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Global Agenda Council on the Future of Software & Society

Deep Shift
Technology Tipping Points and Societal Impact

Survey Report, September 2015

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Contents

Preface

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Software has the potential to drastically change our lives.

Earlier this year, the World Economic Forum's Global Agenda Council on the Future of Software and Society set out to help people prepare for changes enabled by software. We found 21 examples of these that will have far-reaching impacts on human health, the environment, global commerce and international relations.

We are entering a time of momentous societal shifts brought on by advancements in software. According to Erik Brynjolfsson, Council Vice-Chair; Director, MIT Initiative on the Digital Economy, Massachusetts Institute of Technology, USA, and a prolific author: "Now comes the second machine age. Computers and other digital advances are doing for mental power – the ability to use our brains to understand and shape our environments – what the steam engine and its descendants did for muscle power."

These changes will impact people around the world. Inventions previously seen only in science fiction, such as artificial intelligence, connected devices and 3D printing, will enable us to connect and invent in ways we never have before. Businesses will automate complicated tasks, reduce production costs and reach new markets. Continued growth in internet access will further accelerate change. In Sub-Saharan Africa and other underdeveloped regions, connectivity has the potential to redefine global trade, lift people out of poverty and topple political regimes. And for many of us, seemingly simple software innovations will transform our daily routines. These changes are not without their challenges; as technology improves the lives of many, we hope to help prepare people to understand and address concerns on privacy, security and job disruption.

I would like to thank my colleagues who serve on the Global Agenda Council on the Future of Software & Society for their efforts to help people around the world better understand and prepare for these shifts. This report is a small first step in understanding the changes that lie ahead. We hope it will provide important insights to consider as we navigate the complex issues related to changing technologies.

Introduction

Digital connectivity permeates all aspects of daily life – from the way people interact to the economic landscape, political decision-making and the skills needed to get a job. A greater reliance on networked resources makes people more interdependent, while many stakeholders are concerned about whether the industry can strike the right balance between privacy, security and trust.

At the same time, increasing digitization is driving industries from product-based to service-based offerings. While these offerings are highly automated and standardized, they are also personalized through software. The seamless integration of the physical and digital worlds through networked sensors, actuators, embedded hardware and software will change industrial models.

In short, the world is about to experience an exponential rate of change through the rise of software and services.

The mandate of the World Economic Forum's Global Agenda Council on the Future of Software & Society is to help society navigate the impacts of the shifts to come.

Building on this mandate, the council aims to help the broader society navigate the transition to the future digital and hyperconnected world by explaining the societal impacts generated by major technology trends and the new business models in plain language, and through engaging, accessible media.

This report is the first of its kind – one aimed at trying to capture some of the deep shifts occurring in society as a result of software and services, and to encourage everyone to think about the impact of these changes on our society and how to prepare for the changes ahead.

Survey Methodology

In March 2015, the Global Agenda Council on the Future of Software & Society launched the Technological Tipping Points survey. Based on the council's discussions over previous months, the survey asked respondents for their views on 21 "tipping points" – moments when specific technological shifts hit mainstream society.

Aiming to provide a snapshot of expectations from a community of over 800 executives and experts from the information and communications technology sector, the survey asked respondents for their perception of *when* these tipping points would occur, offering date ranges from "it has already happened" to "20+ years". The option of "never" was also available. A total of 816 responses were received.

The results were aggregated, analysed and collated into two main formats. Firstly, a weighted mean system was used to calculate the average year by which each tipping point was expected to have occurred. The resulting timeline (Figure 1) ranges from 2018 to 2027. To calculate this effectively, the responses of those who answered "never" were discounted; thus, the timeline reflects the perceptions *only of those who thought the shift would occur at some point in time*.[1]

Secondly, to get a more global view of the momentous change within the next decade, the percentage of people who answered "10 years" or less for each tipping point was aggregated. The resulting overview of the expectations in 2025 are shown in the Table.

The Six Megatrends

As a foundation to its work, the council sought to identify the software and services megatrends which are shaping society, and their associated opportunities and risks.

People and the internet
How people connect with others, information and the world around them is being transformed through a combination of technologies. Wearable and implantable technologies will enhance people's "digital presence", allowing them to interact with objects and one another in new ways.

Computing, communications and storage everywhere
The continued rapid decline in the size and cost of computing and connectivity technologies is driving an exponential growth in the potential to access and leverage the internet. This will lead to ubiquitous computing power being available, where everyone has access to a supercomputer in their pocket, with nearly unlimited storage capacity.

The Internet of Things
Smaller, cheaper and smarter sensors are being introduced – in homes, clothes and accessories, cities, transport and energy networks, as well as manufacturing processes.

Artificial intelligence (AI) and big data
Exponential digitization creates exponentially more data – about everything and everyone. In parallel, the sophistication of the problems software can address, and the ability for software to learn and evolve itself, is advancing rapidly. This is built on the rise of big data for decision-making, and the influence that AI and robotics are starting to have on decision-making and jobs.

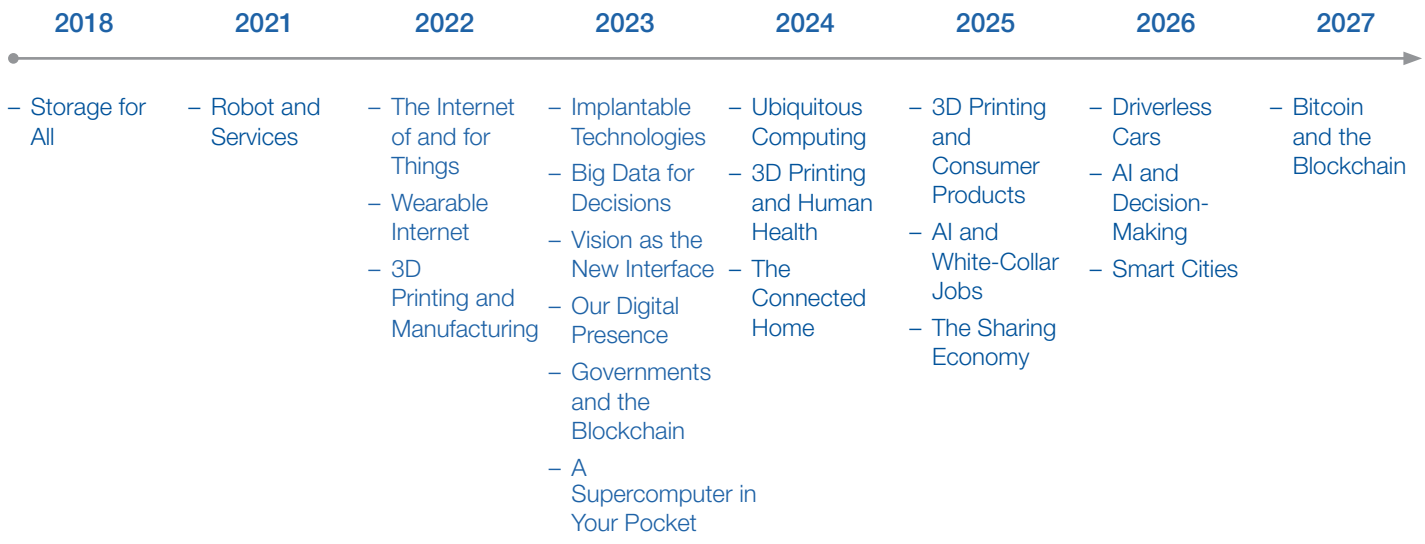
The sharing economy and distributed trust
The internet is driving a shift towards networks and platform-based social and economic models. Assets can be shared, creating not just new efficiencies but also whole new business models and opportunities for social self-organization. The blockchain, an emerging technology, replaces the need for third-party institutions to provide trust for financial, contract and voting activities.

The digitization of matter
Physical objects are "printed" from raw materials via additive, or 3D, printing, a process that transforms industrial manufacturing, allows for printing products at home and creates a whole set of human health opportunities.

Survey Results

Respondents who thought the tipping points (shifts) would occur at some point in time provided the years when they expected that these would occur (Figure 1), with the earliest shift in 2018 and the latest in 2027. The results show that a significant number of shifts were expected to occur in the early years of the next decade.

Figure 1: Average Year Each Tipping Point Is Expected to Occur [1]



The survey results were also analysed to see what percentage of the respondents expected the tipping point to have occurred by 2025, or ten years from now. Eleven of the 21 transition points had a high expectation (over 80%) of occurring by this date.

Table: Tipping Points Expected to Occur by 2025

	%
10% of people wearing clothes connected to the internet	**91.2**
90% of people having unlimited and free (advertising-supported) storage	**91.0**
1 trillion sensors connected to the internet	**89.2**
The first robotic pharmacist in the US	**86.5**
10% of reading glasses connected to the internet	**85.5**
80% of people with a digital presence on the internet	**84.4**
The first 3D-printed car in production	**84.1**
The first government to replace its census with big-data sources	**82.9**
The first implantable mobile phone available commercially	**81.7**
5% of consumer products printed in 3D	**81.1**
90% of the population using smartphones	**80.7**
90% of the population with regular access to the internet	**78.8**
Driverless cars equalling 10% of all cars on US roads	**78.2**
The first transplant of a 3D-printed liver	**76.4**
30% of corporate audits performed by AI	**75.4**
Tax collected for the first time by a government via a blockchain	**73.1**
Over 50% of internet traffic to homes for appliances and devices	**69.9**
Globally more trips/journeys via car sharing than in private cars	**67.2**
The first city with more than 50,000 people and no traffic lights	**63.7**
10% of global gross domestic product stored on blockchain technology	**57.9**
The first AI machine on a corporate board of directors	**45.2**

Source: Survey

The Tipping Points (Shifts)

Shift 1: Implantable Technologies

The tipping point: The first implantable mobile phone available commercially
Expected date: 2023
By 2025: 82% of respondents expected this tipping point will have occurred

People are becoming more and more connected to devices, and those devices are increasingly becoming connected to their bodies. Devices are not just being worn, but also being implanted into bodies, serving communications, location and behaviour monitoring, and health functions.

Pacemakers and cochlear implants were just the beginning of this, with many more health devices constantly being launched. These devices will be able to sense the parameters of diseases; they will enable individuals to take action, send data to monitoring centres, or potentially release healing medicines automatically.

Smart tattoos and other unique chips could help with identification and location. Implanted devices will likely also help to communicate thoughts normally expressed verbally through a "built-in" smartphone, and potentially unexpressed thoughts or moods by reading brainwaves and other signals.

Positive impacts
- Reduction in missing children
- Increased positive health outcomes
- Increased self-sufficiency
- Better decision-making
- Image recognition and availability of personal data (anonymous network that will "yelp"[2] people)

Negative impacts
- Privacy/potential surveillance
- Decreased data security
- Escapism and addiction
- Increased distractions (i.e. attention deficit disorder)

Unknown, or cuts both ways
- Longer lives
- Changing nature of human relationships
- Changes in human interactions and relationships
- Real-time identification
- Cultural shift (eternal memory)

The shift in action
According to an article published on *Yahoo! News*:

> **A team at Brown University called BrainGate is at the forefront of the real-world movement to link human brains directly to computers for a host of uses. As the BrainGate website says, 'using a baby aspirin-sized array of electrodes implanted into the brain, early research from the BrainGate team has shown that the neural signals can be "decoded" by a computer in real-time and used to operate external devices.' Chip maker Intel predicts practical computer-brain interfaces by 2020. Intel scientist Dean Pomerleau said in a recent article, 'Eventually people may be willing to be more committed to brain implants.' Imagine being able to surf the Web with the power of your thoughts.**

In "Nine real technologies that will soon be inside you", Mike Edelhart, *Yahoo News!*, 19 October 2014, https://au.news.yahoo.com/technology/a/25293925/nine-real-technologies-that-will-soon-be-inside-you/

Shift 2: Our Digital Presence

The tipping point: 80% of people with a digital presence on the internet
Expected date: 2023
By 2025: 84% of respondents expected this tipping point will have occurred

Having a presence in the digital world has evolved rapidly in the past 20 or more years. Just 10 years ago, it meant having a mobile phone number, email address and perhaps a personal website or a MySpace page.

Now, people's digital presence is regarded as their digital interactions, and traces through a multitude of online platforms and media. Many people have more than one digital presence, such as a Facebook page, Twitter account, LinkedIn profile, Tumblr blog, Instagram account and often many more.

In our increasingly connected world, digital life is becoming inextricably linked with a person's physical life. In the future, building and managing a digital presence will become as common as when people decide how to present themselves to the world everyday through fashion, words and acts. In that connected world and through their digital presence, people will be able to seek and share information, freely express ideas, find and be found, and develop and maintain relationships virtually anywhere in the world.

Positive impacts
- Increased transparency
- Increased and faster interconnection between individuals and groups
- Increase in free speech
- Faster information dissemination/exchange
- More efficient use of government services

Negative impacts
- Privacy/potential surveillance
- More identity theft
- Online bullying/stalking
- Groupthink within interest groups and increased polarization
- Disseminating inaccurate information (the need for reputation management); echo chambers[3]
- Lack of transparency where individuals are not privy to information algorithms (for news/information)

Unknown, or cuts both ways
- Digital legacies/footprints
- More targeted advertising
- More targeted information and news
- Individual profiling
- Permanent identity (no anonymity)
- Ease of developing online social movement (political groups, interest groups, hobbies, terrorist groups)

The shift in action
The point when most people will have at least one digital presence is soon approaching, given that the world already has more than 2 billion smartphone users[4], and that social media companies are prevalent with growing online populations, such as Facebook's 1.4 billion users[5] (larger than the population of China). In turn, quoted from *wiredFINANCE*:

> **Digital strategy and the integration of digital technologies into companies' strategies and operations in ways that fundamentally alter the value chain is emerging as a significant source of competitive advantage and driving dramatic changes in the products and services companies bring to market, as well as how they do business**

In "Your Digital Presence is a Valuable Asset", Alan Radding, *wiredFINANCE*, 30 August 2013, http://businessfinancemag.com/blog/your-digital-presence-valuable-asset

Shift 3: Vision as the New Interface

The tipping point: 10% of reading glasses connected to the internet
Expected date: 2023
By 2025: 86% of respondents expected this tipping point will have occurred

Google Glass is just the first of many potential ways in which glasses, eyewear/headsets and eye-tracking devices can become "intelligent" and lead to eyes and vision being the connection to the internet and connected devices.

With direct access to internet applications and data through vision, an individual's experiences can be enhanced, mediated or completely augmented to provide different, immersive reality. Also, with emerging eye-tracking technologies, devices can feed information through visual interfaces, and eyes can be the source for interacting with and responding to the information.

Enabling vision as an immediate, direct interface – by providing instruction, visualization and interaction – can change the way that learning, navigation, instruction and feedback for producing goods and services, experiencing entertainment and enabling the disabled are helping people to engage more fully with the world.

Positive impacts
- Immediate information to the individual to make informed decisions for navigation and work/personal activities
- Improved capacity to perform tasks or produce goods and services with visual aids for manufacturing, healthcare/surgery and service delivery
- Ability for those with disabilities to manage their interactions and movement, and to experience the world – through speaking, typing and moving, and via immersive experiences

Negative impacts
- Mental distraction causing accidents
- Trauma from negative immersive experiences
- Increased addiction and escapism

Unknown, or cuts both ways
- A new segment created in the entertainment industry
- Increased immediate information

The shift in action
The company Magic Leap is looking to create a head-mounted virtual retinal display which superimposes 3D computer-generated imagery over real-world objects. In 2014, it raised $540 million from Google, Qualcomm, Andreessen Horowitz, and Kleiner Perkins Caufield & Byers. Its goal is to project a digital light field directly into a user's eye to create these lifelike objects. According to its website, "the human brain is still the best display ever made."

Shift 4: Wearable Internet

The tipping point: 10% of people wearing clothes connected to the internet
Expected date: 2022
By 2025: 91% of respondents expected this tipping point will have occurred

Technology is becoming increasingly personal. Computers were first located in large rooms, then on desks and, following that, on people's laps. While technology can now be found in people's mobile phones in their pockets, it will soon be integrated directly into clothing and accessories.

Released in 2015, Apple Watch is connected to the internet and contains many of the same functional capabilities as a smartphone. Increasingly, clothing and other equipment worn by people will have embedded chips that connect the article and person wearing it to the internet.

Positive impacts
- More positive health outcomes leading to longer lives
- More self-sufficiency
- Self-managed healthcare
- Better decision-making
- Decrease in missing children
- Personalized clothes (tailoring, design)

Negative impacts
- Privacy/potential surveillance
- Escapism/addiction
- Data security

Unknown, or cuts both ways
- Real-time identification
- Change in personal interactions and relationships
- Image recognition and availability of personal data (anonymous network that will "yelp" you)

The shift in action
As for smartwatch developments, *ZDNet* recently reported that:

> **Smartphone makers are turning to wearables for a new source of growth. Gartner, [the research and advisory firm], expects to see around 70 million smartwatches and other bands sold will be sold this year, rising to 514 million within five years. Research by Accenture, [the global management and technology services company], suggests that only 12 percent of consumers intend to buy a smartwatch in the next 12 months, while 41 percent plan to do so within five years.**

In "Wearables, Internet of Things muscle in on smartphone spotlight at MWC", Steven Ranger, ZDNet, 26 February 2015, http://www.zdnet.com/article/wearables-internet-of-things-muscle-in-on-smartphone-spotlight-at-mwc/

Shift 5: Ubiquitous Computing

The tipping point: 90% of the population with regular access to the internet
Expected date: 2024
By 2025: 79% of respondents expected this tipping point will have occurred

Computing is becoming more accessible every day, and computing power has never been more available to individuals – be that via a computer with internet connection, a smartphone with 3G/4G or services in the cloud.

Today, 43% of the world's population is connected to the internet.[6] And, 1.2 billion smartphones were sold in 2014 alone.[7] In 2015, sales of tablets are estimated to take over sales of personal computers (PCs), while mobile phone sales (all combined) will outpace computers by 6 to 1.[8] As the internet has been outgrowing every other media channel in speed of adoption, it is expected that, in only a few years, three-quarters of the world's population will have regular access to the web.

In the future, regular access to the internet and information will no longer be a benefit of developed economies, but a basic right just like clean water. Because wireless technologies require less infrastructure than many other utilities (electricity, roads and water), they will very likely become accessible much quicker than the others. Hence, anyone from any country will be able to access and interact with information from the opposite corner of the world. Content creation and dissemination will become easier than ever before.

Positive impacts
- More economic participation of disadvantaged populations located in remote or underdeveloped regions ("last mile")
- Access to education, healthcare and government services
- Presence
- Access to skills, greater employment, shift in types of jobs
- Expanded market size/e-commerce
- More information (see "Our Digital Presence")
- More civic participation
- Democratization/political shifts
- "Last mile": increased transparency and participation versus an increase in manipulation and echo chambers

Negative impacts
- Increased manipulation and echo chambers
- Political fragmentation
- Walled gardens (i.e. limited environments, for authenticated users only) do not allow full access in some regions/countries

The shift in action
To make the internet available to the next 4 billion users, two key challenges must be overcome: access must be available, and it must be affordable. The race to provide the rest of the world access to the web is underway. Already, over 85% of the world's population lives within a couple kilometres of a mobile phone tower that could deliver internet service.[9] Mobile operators around the world are expanding internet access rapidly. Facebook's Internet.org, a project with mobile network operators, has enabled access to free basic internet services for over a billion people in 17 countries in the last year.[10] And, many initiatives are under way to affordably connect even the most remote regions: Facebook's Internet.org is developing internet drones, Google's Project Loon is using balloons and SpaceX is investing in new low-cost satellite networks.

Shift 6: A Supercomputer in Your Pocket

The tipping point: 90% of the population using smartphones
Expected date: 2023
By 2025: 81% of respondents expected this tipping point will have occurred

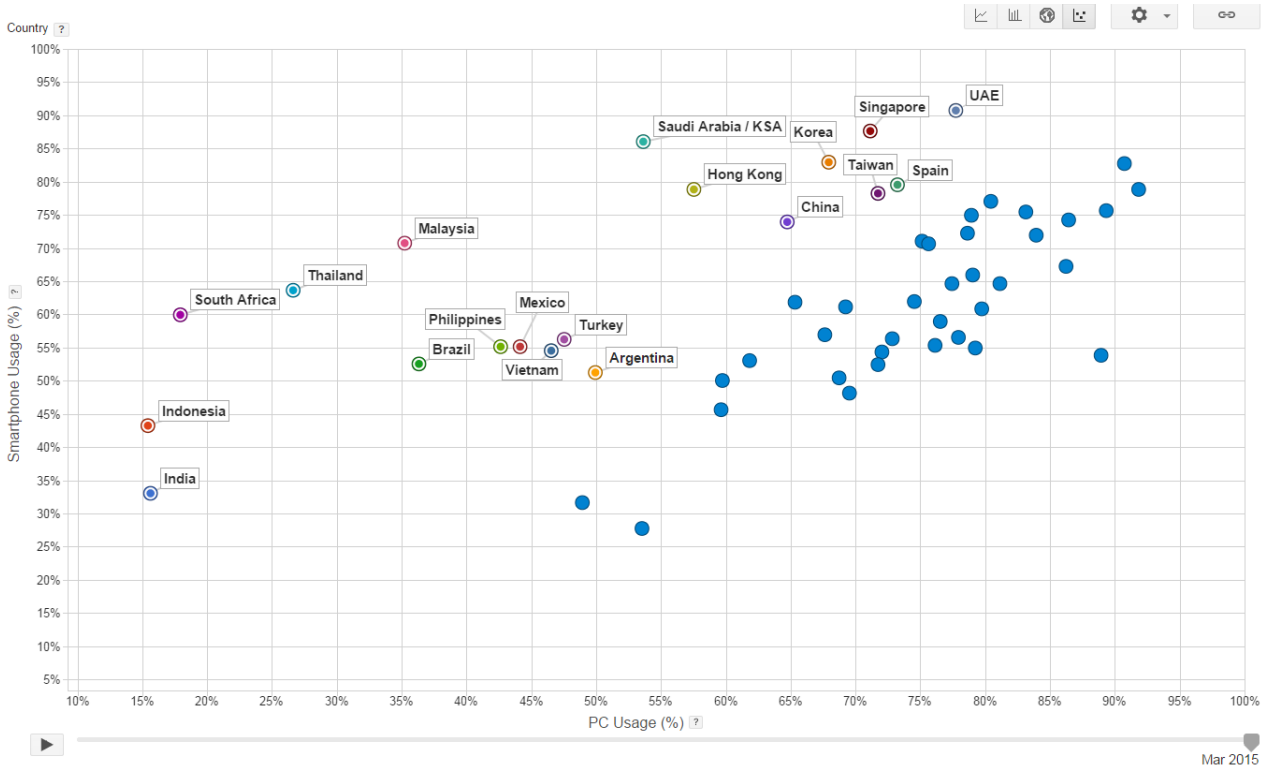
Already in 2012, the Google Inside Search team published that, "It takes about the same amount of computing to answer one Google Search query as all the computing done – in flight and on the ground – for the entire Apollo programme!"[11] Moreover, current smartphones and tablets contain more computing power than many of the formerly known supercomputers, which used to fill an entire room.

Global smartphone subscribers are anticipated to total 3.5 billion by 2019; that will equate to 59% smartphone penetration by population, surpassing the 50% penetration of 2017 and underlining the significant growth from the 28% level in 2013.[12] In Kenya, Safaricom, the leading mobile service operator, reported that 67% of handset sales were smartphones in 2014, and the GSMA forecasts that Africa will have over half a billion smartphone users by 2020.[13]

The shift in devices has already occurred in many countries across different continents (with Asia leading the trend today), as more people are using their smartphones rather than traditional PCs. As technology is progressing to miniaturize devices, increase computing power and, especially, decrease the price of electronics, smartphone adoption will only accelerate.

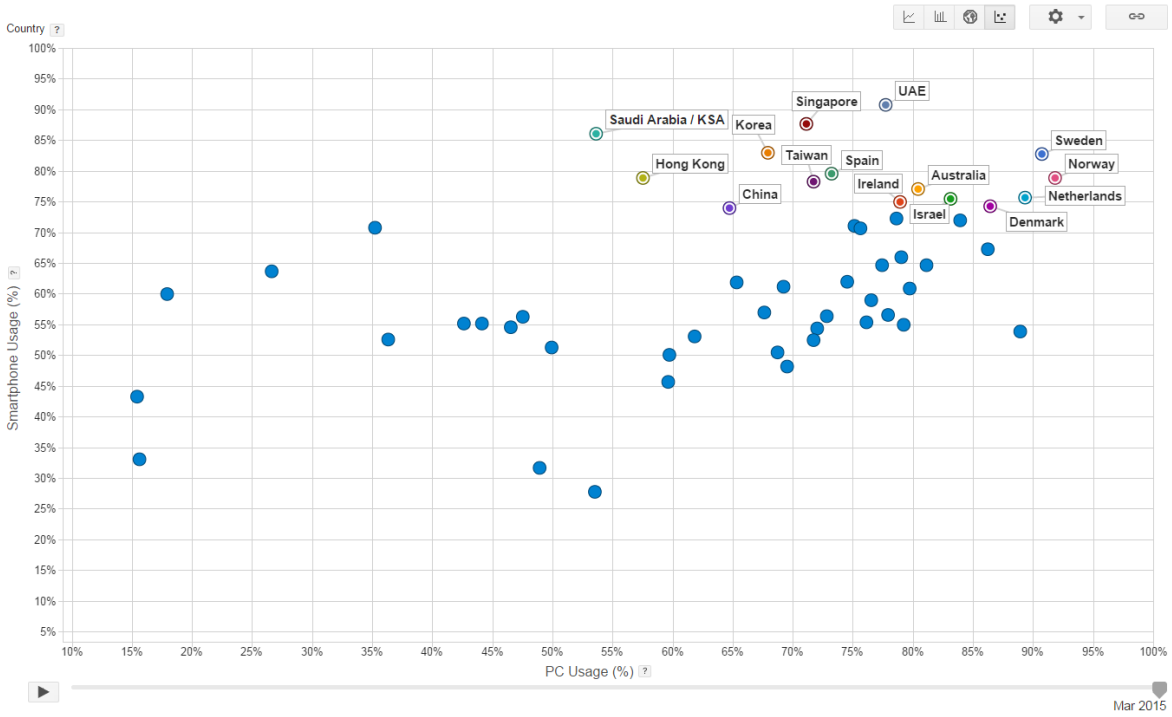
According to Google, the countries in Figure 2 have a higher usage of smartphones than PCs.

Figure 2: Countries with Higher Smartphone Usage than PC (March 2015)



Source: http://www.google.com.sg/publicdata/explore

Figure 3: Countries with Nearly 90% of Adult Population Using Smartphones (March 2015)



Source: http://www.google.com.sg/publicdata/explore

Countries such as Singapore, South Korea and the United Arab Emirates (UAE) are the closest to reaching the tipping point of 90% of the adult population using smartphones (Figure 3).

Society is headed towards adopting even faster machines that will allow users to perform complicated tasks on the go. Most likely, the number of devices that each person uses will grow strongly, not only with new functions performed but also with specialization of tasks.

Positive Impacts
- More economic participation of disadvantaged populations located in remote or underdeveloped regions ("last mile")
- Access to education, healthcare and government services
- Presence
- Access to skills, greater employment, shift in types of jobs
- Expanded market size/e-commerce
- More information (see "Our Digital Presence")
- More civic participation
- Democratization/political shifts
- "Last mile": increased transparency and participation versus an increase in manipulation and echo chambers

Negative impacts
- Increased manipulation and echo chambers
- Political fragmentation
- Walled gardens (i.e. limited environments, for authenticated users only) do not allow full access in some regions/countries

Unknown, or cuts both ways
- 24/7 – always on
- Lack of division between business and personal
- Be anywhere/everywhere
- Environmental impact from manufacturing

The shift in action

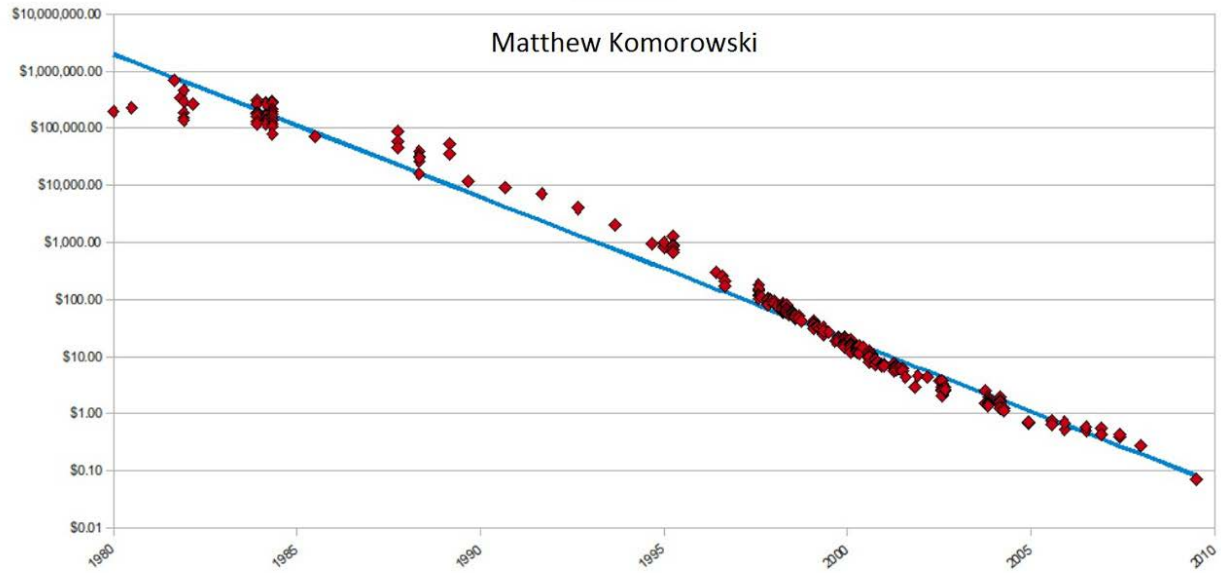
In 1985, the Cray-2 supercomputer was the fastest machine in the world. The iPhone 4, released in June 2010, had the power equivalent to the Cray-2; now, the Apple Watch has the equivalent speed of two iPhone 4s just five years later.[14] With the consumer retail price of smartphones tumbling to below $50, processing power skyrocketing and adoption in emerging markets accelerating, nearly everyone will soon have a literal supercomputer in their pocket.

Shift 7: Storage for All

The tipping point: 90% of people having unlimited and free (advertising-supported) storage
Expected date: 2018
By 2025: 91% of respondents expected this tipping point to have occurred

Storage capabilities have evolved tremendously in the past years, with an increasing number of companies offering it almost for free to their users as part of the service benefits. Users are producing increasing amounts of content, without worrying about ever having to delete it to make room for more. A clear trend of commoditizing storage capacity exists. One reason for it is that the storage price (Figure 4) has dropped exponentially (by a factor of approximately 10, every 5 years).

Figure 4: Hard Drive Cost per Gigabyte (1980-2009)



Source: "a history of storage costs", *mkomo.com*, 8 September 2009[15]

An estimated 90% of the world's data has been created in the past two years, and the amount of information created by businesses is doubling every 1.2 years.[16] Storage has already become a commodity, with companies like Amazon Web Services and Dropbox leading this trend.

The world is heading towards a full commoditization of storage, through free and unlimited access for users. The best-case scenario of revenue for companies could potentially be advertising or telemetry.

Positive impacts
- Legal systems
- History scholarship/academia
- Efficiency in business operations
- Extension of personal memory limitations

Negative impact
- Privacy surveillance

Unknown, or cuts both ways
- Eternal memory (nothing deleted)
- Increased content creation, sharing and consumption

The shift in action
With over 40% of the world connected to the internet today, virtually unlimited storage is at the tip of everyone's connected fingers, whether by computer or smartphone. Over 1.4 billion people are users on Facebook, and hundreds of millions are using WeChat, Google and Yahoo applications; YouTube; and thousands of other rapidly growing and evolving consumer platforms for creating, storing and sharing personal information for free. These services provide free storage based on ad revenues and/or "freemium" (free at entry level) pricing. With the ultra-low cost of data storage and the rapid rise of new services globally, anyone with access can have almost unlimited storage today.

Shift 8: The Internet of and for Things

The tipping point: 1 trillion sensors connected to the internet
Expected date: 2022
By 2025: 89% of respondents expected this tipping point to have occurred

With continuously increasing computing power and falling hardware prices (still in line with Moore's Law[17]), it is economically feasible to connect literally anything to the internet. Intelligent sensors are already available at very competitive prices. All things will be smart and connected to the internet, enabling greater communication and new data-driven services based on increased analytics capabilities.

A recent study looked into how sensors can be used to monitor animal health and behaviour.[18] It demonstrates how sensors wired in cattle can communicate to each other through a mobile phone network, and can provide real-time data on cattle conditions from anywhere.

Experts suggest that, in the future, every (physical) product could be connected to ubiquitous communication infrastructure, and sensors everywhere will allow people to fully perceive their environment.

Positive impacts
- Increased efficiency in using resources
- Rise in productivity
- Improved quality of life
- Effect on the environment
- Lower cost of delivering services
- More transparency around the use and state of resources
- Safety (e.g. planes, food)
- Efficiency (logistics)
- More demand for storage and bandwidth
- Shift in labour markets and skills
- Creation of new businesses
- Even hard, real-time applications feasible in standard communication networks
- Design of products to be "digitally connectable"
- Addition of digital services on top of products
- Digital twin provides precise data for monitoring, controlling and predicting
- Digital twin becomes active participant in business, information and social processes
- Things will be enabled to perceive their environment comprehensively, and react and act autonomously
- Generation of additional knowledge, and value based on connected "smart" things

Negative impacts
- Privacy
- Job losses for unskilled labour
- Hacking, security threat (e.g. utility grid)
- More complexity and loss of control

Unknown, or cuts both ways
- Shift in business model: asset rental/usage, not ownership (appliances as a service)
- Business model impacted by the value of the data
- Every company potentially a software company
- New businesses: selling data
- Change in frameworks to think about privacy
- Massively distributed infrastructure for information technologies
- Automation of knowledge work (e.g. analyses, assessments, diagnoses)
- Consequences of a potential "digital Pearl Harbor" (i.e. digital hackers or terrorists paralysing infrastructure, leading to no food, fuel and power for weeks)
- Higher utilization rates (e.g. cars, machines, tools, equipment, infrastructure)

The shift in action
The Milky Way, the earth's galaxy, contains around 200 billion suns. Worldwide, more than 50 billion devices are expected to be connected to the internet by 2020.

Shift 9: The Connected Home

Tipping point: Over 50% of internet traffic delivered to homes for appliances and devices (not for entertainment or communication)
Expected date: 2024
By 2025: 70% of respondents expected this tipping point to have occurred

In the 20th century, most of the energy going into a home was for direct personal consumption (lighting). But over time, the amount of energy used for this and other needs was eclipsed by much more complex devices, from toasters and dishwashers to televisions and air conditioners.

The internet is going the same way: most internet traffic to homes is currently for personal consumption, in communication or entertainment. Moreover, very fast changes are already occurring in home automation, enabling people to control lights, shades, ventilation, air conditioning, audio and video, security systems and home appliances. Additional support is provided by connected robots for all kinds of services – as, for example, vacuum cleaning.

Positive impacts
- Resource efficiency (lower energy use and cost)
- Comfort
- Safety/security, and detection of intrusions
- Access control
- Home sharing
- Ability to live independently (young/old, those disabled)
- Increased targeted advertising and overall impact on business
- Reduced costs of healthcare systems (fewer hospital stays and physician visits for patients, monitoring the drug-taking process)
- Monitoring (in real-time) and video recording
- Warning, alarming and emergency requests
- Remote home control (e.g. close the gas valve)

Negative impacts
- Privacy
- Surveillance
- Cyberattacks, crime, vulnerability

Unknown, or cuts both ways
- Impact on workforce
- Change in work's location (more from and outside the home)
- Privacy, data ownership

The shift in action
An example of this development for use in the home was cited by *cnet.com*:

> **Nest, makers of the Internet-connected thermostat and smoke detector … announced [in 2014] the 'Works with Nest' developer program, which makes sure products from different companies work with its software. For example, a partnership with Mercedes Benz means your car can tell Nest to turn up the heat at home so it's warm when you arrive … Eventually … hubs like Nest's will help the home sense what you need, adjusting everything automatically. The devices themselves might eventually disappear into the home, merely acting as sensors and devices controlled from a single hub.**

In "Rosie or Jarvis: The future of the smart home is still in the air", Richard Nieva, 14 January 2015, cnet.com, http://www.cnet.com/news/rosie-or-jarvis-the-future-of-the-smart-home-is-still-in-the-air/

Shift 10: Smart Cities

Tipping point: The first city with more than 50,000 inhabitants and no traffic lights
Expected date: 2026
By 2025: 64% of respondents expected this tipping point to have occurred

Many cities will connect services, utilities and roads to the internet. These smart cities will manage their energy, material flows, logistics and traffic. Progressive cities, such as Singapore and Barcelona, are already implementing many new data-driven services, including intelligent parking solutions, smart trash collection and intelligent lighting. Smart cities are continuously extending their network of sensor technology and working on their data platforms, which will be the core for connecting the different technology projects and adding future services based on data analytics and predictive modelling.

Positive impacts
- Increased efficiency in using resources
- Rise in productivity
- Increased density
- Improved quality of life
- Effect on the environment
- Increased access to resources for the general population
- Lower cost of delivering services
- More transparency around the use and state of resources
- Decreased crime
- Increased mobility
- Decentralized, climate friendly energy production and consumption
- Decentralized production of goods
- Increased resilience (to impacts of climate change)
- Reduced pollution (air, noise)
- Increased access to education
- Quicker/speed up accessibility to markets
- More employment
- Smarter e-government

Negative impacts
- Surveillance, privacy
- Risk of collapse (total black out) if the (energy-)system fails
- Increased vulnerability to cyberattacks

Unknown, or cuts both ways
- Impact on city culture and feel
- Change of individual habitus of cities

The shift in action
According to a paper published in *The Future Internet*:

> **The city of Santander in northern Spain has 20,000 sensors connecting buildings, infrastructure, transport, networks and utilities. The city offers a physical space for experimentation and validation of functions, such as interaction and management protocols, device technologies, and support services such as discovery, identity management and security.**

In "Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation", H. Schaffers, N. Komninos, M. Pallot, B. Trousse, M. Nilsson and A. Oliveira, The Future Internet, J. Domingue et al. (eds), LNCS 6656, 2011, pp. 431-446, http://link.springer.com/chapter/10.1007%2F978-3-642-20898-0_31

Shift 11: Big Data for Decisions

The tipping point: The first government to replace its census with big-data sources
Expected date: 2023
By 2025: 83% of respondents expected this tipping point to have occurred

More data exists about communities than ever before. And, the ability to understand and manage this data is improving all the time. Governments may start to find that their previous ways of collecting data are no longer needed, and may turn to big-data technologies to automate their current programmes and deliver new and innovative ways to service citizens and customers.

Leveraging big data will enable better and faster decision-making in a wide range of industries and applications. Automated decision-making can reduce complexities for citizens and enable businesses and governments to provide real-time services and support for everything from customer interactions to automated tax filings and payments.

The risks and opportunities in leveraging big data for decision-making are significant. Establishing trust in the data and algorithms used to make decisions will be vital. Citizen concerns over privacy and establishing accountability in business and legal structures will require adjustments in thinking, as well as clear guidelines for use in preventing profiling and unanticipated consequences. Leveraging big data to replace processes that today are done manually may render certain jobs obsolete, but may also create new categories of jobs and opportunities that currently do not exist in the market.

Positive impacts
- Better and faster decisions
- More real-time decision-making
- Open data for innovation
- Jobs for lawyers
- Reduced complexity and more efficiency for citizens
- Cost savings
- New job categories

Negative impacts
- Job losses
- Privacy concerns
- Accountability (who owns the algorithm?)
- Trust (how to trust data?)
- Battles over algorithms

Unknown, or cuts both ways
- Profiling
- Change in regulatory, business and legal structures

The shift in action

The United Nations Global Pulse programme focuses on leveraging big data for sustainable development and humanitarian action, and envisions a future in which big data is harnessed safely and responsibly as a public good. According to United Nations Global Pulse:

> **The initiative was established based on a recognition that digital data offers the opportunity to gain a better understanding of changes in human well-being, and to get real-time feedback on how well policy responses are working. To this end, Global Pulse is working to promote awareness of the opportunities Big Data presents for relief and development, forge public-private data sharing partnerships, generate high-impact analytical tools and approaches through its network of Pulse Labs, and drive broad adoption of useful innovations across the UN System.**

In “About”, United Nations Global Pulse, Harnessing big data for development and humanitarian action, http://www.unglobalpulse.org/about-new

Shift 12: Driverless Cars

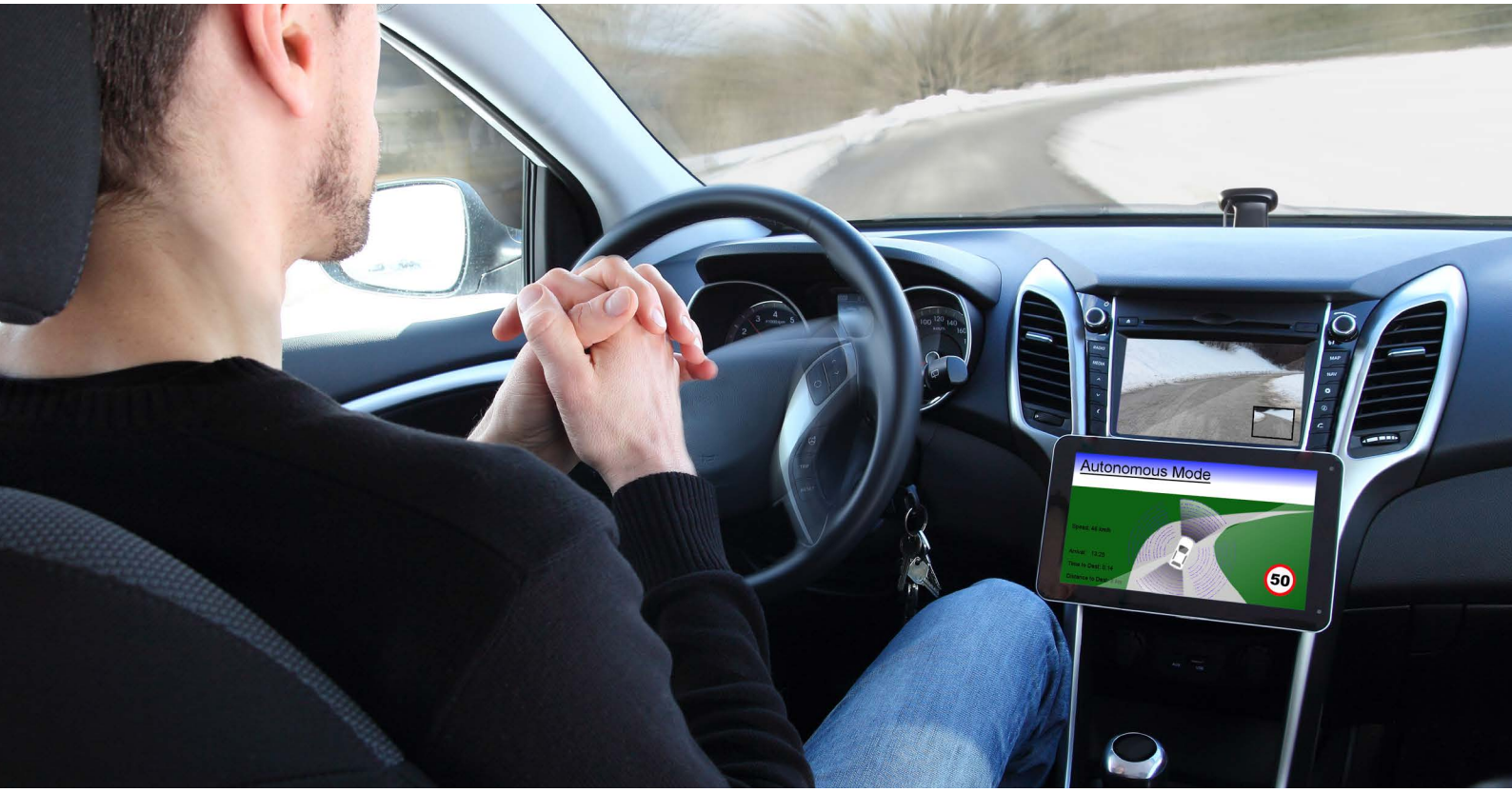
The tipping point: Driverless cars equalling 10% of all cars on US roads
Expected date: 2026
By 2025: 79% of respondents expected this tipping point to have occurred

We are already seeing trials of driverless cars from large companies such as Audi and Google, with a number of other enterprises ramping up efforts to develop new solutions. These vehicles can potentially be more efficient and safer than cars with people behind the steering wheel. Moreover, they could reduce congestion and emissions, and upend existing models of transportation and logistics.

Positive impacts
- Improved safety
- More time for focusing on work and/or consuming media content
- Effect on the environment
- Less stress and road rage
- Improved mobility for those older and disabled, among others
- Adoption of electric vehicles

Negative impacts
- Job losses (taxi and truck drivers, car industry)
- Upending of insurance and roadside assistance ("pay more to drive yourself")
- Decreased revenue from traffic infringements
- Less car ownership
- Legal structures for driving
- Lobbying against automation (people not allowed to drive on freeways)
- Hacking/cyberattacks

The shift in action
The UK Department for Transport has launched a report[19] to confirm that it will make changes to road regulations and car maintenance checks to accommodate driverless cars on the roads. It has also established a code of practice in details[20] to allow for testing autonomous cars.



Shift 13: Artificial Intelligence and Decision-Making

The tipping point: The first Artificial Intelligence (AI) machine on a corporate board of directors
Expected date: 2026
By 2025: 45% of respondents expected this tipping point to have occurred

Beyond driving cars, AI can learn from previous situations to provide input and automate complex future decision processes, making it easier and faster to arrive at concrete conclusions based on data and past experiences.

Positive impacts
- Rational, data-driven decisions; less bias
- Removal of "irrational exuberance"
- Reorganization of outdated bureaucracies
- Job gains and innovation
- Energy independence
- Advances in medical science, disease eradication

Negative impacts
- Accountability (who is responsible, fiduciary rights, legal)
- Job losses
- Hacking/cybercrime
- Liability and accountability, governance
- Becoming incomprehensible
- Increased inequality
- "Falling foul of the algorithm"
- Existential threat to humanity

The shift in action
On AI's impact in business, *IT News Africa* wrote:

> **An artificial intelligent system using natural language processing, ontologies and reasoning can be effective in gathering and extracting information from large data sources and has the ability to identify the cause and effect within data. These knowledge processing systems, through the process of learning, identify relationships and connections between databases, help fulfil the role of marketing companies through effectively aiding in market segmentation and measurement of performance while reducing costs and improving accuracy.**

In "Can Artificial Intelligence enable smarter business decision-making ability?", Shailendra Singh, 9 April 2015, IT News Africa, http://www.itnewsafrica.com/2015/04/can-artificial-intelligence-enable-smarter-business-decision-making-ability/

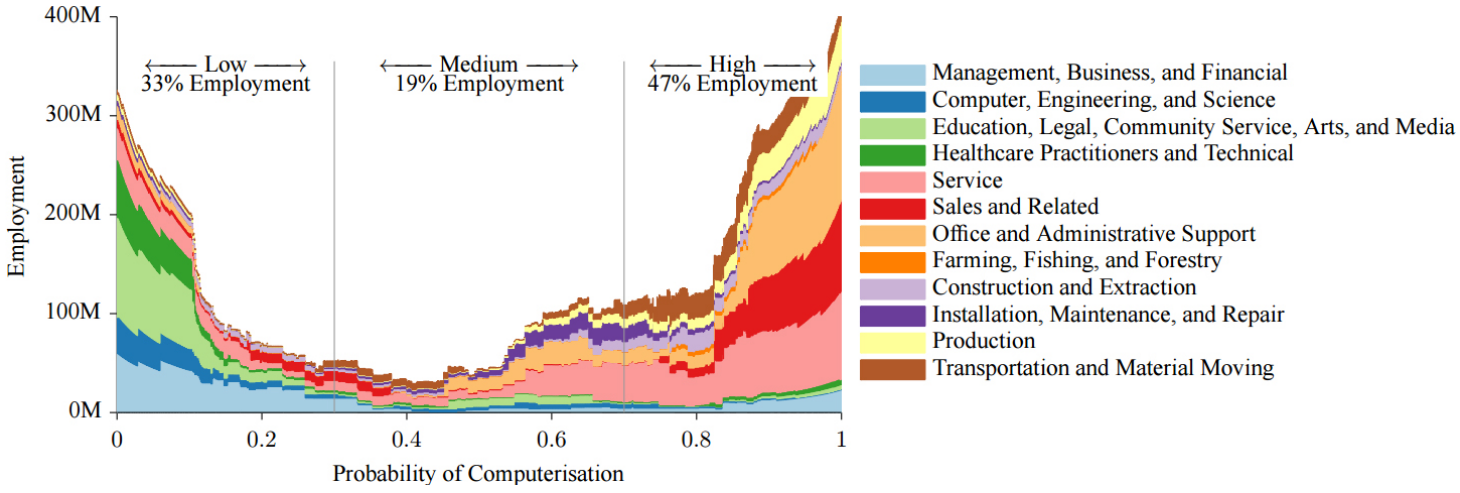
Shift 14: AI and White-Collar Jobs

The tipping point: 30% of corporate audits performed by AI
Expected date: 2025
By 2025: 75% of respondents expected this tipping point to have occurred

AI is good at matching patterns and automating processes, which makes the technology amenable to many functions in large organizations. An environment can be envisioned in the future where AI replaces a range of functions performed today by people.

An Oxford Martin School study[21] looked into the susceptibility of jobs to computerization from AI and robotics, and came up with some sobering results. Their model predicted that up to 47% of US jobs in 2010 were highly likely to become computerized in the next 10-20 years (Figure 5).

Figure 5: Distribution of US Occupational Employment* over the Probability of Computerization



* Distribution based on 2010 job mix.
Source: Frey, C.B. and M.A. Osborne, "The Future of Employment: How Susceptible Are Jobs to Computerisation?", 17 September 2013

Positive impacts
- Cost reductions
- Efficiency gains
- Unlocking innovation, opportunities for small business, start-ups (smaller barriers to entry, "software as a service" for everything)

Negative impacts
- Job losses
- Accountability and liability
- Change to legal, financial disclosure, risk
- Job automation (refer to the Oxford Martin study)

The shift in action

Advances in automation were reported on by *FORTUNE*:

> **IBM's Watson, well known for its stellar performance in the TV game show Jeopardy!, has already demonstrated a far more accurate diagnosis rate for lung cancers than humans – 90 percent versus 50 percent in some tests. The reason is data. Keeping pace with the release of medical data could take doctors 160 hours a week, so doctors cannot possibly review the amount of new insights or even bodies of clinical evidence that can give an edge in making a diagnosis. Surgeons already use automated systems to aid in low-invasive procedures.**

In Erik Sherman, FORTUNE, 25 February 2015, http://fortune.com/2015/02/25/5-jobs-that-robots-already-are-taking/

Shift 15: Robotics and Services

The tipping point: The first robotic pharmacist in the US
Expected date: 2021
By 2025: 86% of respondents expected this tipping point to have occurred

Robotics is beginning to influence many jobs, from manufacturing to agriculture, and retail to services. According to the International Federation of Robotics, the world now includes 1.1 million working robots, and machines account for 80% of the work in manufacturing a car.[22] Robots are streamlining supply chains to deliver more efficient and predictable business results.

Positive impacts
- Supply chain and logistics, eliminations
- More leisure time
- Improved health outcomes (big data for pharmaceutical gains in research and development)
- Banking ATM as early adopter
- More access to materials
- Production "re-shoring" (i.e. replacing overseas workers with robots)

Negative impacts
- Job losses
- Liability, accountability
- Day-to-day social norms, end of 9-to-5 and 24-hour services
- Hacking and cyber-risk

The shift in action
An article from *The Fiscal Times* appearing on CNBC.com states that:

> **Rethink Robotics released Baxter [in the fall of 2012] and received an overwhelming response from the manufacturing industry, selling out of their production capacity through April … [In April] Rethink launch[ed] a software platform that [allows] Baxter to do a more complex sequencing of tasks – for example, picking up a part, holding it in front of an inspection station and receiving a signal to place it in a 'good' or 'not good' pile. The company also [released] a software development kit … that will allow third parties – like university robotics researchers – to create applications for Baxter.**

In "The Robot Reality: Service Jobs Are Next to Go", Blaire Briody, 26 March 2013, The Fiscal Times, http://www.cnbc.com/id/100592545

Shift 16: Bitcoin and the Blockchain

The tipping point: 10% of global gross domestic product (GDP) stored on blockchain technology
Expected date: 2027
By 2025: 58% of respondents expected this tipping point to have occurred

Bitcoin and digital currencies are based on the idea of a distributed trust mechanism called the “blockchain”, a way of keeping track of trusted transactions in a distributed fashion. Currently, the total worth of bitcoin in the blockchain is around $20 billion, or about 0.025% of global GDP of around $80 trillion.

Positive impacts

- Increased financial inclusion in emerging markets, as financial services on the blockchain gain critical mass
- Disintermediation of financial institutions, as new services and value exchanges are created directly on the blockchain
- An explosion in tradable assets, as all kinds of value exchange can be hosted on the blockchain
- Better property records in emerging markets, and the ability to make everything a tradable asset
- Contacts and legal services increasingly tied to code linked to the blockchain, to be used as unbreakable escrow or programmatically designed smart contracts
- Increased transparency, as the blockchain is essentially a global ledger storing all transactions

The shift in action

Smartcontracts.com provides programmable contracts that do payouts between two parties once certain criteria have been met, without involving a middleman. These contracts are secured in the blockchain as “self-executing contractual states”, which eliminate the risk of relying on others to follow through on their commitments.

Shift 17: The Sharing Economy

The tipping point: Globally more trips/journeys via car sharing than in private cars
Expected date: 2025
By 2025: 67% of respondents expected this tipping point to have occurred

The common understanding of this phenomenon is the usually technology-enabled ability for entities (individuals or organizations) to share the use of a physical good/asset, or share/provide a service, at a level that was not nearly as efficient or perhaps even possible before. This sharing of goods or services is commonly possible through online marketplaces, mobile apps/location services or other technology-enabled platforms. These have reduced the transaction costs and friction in the system to a point where it is an economic gain for all involved, divided in much finer increments. Well-known examples of the sharing economy exist in the transportation sector. Zipcar provides one method for people to share use of a vehicle for shorter periods of time and more reasonably than traditional rental car companies. RelayRides provides a platform to locate and borrow someone's personal vehicle for a period of time. Uber and Lyft provide much more efficient "taxi-like" services from individuals, but aggregated through a service, enabled by location services and accessed through mobile apps. In addition, they are available at a moment's notice.

The sharing economy has any number of ingredients, characteristics or descriptors: technology enabled, preference for access over ownership, peer to peer, sharing of personal assets (versus corporate assets), ease of access, increased social interaction, collaborative consumption and openly shared user feedback (resulting in increased trust). Not all are present in every "sharing economy" transaction.

Positive impacts
- Increased access to tools and other useful physical resources
- Better environmental outcomes (less production and fewer assets required)
- More personal services available
- Increased ability to live off cash flow (with less need for savings to be able to afford use of assets)
- Better asset utilization
- Less opportunity for long-term abuse of trust because of direct and public feedback loops
- Creation of secondary economies (Uber drivers delivering goods or food)

Negative impacts
- Less resilience after a job loss (because of less savings)
- More contract / task-based labour (versus typically more stable long-term employment)
- Decreased ability to measure this potentially grey economy
- More opportunity for short-term abuse of trust
- Less investment capital available in the system

Unknown, or cuts both ways
- Changed property and asset ownership
- More subscription models
- Less savings
- Lack of clarity on what "wealth" and "well off" mean
- Less clarity on what constitutes a "job"
- Difficulty in measuring this potentially "grey" economy
- Taxation and regulation adjusting from ownership/sales-based models to use-based models

The shift in action
A particular notion of ownership underlies this development and is reflected in the questions:
- Did you know that the largest retailer doesn't own a single store? (Amazon),
- or that the largest provider of sleeping rooms doesn't own a single hotel? (Airbnb)
- and that the largest provider of transportation doesn't own a single car? (Uber)

Shift 18: Governments and the Blockchain

The tipping point: Tax collected for the first time by a government via a blockchain
Expected date: 2023
By 2025: 73% of respondents expected this tipping point to have occurred

The blockchain creates both opportunities and challenges for countries. On the one hand, it is unregulated and not overseen by any central bank, meaning less control over monetary policy. On the other hand, it creates the ability for new taxing mechanisms to be built into the blockchain itself (e.g. a small transaction tax).

Unknown impacts, or cut both ways
- Central banks and monetary policy
- Corruption
- Real-time taxation
- Role of government

The shift in action
A 2016 mayoral candidate of London has suggested implementing technology[23] to upgrade the existing government ledger for land and for the city's financial and budget records. Because these records are kept permanently, there is a strong possibility (without the blockchain) for them to be altered or faulted.

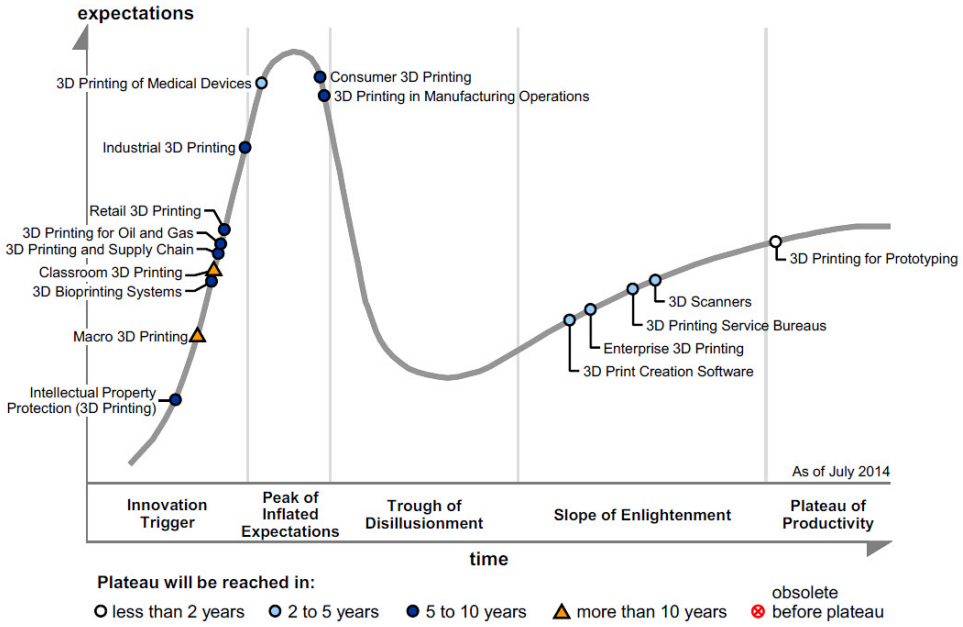
Shift 19: 3D Printing and Manufacturing

The tipping point: The first 3D-printed car in production
Expected date: 2022
By 2025: 84% of respondents expected this tipping point to have occurred

3D printing, or additive manufacturing, is the process of creating a physical object by printing it layer upon layer from a digital 3D drawing or model. Imagine creating a loaf of bread, slice by slice. 3D printing has the potential to create very complex products without complex equipment.[24] Eventually, many different kinds of materials will be used in the 3D printer, such as plastic, aluminium, stainless steel, ceramic or even advanced alloys, and the printer will be able to do what a whole factory was once required to accomplish. It is already being used in a range of applications, from making wind turbines to toys.

Over time, 3D printers will overcome the obstacles of speed, cost and size, and become more pervasive. Gartner has developed a "Hype Cycle" chart (Figure 6) showing the various stages of different 3D printing capabilities and their market impact, and plotting most business uses of the technology as entering the "slope of enlightenment".[25]

Figure 6: Hype Cycle for 3D Printing



Source: Gartner (July 2014)

Positive impacts

- Accelerated product development
- Reduction in the design-to-manufacturing cycle
- Easily manufactured intricate parts (not possible or difficult to do earlier)
- Rising demand for product designers
- Educational institutions using 3D printing to accelerate learning and understanding
- Democratized power of creation/manufacturing (both limited only by the design)
- Traditional mass manufacturing responding to the challenge by finding ways to reduce costs and the size of minimum runs
- Growth in open-source "plans" to print a range of objects
- Birth of a new industry supplying printing materials
- Rise in entrepreneurial opportunities in the space[26]
- Environmental benefits from reduced transportation requirements

Negative impacts

- Growth in waste for disposal, and further burden on the environment
- Production of parts in the layer process that are anisotropic, i.e. their strength is not the same in all directions, which could limit the functionality of parts
- Job losses in a disrupted industry
- Primacy of intellectual property as a source of value in productivity
- Piracy
- Brand and product quality

Unknown, or cuts both ways
– Potential that any innovation can be instantly copied

The shift in action
An example of 3D printing for manufacturing has been recently covered by *FORTUNE:*

> **General Electric's Leap jet engine is not only one of the company's bestsellers, it's going to incorporate a fuel nozzle produced entirely through additive manufacturing. The process, popularly known as 3-D printing, involves building up layers of material (in this case alloyed metals) according to precise digital plans. GE is currently completing testing of the new Leap engines, but the benefit of additive manufactured parts has already been proven on other models.**

In "GE's first 3D-printed parts take flight", Andrew Zaleski, FORTUNE, 12 May 2015, http://fortune.com/2015/05/12/ge-3d-printed-jet-engine-parts/

Shift 20: 3D Printing and Human Health

The tipping point: The first transplant of a 3D-printed liver
Expected date: 2024
By 2025: 76% of respondents expected this tipping point to have occurred

One day, 3D printers may create not only things, but also human organs – a process called "bioprinting". In much the same process as for printed objects, an organ is printed layer by layer from a digital 3D model.[27] The material used to print an organ would obviously be different from what is used to print a bike, and experimenting can be done with the kinds of materials that will work, such as titanium powder for making bones. 3D printing has great potential to service custom design needs; and, there is nothing more custom than a human body.

Positive impacts

- Addressing the shortage of donated organs (an average of 21 people die each day waiting for transplants that can't take place because of the lack of an organ)[28]
- Prosthetic printing: limb/body part replacements[29]
- Hospitals printing for each patient requiring surgery (e.g. splints, casts, implants, screws)
- Personalized medicine: 3D printing growing fastest where each customer needs a slightly different version of a body part (e.g. a crown for a tooth)
- Printing components of medical equipment that are difficult or expensive to source, such as transducers[30]
- Printing, for example, dental implants, pacemakers and pens for bone fracture at local hospitals instead of importing them, to reduce the cost of operations
- Fundamental changes in drug testing, which can be done on real human objects given the availability of fully printed organs
- Printing of food, thus improving food security

Negative impacts

- Uncontrolled or unregulated production of body parts, medical equipment or food
- Growth in waste for disposal, and further burden on the environment
- Major ethical debates stemming from the printing of body parts and bodies: Who will control the ability to produce them? Who will ensure the quality of the resulting organs?
- Perverted disincentives for health: If everything can be replaced, why live in a healthy way?
- Impact on agriculture from printing food

The shift in action

The first use of a 3D-printed spine implant was reported by *Popular Science*:

> **"[In 2014], doctors at Peking University Third Hospital successfully implanted the first ever 3-D-printed section of vertebra into [a] young patient to replace a cancerous vertebra in his neck. The replacement vertebra was modelled from the boy's existing vertebra, which made it easier for them to integrate."**

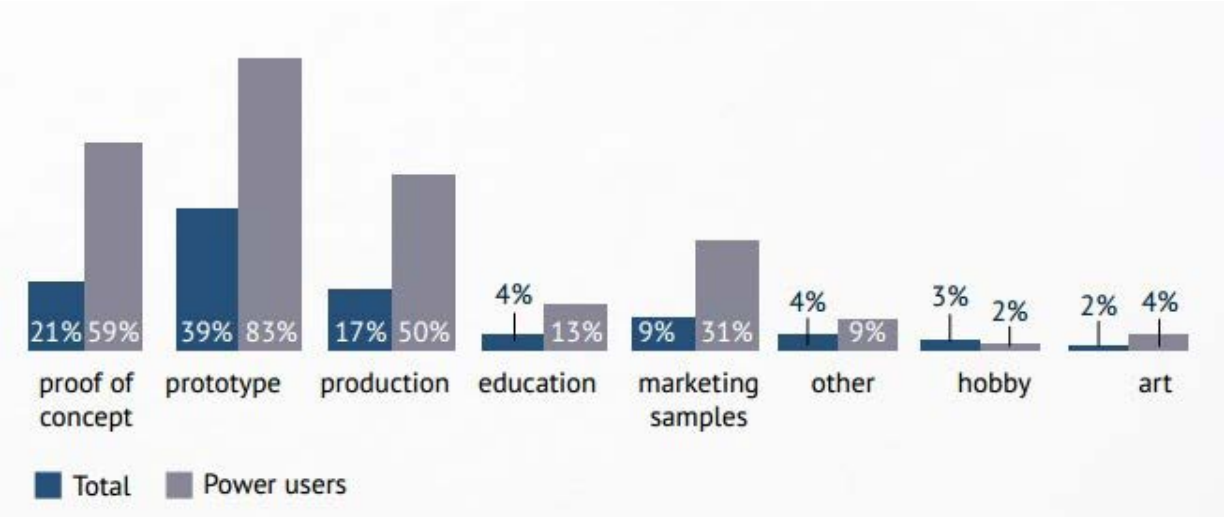
In "Boy Given a 3-D Printed Spine Implant, Loren Grush, Popular Science, 26 August 2014, http://www.popsci.com/article/science/boy-given-3-d-printed-spine-implant

Shift 21: 3D Printing and Consumer Products

The tipping point: 5% of consumer products printed in 3D
Expected date: 2025
By 2025: 81% of respondents expected this tipping point to have occurred

Because 3D printing can be done by anyone with a 3D printer, it creates opportunities for typical consumer products to be printed locally and on demand, instead of having to be bought at shops. A 3D printer will eventually be an office or even a home appliance. This further reduces the cost of accessing consumer goods and increases the availability of 3D printed objects. Current usage areas for 3D printing (Figure 7) indicate several sectors related to developing and producing consumer products (proof of concept, prototype and production).

Figure 7: Use of 3D Printing in Various Areas (% of respondents*)

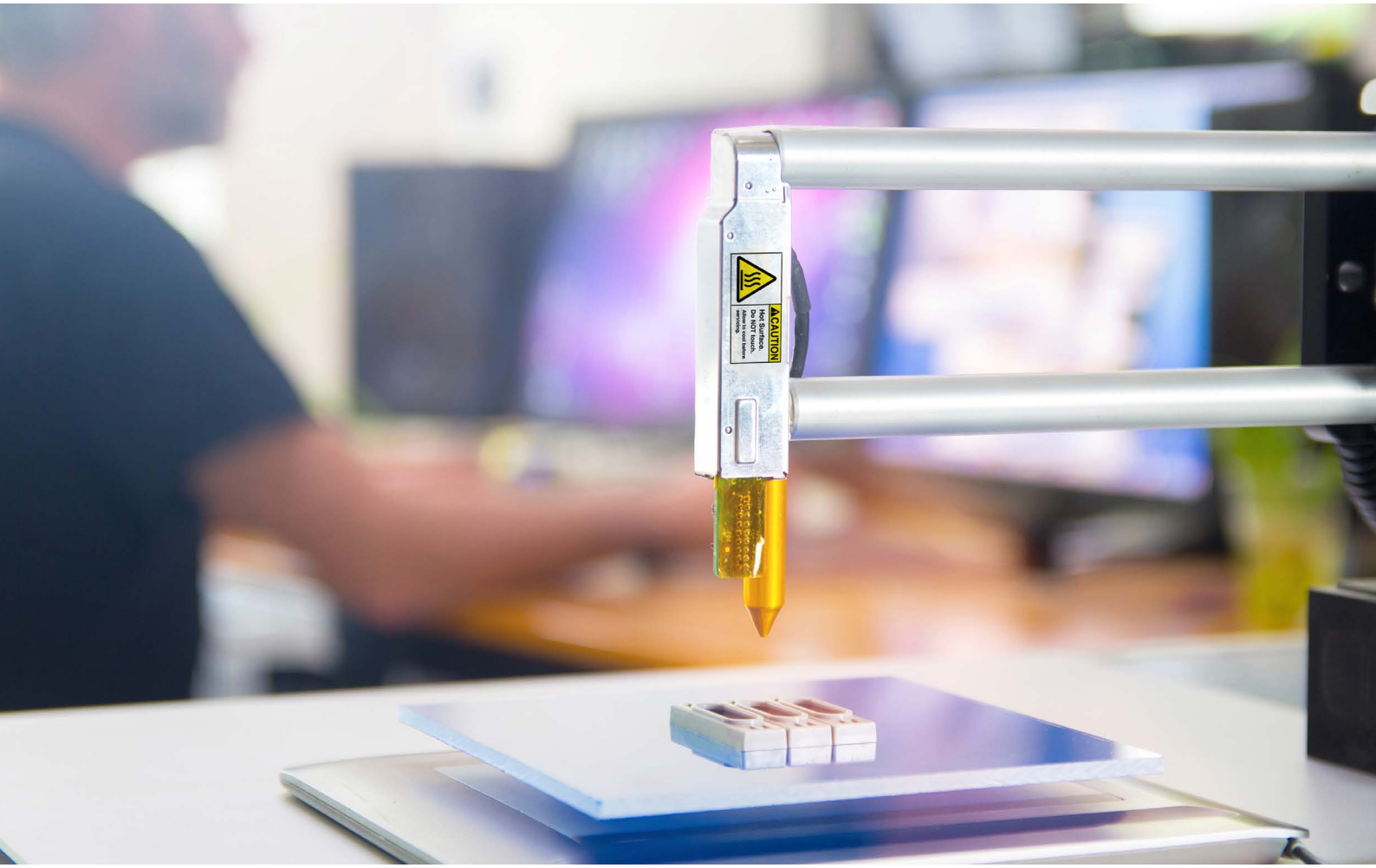


* Percentages are of respondents from the Sculpteo survey.
Source: Sculpteo, *The State of 3D Printing* (survey of 1,000 people), as published in Hedstrom, J., "The State of 3D Printing…", *Quora*[31]

Positive impacts
- More personalized products and personal fabrication
- Creating niche products, and making money selling them
- Fastest growth of 3D printing where each customer has slightly different needs from a product – e.g. a particular shaped foot requires a specially sized shoe
- Reduced logistics costs, with the possibility of huge energy savings[32]
- Contributing to abundant local activities; crafting own goods that benefit from the removal of logistics costs (circular economy)

Negative impacts
- Global and regional supply and logistics chain: lower demand resulting in job losses
- Gun control: opening opportunities for printing objects with high levels of abuse, such as guns
- Growth in waste for disposal, and further burden on the environment
- Major disruption of production controls, consumer regulations, trade barriers, patents, taxes and other government restrictions; and, the struggle to adapt

The shift in action
Almost 133,000 3D printers were shipped worldwide in 2014, a 68% increase from 2013. The majority of printers, selling for under $10,000, are thus suitable for applications from laboratories and schools to small manufacturing businesses. As a result, the size of the 3D materials and services industry grew strongly, to $3.3 billion.[33]

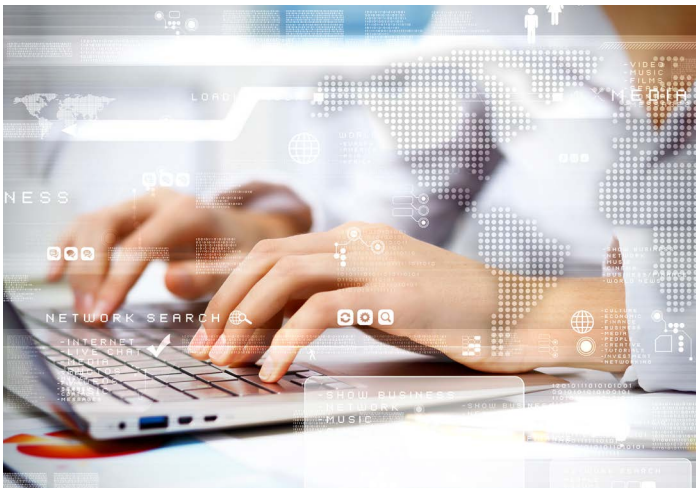

CAUTION
Hot Surface.
Do not touch.
Allow to cool before
servicing

Cross-Cutting Impacts

Of course, many of the impacts felt as a result of these transitions cut across many facets of society and the economy. The Global Agenda Council on the Future of Software & Society has attempted to draw these together in this section, in areas ranging from jobs to ownership, government to security.

Jobs and the Nature of Work

Published as, "How technology will change the way we work," by Derek O'Halloran, Head of Information Technology and Electronics Industries, World Economic Forum, 13 August 2015, AGENDA, https://agenda.weforum.org/2015/08/how-technology-will-change-the-way-we-work/



People have always developed tools and technology to help pursue their goals. As civilizations emerged, the social and economic structures of societies were defined, to a large degree, by the roles of the different participants – which, in turn, were defined by the technological tools available. Large shifts in technology resulted in large shifts in social structures, and in how individuals both contributed to society and made their own living within it. Most recently, the Industrial Revolution brought large scale changes to socio-economic structures – and the kinds of work people engaged in.

Technological advances are rapidly making it possible to automate many activities that currently require human work. This applies to blue-collar jobs, through robotics and the Internet of Things, as well as to white-collar work through AI. The wide applicability of these technologies has led to concern about the destruction of jobs. A 2013 Oxford Martin School study[34] estimated that 47% of US jobs could be replaced by automated processes within two decades. While always removing the need for some types of jobs, technology creates new ones and provides a set of tools to leverage in different ways for increasing the efficiency of labour inputs. The Industrial Revolution destroyed some jobs but created many more; it further increased the aggregate wealth of society and began to create a middle class that could start enjoying health, education and other benefits previously available to only the wealthiest people. Furthermore, it can be challenging to predict what kinds of jobs will be created, and almost impossible to measure them. The picture looks worse than it actually is. Nine of the 10 most in-demand jobs in 2012 did not exist in 2003.[35]

For many, this picture is overly optimistic. A disparity exists in the skills required for the old and new jobs – you can't turn an assembly-plant worker into a data scientist overnight, if at all. The Industrial Revolution played out over several decades and, yet, still caused massive social upheaval, unrest and widespread deprivation for many. The digital revolution may happen much faster, across large areas of a complex, interconnected economy which has very tight feedback loops built in.

Others are concerned that this time, it might, in fact, be different – that we are facing a permanent reduction in the need for human labour. While many initially view this as economically naïve, some eminent individuals, including Lawrence Summers, Charles W. Eliot University Professor, Harvard University, USA and Secretary of the Treasury of the United States (1999-2001), are now not so sure. Science fiction has long imagined the future where people no longer have to work and could spend their time on more noble pursuits. Could it be that society is reaching that inflection point in history?

If it is, neither social norms nor economic systems are ready for it. Today, self-worth is inherently tied up with jobs, professions, careers and trades. And, in a global economy based on neoclassical models of capitalism, mass unemployment spells depression, not utopia.

On the question of jobs, novelist William Gibson's famous aphorism may hold true: "the future is already here, it is just not evenly distributed". Certainly, some of these concerns can seem academic or blinkered from the context of a developing country looking to develop key industries and provide employment for its people. At the other extreme, we can already see post-industrial pockets in different advanced economies – from Detroit to Japan. In "A World Without Work", a recent article in *The Atlantic*, the possible futures that may play out are explored, as well as a blend of the unleashing of creativity and freedom to pursue one's passions with an uncomfortable contingency on smaller parcels of work replacing the security of full-time "jobs".

Ultimately, the extent to which jobs are transformed or replaced, or the extent to which this is a transitional shift or a permanent change, may not be set *a priori*. A choice exists over how to use technology, which path to take and which scenario should emerge. Perhaps the question is not a theoretical or empirical one, but one of intent and principle. Perhaps the question is: what kind of society do we want to have?

Security

As software becomes even more ubiquitous in daily life, existing norms about security will have to be rethought, and new policy as well as behavioural and operational frameworks will be needed to institutionalize sound security models and instil confidence for individuals, companies and governments.

New connected solutions, in and of themselves, will be neither more nor less secure than current technologies or ways people conduct business and interact online. Remarkable opportunities exist, however, as software continues to drive the "application economy" forward to ensure that new technologies have the confidence of the constituencies that depend on and trust them.

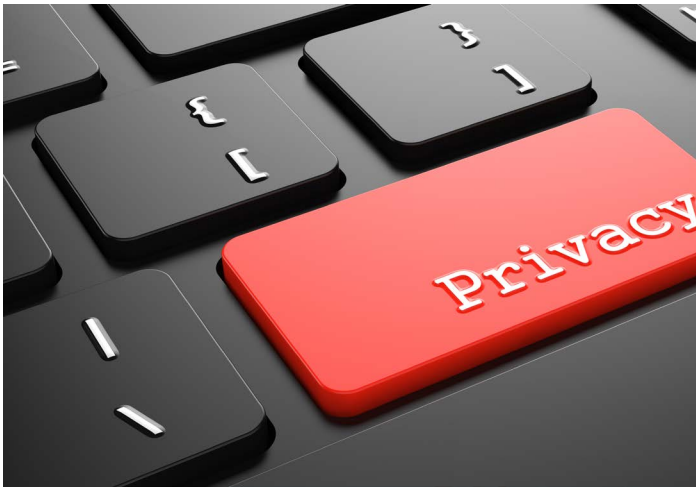
Rarely does a week go by without news of another breach or penetration. Society's move to the internet and the evolving application economy create vast amounts of new data and vulnerabilities. The demands to innovate quickly, to meet user demands and upend existing business models must look to security as a competitive differentiator and mechanism of trust for users and partners. The risks and consequences of poor security are significant and wide-ranging; corporate secrets and reputations, government confidence and trust in technology can all erode quickly when security is breached.

In new software-driven economies, traditional security perimeters disappear. Previously, the path to delivering new services ran through the browser. Today, it's all about the variety of methods for delivering services, whether it be through innovation applications, the internet of things, or through the browser. The demands for user convenience and trust necessitate that new approaches to security take root in this environment. Increasingly instead of securing networks, we must secure the data itself. Security has traditionally been viewed as an expense to protect the business – in a world where everything is driven through software, security must both protect and instill confidence and enable business.

Virtually all of the megatrends presented here have security risks and opportunities. A deliberate focus on international norms in cyberspace must be undertaken by governments globally.

Security is not just about data or networks; attitudes, and physical and financial risks, must all be addressed for the megatrends to take root. The intersection between virtual and physical security continues to come into sharper focus.

Transparency, Trust and Privacy



The rise of software applications and app-driven economies necessitates enhanced focus on trust, privacy and transparency. The megatrends presented in this report all present both risks and opportunities when it comes to trust and transparency. As people continue to share, collaborate and interact online, these issues will continue to intensify.

The technology solutions powering the megatrends covered here must be built on users' trust for them to deliver on their potential. Both privacy and security, as interrelated components, are critical. Protecting privacy and ensuring trust is a shared responsibility of all actors involved, and cooperative development of acceptable practices and consequences will be vital to enabling further growth in information services.

Awareness raising must be a critical emphasis for public and private actors that develop, implement and incentivize technology development. Consumers and citizens can only have confidence in solutions they understand; as such,

technologists and governments must find new ways to connect users to the services offered. New approaches to disclosure of data usage policies, for example, will be needed. Dissertation-length privacy policies, with technical and legal jargon that make little sense to the average user, must be transformed.

Providers must be clear how customer data is used and for which ancillary purposes, and who – whether governments or private-sector partners – may have access to data and services, and under which circumstances. Governments must be willing to stand up and tell citizens what data is subject to government access; and, the balance between national security and citizens' privacy must be maintained and clearly explained. Uncertainty breeds confusion and mistrust.

An enhanced focus on accountability must be generated so that differing attitudes on privacy and civil liberties can be harmonized – and this, in a way that allows technology to serve the needs of varying geographies, in accordance with diverse legal and societal structures. Updates to existing frameworks to safeguard privacy, such as the Fair Information Practice Principles, Binding Corporate Rules or the Privacy Framework of the Asia-Pacific Economic Cooperation, should be pursued. Many nations still do not have privacy laws. To ensure continued growth and acceptance of software-driven solutions, governments will need to ensure their legal systems have adequate policies to balance personal, corporate and government interests.

The Economy

The economic organization of the perfect society, according to Karl Marx, would be such that man can "hunt in the morning, fish in the afternoon, rear cattle in the evening, criticize after dinner [...] without ever becoming hunter, fisherman, herdsman or critic".[36] The market forces of the 20th century, and the regulated hours and ever-deepening specialization which they promoted, made this a utopian dream for over a century. But with the present third wave of disruption heralded by the technological revolution, and the tipping points outlined in this report, such a society of managed abundance no longer seems so far-fetched.

From an economic standpoint, many of the tipping points offer a means through which productivity, efficiency and even creativity can be enhanced. The rise of 3D printing will vastly reduce production costs of daily products, as well as shipping and logistics overheads. Automation and AI will be part of a world in which goods are produced for little more than the cost of their design and materials. Increased data monitoring could help to rationalize supply chains and ensure that the right quantity and type of goods and services are in the right place at the right time. Similarly, connected homes have the potential to be vastly more energy efficient, reducing direct costs for consumers as well as mitigating economically damaging environmental degradation.

Meanwhile, these savings and dwindling production costs will free up more time and space for a new type of economy – one based on innovation, ideas and information rather than time and toil. Talent has become one new form of capital, as the knowledge economy drives people towards higher-paying forms of work that manage the automated productivity created by technology. Information and data has become the new currency, one which big businesses and even governments increasingly attempt to control and harness in order to extract economic gain.

On a broad level, such developments have a huge emancipatory and egalitarian potential, but only if managed correctly. The progression of Moore's Law and the reduction in the cost of smartphones and other technological interfaces means that increasingly more people have access to the unlimited world of online information. This includes developing regions such as Africa, where many people have skipped the "landline generation" altogether to go straight to digital communication, and where mobile and digital banking also offers financial inclusion to swathes of population previously frozen out of such markets. In many parts of the West, the sharing economy (analysed in more detail in this report) has reduced the fixation on ownership and capital, and offers easier access to anything from accommodation to entertainment.

However, many of these shifts can also create new divisions if not navigated correctly. On the jobs front, automation has already caused and will continue to create widespread disruption to both blue- and white-collar employment, and will need to be accompanied by new models of education and skills training in order not to alienate the growing number of displaced workers. Not everybody is ready to integrate the knowledge economy; and, without adequate social systems in place, a divide could grow between those who can innovate and those who cannot. Although some are confident of the socialist aspect of technology and abundant information, global connectivity and scalable online models tend to lead to monopolization in the internet, as big online firms win larger portions of the market.

In this context, traditional roles and institutions will have to be extensively rethought. Governments in particular (explained in more detail in Shift 18, "Governments and the Blockchain") will be able to move more quickly and assume the role of engaged facilitator rather than supreme commander, as they understand that ultimate control of a digital planet is impossible. Economic and monetary management will be overhauled by new systems anchored in digital currencies and the blockchain, making traditional pricing mechanisms and exchange rate systems less relevant.

Ultimately, in a world where knowledge, information, networks and access rather than ownership take precedence, the biggest shift may come in how the concept of economic wealth in general is measured. Just as some have called for alternative methods of measuring GDP, wealth in the future may be based on the potential to activate resources, rather than the ownership of those resources themselves. Whether or not this is a positive development will depend on how it is managed by government, business and broader society.

Government

"New Public Management Is Dead – Long Live Digital-Era Governance", as Patrick Dunleavy et al. put it almost 10 years ago.[37] Society has certainly gone through a rapid transformation during the past decade: information technology has been driving profound changes, from businesses to people's daily lives, and with unprecedented speed. However, government and public administration, at least in most regions of the world, have not reacted and adapted to these changes quickly enough, and thus have faced immense external and internal pressure. The demand for openness and transparency, increased connectivity to share knowledge and information, as well as efficiency and effectiveness, is at a historical high. A new model of government, based on the digital and software platform, is therefore an urgent need, and will eventually redefine the relationship between governments and their people.

In the digital age, data and information have become more accessible through multiple channels. Government needs to evolve from being the top-down "authority" to the network-based "authentic data hub". It needs to be more open in sharing data in order to earn trust and be seen as accountable. It must be more proactive in engaging the public through activities in order to drive public value, and be more willing to empower the public for decision-making to better address social issues and challenges. Government's role is to better assess the social environment, connect stakeholders and relocate and integrate resources to create the foremost social value for everyone.

In addition, the digital government needs to provide personalized one-stop service based on the individual's needs. To do this, government must transplant all services online, break silos, rebuild the architecture of services based modules, and then provide the public with access to these modules to create personalized menus for services, individuals and businesses. Different functions within the government may still exist, but based on the software platform, these departments will be able to share and track related data, and work with each other on a real-time basis. Some process-based work may even be taken by algorithms so that waiting times and unnecessary mistakes can be avoided.

A more transparent, service-based digital government will find it less necessary to withhold the heavy weight of resources. Its role will shift towards being a dispatcher of resources through digital platforms. In the network-based economy, the critical tasks will be the ability to track and assess the need for resources, and to coordinate the flow of activities and monitor abnormal ones that might jeopardize the public value and inclusiveness. To a certain extent, when the economy is network based, enterprise will also become network based – as will the government.

Of course, all of these will not become reality unless government adapts quickly to new tools and platforms, such as adopting the blockchain to create new taxation mechanisms, or leveraging big data and data analytics to enhance the precision of public resource planning and allocating. The government must act on certain issues, and act fast – for example, on governing cyberspace, balancing access to data and data privacy, and eliminating the border between data and information control. Therefore, governments in the digital age need to be responsive to rapid changes and challenges. They need to adapt and continuously evolve in order to co-create public value with the private and public sectors.

Organizations, Communities – and the Individual

As connecting to the internet becomes increasingly more routine, and people use it to stay informed and to communicate, the nature of human organization will shift. This shift is especially significant for companies, governments and countries. Whether people are functioning as employees, customers or citizens, their behaviour is altered as they take advantage of connectivity and connected communications with each other.

At a macro level, the shift can be characterized as a movement from top-down structures to those that are bottom-up. Technology, communications and information are empowering ordinary people. This shift is also often characterized as a "flattening" or "levelling." Systems of authority, accepted for generations or even centuries, are being challenged and remade. Nearly all organizations will see their functions altered as these behaviours continue to shift, and as the tools continue to evolve. In general, the world is becoming more empowering for individuals than it is for institutions.

The central reason for this development is that ordinary people have access to communications tools of ever-increasing power. The tools range from email or texting to complex commercial services such as Facebook, Twitter, Sina Weibo, WeChat, Instagram, Snapchat, YouTube, Skype and many others. Such services allow ordinary citizens to communicate instantly with others anywhere in the world. Even more importantly, the services often confer broadcast power – the kind of power that, until recently, was reserved for rarefied elites who had exclusive access to expensive broadcast and print technologies.

A related liberating set of changes is happening with information. Anyone now has easy access to facts and opinions because of the web itself and, specifically, services like Google, Baidu, Bing and Wikipedia. Technologist Ray Kurzweil said recently: "A kid in Africa with a smartphone has more intelligent access to knowledge than the President of the United States had 20 years ago."[38] The result of the concentrated powers of the past was an asymmetry of both knowledge and potential societal impact. Those higher up knew more and could achieve more than the people lower down. But as that asymmetry diminishes, and people of all sorts gain access to information, they can take more informed action. This means any employee can innovate and generate valuable ideas inside a company, if the company is structured to notice. It means customers don't have to spend until they can conclusively research the price and features of products and services, and learn what other consumers have experienced. And it means citizens can mobilize their peers on Facebook or other services and have political impact, with or without the assistance of organized political parties.

The efficiency and power of communications give people the ability to alert and sometimes mobilize others to organize, undertake common action and protest. Combined with the extraordinary and growing access to information, they enable people to get a better deal as customers, and a better government as citizens.

Along with all this comes new mandates for leaders. Decision-making will become more transparent, as affected communities expect to understand how decisions are arrived at. A more consultative mindset will often be necessary. Products will increasingly be developed in consultation with customers. Leaders will more rapidly rise up from communities in response to crises. And, leaders with global appeal, such as Pope Francis, will find their influence heightened and the speed of their impact accelerated.

The power of these changes, and their potential to have political impact in organizations and especially countries, are already leading many leaders to react against the tools of software and connectivity. Governments around the world are instituting restrictions of various sorts to prevent citizens from gaining access to information that might challenge the status quo, and to prevent them from using broadcast internet tools to communicate with other citizens.

How successful these efforts to restrict the free flow of digital information will be is not certain, but, in general, the recent history of the digital age suggests it is hard to effectively restrict information flows.

Many of the six megatrends characterizing the impact of software and services on society in the coming years also contribute to changes in the impact of individuals. Increasingly, everyone has a digital presence, and tools to connect to the internet are becoming cheaper, more available and more diverse. Ordinary citizens have genuine power with "a supercomputer in their pocket".

The tools of big data and AI will initially be most easily accessible to large, rich and powerful organizations. However, if the past is any guide, such tools will increasingly become commoditized and accessible to anyone. Google itself, for that matter, is a universally accessible and intelligent way to search a massive quantity of data, offered as a free service. As the world shifts towards networks and platform-based social and economic models, the beneficiaries of these more equitable, transparent and widely shared systems of value creation will be people who, in many cases, had previously little or no access to the systems of power.

But the consequences of all this individual empowerment cannot be fully foreseen. The shifts entailed will not always be comfortable or easy. Already, for example, a sort of mob rule is sometimes developing, as consumer-driven social media amplifies issues and demands immediate resolution of problems and apparent injustices. Often this can have positive consequences, such as liberating a country from a dictator. However, it can also lead to uncertain, unreasonable and unstable results in systems at all levels of society. Regardless, our organizations and institutions need to anticipate and prepare for an increasingly empowered and engaged citizenry.

Shifting Ownership

Ownership has always been an important factor of wealth, stability and power in society. In developed economies, graduates forsake mobility and took on large debts to get a foot on the property ladder, while around the world, the ownership of physical assets such as vehicles remains a solid symbol of status and independence. As far back as 1755, Jean-Jacques Rousseau described the ownership of private property as the ultimate foundation of both civil society and inequality.[39]

This has shifted in recent years. The sharing or collaborative economy – loosely defined as the distribution and sharing of excess goods and services between individuals largely enabled by modern technology – has expanded to touch upon almost all aspects of society. Cars are pooled and shared on Uber and Lyft, entertainment is rented rather than purchased on Spotify and Netflix, and even the home is periodically leased to ephemeral travellers on Airbnb. People are now more concerned with paying for access than with ownership, which has deep consequences for individuals, business, society and the economy.

The advantages for individuals are abundant. Access to quality goods and services at highly competitive rates has been enhanced, with such products often available instantly through mobile booking. The ability to lease previously fixed assets such as cars opens up new, relatively informal avenues for generating income. Employment options have grown with working remotely and peer-to-peer task sharing of anything from translation to writing tenders. All of this has led to a more flexible form of economic life, which allows individuals to be more independent and flexible than in the past, living primarily from cash flow rather than from fixed assets and wealth.

Yet, more flexibility can also imply less stability, and the move towards such an economy could leave workers vulnerable in the next downturn in employment. They might not be “too big to fail”, but less saving and asset ownership mean more dependence on regular work. In a society where short-term and zero-hour contracts are increasing, this could lead to an agile but fragile workforce.

Similarly, on the more macro societal and economic level, these shifts should theoretically lead to a large-scale overhaul of traditional organizational structures. Tax systems, pension schemes and trade unions will all have to be conceptually rethought or will become obsolete. Global inequality could be reduced and financial inclusion boosted by granting access to millions of citizens previously locked out of capital-based marketplaces. Shared access to 3D printing resources could provide a welcome boost to the environment by reducing dependence on large-factory employment in developing countries, and by reducing pollution and wastage in supply chains in developed nations.

Of course, not only physical assets are concerned by ownership shifts. In a digital world, data and online presence are themselves assets, and the question of who owns them has already sparked legal battles and fierce competition between large online corporations as well as governments. Indeed, in a knowledge future where the concept and measurement of “wealth” will need to be reassessed, and where connectivity and access will be prioritized over physical possession, perhaps the ownership of this data will measure the worth of a person or organization.

Conclusion

The software-enabled shifts described in this report fundamentally provide the capability for two things: digital connectivity of everyone to everything (in smaller and smaller units of both), anywhere and at any time; and a set of mechanisms or tools for analysing and using the data associated with almost all aspects of daily life. The world and what people can do is increasingly being is increasingly being driven and enabled by software, and what people can access and analyse is simultaneously becoming more "bite-sized" and aggregable. This creates the opportunity to offer innumerable services by and between individuals and organizations of all types, from companies to non-profit organizations and governments. It also, however, portends large-scale change that could be difficult to absorb in both scale and speed.

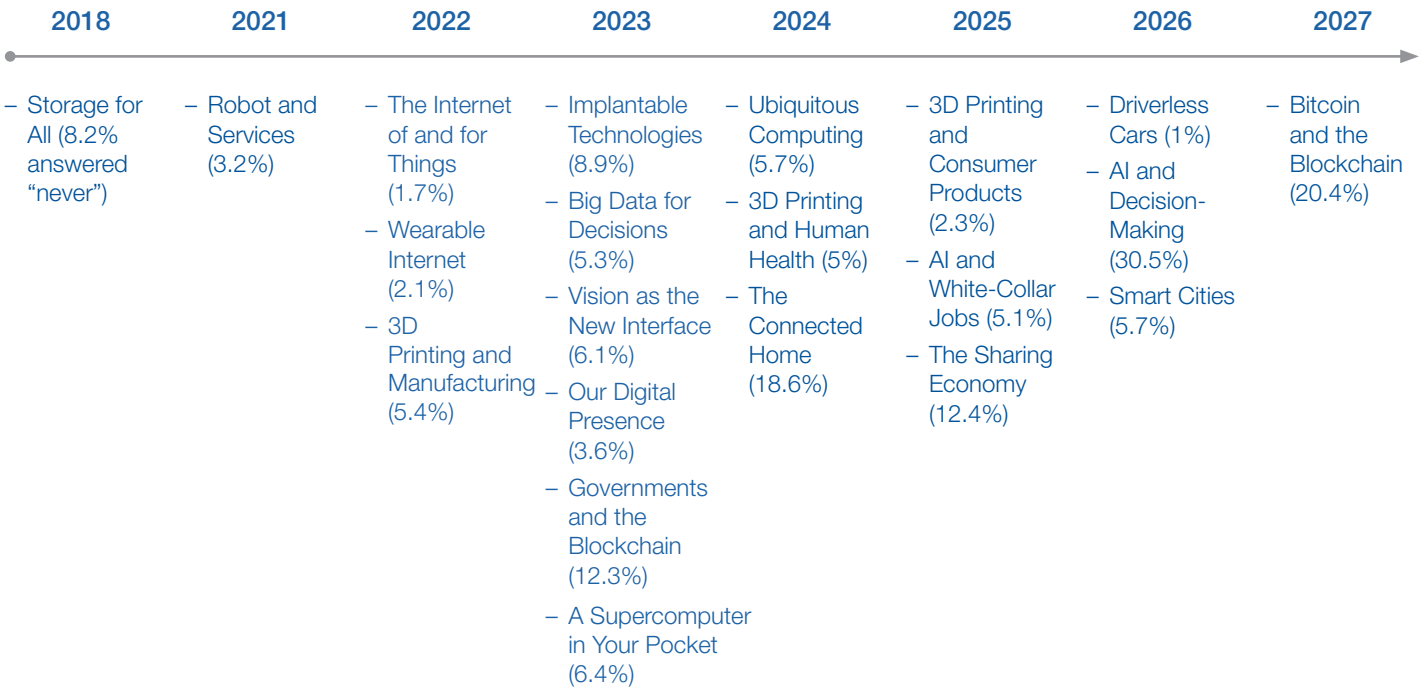
The potential is huge. Imagine the positives of being able to access any service you want, or physical asset or tool you need, when and where you need it; or being able to predict a serious health problem before it happens, and get the needed service – or an organ perfectly made just for you – wherever you are. While the potential for democratization and transparency are great, real concerns arise. With data created on everything, will individuals still have acceptable levels of privacy? What will happen to the sense of worth, place and contribution to society that people derive from work and have felt throughout history?

The challenges of navigating the transition are great as well. As highlighted in this report, the individual, organizational, governmental and societal adjustments are not trivial, and everyone will feel their impact. The speed of various aspects of the transition is hard to predict, but it is not difficult to see that the world will function quite differently 10 to 15 years from now. Being prepared to navigate the transition begins with awareness of the shifts to come, and some understanding of their implications.

Appendix

Timeline of Future Shifts: Taking the "Never" Response Out of the Equation

A weighted average system was used to calculate these timelines. The most difficult consideration was how to weight the responses that a shift would "never" happen. Two main options existed: the first was to take "never" out of the equation and present the timeline as "of those who thought this shift would happen, they thought it would happen in [year]"; the second was to give an arbitrary number to "never", for example 50; this would give a larger spread, but is less methodologically sound.



Endnotes

1. See the Appendix for the percentage breakdown of “never” responses per tipping point.
2. Borrowing from the concept of the yelp.com website, in that people would be able to provide reviews directly to others, and those reviews would be recorded and/or shared online through chips implanted in them.
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