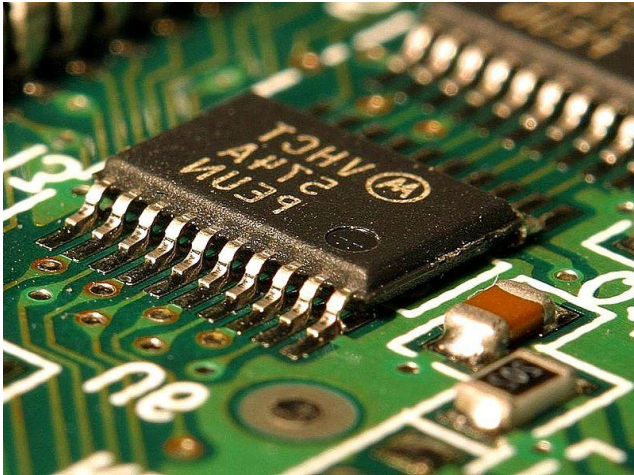


Trends in ICT



This note looks at developments in information and communication technology (ICT) and their relevance for UK policy in the next five years. It examines the capability, use and economic impact of ICT; technical barriers; and implications for cybersecurity, privacy and internet governance.

Background

ICT is integral to UK life. The average UK adult spends more time consuming media or communications than sleeping (8h 41m versus 8h 21m).² Social media use has risen from 22% of UK adult internet users in 2007 to 72% in 2015.³ The Government identifies telecommunications as part of the UK's Critical National Infrastructure.⁴ The UK's ICT sector is worth an estimated £58bn per year,⁵ with the highest annual average labour productivity growth of all UK sectors (1998-2013).⁶ The European Commission says ICT is key for growth, and its 2015 'Digital Single Market' strategy aims to lift barriers to online trade.⁷

Trends

Computing Capability

Processing Power

The miniaturisation of transistors (components of computer chips), has been a key driver for computers becoming more powerful, cheaper and smaller (Figure 1).⁸ However, future improvements are likely to require new types of transistor,⁹ which may take longer to develop, slowing future progress.¹⁰ Quantum computers, which store and process data using the unique characteristics of very small-scale systems, could dramatically improve capability. Many predict large-scale quantum computing to be over 15 years away.¹¹

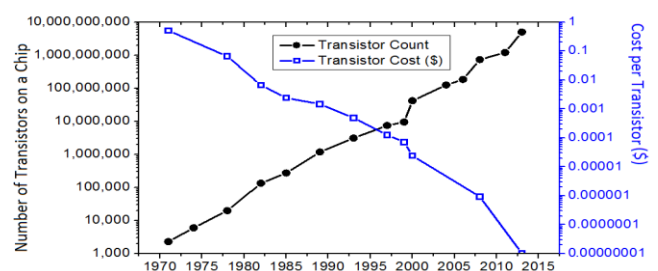
Overview

- Trends in ICT include increasing processing power, data storage and connectivity.
- Benefits include easier access to services, more efficient management of infrastructure and resources, and new business models.
- Digital skills are needed to maximise the benefits of ICT, but the European Commission forecasts that the UK workforce will have the largest digital skills deficit in the EU by 2020.¹
- Access to ICT is increasing, but disparities across social groups mean that benefits are not equally available to all.
- The growing use of ICT is driving a review of privacy and security legislation.
- This legislation, combined with traffic management techniques, is increasingly regulating data flow across the internet.

Data Storage

The cost of data storage is decreasing exponentially.¹² The quantity of data stored worldwide has doubled roughly every two years since 2005, and is expected to continue.¹³ In some sectors, the volume of data is growing faster than the ability to process and analyse it.¹⁴ Sources of new data include customer and operational information, videos, social media and sensors such as those used in the utilities, health and retail.¹⁵ Data are increasingly held in data centres: facilities for data storage and processing,¹⁶ which underpin many activities such as teleworking, email and social networking.¹⁷

Figure 1. Trends in Processor Development



The number of transistors in a microprocessor and approximate price per transistor over time (inflation-adjusted \$).¹⁸ The scales are logarithmic, so each step on the vertical axes increases by a factor of ten.

Analytics

The ability to analyse large and unstructured datasets is growing as new tools are developed (POSTnote 468).¹⁵ These can identify patterns in data and simulate complex systems.¹⁹ Advances in robotics and artificial intelligence (computer systems able to conduct tasks that otherwise require human intelligence)²⁰ are enabling machines to perform increasingly complex, non-routine tasks (Box 1).²¹ The trend for publicly accessible and modifiable software may foster innovation and speed up problem solving.^{22,23}

Cloud Computing

Cloud computing involves the remote use of shared computing resources. This can lower the investment needed to use such facilities and allows more flexible, resilient and efficient use.²⁴ The Cloud Industry Forum estimates that 84% of UK organisations use cloud-based services, up from 48% in 2010.²⁵ The proportion of data passing through the cloud is rising, from under 20% globally in 2013 to a predicted 40% in 2020.¹³ Some raise security and privacy concerns with cloud computing, especially if it crosses jurisdictions.^{26,27}

Connectivity

Fixed Connections

The average maximum download speed of UK fixed-line broadband connections rose from 7.5 to 23 megabits per second (Mbps) during 2011-2014.²⁸ This has been driven partly by private and public investment (POSTnote 494). The Government aims to provide ‘superfast’ broadband (download speeds over 24 Mbps) to 95% of UK premises by 2017.²⁹ Broadband speeds vary across the UK, with technical challenges to providing ‘superfast’ speeds to the final 5% of premises.³⁰ Ofcom is reviewing UK digital communications, including fixed and mobile networks.³¹

Mobile Connections

Mobile internet connections in the UK are improving. In 2015, Ofcom reported increased 4G mobile broadband coverage, with 90% of UK premises in areas where 4G is offered by at least one operator.³ Meanwhile, smartphone ownership is at 66% of the adult population, up from 11% in

2008.³⁹ 5G mobile technologies are being developed and are expected to be implemented from around 2020.⁴⁰ WiFi has become the standard way to connect to the internet at home.⁴¹ The number of public WiFi hotspots in the UK increased from 34,000 in 2013 to 42,000 in 2014.⁴² Beyond connecting people to the internet, devices that communicate with each other are increasingly common (Box 2).

Use of ICT

ICT is increasingly important for everyday tasks such as shopping, banking and booking medical appointments.⁴³ The Government has been making 25 public services ‘digital by default’, with the aim of making them simpler and faster to access. Twenty of them are now available online,^{44,45} including registering to vote and filing tax returns. The Government estimates that digitising services could save £1.7bn a year.⁴⁵

Figure 2 shows rising levels of internet access in the UK, including for those least likely to have basic digital skills: people who are elderly, disabled or from the lowest socioeconomic groups (DE).^{43,46,47} The proportion of people with basic online skills is also expected to rise, driven by the falling cost of internet access, increasing number of online services, more people with the skills to support others and younger people generally having better digital skills.⁴⁸ A 2014 BBC survey found 77% of non-users cited lack of motivation (being unaware of the benefits) as the main reason for not using the internet, ahead of lack of access (42%), lack of knowledge/confidence (28%) and cost (14%).⁴⁹ Questions have been raised about the effect of increasing internet use on health and behaviour (Box 3).

Digital Inclusion

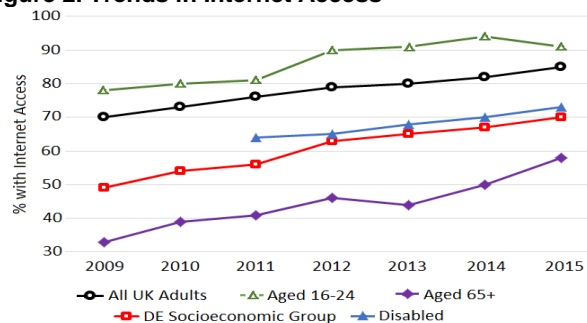
Moving services online offers convenience and speed for many, but risks further exclusion for those who cannot or do not go online.⁴³ Basic internet use is estimated to bring benefits worth £1,064 per year to an individual.⁵⁰ The cost of equipping the whole population with basic digital skills has been estimated at £875m.⁴⁸ The Government’s ‘Digital Strategy’ aims to support anyone unable to use Government digital services unassisted, for example by providing staff

Box 1. Impacts of Automation

Applications of automation can range from the use of robots on factory production lines to software that produces due diligence reports for legal cases.²¹ The potential benefits of automation include greater productivity,³² job creation, and some suggest it might encourage the ‘re-shoring’ of manufacturing to the UK as advanced robotics become cheaper and the wages of workers overseas rise.³³ Others fear it may also disrupt the job market and drive inequality.³⁴ It is increasingly possible to automate non-routine cognitive and manual tasks.²¹ A recent study predicted that it could be technically feasible to automate 35% of UK jobs within the next 10-20 years, with lower-paid jobs more susceptible.³⁵ Jobs requiring creativity, social skills or complex problem solving may be affected less by automation.³⁶

As the scope for automation grows, the legal framework for deciding liability in the event of an accident may need to be examined. For example, the Government aims to update regulation for driverless cars by 2017.³⁷ (A code of practice allows for testing already.³⁸)

Figure 2. Trends in Internet Access



Internet access in different social groups. Disabled access data (Office for National Statistics) were obtained by asking self-assessed disabled people if they had ever used the internet.⁵¹ Other data (Ofcom) were obtained by asking people if anyone in their household has internet access via any device.⁵²

Box 2. Internet of Things (IoT)

The number of devices connected to the internet grew from about 0.5bn in 2003⁵³ to over 13bn in 2013,¹³ and is projected to reach between 20bn and 100bn by 2020.⁵⁴ Reductions in the cost and size of sensor technology, and the wider availability of wireless networks, makes it feasible to place communicating sensors in objects varying from exercise wristbands and fridges to car tyres and cows' stomachs.^{32,54,55,56}

One use for the IoT is in 'smart cities'. Sensors placed in anything from traffic lights⁵⁷ to roads,⁵⁸ water pipes⁵⁸ and bins,⁵⁹ could collect data to inform the management of traffic, street lighting, water and electricity supplies, and waste disposal.^{60,61} 'Smart factories' use sensors embedded in products to track and adapt manufacture across the production chain. Telehealth sensors can also monitor patients' health at home, improving patient wellbeing and reducing demand for services.^{54,62} The 2015 Budget announced £40m for IoT development, focusing on health, social care and smart cities.⁶³

who enter users' details for them.⁶⁴ However, the Tinder Foundation estimates that current support will leave 6.2m people without basic digital skills by 2020, many of whom will be those who use government services most frequently.⁴⁸ The UN includes ICT accessibility in its Convention on the Rights of Persons with Disabilities.^{65,66}

Economic Impact

The ICT Sector

Estimates suggest that the digital economy (firms whose main output is software, hardware or digital content) covers almost 15% of UK companies.⁶⁷ UK expertise includes data analytics and cybersecurity.⁶⁸ According to KPMG, jobs in the technology sector have grown by about 25% since 2010, over triple the rate for the UK economy overall.⁶⁹

Other Sectors

ICT makes it easier to co-ordinate services and consumers by making information readily available, often bypassing traditional intermediaries (Box 4).⁷⁰ It could also affect the number of jobs available and the skills they demand (Box 1). In the financial sector, 'Blockchain' technology can create secure, decentralised records of transactions, which might challenge central banking, taxation and regulation (POSTnote 475).⁷⁰ Other sectors influenced by ICT include construction, where computer models are used during the design, construction and operation of buildings with the aim of lowering costs and carbon emissions.^{71,72} Online retail is projected to account for 23% of the retail sector's total contribution to UK GDP in 2016, the highest percentage in the G20.⁷³ One study has estimated that the UK could have increased its 2011 GDP by up to £63bn if it had been the global leader in adopting ICT, and that total revenue could have increased by up to £18.8bn if all UK SMEs had fully adopted ICT.⁷⁴

Skills for Work

Although the UK ranks highly for technological readiness,⁷⁵ the European Commission predicts that the UK workforce will have the largest digital skills gap in the EU by 2020.⁷⁶ One study estimates that by 2017, the UK will need an average of 150,000 extra workers with digital skills per year.⁷⁷ The skills required range from the confident use of

Box 3. Impacts of Internet Use on Health and Behaviour

Internet use is increasing across the population.⁴¹ Online communities are a valuable social tool,⁷⁸ but for a minority of vulnerable users they may also have the potential to validate or promote harmful views such as extremism⁷⁸ or self-harm.⁷⁹ The effects of problematic behaviour, such as bullying and gambling, may also be exacerbated online.^{79,80} Mental health charity, YoungMinds, says that online communities can also provide support to help address these problems.⁸¹ The 2013 EU Kids Online study identified opportunities available to young people from going online, including gaining digital skills.⁸² They found these were reduced in the UK by restrictive parental protection measures (such as banning access to certain sites), compared to the more active mediation used in some EU nations (such as accompanying children when online).^{83,84} Before its closure in 2014, the charity Beatbullying advocated better content regulation and digital awareness to facilitate helpful internet use,⁸⁵ e-safety is now part of the national curriculum.⁸⁸

Box 4. ICT-Enabled Business Models

A range of new business models and technologies have emerged, which some argue have the potential to 'democratise' business:

- **Crowdsourcing:** tasks, loans or other services can be outsourced to online communities. For instance, peer-to-peer lending facilitates personalised loans between participants.
- **Sharing Economy:** ICT makes it easier to share resources, for example car sharing. An independent review commissioned by the Government in 2014 made over 30 recommendations on how the UK could become a global centre for the sharing economy.⁸⁶
- **3D-Printing:** enables SMEs and consumers to make products directly from computer designs. Despite the falling cost of printers, some expect 3D printing to be limited to industrial prototyping or niche manufacture in the near future.^{32,87}

basic communication services to data analysis and building digital technology. Government initiatives to improve ICT skills include a new school computing curriculum in 2014,⁸⁸ University Technical Colleges focusing on technology,⁸⁹ higher education courses with more industrial engagement⁹⁰ and an £18m investment (matched by industry) in the Tech Partnership to promote training for ICT specialists.⁹¹ However, the House of Lords Digital Skills Select Committee and others have raised concerns over insufficient funds, training for school teachers, and immigration restrictions that may make it harder to fill the skills gap. Greater female participation in IT specialist roles (which has remained at about 16% for 10 years) could help to meet the skills gap.^{43,68,92,93,94}

Challenges and Opportunities

Technical

Many technical challenges are common across ICT, such as creating standards, managing spectrum use and battery life (Box 5). Energy usage is also an issue. Three major ICT components – data centres, consumer devices and voice and data networks – account for almost 2% of global CO₂ emissions.⁹⁵ Data centre emissions are expected to grow the most over the next five years,⁹⁵ despite tax concessions for centres meeting energy efficiency targets,⁹⁶ they already consume around 1% of total UK electricity usage.⁹⁷ By contrast, emissions growth from consumer products is expected to slow as device efficiencies improve.⁹⁵

Box 5. Technical Challenges for ICT

There are a number of challenges common across ICT, including:

- Interoperability – common standards are required to allow different types of devices or systems to communicate with each other. Publicly available ‘open standards’ can facilitate interoperability.²²
- Spectrum use – wireless communication uses the electromagnetic spectrum, a limited resource managed mostly by Ofcom.⁹⁸ Subject to international treaties, Ofcom allocates sections to competing uses such as mobile, broadcasting, satellite and the ‘Internet of Things’.⁹⁹
- Battery life – this is improving more slowly than processing power⁸⁷ due to physical limitations of existing lithium-ion technology,⁸⁷ which is unlikely to improve dramatically in the next five years.¹⁰⁰ However, future devices may harvest background energy (such as vibrations) to passively recharge batteries.¹⁰¹ Additionally, alternative technologies may replace lithium-ion in the longer term.¹⁰²

The Global e-Sustainability Initiative estimates that ICT has the potential to reduce global greenhouse gas emissions in eight key sectors (including transport, health, agriculture and energy) by 9.7 times its own emissions – about a 20% drop in business-as-usual projections by 2030.¹⁰³ It says this could mostly come from improved efficiency and resource management, for example using smart, connected supply chains to reduce redundancy in global logistics networks.¹⁰³

Cybersecurity

Estimates of the scale of cybercrime vary considerably.¹⁰⁴ A PwC survey found that the average cost incurred by a large organisation from their single most severe cyberattack in a year has steadily risen to above £1.46m.¹⁰⁵ 51% of Britons reported being a victim of online crime in 2014.¹⁰⁶ Damage ranges from fraud and identity theft, to espionage, data loss, reputational damage and the destruction of physical infrastructure.^{107,108,109} Cyberattacks are listed in the 2015 UK National Risk Register of Civil Emergencies, which notes the growing possibility that terrorists might mount attacks online.¹¹⁰ In 2013, the Director of GCHQ warned businesses about massive-scale intellectual property theft, commercial data compromises and network disruption, and said that up to 80% of cyberattacks could be prevented through basic information risk management.¹¹¹ The £860m National Cyber Security Programme (2011-2016), aims to raise awareness, improve understanding and mitigate risk.^{112,113} ICT can also help to tackle crime, for example in detecting fraud.¹¹⁴

Privacy

The growing collection and use of data has implications for data protection, and a new EU General Data Protection Regulation is being discussed ([POSTnote 469](#), Box 4). Some studies suggest that public awareness of data collection is growing,¹¹⁵ while others report that understanding of how it is used is often limited.^{116,117} ICT devices are becoming smaller and in some cases wearable, such as smart glasses,⁸⁷ health sensors⁶² and devices connected to the ‘Internet of Things’ (Box 2).³² This may make data collection more pervasive but less obvious.¹¹⁸ Attitudes to privacy vary: many are willing to swap some privacy for direct benefits,^{117,119} but this depends on

Box 6. Investigatory Powers Legislation¹²⁰

The Government has indicated that it will introduce draft legislation in Autumn 2015, aiming to improve the ability of law enforcement and intelligence agencies to combat terrorism and other serious crime. It will address issues raised in a 2015 review of the Data Retention and Investigatory Powers Act 2014 (parts of which have recently been declared unlawful by the High Court),¹²¹ including data retention and bulk interception.¹²² See [HoC Library Briefing SN06373](#) for details.

Box 7. Net Neutrality

Proponents of ‘net neutrality’ say all internet traffic should be treated equally, regardless of content, destination or source.¹²³ However, ISPs manage traffic to deliver services more efficiently.¹²⁴ For example, ISPs can prioritise certain types of content, such as streaming videos, to minimise delays that would impair that service.¹²⁴ Other content (such as emails) is less delay-sensitive. While some practices such as blocking or slowing other providers’ services could allow ISPs to disadvantage competitors or stifle innovation,¹²⁵ major UK ISPs have signed a voluntary code of practice that includes a commitment not to use traffic management to degrade competitors’ services.¹²⁶ EU legislation has been agreed that aims to guarantee net neutrality.¹²⁷ For further details, see [HoC Library Briefing ‘Regulating the web: The open internet and net neutrality’](#).

context.¹²⁸ In some cases, consumers’ consent is needed before their personal data can be used. There are calls to simplify the terms and conditions of such agreements.¹¹⁹ However, some argue that as data are often used for purposes not anticipated when collected, obtaining consent can be challenging.¹²⁹

Technologies for using the internet anonymously are increasingly accessible; around 10% of online traffic is encrypted,¹³⁰ and this is growing.¹³¹ Anonymity has benefits, for example for whistle-blowing,¹³² but the 2010 Government highlighted that new communication technologies can be harder for security services to monitor.¹³³ The current Government has announced draft legislation (Box 6), which would extend the scope for the state to conduct surveillance. However, there are calls for greater transparency to ensure that surveillance is proportionate to achieving a legitimate aim,¹³⁴ as required by the European Convention on Human Rights.¹³⁵

Internet Governance

As internet use has grown, the flow of data across it has become increasingly regulated. For instance, internet service providers (ISPs) manage internet traffic to ensure network efficiency. The extent to which this should occur is under debate (Box 7). EU data protection law currently permits the transfer of personal data outside the EU only if adequate data protection is guaranteed.¹³⁶ Other countries including China¹³⁷ and Russia¹³⁸ are passing ‘data localisation’ laws, restricting the transfer of personal data abroad. Critics say this harms GDP without improving security and enables governments to surveil their citizens.¹³⁹

New ways of consuming media (for example watching TV over the internet) can challenge content regulation, as they may not fit into existing regulatory frameworks.¹⁴⁰ There are also challenges to regulating content hosted outside the

regulator's jurisdiction.¹⁴¹ Methods of regulation include removing content from the server hosting it, filtering it out or removing it from search engine results.¹⁴¹ ISPs have voluntarily deployed adult material filters since 2013 (which users can opt-out of),¹⁴² and attempts have been made to make this a legal requirement.¹⁴³ Critics argue that filters block legal sites (including sites offering advice on issues such as child abuse) without blocking all intended content.^{144,145}

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