatically cut the costs of aerial surveillance, allowing companies to carry out weekly or even daily inspections. This dramatically increases the amount of data that can be gathered, allowing more in-depth analysis. This can be especially useful for the maintenance of existing infrastructure, and energy and mining companies are using drones to inspect construction sites, mining operations, pipelines, power lines, power plants, and wind farms.

Robots are particularly useful in environments where human safety is a major concern and are now being used for inspection and maintenance of infrastructure in underground and underwater locations, including offshore and inland waterways.

The construction industry is already using inspection drones to detect leaks and cracks in infrastructure, and this usage will lead to a greater level of safety and security than that permitted by human inspections.

10. https://link.springer.com/content/pdf/10.1007%2Fs40684-014-0033-0.pdf

11. https://www.pwc.pl/pl/pdf/clarity-from-above-pwc.pdf

> "Machine learning will greatly improve the service, and the potential of such tools should not be underestimated."

Drones can also be used to replace traditional infrastructure. A good example is the use of small replacement cell tower drones in disaster zones or during the management of large-scale events, as they spread the loads placed on static towers. Facebook is reportedly building a massive solar-powered drone that could provide internet access to remote areas.

Large retailers such as Amazon and Walmart are now using drones to scan warehouses to check their inventories, a job that used to be extremely labour intensive. This technology will soon become widely available enabling smaller retailers to take advantage of the cost savings. Retailers are also experimenting with the use of drones for deliveries, although this application is still in the testing phase.

Humanoid robots

The service sector is embracing humanoid robots for customer services. The aim is to improve the experience of the client and, of course, reduce costs. The advantage is that customer service robots are available 24/7 and can serve multiple clients simultaneously, so that clients are not kept waiting. However, customers are often frustrated by the fact that a "service bot" cannot handle unexpected queries or make a decision. However, machine learning will greatly improve the service, and the potential of such tools should not be underestimated.

Exoskeletons

The use of exoskeleton systems such as robotic suits, and power jackets is also evolving. The new models, which are controlled through artificial intelligence and use smart robotics, can enhance human performance in a variety of tasks. Manufacturing, logistics, agricultural, and construction sectors are showing particular interest in exoskeletons, as the systems can reduce muscle strain and injury and provide an easier and more comfortable working environment.

Augmented reality

Utilities and other service companies are already adopting augmented reality (AR) systems to help their field service technicians deal with repairs. Connected AR glasses allow service technicians to transmit videos in real time back to an experienced supervisor, who can provide advice complemented by the use of videos or graphics. Some companies are already experimenting with "virtual" technicians to help customers fix simple problems themselves.
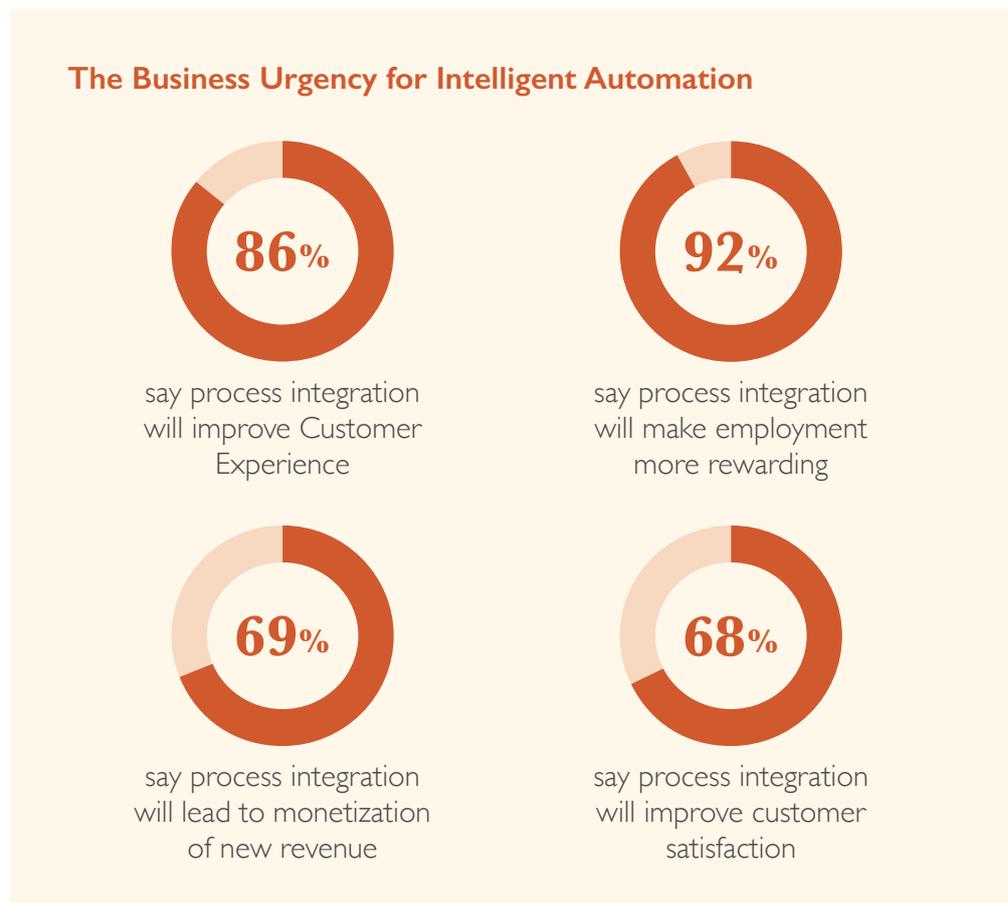
Intelligent automation

Automated systems, also known as "lights out" operations, allow computer systems, network devices or machines to function without a human operator at the site where the system is installed. Such systems are already being used for batch processing, factory automation, printing, network monitoring, bug detection, automated message response systems, and data security. Companies benefit from reduced labour costs, quicker response times and a greater level of accuracy. These systems are increasingly incorporating artificial intelligence and robotics to improve efficiency. At the moment the upfront costs of installing such systems can be high, but the costs are expected to become more affordable as more companies adopt the technology. The 2018 KPGM report, "Ready, set, fail?"[12] estimated that investment in intelligent automation would be USD 18.3 billion in 2019, but predicted that it would reach USD 232 billion by 2025.

A survey conducted by IDG for app technology firm Appian found that cost reduction was the least important reason for digital transformation and that most companies were investing in intelligent automation in order to improve customer experience and efficiency.

Source: *Future of work survey part 3, Appian / IDG (2019)*

The Business Urgency for Intelligent Automation

86% say process integration will improve Customer Experience

92% say process integration will make employment more rewarding

69% say process integration will lead to monetization of new revenue

68% say process integration will improve customer satisfaction

Top Goals for Intelligent Automation
(DX programs focused on Operational Efficiency vs. Customer Experience)

Legend: ■ Operational Improvement ■ Customer Experience

Categories: Greater efficiency | Product and service innovation | Faster actions and decision making | Enhance the customer journey/experience | Greater scale
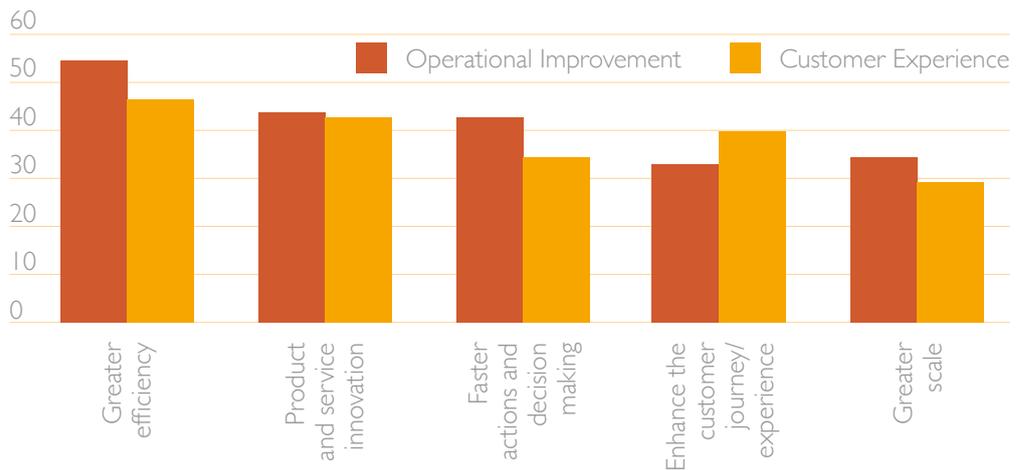
Robotic fulfilment

Online retail giant Amazon has been pioneering robotic fulfilment to provide faster, more flexible fulfilment of orders. However, the system still requires humans, who work together with robotic arms and small drive units to get packages delivered to clients. The employees at such centres are reaping the benefits as the robots lift heavy objects, move them around the warehouses, and finally bring them to staff for selection. Instead of technology replacing workers, Amazon says that it has added more 300,000 full-time jobs globally since introducing robots in 2012. Other companies are closely watching these developments and such systems are likely to become commonplace in fulfilment centres.

As companies compete to attract and retain skilled employees, automation processes will be key to attracting talent, as workers increasingly want to be freed up from tiring, boring, and exhausting physical tasks.

However, although research by tech researcher IDG reveals that most executives feel that automation is a good idea, apparently only 46 per cent of companies are using it[13].

Smart systems

Since the rise of personal computing and the internet, people have been living in two seemingly parallel worlds: the physical one and the world of information. As technology advances, the border between these two worlds is becoming blurred, as technology is increasingly being incorporated into the world of physical things. A few decades ago, telephones, domestic appliances, and cars were unconnected physical lumps of metal, plastic, and electronics, but now embedded sensors allow them to become "smart": capable of analysing data, making decisions based on that data, and communicating with other machines.

Internet of Things (IoT)

The Internet of Things allows devices equipped with sensors to connect to the internet and exchange data between each other without the need for human interaction. Objects such as fridges, cars, trackers, and watches can now be connected to the IoT to provide a range of services such as smart electricity grids, intelligent home systems, and intelligent transport. Such systems will become "smarter" as they continuously create new data and then learn from the output. In a July 2019 report, McKinsey estimated that the worldwide number of IoT-connected devices would increase to 43 billion by 2023.

Smart devices are powered by both Bluetooth and Wi-Fi. The use of Bluetooth is already familiar for connecting short-range devices such as headsets, speakers, and mobile accessories, but it is now being used for consumer electronic devices and IoT devices such as wearables, beacons, or activity trackers. A report by the tech market advisory firm ABI Research predicts that shipments of Bluetooth-powered IoT devices will exceed smartphones by 2024[14].

Systems integration (SI)

Systems integration links existing computing systems and software applications, enabling them to act together as one, and giving people across the whole organisation easy access to information. Companies are embracing SI for both business-to-business, and internal communication in order to gain a competitive advantage, as such systems reduce operating costs and speed up decision-making.

Distributed ledger technology (DLT)

Distributed ledger technology (DLT) is a database of records, stored across a range of servers that communicate with each other to synchronise transactions and ensure that each electronic ledger is updated and accurate. The World Bank estimates that DLT could increase efficiency across the financial services sector, and potentially improve access to finance for communities without banking facilities.

Perhaps the best-known form of DLT is blockchain, which organises data into connected blocks to create an unchangeable digital ledger of financial transactions. Blockchain is maintained by a decentralised network and is already widely used for Bitcoin and other cryptocurrencies.

Such technologies could have significant social and economic benefits. For example, they could be used to provide consumers with a platform for trading locally produced energy, without the need for an intermediary. Companies engaged in data storage, financial transactions, real estate, and asset management are also exploring these kinds of technologies and their use is likely to become more widespread.

> *"Big data analytics allows data scientists and statisticians to examine large datasets to uncover insights such as market trends, customer preferences, and activity patterns."*

However, such technologies are energy-hungry, because of the sheer amount of computing power needed to verify transactions (and the incentive systems that reward those who contribute computing power). Widespread usage could exacerbate greenhouse gas emissions. Further development, as well as legal and policy tools, will be required to mitigate their consumption of energy.

Big data

Big data analytics allows data scientists and statisticians to examine large datasets to uncover insights such as market trends, customer preferences, and activity patterns. By analysing this data, an organisation can gain competitive advantage by marketing their products more effectively, providing enhanced customer services, improving efficiency, and exploring new profit-making opportunities. The data could also be used to monitor the activities and health of employees to ensure an optimal working environment.

A company's existing data servers may not have the capacity to store such large datasets and there is therefore a tendency to outsource such work to third-party data providers. However, companies such as Amazon Web Services and Microsoft are now offering cloud options for the management and storage of large datasets, allowing companies to avoid costly subscription licenses.

In this area too, the lack of experienced data scientists and data engineers is currently holding back the development of big data analytics.

The future of the internet

According to the US Internet & Television Association, 80 per cent of Americans now have access to internet speeds of one gigabit per second via cable broadband networks. Fibre-optic broadband networks are now also becoming widely available in developed economies. New technologies are dramatically improving the speed of data transmission and 10 gigabit networks are already up and running in some locations including Adelaide, Australia. This speed allows consumers to download a high-definition movie in a few seconds or play video games without any hint of buffering.

There are fears, however, that people who do not have the financial means to access this new technology, or whose mental health prevents them from using it, will become increasingly marginalised. This has prompted calls for the web to remain neutral and universally accessible.

However, some large companies have called for a second, more secure, Internet, using an entirely different network of servers and IP addresses. The technology is apparently already in place. Hewlett Packard is reportedly already using a private network called Visual Collaboration that is separate from the main Internet.

There are conflicting thoughts about the desirability of a second internet. Some tech companies like the idea of a more controlled and secure environment that could be used by governments and businesses, even though the costs would be higher. They highlight the potential benefits of enhanced privacy, secure transactions, and protection from hackers. Others fear that it would cause confusion, lead to serious technical problems, and maybe even harm small businesses.

The costs of launching a second internet would be high, but many large companies and government departments are championing the idea, and it would be wise for businesses to keep an eye on developments. [15] [16]

Impact on supply chains

Supply chain managers are embracing big data to take informed decisions across supply chains. Artificial Intelligence can incorporate data from various sources to predict disruptions due to weather conditions, natural disasters, transportation bottlenecks, and even civil disturbances. Machine learning will gradually enable AI to recommend solutions to enable companies to respond rapidly.

Blockchain technology will also allow goods to be tracked in real time by all interested parties. However, companies must be prepared to transform their whole organisation and ensure that each stage in the supply chain is integrated into a fully transparent system. Such systems, if properly implemented, will improve efficiency, greatly reduce costs, and offer huge advantages to customers.

Of course, some companies hope that technology will replace manual work in the factories of their suppliers, allowing them to process large orders – even those with sudden deadlines – without the need to outsource to second or third-tier organisations.

15. Brandon, John, "What a second internet means for small business", *Inc.com* (11/2018) https://www.inc.com/articles/201108/what-a-second-internet-means-for-small-business.html

16. "Everything you need to know about 10G, the future of broadband technology", *Computerworld* (20/11/2019) https://www.computerworld.com/article/3448623/everything-you-need-to-know-about-10g-the-future-of-broadband-technology.html

Workflow challenges

» Technology and cost not biggest barriers: main problem is disconnect between IT and core business priorities.

» Internal development teams cannot keep pace with demand for new software applications.

» "Technical debt" is a real problem affecting bottom line.

» Not enough IT developers to fill demand.

05. Impact on Society

Populations have traditionally been reluctant to accept changes. One only has to look at the 19th century protests against the age of motorisation to see how workers and the general population have opposed new technology. Before the First World War, there were hardly any road regulations or standards for motorised vehicles, and cars caused multiple accidents and traffic chaos. Early vehicles had poor brakes and steering, were driven by inexperienced drivers, and were rejected by the general population as being highly dangerous contraptions that posed a real threat to bystanders. Streetcars ran down the centre of the street, and alighting passengers risked life and limb dodging cars and horse-drawn vehicles.

However, the rise of motorisation was rapid and unstoppable. The Automobile Club of America recorded 200,000 motorised vehicles in the US in 1909. Seven years later in 1916, there were 2.25 million.

Governments were slow to adapt to the evolving situation and it was not until the 1920s that US cities began adopting the three-coloured traffic light system to regulate traffic. Even after the First World War, blacksmiths, coach builders, and owners of staging posts held protests, fearing that they would lose their livelihoods. However, those that accepted the change and learned new skills found themselves lucrative work as mechanics, car body builders, and operators of petrol stations.[17][18]

A similar scenario can be expected for the digital revolution. Initially digital solutions will be adopted by affluent individuals in countries that already have a technical infrastructure and are therefore easier placed to adapt to the changes. However, slowly digitalisation will permeate through all layers of society.

The challenge is that people with low cognitive skills, or who live in areas with poor infrastructure, will become increasingly marginalised. The middle class will be eroded, as tasks performed by such staff as receptionists, call centre clerks, cashiers, bookkeepers, warehouse operators, production line workers, insurance underwriters, and bus, train, and long-haul truck drivers, will be largely automated.

The basic state education in most countries will not equip people to function in the new age of digitalisation, and people will need to take charge of their own ongoing training. People will need to learn new skillsets and be able to operate confidently in the new digital environments if they are to be fully integrated into the new tech society.

17. "1900-1930: The years of driving dangerously", *The Detroit News* (26/4/2015), https://eu.detroitnews.com/story/news/local/michigan-history/2015/04/26/auto-traffic-history-detroit/26312107/

18. "Road traffic history – Before the streets got swamped", *Auto Evolution* (8/11/2009), https://www.autoevolution.com/news/road-traffic-history-before-the-streets-got-swamped-12954.html

5.1   Demographics

A study by the Economist Intelligence Unit estimates that the global working population will increase by 900 million people between 2010 and 2030 but that the increase will vary across regions:

» In developed countries, the workforce is estimated to decline due to falling birth rates and Baby Boomers reaching retirement age

» In emerging economies, where the birth rate is still high, the workforce is estimated to increase by almost a billion

OECD countries, which have developed technological infrastructure and populations who are confident in using it, will be better able to adapt to new technical developments. However, countries that have poorer education systems, little connectivity, and where technical infrastructure is lacking, will lose out, despite the advantages of having a youthful population.

Innovation Environment for Automation
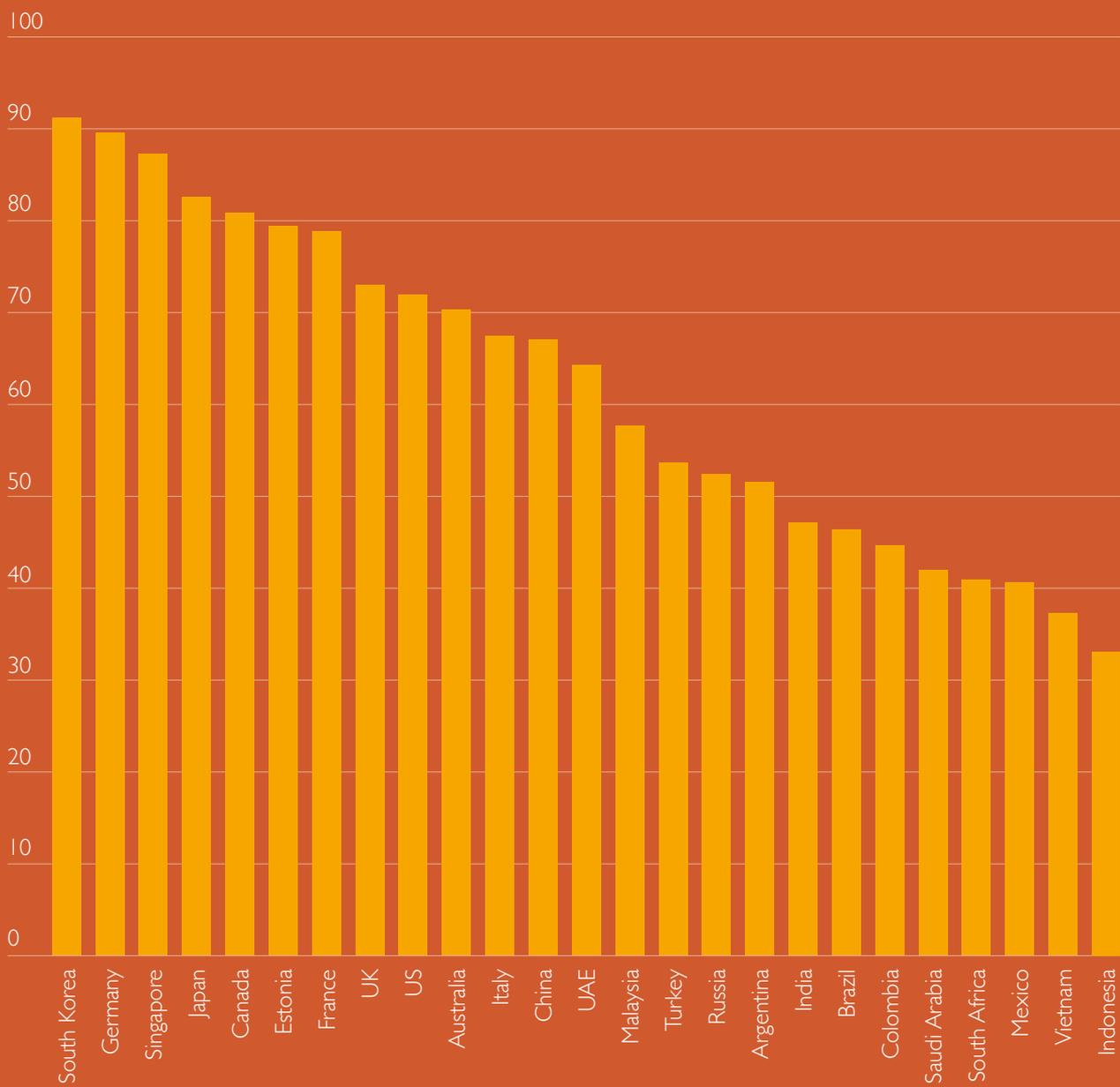
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"The concept that older people are a social burden also needs to be addressed, and new ways need to be found for older people to contribute to society."

Advances in medical care have allowed people to live into their seventies and beyond, and these advances will be further developed, allowing ages of 90 years-plus to be quite common.

According to the World Health Organization (WHO), the world's population is ageing much faster than in the past. The WHO estimates that there were 900 million people over 60 in 2015 and expects this to rise to a total of two billion by 2050. The organisation also estimates that by 2020, those aged 60 years and older will outnumber children younger than five years.

These demographic shifts will dramatically alter people's lives and allow them to pursue different activities after retirement. Governments need to actively encourage populations to lead a healthy lifestyle throughout their life, to enable them to fully enjoy their retirement years. However, these years need to be financed, and the timebomb problem of pensions needs to be tackled, despite widespread opposition to the idea of extending the retirement age.

The concept that older people are a social burden also needs to be addressed, and new ways need to be found for older people to contribute to society. Infrastructure also needs to provide for older people, many of whom are now living in separate accommodation rather than with their family. Healthcare services need to be strengthened to provide for the specific needs of an ageing population. Older people will need long-term social care as well as palliative care, and governments around the world need to address this problem and develop public-private partnerships to put in place viable systems to finance it.

However, society also needs to take steps to ensure that young populations in developing countries have access to technology to enable them to pursue a worthwhile career. The rise in technology, unless carefully managed, risks increasing the gap between emerging economies and the developed world. Although the digital revolution will create new jobs in developing countries, these will require skillsets that the majority of the population does not currently have. Automated systems will require less labour and the risks and impacts of mass unemployment should not be underestimated. Youthful populations who feel marginalised will increase their efforts to migrate to developed countries, putting strain on border controls and social services.

5.2 Migration to cities

According to a UN report on urbanisation, 55 per cent of the world's population lived in urban areas in 2018.[19] However, this is estimated to increase to 68 per cent by 2050, with the main changes being in Asia and Africa. Rural workers are expected to migrate to areas that offer technical infrastructure and developed countries will face increased immigration from countries with meagre technology.

Governments will face enormous challenges to cater for this influx of urban dwellers and unless steps are taken, housing, transportation, utilities, education, and healthcare will be put under huge strains.

With the right infrastructure and skills, the worker of the future will be able to work in any location. However, unless governments and the private sector work together to offer technical infrastructure and training programmes in rural areas, countries risk being left with rural wastelands.

Smart cities

We have already seen the introduction of smart cities in places such as Singapore, Dubai, Milton Keynes, Amsterdam, Madrid, and New York, where IT and communication technology is used to improve the quality of urban services. New technologies enable municipalities to better manage their energy and water systems and enhance such things as public safety, street lighting, and urban transport. A 2015 report by Navigant Research forecasts that revenue from smart city technology will grow from USD 8.8 billion annually in 2014, to USD 27.5 billion in 2023[20].

19. *2018 Revision of the world urbanization prospects*, United Nations Department of Economic and Social Affairs (2018) https://population.un.org/wup/
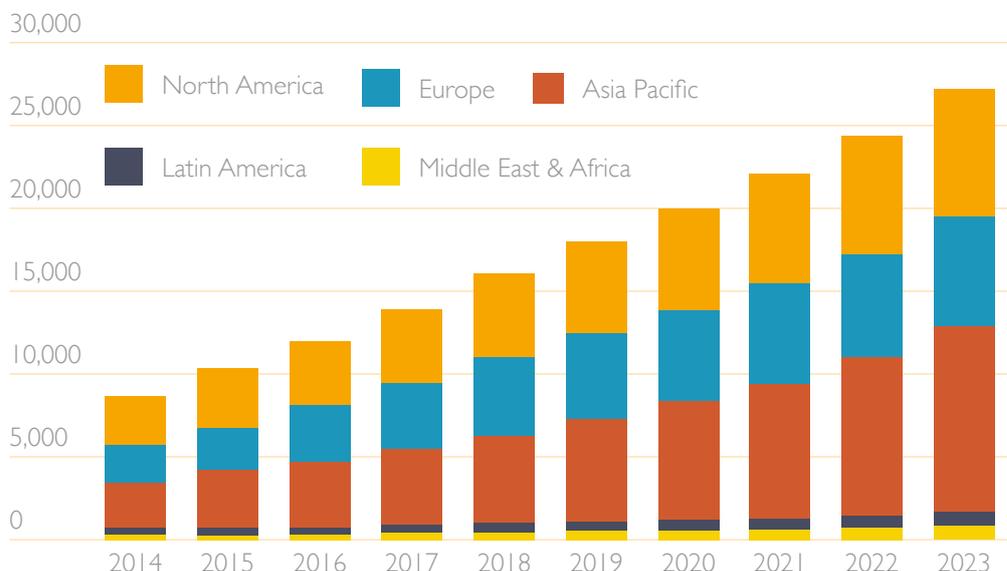
20. https://www.businesswire.com/news/home/20150213005076/en/Smart-City-Technology-Market-Expected-Worth-27.5

Source: *Navigant Research*

Smart City Technology Annual Revenue by Region, World Markets 2014 - 2023 ($)

More than a thousand smart city pilot projects are underway around the world, with China pushing ahead with 500 of them. The City Brain project in Hangzhou collects traffic and weather data and uses it to manage traffic signalling. This has reportedly reduced the travelling times for ambulances and commuters by 50 per cent and has allowed police to respond more quickly to accidents and traffic violations. In Shanghai, the Citizen Cloud provides easy online access to government services for local residents. Many cities have introduced smart parking, which uses sensors to allow drivers to find a vacant spot. Such projects will increase and will become the norm for major urban areas, making life easier for residents.

Transport

Public transport will become automatic. The Docklands Light Railway in London is one example of a driverless train system – and similar systems operate in numerous cities including Copenhagen, Delhi, and Dubai. There are pilot schemes to operate fully automated minibuses in Lyon, and other cities are exploring plans to operate fully automated buses on dedicated lanes. There are also pilot projects to equip small buses with advanced algorithms to allow them to pick up and drop off passengers on request, thus eliminating the need for passengers to walk long distances to a bus stop. It is hoped that such systems will reduce the number of private vehicles on the road.

Motorised personal transport devices that assist or replace walking are in their infancy, but their usage is set to grow. Although the use of self-service electric scooters caused multiple problems in France, until they were banned by some municipalities, this was mainly due to lack of regulation. Operators failed to remove the discarded scooters, and they were used indiscriminately on both the pavement and roadway, causing hazards for both traffic and pedestrians. However, the devices are very popular, and municipal governments are under pressure to find ways for people to use them in a safe and socially responsible manner.

Self-driving cars are still in the testing phase, and companies are trying to overcome problems posed by the unpredictable actions of drivers and pedestrians. There are also concerns that self-driving cars could be manipulated by third parties. However, partly autonomous cars are already in use. Features such as automated parking, intelligent cruise control, crash avoidance and lane-changing technology, and cameras that read road signs, will soon become commonplace. Experts agree though that it will probably be some time before self-driving cars are available for public use.

The shipping industry is also integrating AI and autonomy in both the commercial and naval sectors. By using remotely controlled autonomous ships the industry could reduce manpower, reduce accidents caused by human error, and reduce emissions. However, concerns have been raised about cybersecurity, as the industry has already been targeted by fraudsters creating fake websites that impersonate freight forwarders and shipping lines.[21][22]

21. Saraogi, Varsha, ''How will autonomy shape the UK shipping industry?'', *Ship Technology* (30/7/2019) https://www.ship-technology.com/features/how-will-autonomy-shape-the-uk-shipping-industry/

22. Can Ozkan, Utku, ''How to avoid fake shipping line websites and freight forwarding scams'', *More Than Shipping* (28/5/2019), https://www.morethanshipping.com/how-to-avoid-fake-shipping-line-websites-and-freight-forwarding-scams/

"Indigenous communities are using
social media to alert a wider audience
if their rights are being threatened."

5.3 Leisure and entertainment

Society has already accepted the concept of digitalisation in areas such as travel bookings, music, media, online dating, and translation. Companies such as Uber are revolutionising both personal travel and takeaway deliveries, and people in developed societies find it normal to use PayPal to purchase items via the internet. Household appliances and clothing will increasingly be equipped with digital sensors designed to provide a better customer service.

Healthcare systems have already embraced technology and the general public are familiar with the use of robotic equipment during medical consultations and surgery. New developments will allow doctors to treat patients in a virtual environment through the use of video conferencing.

Social media

Social media has given a voice to previously isolated groups. Migrants rely on communications technology to share information with other migrant groups. Protestors coordinate their activities via messaging apps and use crowdfunding to launch legal challenges. Indigenous communities are using social media to alert a wider audience if their rights are being threatened. Social media played a major role in coordinating activities during the Arab Spring of 2010-11 and the more recent Yellow Vest movement in France. The use of social media can also expose businesses to reputational risk. Negative reviews posted anonymously on sites such as Glassdoor and TripAdvisor can cause considerable problems for the company being criticised.

There are also fears that social media is being used to undermine democracy. Orchestrated campaigns on social media have been used to spread lies and fear and are often used to influence views for political motives. It is becoming harder to distinguish between fact and fabrication. When news goes viral, it is impossible to pull it back, even if it is proven to be false. Inaccurate news reports have led to incitement of mass actions against vulnerable groups, and politicians have been accused of spreading false rumours about their opponents.

Facebook and YouTube have already faced backlash for spreading misinformation and were criticized during the recent UK election for choosing not to remove misleading political advertisements. Facebook founder Mark Zuckerberg has predicted that there will be a move from social media to private messaging, and expects WhatsApp and Facebook Messenger, both owned by Facebook, to become the preferred method for users to interact. This means, however, that the sharing of news will become less transparent.

A 2019 survey by the Reuters Institute across 38 countries found that 55 per cent of the people surveyed were concerned about their ability to recognise fake news on the internet. The high proportion in the UK is likely to be due to concern about the spread of misinformation about Brexit.

The survey also found that internet users were opting for trusted news outlets and many had begun to turn to sources they deemed more reputable.

Proportion concerned about what is real and what is fake on the internet when it comes to news - all markets (%)
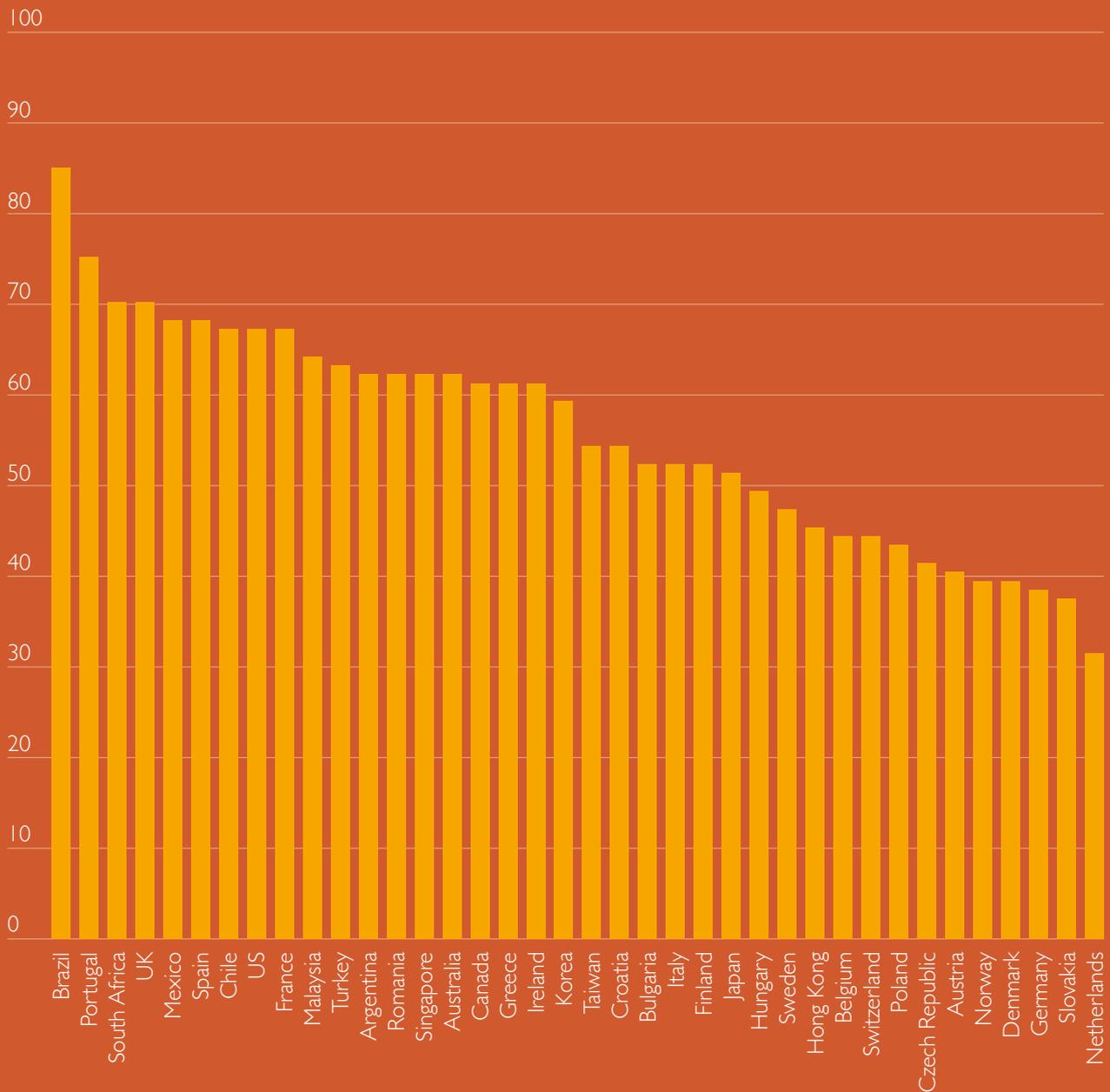
News sources

The 2019 Reuters Digital News Report also found that while older groups cling to the traditional news providers (TV, radio, and print), one in three 18-24-year-olds uses social media as their main source of news.

The opening up of media to private ownership in some regions has led to a proliferation of privately-owned news outlets, which often give a voice to local communities and groups. However, UNESCO has raised concerns that the concentration of ownership of media companies is leading to biased content. In 1983, 50 corporations controlled the majority of US media outlets[23]. In 2018, Fortune reported that US media (entertainment and news channels and internet services) was mostly controlled by AT&T (through its June 2018 acquisition of acquired Time Warner), Disney, Comcast, Netflix, and Amazon, and claimed that Apple and Google were also entering the media sector[24] [25].

There are also concerns that algorithmic profiling by news organisations is shielding users from accessing a range of sources and often only serves to reinforce an individual's existing views.

Engaging with social media allows companies a cost-effective way of interacting directly with their customers and promoting their brand image. According to the research firm GlobalWebIndex, social media now captures over 30 per cent of online time, so it makes sense for companies to establish a high-profile social media presence to ensure brand awareness.[26] [27]

Virtual entertainment

The fascination of young people with social media is expected to wane, but it will be replaced by virtual forms of entertainment that will allow people to experience enjoyable situations in a solitary environment. Psychologists have expressed fears that people will lose the ability to interact with others on a face-to-face basis. Although digital communication can be fast and efficient, the art of listening and the use of gestures, vocal tone, body language, and facial expressions, can be fundamental in putting across a point of view in both professional and personal life. It is difficult to show empathy or build trust via email or text messages, and there is a risk of miscommunication, misunderstanding and even disputes.

23. https://www.businessinsider.com/these-6-corporations-control-90-of-the-media-in-america-2012-6

24. https://fortune.com/longform/media-company-ownership-consolidation

25. https://deadline.com2018/06/att-completes-time-warner-acquisition-1202411103/

26. Young, Katie, "Social media captures over 30% of online time", *GlobalWebIndex* (11/9/2017) https://blog.globalwebindex.com/chart-of-the-day/social-media-captures-30-of-online-time/

27. O'Brien, Tom, "Why social media engagement is important for your business", *TimeTrade* (16/8/2018) https://www.timetrade.com/blog/why-social-media-engagement-is-important-for-your-business/

> "Indigenous communities are using social media to alert a wider audience if their rights are being threatened."

Addictions

In 2018 the World Health Organization included "gaming disorder" in its International Classification of Diseases, due to the increase in online gaming. Tech companies who run social networks, online shopping sites and gambling sites, are using persuasive marketing techniques to encourage users to repeatedly return to their platforms. Users of digital devices frequently feel the need to check their gadgets for fear that they might be missing something. A survey carried out by the UK's communications regulator Ofcom, found that 15 million UK internet users have tried a "digital detox". Although 27 per cent reported a feeling of liberation, 19 per cent said they had felt "lost" or "cut-off".

Digital eye strain is now a recognised health condition. People who sit for hours in front of a screen report headaches, blurred vision, burning eyes, and being unable to sleep. There are also reports of neck strain and shoulder pain. People are often looking at screens during their working day, and then continue to look at them during leisure hours. Digital devices have increased our exposure to high energy visual light (HEV), more commonly known as "blue light", which is blamed for sleeplessness. There have also been worrying studies that suggest that HEV can contribute to retinal damage and macular degeneration. Some computers give users the option of switching to "night mode," which filters out exposure to blue light. It is crucial for individuals to be aware of the dangers so that they can take informed decisions.

While smoking has declined significantly in many countries, use of e-cigarettes, or "vaping", has risen dramatically. The long-term consequences of using e-cigarettes has yet to be determined, but there are fears that these devices may be seriously harming our health. In June 2019, San Francisco became the first city to ban the sale of e-cigarettes until the long-term health issues are known. The law came into effect in January 2020, despite legal challenges from manufacturers of vaporisers.

Some e-cigarette manufacturers have faced serious criticism for their aggressive advertising campaigns, which often target minors by offering e-cigarettes in appealing flavours. It will be some years before the medical profession understands the health implications of such devices, but the US Food and Drug Administration worryingly reports that the use of e-cigarettes increased by 28 per cent among American high school students, and 48 per cent among middle school students between 2017 and 2018.

06. Impact on the Environment

The impacts of the digital revolution on the environment are two-fold. Firstly we need to consider the environmental impact of the e-devices themselves: the use of raw materials and the energy used to extract them, the energy used in manufacturing and the emissions produced, the energy used by the devices themselves, and finally the issues of dealing with waste when they are discarded.

However, the same questions need to be raised about the proliferation of single or short-use domestic products that will increase as a result of automated manufacturing processes.

6.1 Raw materials

When computers were introduced, there were predictions that people would use less paper, but Greenpeace claims that we now use six times more paper than before the use of computers, as well as six times more lithium, five times more cobalt, more iron copper and more rare earth metals[28].

The term "economic minerals" describes minerals, metals, rocks, and hydrocarbons that are extracted by mining, quarrying, and pumping techniques to provide materials that are essential for modern society. Minerals are extracted by underground mining, surface mining (open pit), or placer mining, the recovery of minerals from river channels and beach sands. Some minerals are abundant, but others, such as rare earth elements, are more difficult to extract, and the mining process causes huge environmental damage. There are also concerns about the use of child labour in mineral extraction.

Most e-devices contain plastic, which are mostly made from crude oil, natural gas, and coal. However, minerals such as mica, clay, silica, alumina trihydrate, and calcium carbonate are sometimes added to plastic to improve its moldability and stability, increase its capacity to withstand heat, and make it flame-retardant.

As the electronics sector requires more and more minerals and metals, mining companies are planning deep-sea mining operations as valuable metals and minerals have been located far beneath the ocean floor, deposited by hydrothermal geysers that regularly spew them out from the earth's core. Ecologists claim that such mining methods would cause irreparable harm to precious ecosystems, which are sometimes unexplored by scientists.

28. https://www.greenpeace.org/international/story/23747/its-a-waste-world/

6.2 Energy

A July 2019 report by the Shift Project, a French think tank that advocates for a shift to a post-carbon economy, claims that digital technologies currently account for four per cent of greenhouse gas emissions and predicts that this will increase by nine per cent a year. Companies and the public are sometimes unaware of the amount of energy used by digital devices and the amount of CO_2 emissions they produce.

Video streaming

Online streaming of music and video has been touted as an environmentally friendly choice, because it reduces waste associated with physical media formats such as CDs and DVDs. However, streaming accounts for considerable greenhouse gas emissions. The Shift Project alleges that online video streaming, used mainly for entertainment and advertising, currently generates over 300 million tons of CO2 per year, representing 20 per cent of the greenhouse gas emissions of all digital devices. It would be extremely difficult to reduce the amount of video being streamed by businesses and individuals around the world. NGOs are therefore calling on governments to introduce regulations to reduce this consumption and are urging tech companies to find ways of drastically reducing the energy required for video streaming activities.

Data servers

Data servers are also massive consumers of energy. Google is pioneering the way towards renewable energy and achieved 100 per cent renewable energy for its data centre and office operations in August 2017. Amazon, Microsoft, and Facebook are also striving to use renewable energy, but many other tech companies are only concerned with rapid growth, regardless of their environmental footprint.

Some companies are exploring shared data networks as a way of reducing both carbon emissions and costs. Closing down existing data servers and migrating to cloud computing reduces expenditure on hardware as well as CO2 emissions. However, there are major concerns about data security.

The International Energy Agency (IEA) warns that the growth in renewable energy is not keeping pace with our total energy requirements, predicting that global energy demand will have risen 25 per cent by 2040 if it stays on its current trajectory. Worryingly, the IEA also reports that the average coal plant in Asia is 11 years old, meaning that they will continue to spew out CO2 emissions for years to come, even though coal-fired plants are being phased out in developed countries.

6.3 Waste

The digital economy is producing massive amounts of waste, and innovative ways need to be developed to deal with this debris. There is strong consumer demand for the latest products, and mass consumption has made electronics the world's fastest-growing source of solid waste.

E-waste

In 2019 Greenpeace reported that the world was producing 65 million tonnes of electronic waste a year and that small personal devices accounted for about 22 percent of that waste[29]. Statista, the German online statistics portal, claims that around 1.5 billion cell phones and 250 million computers are sold every year. These devices usually have a lifetime of around two-and-a-half years, as they are often difficult or impossible to repair, and consumers may choose to replace even fully functioning devices with newer ones. Tech manufacturers have been criticised for "designing in" obsolescence, making it too hard to repair devices and requiring software upgrades that render older models slow or unusable. Greenpeace is calling for minimum standards of durability and repairability and is urging manufacturers to implement take-back programmes for all electronic products, not just their own brand.

Environmentalists are pushing the idea of e-waste recycling factories, which would generate revenue, create jobs and avoid the devices leaking toxic waste into landfills. Electronic devices now include many household appliances, which are also contributing to e-waste.

Plastics

Plastics commonly used in electronics are ABS (acrylonitrile butadiene styrene) and PVC (polyvinyl chloride), both of which are treated with chemical additives such as brominated flame retardants, during the manufacturing process. There are claims that such chemicals can cause brain damage as well as damage to the endocrine system of both humans and animals.

Environmental groups have expressed major concerns about plastic waste produced by the food and beverage sector as many companies are using digital manufacturing methods to increase their production of plastic packaging. The rise in online deliveries of consumer goods and fast food has caused a massive spike in packaging waste such as polythene bags, aluminium containers, and plastic plates, cups, straws, and cutlery. A good example is the proliferation of single-use coffee capsules for coffee machines. These are mostly made of plastic or virgin aluminium and are usually discarded into the normal waste bin, ultimately to end up in landfills, because consumers cannot be bothered to recycle them. Manufacturers need to offer innovative incentives to recycle such products and provide outlets to encourage users to do so.

29. https://www.greenpeace.org/international/story/23747/its-a-waste-world/

"The Pew Charitable Trust estimates
   that 13 million tons of plastic waste
   enters the ocean every year."

Wealthy nations have been exporting their plastic waste to poorer countries and, until recently, much of it was sent to south east Asia. However, since China banned the import of plastic waste at the end of 2017, other countries have followed suit, leaving affluent countries to look for new solutions.

Much of the plastic waste is dumped into landfills, which allows chemicals to leach into the soil, and ultimately the human body, which exposes people to health issues. Recycling plants have faced opposition from local residents who complain about toxic emissions. However, most plastic waste ends up on beaches and in the ocean. The Pew Charitable Trust estimates that 13 million tons of plastic waste enters the ocean every year. This waste has an enormous impact on marine life as fish, birds, and marine mammals can suffocate or starve after becoming entangled in the debris. They also ingest small particles of plastic, allowing it to enter the food chain.

Some electronic manufacturers are trying to address the problem, and Sony has announced that it will reduce the amount of plastic packaging used to wrap its electronic devices. The food and drink sector is also looking at ways to reduce the amount of single-use packaging. Researchers are also working hard to develop methods for the sustainable recycling of plastics and minerals found in electronic products.

However, much more needs to be done if we are to reduce the amount of plastic and chemicals that are devastating the environment and ultimately entering our food chain.

07. Crime and Cybersecurity

Cybersecurity threats are constantly evolving, eroding public faith in online interaction. A 2019 report by the University of San Diego identifies the following types of cybersecurity threats:

Malware: Malicious software such as viruses, worms, and spyware that can steal or delete data from a computer without the permission of the user

Phishing: An attempt to obtain personal information by pretending to be a trustworthy entity
Phishing techniques are becoming more sophisticated as machine learning is used to create more convincing fake messages.

Ransomware: Enables hackers to "kidnap" a database and hold it for ransom

Cryptojacking: Enables hackers to hijack computers and use them to "mine" for cryptocurrency

IoT attacks: Hackers attack connected devices and try to disable essential equipment
There is particular concern that the medical sector could be at risk as sensitive patient data is available on a variety of devices.

Physical cyberattacks: Hackers attack computerised utilities and infrastructure
Concerns have been raised about hackers exploiting semi-autonomous vehicles to steal personal data or even cause harm to drivers.

State-sponsored attacks: Hackers target critical national infrastructure[30]

30. https://onlinedegrees.sandiego.edu/top-cyber-security-threats/

Quantum computing

Some of the world's largest companies are investing in quantum computing, which harnesses the behaviour of particles at an atomic level to perform large calculations very quickly. A quantum computer developed by Google has reportedly taken just over three minutes to complete a task that experts estimate would take a normal computer around 10,000 years to process.[31] *The Economist* believes that this new technology will put systems at risk, as a quantum machines could theoretically unravel, in a matter of minutes, the complex maths used for encryption. IT engineers are exploring ways to safeguard encryption from such technology, but solutions are not expected in the near future.

Cybercrime is on the increase and attacks are becoming more sophisticated. Companies are investing heavily in cybersecurity and a survey by International Data Corporation (IDC) found that digital security was a top priority for most organisations.

However, there is a severe shortage of cybersecurity professionals, and the University of San Diego estimates that industry will require an additional 3.5 million specialists by 2021.

31. "Google claims to have demonstrated 'quantum supremacy'", *The Economist* (28/9/2019) https://www.economist.com/leaders/2019/09/28/google-claims-to-have-demonstrated-quantum-supremacy

Source: IDC Digital Transformation Executive Sentiment - Survey 2018, IDC, May, 2018

Top IT Digital Investments
%
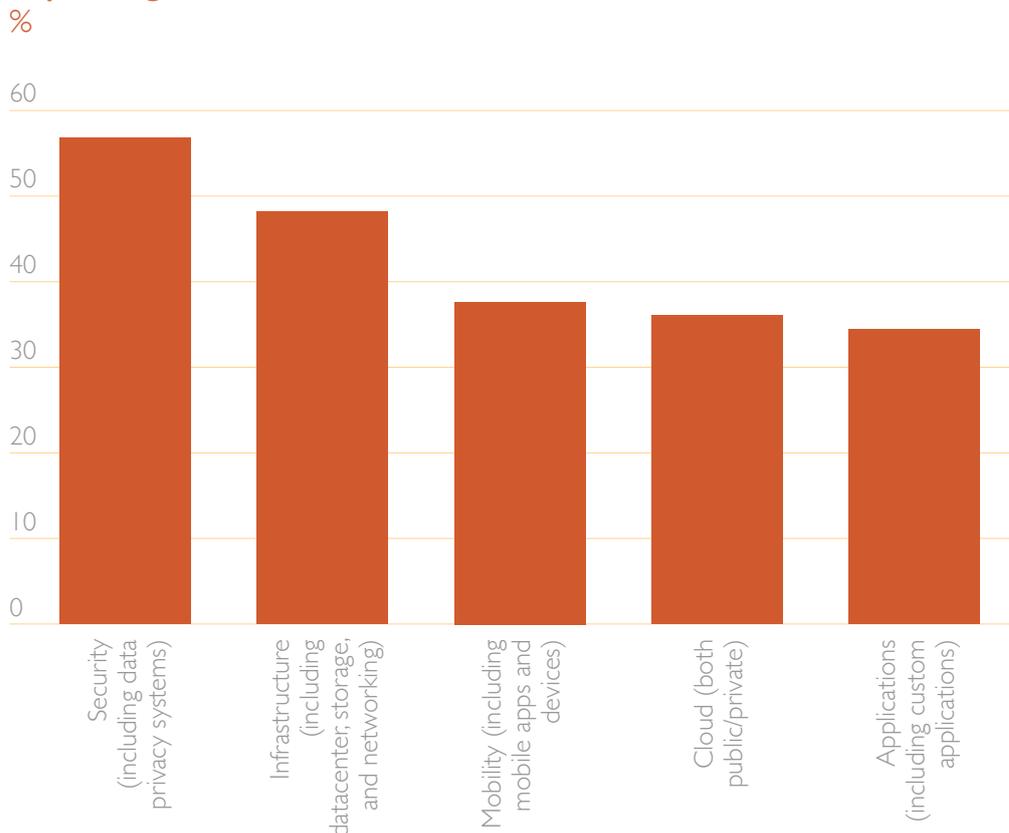
> *"Countries outside the EU have also begun to adopt GDPR regulations and it is thought that it will eventually become a global standard."*

GDPR

The European Union's General Data Privacy Regulation (GDPR), which came into force in May 2018, was a huge step towards ensuring the security of personally identifiable information (PII) of people in the EU and EEA areas. Countries outside the EU have also begun to adopt GDPR regulations and it is thought that it will eventually become a global standard. To be GDPR compliant, companies need to provide safeguards to protect personal data and ensure that their IT systems are protected from cyberattacks, both malicious and accidental. It also addresses the transfer of PII outside the EU and EEA areas.

Counterfeiting

3D printing lends itself to counterfeiting, and products can be forged very easily. The counterfeited items are sometimes impossible to identify, and patent holders and copyright holders will need to find ways of protecting their rights as this kind of technology evolves.

Dangerous weapons

3D printers also allow the easy production of dangerous weapons and criminals can therefore make items such as components for firearms and explosives, as well as bank card readers without being detected. Governments will need to put strict controls in place to avoid such items flooding the black market.

08. Ethics and Sustainability

The digital age has raised a number of ethical questions that need to be resolved. Although the hope is that digital technology will be used to enhance the lives of the people on our planet, there are also fears that it could be used to exploit or harm them. Society must avoid being passive users of technology and play an active role in how it is regulated, if we are to build a more equal world.

There was public outcry following the revelations that the personal information of millions of Facebook users was leaked to Cambridge Analytica without their consent, and that the data had been used for political purposes. There are fears that medical data could be sold to insurance companies, who could use it to offer policies at higher premiums to people with health problems.

There is currently no consensus on the ethical development of digital technology. In March 2019, the UN Secretary General called for a ban on "machines with the power and discretion to take lives without human involvement", but so far, no resolution has been adopted.

8.1 The power of data

Computer code, which allows humans to interact with computers and computers to interact with each other, is at the heart of the digital revolution. However, who owns computer code?

A European Commission Directive dated 25 May 2009, states that:

» The author of a computer program is the **person or group of people** who have created the program or, where national legislation permits, a **legal person**, i.e. a company or other legal entity.

» If several persons participate in creating a program, the exclusive rights are held jointly by these persons.

» If an **employee** creates a computer program in the course of his duties or following the instructions given by his employer, the **employer** exclusively has the economic rights relating to that computer program. [32]

32. *Directive 2009/24/ EC — the legal protection of computer programs*, EUR-Lex (2009) https://eur-lex.europa. eu/legal-content/EN/ TXT/?uri=LEGISSUM %3Ami0016

The directive further states that EU countries must protect computer programs by copyright and that programs, including their preparatory design material, should be "protected as literary works with the meaning of the Berne Convention for the Protection of Literary and Artistic Works".

> **In 2016, the FBI asked Apple to help them unlock the iPhone of the terrorist who had killed 14 people in the San Bernardino massacre the previous year. Apple refused, saying that this would require the creation a "backdoor" which authorities could then use to access other phones, threatening privacy and increasing the risk of cybercrime. The company argued that computer code counts as free speech and so is protected by the First Amendment. In the end the FBI withdrew its request, claiming they had managed to get into the phone anyway.**

Questions have also been raised about the power of the large software companies. The global reach of the platforms used by these companies, who use data to fuel their expansion, gives them the power to influence the way people think and ultimately could undermine democracy. Think tanks have raised fears that the power of such data is in the hands of a relatively small number of entities and are calling for more transparency about how the data is held, where it is held, and who has access to it.

8.2 Surveillance

Many people are concerned about surveillance. Technology has eroded our privacy in many ways, and everything we do is now logged and monitored. From cameras in public places, to the use of loyalty cards by retail outlets, surveillance technology enables companies to glean information about each person and build up profiles, which can then be used for selective marketing campaigns.

The justification for surveillance often depends on who is using it. It is considered acceptable for state security agencies to intercept telephone messages and emails of suspected criminals and terrorists if it allows them to provide a greater level of security for the country's citizens. However, is it ethical for a company to develop and sell software to a government, knowing that it will be used to identify, monitor, and possibly even eliminate dissidents? Is it ethical for a company to monitor the emails of its employees to identify possible whistle blowers?

These issues need to be discussed and clear guidelines put in place before new technology allows even more invasive methods of surveillance.

Many companies are developing their own code of ethics to deal with the above issues, but these need to be standardised if we are to ensure that they are systematically integrated into corporate decision-making.

"Countries outside the EU have also begun to adopt GDPR regulations and it is thought that it will eventually become a global standard."

8.3 Threat of mass unemployment

The OECD categorises the impact of technology on the labour market as:

» **Job substitution:** Jobs become obsolete as they are replaced by automated systems or are outsourced to "gig economy" workers

» **Job augmentation:** Humans work together with machines, but fewer machine operators will be required

» **Job creation:** New jobs – as yet unknown – are created, which may require skillsets not currently present in the workforce

All of these categories point, however, to the same thing: mass unemployment of low-skilled workers.

Automation offers many advantages. The most obvious is a reduction in labour costs, not only the cost of salaries but also social charges, pensions, and the cost of providing infrastructure such as sanitary facilities, canteens, parking places, and transport. However, the key challenge is how to deal with the mass unemployment it will create. Although a handful of staff may be retained in a supervisory capacity, the majority of workers are likely to find themselves redundant. Is it ethical for a company to expect to reap all the rewards of reduced costs and enhanced production, while potentially leaving the taxpayer to support redundant workers?

Other benefits of automation include a reduction in the complexity of supply chains, especially for companies engaged in manufacturing, as illicit outsourcing by contractors to second and third-tier suppliers will become unnecessary. Companies will also be able to avoid allegations of abusive working conditions in supply chains, as machines will take over such tasks as manufacturing, crop picking, and call centres. Here again, the problem of mass unemployment must be confronted. Emerging markets that have built their economies on the provision of services and products for developed nations should not be left to pick up the pieces when these tasks are automated.

Companies need to ask themselves whether an expectation of continuous economic growth is sustainable. To ensure a sustainable environment that reduces carbon emissions and the overuse of resources, there needs to be a "culture shift" to embrace more modest consumption. Companies can play a major role here, by manufacturing quality products that can be easily repaired and by encouraging customers to return unwanted items so that they can be recycled.

09. Role of Government

The new digital era raises a plethora of social, legal, and ethical questions, and governments need to urgently address the issues and put in place an institutional framework to govern the ethics of technological advancement.

Topics such as the ethical limits of genetic engineering and embryonic and stem cell research need to be discussed. There also needs to be a legal framework for self-driving cars and private drones.

Tech companies now control our online interactions and clear ethical parameters need to be put in place to protect users from unscrupulous practices.

9.1 Labour laws

Governments will need to introduce new flexible local labour laws. More workers are likely to embrace platform work (using platforms such as Uber to find work and connect them with customers) for the flexibility it offers. Governments must therefore force companies to provide platform workers with the benefits enjoyed by conventional workers, such as sick pay, maternity pay, holiday pay, and pensions.

In an age of unemployment, there are fears that workers will accept lower salaries to secure job offers and end up working on poverty wages. A minimum liveable wage would go a long way to prevent this from happening.

9.2 Education and training

The key challenge facing governments is the education of young people and the re-skilling of existing workers to allow them to move to new technical jobs. Private organisations can play a major role here: providing hardware and software to cash-strapped governments and partnering with them to offer ongoing training courses. The organisations will ultimately reap the benefits as they will be able to tap into a pool of tech-savvy workers.

Education needs to focus on creative skills which can be more easily transferred to a new technical environment, rather than the learning of facts. Another possibility is to reduce the working hours and spread the remaining out more fairly among the population. Governments could also consider "job guarantees", i.e. guaranteeing paid employment when a job is lost. Such jobs in the health, care, and cultural sectors could possibly be financed by their social benefits. Sovereign investment funds could also create revenue to finance such systems.

Public-private partnerships will also be necessary to ensure that rural areas benefit from up-to-date technical infrastructure. It is in the interest of the government to enable workers to work outside cities, as this will lessen the burden on municipal infrastructure.

9.3 Universal basic income

As we have already mentioned in this report, there are grave fears that the digital revolution will create a class of low-paid, low-skilled workers who are resentful and envious of their highly-paid, highly-skilled counterparts.

Governments need to revisit the idea of a universal basic income (UBI) to see whether it could provide a solution to large-scale unemployment. However, a guaranteed income still does not provide the self-esteem that comes with work. People on a UBI might also find it difficult to re-enter the job market as the rapid pace of technological change makes their existing skills obsolete.

"Legislation needs to be passed to prevent companies from building-in obsolescence and manufacturing goods that cannot easily be repaired."

9.4 Taxation

Digitalisation also has implications for taxation. Although leaders of the G20 have made progress on measures to combat BEPS (base erosion and profit shifting), to stop companies artificially shifting profits to exploit different tax regimes, more work needs to be done on issues such as the allocation of tax on income generated from online cross-border sales, and on companies that do business in a country without having a physical presence.

The tricky question of Intellectual Property (IP) also needs to be tackled, as IP assets could either be owned by the business or leased from a third party. The ownership of user-generated content is also crucially important for business models that rely on collecting information linked to a specific customer.

The OECD is currently working on the above tax issues and will submit a report to the G20 by the end of 2020.

9.5 E-waste

Some regional governments have passed "extended producer responsibility" laws, which force tech manufacturers to recycle and collect obsolete products. More governments need to join this initiative, which includes banning e-waste from being disposed of with general waste. Legislation needs to be passed to prevent companies from building-in obsolescence and manufacturing goods that cannot easily be repaired.

10. Conclusion

The digital revolution cannot be stopped, but companies and governments need to control its development. Technology will create new, previously unthought-of, job opportunities. Some sectors and roles will become obsolete, and while most experts agree that new livelihoods will more than compensate for job losses, there will inevitably be winners and losers, and big changes to the profile of the working population. It is also clear that automated workplaces will need human skills too, although possibly not to the same extent as before. However, the new range of opportunities will require skillsets that the current workforce does not have.

The transition will therefore be difficult. To avoid mass unemployment, governments need to initiate programs to encourage individuals to undertake lifelong learning. Companies, too, need to be proactive in reskilling and upskilling the whole of their existing workforces, rather than focusing on a selected group of key employees.

If companies see automation just as a way to reduce costs and take the easy option of outsourcing tech tasks to outside contractors, it will lead to mass redundancy in the existing workforce.

Likewise, if companies channel all the profits to be earned from the digital revolution into the pockets of their shareholders, society will become even more polarised between the "haves" and the "have nots".

Corporations need to remember that mass unemployment – and as a result mass poverty – will leave fewer customers to buy the proliferation of goods and services that they will produce.

The digital revolution offers a wealth of new opportunities. If it is managed wisely, it could lead to good quality jobs, fewer working hours, and an improved quality of life. However, if managed poorly, it will lead to widening skills gaps, greater inequality, and broader polarisation.

It is crucial for all stakeholders to act now if society as a whole is to reap the benefits of the digital revolution.

11. Considerations for the Quality Profession

11.1. Strategic quality management

To remain relevant, quality management will need to shift focus from the conventional tactical approach and move towards strategic management. Quality professionals (QPs) need to grow customer/stakeholder value and help leadership teams embed a quality culture in their organisations' DNA. As with all professions, technology may well automate tactical activities over time, allowing smaller quality management teams to focus on more strategic issues.

Quality control, currently the responsibility of the operational domain, will become automated, with sensors allowing 100 per cent inspection. Robotic process automation will reduce human error and may improve the quality of products and services. With data flowing throughout interconnected value chains and supply chains, quality audits will need to focus on risk mitigation and data analysis. Within this context, the quality profession has the opportunity, and indeed the responsibility, to become "trusted advisors" in planning and establishing connected, autonomous, and intelligent systems that deliver quality, risk-free operations, while transforming value for the organisation and its customers.

This will mean focusing on governance to help organisations design and build optimal solutions that capture the data required to analyse and improve performance. QPs have always been data scientists, gathering data and using scientific analysis to measure performance and suggest improvements. These principles will continue to remain relevant, but with new digital data analysis tools offered by machine learning and quantum computing, the profession will need to reposition itself as the "digital translator" between operational risk/opportunity and the data governance and science communities, to help organisations translate data into value through strategically aligned improvement.

The quality of products, services, and processes will remain a strategic imperative for organisational reputation and competitiveness. But the human customer and stakeholder communities must not be forgotten in the new digital world. Although digitalised, organisations will remain human endeavours focused on delivering human outcomes. Positive quality cultures will be crucial in guiding human decisions and behaviours at all levels, and the quality professional's role as "quality culture champion" will be fundamental. Leadership and soft skills will increasingly become the "magic dust" that allows the profession to advise, translate, and champion, and the measure of success will be how often the quality professional is proactively asked to contribute, not just when things go wrong, but in order to make sure they go right.

11.2. Trust and guardianship

The QP's role as the conscience of the organisation will be expanded, and the scope of the management system will need to embrace the full set of stakeholder requirements – including those of the customer – and connect with the organisation's strategic management of risk and performance monitoring.

Until the latter part of the last century, an organisation's management system would have been designed, built, and operated solely to ensure that customers received products and services that met their expectations. This was viewed as the best way to derive value for a company's shareholders. The role of QPs was to ensure that this happened consistently, so that product and service issues were resolved at source. QPs helped companies deliver conforming products, competently and consistently, to their customers. Consistent delivery to the product and service expectations engendered and maintained customer trust.

Over the past 20 years, customer expectations have evolved to the point that organisations now need to take responsibility not only for the quality of their products, but also for all the organisation-wide processes and external touchpoints that affect the customer's view of their products and services. Management systems were first expanded to support customer care in the delivery of products and services, and the role of the QP expanded in equal measure to include, by way of example, the robustness of supply chains and the effectiveness of finance and marketing processes. But this development did not go far enough. Trust in an organisation increasingly derives not only from competence, but also from people's perceptions of alignment with the organisation's strategy, compliance, and principles, and from their perceptions of a company's sincerity in championing its values. People increasingly expect an organisation to behave conscientiously, be a "good neighbour", and promote humane and widely respected values. Consequently, management systems now recognise a much wider scope for failure, as businesses shift from being "for profit" to "not just for profit". QPs promote integrated management systems that sympathetically support the delivery of strategy, compliance, and principles that keep the organisation firmly within its strategic arrow.

In today's world, QPs have become "guardians of reputation" and "stewards of trust". As people come to expect that companies will deliver value to all their stakeholders, stakeholders other than customers are gaining in prominence and influence.

Organisations must also be seen to deliver the legitimate needs of their staff, their supply partners, their community, and the environment. The ongoing decline of investor supremacy in corporate decision-making is a seismic shift, and existing management systems are struggling to keep up. In the future, as artificial intelligences approach sentience, companies may be expected to consider their legitimate needs too – perhaps to data, to processing power, to connection with the world around them, to other needs that we have yet to discern – together with those of today's stakeholders.

QPs understand how to interpret stakeholder needs. They know how to build the so-called voice of customer (VOC) and the requirements of other stakeholders into the systems, processes, and behaviour of the organisation. They are a key enabler of the development of good management systems that address the needs of many stakeholders, keeping them in balance and ensuring that they are considered in performance monitoring systems. QPs are playing an ever-growing role in the mitigation of strategic business risk and in the development of strategic business opportunities. This is a trend that is likely to continue well into the foreseeable future.

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11.3. Big data and analytics

The QP will need to act as a "translator" between the data science and operations communities to help devise data strategies, govern data quality, and facilitate rapid problem solving.

The term "big data" describes a situation involving a lot of data, from a lot of different sources, in a lot of different types, often in real time. Although it is still early days in terms of methods for both the collection and the analysis of big data, the availability of highly dimensional, highly available data promises to shift the grounds of what it is possible to know, what it is possible to foresee, and what it is possible to risk-evaluate. The QP will need to adjust to this new reality.

Consider worker safety. Safety practice is highly regulated, particularly in industrial sectors and transportation. The typical management system considers accidents and near misses, often as though they were events in isolation, to derive recommendations and new rules for prevention. What data are gathered in support of an investigation currently depends on what experienced professionals deem worthy of investigation. Big data promises a different approach. A national railway could want, for example, to marry location data from Internet of Things (IoT) devices like intelligent hard hats worn by track workers, with rail operations

data, data from security cameras and monitors, and a large collection of electronic communications, to establish a comprehensive, dynamic risk map that allows near misses to be avoided altogether. Analytics themselves are big data, in such an environment. One can imagine an AI trained on medical records from A&E departments around the world, with a mission to warn of the possibility of serious injury. Of course, the data engineering task to achieve such a dream today would be huge – the analytic paradigm doesn't yet even exist, but it is coming, and relatively soon. Such AI will be kinds of panopticon – its management by a human intelligence will be absolutely necessary, and within the competence of the QP. In respect of big data systems then, the QP will increasingly concentrate on risk management and the larger governance context of how the system learns, potentially without any need to understand or translate the language of data science into operations.

In contrast, today's organisations gather huge datasets, but analyse them in very focused, minuscule ways, as though the breadth and depth of data available were solely to provide a high degree of statistical evidence to support decision-making. Having more data does provide opportunities to analyse the behaviour of customers, supply chains, and management systems in greater detail than has previously been practical or possible. Even today big data helps organisations forecast performance outcomes and allow for timely interventions to protect the integrity of systems, products and services. But what big data promises in the not-too-distant future is a complete up-ending of what it means to understand data structure.

Enhanced with analytic tools that can explore structure in innumerable configurations – with AI, with quantum computing, with a myriad of technologies still in the realm of the dream just before dawn – the QP will cut through the noise, the unimportant chatter, without so much as a passing reference to data accuracy and relevance. The QP's focus will be in the governance of data with myriad implications for privacy, discrimination, malicious targeting and invidious control. The QP will not be so much a translator between data science and operations communities, but a regulator of management systems behaviour.

It will be up to QPs to determine how effective decision-making will be eased in this new world, just around the corner from today. The five-component Competency Framework developed and championed by the CQI will be even more relevant to the strategic choices, governance, and excellence of organisational activities. In particular, QPs should increasingly pay more attention to developing their skills within the governance competence. When their organisations find that they need the governance skills to grapple with true big data systems, QPs will then be ready to step up to the plate.

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"The term "big data" describes a situation involving a lot of data, from a lot of different sources, in a lot of different types, often in real time."

11.4. Automation/IoT

The QP will need to work with the technology and operations communities to facilitate the design of automated systems and processes to prevent failure in delivering desired value for the organisation, its customers and stakeholders.

Automation has been said to have "killed" quality assurance in the software industry, all but removing the need for any human intervention. Intelligent "continuous inspection", which automates tests, generates, and interprets data, and responds accordingly, is increasingly prevalent. Machines are more reliable than people for this type of work and increasing automation will inevitably reduce human error.

Automation is, essentially, a form of documentation, conducting pre-ordained tasks consistently, reliably, and without variation. The advantages of this are clear, particularly in a profession whose purpose has been to ensure organisations produce products and services consistently, reliably, and according to their customers' requirements. The quality profession will therefore find itself increasingly responsible for designing and implementing intelligent systems that analyse the correct data, determining what and how is being inspected, defining the known errors or prescribed "norm", and determining whether an automated response or human intervention is required. This process will involve fewer "low-skilled", routine tasks, and instead will require more creative, intelligent, and systems-orientated skills.

Alexander Woods
Policy Manager, Chartered Quality Institute

11.5. Agility and adaptability

The QP will need to adapt to the increasing speed of change and agile approaches to support improvement and transformation at pace.

Today's world is changing at an unprecedented rate and we are witnessing both technological and cultural change occurring faster than ever before. Presently, business expectations, needs, and demands are evolving too, as organisations ostensibly live or die on their ability to quickly adapt. In this climate, people in practically every role must now focus on customer satisfaction and deliver continuous improvement in their day-to-day work.

Many organisations are struggling to navigate these disruptive times. Others seemingly navigate with ease, demonstrating adaptiveness, creativity, and resilience when dealing with the complexity and uncertainty they face. What makes these organisations stand out is their ability to adapt quickly (to market changes), respond rapidly and flexibly (to customer demands), and continuously innovate and retain a competitive advantage. Using uncertainty and change as an opportunity to become better. These organisations have embraced business agility.

Agility, in a business context, is the ability of an organisation to rapidly adapt to changes in the most productive and cost-effective ways. Business agility is crucial for organisational survival in these uncertain, volatile times. It changes how you think, how you work, and the way you interact with people.

Martin Brenig-Jones
Managing Director of Catalyst Consulting Ltd

11.6. Global perspective

The QP will need to understand shifts in global markets and supply chains, including the impact of technology, to prevent failure in supply networks.

As population growth and a rise in middle classes accelerates in the developing world, there will be a fundamental shift of global markets to emerging economies, as has been seen in China and India. This will fuel the need for a new cadre of quality professions to be trained in these countries. The rising concern over safety standards and environmental issues worldwide will also drive an increasing need for these quality professionals to be able to apply their skills to these challenges within organisations. The QP has an increasingly critical role to play in maintaining public trust in an ever transparent and untrusting world.

As supply chains incorporate more and more technology, the way quality is managed and assured throughout the supply chain will need to adapt. For example, it is likely that the increasing trend to partner, rather than contract, together with the explosion of independent start-ups, will make supply chains more fluid and fragmented than before. How to manage quality through the supply chain will be a challenge for QPs. Blockchain or DLT may be a solution, but it is yet to prove itself scalable outside of the financial sector. Although social media presents a challenge to organisations, it could potentially provide additional data sources for QPs, allowing them to analyse incidents or product complaints from public networks.

Dr Claire Ruggiero
Customer Experience Director, Business Assurance and Inspection Services, Lloyd's Register

11.7. Standards, accredited certification and regulation challenge

Standards, testing, inspection and certification (TIC), and regulatory infrastructures will need to engage with industry at an early stage to help facilitate technological innovation for businesses and eliminate risks for society. Those organisations providing assurance and accreditation services must adapt their own assessment methods to focus on validation of digital assurance systems.

Technological advances and the pace of their introduction will challenge traditional approaches to standards and regulations, likely requiring them to be more orientated to performance rather than procedures. Although there will be a need to assure public safety and product suitability, it is important that standards and regulation do not stifle innovation. There will also be a need to ensure that standards and regulations keep up with the pace of technological development, so they remain valid and fit for purpose.

The introduction of technologies such as artificial intelligence (AI) and the Internet of Things, accompanied by continuing improvements in internet connectivity, will

> "Autonomously generated systems data will provide recording and reporting in real time, which may greatly facilitate risk-based audit and assessment."

challenge traditional approaches to auditing and assessment. AI will open up the need to assess the competence of the machine rather than individuals. IoT will allow in-depth, real-time audits and provide a continuous stream of data that can be analysed for anomalies. These developments will improve both internal and external assurance functions and potentially provide regulators with a real-time evaluation of an organisation's compliance with regulation.

These technologies also present significant opportunities for accredited certification. Already we have seen an increase in the number of accreditation and certification bodies using online, connected systems to communicate customer information, such as distributed ledger technology (DLT). This is turn lends itself to increasing trust and transparency in immutable, verified information.

Autonomously generated systems data will provide recording and reporting in real time, which may greatly facilitate risk-based audit and assessment. Intelligent machines and interconnected devices will increasingly allow for audit and assessment to be carried out remotely and with minimal human intervention.

Jeff Ruddle
Strategic Development Director, United Kingdom Accreditation Service

11.8. Diversity and learning

Each individual QP will need to invest in ongoing learning, and plan for the future skills and diversity in their quality teams – taking into account forecasts of skills shortages and changes in workforce expectations.

To stay relevant, the quality profession needs to understand the opportunities and challenges presented by new technologies, the interconnectivity of business, and the pace of change.

Technology is changing the way businesses operate and measure quality. It is crucial therefore for quality professionals to acquire new skills in order to retain relevance and deliver value to their organisations by effectively exploiting the newly available tools and opportunities.

While technology has undoubtedly had an impact on the way we live and work, businesses are becoming increasingly aware that "softer skills" such as emotional intelligence, multidisciplinary working, and a strong focus on ethics and sustainability, are key to effective performance. Furthermore, in a work environment where technology allows more and more skilled "technical" work to be automated, soft skills become pivotal differentiators in the workplace.

At the core of the quality professional's development is the Chartered Quality Institute Competence Framework, which provides an overview of the competence that the profession requires to do its job effectively, described in terms of

> "Quality has always embraced diversity by attracting technical and business professionals from the manufacturing, service and education sectors."

governance, assurance, improvement, context, and leadership. Each element of this framework is affected by new technologies. These effects will present challenges but also offer great potential, particularly in terms of data collection and analysis, customer relationship management, and predictive maintenance.

The approach to learning and diversity within the field is critical in order to upskill existing professionals and offer flexible learning opportunities based on their level of expertise, availability, location, preferred mode of learning and personal circumstances.

The concerns for quality professionals are multifaceted. Not only must they consider what to learn, and how to do so, but they must also take into account the pace of change. This requires the QP to not only keep a finger on the pulse of change for their own professional benefit, but also for the evolution of governance, assurance, and improvement within their organisations.

Opportunities also exist for quality management educators and training providers to evolve the way they deliver training and education, by offering personalised learning opportunities, engagement, and diversity.

Quality has always embraced diversity by attracting technical and business professionals from the manufacturing, service and education sectors. To remain ahead and furthermore lead the way, we need to ensure that similar diversity is applied not only to learning, but also to those delivering and undertaking the learning.

Dr Michele Cano
Head of Division – Engineering, University of the West of Scotland

The CQI Competence Framework lies at the heart of how the CQI helps quality professionals plan their development and fulfil their potential.

It sets out the knowledge, skills, and behaviours that quality professionals need in governance, assurance and improvement – helping both individuals and organisations succeed.

The Competence Framework helps, quality professionals to plan and advance their careers and employers of quality professionals to support and develop their people. It describes to the wider world what quality professionals do and aligns CQI and IRCA Certified Training to the knowledge, skills and behaviours called on by industry.

12. Acknowledgements

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13. Glossary of Terms

CAPA	Corrective and Preventive Action
CDP	Continuing professional development
FDA	Food & Drug Administration (USA)
EQMS	Enterprise Quality Management System
HARPC	Hazard Analysis and Risk-Based Preventive Controls
IIoT	Industrial Internet of Things
IoMT	Internet of Medical Things
OSHA	Occupational Health and Safety Administration (USA)
MES	Manufacturing Execution Systems
NPI	New product introduction
P&Ps	Pick and Place Machines
QCS	Quality Control Systems
QP	Quality Professional
RFID	Radio Frequency Identification
SQM	Software Quality Management
SMT	Surface Mount Technology
SMDs	Surface Mount Devices
SOPs	Standard Operating Procedures
TIC	Testing, Inspection and Certification
TRIZ	Teorija Rezhenija Izobretatelskih Zadach (Russian) = Theory of Inventive Problem Solving
UX	User Experience